

Feb. 2, 1954

H. A. WINTERMUTE

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ELECTRIFIED, CENTRIFUGAL GAS CLEANING DEVICE

Filed Nov. 7, 1951

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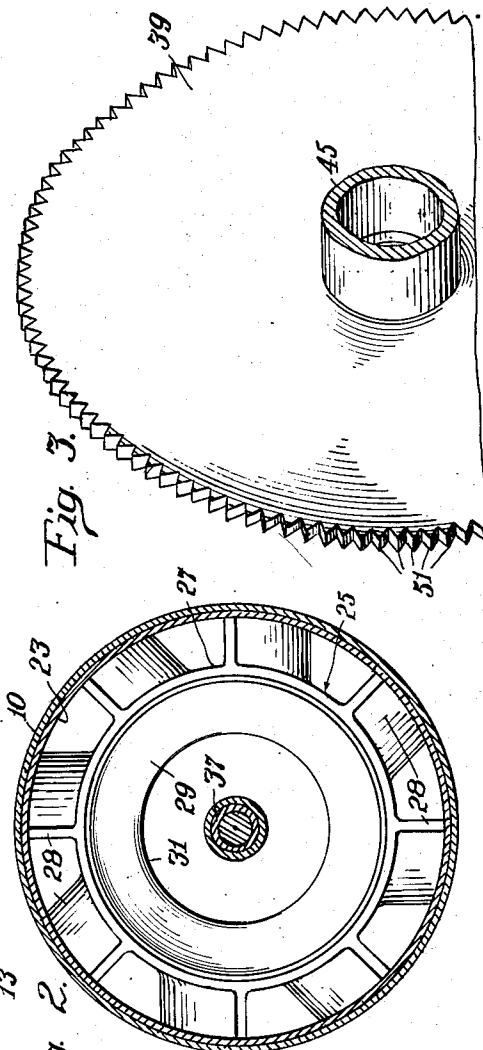
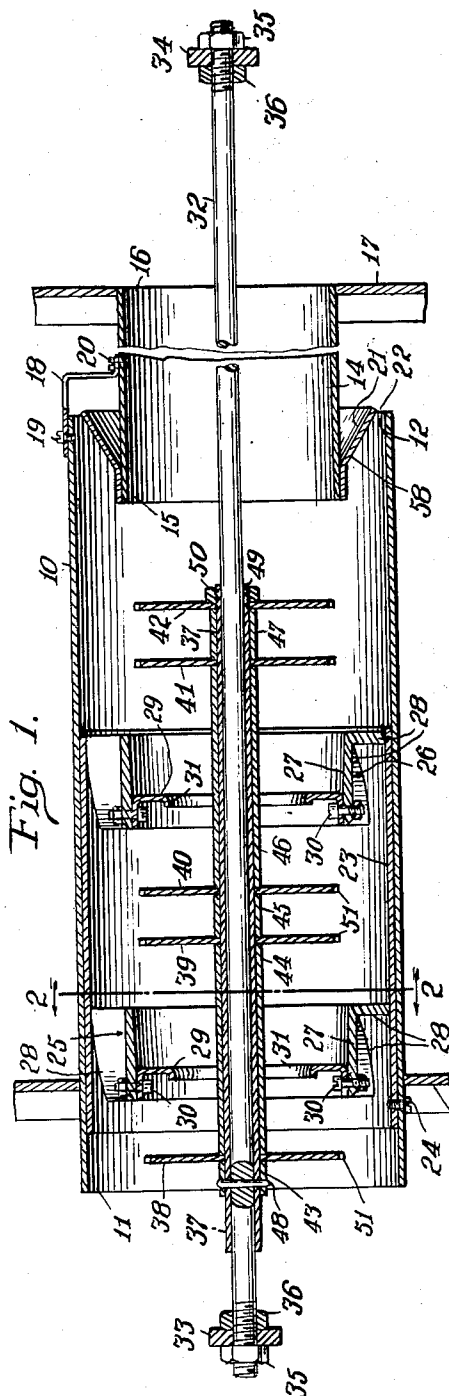


Fig. 3.

Fig. 2.

