

[54] **FLUID INLET STRUCTURE FOR CYCLONE COLLECTORS**

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[58] Field of Search 55/459, 460, 418; 209/211, 144; 210/512

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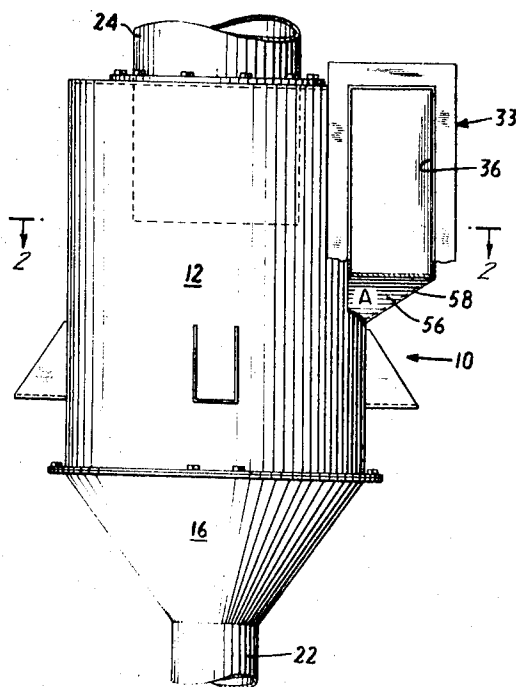
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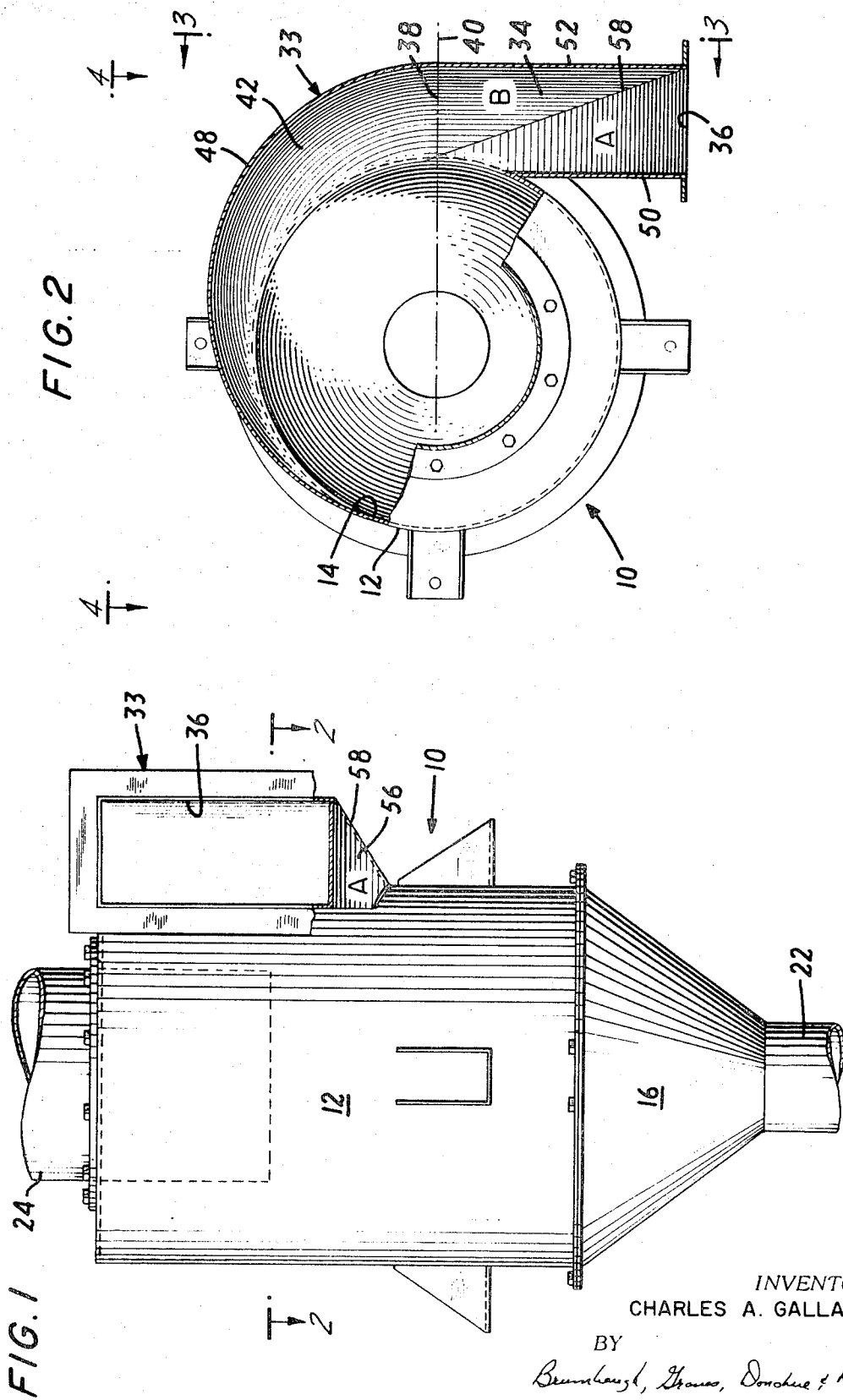
[57] **ABSTRACT**

