

Dec. 31, 1963

R. A. SMITH
AIR CONFINED SYSTEM

3,115,818

Filed June 17, 1960

2 Sheets-Sheet 1

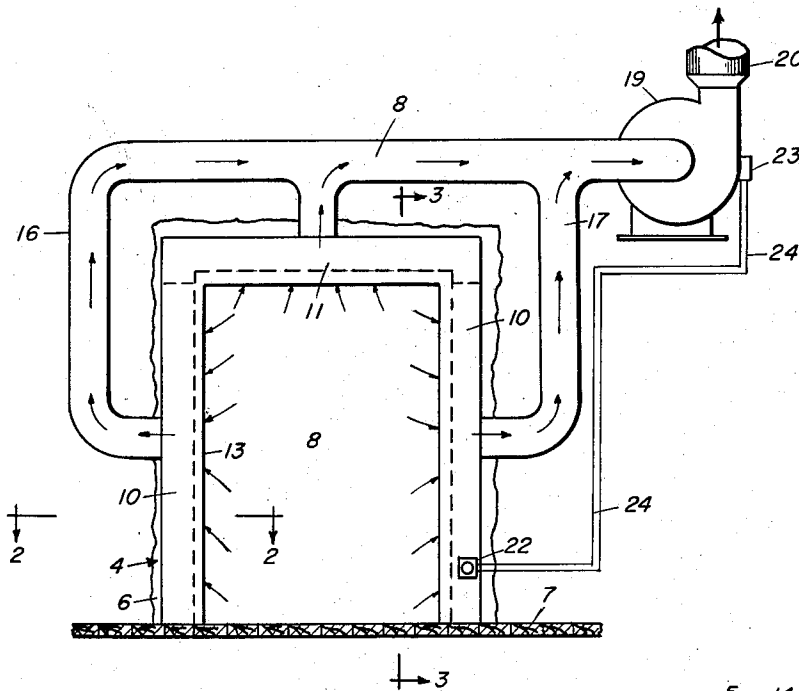


FIG. 1

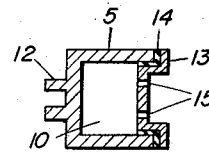


FIG. 2

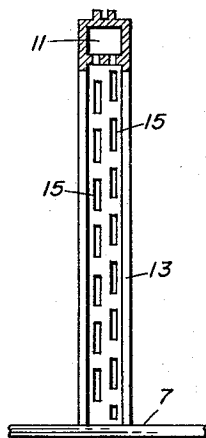


FIG. 3

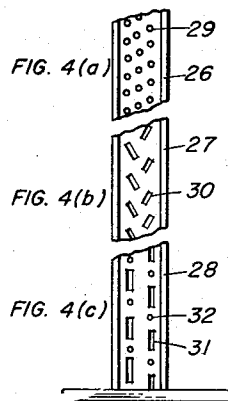
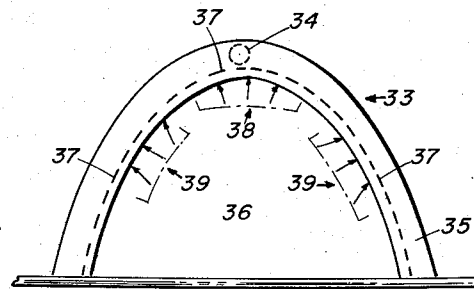


FIG. 5

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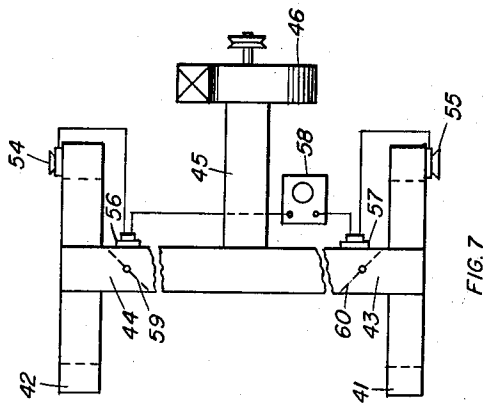


