

[54] AIR MODULATING FUME SYSTEM
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[73] Assignee: Industrial Clean Air, Inc., Berkeley, Calif.
[22] Filed: Sept. 26, 1973
[21] Appl. No.: 400,889
[52] U.S. Cl. 98/115 R; 98/36
[51] Int. Cl. F24f 9/00
[58] Field of Search..... 98/115 VM, 115 R, 98/36, 115 K, 115 SB

[56]

References Cited

UNITED STATES PATENTS

1,774,072	8/1930	Whitmore	98/36
2,565,933	8/1951	Schneible.....	98/36
2,997,132	8/1961	Allander et al.	98/115 R
3,018,712	1/1972	Walker	98/36
3,254,588	6/1966	Truhan.....	98/115 LH
3,515,766	5/1970	Ahlich	98/115 K

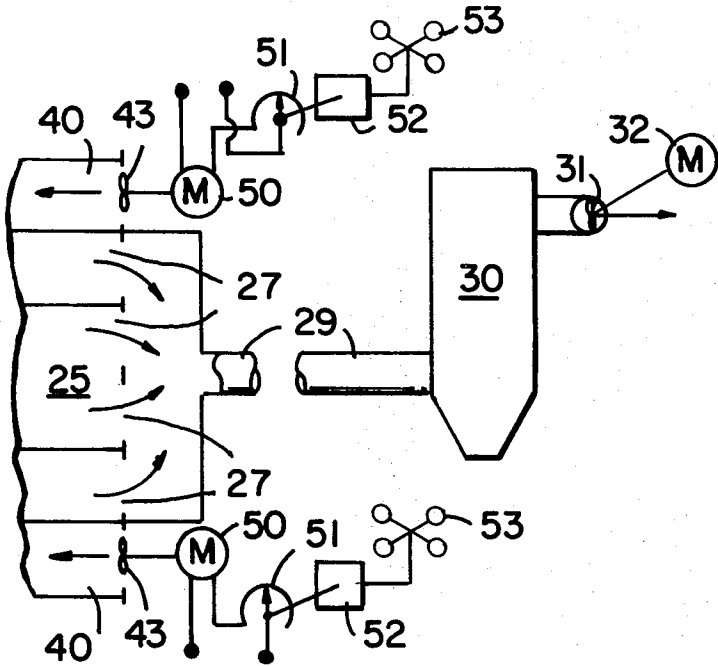
3,800,689	4/1974	Brown.....	98/115 K
FOREIGN PATENTS OR APPLICATIONS			
930,653	8/1955	Germany.....	98/115 R
962,372	4/1957	Germany	98/36

