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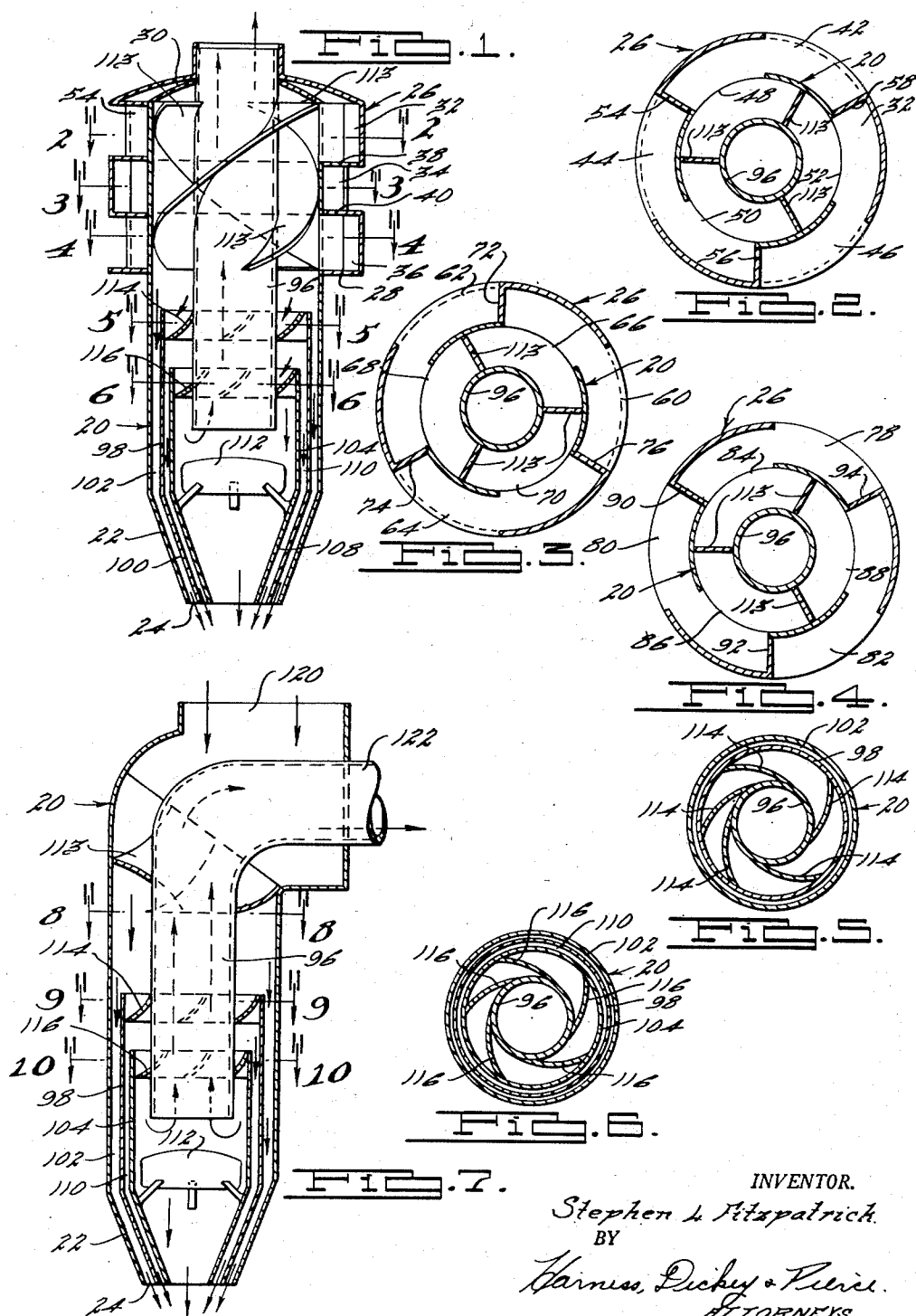
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2,569,710

