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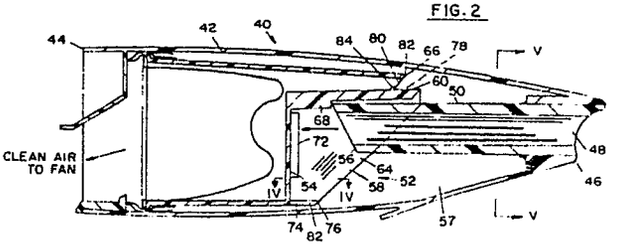
(54) Apparatus for separating material from a flow of air in a vacuum cleaner.

(57) A wet-dry vacuum cleaner includes a liquid separator (52) having an end wall (54) facing air flow from an inlet chute (50). The end wall (54) is surrounded by a top shelf (60), lateral sidewalls (58) and a lower shelf (62) to define a pocket (64) within which moisture droplets entrained in the flow of air are encouraged to precipitate. Turbulence fences (68, 70, 72) within the pocket (64) induce eddies in the air flow to further induce moisture precipitation. The top shelf (60) forces swirling air from the inlet chute (50) to contact the top shelf (60) before entering the air inlet (66), thereby reducing the tendency for swirling air flow to carry moisture directly into the air inlet (66). An entry step (84) at the bottom of the air inlet (66) inhibits moisture precipitated on the top shelf (60) from passing into the air inlet (66). Additional ribs and/or turbulence fences (86, 88) may be disposed on an inner surface of the dust bowl housing (42).

FIG. 2



EP 0 357 189 A2

APPARATUS FOR SEPARATING MATERIAL FROM A FLOW OF AIR IN A VACUUM CLEANER

This invention relates to an apparatus for separating material from a flow of air in a vacuum cleaner.

BACKGROUND OF THE INVENTION

Vacuum cleaners have found wide application in cleaning up hard surfaces and fabric-covered surfaces. Hard surfaces such as, for example, wooden and tile-covered floors, are usually cleaned by a vacuum cleaner employing pure suction. Fabric-covered surfaces such as, for example, carpets and car seats, sometimes require the agitation provided by a brush to enhance the cleaning effect of suction.

Vacuum cleaners for picking up dry materials fall roughly into two categories, namely, clean-motor and dirty-motor types. In a clean-motor type of vacuum cleaner, a filter is placed between an air intake and a fan motor. This ensures that the motor is protected from contamination by the soil being removed from the surface. In a dirty-motor type of vacuum cleaner, the filter is placed downstream of the fan motor.

The present invention is indifferent to whether the vacuum cleaner providing the environment for the invention is a clean-motor or a dirty-motor type. However, special precautions must be made to prevent moisture entering the motor and wiring of a dirty- motor type vacuum cleaner used to pick up both soil and moisture. For concreteness of description, the following disclosure is discussed in the environment of a clean-motor vacuum cleaner.

It is sometimes useful to be able to remove a liquid from a surface using a vacuum cleaner. For example, this may be convenient for picking up spilled liquid. A fabric can be cleaned by applying a liquid, which may include a cleaning solution therein, to a surface of the fabric. When the liquid is removed, entrained soil is removed with it. The presence of liquid droplets entrained in a stream of air complicates the problem of retaining the soil while discharging the air. That is, it is desirable to isolate the filter from the liquid droplets in order to maintain filtering effectiveness, facilitate disposal of liquid and dirt, and to ensure that liquid is kept separate from the electrical and mechanical components of the remainder of the vacuum cleaner, and especially the fan motor.

U.S. Patent No. 3,267,511 discloses a vacuum mopping device for a vacuum cleaner. Air is drawn upward from a surface to be cleaned by a reduced pressure. The air, with its entrained moisture is turned into a downward path toward a bottom wherein the liquid is retained. The air turns upward again to depart through a baffle.

