Oct. 31, 1961 H. S. STARBUCK ET AL 3,006,436

AIR WASHER

Filed April 9, 1958

2 Sheets-Sheet 1

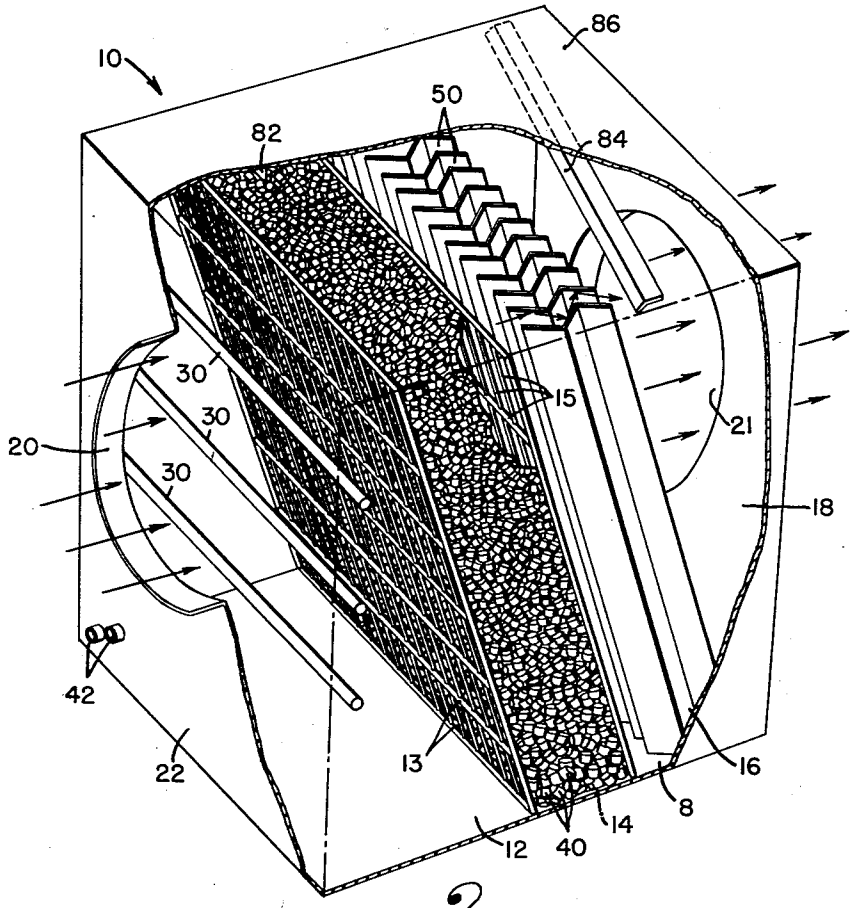


Fig. 1

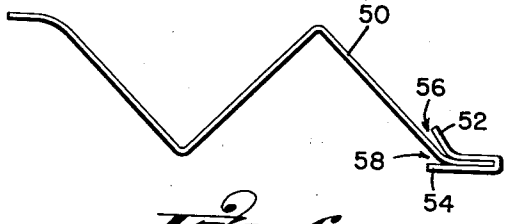


Fig. 6

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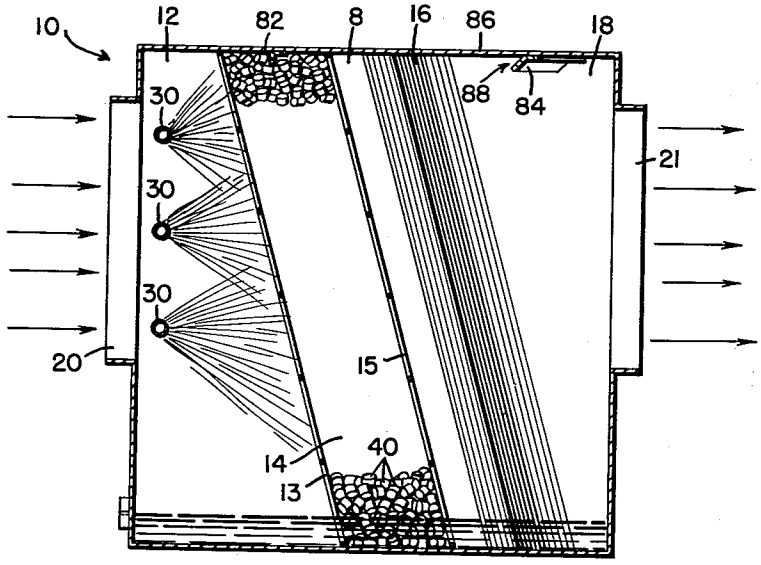