A fluid inlet structure for a cyclone collector includes an inlet conduit having an inlet end opening remote from the cyclone chamber and an outlet opening which constitutes the inlet to the chamber. An inlet flow guide has an upstream portion substantially contiguous to the inlet conduit and an outer wall which converges with the chamber in the downstream direction for guiding fluid flowing through the inlet conduit into the chamber. The cross-sectional shape and dimensions of the inlet conduit vary in size along the direction of flow for gradually generating a velocity gradient in the fluid conduit flow at the outlet opening such that the velocities of flow streams at the outlet opening are greater, the greater the distance they are from the housing axis. This velocity gradient results in all fluid entering the flow guide at about the same given point in time tending to progress around the guide substantially along an imaginary rotating plane and inhibits the formation of eddy currents in the inlet flow guide.

4 Claims, 4 Drawing Figures

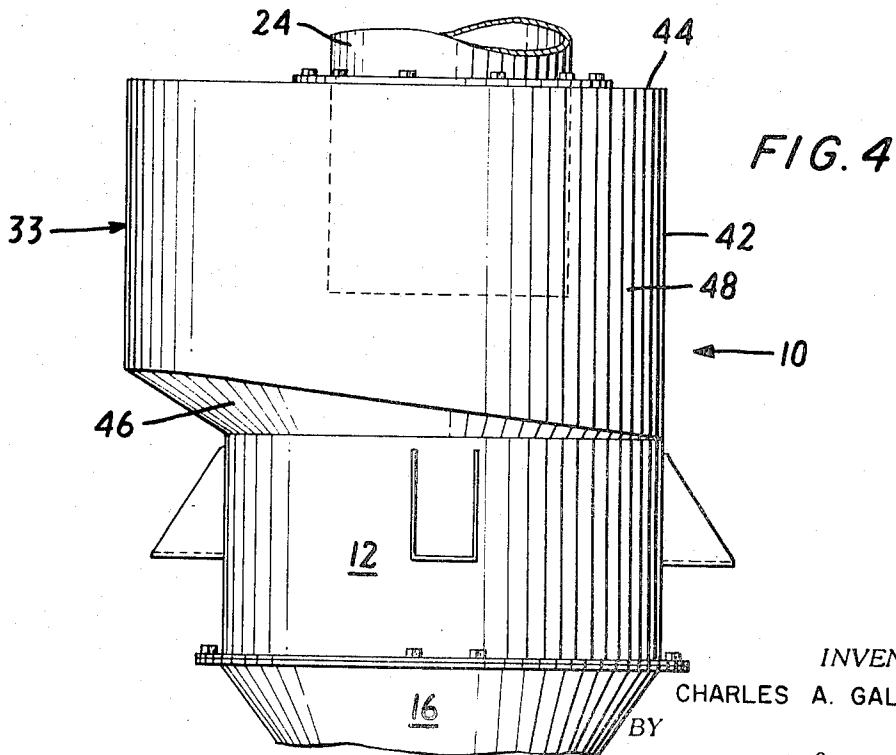
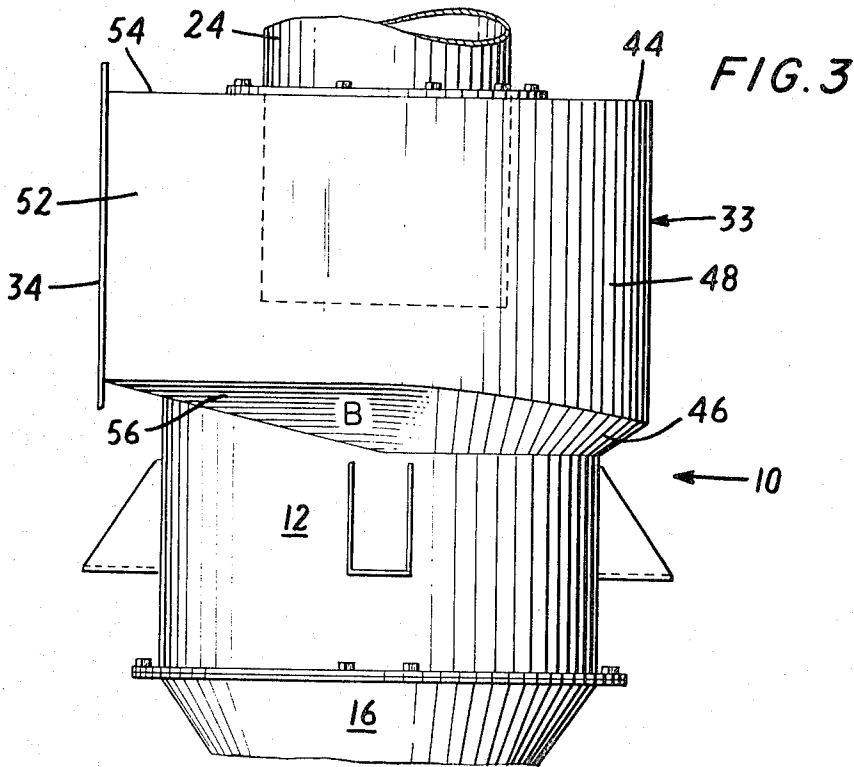