U.S. Patent No. 4,542,557 discloses a wet-dry vacuum cleaner with a water deflector especially adapted for use in a hand-held vacuum cleaner. As detailed therein, the '557 patent describes a device in which airflow through an entry chute is diverted at an angle to prevent entrained liquid droplets from passing directly to the filter.

I have discovered that both of the referenced patents have ignored the effect of air flow between the air inlet and the outlet. In particular, devices described in both of these patents permit swirling flow of air between their inlets and their outlets. Such swirling flow of air permits liquid droplets to remain entrained in the swirling flow to impact on the filter, thus degrading its filtering effectiveness. In the extreme, the filter may become saturated and permit the liquid to pass through to the fan and fan motor.

According to an embodiment of the invention, there is provided apparatus for separating material from a flow of air in a vacuum cleaner, the vacuum cleaner including an inlet chute for admitting any combination of air, soil and liquid therein, comprising: a separator having an end wall, characterized in that said end wall is disposed substantially at right-angles to an axis of said inlet chute, whereby, in use, said combination impacts said end wall substantially at right-angles thereto for forcing said material to precipitate from said combination.

The substantially right-angle impact of the air upon the end wall tends to force liquid droplets to contact the wall, and thus to be taken out of the air flow. In addition, optional turbulence-generating fences on the face of the end wall induce turbulence within the air flow as it attempts to flow in a span-wise direction along the face of the end wall. This further tends to induce liquid droplets to contact surfaces upon which they can collect.

According to a feature of the invention, there is provided apparatus for separating material from an air flow in a vacuum cleaner, comprising: an inlet chute for permitting entry of said air flow into said vacuum cleaner, a separator, deflecting means on the separator facing an exit of said entry chute for deflecting the air flow, an air opening disposed above said deflecting means, an entry shelf overlying an end of said inlet chute for inhibiting direct flow of said air flow from said inlet chute to said air opening; and the entry shelf extending a substantial distance outward from the air opening; whereby swirling air flow in the vacuum cleaner tends to contact the entry shelf before entering the air opening.

According to a further feature of the invention, there is provided a dust bowl for a vacuum cleaner comprising: a housing enclosing the dust bowl, an inlet chute in the housing, the inlet chute being adapted for admitting an air flow into the housing, a separator in the housing, an air opening in the separator, the separator including means for deflecting a flow of air from the inlet chute; and at least one baffle rib extending inward from the housing for disturbing a swirling flow of air therein.

For a better understanding of the invention, reference will now be made, by way of example, to the accompanying drawings, in which:-

Fig. 1 is a cross-section of a dust bowl of a wet-dry vacuum cleaner according to the prior art.

Fig. 2 is a cross-section of a dust bowl of a wet-dry vacuum cleaner according to an embodiment of the invention.

Fig. 3 is an end view of the moisture separator of Fig. 2, from which the remainder of the dust bowl is omitted.

Fig. 4 is a cross-section taken along IV-IV of Fig. 3.

Fig. 5 is a cross-section taken along V-V of Fig. 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, there is shown, generally at 10, a dust bowl according to the prior art. It will be understood that dust bowl 10 is adapted for installation on a vacuum cleaner power unit (not shown) which develops a partial vacuum, thereby to draw air and entrained soil and moisture thereto. A housing 12 includes an anterior end 14 adapted, in known fashion, for attachment to the vacuum cleaner power unit. A forward snout 16 includes an inlet opening 18 of an inlet chute 20. A liquid deflector, shown generally at 22, includes a curved deflector surface 24 facing an inner end 26. A liquid storage region 28 is disposed below inlet chute 20 to retain entrained liquid which may enter inlet chute 20 along with air and soil. A seal 30 about a perimeter of liquid deflector 22 bears sealingly against an inner surface of housing 12 to prevent passage of air, soil or moisture in a bypass path past liquid deflector 22. An air opening 32 is disposed near the top of liquid deflector 22, either on top as shown, or facing liquid storage region 28, to provide a single entry for air and soil to an interior 34 of liquid deflector 22. A filter 36 is disposed in liquid deflector 22 to permit air to pass therethrough toward the vacuum cleaner power unit, but to prevent the passage of soil.