FLY ASH PRECIPITATOR

Filed May 29, 1948

2 Sheets-Sheet 1



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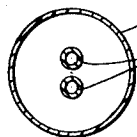
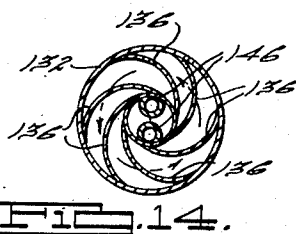
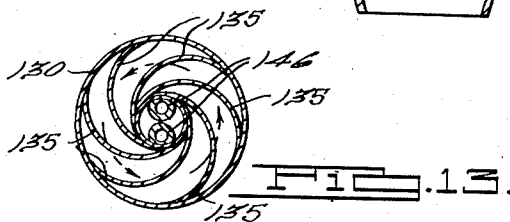
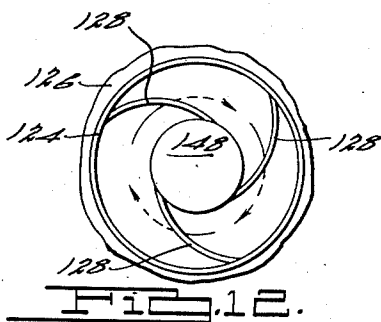
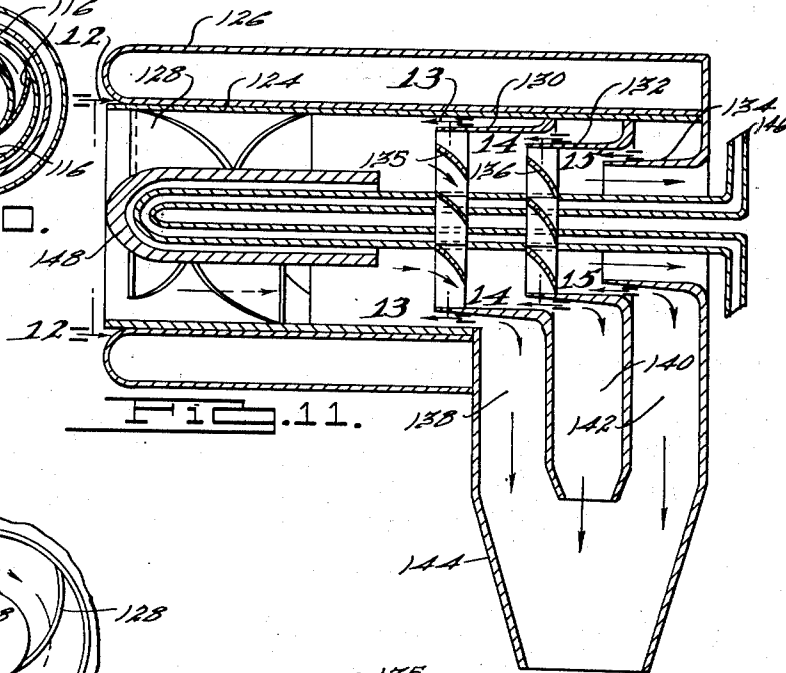
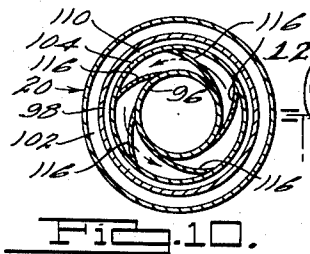
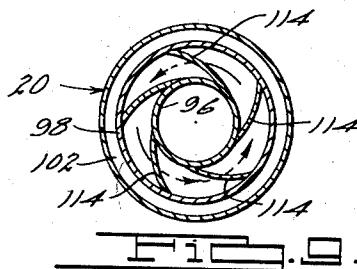
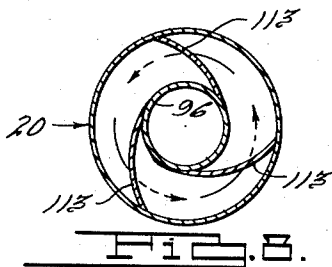
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FLY ASH PRECIPITATOR

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UNITED STATES PATENT OFFICE

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FLY ASH PRECIPITATOR

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2 Claims. (Cl. 183—80)

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This invention relates broadly to new and useful improvements in centrifugal precipitators, and more particularly to precipitators of this type that are primarily adapted for removing relatively light, fine fly-ash from flue gases.

