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Leith

[11] **3,785,117**

[45] **Jan. 15, 1974**

[54] **ROTATING CONCENTRIC HOMOGENEOUS TURBULENCE ELECTROSTATIC PRECIPITATION GAS CLEANER METHOD**

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[52] **U.S. Cl.** **55/2,** 55/12, 55/108, 55/113, 55/127, 55/149

[51] **Int. Cl.** **B03c 3/74**

[58] **Field of Search** 55/113, 114, 108–111, 55/121, 127, 149, 2, 12

[56] **References Cited**

FOREIGN PATENTS OR APPLICATIONS

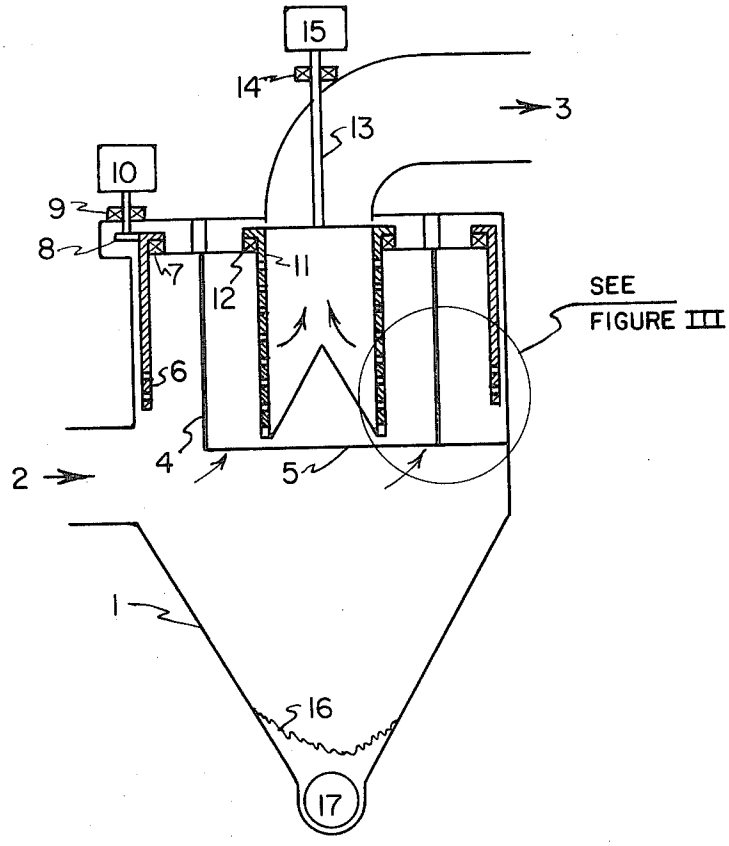
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Primary Examiner—Bernard Nozick

[57] **ABSTRACT**

This invention relates to the application of couette motion caused by centrifugal forces in a rotating concentric "homogeneous turbulence" electrostatic precipitation gas cleaner, to provide uniform separation of gaseous, liquid, and solid particulates in a carrier fluid, by adjustable levels of imposed discrete "homogeneous turbulence" established by Taylor circular couette motion with a multiple array of double rows of secondary flow cellular vortices in the annulus between the inner perforated cylinder and the outer perforated cylinder, with the cylinders rotating at about the same velocity in opposite directions. When the outer cylinder rotates about three times faster and in the opposite direction to the inner cylinder, with the electrical power turned off, an adjustable level of imposed discrete spiral band of turbulence in a travelling wave, will move up or down in the annulus, and will clean the collected material from the surfaces of the discharge and collecting electrodes.