Fig. 2

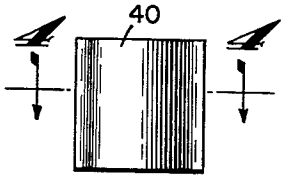


Fig. 3

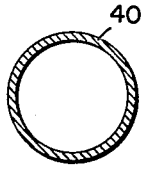


Fig. 4

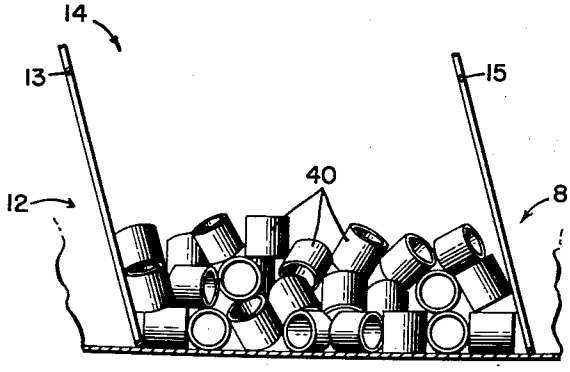


Fig. 5

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AIR WASHER

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5 Claims. (Cl. 183—22)

This invention relates to an air washer, and more particularly to an air washer capable of effectively removing any fluid soluble contaminants from a stream of air passing therethrough.

An object of the invention is to provide an air washer which is so constructed and arranged as to effectively remove any fluid soluble contaminants from air passing once through the device, and wherein the degree of contaminant removal is such that the washed air may be re-used without further processing.

Another object of the invention is to provide an air washer which is considerably smaller in size and lighter in weight than air washers heretofore used.

A further object of the invention is to provide an air washer of the packed-tower type comprising a ring-bed consisting of a plurality of thin, cylindrical rings which are located in such a manner as to impart a predetermined, positive turbulence to an air stream passing therethrough.

Still a further object of the invention is to provide an air cleaner having the hereinabove described characteristics wherein the ring-bed is located at an angle which insures that all of the rings comprising the bed will be thoroughly wetted during operation of the device.

Still another object of the invention is to provide an air cleaner having means for initially removing any and all water-soluble contaminants from the air and of other means for removing particles of water from the decontaminated air prior to discharge from the device.

These and other objects are attained by the means described herein and as illustrated in the accompanying drawings in which:

FIG. 1 is a perspective view, with portions thereof cut away for clarity of detail and understanding, of an air washer embodying the teachings of the present invention.

FIG. 2 is a vertical section through the device of FIG. 1.

FIG. 3 is an enlarged side view of one of the rings from the ring-bed.

FIG. 4 is a sectional view taken on line 4—4 of FIG. 3.

FIG. 5 is an enlarged, fragmentary view illustrating the manner in which the rings are random packed in the ring-bed.

FIG. 6 is an enlarged top view of a stripper plate comprising a detail of the present invention.

With particular reference now to FIGS. 1 and 2, it will be noted that the device comprises a housing **10** fabricated from a material such as, by way of example, unmodified, rigid, polyvinyl chloride, which is impervious to attack by most, if not all, of the commercial acids such as, by way of example, but not by way of restriction, nitric and sulphuric acids.

The interior of the housing may be considered as being divided into five in-line chambers **12, 14, 8, 16** and **18**, wherein **12** denotes, generally, a spray chamber; **14** a scrubber chamber; **8** an intermediate chamber; **16** a drying chamber and **18** a collection chamber.

An inlet **20** may be provided in front wall **22** of the housing, and in the preferred body of the invention the relationship of the area of intake **20** to area of spray chamber **12** is such that the velocity of air passing through spray chamber **12** will be reduced to about 450 feet per minute; whereas the velocity of contaminated air entering inlet **20** may be in the neighborhood of 2000 feet per minute, or more.