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FLUID INLET STRUCTURE FOR CYCLONE COLLECTORS

BACKGROUND OF THE INVENTION

This invention relates to cyclone collectors and, in particular, to the fluid inlet arrangements through which fluids are introduced into cyclone collectors.

Cyclone separators and collectors are widely used to separate materials of different densities. For example, particulate solids can be removed from gases or liquids by a cyclone collector.

An important and long-standing problem with cyclone separators and collectors arises from the phenomenon of double eddy currents which form when the direction of a fluid flow is changed in a channel which has a uniform cross-section. When fluid flows, for example, through a bend in a channel a pressure gradient develops across the bend due to the non-uniform centrifugal forces of fluid particles moving around the bend. In an ideal fluid, stability occurs when this pressure gradient brings about a balance between centrifugal and centripetal forces on the fluid particles. In a real fluid, however, this stability is disrupted by reduced velocity near the channel walls. The reduction of velocity of fluid near the outer wall of the bend reduces the centrifugal force on the fluid particles moving in that portion of the bend to be below that of an ideal fluid, and causes the fluid pressure there to drop. The fluid velocity and pressure toward the center of the bend remain about the same as those in the ideal fluid. This lowering of the relative fluid pressure at the outer wall causes a redistribution of fluid energy and a secondary fluid motion in the bend from the inner wall toward the outer wall in the form of a double spiral motion or double eddy current. The energy of the secondary motion is ultimately dissipated into heat as the energy is broken down by fluid viscosity, but not before smooth and efficient flow is interrupted.

In cyclone separators and collectors fluid is normally introduced into a main cylindrical chamber through an inlet structure which has a curved portion that guides the fluid into the chamber from a straight, tangential inlet conduit and turns the flow from straight to arcuate. The combination of fluid flowing through the curved guide and the high speed whirling action of fluid circulating around the chamber results in a highly complicated current distribution pattern. The formation of eddy currents in the curved guide, as well as within the chamber itself, is a factor which has frequently been overlooked in the design characteristics of cyclone collectors. For the most efficient operation of a cyclone the fluid should be introduced into the chamber as smoothly as possible.

It has heretofore been proposed that cyclones can be constructed to take advantage of the double eddy current phenomenon and compensate for some of the efficiency loss caused by the turbulent fluid movement by incorporating specially shaped channels within the chamber to skim off particles that tend to concentrate in certain portions of the chamber. These cyclone collectors usually include a complicated series of additional ducts, vanes, and/or grooves within the chamber. Unfortunately, such devices themselves reduce efficiency because of the additional surface area across which the fluid must flow, and the consequent energy losses, and the interruption of simple flow patterns.

Cyclone collectors have been developed which employ specially designed inlet ducts that extend into the main chamber of the cyclone collector and which direct fluid to a certain portion of the chamber or which otherwise regulate the flow of the introduced fluid in some manner.

