United States Patent [19]

Turko

[11] **3,747,505**

[45] **July 24, 1973**

[54] **AIR FLOW SYSTEM FOR FUME HOOD**

[75] Inventor: **Michael Turko,** Manitowoc, Wis.

[73] Assignee: **American Hospital Supply Corporation,** Evanston, Ill.

[22] Filed: **Feb. 18, 1972**

[21] Appl. No.: **227,510**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 172,746, Aug. 18, 1971.

[52] **U.S. Cl.** ..... **98/115 LH**

[51] **Int. Cl.** **F23j 11/00**

[58] **Field of Search** ..... 98/36, 115 LH; 62/256

[56] **References Cited**

UNITED STATES PATENTS

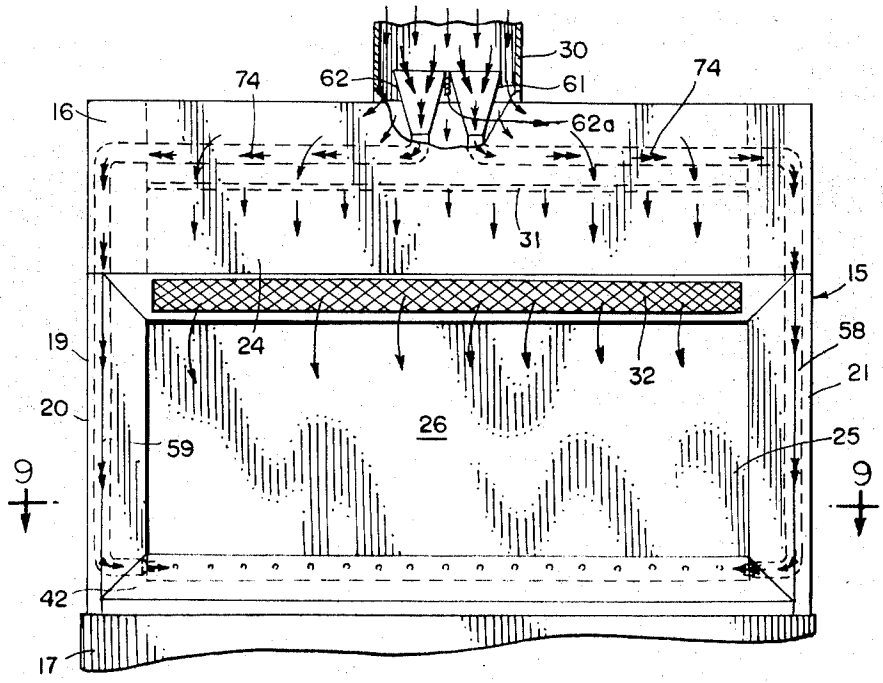
3,408,914	11/1968	Bayern	98/115 LH
3,111,077	11/1963	Cortright	98/115 LH
3,218,953	11/1965	Grow et al.	98/115 LH
3,237,548	3/1966	Bayern	98/115 LH

Primary Examiner—Meyer Perlin
Assistant Examiner—Ronald C. Capossela
Attorney—Horace Dawson, John W. Chestnut et al.

[57] **ABSTRACT**

A balanced air fume hood is provided with an air flow system for inwardly directing high velocity auxiliary air over the top of the work surface and/or along the sides of the hood. An elongated air flow conduit is secured below the foil of the fume hood adjacent the front of the work surface, and an elongated tube extends from each end of the conduit to the auxiliary air chamber which supplies auxiliary air to the work enclosure. The ends of the tubes are provided with funnel-shaped air collectors which are positioned in the path of the incoming auxiliary air, and high velocity auxiliary air flows through the tubes to the conduit. The conduit is provided with a plurality of openings for permitting auxiliary air to flow between the foil and the work surface and over the top of the work surface. The vertically extending portions of the tube may be provided with openings for directing high velocity auxiliary air inwardly toward the work enclosure to provide a positive inwardly sweeping curtain of air along the sides of the hood.

