United States Patent

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[54] **MULTIPLE UNIT PRECIPITATOR APPARATUS**
4 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **55/133,** 55/344, 55/418, 110/119, 110/184, 266/15
[51] **Int. Cl.** **B03c 3/36**
[50] **Field of Search** 55/133, 127, 128, 129, 130, 131, 132, 342, 343, 344, 346, 347–350, 418; 110/119, 184; 266/15

[56] **References Cited**

UNITED STATES PATENTS

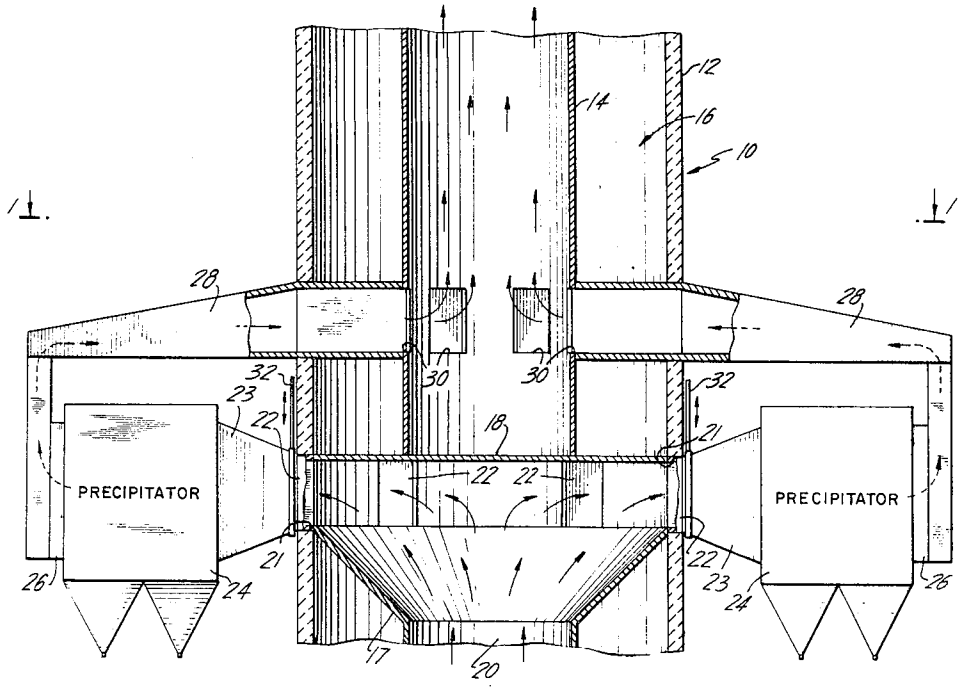
1,304,729	5/1919	Bendit	55/133 X
1,413,877	4/1922	Schmidt	55/122 X
2,171,798	9/1939	King et al.	110/119 X
2,740,493	4/1956	Wintermute	55/127 X
3,063,219	11/1962	Copcutt	55/344 X
3,063,694	11/1962	Gaw	266/15
3,365,858	1/1968	Penney	55/343 X
3,458,178	7/1969	Warnick	261/17

FOREIGN PATENTS

931,259	10/1947	France	55/343
219,570	7/1924	Great Britain	55/133
667,142	2/1952	Great Britain	55/344
800,345	8/1958	Great Britain	55/127

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ABSTRACT: Apparatus for cleaning gases, such as industrial stack effluents and the like, comprises a plenum chamber for receiving and distributing the gases to be cleaned and a multiplicity of separately enclosed electrostatic precipitators connected in parallel with each other to the plenum chamber. The precipitators are arranged relative to the plenum chamber, and the plenum chamber appropriately constructed, to distribute the gas flow volume substantially uniformly among the several precipitators and to provide improved cross section gas distribution conditions within each precipitator. Each of the precipitators may be individually isolated from the gas flow and its enclosure opened for maintenance or repair. The remaining precipitators pick up the cleaning load carried by the one or more that are shut down without substantial impairment of the effectiveness of the cleaning.