An important object of the present invention is to provide an efficient means for removing suspended solid matter from a moving gaseous stream.

Another object of the invention is to provide a fly-ash precipitator that is mechanically simple and that can be manufactured economically.

Still another object of the invention is to provide a fly-ash precipitator that will remove solid particles continuously without obstructing the flow of flue gases from the furnace.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the drawings forming a part of this specification, and wherein like numerals are employed to designate like parts throughout the same;

Figure 1 is a longitudinal sectional view through a fly-ash precipitator embodying the invention;

Fig. 2 is a transverse sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a transverse sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is a transverse sectional view taken on the line 4—4 of Fig. 1;

Fig. 5 is a transverse sectional view taken on the line 5—5 of Fig. 1;

Fig. 6 is a transverse sectional view taken on the line 6—6 of Fig. 1;

Fig. 7 is a longitudinal sectional view through a modified form of the invention;

Fig. 8 is a transverse sectional view taken on the line 8—8 of Fig. 7;

Fig. 9 is a transverse sectional view taken on the line 9—9 of Fig. 7;

Fig. 10 is a transverse sectional view taken on the line 10—10 of Fig. 7;

Fig. 11 is a longitudinal sectional view through still another modification of the invention;

Fig. 12 is a fragmentary end elevational view looking in the direction of the arrows 12—12 of Fig. 11;

Fig. 13 is a transverse sectional view taken on the line 13—13 of Fig. 11;

Fig. 14 is a transverse sectional view taken on the line 14—14 of Fig. 11; and

Fig. 15 is a transverse sectional view taken on the line 15—15 of Fig. 11.

When coal is burned perfectly, a small amount of fine, light-colored powder remains. When

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coal is burned imperfectly, as in a conventional stoker or hand-fired furnace, the powdered particles are combined with particles of combustible material to form much larger particles. This residue, whether made up of incombustible material alone or of combined incombustible and combustible material, is called fly-ash. Fly-ash particles comprising both combustible and incombustible material usually are quite large. The loss of combustible material in the fly-ash materially increases the cost of operation and represents an unnecessary loss of fuel.

I propose to pulverize the coal completely and to burn it in such a manner so that all, or essentially all, of the combustible materials are burned. One means of doing this is disclosed in my co-pending application Serial No. 2,313 for combustion chamber, and the precipitators embodying the present invention are preeminently suited for removing fly-ash and other solid particles from the flue gases from the chamber. When combustion is completed, the fly-ash contains little or no combustible material and it comes from the combustion chamber in the form of a fine, light powder which is practically invisible. This is in sharp contrast with the fly-ash from a stoker or hand-fired furnace which because of their size and color make the stack discharge appear as dark smoke. Being light in weight, the ash powder coming from a pulverized coal furnace spreads over a wide area and is relatively unobjectionable as a nuisance. On the other hand, a discharge from a stoker fired or hand-fired furnace consisting of heavier particles tends to settle in a concentrated area near the heating or power plant from which it has come. Its dark color and concentration make it readily visible and, therefore, objectionable.

While it might not be objectionable as a nuisance in some particular installations, the light fly-ash from a pulverized coal furnace might still be undesirable because of possible damage from its abrasive action on equipment surfaces. This would be true in a high-pressure furnace where the gases travel at a high velocity and most particularly true in application to a gas turbine where the high rotating speed of the turbine blades makes them subject to erosion. The light particles from a pulverized fuel furnace are not as bad in this regard as the heavier particles from other methods of firing since the greater momentum and impact of the heavier particles make their abrasive action more severe. Another objection is that fly-ash accumulating on boiler tubes reduces heat transfer and efficiency.