2 Claims, 4 Drawing Figures



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SHEET 1 OF 2

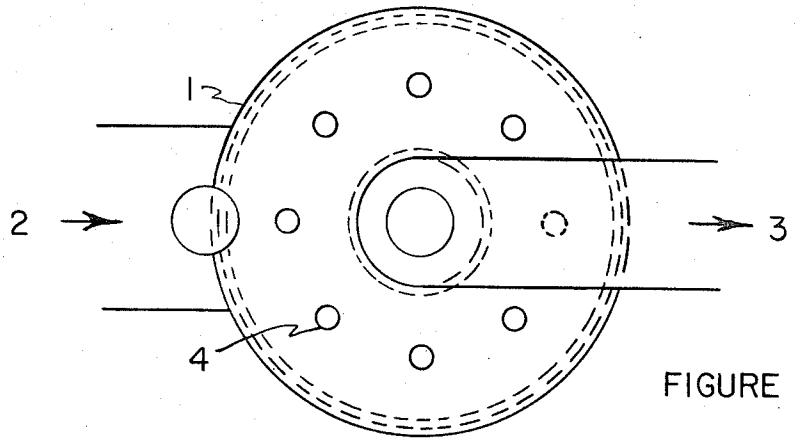


FIGURE I

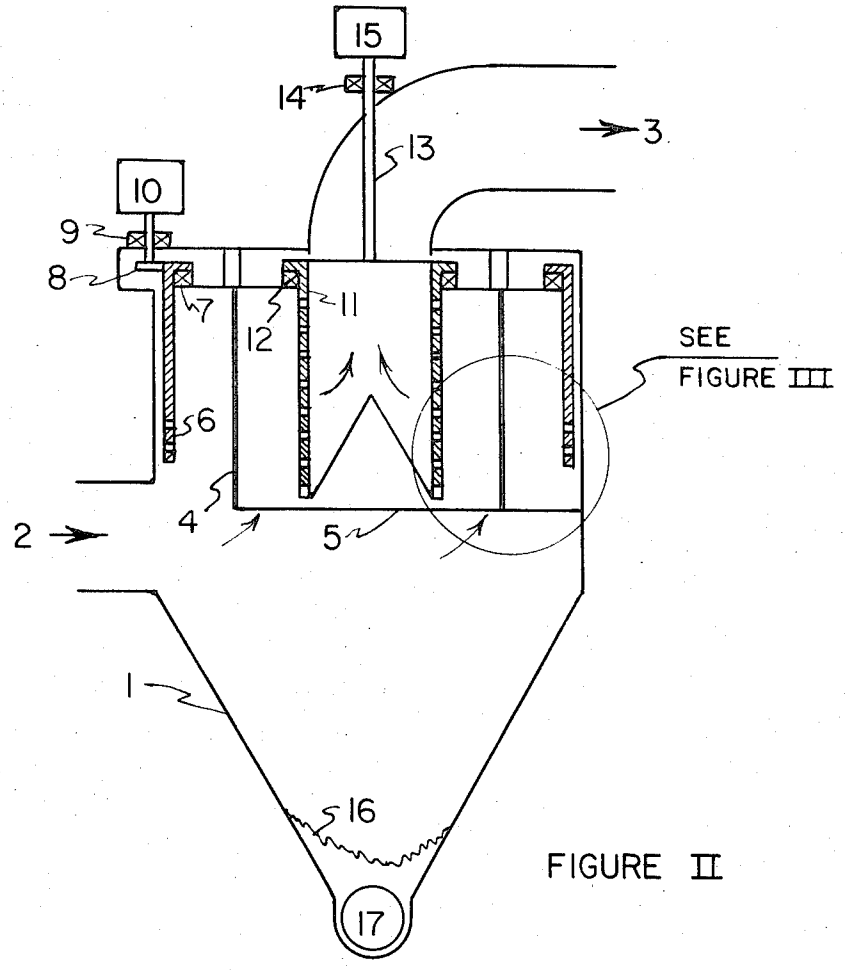


FIGURE II

INVENTOR – William Cumming Leith

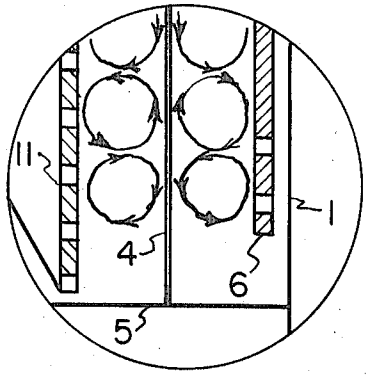


FIGURE III

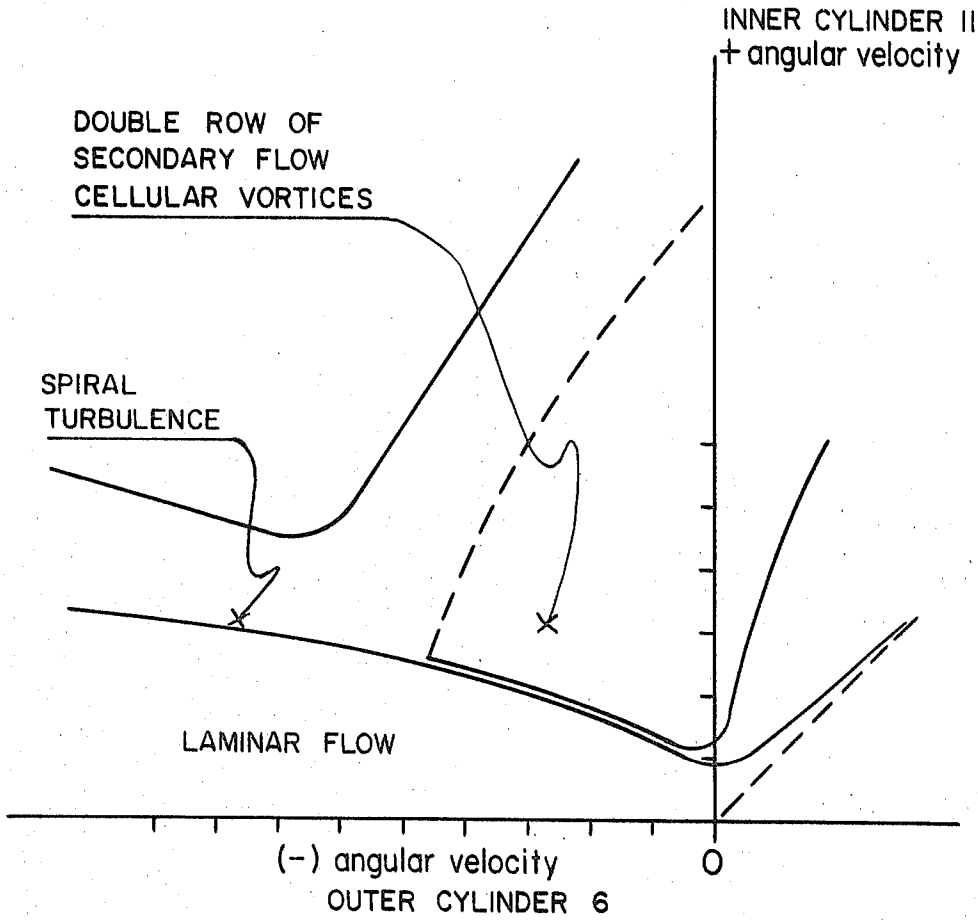


FIGURE IV

INVENTOR - William cumming Leith

ROTATING CONCENTRIC HOMOGENEOUS TURBULENCE ELECTROSTATIC PRECIPITATION GAS CLEANER METHOD

PERTINENT PRIOR ART

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SUMMARY

This present invention consists essentially in the method of utilizing Taylor circular couette motion caused by centrifugal forces in a rotating concentric "homogeneous turbulence" electrostatic precipitation gas cleaner to provide uniform separation of gaseous, liquid, and solid particulates in a carrier fluid by adjustable levels of imposed discrete "homogeneous turbulence" established by a multiple array of double rows of secondary flow cellular vortices in the annulus between the inner perforated cylinder and the outer perforated cylinder with the cylinders rotating at about the same velocity in opposite directions. When the outer cylinder rotates about three times faster and in the opposite direction to the inner cylinder, with the electrical power turned off, an adjustable level of imposed discrete spiral band of turbulence in a travelling wave, will move up or down in the annulus, and will clean the collected material from the surfaces of the discharge and collecting electrodes.

This invention utilizes the basic functions of an electrostatic precipitation gas cleaner described in references 1 and 5; but depends on Couette's original work in reference 2; and depends on Taylors work in reference 3; and Coles's observations given in reference 4.