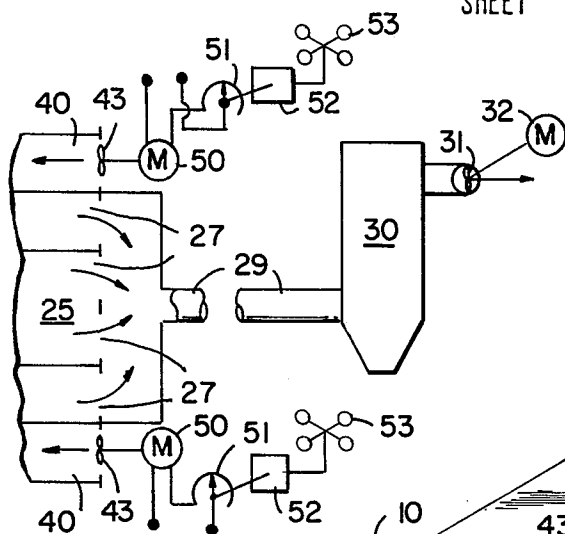
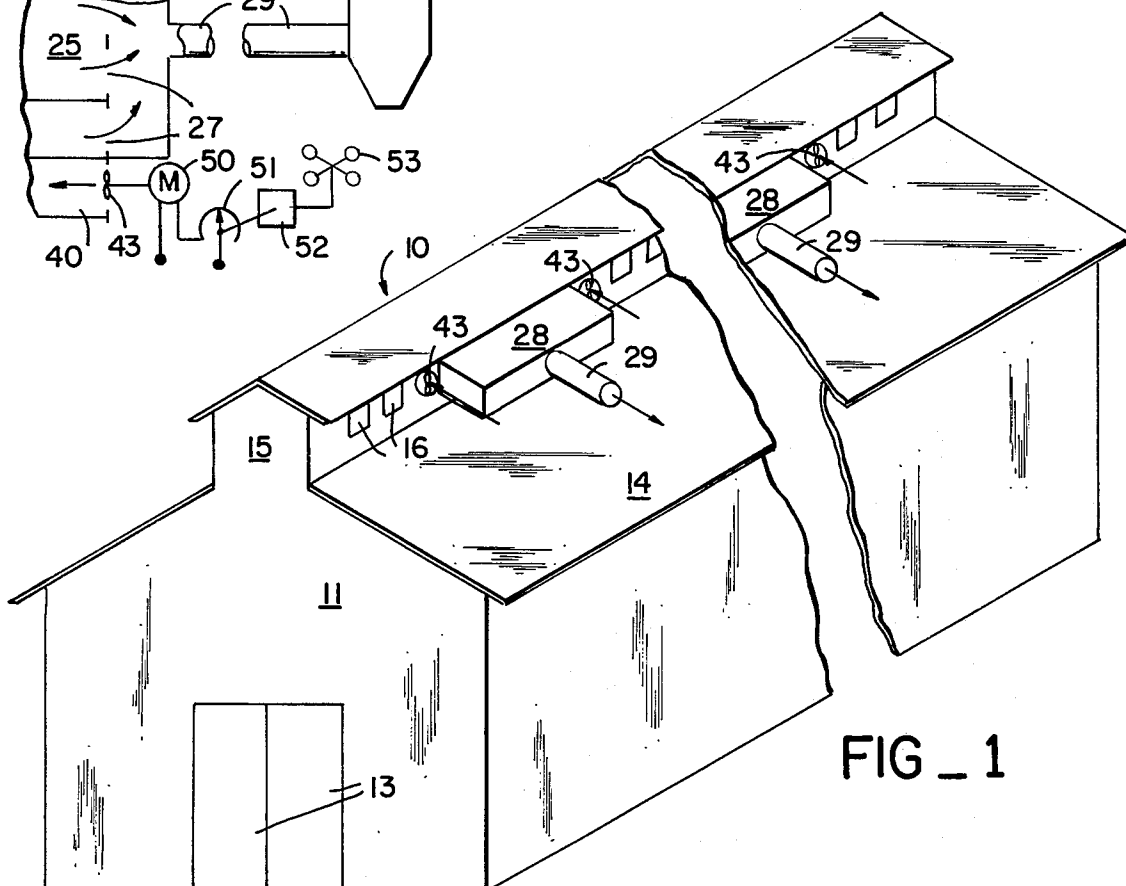
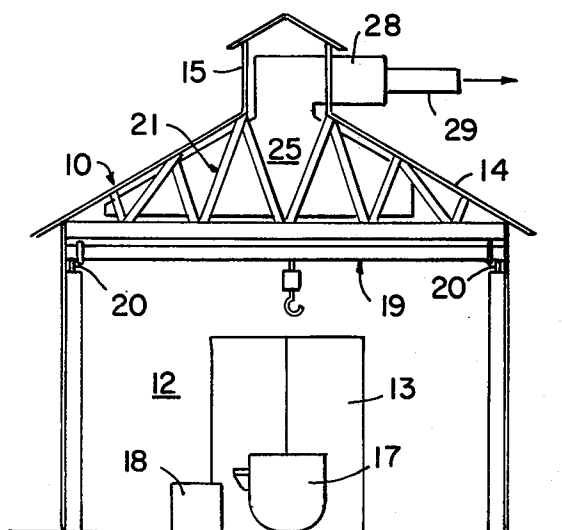
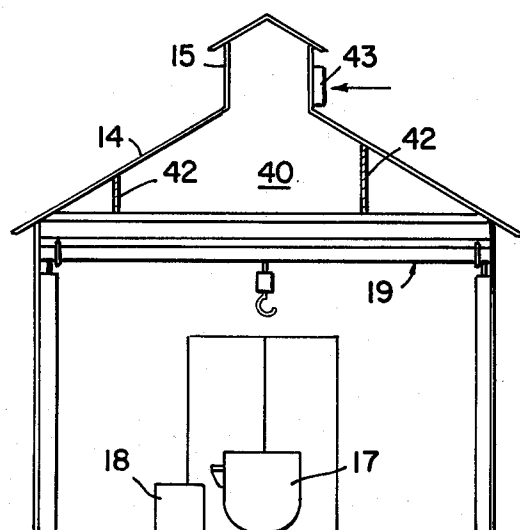
