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(54) **SOLAR AIR-HEATING SYSTEM**

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(52) **U.S. Cl.** **126/652**; 126/663

(57) **ABSTRACT**

A roof-mounted solar air-heating system containing a solar absorber with at least one air manifold integrated structurally with the solar absorber to effect improved heat transfer efficiency and airspeed. The improved airspeed in combination with integrated air entrance and exit tubes improves solar-heated air displacement and temperature de-stratification in buildings without need for tie-in to other ventilation equipment.

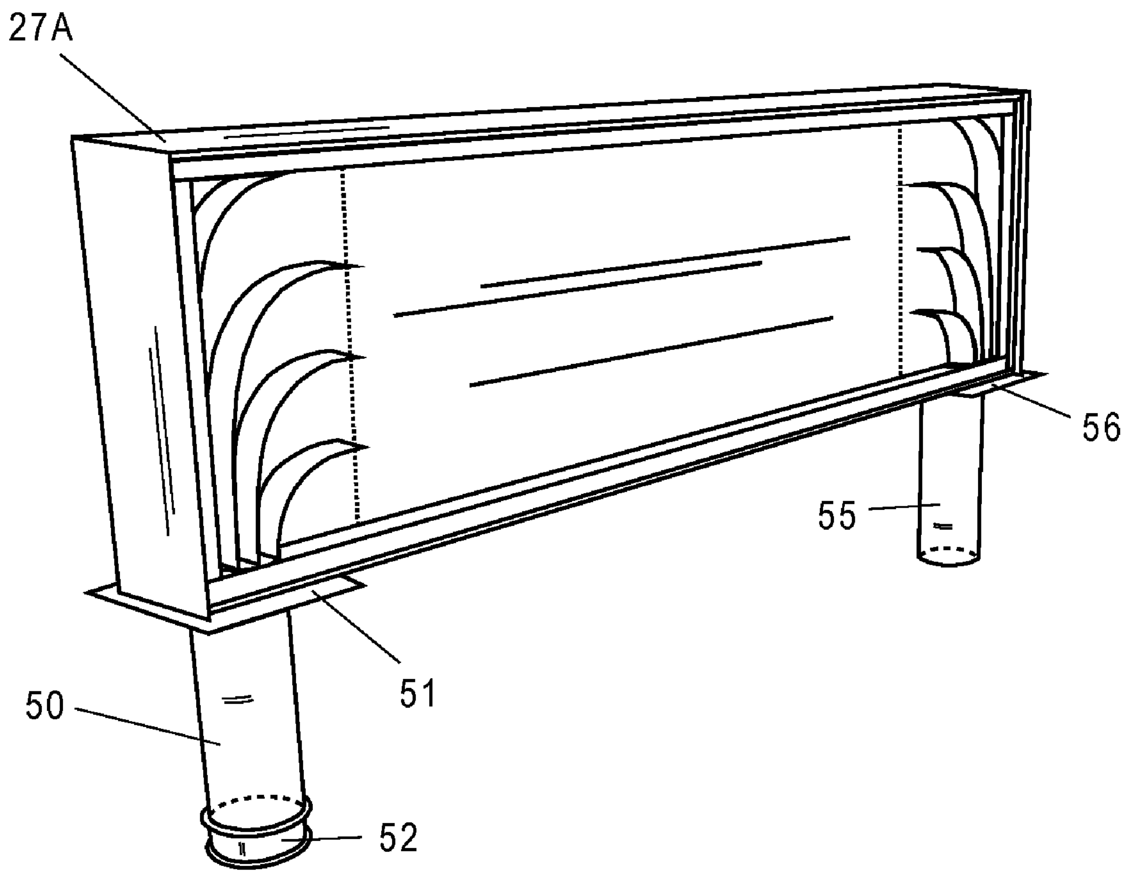


FIG. 1

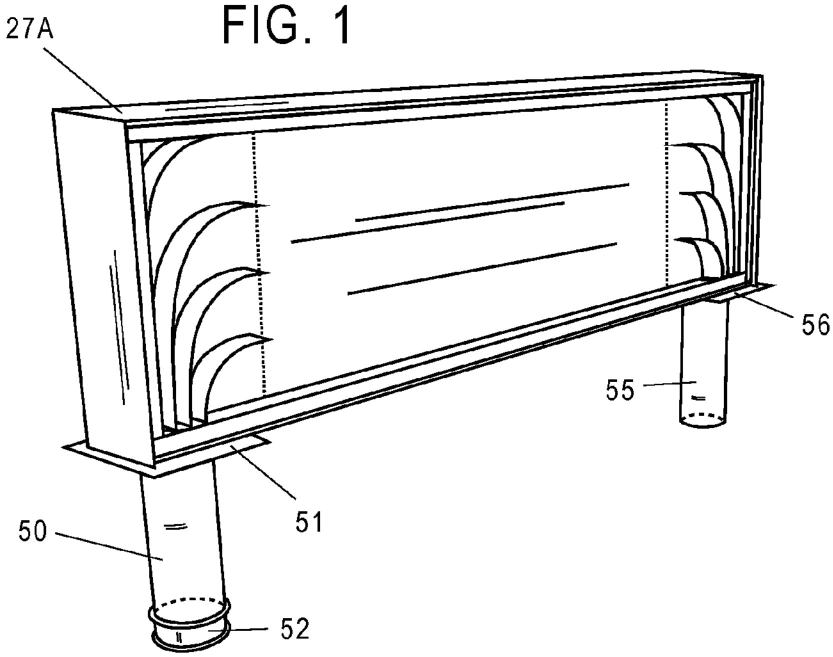


FIG. 2

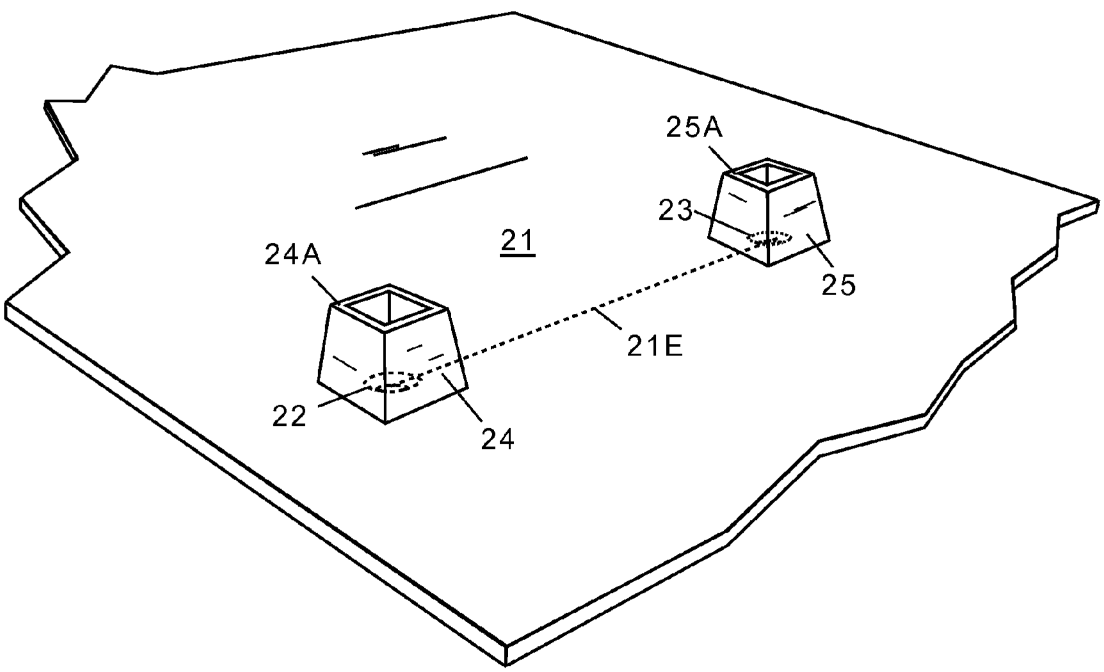


FIG. 3

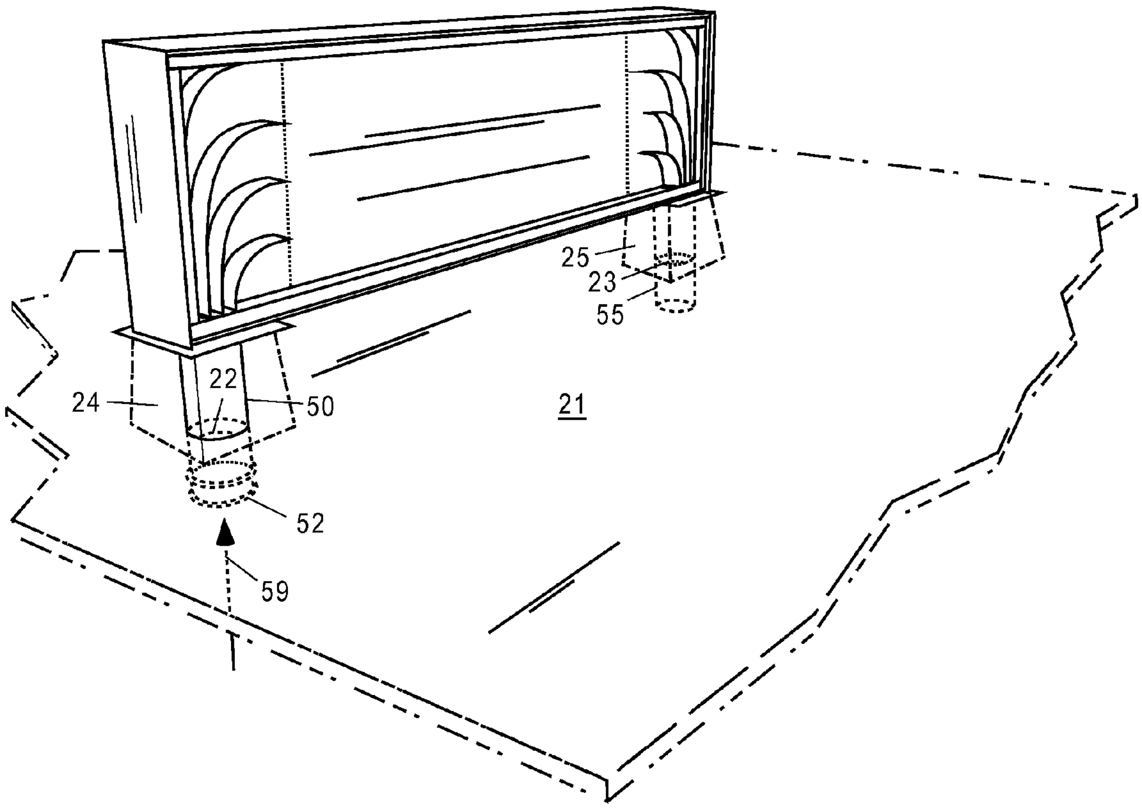


FIG. 4

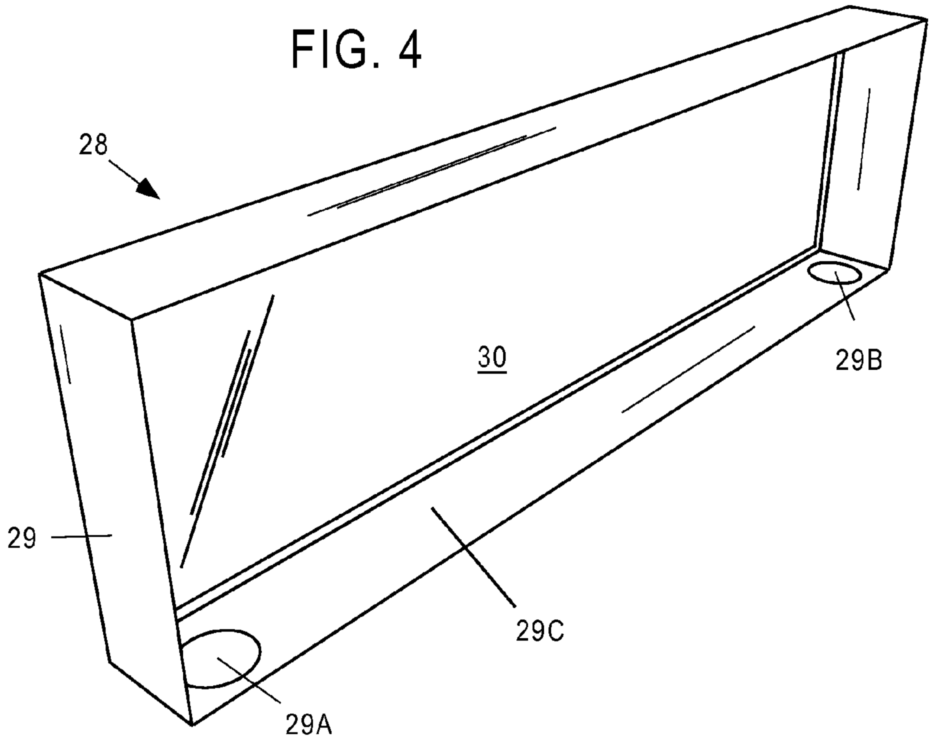


FIG. 5

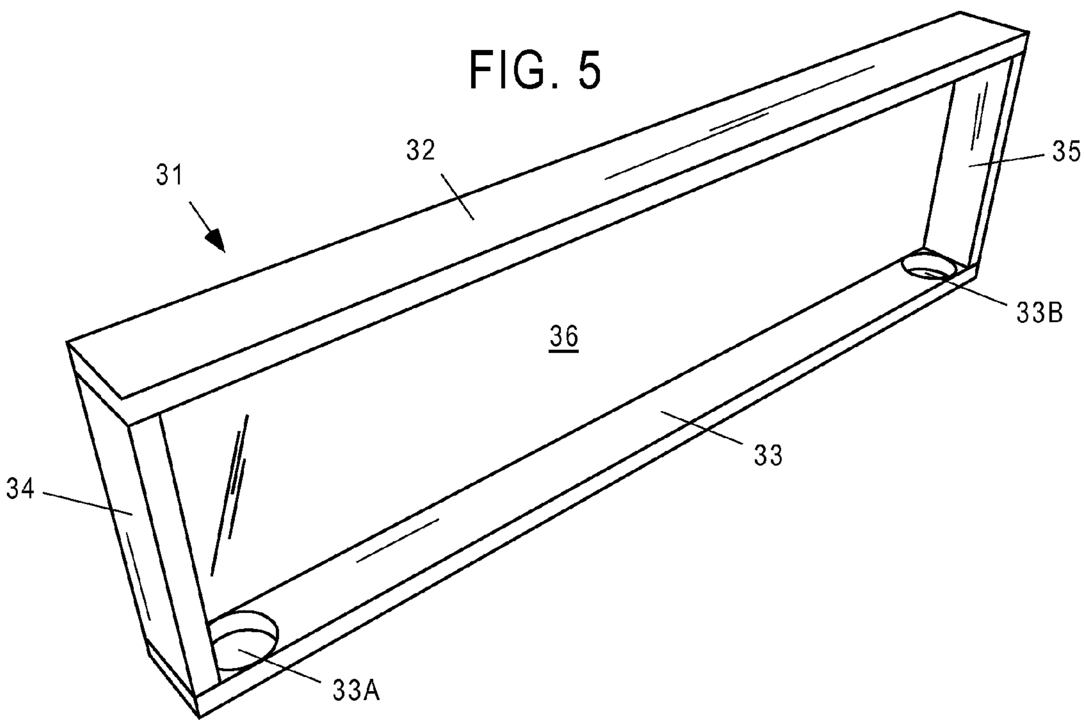


FIG. 6

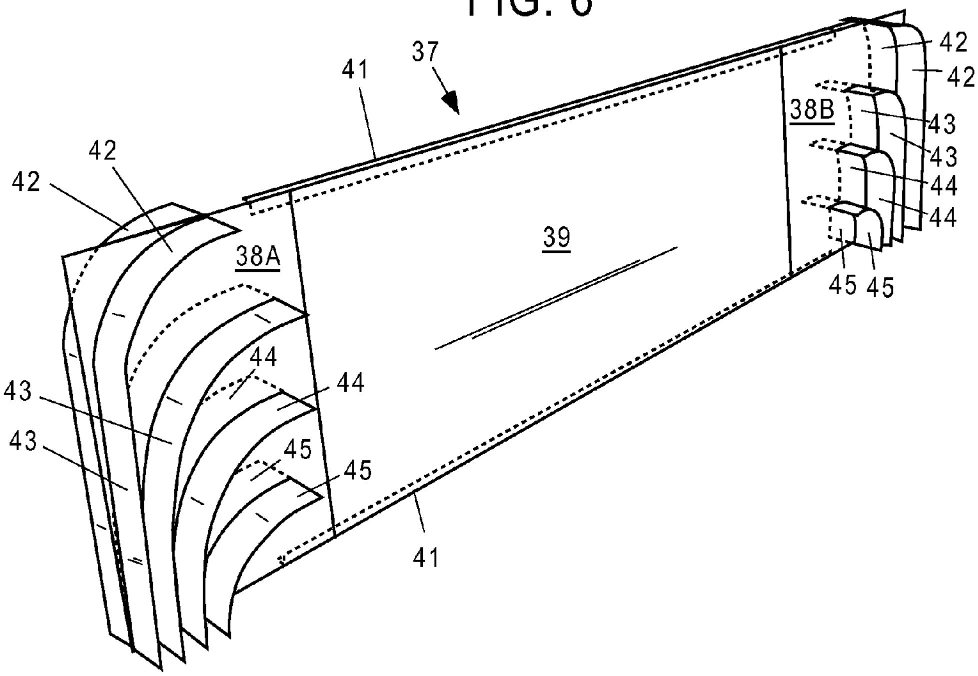
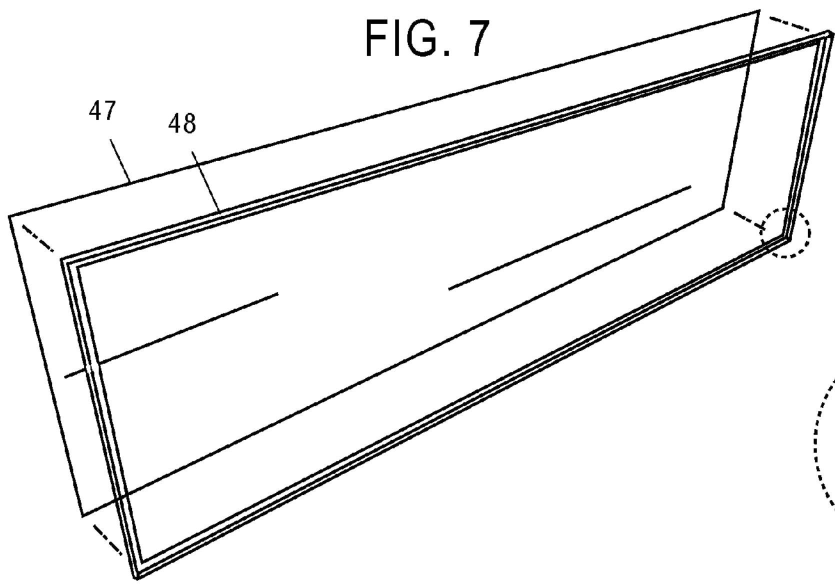