FIG. 7

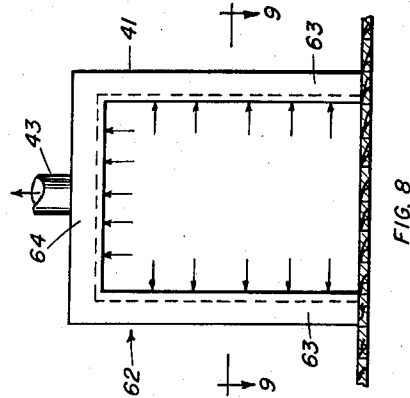


FIG. 8

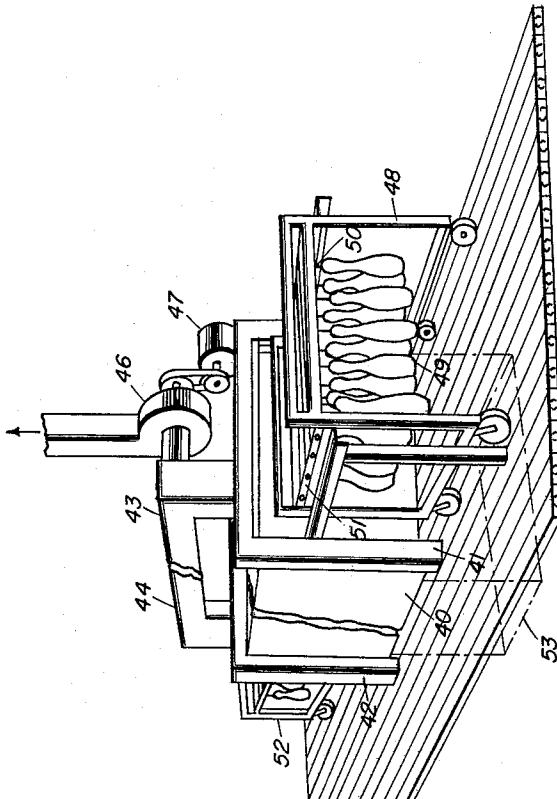


FIG. 6

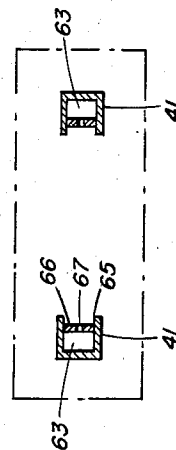


FIG. 9

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3,115,818

AIR CONFINED SYSTEM

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5 Claims. (Cl. 98—36)

This invention relates to an air exhaust system for preventing passage of gases, moisture, dust, insects or other contaminants, etc. from one space into an adjoining space which is open to the former for free passage of persons, materials and the like, and which does not require a door or other closure for this purpose.

In a more specific and preferred application the invention relates to an air confined unit, employing highly inflammable or explosive material, such as is located in a large continuous processing area and wherein the materials being processed are fed in at one end of the unit and after treatment are removed from the opposite end of the unit in a substantially continuous operation.

The use of an air "curtain" or air "seal" for building doorways as a replacement for conventional swinging or revolving doors to prevent the escape of heat from the building when outside temperatures are low or alternately to prevent the entry of hot air into air-conditioned buildings is known. There prior devices are relatively complicated and expensive and for at least these reasons the use thereof is frequently prohibitive. Generally these systems comprise a device which forces air across the door opening and which co-acts with an air entry arrangement positioned at the opposite side of the opening which draws in the air. To be effective, mechanisms must be installed to deal with significant pressure changes which occur in nature and with sudden and/or prolonged gusts of wind thereby further complicating such systems. These systems require a "dual" operation, i.e. one part of which must furnish forced air and the second which must exhaust the directed air, each located in a position such as to be capable of coordinating air into an air exhaust chamber under changing conditions. Two systems of this type are described in U.S. Patent Nos. 1,279,993 and 2,863,373, for example.

I have discovered a relatively simple, inexpensive and highly useful and efficient system which provides an atmospheric seal between two adjoining spaces in which it is necessary or desirable that an opening be maintained for the unrestricted passage of solid objects. In essence, the system comprises a frame at the threshold separation point of the two spaces, said frame having apertures and an air chamber therein through which the interstitial air within the frame threshold area between the enclosure and outside space surrounding the enclosure, is exhausted. When the exhaust mechanism is in operation, the effect is a barrier or continuous sheet of air drawn from the lower pressure space outside the room or enclosure. Because the system comprises solely an air exhausting mechanism, arrangements for furnishing forced air to the atmosphere and coordinating controls for removal of forced air are unnecessary.