Spray chamber **12** is provided with a plurality of fluid conducting pipes **30** having nozzles therein for directing a continuous spray of fluid rearwardly toward, into, and onto the second or scrubber chamber **14**. Uniformly satisfactory results have been obtained in those instances wherein the rate of water discharge approximates one gallon per 1000 c.f.m. of air. The pipes **30** are so constructed and arranged as to not only wet the income air, but what is of even greater importance, they are arranged whereby to thoroughly and continuously effect a saturation and wetting of the bank of rings contained within the scrubber chamber **14**.

At this point it should be noted that the scrubber chamber is inclined up to thirty degrees downwardly away from the spray chamber; hoyever, in the preferred embodiment of the invention this inclination is 15°, which inclination has been found satisfactory for effecting a continuous and uniform wetting of the rings incident to a flow of air from the spray chamber through the scrubber chamber to the drying chamber **16**.

In FIGS. 3 and 4 the numeral **40** denotes generally a ring from the ring-bed, said ring having been fabricated from unmodified rigid polyvinyl chloride approximately $\frac{1}{16}$ inch thick, and wherein the overall height of the ring approximates its outer diameter. Uniformly satisfactory results have been obtained in those instances wherein the rings are 1 inch high by 1 inch O.D.; 1½ inch high by 1½ inch O.D., or 2 inches high by 2 inches O.D. As best illustrated in FIGS. 1, 2 and 5, the rings are random packed in scrubber chamber **14** whereby to entirely fill the chamber which is defined by front and rear open grillworks **13** and **15** disposed in spaced parallelism and both being as open as possible while retaining the rings in the manner best illustrated in FIG. 1. Each of the front and rear grillworks **13** and **15** may be fabricated from inert material such as unmodified, rigid, polyvinyl chloride. Uniformly satisfactory results have been obtained in those instances wherein the ring-bed contains 7% solids; and with the bed 12 inches thick and using rings of $\frac{1}{61}$" stock by 2" high and 2" O.D., air passing through the scrubber chamber is directionally changed a minimum of six times.

The operational theory of the scrubber chamber is that any and all fluid-soluble contaminants in the air passing through this chamber will be removed from the air upon contact with the wetted surfaces of the rings, the contaminant in the the air being transferred to the wetted surfaces. The function of spray pipes **30** is to provide an adequate and continuous flow of fluid onto and downwardly through the scrubber chamber, which fluid will drain into the lower portion of the housing where it will accumulate as in a sump, to be removed through discharge pipes **42**.

The drying chamber comprises a bank of elongate, duplicate, laterally spaced, substantially Z-shaped members, the forward edges of which are spaced from two to three inches rearwardly of rear grill **15** of the scrubber chamber. Uniformly satisfactory results have been obtained in those instances wherein the elongate Z-shaped members **50** have been laterally spaced on 2-inch centers, and inclined vertically, whereby to be located in substantial spaced parallelism with the scrubber chamber. The purpose of the drying chamber is to remove any moisture particles which might be carried by the air leaving the scrubber chamber. The relationship illustrated in FIG. 1 has been found highly effective for removing practically all detectable quantities of moisture from the air before it reaches the collection chamber **18**.

With particular reference now to FIG. 6, it will be noted that in the preferred embodiment of the device

each of the Z-shaped elements is provided at its trailing edge with a pair of stripper elements **52** and **54**, which provide pockets **56** and **58**, respectively, into which fluid will be collected and thence automatically drained downwardly into the sump; it being noted that the fluid so collected and drained will be that which adheres to plates **50** from the air flowing over the plates.

In the preferred embodiment of the invention, the arrangement of each pair of adjacent Z-shaped members **50** is such that at least three directional changes will be imparted to the air passing from the scrubber chamber to the collection chamber.