FIG. 7



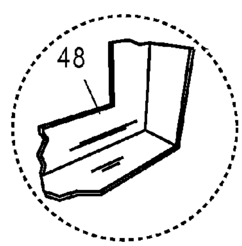


FIG. 8

FIG. 9

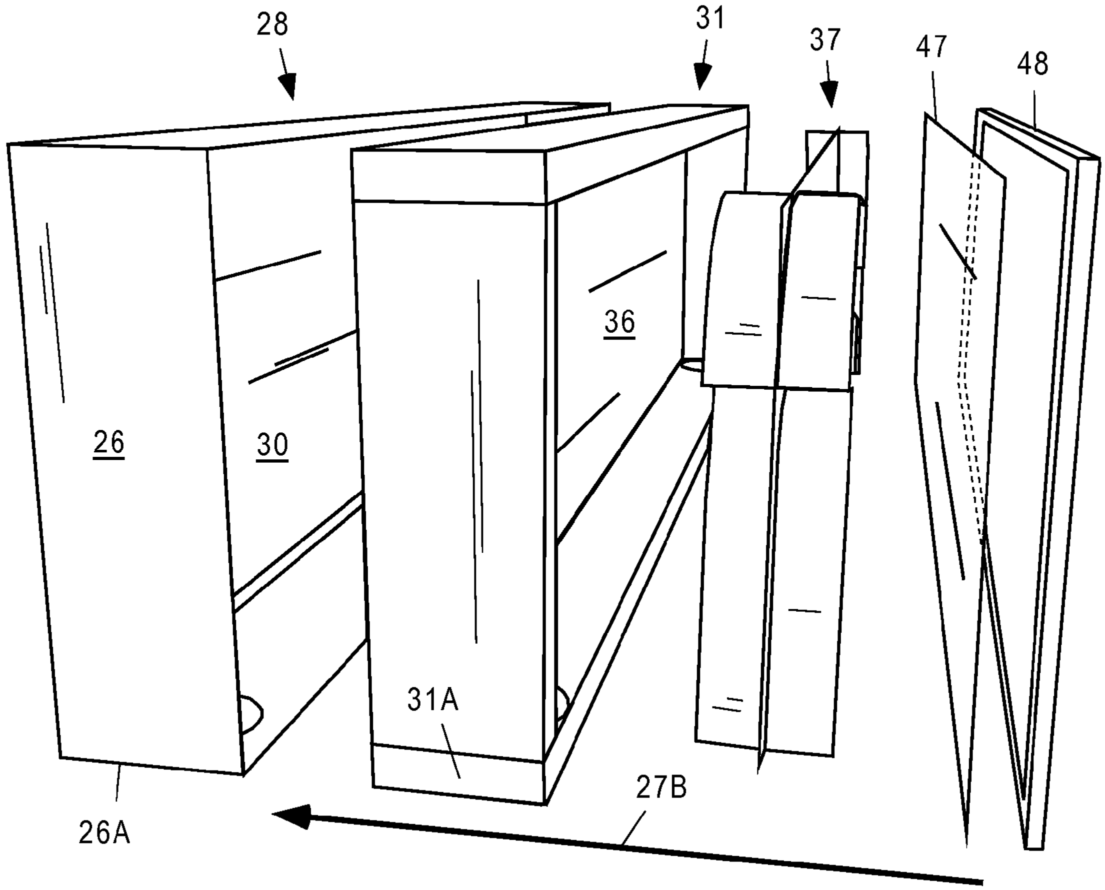


FIG. 10

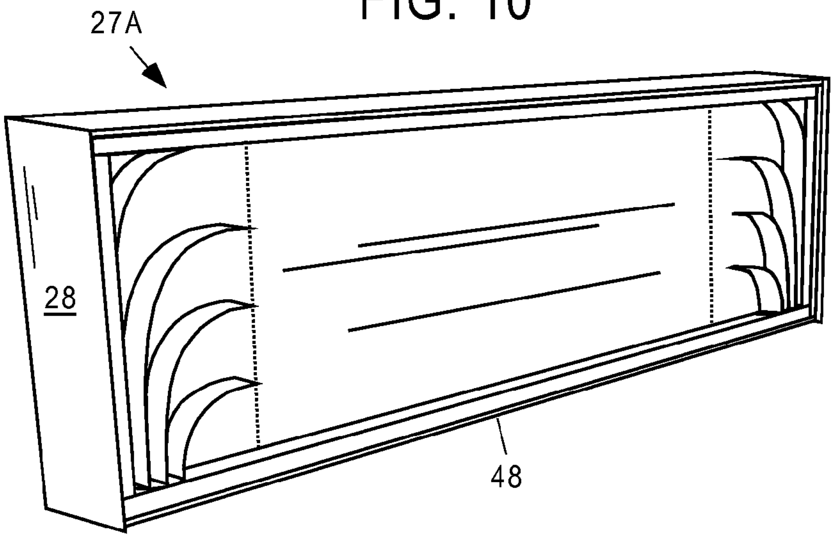


FIG. 11

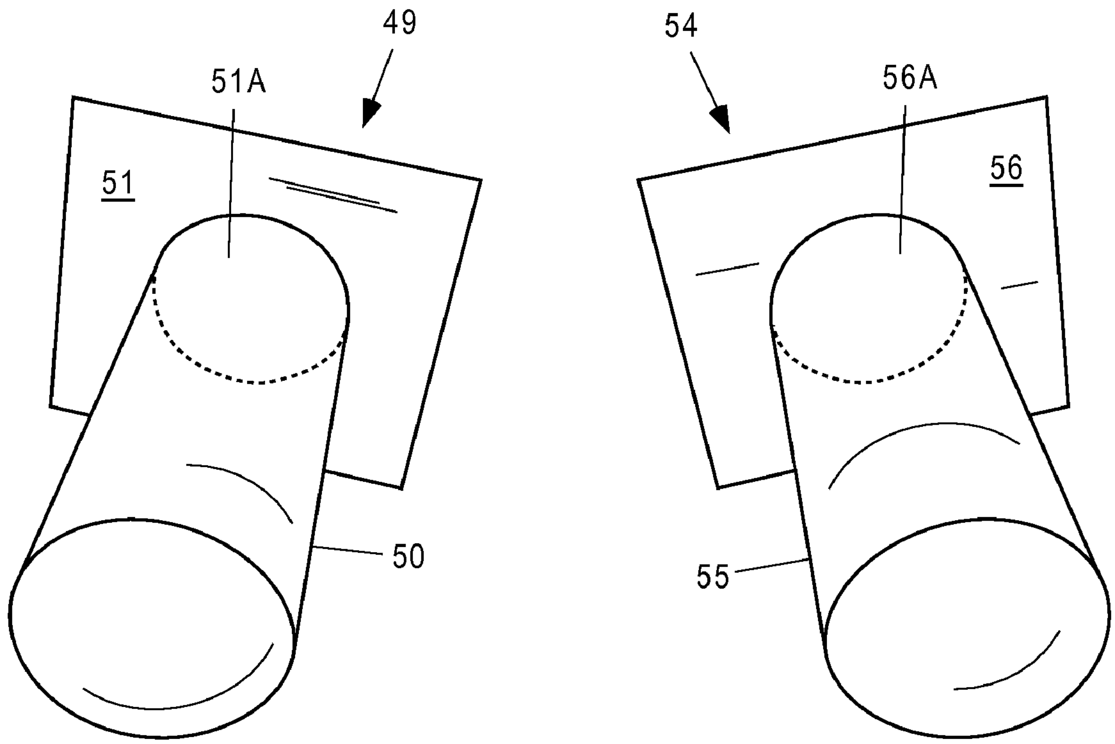


FIG. 12

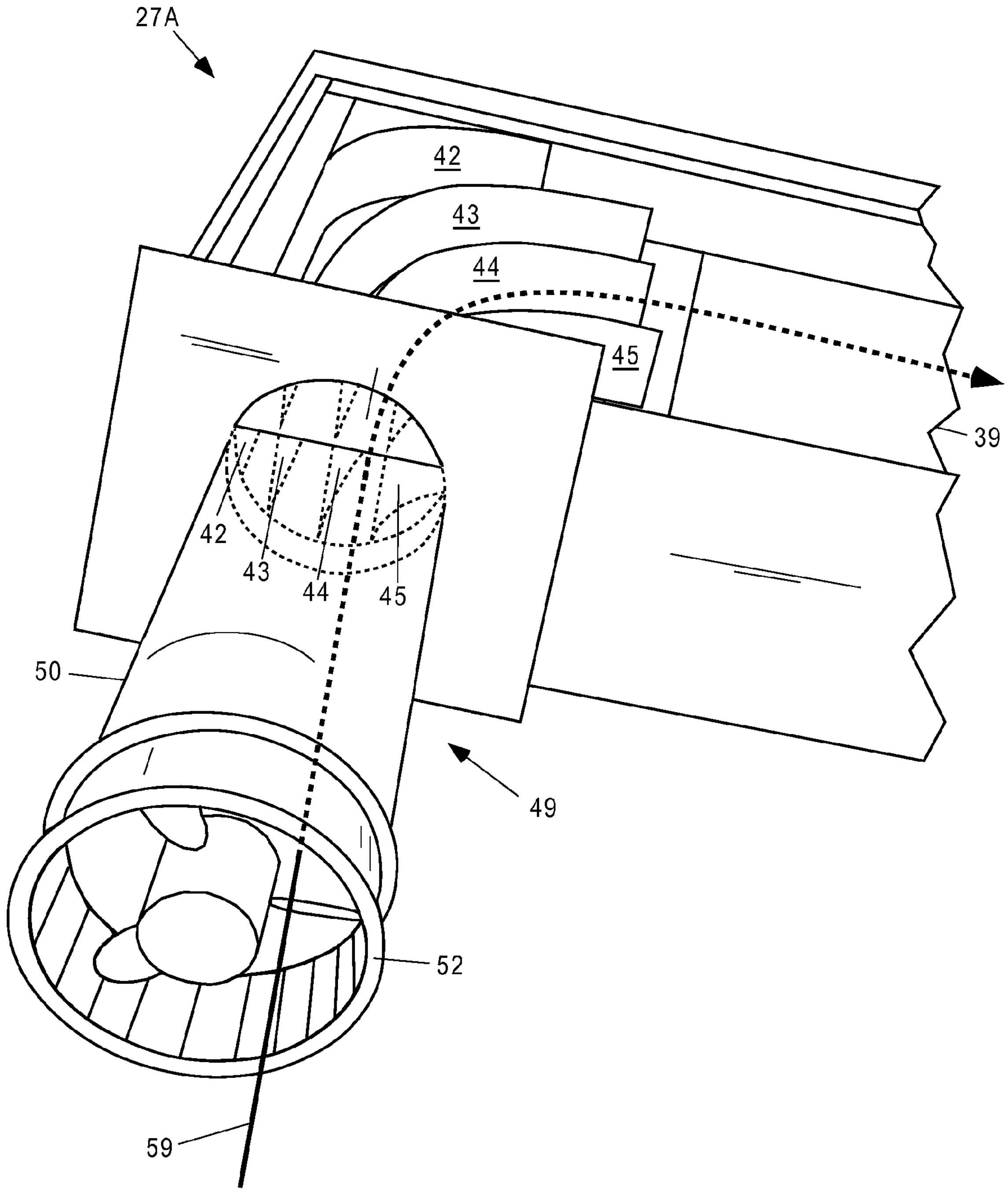


FIG. 13

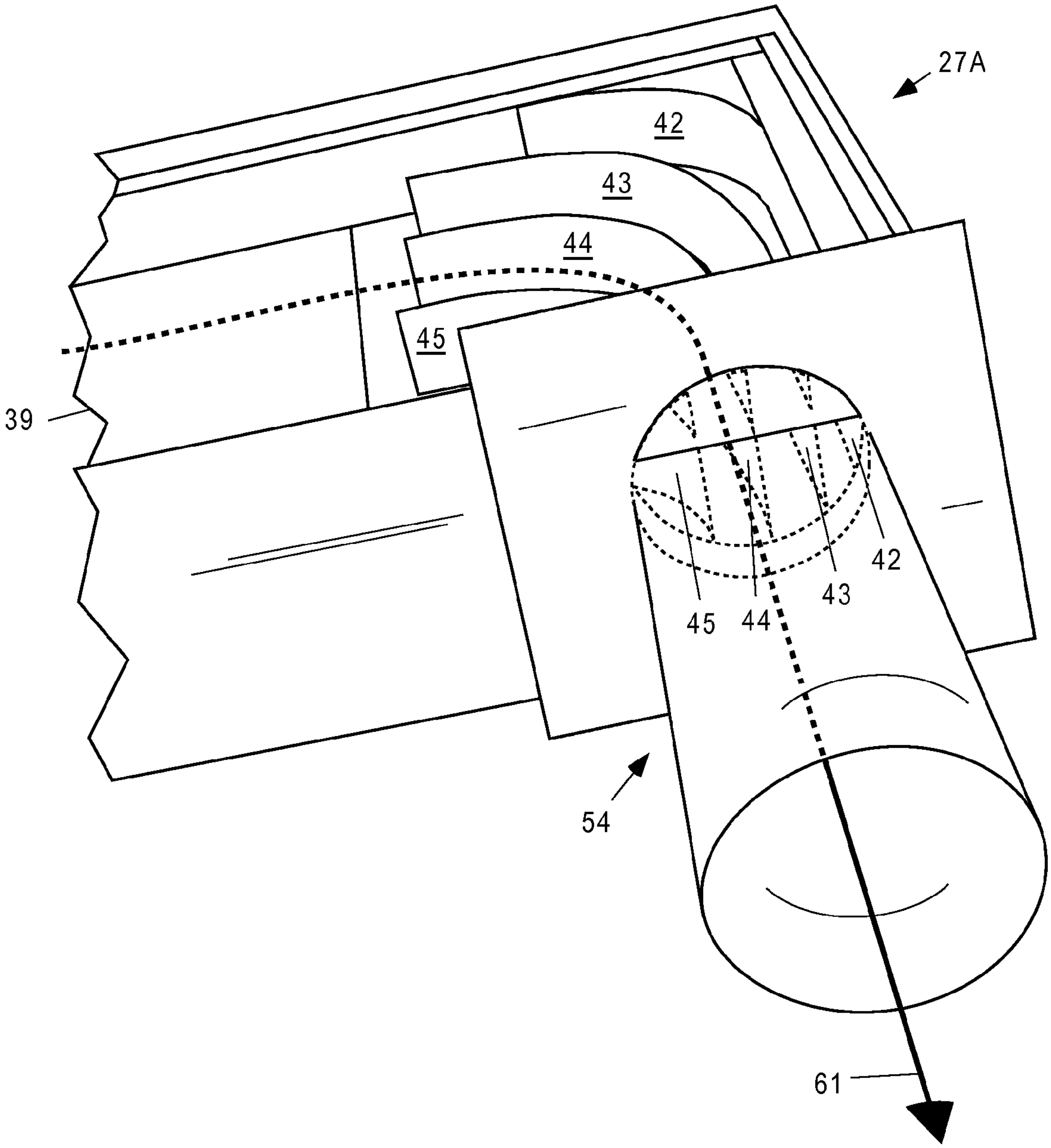


FIG. 14

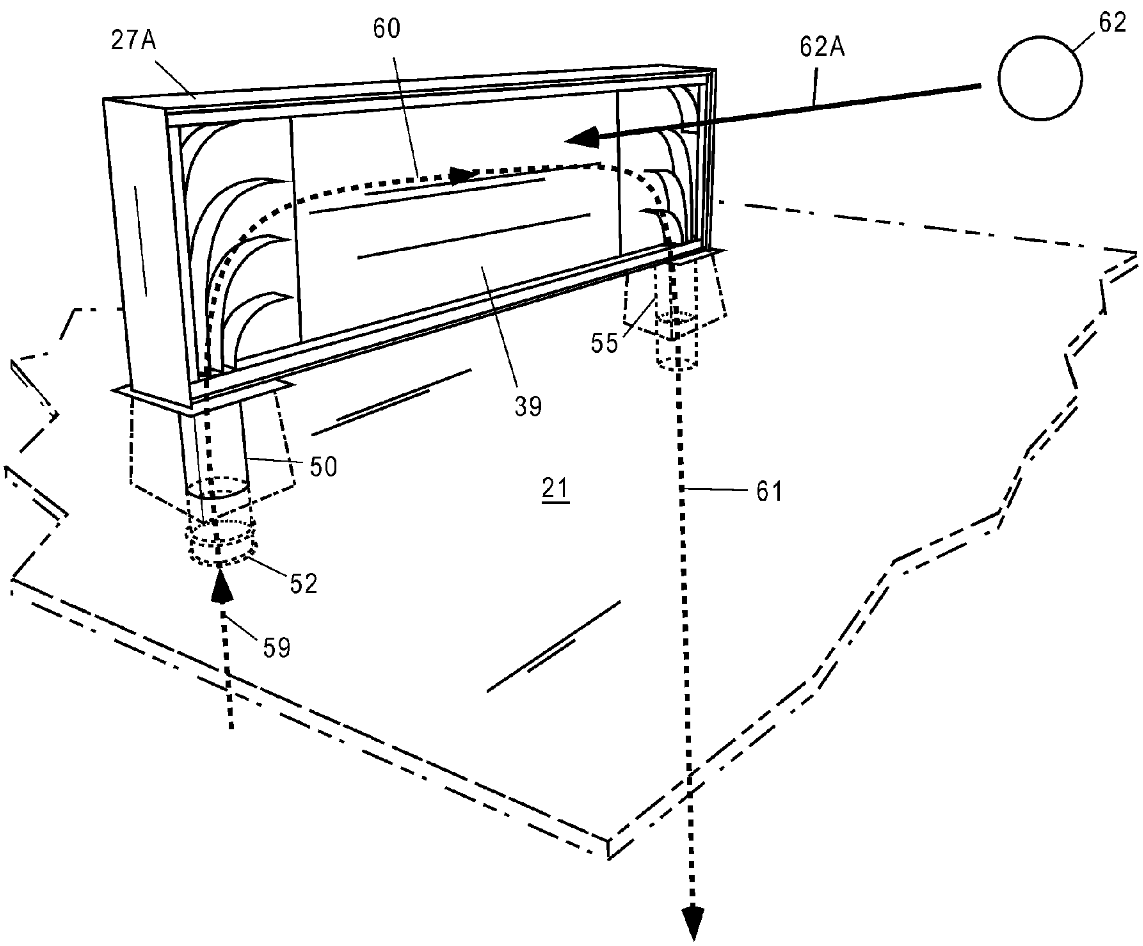


FIG. 15

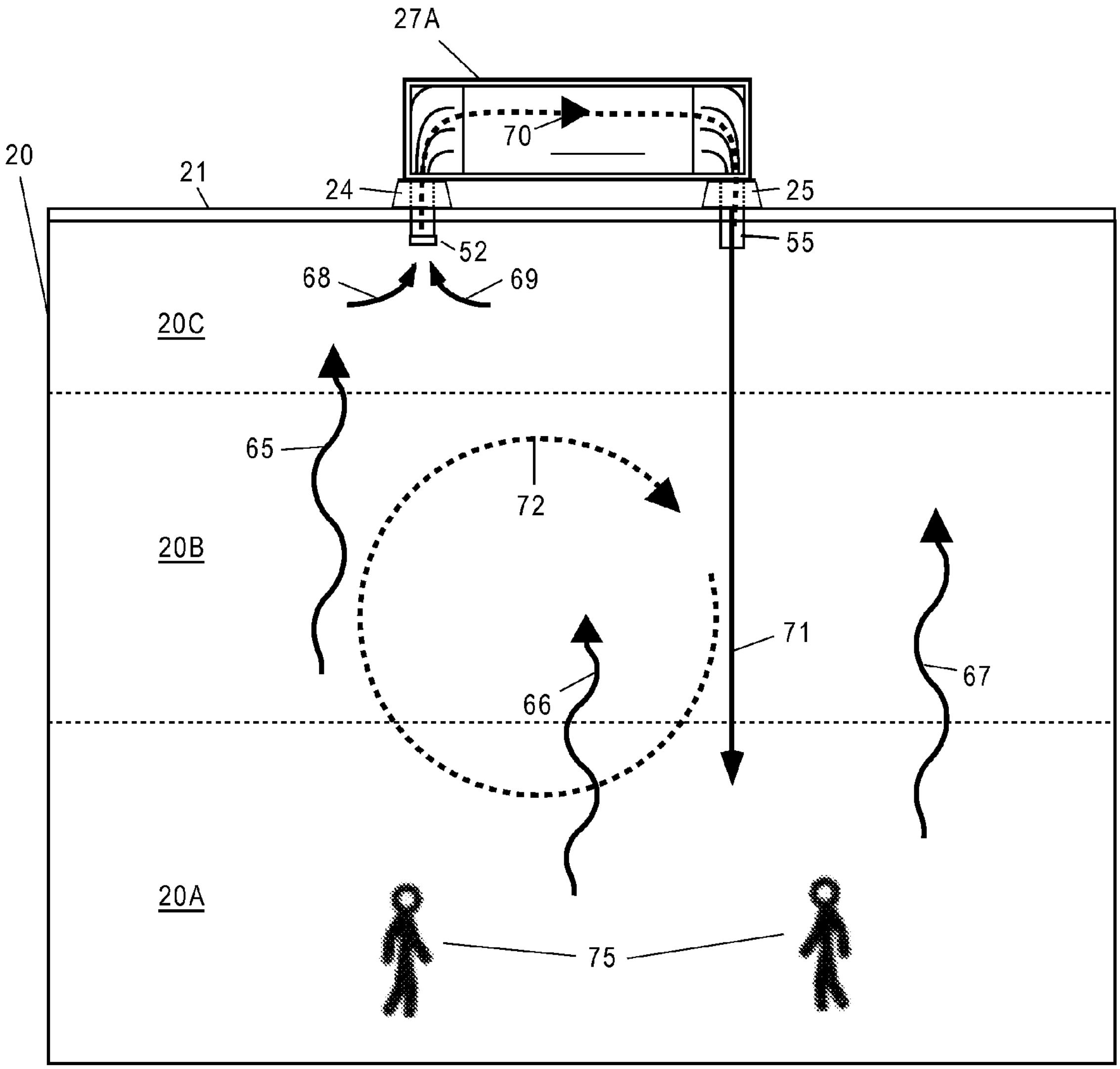
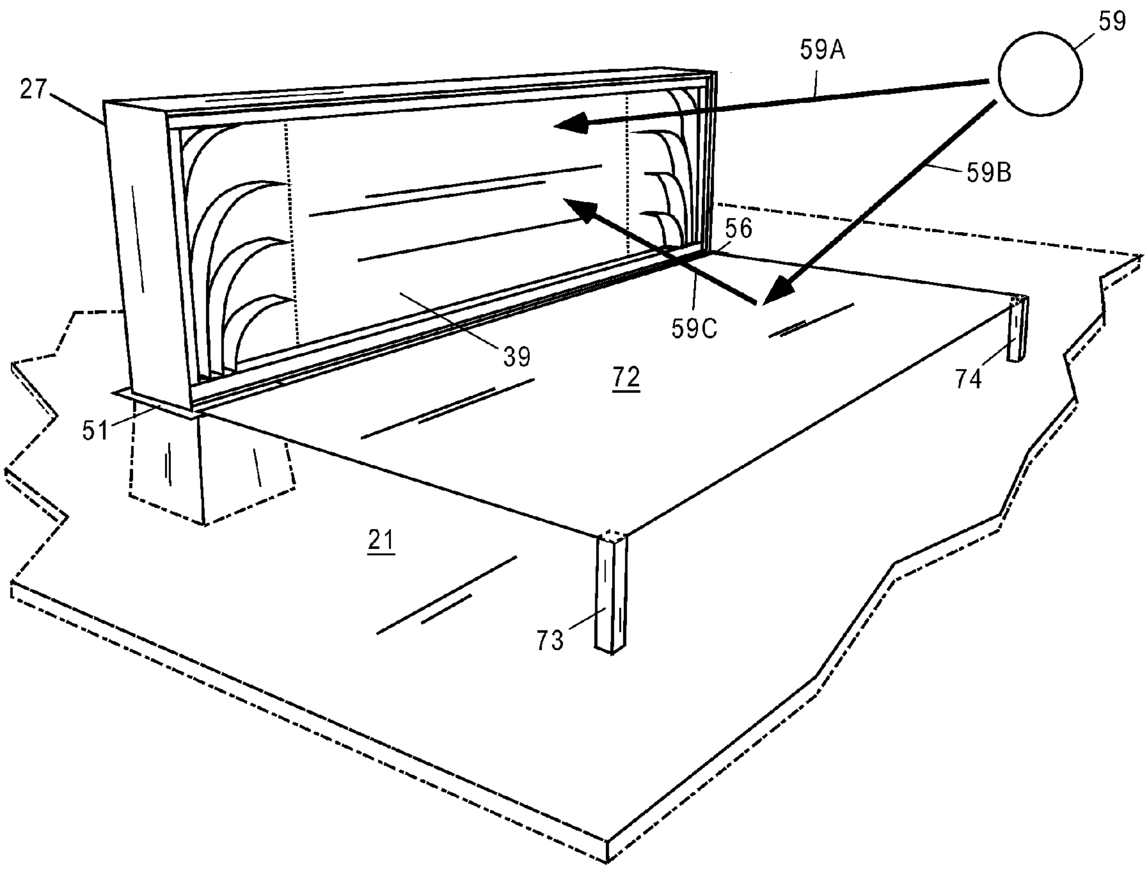


FIG. 16



SOLAR AIR-HEATING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of PPA application No. 61/021,984, filed Jan. 18, 2008 by the present inventor, which is incorporated by reference.

FEDERALLY SPONSORED RESEARCH

[0002] Not Applicable

SEQUENCE LISTING OR PROGRAM

[0003] Not Applicable

BACKGROUND OF THE INVENTION

[0004] 1. Field of the Invention

[0005] This invention generally relates to solar heating systems, specifically where heating is effected by air medium.

[0006] 2. Prior Art

[0007] Glossary of Terms:

Air plenum: An air containment structure.

Building: Man-made roofed structure encompassing an open or closed space.

Collimated: Alignment of air movement in one consistent direction.

Communicating: Allowing air flow.

De-stratify: Unify air temperature at different heights in a space.

Manifold: Structure that divides and distributes airflow.

Solar absorber: Solid material that collects solar radiation and retains it as heat.

Solar heat collector: Structure that collects solar radiation and retains it as heat.