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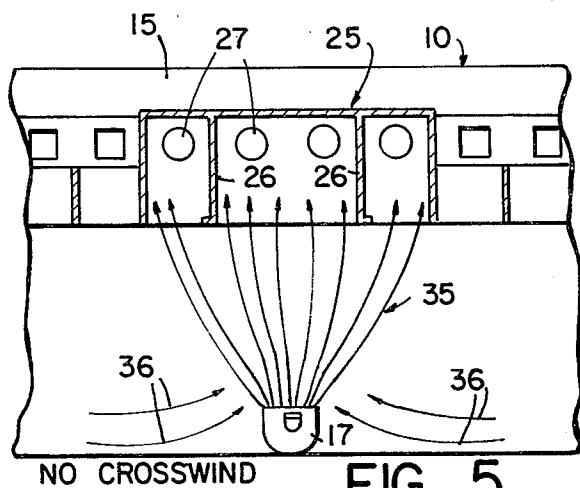
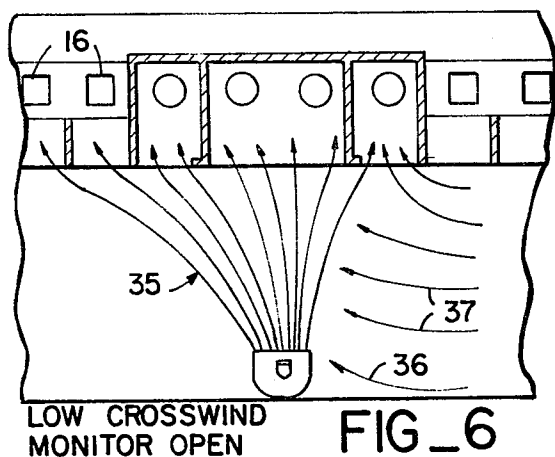
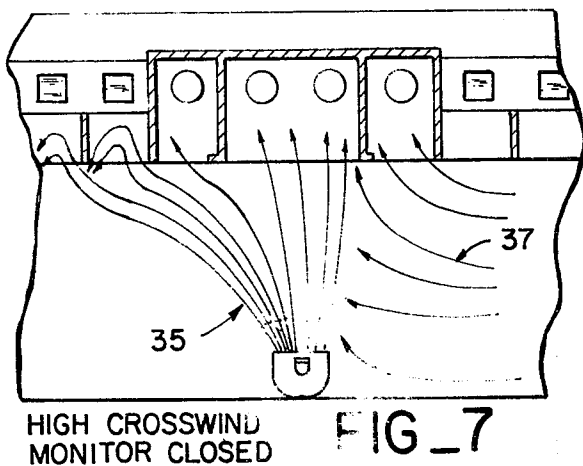
[57] ABSTRACT