The system of the present invention is most advantageous for use in a booth or enclosure situated in a continuous processing area, i.e. where materials treated undergo a series of operations, in which one or more steps require

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an operation best isolated from the larger process area and other steps in the process. The system, however, is also highly advantageous for separating the atmosphere in two adjoining rooms which open into each other one of which for example may house an operation creating a flammable or explosive atmosphere and the other of which may be a laboratory or the like in which open flames may be used. It is apparent that in the absence of an atmosphere isolating system such operations could not safely coexist in close proximity. It will be obvious that a variety of operations in a multi-step process are the type which are preferably or, must necessarily be, closed off or isolated from the surrounding area. Many reasons may require such isolation. For example, the operation in the "sealed off" area may utilize flammable, or explosive materials; or a carefully conditioned atmosphere of temperature and/or humidity or a saturated atmosphere of solvent vapors may be necessary to produce an acceptable product. Also, the presence or absence of noxious odors, toxic vapors, dust etc. may require, for employee safety comfort or for the carrying of other steps in the process, the complete detachment of a step from the process thereby substantially delaying the operation, requiring greater space and increasing cost. Another important advantage afforded by the invention when used to confine an area is the cost savings made by avoiding the need for explosion proof equipment outside of the isolated area.

It is the object of the present invention to provide an exhaust system, at the separation point of two adjoining spaces open to each other, capable of preventing passage of air from one space into the other.

It is a further and more specific object of the present invention to provide a system preventing passage of atmospheric gases from a defined area or room which is open to the surrounding space and which permits the unhindered traffic of solid objects therethrough without cross-contamination of adjoining atmospheres. Additional objects and advantages will become apparent hereinafter as a more detailed description of the invention proceeds.

The invention will be described in conjunction with the accompanying drawings which form a part of the application and in which:

FIG. 1 is a view of a framed threshold entry way leading into a closed space showing a portion of wall area with air passages and exhaust device exposed.

FIG. 2 is a sectional view of the threshold frame taken on the line 2—2 of FIG. 1.

FIG. 3 is a view of the threshold frame partially in section taken on the line 3—3 of FIG. 1.

FIG. 4(a), FIG. 4(b) and FIG. 4(c) are views of modifications of various air aperture constructions of the frame as they would appear taken as portions of the frame face shown in FIG. 3.

FIG. 5 is a view of a modified framed threshold entry way in the form of an arch.

FIG. 6 is a perspective view of materials treatment space in which explosive volatiles are utilized illustrating ingress and egress of objects being treated.

FIG. 7 is a top plan diagrammatic representation of the materials treating space of FIG. 6.

FIG. 8 is a front view of the ingress or egress frame threshold facing into the space of FIG. 6.

FIG. 9 is a sectional view of the threshold frame taken on the line 9—9 of FIG. 8.

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In the construction illustrated in FIG. 1 a threshold air intake frame 4 set in the wall 6 (shown in part only) defines, with the floor 7, the access opening to the space or room 8 from which ingress or egress of air is to be prevented. The frame 4, the cross section of which will be defined more in detail in connection with FIG. 2 comprises a substantially U-shaped basic member 5 which may have as an integral part thereof a wall securing extension 12. It will be understood that any suitable alternate construction which permits the exhaustion of air therethrough may be utilized for the frame member 4. In the embodiment shown the vertical air inlet chambers are designated by the numeral 10 and the horizontal chamber by the numeral 11. As the closure for the face of the U-shaped member 5 to form the air chambers 10 and 11, a channel closure member 13 provided with suitable apertures 15 is secured with the aid of a suitable gasket 14. As shown in FIG. 3 the air inlet aperture 15 comprises a series of slots arranged in two parallel rows. It will be apparent that a variety of other openings may be suitably used combining, where desirable, functional with decorative purposes. Shown in FIGS. 4(a), 4(b) and 4(c) are illustrative alternate air entry apertures. In FIG. 4(a) three rows of holes 29 are shown in staggered relationship in the channel closure member 26. A larger number of rows may be employed and in many applications even a single row of holes or a single slot may be adequate depending on conditions of use such as the operation being serviced, the size of the framed opening, the temperature and/or pressure differential between the space "sealed off," the surrounding area and the like. The modification of FIG. 4(b) illustrates a series of openings in the channel closure member 27 comprising slots 30 arranged to produce the effect of a herringbone design. FIG. 4(c) comprises two parallel rows of alternating slots 31 and holes 32 in the channel closure member 28.