This invention utilizes the stabilized boundary layer of couette motion to dampen out non-uniformities in the supply flow of a carrier fluid with gaseous, liquid, and solid particulates at present in use in electrostatic precipitation gas cleaners, which are due to variable levels of steady, random, and cyclic excitation forces initiated by disturbance energy sources from hydrodynamic origins in the fluid, hydroelastic origins in the structure, and thermodynamic origins in the pressure-temperature environment.

The accompanying drawings illustrate the following detailed specifications:

FIG. I shows a plan view of a rotating concentric "homogeneous turbulence" electrostatic precipitation gas cleaner 1, with the dirty gas inlet 2, the discharge electrodes 4, and the clean gas outlet 3.

FIG. II shows a front sectional elevation of a rotating concentric "homogeneous turbulence" electrostatic precipitation gas cleaner 1, with the discharge electrodes 4, supported by a frame 5. The discharge electrodes 4 are nested in the annulus between the outer cylinder 6, and the inner cylinder 11. The outer perforated cylinder 6 is supported by a bearing 7, and driven by a gear 8, supported by bearing 9, and a motor 10. An inner perforated cylinder 11, is supported by bearings 12 and 14, and driven by a shaft 13, and a motor 15. The gaseous, liquid, and solid particulates in the dirty gas inlet 2, sweep into the annulus between the cylinders 6 and 11, where the electrostatic forces produced by discharge electrodes 4, make the particulates to collect on the collecting electrodes, which are the perforated cylinders 6 and 11; and Taylor circular couette motion provides a uniform separation by a double row of secondary flow cellular vortices, with both cylinders rotating in opposite directions at about the same velocity. When the outer cylinder rotates about three times faster and in the opposite direction to the inner cylinder, with the electrical power turned off, a spiral band of turbulence in a travelling wave, will move up or down in the annulus, and will clean the collected material from the surfaces of the electrodes.