By way of further explanation and in order to enable others skilled in the art to understand and practice the invention, uniformly satisfactory results have been obtained with a housing measuring 57" high by 47" wide and 44" deep for removing chromic acid from air entering inlet **20** at from 1500 to 2000 feet per minute. The velocity is reduced in the spray chamber **12** from 400 to 500 feet per minute. The velocity of the air passing through the scrubber chamber **14** increased by about 10%; said air velocity decreasing by 10% between the discharge side of the scrubber chamber and the intake side of the drying chamber **16**. The velocity of the air again increases by about 10% as it passes through the dryer chamber and slows down by about 10% in the collection chamber **18**. At the discharge port **80** the velocity of the cleansed air may increase by about 400% to the initial velocity of the air entering the inlet port **20**.

The overall effectiveness of our device is indicated from the fact that we are able to remove 97% of the acid content of the acid-contaminated air entering intake port **20** in one pass through the device. This phenomenal degree of cleansing enables the washed air to be returned and recirculated through the plant without any further conditioning.

In the foregoing example the thickness of the ring-bed was 12 inches, which provided approximately 2 cubic feet of rings per 1000 cubic feet of air; the spacing between the discharge face of the scrubber chamber and the intake side of the nest of elongate Z-shape members **50** was from 2 to 3 inches, and the thickness of the bank of Z-shaped members **50** in the drying chamber was 8 inches. When the acids to be removed were nitric or chromic, water was the fluid discharged through the nozzles **30** at the rate of one gallon per 1000 cubic feet per minute of air passing through the spray chamber.

It should be clearly understood that the foregoing example is exemplary in nature, rather than restrictive, and that any type of fluid that is capable of passing through the spray nozzles may be used, such as, by way of example, one or more bases to neutralize various acids.

Unlike other air washers of which we are aware, our device provides prolonged efficient operation, and unlike other devices in which porcelain and metallic rings or saddles are used in the ring-bed, our rings do not become contaminated. In our device, after prolonged and extended operation, the rings may be quickly freed of any substance adhering thereto by tapping or tumbling the rings, after which they may be replaced and reused in the ring-bed. This feature alone is of great importance from an economic factor.

While we are unable to explain the theory of operation, we are aware that a decided electrostatic effect is present in the operation of our device, since the air passing over the various rings in the scrubber chamber and the Z-shaped members **50** in the drying chamber greatly increases and enhances the ability of such rings and members to attract the particles with which the air is contaminated; and this result is markedly greater than the results obtained when the said rings and Z-shaped members are fabricated from materials other than plastic such as unmodified, rigid, polyvinyl chloride.

With reference now to FIGS. 1 and 2, the numerals **82** denote a skimmer secured to, carried by and depending from the top of the housing in the scrubber chamber **14**, for precluding the passage of fluid along the underside of the housing top. The skimmer will deflect any fluid flowing rearwardly along the underside of the housing top downwardly into the ring-bed, thence into the sump.

In FIGS. 1 and 2, the numerals **84** denote generally an elongate, depending, strip extending across and at an angle transversely of the housing top and rearwardly of the discharge end of the drying chamber **16**. The intersection of strip **84** with the housing top **86** provides a pocket or trap **88** (FIG. 2) in which any fluid passing rearwardly along the underside of the housing top will be effectively collected and discharged down a side wall of the housing into the sump in the bottom thereof.

What is claimed is:

1. An air washer comprising a closed housing, said housing including an inlet means and an outlet means, said housing being divided into at least four in-line chambers between said inlet means and said outlet means for permitting air flow from said inlet means to said outlet means successively through said in-line chambers, a spray chamber being disposed adjacent to and in communication with said inlet means for receiving air from said inlet means, spray means disposed within said spray chamber for directing a spray of fluid downstream of the housing for thoroughly wetting air passing through the spray chamber, a scrubber chamber being defined adjacent to said spray chamber and downstream thereof, said scrubber chamber being inclined at a sharp angle to the direction of normal flow of air through the housing, said scrubber chamber including a plurality of loose, right cylindrical rings random-packed and forming a ring bed having a thickness of at least substantially six times the height of one of said rings for imparting at least six directional changes to a flow of air passing through the scrubber chamber, the fluid spray from the spray means in said spray chamber producing a continuous flow of fluid onto and downwardly through said scrubber chamber for continuously wetting the surfaces of said rings, the fluid draining downwardly at a sharp angle out of the air stream passing through the apparatus, a drying chamber being defined downstream of said scrubber chamber, and including a plurality of elongate baffles arranged to impart at least three directional changes to a flow of air passing through the apparatus, and a collection chamber being defined downstream of said drying chamber, said collection chamber being disposed adjacent to and in communication with said outlet means.