Referring again to FIG. 1 an air exhaust device 19 (or other suitable apparatus) driven by a motor, not shown, expels air through the extension 20 which conducts the exhausted air to a scrubber not shown for removal of one or more components thereof or to the atmosphere is illustrated. As shown in FIG. 1 vertical conduits or ducts 16 and 17 and the horizontal duct 18 exhaust air which is drawn into the air chambers 10 and 11 through the apertures 15. The direction of air flow into the chambers and through the conduits is shown by the arrows. The exhaustion of the interstitial air through the apertures 15 is such as to produce a seal or barrier across the threshold area defined by the frame 4 and floor 7, effectively preventing exchange of atmosphere between the two adjoining spaces.

The illustration presented in FIG. 1 employs a 3-duct system which may have the respective conduits coordinated or balanced to regulate the quantity of air removed by the respective conduits. It will be apparent that for some applications a four sided exhaust arrangement may be used or a less elaborate exhaust unit than that illustrated may be adequate. Accordingly the exhaust provided by side ducts 16 and 17 through vertically disposed air chambers alone may be adequate. These two ducts may service the horizontal chamber 11 or alternately the air chamber 11 may be blocked or avoided entirely.

Another modification is one in which a two-sided (top and bottom) exhaust system may be employed. In such a unit the air from the threshold area is removed through vents in the horizontal member above the opening and through vents (not shown) positioned in the floor. In other application vents exhausting air at the top only of the rectangular frame separating the two adjoining spaces may be adequate.

When accurate control over the pressure differentials between the two spaces to be separate is desirable, a differential pressure gauge system or any differential pressure sensing device such as an aneroid velometer or manometer 22 outside the chamber or enclosed space 8 may be

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employed to assure the maintenance of the desired pressure differences. Manual or automatic means may be used to make adjustment for appropriate pressure differences. For this purpose, for example, a servomotor electrically or pneumatically connected to the sensing element may be employed to vary the air volume removed through the exhaust unit. Alternately an air flow control valve or baffle operated by a servomotor may be utilized to regulate the quantity of air exhausted by an exhaust mechanism driven at a constant rate. Another means for varying the volume of air withdrawn by a constant driving unit is pulley or clutch variable drive arrangement, pneumatically or electrically controlled.

The shape of the framed threshold area from which air is exhausted and through which admittance to the sealed off space is arranged may be a conventional rectangular design or may have any suitable shape which includes functional and, optionally, esthetic features. In FIG. 5 an arcuate shaped threshold frame 33 exhausting by suitable arrangement as through conduit 34 separating an inside space 36 from the surrounding outer area is illustrated. This structure may have the frame of cross-section substantially that illustrated in FIG. 2 or it may comprise other suitable construction. Air may be exhausted from the threshold area by a continuous aperture or a plurality of apertures around the full inside periphery of the frame 33 or from a portion of the peripheral distance, e.g., in the areas shown by brackets 38 and 39. Alternately air may be withdrawn at either the vicinity of 38 alone or the areas covered by brackets 39.

Referring to FIG. 6 of the drawing a specific and preferred application of the inventive system in which a treating room, space, booth, or open-ended enclosure or tunnel arrangement, which may comprise, for example, one step among a multi-step processing operation is described. In the process of finishing bowling pins, to provide a more specific illustration, at least 2 separate steps among others are employed in which highly flammable materials are used. One is the application of a sealer coat in which the volatile composition is sprayed over the bowling pins. The structure illustrated in FIG. 6 is representative of a unit for applying this sealer coat. Another operation is that of applying a heavy gel white protective coat, a step which utilizes a dip tank. The construction of a gel coating unit differs from that shown in FIG. 6 for the spray unit only to the extent as to more appropriately accommodate a dip tank. A suitable arrangement comprising a dip tank and air exhausting ingress and egress frames may be constructed with obvious modifications from the teachings of FIG. 6 so as to permit a dipping of articles. As shown by the broken line in FIG. 6 a tank 53 may be recessed in the floor. Alternately the entry to the sealed space for a unit accommodating a dip tank may be elevated thereby accommodating the dip tank above floor level. In another modification of the system, the tank may be elevated to coat the pins and then retracted. In any event the preferred procedure for applying the gel coat is by dipping. Among the volatile constituents which may be employed in such process steps are acetone ethyl acetate, ethyl alcohol, toluene, xylene, naphtha and ethylene glycol monoethyl ether, for example.