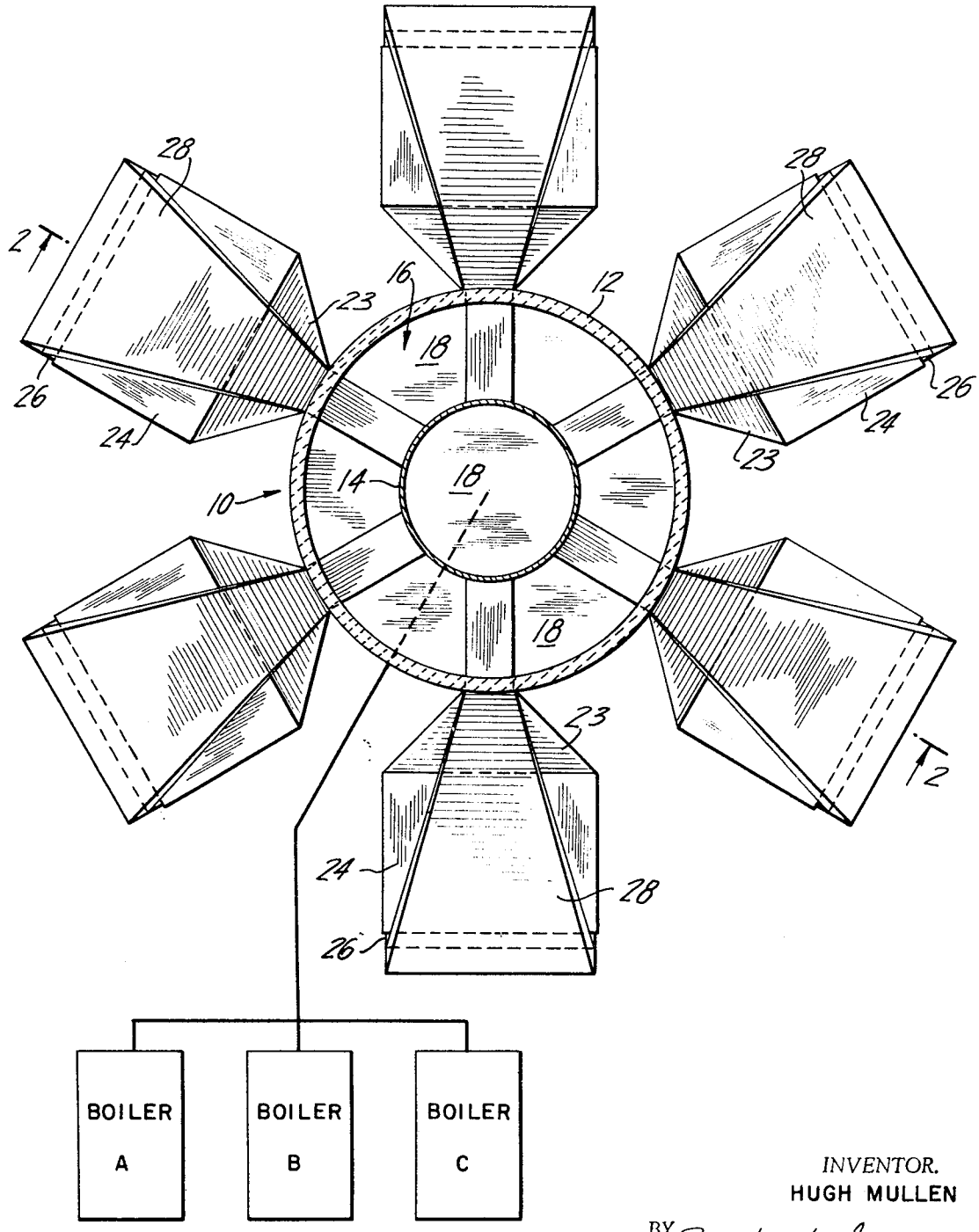


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SHEET 1 OF 2

FIG. 1



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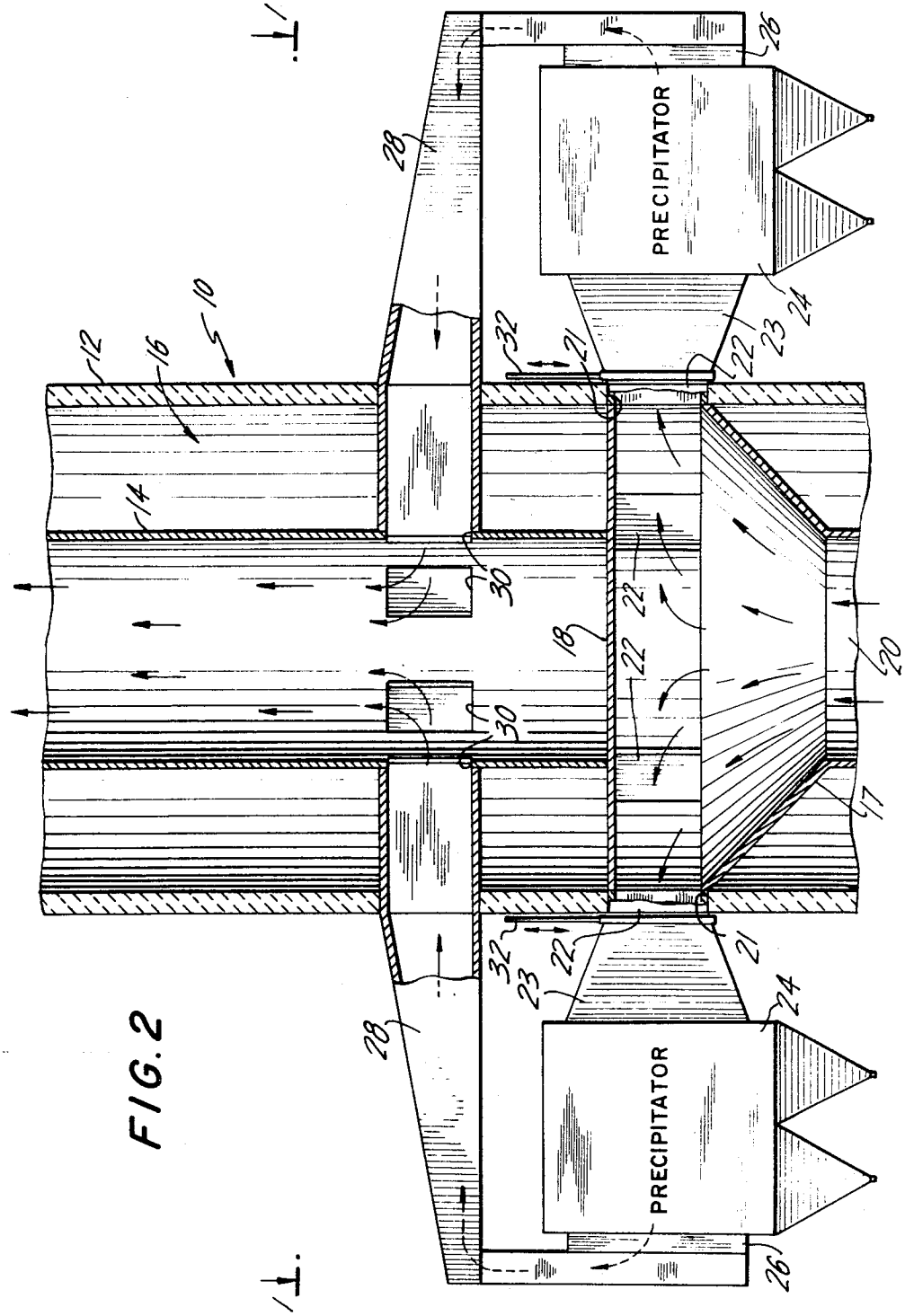


FIG. 2

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MULTIPLE UNIT PRECIPITATOR APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to gas-cleaning apparatus and, in particular, to a multiple precipitator system for removing particulate materials entrained or suspended in gases.

In response to the increasing public outcry against air pollution, more wide spread and efficient utilization of gas cleaning equipment is gradually taking place. Any industrial operation involving the generation of dust, smoke and other forms of particulate matter entrained in a gas or the generation of noxious gases mixed with harmless gases that are discharged into the atmosphere should provide for removal of the objectionable materials to the greatest possible extent before the gas is discharged. This invention relates to a system and arrangement of electrostatic precipitators that allow more efficient and reliable operation, permit more effective maintenance of the equipment, and also frequently afford installation of the equipment at a significantly lower cost, than have been possible with systems and arrangements previously proposed or used.

One problem with previously proposed multiple unit precipitator equipment is that the gas flow distribution frequently is not uniform either among the units or within the individual units themselves. As a consequence, one unit may be loaded beyond its efficiency while a companion unit receives only a part of its rated load. This condition does not allow optimum utilization of the gas-cleaning equipment or efficient operation of the cleaning systems.