In theory, at least, when incoming air and moisture impact curved deflector surface 24, the moisture, with some of the soil, is diverted into liquid storage region 28. The air, including additional soil, follows a curving path 38 before entering air opening 32. In practice, this is only partly successful in removing moisture from the air stream.

I have discovered that inducing air to flow in curving paths 38, as is done in the illustration in Fig. 1 and in both of the referenced U.S. Patents, permits a substantial amount of moisture to remain entrained in the air stream to enter air opening 32. As a consequence, the prior-art devices permit such entrained moisture to dampen filter 36 and, in an extreme case, leak through filter 36 into the vacuum cleaner power unit. Even when used on dry soil only, the facility with which much dry soil can follow the air stream permits more of the soil to enter air opening 32 and deposit on the filter, thereby reducing the time that the apparatus works until the filter becomes clogged. As a consequence of the filter clogging problem, a greater surface area of filter is required in prior-art devices to permit operation over time with a predetermined maximum pressure drop across the filter.

Referring now to Fig. 2, there is shown, generally at 40, a dust bowl according to an embodiment of the invention. A housing 42 includes an anterior end 44 for attachment, in conventional fashion, to a vacuum cleaner power unit (not shown). A forward snout 46 of housing 42 includes an inlet opening 48 leading to an inlet chute 50. A liquid separator, shown generally at 52, includes a bluff wall 54 facing an inner end 56 of inlet chute 50. It will be noted that bluff wall 54 is disposed at right angles to an axis of inlet chute 50, whereby a tendency to induce whirling motion in the vertical direction is avoided. A liquid storage region 57 is disposed upstream of liquid separator 52 to contain moisture and/or soil removed from the airstream.

First and second side walls 58 are disposed alongside inlet chute 50 (only one side wall 58 is shown, the other is omitted from the cross section). Each side wall 58 extends toward forward snout 46 well past inner end 56. An upper shelf 60 extends to the extremities of side walls 58, whereby overlying a substantial portion of the length of inlet chute 50. A bottom shelf 62 extends outward from the bottom of bluff wall 54 toward forward snout 46. Upper shelf 60, side walls 58 and bottom shelf 62, together, define a pocket 64 into which the air stream enters from inner end 56. The elements defining pocket 64 ensure that air, with entrained contaminants, is prevented from smooth flow toward an air opening 66 of liquid separator 52 disposed above upper shelf 60.

In a further, unillustrated embodiment, air opening 66 may relocated to a top or side surface of liquid separator 52. This positioning tends to avoid

entry of entrained liquid when liquid storage region 57 is nearly full.

Referring now also to Fig. 3, bluff wall 54 is seen to include a longitudinal turbulence fence 68 pendant from upper shelf 60. As will be clear to one skilled in the art, the presence of longitudinal turbulence fence 68 tends to disturb corkscrew motion of air within pocket 64. In addition, first and second diagonal turbulence fences 70 and 72 (diagonal turbulence fence 70 is not seen in Fig. 2) extend from bluff wall 54. Diagonal turbulence fences 70 and 72 disturb corkscrew motion, as well as smooth downward motion of air within pocket 64.

As is well known in aeronautical arts, the presence of a turbulence fence extending outward from a surface tends to induce eddies and other turbulence, thereby breaking up a smooth flow of air along the surface. As a result of breaking up the smooth flow, the tendency for moisture and/or dirt to travel in a whirling motion toward air opening 66 is strongly discouraged. In addition, the eddies tend to force multiple impacts between moisture droplets in the air flow with surfaces of pocket 64, and the interior of liquid storage region 57. Such multiple impacts tend to force moisture droplets to adhere to the surfaces, thereby to precipitate the moisture from the air flow.

