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Grisell

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[45] July 1, 1975

[54] ELECTROSTATIC PRECIPITATOR

[75] Inventor: Charles P. Grisell, Homewood, Ala.

[73] Assignee: Rust Engineering Company, Birmingham, Ala.

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[51] Int. Cl. B03c 3/36

[58] Field of Search ..... 55/101, 128, 129, 130, 55/133, 136, 137, 138, 140, 150, 151, 154, 108, 110, 112; 138/37, 39, 40, 42, 103, 111, 115, 116, 117, 178; 98/8, 13, 19, 32, 37, 40 R, 40 C, 40 N, 42

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Primary Examiner—Dennis E. Talbert, Jr.

[57] ABSTRACT

An electrostatic precipitator in which the gas flow passage converges in height and diverges in width from inlet to outlet, but is of constant cross-sectional area throughout its entire length. The aspect ratio is constant for one direction of gas flow. The precipitator is divided by discharge electrodes into a number of gas flow sub-passages. Each sub-passage is of constant cross-sectional area and constant aspect ratio.

10 Claims, 5 Drawing Figures

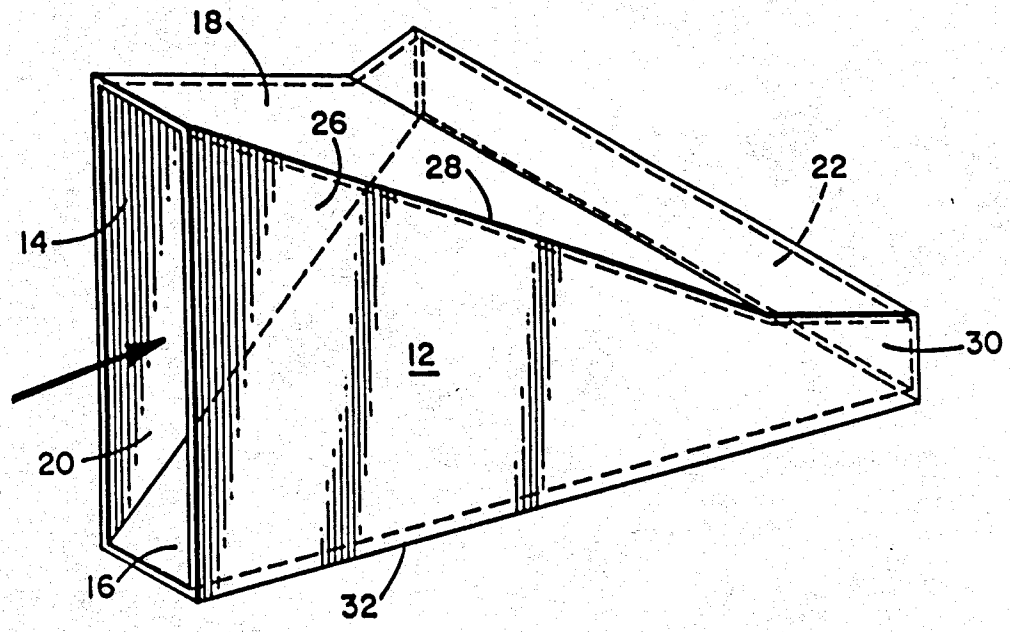


FIG. 1A

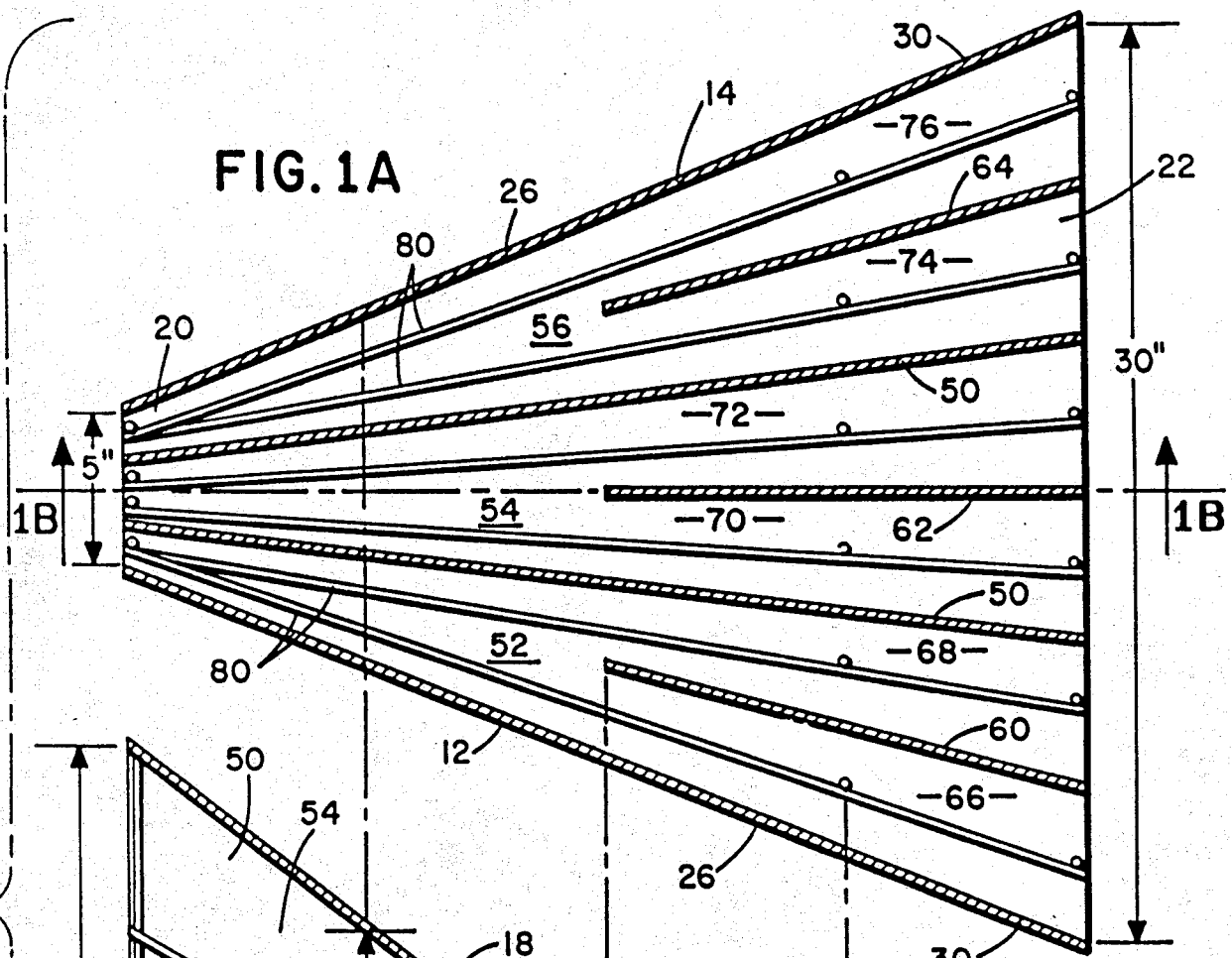

30
14
-76-
64
22
26
80
-74-
20
56
50
30"
-72-
5"
1B
54
-70-
62
1B
50
52
-68-
80
60
12
-66-
50
54
26
18
30
28
20
24"
18"
62
AIR FLOW
30
80
22
12"
5"
4"
1
16
2
32
3
4
8"
5
16"
24"
32"