Moreover, the arrangement of conduits in known multiple unit equipment is often such that poor gas distribution within the separate units causes uneven loading of the cleaning elements of the units and an accompanying deterioration in cleaning performance. In other words, the cross-sectional flow distribution within a given unit is not uniform, as it should be for optimum efficiency. Although a uniform cross-sectional distribution of the gas within an electrostatic precipitator is essential to its efficient operation, it is difficult to achieve because of the relatively low gas velocity (on the order of five feet per second) at which precipitators are operated.

Another difficulty in operating gas-cleaning equipment on line with an industrial process has been that of performing routine maintenance, as well as desirable or necessary repairs, on the gas-cleaning equipment without the necessity of shutting down the industrial process being served by the equipment or discharging uncleaned gases into the atmosphere. For example, the smoke from a boiler may be discharged through a single gas-cleaning device, such as an electrostatic precipitator, for removing particulate matter in the smoke before it is discharged to the stack. If repair work or routine maintenance of the precipitator is required, the boiler has to be shut down. Usually, the precipitator is allowed to remain out of service until such time as the boiler is shut down, and dirty gas is discharged in the meantime.

In some instances, large boilers, furnaces and other combustion apparatuses are served by two or more precipitators in parallel with each other. In such multiple unit systems, smoke from the combustion apparatus typically is conducted through separate conduits or tunnels, each of which is equipped with a precipitator, and then the cleaned gases are discharged to a single stack. Here, if any of the precipitators requires service, operation of the combustion apparatus generally will not be interrupted for such service and again only partial gas cleaning is effected.

Where multiple pieces of combustion equipment, such as boilers, incinerators, furnaces of various types and the like, are served by one stack and such equipment employs precipitators, they have heretofore been on line with each conduit leading from each piece of equipment to the stack. Once again, the maintenance and repair of the precipitator associated with a given unit of a bank of combustion equipment necessitates shutting down the unit for repair or service.

SUMMARY OF THE INVENTION

There is provided, in accordance with the invention, a novel and improved multiple unit system or arrangement of separate electrostatic precipitators that affords substantially uniform gas distribution among the precipitators and within each separate precipitator. Balanced loading of the multiple unit system is thus achieved, and improved particulate removal efficiency accordingly obtained. The improved precipitator system also enables any of such precipitators to be isolated from the system and their enclosures to be opened to allow work to be performed, while permitting the source of gases being cleaned to remain in operation and affording effective gas cleaning during such maintenance or repair work. The precipitators may be of any suitable type, such as single stage, Cottrell-type precipitators, two-stage precipitators, and the like. Moreover, the apparatus may be employed in a system carrying on any process involving the generation of gas contaminant that is removed by such precipitators.

More particularly, the apparatus of the invention comprises the multiplicity of separately enclosed precipitators that are separately connected to a common plenum chamber that receives the gas to be cleaned from one or more sources. If appropriate, the gases may be released from the individual precipitators directly to the atmosphere, or they may be conducted to one or more stacks, serving several or all of the units. Advantageously, however, the system is arranged such that the differential pressure across all of the precipitators is substantially equal so that the devices will share substantially equally the cleaning load of the gases being cleaned, thus ensuring uniform gas flow distribution among and within the several precipitators at all gas volumes. An important advantage of the invention is thereby realized, inasmuch as optimum utilization of each precipitator is achieved, with correspondingly increased cleaning effectiveness.

Equalizing of the precipitator loads, or in other words, uniform distribution of the gas flow among the precipitators, is achieved through the use of a generally circular, in cross section, plenum chamber, to which the precipitators are communicated at preferably equally spaced circumferential positions. Gas flowing to the plenum chamber is therefore delivered to the separate precipitators in substantially equal volumes, regardless of the inlet gas flow rate to the plenum chamber. To this end, the plenum chamber is sized and constructed to direct the incoming gas flow radially, and with the same, or nearly the same, velocity in all radially directions, to the precipitators. The plenum chamber also preferably expands in the downstream direction to define a relatively quiescent zone of stabilized gas flow in the vicinity of the precipitator inlets. By this arrangement, not only is gas distribution among the precipitators rendered more uniform, but improved cross-sectional distribution of the gas flow within each precipitator is obtained as well. Accordingly, channeling of the flow within the precipitators is largely avoided, and even loading of the cleaning elements of the individual precipitators is accomplished.