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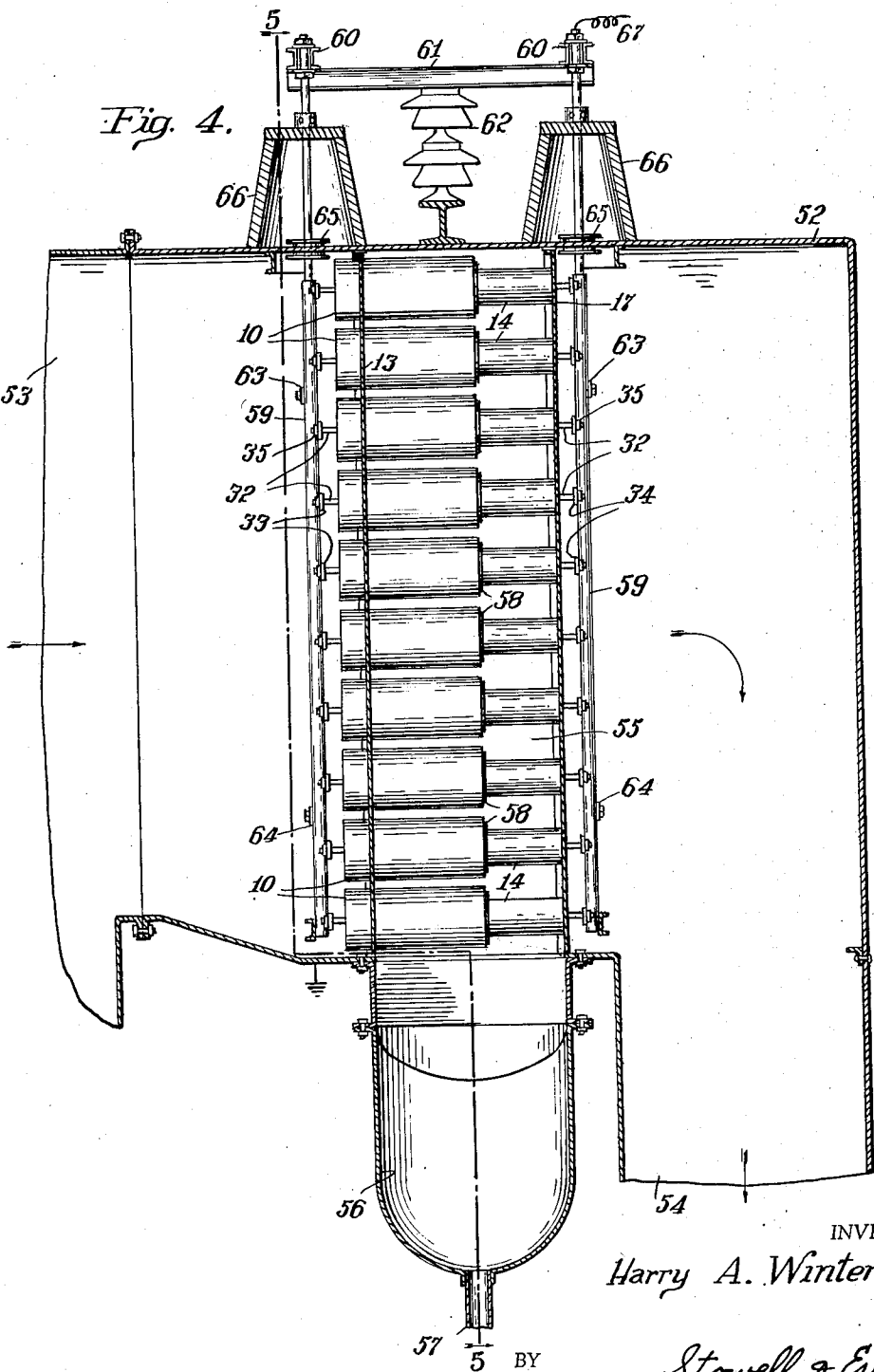
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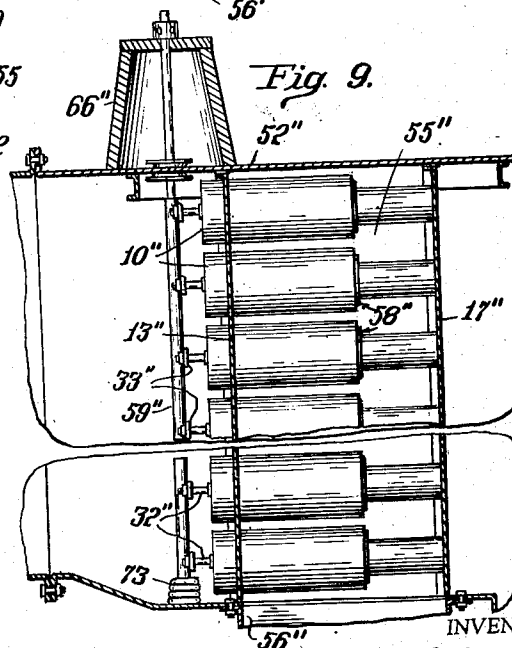
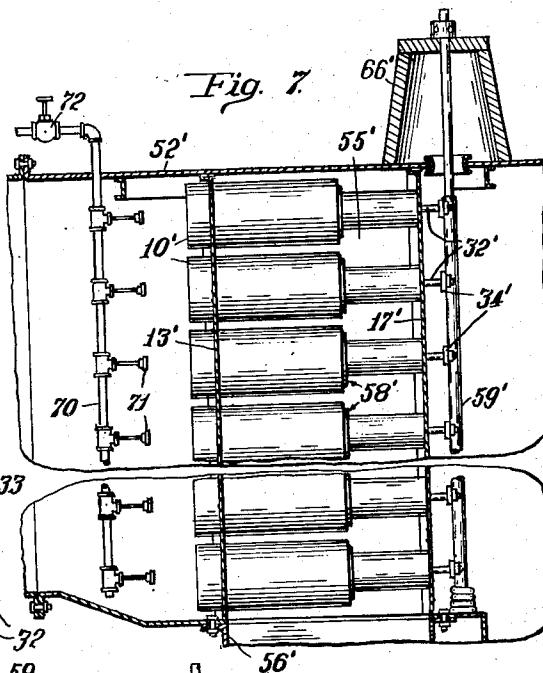
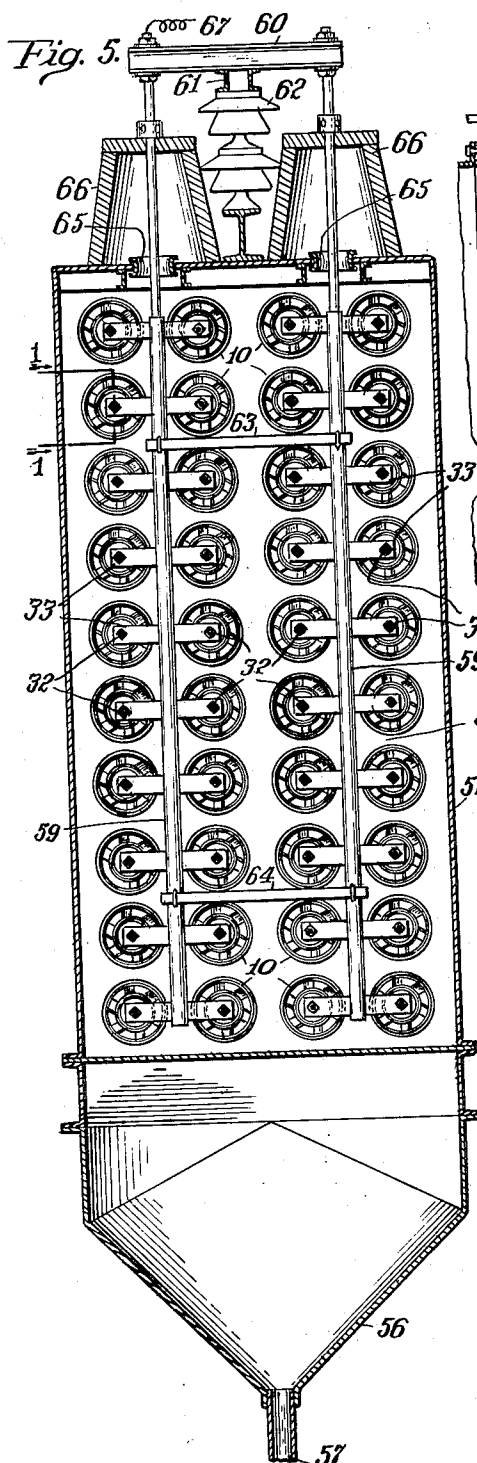
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4 Sheets-Sheet 3