Referring now also to Fig. 4, bottom shelf 62 contains a notch 74 centrally disposed therein extending from an outer edge 76 to bluff wall 54. Notch 74 permits moisture precipitated from the air stream within pocket 64 to drain into liquid storage region 57.

Returning full attention now to Fig. 2, upper shelf 60 extends substantially forward of the opening of air opening 66, whereby an entry shelf 78 is formed. Air opening 66 includes an inclined lateral perimeter 80, whereby a top 82 of air opening 66 juts forward over entry shelf 78. An entry step 84 blocks a lower portion of air opening 66 a small distance above entry shelf 78, whereby moisture precipitated on entry shelf 78 is prevented from entering air opening 66.

The overhang of inclined lateral perimeter 80 over entry shelf 78 tends to prevent a vertical swirling air motion from permitting direct entry of air and moisture into air opening 66. Instead, such vertical swirling air motion tends to carry its entrained moisture into contact with entry shelf 78 before entering air opening 66. As a consequence, the entrained moisture tends to precipitate out on side wall 58.

Referring now to Fig. 5, at least a forward portion of liquid storage region 57 includes first and second baffle ribs 86 and 88 extending inward from housing 42. Baffle ribs 86 and 88 may extend the full distance between housing 42 and inner components or, alternatively, may end short of inner components to present the equivalent of a turbulence fence. Portions of baffle ribs 86 and 88 bridging between housing 42 and inner components divide the adjacent portions of liquid storage region 57 into upper and lower compartments. Such upper and lower compartments tend to reduce the tendency for swirling air motion, and thus reduce the tendency for the air flow to carry entrained moisture to air opening 66 (Fig. 2). In portions in which baffle ribs 86 and 88 stop short of inner components, the turbulence they generate has the same effect as the turbulence fences extending from bluff wall 54 (Figs. 2 and 3).

Having described preferred embodiments of the invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope of the invention as defined in the appended claims.

Claims

1. Apparatus for separating material from a flow of air in a vacuum cleaner, said vacuum cleaner including an inlet chute (50) for admitting any combination of air, soil and liquid therein, comprising:
a separator (52) having an end wall (54);
characterized in that said end wall (54) is disposed substantially at right-angles to an axis of said inlet chute (50), whereby, in use, said combination impacts said end wall (54) substantially at right-angles thereto for forcing said material to precipitate from said combination.

2. Apparatus as claimed in Claim 1, characterized in that said end wall (54) includes at least one turbulence fence (68, 70, 72) extending therefrom.

3. Apparatus as claimed in Claim 2, characterized in that said at least one turbulence fence (68, 70, 72) includes at least two turbulence fences (70, 72) disposed in locations on said end wall (54) to disturb spanwise flow of air along said end wall (54).

4. Apparatus as claimed in Claim 1, 2 or 3, characterized in that it comprises a pocket (64) formed about said end wall (54);
said pocket (64) including at least first and second side walls (58) disposed to first and second sides of said inlet chute (50),
said first and second side walls (58) extending a substantial distance beyond an end of said inlet chute (50), whereby direct air flow from said inlet chute (50) past said first and second side walls (58) is prevented;
said pocket (64) further including an upper shelf (60) joined to said first and second side walls (58);

and
said upper shelf (60) extending a substantial distance beyond said end of said inlet chute (50), whereby direct air flow from said inlet chute (50) past said upper shelf (60) is prevented.

5. Apparatus as claimed in Claim 4, characterized in that said pocket (64) further includes a bottom shelf (62).

6. Apparatus as claimed in Claim 5, characterized in that said bottom shelf (62) is joined to said first and second side walls (58).

7. Apparatus as claimed in Claim 5 or 6, characterized in that said bottom shelf (62) includes at least one notch (74) therein; and
said notch (74) is positioned to permit moisture to drain from said pocket (64) therethrough.