13 Claims, 19 Drawing Figures



PATENTED JUL 24 1973

3,747,505

SHEET 1 OF 4

FIG. 1

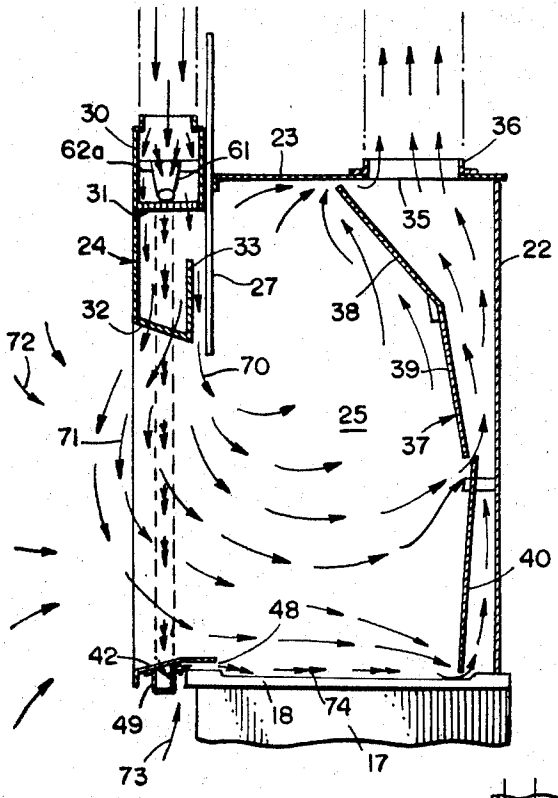


FIG. 2

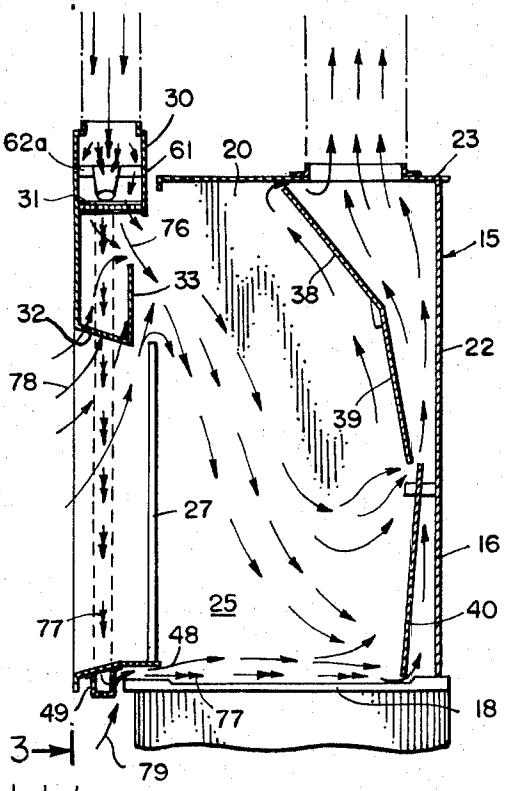
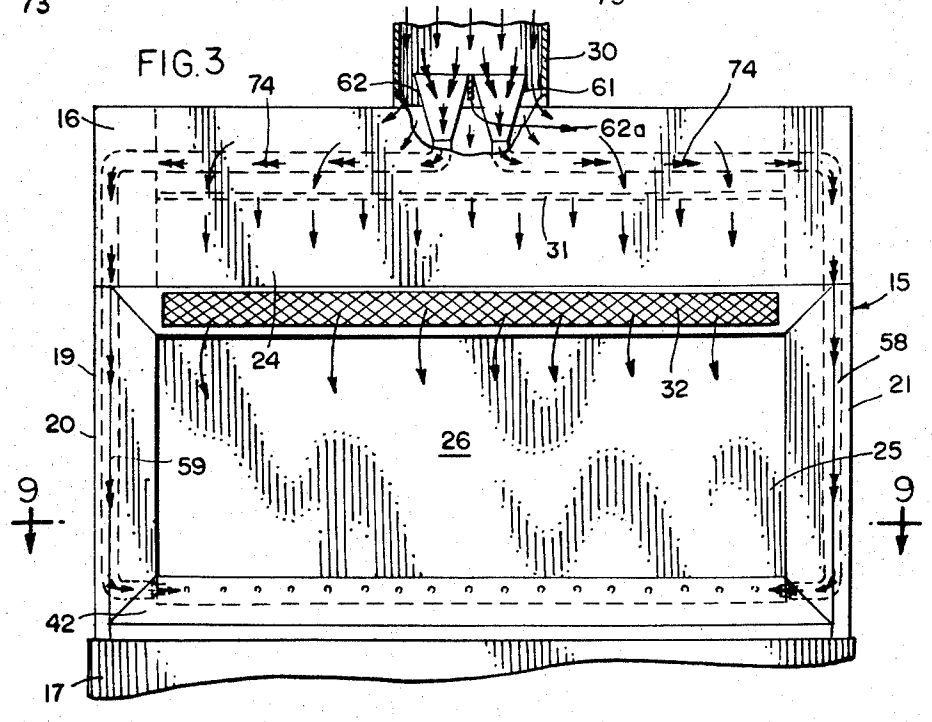