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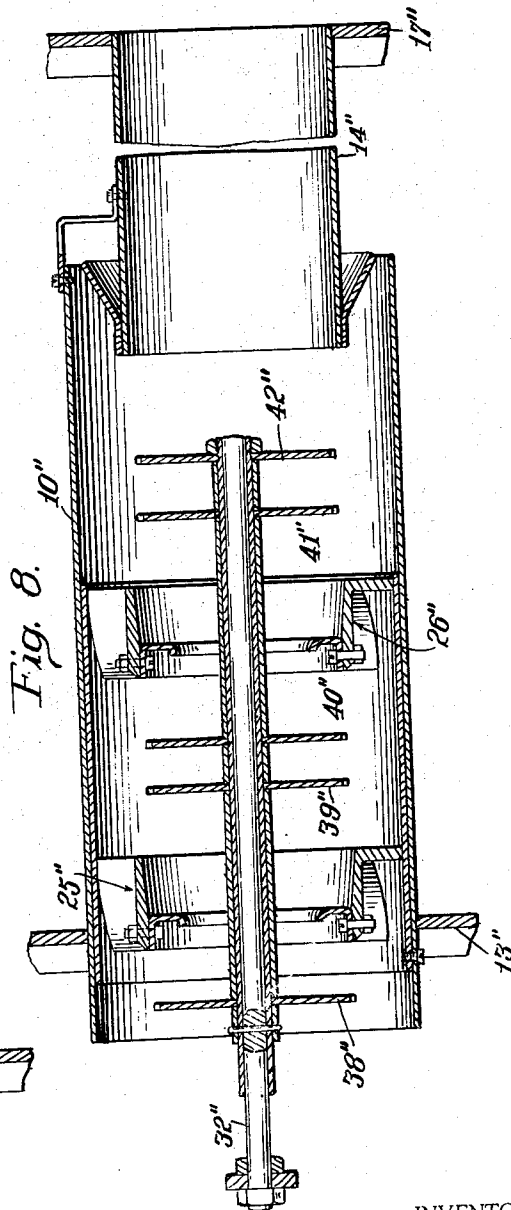
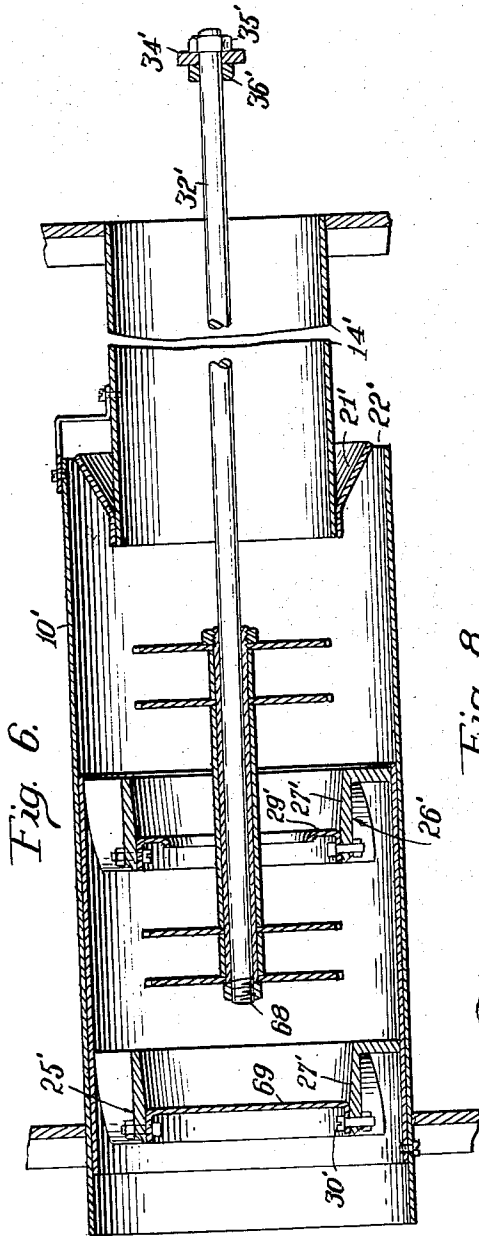
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4 Sheets-Sheet 4