8. Apparatus for separating material from an air flow in a vacuum cleaner, comprising:
an inlet chute (50) for permitting entry of said air flow into said vacuum cleaner;
a separator (52);
deflecting means (68, 70, 72) on said separator (52) facing an exit of said entry chute (50) for deflecting said air flow; and
an air opening (66) disposed above said deflecting means (68, 70, 72);
characterized in that said apparatus further comprises:
an entry shelf (60) overlying an end of said inlet chute (50) for inhibiting direct flow of said air flow from said inlet chute (50) to said air opening (66); and
said entry shelf (60) extending a substantial distance outward from said air opening (66); whereby swirling air flow in said vacuum cleaner tends to contact said entry shelf (60) before entering said air opening (66).

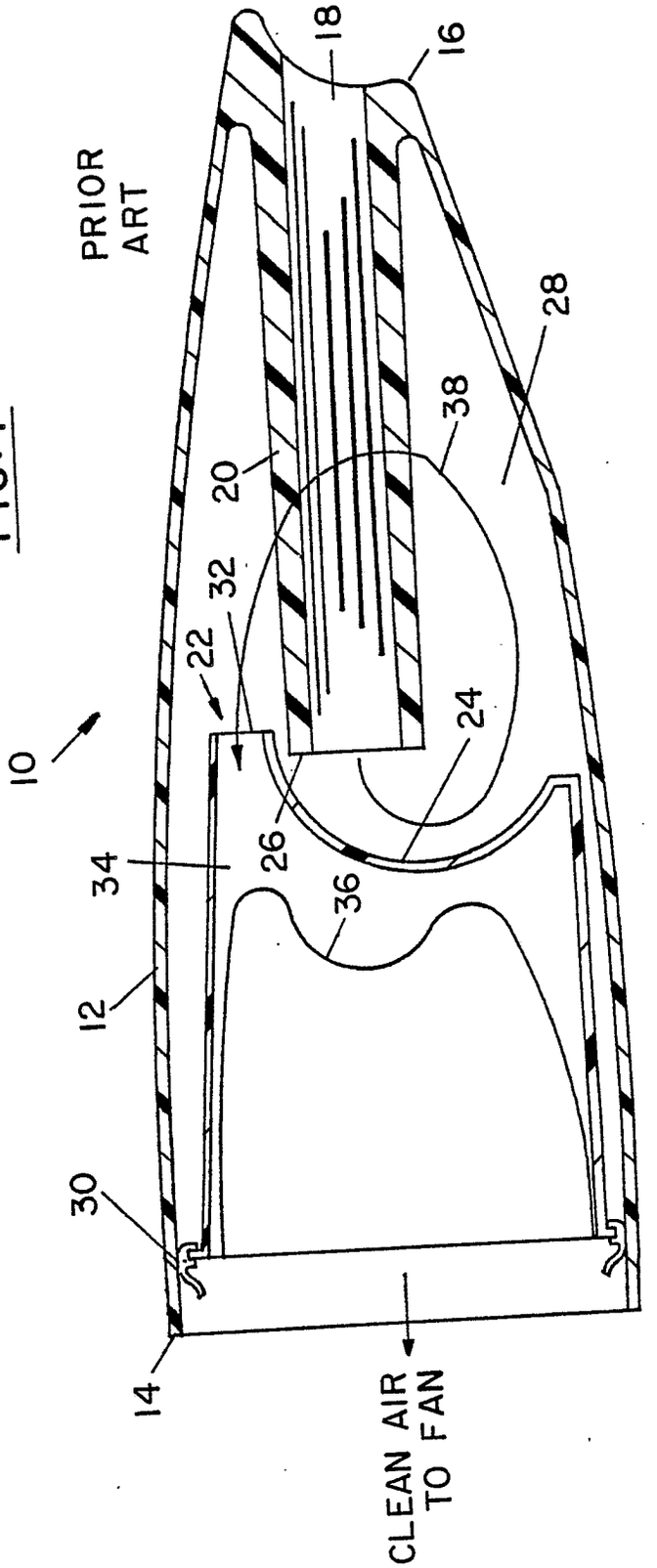
9. Apparatus as claimed in Claim 8, characterized in that it comprises:
an entry step (84) between said entry shelf (60) and said air opening (66); and
said entry step (84) being effective for blocking direct passage of said material from said entry shelf (60) into said air opening (66).