Each of the precipitators is communicated to the plenum chamber through a conduit, and each of the conduits is provided with an appropriate valve or valve-type device for selectively cutting off communication from the plenum chamber to the precipitator so that the precipitator may be separated from the system for maintenance, repair or any other reason without making it necessary to shut down the entire system or the equipment which it serves. Another important advantage of the apparatus, according to the invention, resides in this feature, namely, the ability of maintaining continuous operation of a gas-cleaning system while permitting one, and possibly two or more, gas-cleaning precipitators to be shut down for maintenance or repair. Also, a malfunction in one cleaning unit of the system does not reduce the effectiveness of cleaning below an acceptable level. In addition, the employment of a multiplicity of precipitators of relatively small

capacity, compared with the total capacity of the overall apparatus, may enable significant savings in capital investment and operating expenses.

In one embodiment, the gas-cleaning apparatus, according to the invention, is employed in and is integrated into a smoke stack, such as a smokestack serving one or more boilers, furnaces or other combustion devices. The plenum chamber for the apparatus may be constituted by a lower portion of the stack that is blocked off from the upper portion. Conduits lead off radially, preferably symmetrically, from the plenum chamber portion of the stack and are coupled to the inlets of the several precipitators, and the outlet of each precipitator is coupled by a conduit to a part of the stack above the blocking wall that closes off the plenum chamber, the smoke passing up and out of the stack in the usual manner. Each of the conduits connecting the plenum chamber to the respective precipitators includes a suitable device for closing it off from the plenum chamber, such as a gate or guillotine-type valve. If the stack is under negative pressure, relative to the atmosphere, no valves need be provided in the outlet conduits from the outlets of the precipitators to the stack, but if the stack is under positive pressure at the point where the smoke is discharged from the precipitators to the stack, a valve may be provided in each outlet conduit to ensure that smoke is not released to the atmosphere through the precipitator when it is opened for maintenance, repair or any other purposes.

In a preferred embodiment, the gas-cleaning precipitators are positioned and oriented in a symmetrical arrangement, relative to the plenum chamber from which they receive the gases, to afford an optimum condition for uniform flow of gases to the individual gas-cleaning units and for even distribution of the gas within each unit. A symmetrical arrangement also usually facilitates the mechanical, electrical and structural design of the system and ancillary components. For example, where the system is employed with a smokestack, symmetrical arrangement of the precipitators affords locating conduits, structural supports and the like in a symmetrical arrangement, which is of advantage as far as structural design considerations. Openings through the wall of the stack are also more readily designed for in a symmetrical system.

In this description, any reference to an electrostatic precipitator is intended to refer to a separately enclosed unit that may contain only one type of precipitator or may contain two or more different types of precipitators arranged in series with each other. Each device may, and usually will, have several precipitator elements of the same type in parallel in one enclosure.

In the apparatus, according to the invention, it is, moreover, preferable that all of the precipitators be substantially identical, inasmuch as the apparatus preferably operates with a balanced load distribution among the multiplicity of precipitators in the system. Further, the apparatus should be composed of a sufficient number of precipitators, preferably not less than four and possibly even five, such that when any one is shut down for maintenance or repair, the amount of load to be redistributed to the other devices is not overly large, and in any event is not so great as to reduce the effectiveness of gas cleaning below an acceptable level.

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 view in cross section taken through a smoke stack equipped with a precipitator cleaning system according to the invention, the view being taken generally along a plane represented by the lines 1—1 of FIG. 2 and in the direction of the arrows; and

FIG. 2 is a cross-sectional view taken generally along a dimetrical plane through the axis of the stack, portions of the equipment being shown in full to eliminate unnecessary detail in the illustration and the view being taken generally along a plane represented by the lines 2—2 of FIG. 1.