FIG. III shows the double row of secondary flow cellular vortices.

FIG. IV shows data given by Coles in reference 4, with specific regimes for the double row of secondary flow cellular vortices and for the spiral band of turbulence in a travelling wave.

DETAILED DESCRIPTION

The object of the invention is the application of couette motion caused by centrifugal forces in a rotating concentric "homogeneous turbulence" electrostatic precipitation gas cleaner to provide a laminar flow with adjustable levels of imposed discrete "homogeneous turbulence" in the radial direction, which promotes the uniform separation of gaseous, liquid, and solid particulates in a carrier fluid, with a multiple array of double rows of secondary flow cellular vortices in the annulus between the perforated cylinders, with the cylinders rotating at about the same velocity in opposite directions. When the outer cylinder rotates about three times faster and in the opposite direction to the inner cylinder, with the electrical power turned off, a spiral band of turbulence in a travelling wave, will move up or down in the annulus, and will clean the collected material from the surfaces of the discharge and the collecting electrodes.

The mathematical basis for the present invention is given in references 3 and 4, in which an imposed hydrodynamic instability can lead usual laminar flow to another state of imposed laminar flow, rather than the expected turbulent flow. In the case of the rotating concentric "homogeneous turbulence" electrostatic precipitation gas cleaner, Taylor circular couette motion caused by centrifugal forces impose a steady secondary flow in the annulus between the two cylinders by establishing a multiple array of double rows of secondary flow cellular vortices when the cylinders rotate at about the same velocity in opposite directions; or it will impose a spiral band of turbulence in a travelling wave, will move up or down in the annulus and will clean the collected material from the discharge and collecting electrodes, when the electrical power is turned off, and the outer cylinder rotates about three times faster and in the opposite direction to the inner cylinder.

Couette motion between rotating concentric cylinders is well known, but this invention is related to perforated cylinders with radial flow thru the perforated cylinders, rather than the usual couette motion with stagnant or longitudinal flow in the annulus between the cylinders.

This invention utilizes the basic functions of an electrostatic precipitation gas cleaner as described histori-

cally in references **1** and **5**; but this invention depends on centrifugal forces caused by flow between rotating concentric cylinders to initiate couette motion as reported by Couette in reference **2**; and depends on the criteria for hydrodynamic instability as reported by Taylor in reference **3**; and depends on the detailed study of various regimes of couette motion as given by Coles in reference **4** in which a multiple array of double rows of secondary flow cellular vortices is established when the cylinders rotate at about the same velocity in opposite directions, or a spiral band of turbulence is established when the outer cylinder rotates about three times faster and in the opposite direction to the inner cylinder.

This invention utilizes the stabilized boundary layer of couette motion to dampen out the non-uniformities in the supply flow of a carrier fluid with gaseous, liquid, and solid particulates at present in use in electrostatic precipitation gas cleaners, which are due to variable levels of steady, random, and cyclic excitation forces initiated by disturbance energy sources from hydrodynamic origins in the fluid, hydroelastic origins in the structure, and thermodynamic origins in the pressure-temperature environment which are expected from operating transients at startup, emergency shutdown, and maintenance shutdown in metallurgical facilities with particulates of typical metals such as lead, zinc, copper, iron, and uranium.

This invention differs from the usual classical couette motion with stagnant or longitudinal flow between the rotating concentric cylinders in that this invention utilizes radial flow thru the perforated cylinders.

This invention is an improvement on present day electrostatic precipitation gas cleaners handling a carrier gas polluted with gaseous, liquid, and solid particulates having non-uniformities in concentration, density, and velocity produced by the dirty gas jetting into the annulus between the perforated cylinders, in that this invention utilizes a final uniform separation by couette motion in addition to the usual separation by electrostatic precipitation.

This invention differs from the usual electrostatic precipitation gas cleaner in that a uniform separation by couette motion produces an imposed residence time for uniform separation of gaseous, liquid, and solid particulates in the carrier fluid.

The rotation speed, the number and diameter of the perforations together with the perforation pattern and percent perforated area can be optimized for a specific separation of gaseous, liquid, and solid particulates in a carrier fluid, such as the metallurgical particulates of lead, zinc, copper, iron, and uranium.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as the following improvements:

1. The method of utilizing Taylor circular couette motion in a fluid to clean an electrode positioned in the annular area between inner and outer perforated cylinders and rotating said cylinders in opposed directions to provide a spiral band of turbulence in a travelling wave to clean the electrode.

2. The method of claim **1** further including collecting particulate material on one of the perforated cylinders functioning as a collector electrode.

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