Referring in greater detail to FIG. 6 a detachable bowling pin supporting rack 51 carried by any suitable arrangement such as a movable carriage 52 is shown at the ingress end of the treating space 40. The bowling pins 49 are supported on the rack 51 by means of dowels 50. At the egress end of the unit 40 a like portable unit 52 (shown in part) is in the process of coming out of the enclosure 40. It will be apparent that the rack supporting the pins may be supported instead on a continuous track passing through the treating area as one of the treatments of a multi-step continuous operation serviced by the track. The unit 40 comprises an ingress air intake frame 41 and, at the opposite end of the enclosure, an egress air

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intake frame 42. The air is exhausted from the threshold ingress and egress areas into air inlet chambers located in the frames 41 and 42 through air holes 67 shown in FIG. 9. The air is drawn in from the holes into the inlet chambers and then into the conduits 43 and 44 by the action of the exhaust unit 46 which is actuated by the motor 47. The result is, in essence, a "curtain" or barrier between the two spaces effected by removal of the interstitial air through the frame separating the two spaces.

FIG. 7 illustrates a pair of differential pressure gauges 54 and 55 connected through the electric equilibrium control unit 58 utilized to effect a constant adjustment of the volume of air removed from each end of the enclosure 40. When the pressure is greater outside and adjacent to the ingress end of the unit than it is at the egress end of the unit, the air flow control valve 60 actuated by the servomotor 57 responding to the impulse from the equilibrium electric control unit 58, admits more air while the valve 59 actuated pneumatically or electrically by a suitable device such as an air pneumatic positioner or servomotor 56 diminishes the quantity of air exhausted to the extent that equilibrium is reestablished. If desired a system completely pneumatic may be utilized to maintain the requisite control.

FIG. 8 is a front view of the frame of the device shown in FIG. 6 comprising a rectangular air intake threshold frame 62 having the vertical air inlet chambers 63 and a horizontal air inlet chamber 64.

FIG. 9 illustrates the cross-sectional arrangement of the air intake frame 62 and the slotted aperture 67 through which the air is exhausted from the threshold seen therein. The frame 62 comprises a substantially U-shaped basic member having a spacer member 66 which contains the aperture holes 67 positioned slightly inside the U member and leaving a slight protrusion or lip 65. The frame may be secured in any convenient way such as by brackets at the base fastened to the floor.

The advantageous features of the invention are further illustrated by the following examples in connection with the system represented by FIGS. 6 through 9 of the drawings. The examples are presented in order to provide a more thorough understanding of the invention and its advantageous features; the specific recitation of details therein should not be interpreted as a limitation on the invention except as such limitations are expressed in the appended claims. In these examples, the system of the invention is described in connection with an arrangement which precludes explosive conditions in an atmosphere accessible to explosive vapors. It will be apparent that the system herein described in connection with isolating flammable vapors, may be adapted to isolating or sealing off a space in which toxic or noxious fumes are used. In the examples, the safety limits of vapors are referred to as the lower explosive limit and the upper explosive limit. Within the lower and upper limits a potentially explosive atmosphere exists. A lower explosive limit as used herein is the maximum amount of volatile or explosive vapor which may be contained in the atmosphere before combustion will occur. Below the lower explosive limit, there is insufficient flammable vapor or gas in the air to support combustions. As general rule, insurance underwriters require that 25% of the lower explosive limit not be exceeded in an area not equipped with explosive proof switches, motors, machinery etc. The upper explosive limit is that point above which combustion will not occur, i.e. there is a maximum amount of vapor in the atmosphere and if further increased the amount of oxygen present will be insufficient to support combustion.

In considering lower and upper explosive limits it will be apparent that in housing an operation which employs a potentially dangerous vapor it would be extremely desirable from a safety standpoint to stay either below the lower explosive limit or to exceed the upper explosive limit. Each situation is a safe one. By use of the exhaust system of the invention it is possible to provide an en-

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closure containing an atmosphere saturated with explosive or flammable vapor and above the upper explosive limit and, immediately adjoining this enclosure, to have a space open to it which is below the lower explosive limit. As such both atmospheres are in a safe condition.

In testing the efficiency of the air exhaust seal of the system at the threshold points (ingress and egress) an explosion meter commercially available from Mine Safety Appliances Co. was employed. Various other instruments are commercially available and may be adapted for this purpose. In general the principle of the device may be described as follows: one of a pair of identical filaments sealed in an inert atmosphere is connected by an electrical bridge to a second filament which is exposed to the atmosphere in question. In an inert atmosphere the filaments are in equilibrium. As the gas in the atmosphere, to which the second filament is exposed, is enriched with flammable vapor, the gas is burned changing the resistance of the hot filament proportionately with the heat produced by the combustion. The change is recorded by an indicator dial.