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ELECTRIFIED, CENTRIFUGAL GAS
CLEANING DEVICE

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8 Claims. (Cl. 183—7)

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This invention relates to electrical, centrifugal gas cleaning wherein gas bearing suspended material, such as dust particles, ash particles, fine droplets of liquid or the like, is passed through a tubular device wherein it is given a swirling movement and is simultaneously subjected to corona discharge to cause the suspended material to become concentrated in a gas layer adjacent the inner wall of the tubular device. The gas layer containing a high concentration of suspended material is separated from the remainder of the gas stream by a skimming device and the remainder of the gas stream passes out of the cleaning device as cleaned gas. The gas and suspended material that is skimmed off may be subjected to further separatory action if desired.

An object of the invention is to provide an electrified, centrifugal gas cleaning device that has no moving parts and is highly effective in removing suspended particles from a stream of gas.

Another object is to provide a gas cleaning device that is simple to assemble and to disassemble for cleaning and repair.

Another object is to provide a gas cleaning device that is readily fabricated.

Another object is to provide a gas cleaning device of this type that directs the flow of gas therethrough in a manner to provide maximum separatory forces with a minimum of pressure drop.

The present invention provides an electrified, centrifugal gas cleaning device including a tubular conduit member having a gas swirling and electrifying chamber, the conduit member having an open gas inlet end and an open gas outlet end, a discharge tube having an open gas inlet end and an open gas outlet end and having an outside diameter smaller than the inside diameter of the tubular conduit member, the discharge tube projecting into the outlet end of the tubular conduit member and being positioned coaxially with respect to the latter, a skirt member carried on the outside of the discharge tube and flaring outwardly towards the outlet end of the tubular conduit member and providing therewith a restricted annular skimming orifice, a first set of annularly arranged swirling vanes positioned against the inner wall of the tubular conduit member near the inlet end thereof, a second set of annularly arranged swirling vanes positioned against the inner wall of the tubular conduit member intermediate the first set of vanes and the inlet end of the discharge tube, a first disc-like discharge electrode insulatedly support-

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ed in the space between the first and second sets of swirling vanes, a second disc-like discharge electrode insulatedly supported in the space between the second set of swirling vanes and the inlet end of the discharge tube, the discharge electrodes having discharge points spaced from the inner wall of the tubular conduit member and cooperating therewith to provide corona discharge when a source of high electrical potential is connected thereacross.

The invention will be described with greater particularity and other of its objects and advantages will be in part apparent and in part pointed out in the following detailed description of the drawings, in which:

Fig. 1 is an axial sectional view of one form of gas cleaning unit in accordance with the invention;

Fig. 2 is a sectional view taken along the plane of the line 2—2 of Fig. 1;

Fig. 3 is an enlarged perspective view of one of the discharge electrodes of cleaning unit of Fig. 1;

Fig. 4 is a vertical longitudinal sectional view of a gas cleaning apparatus including a plurality of gas cleaning units of the type shown in Figs. 1 to 3;

Fig. 5 is a sectional view taken along the plane of the line 5—5 of Fig. 4;

Fig. 6 is an axial sectional view of another form of gas cleaning unit of the invention;

Fig. 7 is a vertical longitudinal sectional view of a gas cleaning apparatus including a plurality of units of the type shown in Fig. 6;

Fig. 8 is an axial sectional view of still another form of gas cleaning unit in accordance with the invention; and

Fig. 9 is a vertical longitudinal sectional view of a gas cleaning apparatus employing a plurality of units of the type shown in Fig. 8.