A fume control system wherein a canopy-type exhaust hood is located in a building a substantial distance above a source of fumes. Cold air is delivered into the building into downwardly open plenum chambers on opposite sides of the hood, the cold air descending around the fumes to form an air chimney for the fumes, thus nullifying disturbance of the fumes from cross winds. The cold air also serves to supply make-up air in the building and thus prevents or reduces unwanted cross drafts in the building.

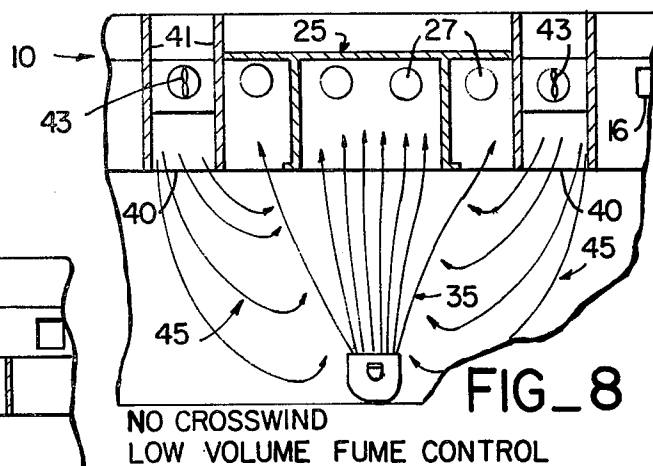
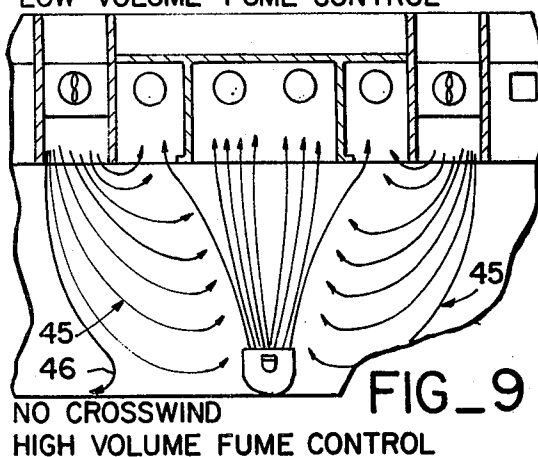
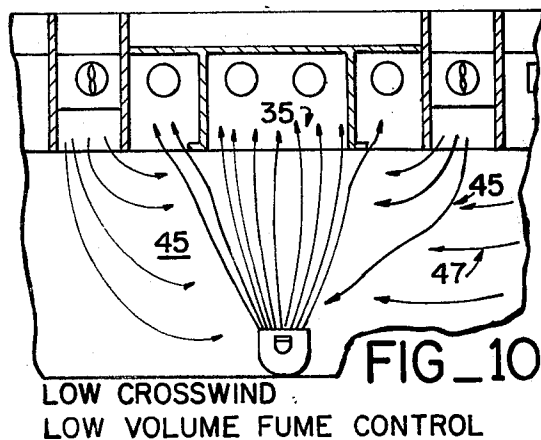
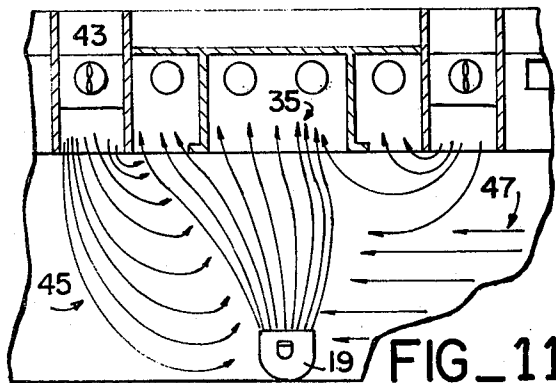
3 Claims, 11 Drawing Figures







HIGH CROSSWIND
HIGH VOLUME FUME CONTROL



AIR MODULATING FUME SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to the control, collection and exhaustion of fumes generated in a process where it is impossible to fully hood the process. A typical example of such a process is that found in steel mills throughout the world wherein open-top furnaces, having molten steel therein at a typical temperature of 3000° F., emit fumes from the furnace, which fumes must be collected and removed from the building in which the furnace is situated.

Traveling overhead cranes are used in such buildings for furnace-charging operations, making it impossible to surround the furnace with a fume-entrapping hood. Instead, overhead, canopy-type hoods are used to contain the upwardly rising fumes which, besides having a large heat content, often have substantial amounts of smoke, steam, dirt, dust and other particulate matter entrained therein. The canopy hood is connected to an exhaust system which produces a negative pressure condition within the hood to draw the fumes thereinto, the fumes then passing out through the exhaust system. Typically, the fumes then pass through air cleaners to remove particulate matter from the fumes before they are discharged into the atmosphere.

The building structures which house the furnaces usually have many doors, which, when open, allow wind to blow through the building, setting up cross winds within the building which blow the fumes sideways. If the capacity of the exhaust system is insufficient to compensate for cross wind conditions some or all of the fumes will overflow or spill beyond the confines of the hood enclosure into the adjacent roof area of the building when cross winds occur. Such spillage is highly undesirable. If the fumes are free to then leak out the building the air outside the building will be polluted. If the fumes remain within the building they will adversely affect the working conditions therein.

In order to meet the increasingly stringent requirements against air pollution and to meet occupational health and safety requirements it is necessary to design the system so that such spillage or overflow of the fumes is prevented. Typically, this is done by designing the exhaust system so that it will have a capacity sufficient to provide a strong enough negative pressure condition to suck the fumes thereinto even when the fumes are acted upon the maximum expectable cross wind condition. Even though operation at full capacity may be required for only a small percentage of the time, the exhaust system must be physically capable of maximum operation at any time. Similarly, the air-cleaning system must be designed with sufficient physical capacity to handle maximum operation of the exhaust system, even though, again, such full capacity of the air-cleaning system might not normally be required. The necessity for providing an exhaust system and air-cleaning apparatus of a size large enough to operate in event of abnormal conditions makes this type of fume control quite costly.