Example 1

Bowling pins are treated with a sealer-coater composition comprising ethyl acetate, toluene and ethyl alcohol within an apparatus substantial that shown by, and described in connection with FIG. 6. The exhaust system is started and air is evacuated at the frames 41 and 42. A reading inside the unit both at the ingress and egress ends is well in excess of the upper explosive limit. A reading at the ingress end immediately outside the frame 41 of FIG. 6 records a value of less than 5% of the lower explosive limit and at the discharge end immediately outside the frame 42, a zero reading on the lower explosive limit is recorded. When the exhaust mechanism is shut off and treatment of the pins continued, the reading recorded within a period of less than five minutes at both the ingress and egress end is in excess of 90% of the lower explosive limit, a condition considered clearly dangerous.

Example 2

A similar test was conducted on a gel dipper operation in which the bowling pins are lowered into a gel lacquer composition comprising xylene, naphtha, and an ethylene glycol monoethyl ether. The temperature inside the unit is approximately 200° F. This operation requires a saturated atmosphere above the coating composition and an absence of drafts during the coating and subsequent removal of the pins from the dip tank. Unless these conditions are obtained, the gel coating dries too rapidly producing blushing and wrinkles on the finish. Also undesirable scum forms at the top of the gel coating composition due to substantial evaporation of solvent from the surface of the gel. When the air exhausting frame is not in operation, blushing and wrinkling of the coating is readily noticeable on the pins. The change in solubility by the rapid evaporation of solvents from the pin surface when the coated pins are lifted from the gel composition produces a distinct surface skin on the gel coat. The temperature loss from the enclosure is also significant when the air exhaust is shut off. After the exhaust was shut down for less than 15 minutes the temperature exceeds 180° at both the ingress and egress points immediately outside the unit ingress and egress points. With the air evacuation through the frames inactive for 10 minutes, explosion meter recordings at the ingress and outside the enclosure and immediately adjacent to the frame exceeds 80% of the lower explosive limit; at the egress end immediately adjacent the frame and outside of the enclosure the reading is in excess of the lower explosive limit, i.e. exceeds 100% of the lower explosive limit. When the system of the invention is operated so as to exhaust the ingress and egress threshold points, the temperature at the ingress adjacent to the frame is below 90° F. and at the egress end adjacent to the frame it is below 95° F.

The reading on the explosion meter at the ingress end is less than 8% of the lower explosive limit, and at the egress end, below 10% of the lower explosive limit.

In an operation requiring the use of large open vats or tanks such as that described in Example 2 where a thick lacquer gel layer is applied, carefully controlled conditions are essential. The coating composition homogeneity depends on maintaining an equilibrium in the gel which is rich in solids and near a minimum in solvent. With these compositions, temperature must be kept within a fairly narrow range. Drafts produce a skinning effect at the top of the gel solution which will cause an uneven coating on the dipped articles. Skinning at the surface of the composition can be avoided only by keeping the lacquer container covered, a condition which is inconvenient and time consuming during operations, or by keeping a solvent rich atmosphere above the solution. The system of the invention provides an ideal remedy for this delicate equilibrium problem by keeping the atmosphere above gel lacquer solvent rich and by isolating this explosive atmosphere from adjoining working spaces.

In an operation of this type it is important that a certain critical viscosity be maintained in the coating composition. Because of the relatively low proportion of solvent in the composition evaporation of even minor amounts of solvents from the gel solution produce an increase in the percent solids and consequently an increase of viscosity rendering the gel lacquer unusable.

The saturated atmosphere discussed hereinabove has another function. In addition to preventing skinning on the surface of the composition in the container, the existence of highly saturated atmosphere into which the coated articles may be raised is important, a saturated atmosphere permits the use of a relatively heavy coating which would not otherwise be possible. If atmospheric conditions are such as to effect a rapid drying at the surface of the article immediately after it is raised out of the composition, the rapid formation of a hard shell or skin at the surface while the bulk of the coating remains fluid beneath adversely affects the uniformity of the finish. The fluid below the surface flows and produces unevenness and substantial sagging of the lacquer before it can set in a uniform layer.