Referring to the drawings, particularly to Figs. 1 and 2, the gas cleaning unit shown has a tubular conduit member 10 of uniform diameter throughout its length and having an open gas inlet end 11 and an open gas outlet end 12. This tubular member is supported at one end in a diaphragm member or wall 13 having a circular opening receiving the tubular member with a close fit; the joint between the tube 10 and the wall 13 may be tack welded if desired.

A discharge tube 14, positioned coaxially with respect to the tubular conduit member 10, has a gas inlet end 15 projecting a short distance inwardly of the gas outlet end of tube 10. The discharge tube is supported at its gas outlet end 16 in a circular opening in the wall 17 and the

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joint therebetween may be tack welded. An L-shaped bracket 18 formed of narrow strip of metal, is secured to the tubes 10 and 14 by screws 19 and 20 to provide proper centering of the tubes and to give support to the assembly. A plurality, for example three, of these brackets may be spaced about the periphery of the tube assembly for added strength.

A conical skirt member 21 is welded to the outside of the discharge tube 14 and this skirt member flares outwardly toward the discharge end of tube 10. Between the outer edge of the skirt member 21 and the discharge end of tube 10 is provided a restricted annular orifice 22.

Fitted within the tube 10 is a sleeve 23 that is removably secured in the tube by a screw 24. The sleeve carries a pair of identical swirling vane sets or assemblies 25 and 26 longitudinally spaced in the sleeve. These vane sets may be fabricated as castings and each has a ring portion 27 carrying generally radially extending vanes 28 that are welded to the sleeve 23. The vanes are inclined to the axis of the gas cleaner to impart a whirling or helical motion to gas that passes between the vanes. Both sets of vanes are inclined in the same direction. A flange 29 is fastened to the interior of ring 27 by bolts 30 and the flange has a central opening 31.

Extending longitudinally through the center of the tube assembly is a discharge electrode support rod 32 that is carried in fixed frame members 33 and 34, as will be explained more fully hereinafter. The rod is threaded at the ends where it passes through the frame members and is retained therein by nuts 35 and 36. A sleeve 37 is slidably fitted on the rod 32 and this sleeve has a plurality of identical disc-shaped discharge electrodes 38 to 42 supported thereon. The discharge electrodes are spaced apart by spacer sleeves 43 to 47. Spacer sleeve 43 and support sleeve 37 are positioned on the rod by a drift pin 48 that passes through matching holes in the rod and sleeves. The end 49 of support sleeve 37 is threaded externally and a nut 50 is screwed thereon for the purpose of retaining the discharge electrodes in position.

One of the discharge electrodes 39 is shown in enlarged detail in Fig. 3. The periphery of the disc is serrated to provide a plurality of discharge points 51.

The gas cleaning unit shown in Figs. 1 to 3 is preferably fabricated entirely of structural metal such as steel, cast iron, or the like.

In operation, gas to be cleaned, for example boiler flue gases carrying suspended fly ash, is passed through the tube assembly from left to right as seen in Fig. 1 under a pressure differential existing between the inlet opening 11 of tube 10 and the outlet opening 16 of discharge tube 14. The unit is energized by impressing a high electrical potential between the discharge electrode assembly and the tubular conduit 10. Sufficient potential is applied to cause the discharge electrodes 38 to 42 to emit corona discharge.

Discharge electrode 38, at the gas inlet end of the unit, serves as a baffle to direct the flow of gas between the vanes 28 of the first vane set 25 and to prevent substantial flow of gas through the opening 31, which opening is provided to space the flange 29 from the sleeve 44 sufficiently to preclude spark over and short circuit between these members. As the gas passes through the corona discharge emitted from the electrode 38,

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the suspended material is electrically charged with a sign the same as the sign of the discharge electrode. The electric field existing between the discharge electrode structure and the tube 10 tends to move the charged particles towards the tube 10.

As the gas passes between the vanes of the first vane set 25, a helical motion is imparted thereto. The centrifugal force thereby produced tends to throw the suspended particles towards the inner wall of tube 10. Centrifugal force thus aids the electrical forces tending to move the suspended material toward the outside of the cleaning zone.

As the gas passes through the zone between vane sets 25 and 26, it continues to whirl but at a diminishing rate. In this zone, the gas is subjected to further discharge and electrical precipitation conditions and the suspended material becomes more concentrated in the outer reaches of the zone. Discharge electrodes 39 and 40 act as baffles to maintain annular flow of gas, to direct the gas stream through the second vane set 26, and to substantially prevent flow of gas through the opening 31 of the second vane set.