FIG. 1B

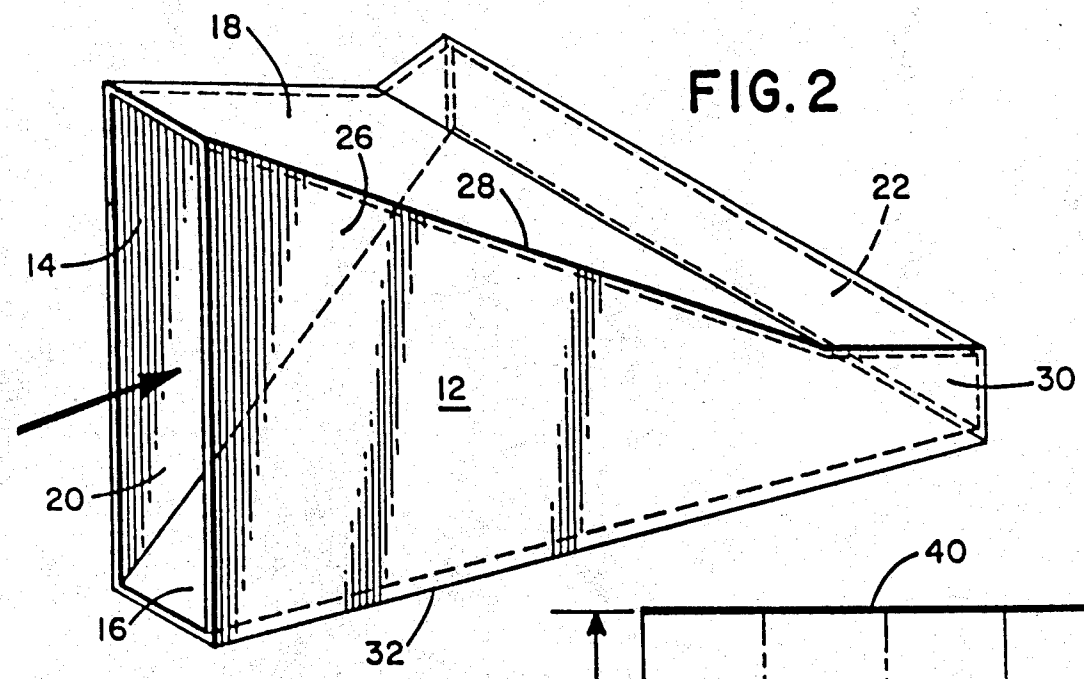


FIG. 2

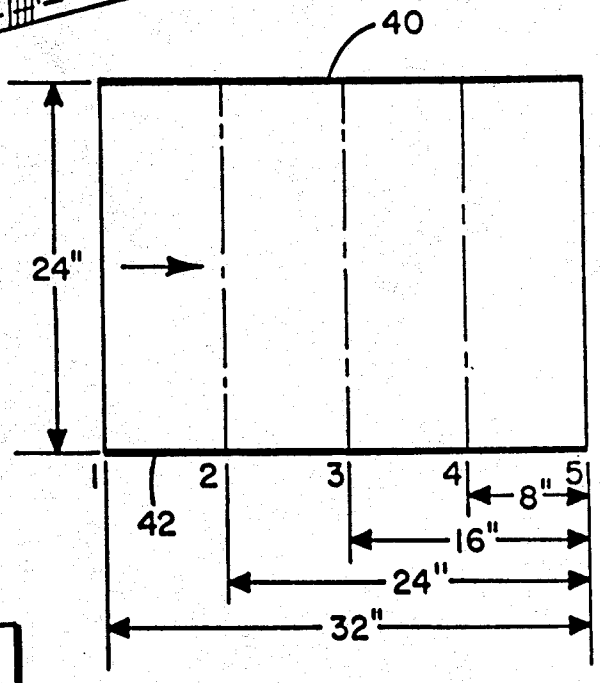


FIG. 3

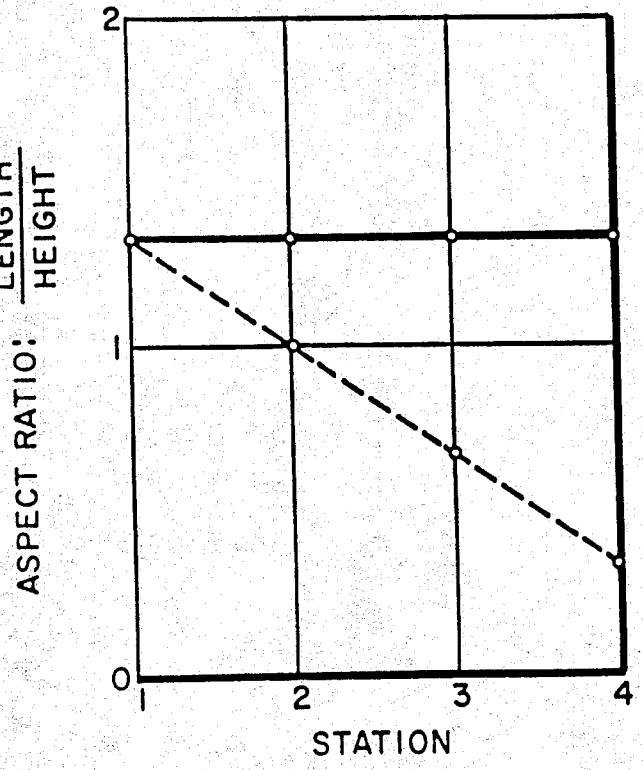


FIG. 4

ELECTROSTATIC PRECIPITATOR

BACKGROUND OF THE INVENTION

This invention relates to generally electrostatic precipitators and more particularly to the design of the gas flow passage through an electrostatic precipitator.

Electrostatic precipitators are widely used for removing particles from a moving stream of gas. The particles are charged by passing near a charged discharge electrode, and then are exposed to a similarly charged collection electrode, to which they are attracted and adhere, thus removing them from the gas stream. At periodic intervals the particles are removed from the collection electrodes by mechanical or electrical means.

A number of factors govern the efficiency of an electrostatic precipitator. Chief among them are: aspect ratio, gas velocity, migration velocity, retention time, and resistivity.

The aspect ratio of the gas passage is the distance from the point of measurement to the outlet (length) divided by the height at the point of measurement. The aspect ratio reflects the probability of removing the particles. The greater the aspect ratio at a particular point, the better the chances of the particles being collected between that point and the outlet. This would suggest that the best design is a very long, low precipitator, but practical considerations limit the length and configuration in most cases. Prior art precipitators have generally been of constant height, and therefore have a diminishing aspect ratio, which means that the farther a particle proceeds into the precipitator, the greater its chances of not being collected.

The velocity of the gas moving through the precipitator is, of course, quite important. An abnormally high velocity will decrease the number of particles that are collected because they will move too swiftly to be properly charged and collected. High gas velocity will increase the chances of re-entraining particles that have once adhered to the collection electrodes. Too low a velocity will mean that comparatively little gas can be treated in a given time, although the efficiency of the precipitator may be high.