FIG. 3



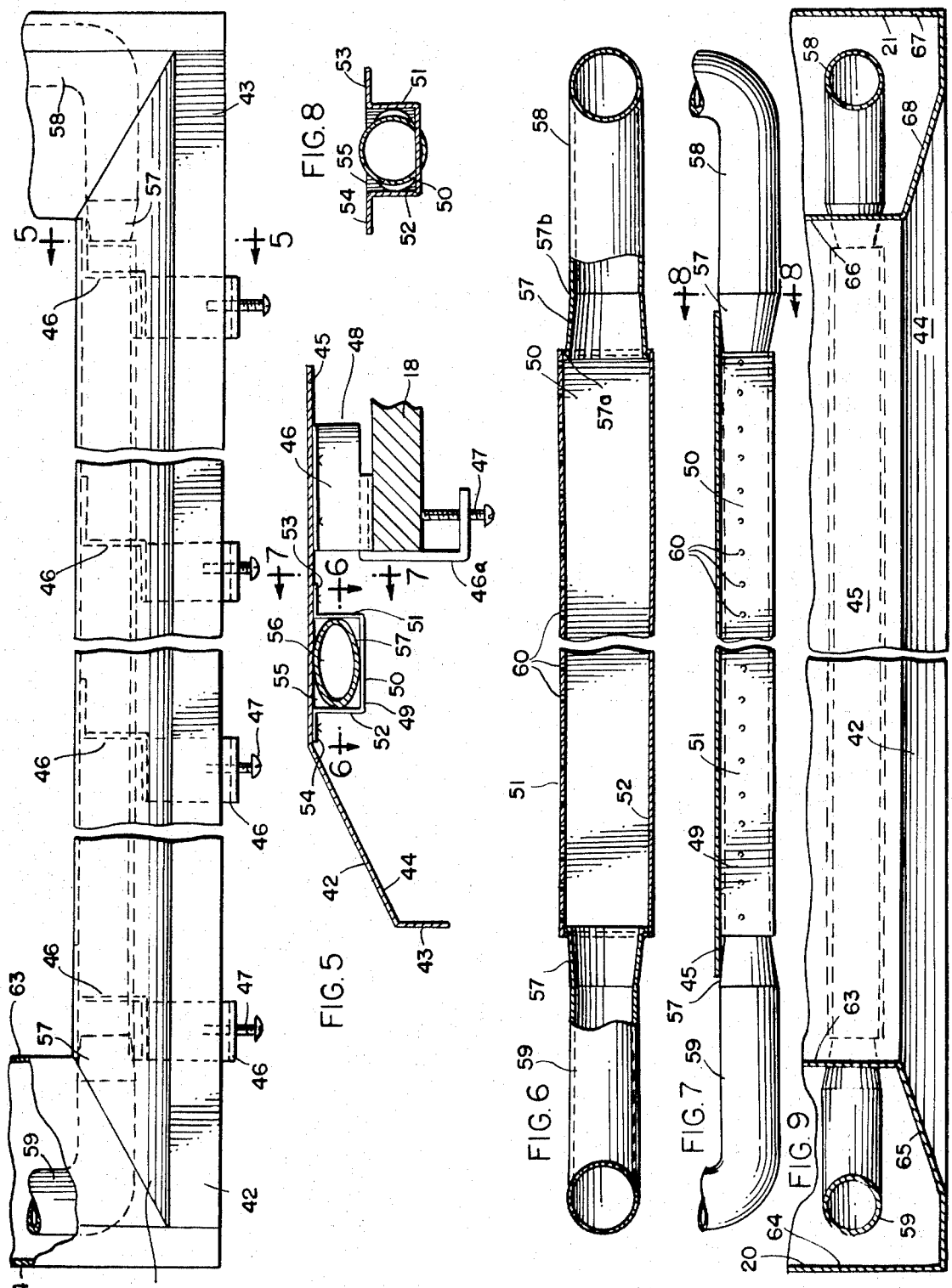
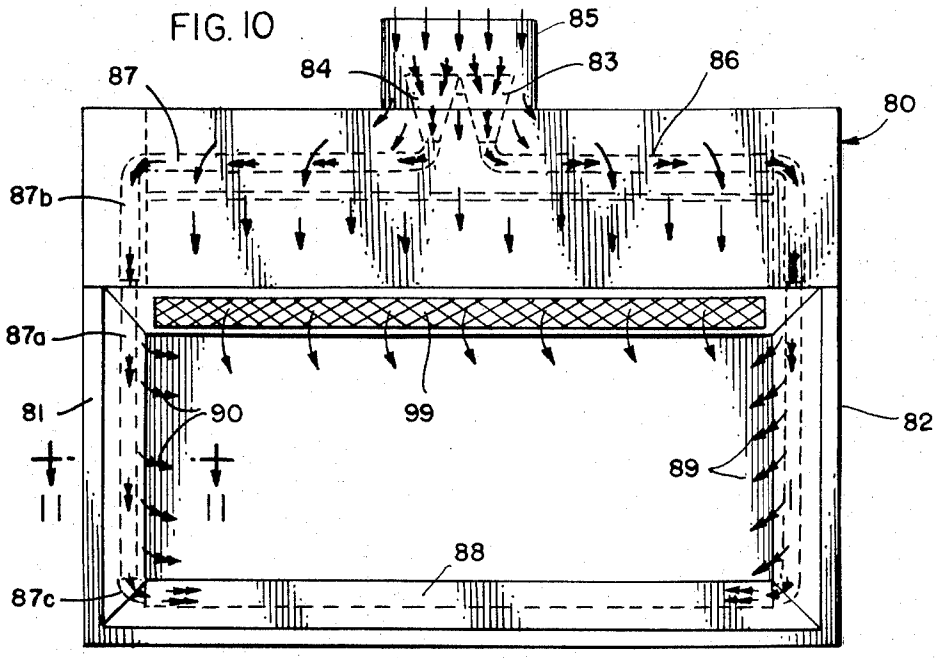