2. An air washer as defined in claim 1, wherein said housing, rings and elongate baffles are all fabricated from unmodified rigid polyvinyl chloride.

3. A washer for removing fluid-soluble contaminants from air comprising an enclosed housing, said housing including an inlet and an outlet means, said housing being divided into at least five in-line chambers between said inlet means and said outlet means for permitting air flow from said inlet means to said outlet means successively through said in-line chambers, a spray chamber being disposed adjacent to and in communication with said inlet means for receiving air from said inlet means, spray means disposed within said spray chamber for directing a spray of fluid downstream of the housing for thoroughly wetting air passing through the spray chamber, a scrubber chamber being disposed adjacent said spray chamber and downstream thereof, said scrubber chamber being defined by a pair of substantially parallel, laterally spaced front and rear open grills having a plurality of loose, right cylindrical rings random-packed therebetween forming a ring bed, said ring bed having a thickness of at least substantially six times the height of one of said rings for imparting at least six directional changes to a flow of air passing through the spray chamber, said scrubber chamber being inclined at a sharp angle to the direction of normal flow

of air through the housing, the fluid spray from the spray means in said spray chamber impinging upon said ring bed to produce a continuous flow of fluid onto and downwardly through said ring bed for continuously wetting the surfaces of said rings, the fluid draining downwardly under the influence of gravity at a sharp angle out of the air stream passing out of the apparatus, an intermediate chamber being defined downstream of said scrubber chamber, a drying chamber being disposed downstream of said intermediate chamber, said drying chamber being defined by a purality of elongate substantially Z-shaped members in laterally spaced relationship to impart at least three directional changes to a flow of air passing through the drying chamber, and a collection chamber being defined downstream of said drying chamber, said collection chamber being disposed adjacent to and in communication with said outlet means.

4. A washer for removing fluid-soluble contaminants from air comprising a closed housing having upper and lower portions and opposite end portions, said opposite end portions having formed therein substantially horizontally aligned inlet and outlet means, said housing being divided into at least five in-line chambers between said inlet means and said outlet means for permitting air flow from said inlet means to said outlet means successively through said in-line chambers, a spray chamber being disposed adjacent to and in communication with said inlet means for receiving air from said inlet means, spray means disposed within said spray chamber for directing a spray of fluid downstream of the housing for thoroughly wetting air passing through the spray chamber, a scrubber chamber being defined adjacent to said spray chamber and downstream thereof, said scrubber chamber being defined by a pair of parallel laterally spaced front and rear open grills having a plurality of loose, right cylindrical rings random-packed therebetween forming a ring bed, said ring bed having a thickness of at least substantially six times the height of one of said rings for imparting at least six directional changes to a flow of air passing through the ring bed, said scrubber chamber being inclined downwardly at an angle of

between approximately 15 degrees to 30 degrees with respect to vertical, the fluid spray from the spray means in the spray chamber producing a continuous flow of fluid onto and downwardly through said ring bed for continuously wetting the surfaces of said rings, the fluid draining downwardly through the ring bed under the influence of gravity and out of the air stream passing through the apparatus, an intermediate chamber being defined adjacent to and downstream of said scrubber chamber, a drying chamber being disposed downstream of said intermediate chamber, said drying chamber being defined by a plurality of elongate Z-shaped members which extend downwardly and downstream of the housing in laterally spaced relationship in substantial spaced parallelism with said scrubber chamber to impart at least three directional changes to a flow of air passing through the drying chamber, and a collection chamber being defined downstream of said drying chamber, said collection chamber being disposed adjacent to and in communication with said outlet means, the housing, rings and Z-shaped members all being fabricated from unmodified rigid polyvinyl chloride.

5. A washer as described in claim 4, wherein the trailing ends of the said Z-shaped members of the drying chamber are each provided with a pair of continuous pockets, one on each side thereof, for collecting and removing any fluid particles adhering to and moving along said members incident to a flow of air thereover.

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