10. Apparatus as claimed in Claim 8 or 9, characterized in that said air opening (66) includes an inclined perimeter (80); and
said inclined perimeter (80) being inclined over said entry shelf (60), to produce a top of said air opening (66) overlying a portion of said entry shelf (60).

11. A dust bowl for a vacuum cleaner comprising:
a housing (42) enclosing said dust bowl (40);
an inlet chute (50) in said housing (42);
said inlet chute (50) being adapted for admitting an air flow into said housing (42); and
a separator (52) in said housing (42);
an air opening (66) in said separator (52);
said separator (52) including means (54) for deflecting a flow of air from said inlet chute (50);
characterized in that said dust bowl further comprises at least one baffle rib (86, 88) extending inward from said housing (42) for disturbing a swirling flow of air therein.

12. A dust bowl as claimed in Claim 11, characterized in that said at least one baffle rib (86, 88) includes at least one turbulence fence.

FIG. 1


PRIOR ART
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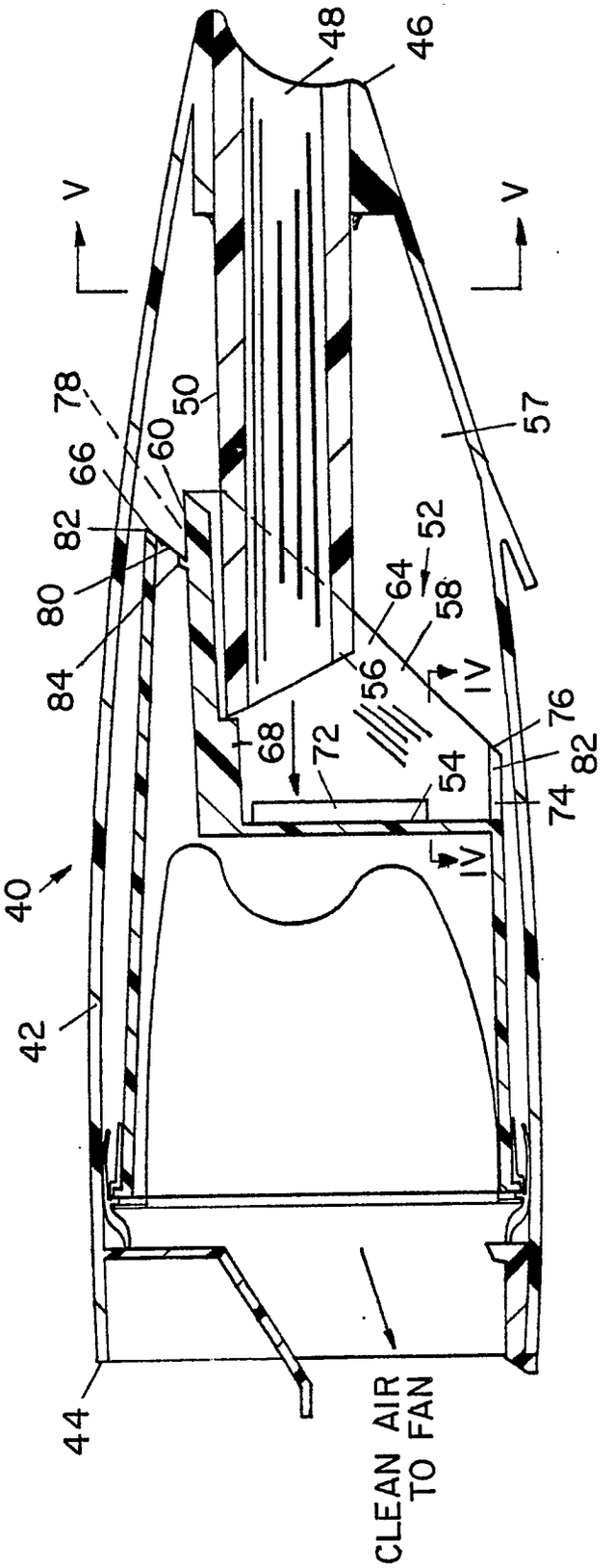
CLEAN AIR TO FAN