Streamlined: Quality of smooth or flowing contour designed for decreasing air resistance.

Ventilation equipment: Equipment for displacing air from one location to other locations.

[0008] Previously, advances in solar absorber materials have ensured efficient capture and retention of solar heat. These materials, usually termed "solar selective," are commercially available for inclusion in solar-heating systems. When such material is heated by the sun, the heat can then be conducted to an air medium. Typically in this field, a stream of air impinging on the solar absorber, also variously termed "solar heat collector," solar absorber plate," "solar collector," or "solar absorbing means," carries heat to a building interior.

[0009] Previous art in this field has neglected efficiency in transfer of heat from solar absorber to the air medium. Air flow is forced through narrow openings and around sharp angles without the broadening and streamlining effect of air manifolds. This results in pressure loss, less heat exchanged, and lower heat output. Also neglected in prior art is effective air displacement into central areas of building spaces.

[0010] In U.S. Pat. No. 6,807,963 (2004) to Niedermeyer, air impinges on a solar heat collector without benefit of air manifolds. As a result, less air comes in contact with the solar heat collector during a given time interval, which reduces heat transfer efficiency. Furthermore, the solar heat collector will retain a greater amount of heat relative to ambient air temperature, an imbalance which encourages radiative heat losses. Also, the device lacks a clear means of displacing heated air into a building.