DESCRIPTION OF AN EXEMPLARY EMBODIMENT

The embodiment illustrated in the drawings and described hereinafter is a precipitator gas-cleaning system for removing particulate materials entrained in smoke issuing from one or more pieces of combustion equipment, such as boilers, furnaces, incinerators or the like prior to discharging the smoke to a stack, the apparatus being integrated into the stack structure. Referring first to FIG. 2, the precipitator equipment is located at a suitable level near the bottom of the stack, which is designated in the drawings by reference numeral **10** and is composed of an outer structural shell **12** of reinforced concrete or masonary and an inner shell **14** of metal supported at intervals (not shown) by the structural shell **12** and spaced somewhat inwardly from the inner wall of the structural shell, leaving a free or dead space **16**. It will be understood by those skilled in the art that the system shown in the drawings can readily be incorporated into any form of stack structure. The smoke to be cleaned is introduced at the base of the stack and flows upwardly toward a portion of the stack that is enclosed within a generally conical extension **17** of the inner shell **14** and a transverse wall **18** that closes off the major, upper part of the stack, such portion being termed herein a plenum chamber and being designated generally in the drawings by the reference numeral **20**. The smoke delivered to the plenum chamber **20** may come from one or more sources, for example, a bank of several boilers.

The plenum chamber has a number (six in the illustrated form) of circumferentially spaced-apart openings **21** formed through the outer shell **12**, and each opening receives a short conduit section **22** that is connected to the inlet **23** of a respective one of a multiplicity of electrostatic precipitators **24**. Referring particularly to FIG. **2**, the openings **21**, conduits **22** and precipitators **24** are arranged symmetrically about the vertical axis of the stack **10**. Moreover, the precipitators **24** are oriented and positioned in the same relation to the axis of the stack. In the illustrated form, the precipitators are located equidistant from the axis of the stack and are aligned on axes that are oriented radially of the stack, and the conduits **22** and precipitators **24** are oriented with the axes of of adjacent pairs defining equal angles. The precipitators are also located at the same vertical elevation, that is, on a plane relative to the stack that is perpendicular to the axis of the stack. The foregoing geometric arrangement, i.e., symmetry relative to the axis of the stack and positioning at the same elevation, affords a balanced flow of smoke to the precipitators. Also, the structural design of the stack and the structure (not shown) for supporting the precipitators is facilitated with a symmetrical arrangement. However, it is within the scope of the invention to vary the arrangement, even to a relatively substantial extent, from the symmetrical arrangements.

According to an important feature of the invention, the smoke flowing to the plenum chamber **20** is distributed uniformly among the several precipitators **24** spaced around the stack. Accordingly, unbalanced loading of the cleaning system is avoided, that is to say, one or two of the precipitators **24** are not loaded beyond their individual capacities while other precipitators in the system receive only partial loads, as sometimes occurs in prior art parallel unit systems. Instead, the precipitators receive approximately equal gas flow volumes. Optimum utilization of each precipitator **24** is therefore realized, with attendant advantages in increased cleaning effectiveness and operating efficiency of the system.

Moreover, balanced loading of the system is maintained at all gas flow volumes, low as well as high. Thus, even when small gas volumes are delivered to the plenum chamber **20**, as where the cleaning system is used to clean smoke emitted from one or more sources (such as the boilers A, B and C of FIG. 1) one of which is shut down, no reduction in cleaning efficiency is experienced. Indeed, higher cleaning efficiencies

are achieved, inasmuch as the balance of the smoke is distributed throughout all of the precipitators so that the small smoke volume is treated by the total precipitator area. Economies in capital expenditure and operating costs also are realized, since none of the precipitators need lie unused when one or more of the gas sources is shut down.

The construction of the plenum chamber **20** and the radially positioned precipitators **24** also contributes to the obtaining of improved gas distribution characteristics within the individual precipitators **24**. As the smoke enters the plenum chamber **20**, it slows temporarily before flowing radially through the inlets **23** of the precipitators. The velocity of the smoke as it enters the precipitators, therefore, tends to be fairly constant over the cross section of the inlets **23**, reducing channeling of the flow within the precipitators and allowing the smoke to be distributed more uniformly among the cleaning elements of the units.

The outlet **26** of each precipitator **24** is coupled by a conduit **28** to an opening **30** in the inner shell **14** of the stack located above the wall **18**. The effluent gases from each precipitator flow through the precipitator outlet **26** and the respective conduit **28** into and up the stack **10**. Preferably, the conduits **28**, like the inlet conduits **22**, are located symmetrically relative to the axis of the stack and enter the stack at the same level so that the smoke distribution among the several precipitators is maintained substantially uniform. To some extent, the symmetrical arrangement of the outlet conduits **28** from the precipitators to the stack plays a part in the maintenance of uniform distribution of flow among the several precipitators, and, again, the symmetry of arrangement also facilitates structural design of the stack.