FIG. 4
FIG. 5
FIG. 6
FIG. 7
FIG. 8
FIG. 9

FIG. 10



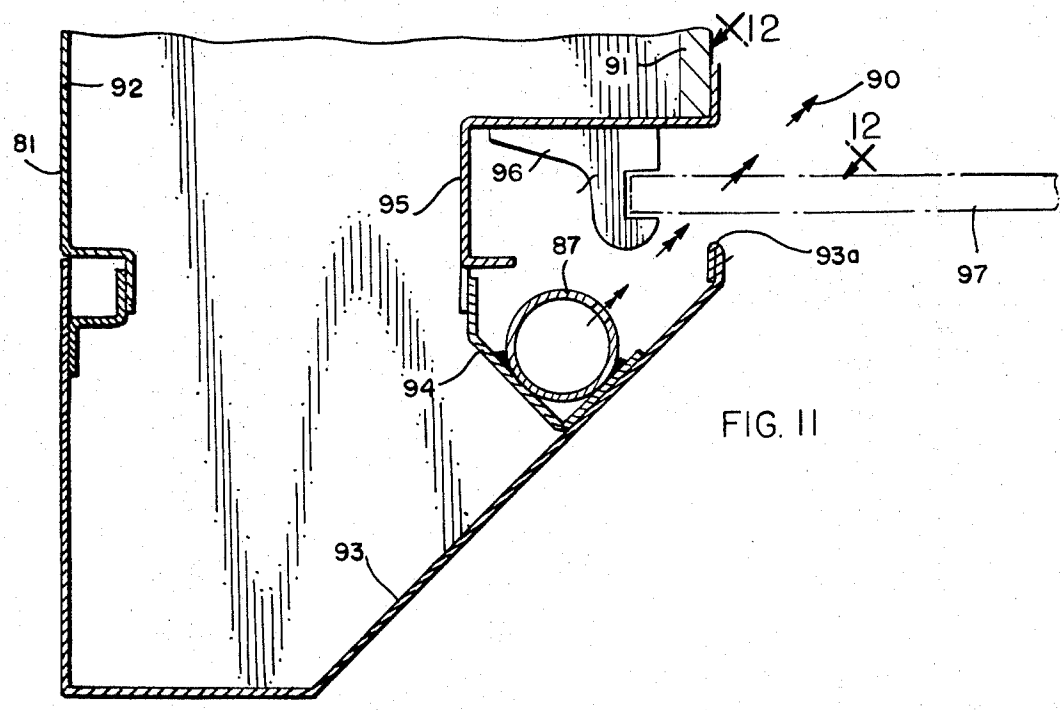


FIG. 11

FIG. 12

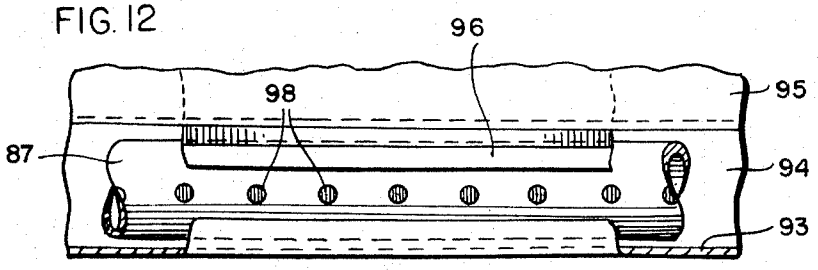


FIG. 13

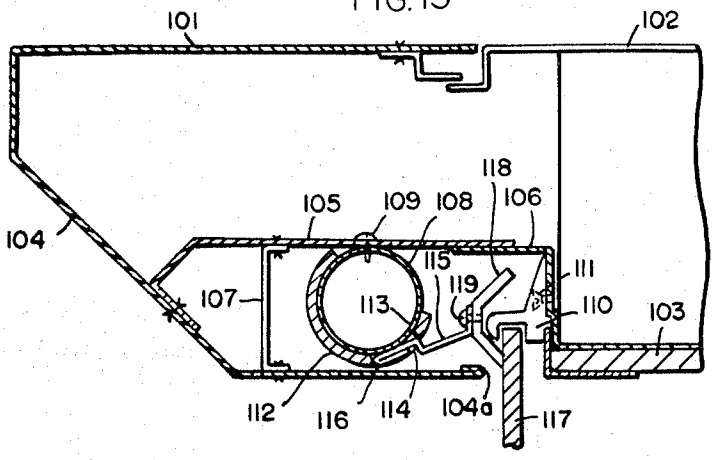


FIG. 14

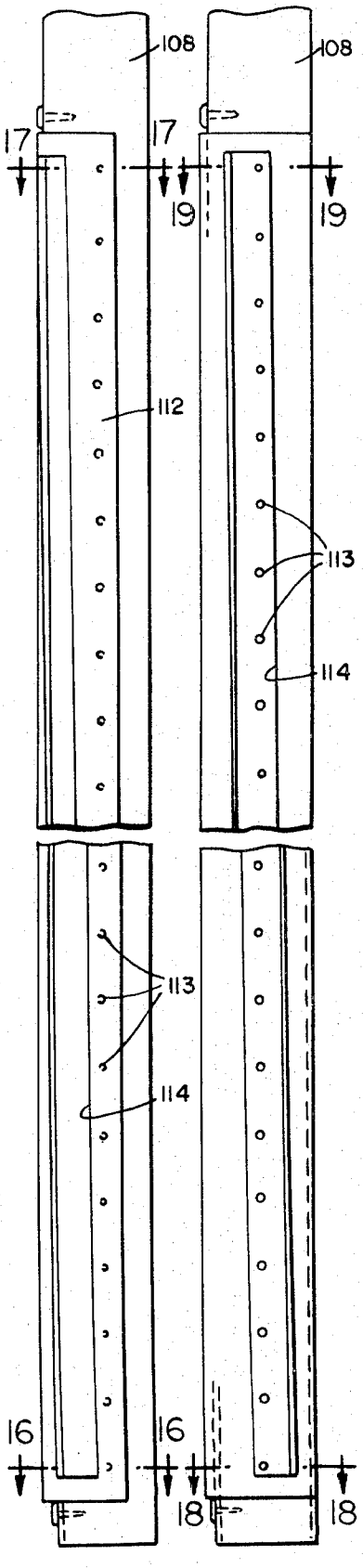


FIG. 15

FIG. 19

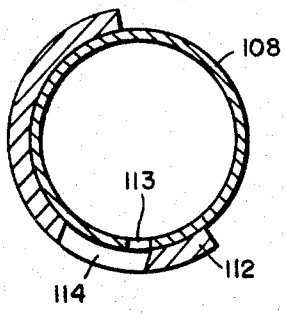


FIG. 18

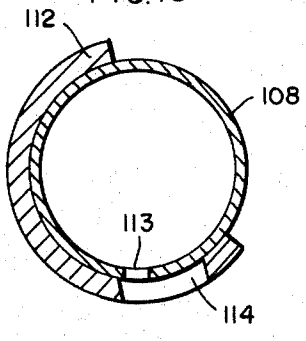


FIG. 17

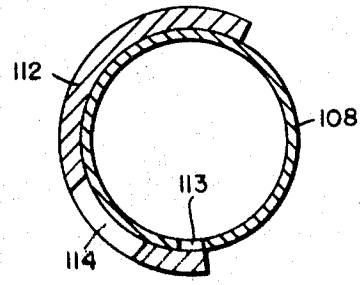
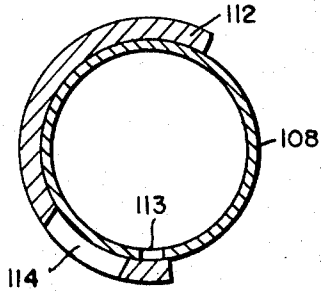


FIG. 16



AIR FLOW SYSTEM FOR FUME HOOD

RELATED APPLICATIONS

This applicaton is a continuation-in-part of the copending application entitled "Fume Hood", Ser. No. 172,746, filed Aug. 18, 1971.

BACKGROUND

This invention relates to fume hoods, and, more particularly, to balanced air fume hoods.

Fume hoods are commonly used in the laboratory for providing a ventilated work area for laboratory activities involving hazardous materials, generated fumes, aerosols, gases, and particulate matter. The fume hood protects laboratory personnel and equipment by confining, containing and exhausting these materials.