[0011] In U.S. Pat. No. 6,494,200 (2002) to Rylewski, air impinges on the solar absorber, termed "panel heated by solar radiation" without the benefit of air manifolds, which reduces heat transfer efficiency. Airflow is restricted to one side of the panel heated by solar radiation, further reducing heat transfer efficiency.

[0012] In U.S. Pat. No. 6,018,123 (2000) to Takada, Fukai, Mimura, Mori, and Shiomi, air impinges on a solar heat collector without benefit of air manifolds, which reduces heat transfer efficiency. Airflow is restricted to one side of the solar heat collector, further reducing heat transfer efficiency. Also, the suggested installation of the apparatus substantially flat on a low-sloping roof does not optimally expose the solar heat collector to low-angled winter sun.

[0013] In U.S. Pat. No. 5,596,981 (1997) to Soucy, air impinges on a solar absorber plate without benefit of air manifolds, which reduces heat transfer efficiency. Airflow is restricted to one side of the solar absorber plate, further reducing heat transfer efficiency.

[0014] In U.S. Pat. No. 5,657,745 (1997) to Damminger, airflow is restricted to one side of a solar heat absorption sheet. Also, the device lacks a clear means of displacing heated air to a building.

[0015] In U.S. Pat. No. 5,692,491 (1996) to Christensen, Kutscher, and Gawlik, an unglazed transpired solar collector lacks a clear means of displacing heated air to a building. Also, lack of glazing encourages conductive heat loss.

[0016] In U.S. Pat. No. 5,081,982 (1992) to MacKenzie, air movement depends on heat convection rather than active air impeller force. This limits the amount of air, in a given interval, impinging on a solar absorbing means. As a result, the solar absorbing means will retain a greater amount of heat relative to ambient air temperature, an imbalance which encourages radiative heat losses. Furthermore, lacking an air impeller, heated air from this device will convect up a wall rather than out into an occupied space. Also, the recommended placement of the device in a window blocks significant natural sunlight and heat.

SUMMARY OF THE INVENTION

[0017] My invention is an improved solar air-heating system that significantly increases heat conversion efficiency and air displacement into buildings. The invention encourages air temperature destratification within building interiors without need for tie-in to additional ventilation equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. **1** is a perspective view of the invention.

[0019] FIG. **2** is a perspective view of a building roof that has been prepared for installation of the invention.

[0020] FIG. **3** is a perspective view of the invention installed on a building roof.