In the use of the system of the invention herein described it may be desirable in some installations to employ in conjunction therewith a safety door to be automatically closed between the open spaces in the event of failure of the exhaust mechanism. Any of the various arrangements, including combination with an audio and/or visual alarm, such as an electromagnetic-link or solenoid actuated catch which releases the door may be used. To assure full closing of the door spring pressure or gravity means may be used.

I claim:

1. An apparatus comprising a chamber for preventing passage of air from the chamber, said chamber having an exposed ingress and an exposed egress and being situated in a surrounding room open to, and allowing free passage of solid articles therethrough, said chamber having its ends open and having a hollow frame extending around the sides and top of each opening, air intake apertures spaced within the periphery of said frame and directed toward the opening to allow withdrawal of air from at least a substantial portion of the inner peripheral distance of the face of said frames, a header duct communicating with said hollow frames, an air exhausting device connected by an air passage with said header duct, damper means in said header duct adjacent to each hollow frame for coordinating the quantity of exhaust drawn from said apertures at the ingress and egress of said chamber to maintain equilibrium in said chamber, and actuating means for operating said air exhausting device to continuously withdraw air through said apertures into said hollow frames and header duct and to direct said air to the exterior of said surrounding room.

2. An apparatus comprising a chamber for preventing passage of air from the chamber, said chamber having an exposed ingress and an exposed egress and being situated in a surrounding room open to, and allowing free passage of solid articles therethrough, said chamber having its ends open and having a rectangular hollow frame extending around the sides and top of each opening, air intake apertures spaced within the periphery of said frame and directed toward the opening to allow withdrawal of air from the upper horizontal and two vertical faces of said frames, a header duct communicating with said hollow frames, an air exhausting device connected by an air passage with said header duct, damper means in said header duct for automatically coordinating the quantity of exhaust drawn from said apertures at the ingress and egress of said chamber to maintain equilibrium in said chamber, and actuating means for operating said air exhausting device to continuously withdraw air through said apertures into said hollow frames and header duct and to direct said air to the exterior of said surrounding room.

3. An apparatus comprising a chamber for preventing passage of air from the chamber, said chamber having an exposed ingress and an exposed egress and being situated in a surrounding room open to, and allowing free passage of solid articles therethrough, said chamber having its ends open and having a rectangular hollow frame extending around the sides and top of each opening, air intake apertures spaced within the periphery of said frame and directed toward the opening, to allow withdrawal of air from the two vertical faces of said frames, a header duct communicating with said frames, an air exhausting device connected by an air passage with said header duct, damper means in said header duct adjacent to each hollow frame coordinating the quantity of exhaust drawn from said apertures at the ingress and egress of said chamber to maintain equilibrium in said chamber, and actuating means for operating said air exhausting device to continuously withdraw air through said apertures into said hollow frames and header duct and to direct said air to the exterior of said surrounding room.

4. An apparatus comprising a chamber for preventing passage of air from the chamber, said chamber having an exposed ingress and an exposed egress and being situated in a surrounding room open to, and allow free passage of solid articles therethrough, said chamber having its ends open and having a substantially rectangular hollow frame extending around the sides and top of each opening, air intake apertures spaced within the periphery of said frame and directed toward the opening in the upper horizontal face of said frames to allow withdrawal of air through said frames, a header duct communicating with said hollow frames, an air exhausting device connected by an air passage with said header duct, damper means in said header duct adjacent to each hollow frame for coordinating the quantity of exhaust drawn from the ingress and egress apertures to maintain equilibrium in said chamber, and actuating means for operating said air exhausting device to continuously withdraw air through said apertures into said hollow frames and header duct and to direct said air to the exterior of said surrounding room.

5. A chamber having its ends open and adapted to be situated in a room and through which articles are passed for treatment, said chamber comprising an entrance at one end and an exit at the other end of said chamber, a hollow frame extending around the sides and top of each open end defining the entrance to said chamber and a second frame defining the exit to said chamber, said frames containing air exhausting apertures in the inner face of said frames directed toward the opening, a header duct communicating with said hollow frames, an air exhausting device connected by conduits to said header duct, damper means in said header duct adjacent to each hollow frame, and an actuating mechanism for operating

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said air exhausting device to exhaust air continuously through said apertures into said frames and header duct from the area contiguous to said entrance and said exit and to direct said air to the exterior of the room in which said chamber is situated.

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