The gas next passes through the second vane set 26 wherein additional helical motion is imparted thereto. The whirling annular stream then flows past the discharge electrodes 41 and 42 and is there subjected to further electrical precipitation conditions. After passing the last discharge electrode 42, the suspended material is concentrated in a very thin layer adjacent the wall of tube 10. Momentum carries a thin layer of gas containing most of the suspended material through the opening 22. Owing to the restricted nature of opening 22, most of the gas stream is turned inwardly around the electrode 42 to flow out of the discharge tube 14 as clean gas. This turning movement throws out of the exhaust gases a final though small increment of suspended material. Substantial separation of suspended material is thus effected by conjoint electrical precipitation and centrifugal action.

It will be seen that the unit thus far described is a two stage unit and that the vane set 26 and discharge electrodes 41 and 42 comprise a second stage. Although less efficient, a single stage unit can be made by omitting the second stage elements, shortening the tube 10, and moving the discharge tube 14 into a relationship with the discharge electrode 40 similar to the relationship it has in Fig. 1 with respect to electrode 42.

From an inspection of Fig. 1 it is seen that the unit is readily disassembled. The drift pin 48 is removed and the sleeves and discharge electrodes are moved forwardly on the rod 32. The flange ring 29 of the vane set 25 is removed after removing bolts 30. The rod 32 is loosened from the frame members 33 and 34 by obvious manipulation of nuts 35 and 36. It will be observed that the outside diameter of the electrode discs 38 to 42 is less than the inside diameter of vane supporting rings 27 so that the former may be withdrawn through the latter. Flange ring 31 of vane set 26 is also detached from the vane set. Thereafter, the entire discharge electrode assembly is withdrawn. The vane assembly is then readily withdrawn after removal of screw 24. Reassembly of the unit is performed by reversing the order of the steps of disassembly.

A plurality of gas cleaning units such as have been described hereinbefore are employed in a gas cleaning apparatus as shown in Figs. 4 and

5. Referring to these figures, 52 represents a casing having a gas inlet opening 53 and a gas outlet opening 54. Gas to be cleaned flows through the apparatus in the direction of the arrows of Fig. 4. The diaphragm plates are shown at 13 and 17 and these plates define a dust compartment 55 communicating with a dust hopper 56 at the bottom of the casing. The dust hopper has an outlet 57. This arrangement of baffle plates causes the main stream of gas to divide and flow through the several gas cleaning units 58 supported by the plates 13 and 17 in the manner described hereinbefore. After cleaning, the gas flows to the outlet 54.

A small amount of gas together with the dust separated in each unit passes from the annular dust skimming openings 22 of the units into the dust chamber 55. The dust falls into the hopper 56 from which it is removed through the outlet 57. The dust chamber and hopper may be vented, for example, through the discharge opening 57, if necessary to control back pressure on the annular openings 22 of the gas cleaning units 58.

As has been described, the high tension electrode assembly rods 32 are supported by frame members 33 and 34. As can best be seen in Fig. 5, each horizontal frame member 33 supports the front ends of two electrode rods 32. The horizontal frame members 33 are attached to vertical frame members 59 that are suspended from a yoke bar 60 carried by a cross bar 61 supported by an insulator 62 on the roof of housing 52. Lateral braces 63 and 64 lend added rigidity to the frame structure. The rear ends of the electrode rods 32 are supported in a similar frame structure.

It will be seen that the vertical frame members pass through openings 65 in the roof of the housing and these openings are covered by insulating bushings 66 that form gas seals between the vertical frame members 59 and the housing.

The complementary electrodes of the cleaning units are energized conventionally as by grounding the casing 52 and connecting the high tension side of a grounded source of current (not shown) to the high tension electrode system through a cable 67.

Referring to Fig. 6, another form of gas cleaning unit in accordance with the invention is shown. This unit differs from that shown in Figs. 1 to 3 primarily in the manner in which the high tension electrodes are supported. Because of the similarity of the units, parts in the unit of Fig. 6 that correspond to parts in the unit of Figs. 1 to 3 are designated by the same reference numerals with prime characters.

In Fig. 6 the unit includes the tube 10', providing a centrifugal and electrical precipitation zone, the main discharge tube 14', and the conical skirt 21', forming with the tube 10' an annular skimming orifice 22'.

It is seen that the high tension electrode rod 32' is supported at one end only in the frame member 34' and is locked therein by nuts 35' and 36'. The rod terminates at the unsupported end 58 in the space between the vane sets 25' and 26'. Since there is no electrode disc corresponding to the disc 38 of Fig. 1, the opening in the ring 21' of the vane set 25' is closed by a flanged plate 69 secured in the opening by bolts 30', this to preclude flow of gas through the opening.

It is contemplated that the plate 69 can be replaced by a flanged ring such as the ring 29', the rod lengthened to extend to the left through the

ring opening, and a discharge electrode positioned on the rod in front of the opening to correspond to the disc 38 of Fig. 1.

Operation of the unit of Fig. 6 is essentially the same as the hereinbefore described operation of the unit of Fig. 1. Also, the method of assembly and disassembly of the unit will be apparent.