[0021] FIG. **4** is a perspective view of a housing assembly.

[0022] FIG. **5** is a perspective view of an insulated air plenum.

[0023] FIG. **6** is a perspective view of a solar absorber assembly.

[0024] FIG. **7** is a juxtaposed view of a glazing and a retainer frame.

[0025] FIG. **8** is a detail view of the retainer frame.

[0026] FIG. **9** is a juxtaposed view of main component assemblies.

[0027] FIG. **10** is a perspective view of nested component assemblies.

[0028] FIG. **11** is a perspective view of an air inlet and an air outlet.

[0029] FIG. **12** is a partial cross-sectional view of incoming air flow.

[0030] FIG. **13** is a partial cross-sectional view of outgoing air flow.

[0031] FIG. **14** is a perspective view showing operation of the installed invention.

[0032] FIG. **15** is a cross-sectional diagram of air de-stratification within a building.

[0033] FIG. **16** is a perspective view of an installed alternate embodiment of a solar air-heating system that utilizes an attached reflector.

DETAILED DESCRIPTION

FIG. 1—Preferred Embodiment

[0034] We will first look at one means of installation of a preferred embodiment of the invention in order to gain an overview. Reference is made to FIG. **1**, which shows the system in its complete, uninstalled condition. Attached underneath nested assembly **27***a* are sheet-metal collars **51** and **56**, to which are mounted, respectively, air inlet tube **50** and air outlet tube **55**. Electric fan **52** is mounted underneath air inlet tube **50**.

[0035] In FIG. **2**, we see a prepared building roof **21** and cut through it are holes **22** and **23** along a line **21**E that is drawn parallel to the earth's equator. Roof curb **24** is attached to roof **21** over hole **22**; in similar fashion, roof curb **25** is attached to building roof **21** over hole **23**. For the purpose of explanation, a roof curb is a commercially available weather-tight equipment support with openings at the top and bottom that allow air communication through a building roof between the building's interior and roof-mounted ventilation equipment. Tack strips **24**A and **25**A are wooden rims integral with roof curbs **24** and **25** and can accept nail or screw fasteners for secure attachment of ventilation equipment.

[0036] Turning to FIG. **3**, the invention is shown attached to roof curbs **24** and **25** so that air inlet tube **50** and air outlet tube **55** each penetrates roof **21** through respective holes **22** and **23**. Below roof **21**, electric fan **52** is attached to the underside of tube **50** so that when switched on, it will impel air in direction **59**. We will describe operational detail of the invention later in this section.

[0037] Now, we will turn to the construction of the invention. In FIG. **4**, housing **28**, consisting of frame **29** and back piece **30** is shown. Frame **29** is a sheet-metal box open at its front and rear vertical planes and flanged at its rear edges 90 degrees inward to provide a flat mounting surface for back piece **30**. Back piece **30** consists of flat sheet metal and is fastened to the rear side of frame **29**. Six-inch diameter openings **29**A and **29**B are cut through the bottom side **29**C of frame **29**, respectively near each long end of bottom side **29**C.

[0038] FIG. **5** shows air plenum **31**, essentially a box open at its front vertical plane and constructed of foil-lined polyisocyanurate foam boards **32**, **33**, **34**, **35**, and **36**, which are glued together with construction adhesive. Air plenum **31** is slightly smaller in all its outer dimensions than housing **28** shown in FIG. **4**. In FIG. **5**, openings **33**A and **33**B are cut vertically through foam board **33** so that when air plenum **31** is nested within the housing **28** shown in FIG. **4**, openings **33**A and **33**B shown in FIG. **5** will align with openings **29**A and **29**B of FIG. **4**.

[0039] FIG. **6** shows absorber assembly **37**, which by general description is a solar absorber with structurally-integrated manifolds. This arrangement comprises a principle design feature of the present invention.

[0040] Solar absorber **39** consists of a rectangle of solar-selective foil and stands vertically on a long edge. Flat absorber plates **38**A and **38**B, each of substantially stiffer metal than solar absorber **39**, are rectangular structural side extensions for absorber assembly **37**, stand vertically on a short edge, and are substantially solar-selective.

[0041] Four sets of four, air vanes **42**, **43**, **44**, and **45** are cut from thin aluminum flashing material in four graduated lengths, attached in order of length as matched pairs on opposite fields of metal plates **38**A and **38**B, each pair's bottom edges spaced at short, regular distances, and top edges spreading in an open-leaf profile. The attachment means can be with threaded rods, with welds, with high-temperature adhesives, or by molded integration with flat absorber plates **38**A and **39**B.

[0042] Absorber assembly **37** is integrated by fastening two rails **41** of right-angle metal stock along the rear top and bottom edges of metal plate **38**A, solar absorber **39**, and metal plate **38**B. The finished outer dimensions of absorber assembly **37** must be slightly smaller than the corresponding dimensions of the opening in air plenum **31**, shown in FIG. **5**.

[0043] FIG. **7** illustrates a transparent, rectangular sheet of glazing **47** consisting of shatter-proof and heat-resistant material. Retainer **48** is an open rectangular frame, consisting of right-angle metal stock, of slightly greater outer dimensions than those of glazing **47**, but with slightly smaller outer dimensions than the corresponding dimensions of the void enclosed by housing **28** in FIG. **4**.

[0044] FIG. **8** is a detail view of joining at the corners, specifically the right bottom corner, of retainer **48**.

[0045] In FIG. **9**, housing **28**, air plenum **31**, absorber assembly **37**, glazing **47**, and retainer **48** are shown juxtaposed prior to final assembly. The assembly proceeds in the following manner: air plenum **31** slides in direction **27**B into housing **28** until it stops against back piece **30**. Absorber assembly **37** slides in direction **27**B—into air plenum **31** until it stops against foam board **36**. Glazing **47** slides in direction **27**B into housing **28** until it stops against the open edges of nested air plenum **31**. Retainer **48** then slides in direction **27**B inside housing **28** and stops against glazing **47**.

[0046] When fastened to housing **28**, retainer **48** holds nested assembly **27**A together as shown in FIG. **10**. Nested assembly **27**A is now by general description an air plenum containing a solar absorber with integrated manifolds.

[0047] Turning to FIG. **11**, air inlet **49** is shown comprised of a sheet-metal tube **50** attached to a corresponding opening **51**A cut through a flat and substantially square sheet-metal collar **51**. Air outlet **54** is comprised of a sheet-metal tube **55** attached to a corresponding opening **56**A cut through a flat and substantially square sheet-metal collar **56**. The lengths of tubes **50** and **55** should be cut to different lengths, if necessary to keep their bottom openings at substantially the same elevation when installed on a building.

[0048] In FIG. **12**, air inlet **49** is shown attached under the left side of nested assembly **27**A (shown without glazing for clarity) so their openings correspond, to form an air entrance passage to the void within nested assembly **27**A. When electricity is supplied to electric fan **52**, air passes through tube **50** and then follows manifold air races **42**, **43**, **44**, and **45** and impinges on both sides of absorber **39** while flowing in the general direction indicated by arrow **59**. This action encourages efficient heat transfer from absorber **39** to the air. The streamlined curvature of manifold air races **42**, **43**, **44**, and **45** shown reduces air turbulence to minimize air pressure loss and maintain airspeed through the invention. The multiplicity of manifold air races **42**, **43**, **44**, and **45** serves to distribute air broadly across absorber **39** to encourage efficient heat transfer.

[0049] In FIG. **13**, air outlet **54** is attached under the right side of nested assembly **27**A (shown without glazing for clarity) so their openings correspond, to form an air exit passage. Air passing through nested assembly **27**A and across both sides of absorber **39** is received by manifold air races **42**, **43**, **44**, and **45** in the general direction indicated by arrow **61**. This action further encourages efficient heat transfer from absorber **39** to the air impinging on it. The streamlined curvature of manifold air races **42**, **43**, **44**, and **45** reduces air turbulence to minimize air pressure loss and maintain airspeed through the invention. The multiplicity of manifold air races **42**, **43**, **44**, and **45** shown also serves to receive air broadly from across absorber **39** to encourage efficient heat transfer.