Fume hood systems conventionally include an exhaust blower for removing air from the fume hood, and when fume hoods are installed in air conditioned laboratories, they withdraw cooled or conditioned air from the laboratory. Since the conditioned air has been supplied to the laboratory at substantial expense, it is desirable to reduce the amount of this costly air which is withdrawn from the laboratory.

Balanced air fume hoods are designed to reduce the amount of room air which is consumed by supplying auxiliary air to the fume hood. The auxiliary air is introduced into the hood, and it is important that some of the auxiliary air and any room air which is drawn into the fume hood from the laboratory sweep across the entire work surface to prevent the escape of fumes from the hood. The velocity of the air which sweeps across the work surface is generally provided by the blowing action of the auxiliary air blower and the sucking action of the exhaust blower. However, the auxiliary air blower is positioned at some distance above the work surface, and the auxiliary air may pass through a diffuser as it passes from the auxiliary air chamber. The velocity of the auxiliary air is therefore substantially reduced by the time it reaches the work surface, and the exhaust blower often does not provide sufficient suction to create a suitable sweeping action over the work surface. Even if means are provided for routing auxiliary air from above the diffuser to the work surface, this air might not have sufficient velocity to provide effective sweeping.

SUMMARY

The invention provides means for supplying high velocity auxiliary air to the space between the foil and the work surface at the front of the work surface and for directing this auxiliary air to flow over the work surface. The auxiliary air is directed over the work surface by an elongated air flow channel which is secured below the foil, and auxiliary air is supplied to the ends of the channel by a pair of tubes. One end of each tube is connected to the channel and the other end is attached to an air-collecting funnel positioned in the path of the incoming auxiliary air which is supplied by the auxiliary air blower. The tubes can be hidden by positioning them between spaced-apart panels which form the side walls of the fume hood, and the auxiliary air which is collected by the tubes flows into the air flow conduit and through openings provided therealong and over the work surface. The air flowing through the air flow conduit is sufficient to provide a high velocity air flow across the work surface. The intermediate portions of the tubes which extend along the sides of the hood may be provided with openings for permitting high velocity air to flow into the work enclosure along the sides thereof. The tubes may be positioned outwardly of the sash so that a positive curtain of air sweeps into the hood when the sash is partially or fully raised. The inward sweeping of high velocity air over both the work surface and the sides of the hood substantially eliminates the possibility that counterflows the air within the hood could carry fumes out of the hood and into the laboratory. Introduction of high velocity air at the work surface and along the sides of the hood also reduces the danger of common fluctuations of electrical power which might cause the auxiliary air blower to slow down to a point that auxiliary air flowing through the diffuser would not have sufficient velocity to provide sufficient sweeping of the work surface and hood sides.

DESCRIPTION OF THE DRAWING

The invention will be explained in conjunction with the illustrative embodiment shown in the accompanying drawing, in which

FIG. 1 is a schematic sectional view of a balanced air fume hood equipped with the invention illustrating the air flow when the sash of the hood is opened;

FIG. 2 is a schematic view similar to FIG. 1 illustrating the air flow when the sash is closed;

FIG. 3 is a schematic front elevational view of the fume hood illustrating the air flow;

FIG. 4 is an enlarged fragmentary view, partially broken away, of the bottom portion of FIG. 3;

FIG. 5 is a fragmentary sectional view taken along the line 5—5 of FIG. 4;

FIG. 6 is a sectional view, partially broken away, taken along the line 6—6 of FIG. 5;

FIG. 7 is a sectional view, partially broken away, taken along the line 7—7 of FIG. 5;

FIG. 8 is a sectional view taken along the line 8—8 of FIG. 7;

FIG. 9 is a fragmentary sectional view taken along the line 9—9 of FIG. 3;

FIG. 10 is a view similar to FIG. 3 of a modified hood equipped with a modified air flow system which directs auxiliary air into the hood along the sides thereof;

FIG. 11 is an enlarged fragmentary sectional view taken along the line 11—11 of FIG. 10;

FIG. 12 is a fragmentary view taken along the line 12—12 of FIG. 11; and

FIGS. 13–19 illustrate another modified hood which is provided with shutter means for opening and closing the auxiliary air discharge openings along the sides of the hood.

DESCRIPTION OF SPECIFIC EMBODIMENT

Referring to FIGS. 1–3, the numeral 15 designates generally a balanced air fume hood having a frame 16 which includes a base 17, a countertop 18 which provides a working surface, and a superstructure 19 mounted on the countertop.

The superstructure 19 includes spaced-apart side walls 20 and 21, rear wall or panel 22, and top wall or panel 23. The walls 20–23 are generally orthogonally related and, together with the countertop or bottom wall 18 define a work enclosure 25. An auxiliary air chamber designated generally by the numeral 24 extends between the side walls 20 and 21 and terminates

above the countertop **18** to provide an access opening **26** to the work enclosure, and the opening can be closed by a vertically slidable sash **27.** The sash is shown in its raised position in FIGS. **1** and **3,** and in its lowered position in FIG. **2.** The sash conventionally includes a glass window to permit observation of materials within the work enclosure when the sash is closed.

An air intake tube **30** extends upwardly from the top panel **23** above an opening in the panel and is connected to a conventional auxiliary air blower (not shown). The auxiliary air blower supplies auxiliary air to the air chamber **24** and forces the auxiliary air through an air diffuser **31** which extends across the air chamber for the entire length thereof and through a directional air grille **32** which directs the auxiliary air outwardly and downwardly. An air dividing plate **33** extends upwardly from the directional air grille for directing a portion of the downflowing auxiliary air to flow between the dividing plate and the sash when the sash is in the raised position shown in FIG. **1.** A more detailed description of the auxiliary air chamber is given in the co-pending application entitled "Fume Hood", Ser. No. 172,746, filed Aug. 18, 1971, to which reference may be had for details.