An additional velocity component is imparted to the gas stream by the action of the charged particles moving toward the collection electrodes. Called the particle migration velocity, this is a function of a number of factors, including the strength of the electrostatic field, the number and spacing of the collection electrodes, the resistivity of the individual particles, and the composition of the gas. A charged particle must possess in migration velocity sufficiently high as to insure that it reaches a collection electrode.

The particle retention time is also a function of a number of factors, principally the length of the precipitator and the gas velocity. The longer a particle is retained in the precipitator, the better the chances of collecting it. Again, practical considerations govern this factor. A long particle retention time will tend to counterbalance an undesirable aspect ratio.

Also, there are the electrostatic characteristics of the system, known as the resistivity of the particles. The chief consideration here is the ability of the individual particles to accept an electrostatic charge. Governing factors are the magnitude of the charges applied to the electrodes and the electrostatic characteristics of the particles. Generally, the greater the charge applied to the particles, the greater the chances of collection.

Finally, there are the practical considerations of manufacturing cost, space for installation, and power required for operation.

It can readily be seen that the above factors are largely interrelated with one another, so that a change in one affects all. This has caused difficulty in designing versatile precipitators, and the prior art designs quite often sacrificed certain of the factors in favor of others, with resulting inefficiency and/or inability to compensate for changes in the factors. For example, perhaps the least expensive gas passage design is constant height and width. This provides a poor aspect ratio, but if it can be made of sufficient length, or provided with good electrostatic characteristics, the poor aspect ratio can be countered. Often, however, this cannot be accomplished, and the result is an inefficient device.

Many precipitators are custom designed to meet specific performance and/or space requirements. These are expensive and cannot usually be altered for use in other situations. Furthermore, many of these precipitators cannot accommodate changes in one of the governing factors, such as gas velocity, and in the face of such they lose their efficiency.