A gas cleaning apparatus utilizing units of the type shown in Fig. 6 is illustrated in Fig. 7. Primed reference numerals in Fig. 7 designate parts corresponding to parts in Figs. 4 and 5 having the same reference numerals.

Referring to Fig. 7, the casing 52' has a pair of partitions 13' and 17' defining a dust chamber 55' communicating with a hopper 56'. The partitions support a plurality of gas cleaning units 58' of the kind shown in Fig. 6. Electrode rods 32' are secured in horizontal frame members 34' that are carried by the vertical frame members 59'.

A washing device is included in the apparatus of Fig. 7. A header pipe 70 runs parallel to each vertical row of cleaning units 58' on the upstream side of the units. Nozzles 71 direct a spray washing liquid into the cleaning units. The washing operation may be performed as desired by opening and closing a main valve 72. Typically the spray nozzles 71 are operated continuously to provide continuous films of flushing liquid along the inner surfaces of the gas cleaning units. The liquid films trap the particles removed from the gas to provide high efficiency of collection. When such a flushing operation is performed, very little gas is required for scavenging purposes as the flushing liquid performs this operation.

The gas cleaning apparatus of Fig. 7 operates in the same way as the apparatus of Figs. 4 and 5 as described hereinbefore.

Still another form of gas cleaning unit of the invention is shown in Fig. 8. In this form, the electrode rod 32'' is supported at the front end only; otherwise, the unit per se is substantially identical to the unit of Figs. 1 to 3. It has the tubular elements 10'' and 14'' supported by the diaphragm plates 13'' and 17'', together with the vane sets 25'' and 26'' and the high tension electrode assembly including the serrated disc electrodes 38'' to 42''.

Fig. 9 shows a plurality of such units embodied in a gas cleaning apparatus similar to the apparatus of Figs. 4 and 5. The casing 52'' has partitions 13'' and 17'' defining with the casing a dust chamber 55'' communicating with the hopper 56'' at the bottom. The partitions 13'' and 17'' support the cleaning units 58''.

Rods 32'' are anchored in horizontal frame members 33'' that are mounted on vertical frame members 59''. The frame members 59'' rest on insulators 73 at the bottom and pass through insulating bushings 66'' at the top of the apparatus.

The operation of the apparatus of Fig. 9 will be obvious from the description given hereinbefore of operation of the apparatus of Figs. 4 and 5.

Although the skirt member 21 of Fig. 1 that provides a restricted skimming orifice 22 is desirable, the skirt may be eliminated under certain conditions as when the annular space between tubes 10 and 14 is sufficiently small to eliminate the need for the skirt member.

From the foregoing description it will be seen that the present invention provides a gas cleaning device and apparatus combining in a unique way principles of centrifugal separation and electrical precipitation. In the gas treating units shown and described herein, the flow of gas

through the units is so directed as to insure maximum efficiency of centrifugal and electrical action. Moreover, the units are easily fabricated, assembled and disassembled. The invention provides a gas cleaning device that satisfies the aims and objects of the invention.

In the light of this disclosure, one skilled in the art will perceive that a variety of engineering and design changes can be made in the physical form of the apparatus without departing from the spirit of the invention.

Similar subject matter is disclosed in my continuation-in-part application Serial No. 285,094 filed April 30, 1952.

I claim:

1. An electrified, centrifugal gas cleaning device comprising a tubular conduit member providing a gas swirling and electrifying chamber, said conduit member having an open gas inlet end and an open gas outlet end, a discharge tube having an open gas inlet end and an open gas outlet end and having an outside diameter smaller than the inside diameter of said tubular conduit member, said discharge tube projecting into the outlet end of said tubular conduit member and being positioned coaxially with respect to the latter, a skirt member carried on the outside of said discharge tube and flaring outwardly towards the outlet end of said tubular conduit member and providing therewith a restricted annular skimming orifice, a first set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member near the inlet end thereof, a second set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member intermediate said first set of vanes and the inlet end of said discharge tube, a first disc-like discharge electrode insulatedly supported in the space between said first and second sets of swirling vanes, and a second disc-like discharge electrode insulatedly supported in the space between said second set of swirling vanes and the inlet end of said discharge tube, said discharge electrodes being of substantial diameter and having discharge points spaced from the inner wall of said tubular conduit member and cooperating therewith to provide corona discharge when a source of high electrical potential is connected thereacross.

2. An electrified, centrifugal gas cleaning device comprising a tubular conduit member providing a gas swirling and electrifying chamber, said conduit member having an open gas inlet end and an open gas outlet end, a discharge tube having an open gas inlet end and an open gas outlet end and having an outside diameter smaller than the inside diameter of said tubular conduit member, said discharge tube projecting into the outlet end of said tubular conduit member and being positioned coaxially with respect to the latter, means providing a restricted annular skimming orifice between said tubular conduit member and said discharge tube, a set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member and spaced from the inlet end of said discharge tube towards the inlet end of said tubular conduit member, and a disc-like discharge electrode insulatedly supported in the space between said set of swirling vanes and the inlet end of said discharge tube.