An exhaust opening **35** is provided through the rear portion of the top wall, and an exhaust collar **36** is secured to the top wall above the opening and is adapted to be connected to a conventional exhaust air blower (not shown).

A baffle assembly **37** is mounted within the work enclosure adjacent the rear wall for providing desired directional flow through the work enclosure under the influence of the exhaust blower. The baffle assembly extends between the two side walls and includes angularly related upper baffle plates **38** and **39** and a lower baffle plate **40.** The baffle assembly is also described in greater detail in the aforementioned co-pending application.

A foil or sill **42** extends between the side walls at the front of the working enclosure and, referring to FIG. **5,** includes a front vertically extending portion **43,** an upwardly and rearwardly incined intermediate portion **44,** and a generally horizontally extending rear portion **45.** The foil is supported above the countertop **18** by four generally Z-shaped support angles **46** which are secured to the horizontal portion **45,** as by soldering or welding, and the foil is clamped to the counter-top by U-shaped brackets **46a** which carry clamping bolts **47.**

The horizontal portion **45** of the foil is spaced above the top or working surface of the countertop **18** to provide an air flow passage **48** therebetween, and an elongated generally U-shaped conduit or channel **49** is secured to the foil in alignment with the air flow passage **48.** The channel includes a bottom wall **50** and a pair of upwardly extending side walls **51** and **52** which terminate in outwardly extending attaching flanges **53** and **54,** respectively, which are secured to the lower surface of the horizontally extending portion **45** of the foil, as by soldering or welding. The channel **49** extends generally perpendicularly to the side walls for substantially the entire length of the horizontal portion **45** of the foil, and a transversely extending end plate **55** is secured at each end of the channel. Each end plate **55** is provided with an oval opening **56,** and each end plate may advantageously be provided as a longitudinally extending extension of the bottom wall **50** which is bent upwardly 90° to extend the side walls **51** and **52.** The side edges of the end plates may be sealed by soldering or the like.

A relatively short connecting tube **57** is connected to each of the end plates **55,** and each connecting tube includes an oval end **57***a* which has a shape corresponding to the oval opening **56** in the end plate and which is soldered or otherwise connected to the end plate and a round end **57***b.* An air tube **58** is connected to the round end of the connecting tube **57** on the right end of the channel **49,** and an air tube **59** is connected to the connecting tube **57** on the left end. As will be explained more fully hereinafter, the tubes **58** and **59** conduct auxiliary air from the auxiliary air chamber to the channel **49,** and the side wall **51** of the channel is provided with a plurality of longitudinally spaced openings **60** which are aligned with the air passage **48** between the foil and the countertop and which permit auxiliary air to flow through this air passage to sweep the working surface of the countertop.

Referring now to FIG. **3,** a pair of air-collecting funnels **61** and **62** are mounted within the auxiliary air chamber in the path of the incoming auxiliary air which flows through the air intake **30.** The upper ends of the funnels extend upwardly into the air intake and are supported by bracket **62***a* which is secured to the air intake, as by welding. One end of the air tube **58** is connected to the lower narrow end of the funnel **61,** and one end of the air tube **59** is connected to the lower end of the funnel **62.** As can be seen best in FIG. **9,** the left side wall **20** is provided by a pair of spaced-apart inner and outer panels **63** and **64,** respectively which are joined by an angularly extending front panel **65.** Similarly, right side wall **21** is formed by spaced-apart inner and outer panels **66** and **67** and angularly extending panel **68.** The air tube **58** extends from the funnel **61** through the auxiliary air chamber toward the right side wall **21** and passes through suitable openings formed in the side wall of the auxiliary air chamber. The air tube **58** then extends downwardly in the space between the panels **66** and **67** and passes below panel **66** to the connecting tube **57.** Similarly, the air tube **59** extends laterally to the left within the auxiliary air chamber from the funnel **62** through the side wall of the auxiliary air chamber and then downwardly in the space between the panels **63** and **64.** The tube then extends below the panel **63** to the connecting tube **57** on the left end of the channel **49.** The tubes **58** and **59** may advantageously be formed from flexible rubber hose or the like, and the ends thereof can be pushed over the ends of the connecting tubes **57** and secured by conventional hose clips.

The operation of the fume hood is illustrated schematically in FIGS. **1–3,** FIGS. **1** and **3** illustrating the operation of the hood when the sash **27** is raised, as when work is being performed on materials within the work enclosure. Auxiliary air is supplied through the air intake tube **30** by the auxiliary air blower, and a portion of the auxiliary air is collected by the wide upper ends of the funnels **61** and **62.** The remainder of the auxiliary air flows into the auxiliary air chamber and through the air diffuser **31.** As explained in the aforementioned application, a portion of the auxiliary air passing the diffuser **31** flows between the air dividing plate **33** and the sash **27** directly into the work enclosure **25,** this portion of the auxiliary air being indicated by the arrows **70.** The remainder of the auxiliary air which passes the air diffuser flows through the directional air grille **32** which guides it forwardly and down-

wardly as indicated by the arrows 71. A portion of this auxiliary air flows into the laboratory and combines with room air indicated by the arrows 72. As the auxiliary air continues to flow downwardly it is drawn inwardly by the exhaust blower through the lower portion of the work opening and sweeps across the top of the foil 42 and the work surface. Room air is also drawn into the work enclosure with this auxiliary air to held satisfy the exhaust requirements of the blower. Additional room air indicated by the arrows 73 may be drawn into the work enclosure through the air passage 48 between the foil and the countertop.

The auxiliary air which is collected by the intake funnels 61 and 62 is indicated by the double-headed arrows 74. This portion of the auxiliary air flows through the air tubes 58 and 59, through the channel 49, through the openings 60 in the side wall thereof, and through the air passage 48 between the foil and the countertop to sweep across the top of the work surface. The auxiliary air which is directed over the work surface by the channel 49 has sufficient velocity to provide proper sweeping action.