FIG. 2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46
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V
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IV
40
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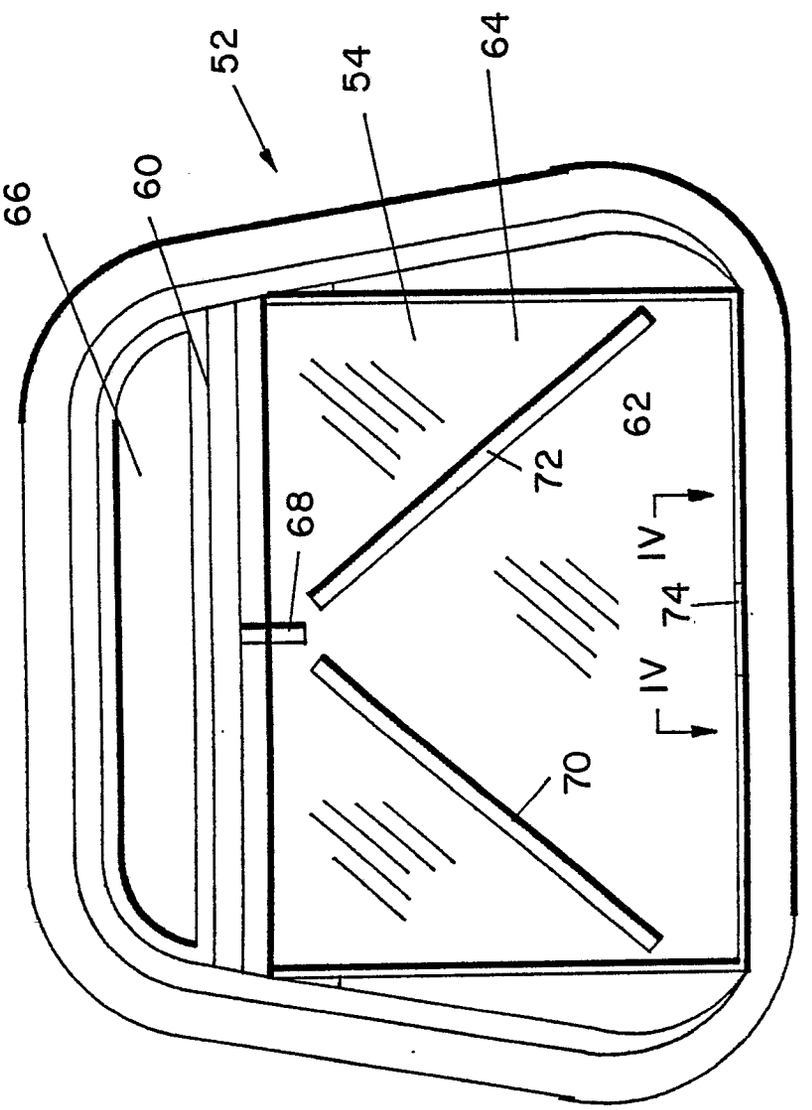
44
CLEAN AIR
TO FAN