Of course, the small amount of pure ash coming from a pulverized furnace is not nearly so objectionable as the gummy tar, coal dust, carbon, soot and ashes that come from other types of furnaces, but in some cases, it is still a point for consideration.

To remove any objections whether from a nuisance standpoint, or in regard to maintenance or performance of equipment, fly-ash can be completely removed for all practical purposes by especially designed fly-ash precipitators of the type embodying the present invention.

Two types of ash and dust precipitators are in use today; namely, the electrostatic type and the centrifugal type. The electrostatic types are more efficient than the centrifugal types now available but they are not rugged enough for most applications. While fairly efficient centrifugal type precipitators are available, they frequently are not adapted for collecting the fine, light particles which represent residue from the coal after all of the combustible materials have been burned. Precipitators of the type here shown are particularly efficient in this regard and capable of collecting all or substantially all of this fly-ash.

In my copending application Serial No. 22,386 for Delivery System, now Patent Number 2,520,239 I disclose means for delivering powdered coal in a forced draft of air. Precipitators of the type embodying the present invention also can be used to remove coal dust from the air when it is vented to the atmosphere.

In the drawings, reference is first had to Figures 1-6 which show one type of fly-ash precipitator embodying the present invention. This precipitator comprises a generally tubular, upright housing 20 having a tapered lower portion 22 provided with a bottom opening 24. The upper portion of the housing 20 is surrounded by a circumferentially spaced annular case 26. The annular space between the housing 20 and the case 26 is closed by a bottom wall 28 and top covers 30, and this space is divided into three separate compartments 32, 34 and 36 by horizontal partitions 38 and 40.

The upper compartment 32 has three openings 42, 44 and 46 in and disposed in equi-spaced relation around the circumference of the case 26 (Fig. 2). This compartment 32 also is provided with three openings 48, 50 and 52 disposed in and in equi-spaced relation around the circumference of the housing 20. These openings collectively provide one series of inlets for the housing 20. In this connection, attention is directed to the fact that the inner openings 48, 50 and 52 are arranged in staggered relation with respect to the outer openings 42, 44 and 46, and that the compartment 32 is divided into three separate chambers by radial partitions 54, 56 and 58. Also, it will be observed that the radial partitions 54, 56 and 58 are so located that each of the chambers is provided with one outer opening and one inner opening. One chamber contains openings 42 and 48, another chamber contains the openings 44 and 50, and the last chamber contains the openings 46 and 52.

The middle compartment 34 is similarly provided with openings 60, 62 and 64 disposed in equi-spaced relation around the circumference of the case 26 and with openings 66, 68 and 70 disposed in equi-spaced relation around the circumference of the housing 20 and in staggered relation with respect to the outer series of openings (Fig. 3). Also, compartment 34 is similarly divided into

three equi-sized chambers by radial partitions 72, 74 and 76. Each chamber is provided with one opening in the case 26 and one opening in the housing 20. Specifically, as shown in Fig. 3, the openings 62 and 68 are grouped together, the openings 64 and 70 are grouped together and the openings 60 and 66 are grouped together. Also, it should be noted that the outer openings 60, 62 and 64 of the second compartment 34 are staggered with respect to the outer openings 42, 44 and 46 of the upper compartment 32.

The lower compartment 36 has three outer openings 78, 80 and 82 arranged in equi-spaced relation around the circumference of the case 26 and three inner openings 84, 86 and 88 disposed in equi-spaced relation around the circumference of the housing 20 and in staggered relation with respect to the outer series of openings (Fig. 4). As in the previous instances, the compartment 36 is divided into separate chambers by radial partitions 90, 92 and 94. By reason of these radial partitions the outer opening 78 is in communication with the inner opening 84, the outer opening 80 is in communication with the inner opening 86, and the outer opening 82 is in communication with the inner opening 88. Attention is directed to the fact that both the outer and inner openings of the lower compartment 36 are arranged in the same general orientation as the corresponding openings in the topmost compartment 32 and in staggered relation with the corresponding openings in the intermediate compartment 34.