Air within the work enclosure is drawn around the baffle plates and exhausted through the exhaust collar 36 by the exhaust air blower.

FIG. 2 illustrates the air flow when the sash 27 is closed. Auxiliary air 76 flows through the air diffuser 31 directly into the work enclosure above the air dividing plate 33. A portion of the incoming auxiliary air flowing through the air intake 30 is again collected by the funnels 61 and 62 and flows through the air tubes 58 and 59, through the channel 49 and air passage 48, and over the working surface, this auxiliary air being indicated by the double-headed arrows 77. Since the auxiliary air is insufficient to satisfy all of the exhaust requirements, substantially all of the auxiliary air flows into the work enclosure, and the remaining air necessary to satisfy the exhaust requirement flows from the room into the work enclosure through the grille 32 and through the space between the dividing plate and the sash, as illustrated by the arrows 78, and through air passage 48 between the foil and the countertop, as indicated by the arrows 79.

Although I have shown the conduit 49 in the form of a channel with spaced circular openings in one side, it will be understood that other types of air flow conduits or tubes could be used. Further, other shapes of openings for permitting the air to flow from the conduit could be provided, such as one or more elongated slots or the like.

A modified air flow system is illustrated in FIG. 10. The fume hood 80 is identical to the fume hood 15 with the exception of the construction of the side walls 81 and 82, as will be explained more fully hereinafter. As previously explained with respect to the fume hood 15, high velocity auxiliary air is collected by air-collecting funnels 83 and 84 positioned in the air intake 85, and this high velocity auxiliary air is directed by tubes 86 and 87 downwardly along the sides of the fume hood to the air flow channel 88 which is positioned below the foil or sill of the fume hood for directing fast-moving auxiliary air across the work surface. However, the vertically extending portions of the tubes 86 and 87 are provided with openings to direct fast-moving auxiliary air into the work enclosure along the sides of the fume hood as indicated by the double-headed arrows 89 and 90.

The construction of the left side wall 81 for permitting inward flow of air along the side of the hood is shown in FIG. 11. The side wall includes a pair of spaced-apart inner and outer panels 91 and 92 which are connected by panels 93, 94, and 95. A sash guide 96 is secured to the panel 95 for slidably supporting the sash 97 which is indicated in phantom.

The tube 87 for conducting the auxilary air is secured to the panel 95 and is provided with vertically spaced openings 98 (FIG. 12) for directing auxiliary air toward the work enclosure of the fume hood thorugh the space between the inner end 93a of the panel 93 and the outer end of the side panel 91. In the embodiment illustrated, the vertically extending portion 87a (FIG. 10) of the air tube is provided by a metal pipe, and the pipe is secured to the panel 95 by welding. The remainder of the tube 87 comprises a rubber hose portion 87b which connects the upper end of pipe 87a to the funnel 84 and a hose portion 87c which connects the lower end of the pipe to the channel 88.

The side wall 82 and air tube 86 are constructed in the same manner as the side wall 81 and tube 87.

When the sash 97 is in the open position, the bottom thereof will be positioned adjacent or above the auxiliary air grille 99, and a portion of the auxiliary air which flows through tubes 86 and 87 flows through the openings 98 into the work enclosure along both sides of the hood. The remainder of the auxiliary air flowing through the tubes flows through the channel 88 and sweeps across the work surface. A positive curtain of air therefore sweeps inwardly along both sides of the hood, and auxiliary air is therefore directed into the work enclosure around the entire periphery thereof.

I have found that when auxiliary air is not introduced into the work enclosure along the sides, introduction of auxiliary air at the top of the work enclosure through the air grille 99 may create counterflows of air within the work enclosure which could carry fumes out of the hood and into the laboratory. These counterflows of air are often particularly noticeable near the side walls of the hood and, if high velocity air is not directed across the working surface, also near the working surface. By introducing high velocity auxiliary air along the sides of the hood, the possibility of fumes escaping into the laboratory along the walls is substantially eliminated.

In the embodiment illustrated in FIGS. 10–12, the vertical portions of the air tubes are positioned outwardly of the sash guide 96. When the sash is closed and occupies the position illustrated in phantom, the air flowing through the tube openings 98 will be deflected by the sash into the laboratory. Introducing this auxiliary air into the laboratory may be unobjectionable since the auxiliary air is clean air and since the air discharge through the openings 98 is only a fraction of the total volume of auxiliary make-up air which is supplied by the auxiliary air blower. The vertically spaced openings 98 extend all the way to the work surface, and auxiliary air begins to sweep into the fume hood along the sides as the sash is raised.

A further modification is illustrated in FIGS. 13–19 and includes means for closing the discharge openings in the vertical portions of the air tubes as the sash is closed. FIG. 13 is a view similar to FIG. 11 of one of the side walls of the fume hood which is slightly modified to accommodate the closing means for the discharge openings. The side wall 101 includes a pair of spaced-apart inner and outer panels 102 and 103 which

are connected by panels **104, 105,** and **106.** A brace **107** extends between the panels **105** and **104,** and the inner end **104***a* of the panel **104** terminates outwardly of the outer end of the side panel **103.** A vertically extending pipe **108** similar to pipe **87** is secured to the panel **105** by sheet metal screws **109,** and a sash guide **110** is secured to the panel **106** by screws **111.**

An elongated shutter **112** is rotatably carried by the pipe **108** and extends longitudinally along the pipe over that portion which is provided with the discharge openings **113** (FIGS. **14** and **15**). The shutter has a generally C-shaped or partially circular transverse cross section and extends around the tube for more than one-half the circumference of the tube so that the shutter is retained on the tube and is provided with an elongated slot **114** which extends from the uppermost discharge opening to the lowermost discharge opening. As can be seen in FIGS. **14** and **15,** the slot extends slightly spirally counterclockwise relative to the longitudinal axis of the pipe and shutter as it proceeds from the bottom portion of the shutter to the top portion. An actuator bracket **115** having a flat end portion **116** which is slidably received in the slot **114** is mounted for vertical movement with the sash **117.** The bracket **115** is secured to the frame of the sash by bracket **118** and screw **119.**

As the shutter actuator **115** moves vertically within the slot **114,** the shutter is caused to rotate relative to the pipe **108** to close or expose the discharge openings **113.** The position of the shutter when the sash is fully closed is illustrated in FIG. **14,** and all of the discharge openings **113** are covered by the solid portion of the shutter. As the sash is raised the actuator **115** slides upwardly within the slot **114** and causes the shutter to rotate counterclockwise as viewed in FIGS. **16–19.** As the shutter and the slot **114** rotate, the discharge openings gradually become exposed proceeding from bottom to top.