[0050] We now turn to the detailed operation of the installed invention as illustrated in the preferred embodiment. In FIG. **14**, absorber **39** inside nested assembly **27**A absorbs solar radiation from sun **62** as indicated by arrow **62**A. Electric fan **52** passes air from under roof **21** into the path shown by arrows **59**, **60**, and **61**, first through air inlet tube **50**, then across absorber **39** within nested assembly **27**A, through air outlet tube **55** where the air movement is collimated, and finally under roof **21**. Due to efficient heat transfer and maintenance of air speed earlier described, heat is displaced 16 to 20 feet below roof **21** as indicated by arrow **61**.

[0051] Electricity to electric fan **52** can be controlled externally by common electrical switches or thermostats, so that during periods when heat is not desired, active airflow will stop. In this inactive state, location of tubes **50** and **55** at a similar height in this embodiment discourages convective heat circulation through the invention.

[0052] The operational description above demonstrates the main purpose of the present invention, that is, to provide solar air heat with improved efficiency and displacement into buildings. The invention also provides air temperature destratification in buildings, according to the FIG. **15** diagram.

[0053] It is well known that heat naturally rises via convection from lower air strata in buildings and then collects near the ceiling in an upper stratum. This presents two problems in colder weather for buildings and occupants: first, heat leaves the occupied lower air stratum, and second, heat is lost convectively through the roof. FIG. **15** illustrates a single-story building **20** seen in cross-section. Within building **20**, we see an occupied lower air stratum **20**A with occupants **75**, a middle air stratum **20**B, and a higher air stratum **20**C. Naturally-occurring heat convection is indicated by arrows **65**, **66**, and **67**. The invention is shown supported and attached to roof **21** by roof curbs **24** and **25**. When fan **52** is turned on, warm air that has collected in air stratum **20**C is siphoned upward into fan **52** as indicated by arrows **68** and **69**. This air then flows in general path **70** within nested assembly **27**A, is collimated by tube **55**, and exits the invention. The collimated air flows downward, as indicated by arrow **71**, through air strata **20**C and **20**B and finally dissipates into lower air stratum **20**A. Warmer air from stratum **20**C is therefore de-stratified through the action of panel **27**. A resulting air turbulence as indicated by arrow **72** helps to mix air strata **20**A, **20**B, and **20**C to accomplish further de-stratification. The invention can also be installed in multiples to achieve greater heat and destratification within buildings.

[0054] FIG. **16** shows an alternate embodiment of the device wherein a flat rectangular reflector **72**, constructed of rigid material with a highly reflective upper surface, is attached to panel **27** horizontally forward so that a long rear edge of reflector **72** attaches above collars **51** and **56**. Vertical supports **73** and **74** are attached under the front edge of reflector **72** and to roof **21**. The orientation of reflector **72** at a substantially right angle to absorber **39** augments direct solar radiation **59**A from sun **59** with reflected solar radiation as indicated by arrows **59**B and **59**C. This reflective augmentation results in increased heat output from the invention.

[0055] From the description above, several advantages of the present invention become evident:

(a) The integration of manifold air races with the solar absorber reduces air turbulence and pressure loss, which increases heat transfer to the air medium.

(b) The open-leaf arrangement of manifold air races in the airflow path distributes air broadly across the solar absorber, which effectively increases heat transfer to the air medium.

(c) Airflow is enabled simultaneously across both sides of the solar absorber, which increases heat transfer to the air medium.

(d) The increased airspeed in the invention displaces solar-heated air far into a building interior.

(e) The presence of downward-extending air tubes in combination with increased airspeed encourages building air temperature de-stratification.

(f) The downward-extending air entrance and exit tubes terminate at substantially the same height, which discourages airflow from passive air convection when the fan is off and heat is not desired.

(g) Separate ductwork for the invention and tie-in with a building's existing ventilation system is obviated because of robust exit airspeed and collimation.

(h) The system is easily installed on low-rise building roofs.

(i) System components are nested in final assembly which saves manufacturing time and expense.

(j) The invention as described in the embodiments will withstand harsh outdoor conditions.

(k) Mirror surfaces are easily attached to the invention to augment solar exposure and thereby increase heat output.

[0056] The specific embodiments described herein should not be construed to:

(a) exclude use of other materials than those mentioned in the construction of the present invention,

(b) limit the position, shape, or number of manifold vanes,

(c) restrict the application of the invention, modified or unmodified, to building structures only,

(d) restrict the invention's purpose to that of providing heat to building occupants,

(e) limit the installation of the invention, modified or unmodified, to building roofs only,

(f) limit the shape and orientation of attached reflective augmenting surfaces.

(g) limit solar reception to one side only of the invention. For example, an embodiment of the invention with a double-side solar absorber: one side receives solar energy directly, and its opposite side simultaneously receives solar energy from reflective surfaces fixed near the invention.

(h) Limit the invention to a standalone form factor. For example the invention could be split into interconnected components, or the invention's separated components could be combined functionally with other devices.

What is claimed is:

1. An improved solar air-heating system comprising:

a. an oblong air plenum with at least one transparent side that permits solar radiation,

b. an entrance opening and an exit opening to the air plenum such that an air pathway is established substantially through the length of the plenum,

c. a substantially flat absorber that heats when exposed to solar radiation and is positioned within the air plenum so that the field of the absorber stands vertically and divides the air pathway along its length,

d. an air manifold intercepting the air pathway,

whereby air, when forced through the air plenum will impinge upon a broader area of the solar absorber field and thereby speed heat conversion from the solar absorber, when it is heated by solar radiation, to the air.

2. The improved solar air-heating system of claim **1**, further including an air exit tube that communicates with and extends downward from the air plenum exit opening, such that when the air plenum is installed above a building, the air exit tube will penetrate a corresponding and necessary pre-cut hole through the building's roof, and allow communication between the air plenum and the building's interior,

whereby any airflow forced through the air plenum is collimated along the length of the air exit tube and thereby carries heat farther into the building interior.

3. The improved solar air-heating system of claim **1**, further including an air entrance and an air exit tube each communicating with and extending downward from the corresponding air plenum's entrance and exit openings, such that when the air plenum is installed above a building, said tubes will penetrate corresponding and necessary pre-cut holes through the building's roof, allowing communication between the air plenum and the building's interior, so that when airflow is forced at a substantial speed through the air plenum, air from the air stratum that exists in the building's interior just under its roof enters the air entrance tube, flows through the air plenum, exits through the air exit tube, and penetrates substantially below said air stratum,

whereby air temperature within the building will become destratified partially or completely.

4. An improved solar air-heating system comprising:

a. an air plenum of substantially oblong box shape, that permits sunlight through a trans-parent sheet that forms one of the plenum's two long vertical sides,

b. an entrance opening and an exit opening to the air plenum, both substantially round holes cut through the bottom side and at opposite ends of the air plenum, such that an air pathway is established through the length of the air plenum,

c. a substantially flat absorber that heats when exposed to solar radiation and is positioned within the air plenum so that the field of the absorber sits vertically and divides the air pathway along its length,

d. an air manifold in a position intercepting the air pathway just after the air entrance opening, consisting of a series of oblong vanes, each vane with its field perpendicular to the absorber and attached to it lengthwise, the vanes placed with their bottom short edges parallel and at substantially equal intervals across the air plenum's said openings, the vanes' parallel top edges fanning from their bottom edge origin across the height of the absorber field, where the vanes span the perpendicular distance between the absorber and one or other of the plenum's long vertical sides, so that absorber, vanes, and one or both of the plenum's long vertical sides enclose manifold air passageways,

whereby each manifold will encourage airflow, when air is forced through the air plenum, across a broader area of the solar absorber field and thereby speed heat transfer from the solar absorber to the air.

5. The improved solar air-heating system of claim **4**, further including an air exit tube that communicates with and extends downward from one of the air plenum openings, such that when the air plenum is deployed above a building, the air exit tube will install through a corresponding hole in the building roof and allow communication between the air plenum and the building interior,

whereby any airflow forced through the air plenum is collimated by the air exit tube,

and thereby displaces

heat farther into the building interior.

6. The improved solar air-heating system of claim **4**, further including an air entrance and an air exit tube each communicating with and extending downward from the corresponding air plenum's entrance and exit openings, such that when the air plenum is installed above a building, said tubes will penetrate corresponding and necessary pre-cut holes through the building's roof, and allow communication between the air plenum and the building's interior, so that when airflow is forced at a substantial speed through the air plenum, air from the air stratum that exists in the building's interior just under its roof enters and flows through the air plenum and subsequently penetrates substantially below said air stratum,

whereby air temperature within the building will become destratified partially or completely.

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