Disposed axially in and spaced circumferentially from the housing 20 is a duct 96 which extends from a point adjacent the bottom of the housing upwardly through the top covers 30. Thus the duct 96 co-operates with the housing 20 to define a generally U-shaped passage. Gases to be treated enter the housing 20 through the various openings in compartments 32, 34 and 36, pass downwardly through the annular space between the housing and the duct 96, enter the latter through the lower open end thereof and pass upwardly therethrough out of the housing.

In order to remove solid particles suspended in the gases that pass through the housing 20 and duct 96, it is necessary to impart and maintain a rotary or a circular motion thereto, and it is desirable to reverse the direction of lineal travel of the gases at least once. If this is done properly, the combined effects of centrifugal force and inertia will remove even fine, lightweight particles from the gases. In the present installation, the gases do not travel in a direct path between the inlets in the case 26 and the outlet at the upper end of duct 96. Instead, the gases are rotated at a relatively high speed in the annular space between the housing 20 and the duct 96 and it will be observed that the gases reverse their direction of travel as they enter the lower inlet end of the duct. As a result of the circulatory motion of the gases, solid particles suspended therein are thrown radially outwardly by centrifugal force, and as the gases reverse their direction of travel, inertia causes additional particles to be thrown from the current. Provision is made for collecting these particles and removing them.

In connection with the foregoing, an inner tubular member 98 having a tapered lower end 100 is disposed in the lower portion of the housing 20. The tubular member 98 extends upwardly and in overlapping relation with the lower portion of duct 96 and it is disposed in circum-

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ferentially spaced relation with respect to the housing 20 to define an annular space 102 therebetween. Also, it will be observed that still another tubular member 104 is disposed within and in circumferentially spaced relation with respect to the tubular member 98. The inner member 104 is similarly provided with a tapered lower portion 108 and it extends upwardly in overlapping relation with the lower portion of the duct 96. By reason of the circumferentially spaced relation between the inner and outer tubular members 104 and 98, an annular space 110 is defined therebetween. Attention is directed to the fact that while both the inner and outer tubular members 104 and 98 extend in overlapping relation with the duct 96, the outer member 98 extends substantially above the inner member 104. A baffle 112 is disposed transversely across the inner tubular member 104 below the duct 96.

Circulatory motion of the gases is begun as it enters the housing 20 by reason of the fact that each outer opening in the case 26 is disposed out of phase with respect to the corresponding inner opening. Thus, the gases entering the outer openings must flow between the walls for about 45 degrees before entering the housing 20. Immediately upon entering the housing 20 the gases strike against helical vanes 113, which vanes surround the upper portion of the duct 96 and extend radially between the duct and the housing 20. These vanes 113 further guide the current of gases into a helical path as it descends through the unit and, as suggested, the centrifugal force caused by the circular motion of the gases throws the ash particles to the walls of the housing 20.

When the gases reach the upper end of the tubular member 98 the helical motion is distributed in the vicinity of housing 20 and the heavier particles suspended in the gases fall by gravity through the annular space 102 and are discharged from the housing. As the current of gases continues downwardly in the tubular member 98, it strikes against helical vanes 114 which extend radially between the duct 96 and the tubular member 98. These vanes 114 direct the current of gases into a helical path within the tubular member 98 and increase the rotational speed of the gases. It is significant in this connection that the vanes 114, though spaced below, are disposed in relatively close proximity to the vanes 113 so that the vanes 114 are engaged by the gases before the latter lose appreciable velocity. Here again, particles suspended in the gases are thrown outwardly against the member 98 and, as the gases enter the inner tubular member 104, these particles fall downwardly into the annular space 110 and are discharged from the bottom of the housing 20.