FIG. 3



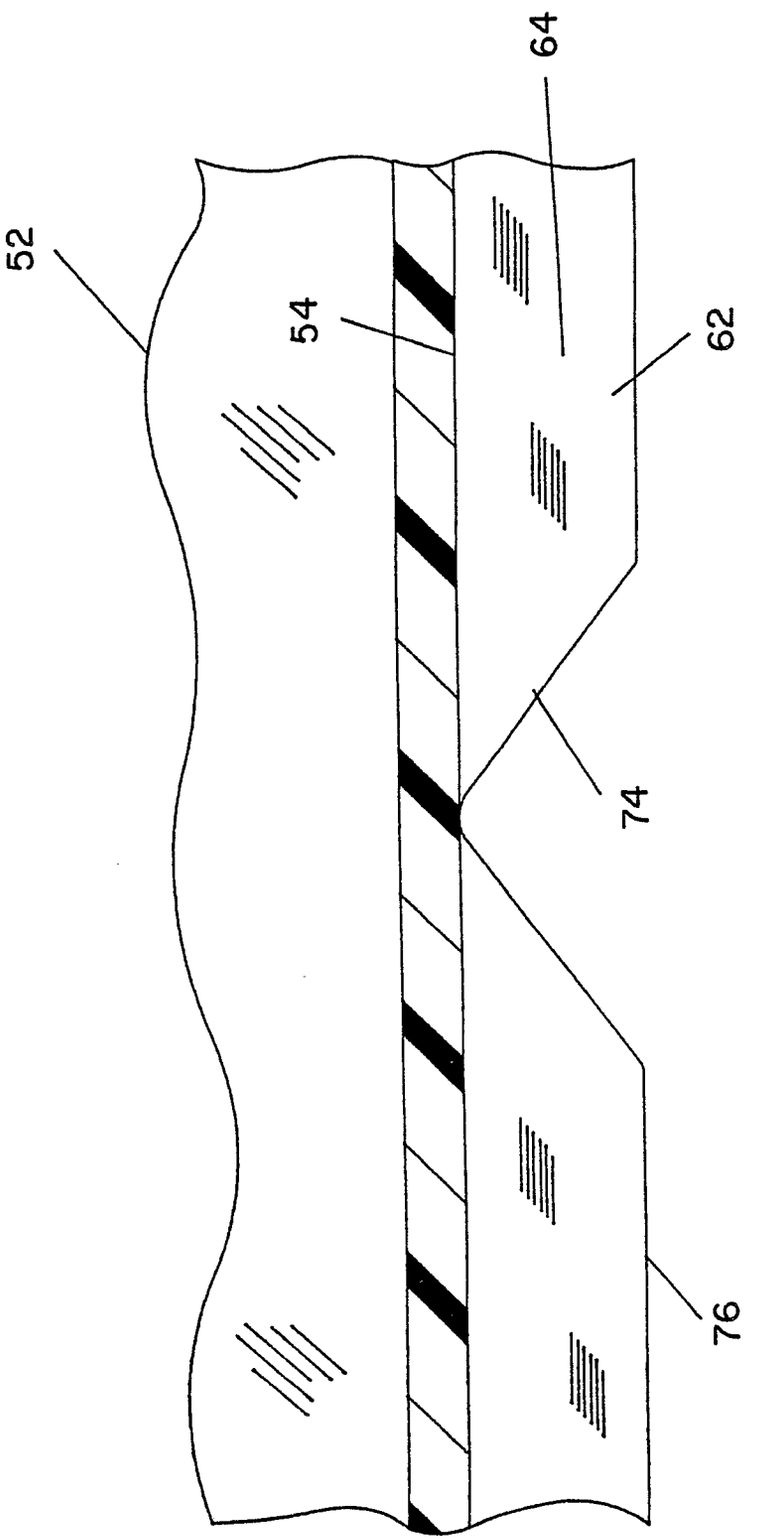


FIG. 4

FIG. 5