SUMMARY OF THE INVENTION

In order to reduce the size and capacity of the exhaust and air-cleaning systems needed for overhead canopy-type hoods, the canopy hood is surrounded by downwardly facing plenum chambers into which cold

ambient air from outside the building is continuously injected. Preferably, the roof truss and roof monitor areas are utilized for these plenum chambers, as this permits the chambers to be formed at quite low expense.

Injection of the air into these plenum chambers accomplishes a number of functions. First of all, injection of this air into the roof truss and roof monitor area places these areas adjacent the canopy hood at a positive pressure which prevents fumes from rising into those areas or from spilling over into those areas from the canopy hood. Secondly, the injected air is colder than the air within the building. It is injected high into the building and, because it is heavier than the warmer air within the building, it moves as a mass downwardly, adjacent the countercurrent to the upward flow of the hot fumes, thus forming an air chimney to confine the upward moving fumes and direct them to the canopy hood.

The descending cold air chimney further provides a counter force resisting the effect of cross winds on the fumes and thus reduces the capacity that the exhaust system would otherwise require. The rate of cold air injection can be increased to oppose the effect of high cross winds. Thus the proper control of the fumes under cross-wind conditions can be achieved by relatively inexpensive blowers rather than by increasing the size of the much more expensive exhaust and air-cleaning systems.

Another important advantage of the present system is that in removing fumes, the presently used canopy hoods constantly remove large volumes of air from the building. A corresponding amount of air must flow into the building and thereacross to the furnace to make up the removed air, creating drafts which make for uncomfortable working conditions. With the present invention, the air required for make-up purposes is the air injected into the top of the building which descends around the rising fumes down to the furnace, thus greatly reducing undesirable cross drafts in the building.

Other objects and advantages will become apparent in the course of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings forming a part of this application and in which like parts are designated by like reference numerals throughout the same,

FIG. 1 is perspective and generally schematic view illustrating a typical building in which steel furnaces are situated and in which the present invention can easily be utilized;

FIG. 2 is a transverse sectional view of the building of FIG. 1 showing the typical roof truss and roof monitor construction, and showing a canopy-type fume hood;

FIG. 3 is a transverse sectional view of the building of FIG. 1 showing the manner in which the building of FIG. 1 can be arranged to convert the roof truss and roof monitor areas into cold air plenum chambers;

FIG. 4 is a diagrammatic view of the air-injection, airexhaust and air-cleaner systems used in the present invention;

FIGS. 5, 6 and 7 are generally schematic elevational views from the longitudinal centerline of the building of FIG. 1, illustrating the fume flow and cross drafts in

existing fume-control systems, under varying cross-wind conditions;

FIGS. 8, 9, 10 and 11 are views similar to FIGS. 5-7, showing the flow of cold air and fumes, when operating according to the present invention, and under the different cross-wind and cold air-injection conditions set forth on the figures.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Buildings which house steel furnaces vary greatly in detail from plant to plant. However, such buildings typically have in common the general construction shown in FIGS. 1, 2 and 4, wherein the building 10 has end walls 11 and 12 having doors 13 therethrough, a roof 14, and a roof monitor 15, the latter having ventilation windows 16 generally along the length thereof. The interior of building 10 will have one or more open-top furnaces 17 therein, along with the receptacles 18 into which the furnace contents are discharged, the interior of the building being serviced by an overhead crane 19 extending across the building and traveling on rails 20 which extend the length of the building. The roof 14 of the building is supported by the roof-truss system 21 above the traveling overhead crane 19.

A canopy-type hood 25 is disposed in the building above each furnace 17, and above the path of travel of the overhead crane 19, the hood being insulated as necessary to protect the structural components of the building. The hood 25 has transverse partitions 26 as necessary, and outlets 27 which discharge into a manifold 28 and flow through flow conduit 29 to the inlet of an air-cleaning system 30 wherein particulate matter is removed from the collected fumes, flow from the hood through the exhaust system and air-cleaner 30 being induced by blower 31 which is driven by motor 32.