As the circulating gases continue downwardly into the inner tubular member 104, they strike other helical vanes 116 which extend radially between the duct 96 and the member 104. These vanes 116 further guide and direct the circulating motion of the gases and increase the rotational speed of the gases to cause particles suspended therein to be thrown outwardly against the tubular member 104 where they slide downwardly along the wall of the member and through the bottom of the housing 20. After leaving the vanes 116 the current of gases abruptly reverses its direction of travel and enters the duct 96. As this occurs, inertia acts together with centrifugal force to expel any particles that remain suspended in the gases. The gases, substantially free from solid particles, enter the duct 96

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through the open bottom thereof and pass upwardly into a suitable exhaust pipe or stack (not shown). A large portion of the suspended fly-ash particles are less than 36 microns in diameter and actual tests have demonstrated that the instant device will remove at least 97% of all such particles from the air or gases. I have found that the clean gases have a better heat transfer as there is no ash settlement on the heat transfer tubes.

It will be readily appreciated that a forced draft is maintained in the device at all times by reason of the stack with which the duct 96 communicates, and it will also be appreciated that the progressively constricted passages through which the gases are forced as they travel from the inlets in the case 26 to the bottom of the duct 96, cause the velocity of the moving current of gases to increase progressively. I have found that the progressively constricting path of travel for gases and the helical vanes located at the strategic points here shown is particularly and unexpectedly effective in removing substantially all of the solid matter suspended in the gases.

Reference is now had to Figures 7-10 wherein is shown a modified form of the invention which is primarily adapted for conditions where the incoming gases are delivered downwardly into the precipitator and should be discharged horizontally therefrom. This form of the invention is generally similar to the form first described except that the case 26 and its adjuncts are omitted, the housing 20 is provided with a top opening 120, and the duct 96 is provided at the upper end thereof with a lateral extension 122 which passes through the side of the housing.

In this form of the invention the gases pass downwardly into the housing 20 through the opening 120 and impinge against the helical vanes 113. These vanes 113 cause the gases to spiral downwardly in the annular space between the housing 20 and the duct 96 and the spiraling motion of the gases causes the heavy particles suspended therein to be thrown radially outwardly against the wall of the housing and expelled from the housing in the manner hereinabove described. The gases next pass progressively through the smaller tubular members 98 and 104 where the finer particles of fly-ash are precipitated out in the manner described.

As suggested, the first spiraling motion imparted to the gases by the vanes 113 takes out only the larger particles of fly-ash. The rotary motion of the gases is maintained by the subsequent sets of vanes 114 and 116, and at the same time the velocity of the gases is increased by the progressively constricted passages through which it travels. The higher centrifugal force which results throws out the medium and lighter weight particles of fly-ash. Then when the gases make a sudden reversal to flow up through the duct 96, the inertia of any particles remaining therein tends to carry them downwardly. Once these particles fall below the baffle 112 they are no longer subject to the updraft of gases entering the duct 22 and they fall readily out of the housing 20.

Reference is now had to Figs. 11-15 which show a straight-flow type of precipitator. This precipitator has a horizontal tubular body 124 which conveniently may be surrounded by a hollow water jacket 126. The gases to be treated enter one end of the housing 124 where they en-

gage helical vanes 128. These vanes 128 impart a circulatory motion to the gases in the manner hereinabove described and the latter advances in a generally helical path through the housing.

In the distal end of the housing 124, and spaced axially or longitudinally with respect to each other, are annular members 130, 132 and 134. It will be observed that all of these members are spaced circumferentially from the wall of housing 124 and that the members are connected to the housing by radial flange portions at the distal ends thereof. Also, it will be observed that the members 130, 132 and 134 decrease progressively in size toward the distal or rearward end of the housing 124. The two forward members 130 and 132 are equipped with relatively short helical vanes 135 and 136.

As in the forms of the invention first described, the rotary motion of the circulating gases is maintained by the vanes 135 and 136 and the rotary velocity of the gases is accelerated by the progressively restricted passages through which the gases flow. After passing through the series of vanes 135 and 136, the gases discharge from the precipitator through the terminal tubular member 134 as indicated by the arrows in Fig. 11. Solid particles suspended in the gases are thrown by centrifugal force radially outwardly against the housing 124. These particles pass forwardly between the housing and the annular members 130, 132 and 134 and are discharged downwardly from the precipitator through openings 138, 140 and 142. If desired, a discharge nozzle 144 may be provided to collect the solid particles discharged through the openings 138, 140 and 142, as shown in the drawings.