SUMMARY OF THE INVENTION

The primary object of this invention is to provide an electrostatic precipitator that eliminates the deficiencies found in prior art devices.

A further object of this invention is to provide an electrostatic precipitator that is more efficient than prior art devices.

Another object of this invention is to provide an electrostatic precipitator that is more versatile than the prior art devices.

In this invention, the aspect ratio is kept constant throughout the length of the precipitator. This means that the height of the precipitator lessens from inlet to outlet. Thus, the chances of a particle being captured remain constant, and the efficiency of the precipitator is greatly enhanced.

It has also been found to be advantageous to combine with the above feature a constant cross-sectional area. Thereby, the gas velocity will remain constant from inlet to outlet and the design of the flow characteristics, electrical power requirements, and the like are greatly simplified. By this design, it has been found that the basic efficiency is maximized. Thereafter, the other factors named above can be considered much more objectively.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a horizontal sectional view of a precipitator constructed in accordance with the teachings of this invention;

FIG. 1B is a vertical sectional view of the precipitator shown in FIG. 1A, taken along line B—B;

FIG. 2 is a perspective view of the precipitator housing with electrodes omitted;

FIG. 3 is a vertical longitudinal sectional view of a prior art precipitator; and

FIG. 4 is a graph of the aspect ratios for the prior art device of FIG. 3 and the inventive device of FIGS. 1A, 1B and 2.

DESCRIPTION OF A PREFERRED EMBODIMENT

A precipitator constructed in accordance with the teachings of this invention is shown in FIGS. 1A, 1B

and 2. It comprises a pair of sides 12 and 14, a bottom 16, and a top 18. These elements define a gas flow passage having an inlet opening 20 and an outlet opening 22.

Each of the sides 12 and 14 includes a main portion 26 substantially of right triangular shape extending between stations 1 and 4 in which the hypotenuse 28 converges from the inlet toward the outlet. A secondary side portion 30 is attached thereto positioned at what would otherwise be the apex of the triangle, extending between station 4 and 5.

There is an important relationship between the slope of the hypotenuse 28 of each of sides 12 and 14 and the base 32 of the triangle, as shown in FIG. 1B. As explained above, the aspect ratio is the ratio, at any given point along the length of the gas flow passage, of the length from that point to the outlet to the height at that point.

$$\text{Aspect Ratio} = \frac{\text{Length}}{\text{Height}}$$

Presuming an inlet height of 24 inches, and a gas passage length of 32 inches, the aspect ratio at station 1 is 1.33. At station 2, where the height is 18 inches and the length to the outlet 24 inches, the aspect ratio is 1.33. The aspect ratio is 1.33 at station 3, where the height is 12 inches and the remaining length is 16 inches. At station 4, the height is 6 inches and the remaining length is 8 inches. Again, the aspect ratio is 1.33. The aspect ratio in the secondary section of the precipitator, between stations 4 and 5, does not remain constant. The secondary section is provided so that attachment to gas exhaust ductwork less than 6 inches in height can be made. However, it should be understood that the outlet of the precipitator could be at station 4.

FIG. 3 is a vertical longitudinal sectional view of typical prior art precipitator. Top 40 and bottom 42 are equidistant throughout the entire length of the device. Therefore, the aspect ratio will decrease markedly from inlet to outlet. The height is 24 inches, and the length is 32 inches, just as illustrated with regard to the inventive device. The aspect ratio at station 1 is 1.33. At station 2, the aspect ratio drops to 1.0; at station 3 to 0.66, and at station 4 to 0.33. The comparison between the prior art devices, and the inventive device, is shown graphically in FIG. 4.

The configuration of top 18 and bottom 16 are shown in FIGS. 1A and 2. The top and bottom diverge from inlet to outlet. The divergence of the top 18 and bottom 16, and the convergence of the sides 12 and 14, are so related as to establish a constant cross-sectional area throughout the length of the precipitator. In the example shown, the inlet area is 120 square inches, and this remains constant even in the secondary section between stations 4 and 5.