The operation of a typical existing canopy hood is illustrated in FIGS. 5-7. FIG. 5 shows a situation wherein furnace 17 is in operation with heated fumes, indicated by arrows 35, rising therefrom towards canopy hood 25. Typically, the fumes rise as an upwardly diverging cone, having a cone angle of about 18° . The hood 25 is designed to have a length and width sufficient to extend a suitable distance beyond the area of the fume cone when it reaches the hood. The hood will also extend laterally above receptacle 18 so as to collect the fumes from that receptacle when the contents of furnace 17 are discharged. At the same time, the hood area should be as small as possible, since the larger the hood, the larger must be the volume of air exhausted therefrom per unit time to provide the desired suction pressure in the hood, and the greater will be the cost of the exhaust and air-cleaning system.

The fumes 35 will rise into hood 25 and be exhausted therefrom through the air-cleaner 30 by blower 31. As fumes 35 are exhausted from the building, a corresponding volume of air per unit time must flow into the building through doors 13 or other openings in the building and flow across the floor to the furnace, creating a cross draft, as represented by the arrows 36. The greater the rate of fume discharge, the greater will be the cross drafts. Depending on the time of the year and the temperature outside the building, these cross drafts can be very uncomfortable to the workmen in the building.

FIG. 6 illustrates the fume pattern when a cross wind blows through the building, the cross wind being indicated by arrows 37. Such cross winds typically occur when there is a wind blowing outside the building and the doors 13 at one or both ends of the building are open. A cross wind 37 from the right will blow against the cone 35 of rising fumes, forcing them to the left, as seen in FIG. 6. If the suction force in the hood 35 is insufficient and/or if the cross wind 37 is sufficiently strong, then some of the rising fumes will be blown beyond the limits of the hood and pass upwardly and out through the ventilation windows 16 in the roof monitor. Cross drafts 36 may exist at floor level, depending upon the velocity of the cross wind 37.

FIG. 7 illustrates the situation where a stronger cross wind 37 exists. In such case even more fumes 35 may be blown past the hood opening and rise up into the roof monitor area. If the monitor ventilation windows 16 are closed, as may be the case in winter operations, these fumes will collect in the roof area or circulate by convection back down into the building.

To prevent the conditions illustrated in FIGS. 6 and 7 from occurring, the typical canopy hood systems are designed so that the exhaust system is of a size larger enough to create a sufficient vacuum to counteract the sideways force on the fume cone exerted by expectable cross winds 37.

In the present invention, downwardly facing air plenum chambers 40 are formed around the canopy hood 25. In a relatively long, narrow building it is usually sufficient to form these plenum chambers on opposite sides of the canopy hoods towards the ends of the building. If flow is also to be controlled transversely of the building, these plenum chambers 40 should be provided on all sides of the canopy hood.

In buildings of the type shown in FIG. 1, the plenum chambers 40 can be easily and inexpensively formed by attaching imperforate panels 41 to the roof trusses 21, the panels extending transversely of the building and preventing air flow longitudinally through the roof and roof monitor area. The plenum chambers formed utilize the existing roof and roof monitor as the top and side walls of the plenum chambers and thus the only significant cost of the plenum chambers is the cost of the panels 41. Partition members 42, extending between panels 41, may be used as desired to provide the desired shape of the plenum chambers or as flow directors. A blower 43 of suitable capacity is mounted in a ventilation window opening into each plenum chamber 40. Such blowers are standard and are relatively inexpensive. The intakes of the blowers are directly open to atmosphere and discharge directly into the plenum chambers 40. Thus, no expensive and energy-consuming intake and discharge ducting is required.

Operation of the fume-control system with air plenum chambers 40 on each side of the canopy hood 25 is illustrated in FIGS. 8-11 under various conditions.

FIG. 8 illustrates the system when there is no cross wind in the building and when a relatively low flow of cold fume-control air is introduced into the plenum chambers 40 by blowers 43. The bottom openings of the plenum chambers 40 are essentially discharge nozzles for the blowers 43 and are at a superatmospheric pressure, thus preventing any entry of the fumes 35 thereinto.

The air injected into the plenum chambers, by blowers 43, is relatively cold in comparison to the air in the building. This is particularly so in winter, but even in the summer the temperature of the air at roof monitor level will be substantially below the temperature of the air at ground level. The mass of cool or cold air discharging from the plenum chambers 40 will then descend in the building, as represented by arrows 45 on each side of the cone of fumes 35, forming a chimney confining the fumes and directing them upwardly to the canopy hood 25.