All of the expedients referred to above are based on either the concept of compensating for the problems caused by the double eddy currents or on the concept of taking advantage of them as much as possible. However, none of these expedients have been directed to preventing the formation of eddy currents in the inlet duct.

SUMMARY OF THE INVENTION

This invention, instead of attempting to adjust the design of a cyclone collector to compensate for the double eddy currents in the fluid inlet, provides an inlet structure that is shaped and dimensioned to prevent the eddy currents from forming within a curved portion of the inlet structure and to provide a smoothly flowing fluid flow in the transition from a straight inlet conduit to a curved inlet guide. The invention significantly increases the operational efficiency of cyclone collectors.

In accordance with the invention, an inlet structure for a cyclone collector includes an inlet conduit which is disposed substantially tangentially to the cyclone housing and includes an inlet end opening remote from the housing and an outlet opening located generally in a radial-axial plane of the housing and extending generally radially outwardly from the chamber, the outlet opening of the inlet conduit constituting the inlet to the cyclone chamber. The inlet conduit is contiguous to a flow guide that extends part way around the cyclone chamber and extends out from the housing wall. The flow guide has upper, lower and outer walls defining an outwardly confined and inwardly open entry flow path for conducting fluid into the chamber. The outer wall of the flow guide converges smoothly toward the housing wall in the downstream direction, relative to the direction of fluid flow as it enters the chamber from the inlet conduit, to a point where it merges with the housing.

An important aspect of the invention is the configuration of the inlet conduit, to wit: The inlet conduit is shaped and dimensioned at successive cross-sections transverse to the direction of fluid flow such as to gradually generate a velocity gradient in the flow at the outlet opening from the inlet conduit in which the linear velocities of substantially all flow streams are functions of their respective distances from the axis of the cyclone chamber, such velocity gradient at the outlet opening where the fluid entering the cyclone is turned from a substantially straight flow to a curved flow is preferably such that all fluid entering the flow guide at a given point in time tends to progress around the flow guide substantially along an imaginary, rotating, radial-axial plane, in other words, such that the rotational velocity of all fluid streams is essentially a constant at the entrance to the flow guide of the cyclone inlet.

The specific shapes and dimensions of the inlet conduit along its length will vary, depending upon a number of design factors such as the cross-sectional shape and the dimensions of the delivery conduit of the cyclone, the flow conditions at the inlet opening to the cyclone inlet conduit, the possible need for decreasing or increasing the velocity of the fluid before it enters in

the cyclone, relative to the velocity as the fluid is delivered to the cyclone inlet conduit, the curvature of the inlet flow guide and cyclone, the fluid being separated, and the like. Usually, the velocity of the fluid at the inlet opening to the cyclone inlet conduit will be uniform across the cross-section (apart from boundary conditions). If so, the inlet conduit will be shaped and dimensioned at succeeding cross-sections so as to produce a decrease in the velocity of flow streams nearest the axis of the cyclone relative to the velocity of the flow streams farthest from the axis of the cyclone.

The gradual change in shapes and dimensions of succeeding cross-sections can be such as to (1) increase the absolute linear velocity of the radially outermost flow streams while maintaining the innermost flow streams constant, (2) reduce the absolute velocity of the innermost flow streams while maintaining the outermost flow streams at a substantially constant velocity, or a combination of reducing the absolute velocity of the innermost flow streams and increasing the innermost velocity of the outermost flow streams. It will be readily apparent to those skilled in the art, therefore, that the design of the inlet conduit can take various specific forms. It is important however, that the velocity of all flow streams at a plane in the vicinity of the transition from straight to curved flow have a gradient such that the linear velocity of a given flow stream is a function of its distance from the axis of the cyclone. By following this principle, the outermost flow streams are travelling at a linear velocity that is faster than that of the innermost flow streams, and the flow along the curved inlet guide, which constitutes a transitional stage for introduction of the fluid to the cyclone, will progress substantially uniformly along an imaginary, rotating, radial-axial plane of the cyclone. Consequently, the conditions that produce double eddy currents are substantially eliminated.

It is apparent that the initial and final cross-sectional shapes and dimensions of the inlet conduit will be different. It is advantageous that the conduit be shaped along its length to provide a reasonably smooth transition from the initial shape and dimensioning to the final shape and dimensioning, in order to ensure a gradual generation of a velocity gradient at the outlet from the inlet conduit to the flow guide of the cyclone. Similarly, the shape of the upstream end of the cyclone inlet flow guide should substantially conform to the shape of the outlet end opening of the inlet conduit, again to ensure smooth flow conditions.

DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be made to the following description of an exemplary embodiment, taken in conjunction with the figures of the accompanying drawings, in which:

FIG. 1 is a front elevational view of the embodiment;

FIG. 2 is a top view partly in elevation and partly in cross-section taken generally along the line 2—2 of FIG. 1;

FIG. 3 is a right side elevational view, as represented by the line 3—3 in FIG. 2;

FIG. 4 is a rear elevational view, as represented by the line 4—4 in FIG. 2.

DESCRIPTION OF THE EXEMPLARY EMBODIMENT

The exemplary embodiment of the fluid inlet struc-

ture, according to the invention, is described below and illustrated in the drawings as it might be employed in a cyclone dust collector (designated generally by the reference numeral 10) of relatively simple and conventional form. The collector 10 is composed of a generally cylindrical wall 12 which defines a chamber 14 through which a dust-laden gas is conducted in a whirling, generally circular flow. The centrifugal forces acting on the gas as it whirls around through the chamber cause the dust particles to collect adjacent the wall of the housing and to gradually move down into a truncated conical collector 16 for removal through an outlet conduit 22 that is equipped with a valve (not shown). The gas fraction of the dust-laden input to the cyclone is removed from the chamber through a tubular outlet conduit 24 that extends part way down into the chamber.

An exemplary form of inlet structure, according to the invention is designated generally in the drawings by the reference numeral 33. The inlet structure 33 includes an inlet conduit 34 which is disposed substantially tangentially to the housing 12 (see FIG. 2), and has a rectangular inlet end opening 36 remote from the housing 12 and a trapezoidal outlet opening 38 which is located generally at a radial-axial plane of the housing 12, the plane being represented by the line 40 in FIG. 2. The outlet opening 38 of the inlet conduit 34 constitutes the inlet to the cyclone chamber 14.

The inlet structure further includes an inlet flow guide 42 that is composed of an upper wall 44, a lower wall 46 and an outer wall 48, which define an outwardly confined and inwardly open entry flow path that extends out from and part-way around the chamber for conducting the fluid into the chamber from the inlet conduit 34. The outer wall 48 of the flow guide 42 is curved and converges with the chamber 14 in the downstream direction to a point where it merges with the housing 12. Because the inlet flow guide 42 is curved, eddy currents would tend to form within the guide 42 if the fluid were to flow through it at a uniform linear velocity, and the resulting turbulence would materially decrease the operational efficiency of the cyclone 10. To prevent the formation of the eddy currents in the inlet flow guide 42, the inlet conduit 34 is, according to the invention, shaped and dimensioned to generate a gradient in the linear velocity of fluid flowing from the conduit 34 into and along the flow guide 42.

In particular, the inlet conduit 34 is composed of a flat, trapezoidal inner wall 50 which is attached at its outlet end to the housing 12, a flat, rectangular outer wall 52 which is attached at its outlet end to the outer wall 48 of the inlet flow guide 42, a flat, rectangular wall 54 which is contiguous to, and may be integral with, the upper wall 44 of the inlet flow guide 42, and a bottom panel 56. Inner wall 50 has a horizontal upper edge, a relatively short vertical edge at inlet opening 36, a relatively larger vertical edge at outlet opening 38, and a downward sloping bottom edge. The bottom panel 56 has two separate sections, designated by letters A and B, which are flat and of generally triangular shape and are attached to each other and to the lower edges of the inner wall 50 and outer wall 52 and to the lower wall 46 of the inlet flow guide 42.

The Sections A and B are attached to each other along a diagonal joint or juncture 58 which slopes down from the lower edge of the outer wall 52 at the inlet end

opening 36 to a point on the cylindrical housing 12 which is located generally where the radial-axial plane 40 intersects the housing 12. Thus, the panel section A slopes down from the inlet end 36 of the conduit, tapers toward its intersection with the housing 12 and lies in a sloping plane that includes the lower edge of the end opening 36 and the juncture 58. The panel section B slopes down from the lower edge of the conduit outer wall 52 toward the juncture 58 and therefore lies in a sloping plane that includes the lower edge of the outer wall 52 and the juncture 58.