This type of precipitator has the advantage of less resistance to flow and is more compact than the reverse flow type first described. However, the straight flow type of precipitator does not give the same efficiency of ash removal as the reverse flow type. It does not have the added effect of the reversal of flow at the end which throws off ash particles by inertia independently of the circulatory movement or centrifugal effect imposed on the particles by the helical vanes. However, the straight flow type of precipitator functions satisfactorily for many purposes; and, where resistance to flow is not an important factor, it may be more desirable than the more efficient reverse flow type.

Where the gases being treated are relatively hot, as in the case of furnace flue gases, a superheater tube 146 for steam or the like may be incorporated in the device, as best shown in Fig. 11. The superheater tube 146 comprises preferably a double, small diameter pipe, which extends inwardly through the discharge end of the housing and preferably terminates adjacent the inlets thereof. The double end of the tube 146 fits into and is protected by a streamlined hub 148. Also, it will be observed that the hub 148 provides a convenient center support for the helical vanes 128.

Where the superheater tube 146 is employed, the jacket 126 can be adapted to contain water and the heated gases traversing the precipitator can be used to heat water in a boiler or the like (not shown). When this is done, the water jacket 126 and the steam tube 146 are connected in the water circulating system of the boiler.

In a typical application, there would be several rows of precipitators through which the flue gases could pass to the boiler and at the same

time heat the water in the water jacket that surrounds each tube assembly. This construction puts the steam tube in the hottest spot and is an ideal location for the superheater tube 146. The steam from the steam drum or water from the jacket makes a double pass through the hot gases and goes out through the top to a superheater delivery drum. The entire assembly is exceedingly compact. The precipitator-superheater combination performs a triple function with little resistance to gas flow and the water heating elements take up very little additional space. Also, the water jacket and superheater tube absorb heat from the gases passing through the precipitator and thus lower the temperature which otherwise might be dangerously high. This installation is particularly desirable under conditions where the heat from the incoming gases might be hot enough to melt or fuse the precipitator tubes.

Having thus described the invention, I claim:

1. A precipitator comprising a housing having a passage and provided with an inlet and an outlet at opposite ends of said passage, circumferentially spaced inner and outer annular walls at the inlet portion of said passage, said inner and outer walls being provided with corresponding openings which are circumferentially out of alignment with each other so that gases entering the passage through the opening in said outer wall must travel in an arcuate path through the annular space between the inner and outer walls before entering the passage through the opening in said inner wall, radial partitions dividing said annular space, one partition being provided for each opening in said outer wall, and said partitions collectively dividing the annular space into compartments each of which is provided with one opening in the outer wall and one opening in the inner wall, and means within said passage for removing solid particles from gases traversing said passage.

2. A precipitator comprising a housing having a passage and provided with radially spaced inner and outer annular walls, said outer wall provided with a plurality of circumferentially spaced inlets and said inner wall provided with an equal number of circumferentially spaced inlets which open into the passage, the inlets in said inner wall opening into the annular space between said inner and outer walls at points between the openings in said outer wall, and radial partitions dividing the annular space between said inner and outer walls, one partition being provided for each opening in said outer wall, and said partitions collectively dividing the annular space into compartments each of which is provided with one opening in the outer wall and one opening in the inner wall, an outlet for said passage remote from said inlets, radial vanes arranged helically within the housing opposite the inlet for imparting a circulatory motion to and simultaneously deflecting downwardly gases entering the housing through said inlet, means within the housing for accelerating and directing the circular motion of the gases so that solid particles suspended in the gases are thrown radially outwardly by centrifugal force, said means including a plurality of progressively restricted annular passages opening in the direction of said radial vanes to receive the centrifugally impelled particles and helical vanes positioned in the mouths or inlet ends of said annular passages, said annular passages provided with separate

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discharge openings through which the particles pass from the housing.

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