The lowermost discharge opening **113** is exposed as soon as the sash is raised from its fully closed position so that auxiliary air is directed into the work enclosure along the sides immediately. As the upward movement of the sash continues, more discharge openings become exposed to increase the inward flow of auxiliary air along the sides of the hood. At any intermediate position of the sash between its fully closed and fully opened positions, only those discharge openings below the bottom of the sash will be exposed, and the discharge openings above the bottom of the sash will remain covered by the shutter so that auxiliary air will not be deflected by the sash into the room. As the sash is lowered from its fully raised position, the shutter rotates clockwise to consecutively close the discharge openings from top to bottom. Each opening becomes covered by the shutter as the bottom of the sash passes, thereby providing an inwardly directed curtain of air at the hood sides which has a height approximately the same as the height of the access opening at any position of the sash. The shutter occupies the position illustrated in FIG. **15** when the sash reaches the fully opened position, and in this position all of the discharge openings are exposed to permit fast-moving auxiliary air to flow into the work enclosure along the sides of the hood.

The other side of the hood is similarly constructed, and the upper and lower ends of the pipes **108** can be connected, respectively, to an air-collecting funnel and an air flow channel as described with respect to the tubes **87** of FIG. **10.**

While in the foregoing specification, a detailed description of a specific embodiment of the invention was set forth for the purpose of illustration, it is to be understood that many of the details hereingiven may be varied considerably by those skilled in the art without departing from the spirit and scope of the invention.

I claim:

1. In a fume hood having a frame providing a work enclosure defined by a back wall, a pair of side walls, and a work surface, the work enclosure having an access opening at the front of the fume hood, auxiliary air supply means on the frame for supplying auxiliary air to the work enclosure, air flow conduit means mounted on the frame adjacent the front of the work surface, the air flow conduit means being provided with an opening for permitting auxiliary air to flow from the air flow conduit means over the work surface, tube means on the frame extending between the auxiliary air supply means and the air flow conduit means for supplying auxiliary air to the air flow conduit means, and air collecting means connected to the tube means and positioned in the path of auxiliary air supplied by the auxiliary air supply means.

2. The structure of claim **1** in which each side wall includes a pair of spaced apart inner and outer side panels and connecting panel means extending between the inner and outer panels, the tube means being secured to the connecting panel means outwardly of the inner panel.

3. The structure of claim **1** in which the air collecting means comprises a funnel.

4. The structure of claim **3** in which at least one of the side walls includes spaced-apart inner and outer panels and an intermediate portion of the tube means extends between the spaced-apart panels.

5. The structure of claim **3** in which the auxiliary air supply means includes an auxiliary air chamber above the work enclosure, the tube means comprising a pair of tubes, a portion of each tube extending along one of the sides of the work enclosure and being provided with an opening for directing auxiliary air into the work enclosure.

6. The structure of claim **5** in which each of the side walls includes a front panel positioned outwardly of the tube associated with the side wall.

7. In a fume hood having a frame providing a work enclosure defined by a back wall, a pair of side walls, and a work surface, the work enclosure having an access opening at the front of the fume hood, tube means on the frame extending along each side wall, means for supplying air to the tube means, each of the tube means being provided with an opening for directing air supplied to the tube into the work enclosure along one side thereof, sash means slidably mounted between the side walls for opening and closing the access opening, and shutter means operatively connected to the sash means for opening and closing the opening in the tube means as the sash means opens and closes the access opening.

8. The structure of claim **7** in which the means for supplying air to the tube means includes auxiliary air supply means on the frame for supplying auxiliary air to the work enclosure, the tube means extending from the auxiliary air supply means.

9. The structure of claim **7** in which the means for supplying air to the tube means includes an auxiliary air

chamber on the frame and means for supplying auxiliary air to the auxiliary air chamber, each of the tube means including an elongated tube having one end positioned in the auxiliary air chamber.

10. The structure of claim **9** including a funnel on said one end of each of the tubes positioned in the path of auxiliary air supplied by the auxiliary air supply means to the auxiliary air chamber.

11. The structure of claim **7** in which each of the tube means includes a generally vertically extending tube adjacent one of the side walls, each tube being provided with a plurality of vertically spaced openings for directing air supplied to the tube into the work enclosure along one side thereof, and means connecting the shutter means and the sash means for moving the shutter means as the sash means moves whereby the tube openings above the bottom of the sash means are closed and the tube openings below the bottom of the sash means are exposed.

12. The structure of claim **7** in which each of the shutter means includes an elongated generally circular shutter rotatably carried by one of the tubes, each shutter being provided with a generally longitudinally extending slot, the slot being circumferentially offset from the openings when the sash is closed whereby the openings are closed by the shutter and the slot being aligned with the openings when the sash is open whereby the openings are exposed.

13. The structure of claim **12** in which the slot is slightly spirally arranged relative to the longitudinal axis of the tube, the connecting means being secured to the sash for movement therewith and being slidably received by the slot whereby vertical movement of the sash rotates the shutters relative to the tubes.

* * * * *