It will be observed that the shaping and dimensioning of the inlet conduit provides vertical differential cross-sectional areas at each cross-section of the conduit that increase as a function of their distance from the outer wall 52. In addition, the extent of the increase of such vertical graduated differential cross-sectional areas in each cross-section is greater, the greater the distance the cross-section is from the inlet end opening. This variation in the cross-sectional dimensions of the inlet conduit 34 results in the establishment of a non-uniform linear velocity gradient in the gas flowing through the outlet opening 38 into the inlet flow guide 42, the velocity of the flowstreams at the outlet opening 38 increasing as a function of their respective distances from the housing axis. By generating this linear velocity gradient at the outlet opening 38, fluid entering the inlet flow guide 42 at about the same point in time will tend to progress around the guide 42 along an imaginary, rotating radial-axial plane. In other words, the rotational velocities of all differential units of the gas flowing past the outlet opening 38 and turning into the inlet guide at a given instant are substantially equal. This results in the substantial elimination of a pressure differential across the gas flow in the guide 42, thereby preventing double eddy currents from forming. In this way, a smooth transition in the flow of gas from the inlet conduit 34 into the cylindrical chamber 14 is maintained.

The lower wall 46 of the inlet flow guide 42 may be integral with the section B of the lower panel 56 of the inlet conduit 34 and is in the shape of a partial conical section which is substantially concentric with the cylindrical housing 12. Provision of a lower wall 46 with this shape enables the gas to proceed from the inlet conduit 34 through the flow guide 40 with a minimum disruption of smooth flow. The vertical dimension of the outer wall 48 of the flow guide 42 gradually increases along the direction of flow. As best shown in FIG. 4, this dimensional increase causes the partial conically shaped lower wall 46 to be tapered in width along that same direction.

In FIG. 2, the point at which the inner wall 50 is attached to the cylindrical housing 12 is shown to be other than along the radial-axial plane 40, which is generally where outlet opening 38 is located. The point of attachment is not, however, critical, and attachment can be made anywhere in proximity to the zone of precise geometric tangency. Also, the diagonal 58 does not have to extend to the housing 12 to where the radial-axial plane 40 intersects the housing 12, but can extend to other points along the housing 12 as long as the velocity gradient described above is induced on the fluid

flowing through the outlet opening 38 into the inlet flow guide 42.

The shape of the inlet conduit 34, as described and illustrated, is merely exemplary and it is within the skill of the designer to create inlet structures of different designs and shapes and varying cross-sectional dimensions along the stream of flow to induce a non-uniform, cross-sectional velocity on fluid flowing through the outlet opening 38 for preventing the troublesome eddy currents from forming in the curved portion of the guide 42.

Thus, there is provided in accordance with the invention a novel and improved inlet structure for cyclone collectors. The embodiment of the invention described above is intended to be merely exemplary and those skilled in the art will be able to make numerous variations and modifications, in addition to those mentioned above, without departing from the spirit and scope of the invention.

I claim:

1. In a cyclone separator of the type having a housing defining a generally cylindrical chamber for the whirling circulator of a fluid and an inlet flow guide connected thereto which includes upper, lower and outer walls defining an outwardly confined and inwardly opened flow path for conducting fluid generally tangentially into the housing, the improvement comprising:

- a. an inlet conduit which is arranged generally tangentially to the housing, said conduit having an outlet connected to the inlet of the flow guide, an inlet remote from the housing, an inner sidewall and an outer sidewall, and top and bottom walls;
- b. said inlet conduit gradually increasing in cross-sectional area from its inlet to its outlet, and the vertical dimension of the cross-sectional area at the outlet gradually increasing from a minimum at the outer side to a maximum near the inner side.

2. An inlet structure in accordance with claim 1, wherein the inlet conduit includes a bottom panel composed of (1) a first section that is attached to the conduit inner wall along the lower edge thereof and (2) a second section that is attached to the first section along a diagonal joint extending from the lower edge of the outer wall adjacent the inlet end opening generally to a point where the radial-axial plane of the outlet opening intersects the cylindrical housing, the second section also being attached to the conduit outer wall along the lower edge thereof and to the lower wall of the guide, and wherein the first section of the bottom panel slopes downwardly from the conduit inlet end opening toward the outlet end opening.

3. A fluid inlet structure in accordance with claim 1, wherein the lower wall of the guide is a partial conical section substantially concentric with the housing.

4. A fluid inlet structure in accordance with claim 3, wherein the outer wall of the guide is substantially parallel to the housing axis and is of gradually increasing height along the direction of flow, such that the width of the lower wall of the guide decreases in the downstream direction of flow.

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