As before, the exhaustion of the fumes 35 from the canopy hood 25 will remove air from the building. In this case, however, the air required to make up the exhausted air is the cool air introduced into the building by the blowers 43. If the rate of air introduced by blowers 43 is equal to the rate exhausted from the hood, then substantially no cross drafts will be produced in the building.

FIG. 9 again illustrates a condition where no cross wind exists but the blowers 43 are operated at a greater capacity. A greater dynamic pressure on the rising fumes 35 will be exerted by the descending cold air 45 confining the fumes to a smaller cone angle than before. If the rate of introduction of fume-control air 45 is greater than the rate of exhaustion from the canopy hood, then some cross draft 46 will occur outwardly from furnace 17.

FIG. 10 illustrates a situation wherein a relatively low velocity cross wind 47 is present through the building, and wherein a relatively low rate of fume-control air is introduced by blowers 43. The cross wind 47 impinges upon the descending cold air 45 (on the right of FIG. 10) and upon the ascending cone of fumes 35, forcing the fumes to the left. In this case, however, the fumes are prevented from spilling to the left past the canopy hood 25 by virtue of the relatively high pressure existing in the left air plenum chamber 40. Similarly, the dynamic force of the descending air from the left air plenum chamber will act on the fume cone in opposition of the force of the cross wind thereon and will continue to confine the fumes for upward flow to the canopy hood 25.

FIG. 11 illustrates the operation when a relatively strong cross wind 47 blows through the building. In this case the blower 43 on the downwind side of furnace 19 is operated at greater capacity. Again, the cross wind 47 acts upon the rising fumes 35 and tends to blow them to the left, and again this motion of the fumes is resisted by the incoming cold air 45 descending from the downwind plenum chamber. With an increased flow of cold air, the pressure at the bottom opening of the plenum chamber is increased, thus increasing the resistance to downwind flow of the fumes past the lower downwind end of the canopy hood. Also, with the increased flow of cold air there is a greater mass of air along the height of the fume cone so that downwind movement of the fumes is blocked so that the fumes again rise to and are collected by and exhausted from the canopy hood.

Since the cross wind upwind of the furnace is itself acting as a pressure front on the ascending fume cone, there is no necessity for increasing the flow of cold air into the upwind plenum chamber. Some air flow is desirable from the upwind plenum chamber, however, to divert the cross wind downwardly from the canopy

hood and thus prevent the hood from filling with the cross wind.

As may be seen, the control of the fume cone is accomplished by the combination of the low pressure in the canopy hood produced by the exhaust blower 31 and the high pressure produced by the action of the blowers 43 into the cold air plenum chambers 40. The relatively high pressure of the incoming air as it exits the cold air plenum chambers will confine the upper part of the fume cone and constrict it against normal lateral expansion so that the upper end of the fume cone will be smaller in area than if the incoming air were not present. Because of this confinement of the fume cone the exhaust and air-cleaning system can be designed with a relatively small capacity, even less than that which would be required for exhaust of an unconfined fume cone under conditions when no cross winds are present. Thus, even if the fume source were in a building where no cross winds would be encountered, the present invention enables effective fume collection to be obtained with a smaller-capacity exhaust and air-cleaning system. Also, the use of the invention under such conditions will reduce or eliminate undesirable cross drafts.

In buildings where cross winds do occur, the savings become even more substantial. The exhaust and air-cleaning system need only to be designed with a capacity to handle exhaust of the fumes under no cross wind conditions. Control of the fumes under cross wind conditions is provided by the considerably less expensive cold air plenum chambers and the cold air blowers 43 therefor.

The effect of cross winds on the rising cone of fumes is greater towards the top of the cone, where the fumes become more diffuse. However, with the cold air plenum chambers discharging downwardly from adjacent the canopy hood, the pressure exerted by this cold air on the fumes is greatest at the top, the pressure decreasing as the cold air diffuses downwardly. Thus, the resistance to lateral flow of the fumes offered by the descending cold air is greatest where needed the most, the resistance diminishing as the need for resistance diminishes.