Another important feature of the apparatus of the invention is the ability of one, and possibly two or more, of the precipitators of the system to be cut off or isolated from the stack for maintenance, repair or any other purpose. To this end, each of the inlets **23** conduits **22** to the several precipitators **24** is equipped with a suitable type of valve, such as a gate or guillotine-type valve **32**. Should it be desirable or necessary to shut down one of the precipitators, the valve **32** is closed to close off communication to the inlet **23** of that precipitator and enable the enclosure of the precipitator to be opened up and maintenance and repair work performed. To this end, each precipitator is separately enclosed and is operated from a power supply and control system (not shown) that allows it to be shut down independently of the other precipitators in the system.

Inasmuch as most smoke stacks are operated under a negative pressure, relative to atmosphere, it will ordinarily be unnecessary to provide any valves in the outlet conduits **28** from the precipitators, but should the stack, at the point where the conduits **28** enter it, be at a pressure above atmospheric, appropriate valves can be provided in the conduits **28** to prevent smoke from being discharged from the stack back to the precipitator when it is opened.

When one or more precipitators is isolated from the plenum chamber **20**, the remaining precipitators will share substantially equally the smoke load previously carried by the unit that is shut down. If the apparatus has a sufficient number of precipitators of appropriate capacity, preferably a capacity several percent above the capacity required for each if all of the precipitators are in operation, the system will operate efficiently when any one, or possibly two, is shut down. Thus, the sources of smoke served by the stack may remain in continuous operation, even if a precipitator is shut down for maintenance or repair without substantially impairing the effectiveness of smoke cleaning afforded by the system.

The embodiment of the invention described above is intended to be merely exemplary, and numerous variations and modifications of it will be readily apparent to those skilled in the art without departing from the spirit and scope of the invention. All such variations and modifications are intended to be included within the scope of the invention, as defined in the appended claims.

I claim:

1. Gas-cleaning apparatus comprising a vertical stack, a transverse wall mounted in the stack and subdividing the stack into an outlet portion above the transverse wall for discharge of gases upwardly to the top of the stack and a plenum chamber below the wall for reception of gases to the stack from one or more sources, the plenum chamber being substantially circular in cross sections perpendicular to the stack axis and having a lower inlet portion spaced from the transverse wall that increases in cross section moving upwardly toward the transverse wall thereby to establish uniform gas flow distribution in the plenum chamber in a gas expansion zone thereof, a multiplicity of substantially identical electrostatic precipitators each having a separate enclosure and having an inlet for receiving a gas to be cleaned and an outlet for discharging the gas after cleaning, the number of precipitators being large enough and the capacity of each being sufficient to enable operation of the apparatus with one of the precipitators out of operation without substantially impairing effective gas cleaning, the precipitators being spaced substantially equidistant from each other and from the plenum chamber and with their axes disposed substantially radially with respect to the longitudinal axis of the plenum chamber, substantially identical inlet conduits communicating the inlet of each precipitator to the plenum chamber, valve means in each inlet conduit for selectively closing off such inlet conduit to preclude gas inflow to the respective precipitator so that its enclosure may be opened while the other precipitators process the portion of the influent gases that would have been processed by such closed off precipitator, and substantially identical outlet conduits communicating the outlet of each precipitator with the outlet portion of the stack.

2. Apparatus according to claim **1** wherein the precipitator inlets face inwardly toward the stack axis and the outlets face outwardly, and wherein the outlet conduits extend upwardly and thence turn inwardly toward the stack and over the tops of the precipitators.

3. Apparatus according to claim **1** wherein a plurality of sources of gas communicate in gas-transmitting relation with the plenum chamber, whereby the total precipitator area is available for cleaning the gas emanating from each operating source irrespective of whether one or more of the other sources is shut down.

4. Apparatus according to claim **1** wherein a plurality of combustion devices communicate in gas-transmitting relation with the plenum chamber, whereby the total precipitator area is available for cleaning the gas emanating from each operating combustion device irrespective of whether one or more of the other combustion devices is shut down.

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