3. An electrified, centrifugal gas cleaning device as defined in claim 2 wherein the outside diameter of said discharge electrode is substan-

tially the same as the inside diameter of said annularly arranged set of swirling vanes.

4. An electrified centrifugal gas cleaning device as defined in claim 3 including means substantially preventing flow of gas through the central opening of said annularly arranged set of swirling vanes.

5. An electrified, centrifugal gas cleaning device comprising a tubular conduit member providing a gas swirling and electrifying chamber, said conduit member having an open gas inlet end and an open gas outlet end, a discharge tube having an open gas inlet end and an open gas outlet end and having an outside diameter smaller than the inside diameter of said tubular conduit member, said discharge tube projecting into the outlet end of said tubular conduit member and being positioned coaxially with respect to the latter, a skirt member carried on the outside of said discharge tube and flaring outwardly towards the outlet end of said tubular conduit member and providing therewith a restricted annular skimming orifice, a first set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member near the inlet end thereof, a second set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member intermediate said first set of vanes and the inlet end of said discharge tube, a rod member extending longitudinally through said tubular conduit member and said discharge tube, mounting means external to said tubular member and said tube insulatedly mounting said rod with respect thereto, a first disc-like discharge electrode carried by said rod in the space between said first and second set of vanes, a second disc-like discharge electrode carried by said rod in the space between said second set of swirling vanes and the inlet end of said discharge tube, said discharge electrodes having a diameter substantially greater than said rod member having discharge points spaced from the inner wall of said tubular conduit member and cooperating therewith to provide corona discharge when a source of high electrical potential is connected thereacross.

6. An electrified, centrifugal gas cleaning device comprising a tubular conduit member providing a gas swirling and electrifying chamber, said conduit member having an open gas inlet end and an open gas outlet end, a discharge tube having an open gas inlet end and an open gas outlet end and having an outside diameter smaller than the inside diameter of said tubular conduit member, said discharge tube projecting into the outlet end of said tubular conduit member and being positioned coaxially with respect to the latter, a skirt member carried on the outside of said discharge tube and flaring outwardly towards the outlet end of said tubular conduit member and providing therewith a restricted annular skimming orifice, a first set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member near the inlet end thereof, a second set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member intermediate said first set of vanes and the inlet end of said discharge tube, a rod member projecting longitudinally into said tubular conduit member from the inlet end thereof and terminating at a point between said second set of vanes and the inlet end of said discharge tube, mounting means positioned in front of the inlet end of said tubular

conduit member insulatingly mounting said rod with respect thereto, a first disc-like discharge electrode carried by said rod in the space between said first and second set of vanes, a second disc-like discharge electrode carried by said rod in the space between said second set of swirling vanes and the inlet end of said discharge tube, said discharge electrodes having a diameter substantially greater than said rod member having discharge points spaced from the inner wall of said tubular conduit member and cooperating therewith to provide corona discharge when a source of high electrical potential is connected thereacross.

7. An electrified, centrifugal gas cleaning device comprising a tubular conduit member providing a gas swirling and electrifying chamber, said conduit member having an open gas inlet end and an open gas outlet end, a discharge tube having an open gas inlet end and an open gas outlet end and having an outside diameter smaller than the inside diameter of said tubular conduit member, said discharge tube projecting into the outlet end of said tubular conduit member and being positioned coaxially with respect to the latter, a skirt member carried on the outside of said discharge tube and flaring outwardly towards the outlet end of said tubular conduit member and providing therewith a restricted annular skimming orifice, a first set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member near the inlet end thereof, a second set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member intermediate said first set of vanes and the inlet end of said discharge tube, a rod member projecting longitudinally into said discharge tube from the outlet end thereof and terminating at a point between said first and second sets of vanes, mounting means positioned at the rear of the outlet end of said discharge tube insulatingly mounting said rod with respect thereto, a first disc-

like discharge electrode carried by said rod in the space between said first and second set of vanes, a second disc-like discharge electrode carried by said rod in the space between said second set of swirling vanes and the inlet end of said discharge tube, said discharge electrodes having a diameter substantially greater than said rod member having discharge points spaced from the inner wall of said tubular conduit member and cooperating therewith to provide corona discharge when a source of high electrical potential is connected thereacross.

8. An electrified, centrifugal gas cleaning device comprising a tubular conduit member providing a gas swirling and electrifying chamber, said conduit member having an open gas inlet end and an open gas outlet end, a discharge tube having an open gas inlet end and an open gas outlet end and having an outside diameter smaller than the inside diameter of said tubular conduit member, said discharge tube projecting into the outlet end of said tubular conduit member and being positioned coaxially with respect to the latter, a set of annularly arranged swirling vanes positioned against the inner wall of said tubular conduit member and spaced from the inlet end of said discharge tube towards the inlet end of said tubular conduit member, and a disc-like discharge electrode insulatedly supported in the space between said set of swirling vanes and the inlet end of said discharge tube said disc-like discharge electrodes having a diameter substantially the same as the inside diameter of said swirling vanes.

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