A plurality of collection electrodes in the form of vertical plates 50 define three gas sub-passages 52, 54 and 56 (FIG. 1A). The collection electrodes extend the entire height of the precipitator, and are electrically charged (by means not shown) so that they collect the charged particles. Periodically, the particles are removed from collection electrodes 50 by conventional methods, such as by interrupting or reversing the charging current, or by striking the collection electrode to shake the particles free. The particles then drop to collection hoppers, not shown. The aspect ratio in each of the three sub-passages 52, 54 and 56 remains the same for the entire length of each, as does the cross-sectional area of each. Subpassages 52, 54 and 56 widen toward outlet 22, and it may be advantageous to further divide them by additional collection plates 60, 62 and 64, which extend over only a portion of the length of each passage 52, 54 and 56. These additional sub-passages 66, 68, 70, 72, 74 and 76 also have constant aspect ratios and constant cross-sectional areas. As shown, the collection electrodes and the various sub-passages extend through to station 5, and thereby the aspect ratio is not constant between stations 4 and 5. However, these elements need not extend into that section of the precipitator.

The electrostatic charge is imparted to the particles by a plurality of discharge electrodes in the form of wires 80. These extend down the center of the various passages. The number and placement of discharge electrodes and collection electrodes depends on a number of factors, but the general idea is to maximize the exposure of the particles.

Many variations and modifications of the embodiment illustrated are possible, and are within the contemplated realm of this invention. For example, the dimensional relationship may be varied from those illustrated. The supplementary section between stations 4 and 5 can be omitted. Also, the precipitator could be operated in reverse flow, upon which the aspect ratio would not be constant, but would sharply decrease, providing special effects.

The invention is defined by the scope of the appended claims.

I claim:

1. A gas flow passage for an electrostatic precipitator comprising

a bottom panel,

a top panel,

a pair of opposed side panels joined to said top panel and said bottom panel to define a gas flow passage having an inlet and an outlet, the height of each of said side panels diminishing from said inlet to said outlet at such a rate as to maintain constant the aspect ratio, which is defined as the ratio between the distance from a point of measurement to the outlet along the length of the precipitator, and the height at said point.

2. The apparatus of claim 1 wherein the width of said gas flow passage increases from said inlet to said outlet.

3. The apparatus of claim 2 wherein the cross-sectional area of said gas passage remains constant from said inlet to said outlet.

4. The apparatus of claim 3 further comprising a secondary gas passage attached to said gas passage at the outlet thereof, the cross-sectional area of said secondary gas passage being equal to the cross-sectional area of said gas passage and constant throughout the length of said secondary gas passage.

5. The apparatus of claim 1 further comprising means dividing said gas passage into a plurality of sub-passages for at least a portion of the length thereof, each of said sub-passages having a constant aspect ratio throughout the length thereof.

6. The apparatus of claim 5 wherein said gas passage has a constant cross-sectional area between said inlet and said outlet, wherein each of said sub-passages has a constant cross-sectional area throughout the entire length thereof.

7. An electrostatic precipitator comprising:

a gas passage defined by a top panel, a bottom panel, and a pair of opposed side panels attached to said top panel and said bottom panel and having an inlet and an outlet, said top panel and said bottom panel converging from said inlet to said outlet such that the aspect ratio remains constant from said inlet to said outlet,

discharge electrode means positioned in said gas passage, and

collection electrode means positioned in said gas passage.

8. The electrostatic precipitator of claim 7 wherein said side panels diverge from said inlet to said outlet, and wherein said collection electrode means comprises at least one collection electrode panel extending from said top panel to said bottom panel along at least a portion of the length of said gas passage and dividing said gas passage into a plurality of sub-passages, each of said sub-passages having a constant aspect ratio for the entire length thereof.

9. The electrostatic precipitator of claim 8 wherein said side panels diverge from said inlet to said outlet, and wherein the cross-sectional area of said gas passage is constant from said inlet to said outlet.

10. The electrostatic precipitator of claim 9 wherein said collection electrode means comprises at least one collection electrode panel extending from said top panel to said bottom panel along at least a portion of the length of said gas passage and dividing said gas passage into a plurality of sub-passages, each of said sub-passages having a constant aspect ratio for the entire length thereof.

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