FIG. 4 also shows, schematically, a control system for operation of the blowers 43. Each blower 43 is operated by a motor 50 which is controlled by a motor controller, indicated on FIG. 4 by a rheostat 51. Although the motor controllers 51 can be operated manually, preferably each motor controller is adapted to be operated automatically by a wind velocity-responsive control device 52 actuated by an anemometer 53, the latter located either within the building to measure the velocity of the actual cross wind therein, or located outside the building to measure the existence and magnitude of winds which may cause cross winds in the event the building doors 13 are opened. In operation, the wind-responsive control device 52 will measure the amount and direction of wind velocity in conventional manner and actuate the downwind blower motors 50 to vary their speeds and provide the desired resistance to downwind movement of the fumes rising from the furnace.

Although the invention is particularly suited for use in buildings of the type described, wherein the cold air plenum chambers 40 can be constructed very cheaply by utilizing the existing structure of the building, the invention can be used in other situations wherein a

canopy-type hood is located substantially above a source of fumes.

In cold-climate operations, it may be desirable to heat the air introduced into the plenum chambers 40 so that working conditions within the building are not adversely affected. However, if the air is heated, such heating must be kept to a sufficiently low degree that the air remains cold enough as it leaves the plenum chambers to achieve the fume containment previously described.

Similarly, in hot-climate operations, the air introduced into the plenum chambers 40 may be pre-cooled, to increase the efficiency of the air containment system.

Having thus described my invention, I claim:

1. A fume-control system comprising:

- a. a building having a roof and roof trusses directly below and supporting said roof,
- b. a source of hot fumes in said building,
- c. a downwardly facing canopy-type hood situated in the roof truss area and spaced above said source of fumes,
- d. means for exhausting fumes from said hood and for conducting said fumes to the exterior of said building,
- e. means forming a plurality of downwardly facing air plenum chambers open at the bottom thereof to permit cold air at a temperature less than the ambient temperature within said building to flow downwardly therefrom, said air plenum chambers being disposed along and contiguous to opposite sides of said hood, said means (e) utilizing portions of said roof to form upper surfaces of said chambers and including panels secured to said roof trusses to form side walls of said chambers,
- f. means for introducing cold air into said plenum chambers comprising blowers for each plenum chamber arranged to take atmospheric air directly from exteriorly of said building at a height above ground level and blow said air into said plenum chambers,
- g. means forming openings in said building whereby winds exteriorly of said building may blow crosswise of said source of hot fumes,
- h. means responsive to changes in velocity of said winds for increasing the speed of at least one of said blowers.

2. A method of controlling fumes in a building having a source of upwardly rising fumes therein and wherein the upwardly rising fumes are at times subjected to

cross winds of varying magnitudes of velocity blowing through said building, said method comprising:

- a. forming a low-pressure suction zone above said source of fumes,
 - b. introducing cold air exteriorly of said building, said air being colder than the ambient air temperature within said building, discharging said cold air downwardly alongside of and directly by opposite sides of said low-pressure suction zone, and then flowing said discharged cold air downwardly in said building towards said source of fumes,
 - c. confining said upwardly rising fumes by and between the downward flows of cold air and directing said fumes by said cold air to said low-pressure suction zone,
 - d. collecting said fumes in said low-pressure suction zone and exhausting said collected fumes to the exterior of said building,
 - e. increasing the volume of downward flow of air on the downwind side of the fumes as the velocity of the cross wind increases and decreasing said volume of downward flow as the cross wind velocity decreases.
- 3. A fume-control system comprising:**
- a. a building having side openings whereby wind exteriorly of said building may blow crosswise through said building,
 - b. a source of hot fumes in said building situated in the path of said crosswise wind,
 - c. a downwardly facing canopy-type hood disposed in said building and spaced above said source of fumes,
 - d. means for exhausting fumes from said hood and for conducting said fumes to the exterior of said building,
 - e. means forming a plurality of downwardly facing air plenum chambers in said building along and contiguous to opposite sides of said hood, said plenum chambers being open at the bottom thereof to permit cold air at a temperature less than ambient temperature within said building to flow downwardly there from,
 - f. means including a plurality of blowers for introducing cold air into said plenum chambers from exteriorly of said building there being at least one blower for each plenum chamber,
 - g. means responsive to changes in velocity of said wind exteriorly of said building for increasing the speed of at least one of said blowers.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,895,569
DATED : July 22, 1975
INVENTOR(S) : Edward M. Miller

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, claim 3, line 40 - "anibiant" should
read --ambient--.

Signed and Sealed this

seventh **Day of** *October* 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks