VENTILATED BUILDING

Filed Feb. 27, 1959 5 Sheets-Sheet 1

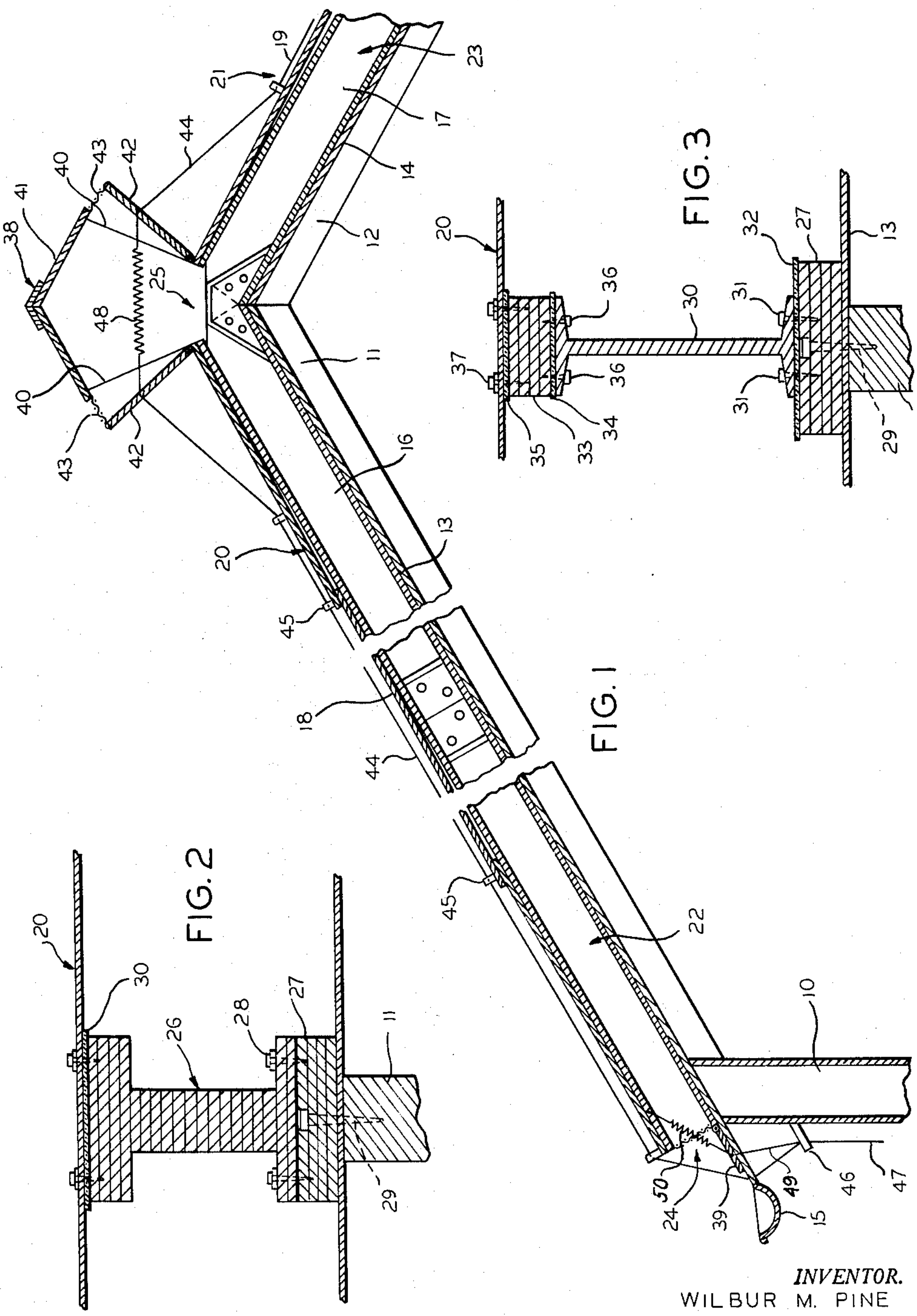

FIG. 1

FIG. 2

FIG. 3

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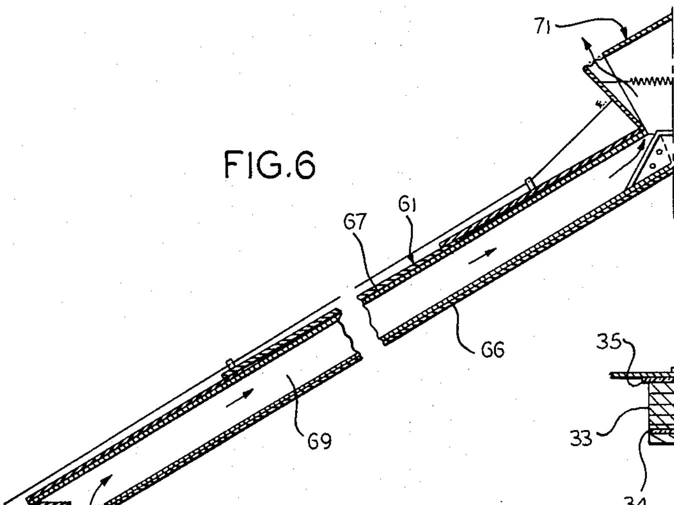

FIG.6

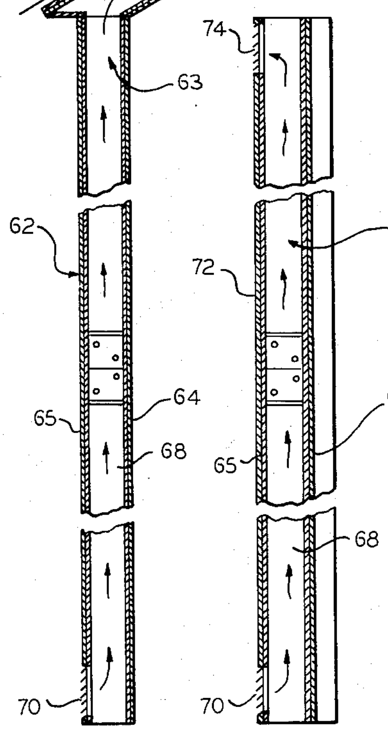

FIG. 7

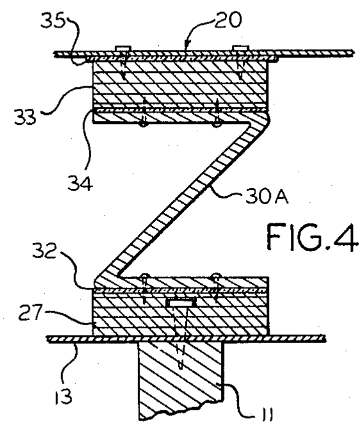

FIG.4

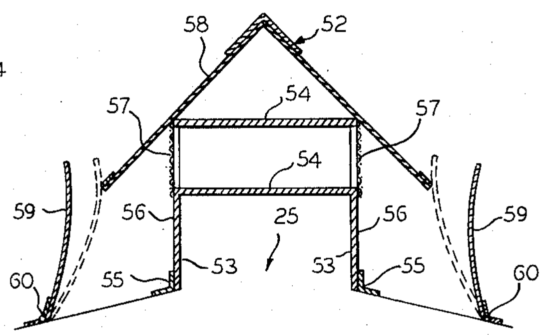

FIG.5

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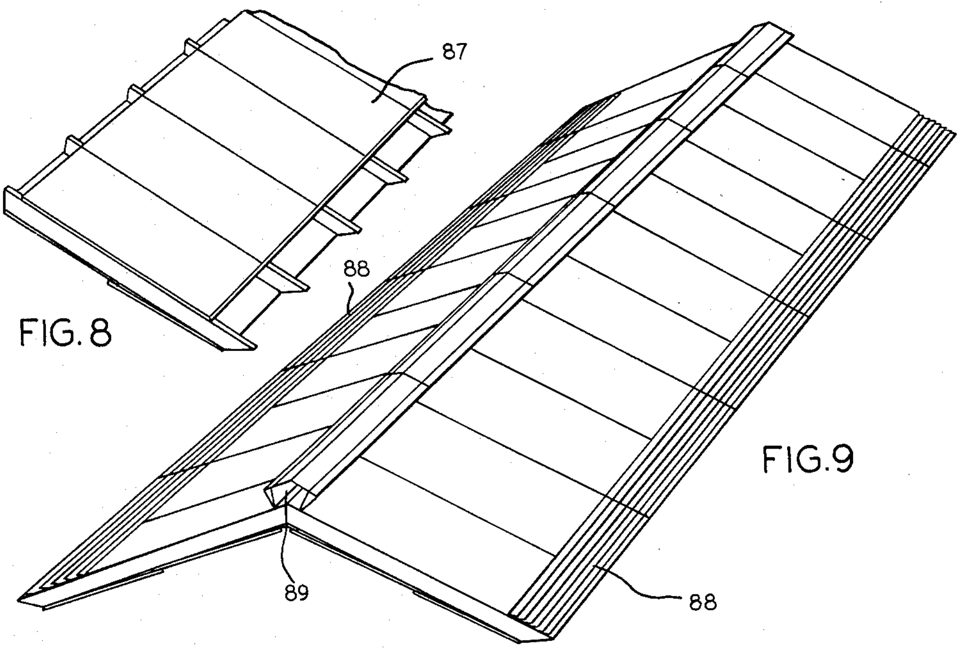

FIG. 8

FIG. 9

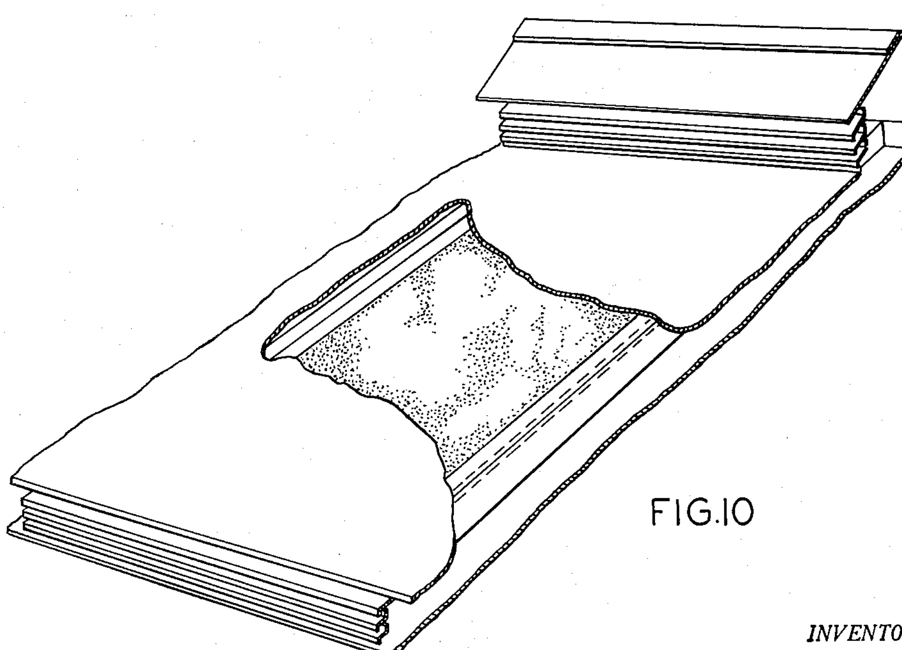

FIG. 10

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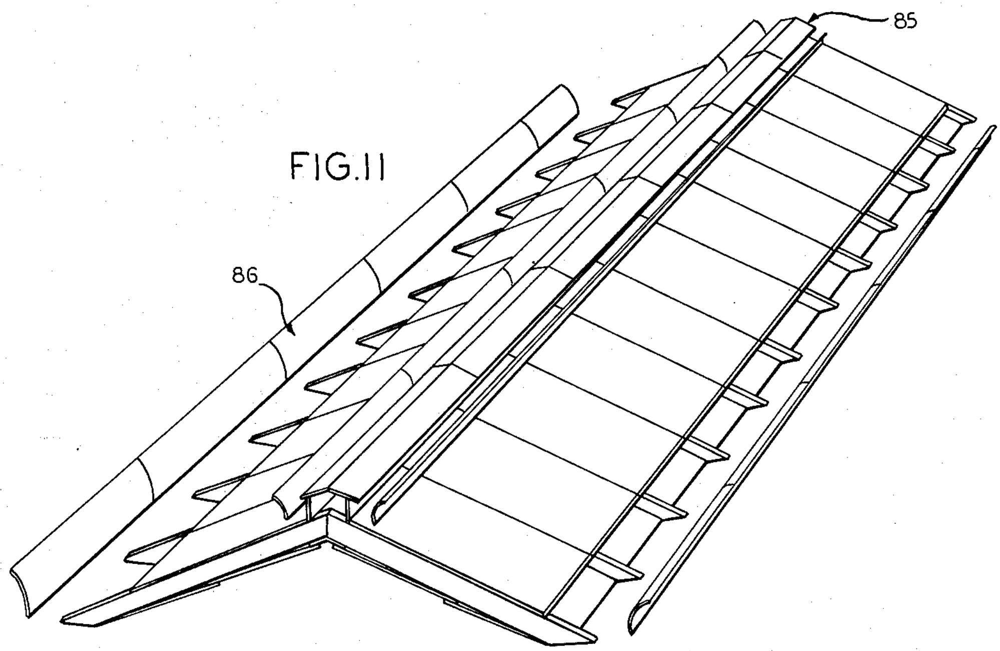

FIG. 11

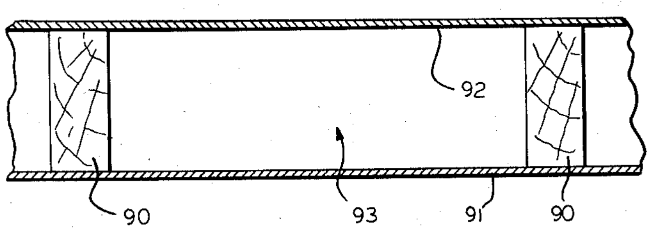

FIG. 12

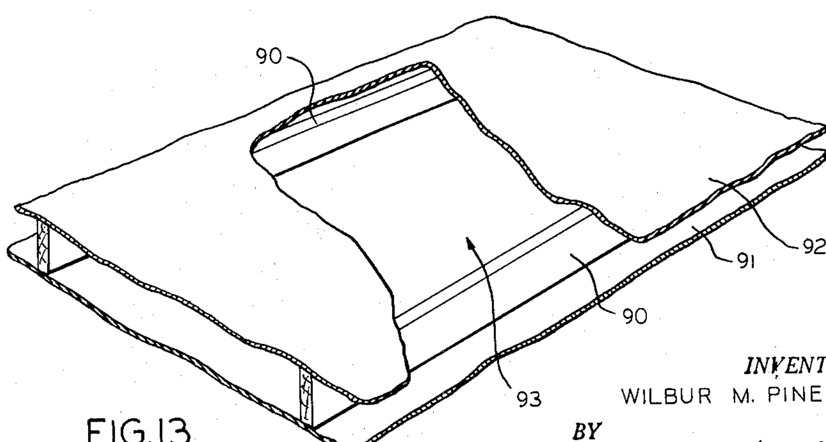

FIG. 13

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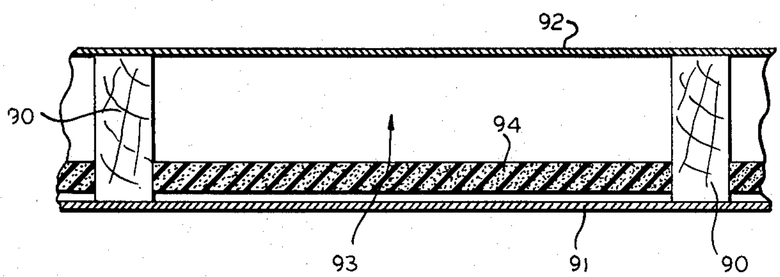

FIG.14

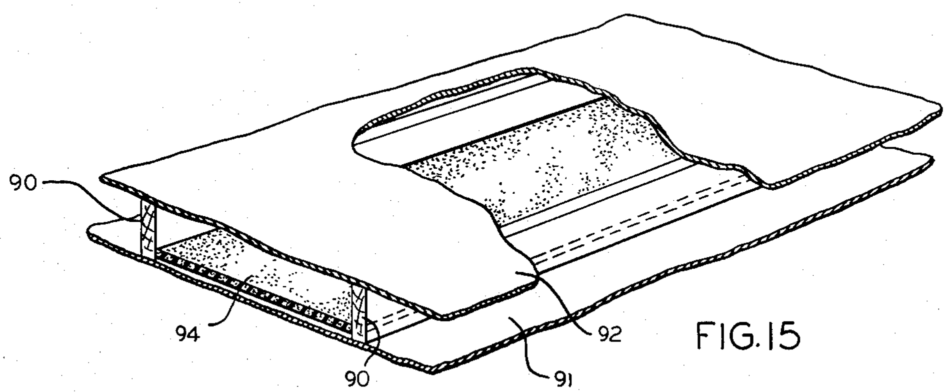

FIG.15

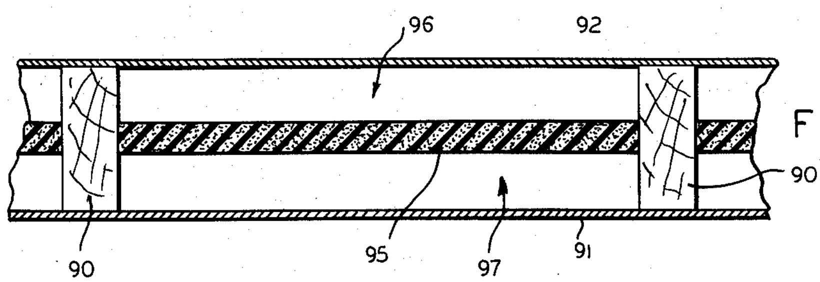

FIG.16

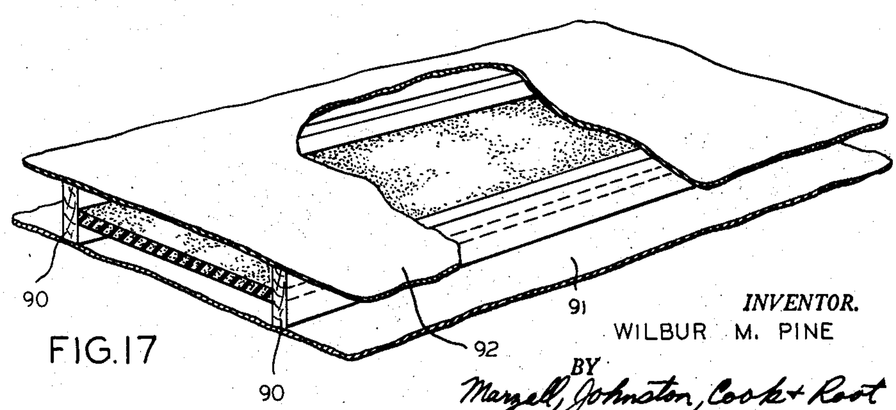

FIG.17

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Patented Apr. 23, 1963

3,086,323

VENTILATED BUILDING

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Filed Feb. 27, 1959, Ser. No. 795,975
7 Claims. (Cl. 50—16)

This invention relates in general to an improved wall or roof panel construction which can be applied in whole or in part to a building structure, and particularly to an inclined wall or roof structure in which the rate and amount of thermal radiation and thermal conduction through the same wall or roof can be selectively and alternately controlled, and more particularly to the controlling of thermodynamic characteristics within a wall or roof structure by selectively accelerating or retarding the conductance and/or radiation of thermal energy through said wall or roof structure in either direction by substantially controlling the factors affecting the transmission of thermal energy by radiation, conduction, and/or convection as they individually or collectively affect the surface temperatures of said walls or roof.

The present invention comprises providing a roof or wall panel structure including inner and outer sheathings or a plurality of sheathings spaced apart by spacer members as applied to a vertical or inclined wall or roof. The innermost sheathing may either consist of the existing wall or roof or may be applied as part of the construction in the form of an imperforate closure. An opening is provided at the top of each outer sheathing for intercommunicating the upper ends of the spaces between the sheathings with the atmosphere. The lower ends of the outer sheathings may also be open to provide communication between the lower ends of the spaces and the atmosphere. The distance between the sheathings may be varied depending upon the inclination of the wall or roof, the orientation of the building, the latitude of the building and the surface characteristics of the materials used in construction in order to permit movement of a sufficient amount of air between the sheathings to substantially control heat impressment on either sheathing. Where desired, a ventilator may be mounted along the top of the wall or roof structure to control the communication of the spaces with the atmosphere and vent flaps may be mounted at the lower ends of the sheathings to similarly control a communication of the atmosphere with the spaces, whereby a blanket of substantially motionless air may be entrapped between the sheathing thereby giving certain substantial and additional insulating effects to the walls or roof of the building. Also, in accordance with requirements, the surface finishes of the sheathings may be variously combined to control reflectivity, absorptivity, and emissivity.

Accordingly, it is an object of this invention to provide a wall or roof panel structure for a building, wherein the rate of transmisison of thermal energy through the wall or roof structure can be selectively and alternately controlled for controlling the thermodynamic conditions within the building.

Another object of this invention is to provide a wall or roof panel structure for a building, wherein the radiation of thermal energy in either direction through said wall or roof structure may be selectively accelerated or retarded by substantially controlling the factors determining the rate and amount of radiation, and conduction and/or convection.

A further object of this invention is in the provision of improved inclined walls or roof for a building structure capable of substantially controlling the thermodynamic conditions within the building structure.

Another object of this invention is in the provision of an interceptor shield for mounting on vertical or inclined

walls and roofs of existing building structures for the purpose of substantially eliminating all of the solar heat which would normally affect the thermodynamic conditions within the building.

Still another object of this invention resides in the provision of a solar shield for a building structure having vertical or inclined walls and a roof, including a ventilator arranged along the top of the walls and roof and the solar shield for the dual purpose of eliminating substantially all of the solar heat affecting the thermodynamic conditions within the building and for gaining certain substantial and additional insulating effects on the walls and roof of the building.

A further object of this invention is to provide a roof panel structure for a building having an inclined roof, wherein a multiple sheathed roof is provided for the purpose of reducing heat impressment on either sheathing and controlling the thermodynamic conditions within the building.

A still further object of this invention is to provide for a building having vertical or inclined walls or roof, an outer sheathing overlying the existing walls and roof and separated therefrom by spacer members, wherein the distance between the sheathings is gauged both to permit movement of a sufficient amount of air to substantially control heat impressment on either sheathing and to adjust to the surface conditions of the materials used, and the distance between the inner and outer sheathings is calculated further in accordance with the inclination of the walls and roof, the orientation of the building, and the latitude of the building.

Other objects, features, and advantages of the invention will be apparent from the following detailed disclosure, taken in conjunction with the accompanying sheets of drawings, wherein like reference numerals refer to like parts, in which:

FIG. 1 is a fragmentary transverse sectional view taken through a building having a roof structure in accordance with the present invention;

FIG. 2 is a transverse sectional view taken through one form of spacer member employed for spacing the outer sheathing from the existing roof decking;

FIG. 3 is a transverse sectional view of another form of spacer member for spacing the outer sheathing from the existing roof decking;

FIG. 4 is a transverse sectional view of still another form of spacer member for spacing the outer sheathing from the existing or new inner wall or roof structure;

FIG. 5 is a transverse sectional view of a ventilator for application with the present invention, wherein the ventilator is of the all-weather type in order to prevent weather from entering the air spaces in the roof structure of the present invention;

FIG. 6 is a fragmentary transverse sectional view through one half of a building structure illustrating application of the present invention to a wall and roof structure;

FIG. 7 is a transverse sectional view through a wall of a building utilizing the present invention;

FIG. 8 is a diagrammatic perspective view of a pitched roof embodying the invention on only one side thereof;

FIG. 9 is a diagrammatic perspective view of a pitched roof structure embodying the invention, where louver-type vents are utilized;

FIG. 10 is a fragmentary diagrammatic perspective view of a pitched roof structure embodying the invention, where another form of louver-type vents are utilized;

FIG. 11 is a diagrammatic perspective view of a pitched roof structure embodying the invention, where venturi-type flaps are utilized;

FIG. 12 is an enlarged fragmentary diagrammatic cross sectional view of the basic wall or roof structure;

FIG. 13 is a fragmentary perspective view of the embodiment of FIG. 12 with some parts broken away to show underlying parts;

FIG. 14 is an enlarged fragmentary diagrammatic cross sectional view of a modified form of the invention, wherein insulation is arranged adjacent the inner sheathing;

FIG. 15 is a fragmentary perspective view of the embodiment of FIG. 14 with some parts broken away to show underlying parts;

FIG. 16 is an enlarged fragmentary diagrammatic cross sectional view of another form of the invention, wherein insulation is arranged centrally between the inner and outer sheathings; and

FIG. 17 is a fragmentary perspective view of the embodiment of FIG. 16 with some parts broken away to show underlying parts.

The present invention may be easily added to existing building structures or may be integrally a part of a new building structure; and the particular embodiment employed will depend upon what results are to be required.

Referring now to the drawings, particularly to FIG. 1, this embodiment of the present invention is constructed on an existing building structure which includes side walls **10**, roof joists **11** and **12** forming a pitched or gabled roof framework, and roof decking or panels **13** and **14** secured over the joists **11** and **12**. At the lower ends of the roof panels, existing eave troughs are mounted, such as the eave trough **15** mounted on the lower end of the roof panel **13**. The roof panels **13** and **14** constitute the inner sheathings of the roof structure according to the invention.

Extending transversely of the roof structure and parallel spaced longitudinally thereof are a plurality of spacer members **16** and **17** respectively secured to the roof panels **13** and **14**. Overlying and secured to the spacer members **16** and **17** are a plurality of overlapping sheathing panels **18** and **19**, respectively defining outer sheathings **20** and **21**. The outer sheathings coact with the inner sheathings or roof panels and the spacer members to define the panel structure of the invention which includes air passages or ducts **22** and **23**. The air passages extend from the lower ends of the sheathing to the ridge of the roof and are juxtaposed along the longitudinal axis of the roof.

Referring now particularly to the air passages or conduits **22**, the lower ends of the sheathings defining the passages with the spacer members are open and, accordingly, lower openings or inlets **24** are provided. The upper ends of the outer sheathings **20** and **21** terminate short of each other to define an upper opening **25** extending longitudinally of the roof structure for intercommunicating the upper ends of the air ducts or passages with the atmosphere. Thus, air can enter the openings **24** at the lower ends of the air spaces, pass between the sheathings and exit through the upper opening **25**.

The spacer members arranged between the sheathings may take any desirable form. The main purpose of the spacer members is to space the sheathings apart, but for efficiency purposes, the spacer members are constructed to have low heat conductivity. Referring to FIG. 2, a wood spacer is shown and designated by the numeral **26**. This spacer member is substantially I-shaped, and is secured to the existing roof structure by means of initial securement to a low heat conducting strip of material **27** by means of lag screws or bolts **28**, wherein the low heat conducting strip **27** is directly secured to the existing roof structure, such as a roof joist **11**, by means of lag screws **29**. A layer of glass tape **30** may be arranged between the spacer member **26** and the outer sheathing **20** in order to prevent any adverse reaction between dissimilar materials. Preferably, the outer sheathing will be of metal.

Another form of spacer member is shown in FIG. 3, wherein a metal I-shaped spacer member **30** is secured along one side of the low heat conducting strip **27** by means of lag screws **31**. A layer of glass tape **32** may be provided between the metal spacer member **30** and the low heat conducting strip **27** in order to prevent any reaction between these dissimilar materials. In order to further lessen the conductance of heat between the metal spacer member **30** and the outer metal sheathing **20**, a low heat conducting member **33** is provided between the metal spacer and the outer sheathing **20**. The low heat conducting members or strips **27** and **33** are preferably of wood, although any other suitable material may be employed. Layers of glass tape **34** and **35** are sandwiched between the low heat conducting member **33** and the metal spacer, and the low heat conducting member **33** and the outer sheathing **20** as seen in FIG. 3. Wood screws or fasteners **36** secure the metal spacer member **30** to the low heat conducting member **33**, while wood screws or fasteners **37** secure the outer sheathing **20** to the low heat conducting member **33**.

Still another form of spacer member is shown in FIG. 4, which differs primarily from that shown in FIG. 3 in that a Z-shaped member **30A** is substituted for the I-shaped member **30**. Inasmuch as the other elements are equivalent to those shown in FIG. 3, like reference numerals will be applied to these elements.

Thus, application of the present invention to an existing building only requires mounting spacer members on the existing walls or roof decking, and sheathing over the spacer members. In areas where the climate is extremely warm the year around, this is all the structure that is necessary to practically eliminate the impressment of solar radiation on the building in order to provide cooler conditions within the building. Air would flow into the openings **24** at the lower ends of the sheathings upwardly through the air spaces **22** and **23** and out the upper opening **25**. Further, air would flow through the air spaces by natural convection when the temperature of either the outer sheathing or inner sheathing is above the ambient temperature of the incoming air to the lower openings **24**, providing the panel structure defining the ducts is inclined. The term "inclined" as applied herein includes anything angularly related to the horizontal. Thus, a vertical panel would be inclined. It is not generally possible to have natural convection in a horizontal air space. It would, in most cases, be necessary to use mechanical means to effect convection or movement of air in horizontal air spaces.

Depending upon the existing climate conditions, the distance between the outer sheathing and the inner sheathing would be varied in order to permit movement of a sufficient amount of air to substantially reduce the heat impressment on either sheathing. Variation of the spacing between the sheathings would be accomplished by varying the height of the spacer members and/or the thickness of the low heat conducting members arranged between the spacer members and the roof decking. Also, where metal spacer members are employed, the distance between the sheathings may be varied by varying the thickness of the low heat conducting member arranged between the spacer and the outer sheathing. The particular dimension or spacing between the inner and outer sheathings is calculated after considering the angle or inclination of the original roof and walls, the orienation of the building, and the latitude within which the building is located, and the materials used in construction.

In addition to eliminating substantially all the solar heat affecting a building thereby effecting a certain control over the thermodynamic conditions within a building, it may be desirable to more closely control the thermodynamic conditions within the building by selectively employing the roof or wall sections of the present invention to insulate the exposed areas, in which case means would be provided to entrap a blanket of substantially motionless air in the air spaces. This may be accomplished by mounting a continuous ventilator **38**, FIG. 1, along the top of the building walls or roof which may be selectively opened and closed, and pivotally mounting a vent flap or closure **39** at the lower ends of the sheathings to selectively open and close the lower openings **24**.

The continuous ventillator **38** is mounted above the upper opening **25** and to the outer sheathings **20** and **21**. The ventilator includes upstanding braces **40** spaced longitudinally of the outer sheatings and secured thereto at their lower ends. The upper ends of the braces have secured thereto an inverted V-shaped cover plate **41**. Thus, the ventilator is open on opposite sides. A pair of closure vent flaps **42**, pivotally mounted to the outer sheathings at their lower ends, serve to close the openings at opposite sides of the ventilator. The vent flaps **42** are shown in open position in FIG. 1, and in order to prevent unwanted debris from entering the ventilator, bird screen **43** extends from the outer ends of the cover plate **41** and to a point including the extreme open position of the vent flaps **42**.

Lanyards or lines **44** may be connected to the outer sides of the vent flaps **42** and threaded through a plurality of guiding eyelets **45** mounted on the outer sheathing. The lanyards then extend downwardly across the ends of the sheathings and through a guide eyelet **46** secured to the sidewall **10** of the building. The lower ends of the lanyards may be secured to any suitable type of bracket or the like for holding them in a position in order to maintain the vent flaps **42** open. A spring or resilient member **47** is provided in the line or lanyards **44** in order to resiliently bias the vent flaps **42** to open position. Should a high wind prevail against either side of the building, it would close the respective vent flaps **42** against the biasing force of the spring **47**. When it is desired to close the vent flaps **42** by releasing the lanyard **44**, a spring **48** connected at opposite ends to the inner sides of the vent flaps **42** contracts to close the vent flaps **42**.

Similarly, the lower vent flaps **39** are controlled by a lanyard **49** tied into the lanyard **44** above the spring **47**. Accordingly, the closing of the upper vent flaps **42** will function to close the lower vent flaps **39** at the same time. A spring **50** is provided to close the lower vent flaps and is connected at one end to the inner side of the vent flaps and at the other end to the framework or outer sheathing of the roof structure. Thus, upon releasing the lanyard **44**, the lanyard **49** is likewise released and the spring tension in the spring **50** will close the lower vent flaps **39** when the upper vent flaps **42** are also being closed. Likewise, when wind closes any one of the upper vent flaps **42**, it will close the respective vent flap **39** on the same side of the building. It may be noted in FIG. 1 that the lower vent flap **39** lays flush with the inner sheathing or existing roof decking **13** so that wind entering the openings **24** will not have any effect on the lower vent flap. Any weather that may enter through the ventilator **38** may readily pass downwardly through the air spaces and be collected in the existing eave troughs **15**.

Generally it would be desirable to protect these spaces between the sheathings where additional insulation has been provided, and therefore it becomes necessary to install an all-weather type ventilator such as that shown in FIG. 5 and generally designated by the numeral **52**. This ventilator would completely protect the spaces between the sheathings from weather and may be defined as a venturi-type ventilator.

The ventilator **52** includes upstanding substantially parallel frame members **53** connected together by horizontally extending and generally parallel frame members **54**, whereby the frame members constitute the ventilator frame. The lower ends of the frame members **53** are secured to the outer sheathing by brackets **55**. An imperforate and weatherproof side panel **56** is secured to opposite sides of the frames and extend substantially half the total height of the frame. Of course, there would be a plurality of longitudinally spaced frames arranged over the opening **25**, all constituting a frame for a continuous long ventilator. Extending upwardly from the top edges of the imperforate siding or panels **56** are bird screens **57** which prevent the entrance of underside matter into the ventilator and the air spaces between the sheathings. An elongated, generally inverted U-shaped cover plate **58** is mounted over the tops of the frames and the opposite ends thereof extend downwardly to a point substantially along a line horizontally extending along the top edges of the perforate panels **56**.

Thus, air discharging from the upper opening **25** must flow upwardly and downwardly along the contours of the cover plate **52**. In order to prevent weather from entering the ventilator and air spaces during adverse conditions, arcuately or concavo-convexly shaped wind deflector flaps **59** are provided at each side of the ventilator. Each flap is hingedly mounted along its lower edge by a hinge **60** of the spring tension type which normally urges the flap to open position as shown in solid lines in FIG. 5. The convex sides of the flaps face the openings at opposite sides of the ventilator. If desired, controls for opening and closing these flaps could be added, such as the type disclosed in FIG. 1. Normally a wind of predetermined force will close one of the flaps **59** against the tension in the spring hinge **60**. Primarily the wind deflector flaps serve to deflect wind up over the ventilator. This prevents the blowing of undesirable weather into the ventilator and downwardly into the air spaces, as well as preventing a gust of wind from blowing off the cover **58**.

The present invention may be applied to a variety of installations, such as for controlling the rate of heat transmission through the wall and roof of a building having a pitched roof, a wall structure of a building, or just a roof structure of a building. In order to better understand the present invention, several embodiments are disclosed in the drawings illustrating the various usages of the present invention.

Referring to FIG. 6, a building structure is illustrated having a pitched roof, wherein the panel structure of the present invention is embodied in the wall and roof structure. The panel structure of the roof, generally designated by the numeral **61**, and the panel structure of the wall, generally designated by the numeral **62**, are constructed to provide a plurality of juxtaposed upstanding air spaces **63** extending from the bottom end of the wall panel structure **62** to the upper end of the roof panel structure **61**. These air spaces are defined by inner and outer sheathings **64** and **65** of the wall panel structure **62** and inner and outer sheathings **66** and **67** of the roof panel structure **61**. The sheathings in the wall panel structure are spaced apart by spacer members **68**, while the sheathings in the roof panel structure are spaced apart by spacer members **69**. The spacer members **68** in the wall panel structure are aligned with the spacer members **69** is the roof panel structure in order to define the continuing air spaces **63** between the lower end of the wall panel structure and the upper end of the roof panel structure. A louvered vent **70** is provided along the entire lower end of the wall panel structure **62** for defining an opening into the lower ends of the air spaces **63**. A continuous ventilator **71** is constructed along the original of the roof panel structure **61** for the purpose of defining a discharge for the upper ends of the air spaces **63**. This ventilator is substantially identical to that shown in FIG. 1, and will function similarly, wherein it may be used to control the movement of air through the air spaces **63**.

Another embodiment of the invention is disclosed in FIG. 7, wherein a wall panel structure **72** is shown and which may be applied to any side of a building wherein it is desired to control the rate of heat transmission through a building side. This panel structure is similar to that in FIG. 6 and, accordingly, like parts will be designated with like reference numerals. The inner and outer sheathings **64** and **65** define a plurality of juxtaposed vertically extending air spaces **73** in cooperation with the spacer members **68** which are open to the atmosphere at their lower ends by virtue of the ventilator **70**, and at their upper ends by virtue of a vent **74**. The vents **74** shown are of the louver type but may be of any other type suitable for the purpose desired. These vents may be of the type which will function to close the openings in order to further control the insulating effects of the wall panel structure. In any event, the cross sectional areas of the vents, when open, will substantially equal the cross sectional area of the air spaces.

FIG. 8 illustrates the application of the present invention to one side of a pitched roof, wherein the upper and lower openings to the air spaces are not provided with vent closures. This embodiment, designated generally by the numeral **87**, would be useful where there would be no need for further controlling the rate of heat transmission through the other side of the roof.

FIG. 9 shows the present invention as being applied to a pitched roof of a building, wherein louver type vents **88** are provided for the lower openings of the air spaces, and a weather protecting ridge ventilator **89** is mounted along the peak of the roof. These vents serve to prevent the entrance of undesirable weather through the air spaces between the sheathings, wherein such would be undesirable if insulation were provided between the spacer members.

FIG. 10 exemplifies a slightly modified type of louvered vent for the upper and lower openings of the air spaces between the sheathings.

In FIG. 11, a pitched roof having the panel construction of the present invention is shown where a centuri-type ventilator **85** like that of FIG. 5 is mounted along the ridge of the building, and venturi-type wind deflector flaps **86** are mounted at the lower ends of the roof. The wind deflector flaps **86** will serve to deflect wind directed thereagainst above and away from the lower openings to the air spaces and onto the upper parts of the building. This will prevent wind and inclement weather from entering directly into the air spaces thereby protecting any insulation that may be mounted in the air spaces. Further, they will prevent gusts of wind from exerting a lifting force on the outer sheathing which might tear it off the roof.

Referring now to FIGS. 12 and 13, the basic panel structure according to the present invention is more specifically shown, wherein wooden spacer members **90** are positioned transversely to the major axis of the roof between the inner sheathing **91** and an outer sheathing **92** to define air spaces **93**.

The distance between the two spacer members and the depth of these spacer members depends both upon the structural design objectives of the building itself and the amount of heat which may be impressed on either or both sheathings. Actually, this is no different from the engineering principles involved in designing an air duct where the volume of air to be carried and the anticipated velocity dictates the size of the duct. It should also be pointed out that in the present panel, the dimensions of this duct are also dependent upon the types of material used in the sheathings and whether or not closure vents are used at both ends of the panels. Therefore, if it is desired only to remove heat from the building or protect against the penetration of solar heat, the exterior surfaces of the sheathings would be reflective and the inner surfaces absorptive. However, if the air space between the two sheathings is to be closed at the ends, in order to use this space for insulating purposes, the exterior surfaces of the two sheathings might be absorptive and the inner surfaces reflective.

A variation of the embodiment of FIGS. 12 and 13 is disclosed in FIGS. 14 and 15, wherein a layer of insulation **94** is positioned between adjacent spacer members **90** and immediately adjacent to the outer surface of the inner sheathing **91**, wherein a sufficient distance is permitted to exist between the insulation and the outer sheathing **92** to provide an adequate flow of air to remove radiant heat from the outer sheathing. When the air spaces are open at the ends thereby permitting air to flow therethrough, the insulating effect or resistivity of the air spaces breaks down and has little or no value. But when the air spaces are closed at the ends, air is entrapped therein thereby giving considerable resistivity value to the air spaces. Thus, the condition of the surfaces of the sheathings are such as to coact with the insulating effect or resistivity of the air spaces between the sheathings to accelerate or retard the rate and amount of thermal energy passing through the panel structure.

In this instance, the design objective would combine an effective insulation of the inner sheathing against the outward flow of heat, and the protection of the outer surface of the insulation from the effects of solar radiancy. Here, again, the exterior surface of the outer sheathing would probably be reflective if no vent closures were to be used; or it might be absorptive if closures were used in order to utilize the additional insulating or resistive value of this air space. It must be remembered that the rate of heat flow by conductance through any mass is materially affected by the temperatures of the exposed surfaces of this mass.

The embodiment of FIGS. 16 and 17 differ from that in FIGS. 14 and 15 in that a layer of insulation **95** is positioned intermediate the outer and inner sheathings thereby defining air spaces **96** and **97** of substantial dimension above and below the insulation **95**.

In this panel, it is necessary to use vent closures at each end in order to control the flow of air through these air spaces. It is the purpose of this particular design to provide a wall structure in which air may be permitted to flow between the lower surface of the insulation and the inner sheathing in order to carry off heat transferred from the interior of the building through the inner sheathing into this air space. The flow of air through the space between the upper surface of the insulation and the outer sheathing would provide a means of carrying off heat impressed on the outer sheathing principally by solar radiation. The dimensions of these two air spaces would be dependent upon the calculated heat impressment on either of the two sheathings.

With effective vent closures at the ends of wall structures, the insulating effectiveness of the combined air spaces would be double that of a single space. By using an outer sheathing in which the surfaces were absorptive, and with the vents closed, the solar heat build-up on the outer sheathing could be radiated through this upper air space to the exterior surface of the insulation. With the vents open, permitting free access of ventilating air to this air space, the heat impressment on the outer sheathing as well as the exterior surface of the insulation could be carried off by convection.

With the vents closed, thus entrapping air in the lower air space, the insulating effect or resistivity of the insulation itself would be enhanced by the insulating effect or resistivity of this air space. With the vents open, air flowing between the lower surface of the insulation and the inner sheathing would carry off heat transferred from the interior of the building through the inner sheathing to this air space. Thus, in this type of wall structure, the selective control of heat through the wall structure would enable the designer to take advantage of all types of heat transfer, thereby increasing the effectiveness of the wall structure and reducing the cost of construction.

One more fact is important in this connection. Recent tests show that the closer insulation is positioned to the outer sheathing and between the wall studs, the less the flow of heat through the studding itself. Thus, this particular design takes maximum advantage of all known principles in producing a unique, light-weight, low-cost element.

It will be understood that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention, but it is understood that this application is to be limited only by the scope of the appended claims.

The invention is hereby claimed as follows:

1. In a building, a planar panel structure inclined from the horizontal, said panel structure comprising an inner substantially imperforate sheathing, upstanding horizontally-spaced spacer members secured to the outer surface of said sheathing, an outer substantially imperforate sheathing secured along its inner surface to said spacer members thereby defining upstanding air spaces between said sheathings having substantially uniform cross-sectional areas throughout their lengths so that the outer surface of said inner sheathing faces the inner surface of said outer sheathing and the outer surface of the outer sheathing and the inner surface of the inner sheathing are non-facing, said outer surface of said outer sheathing having a finish with an absorptivity and emissivity substantially greater than the absorptivity and emissivity of the inner surface finish of said outer sheathing and the inner and outer surface finishes of said inner sheathing, whereby the absorptivity and emissivity of the outer surface finish of the outer sheathing coacts with the absorptivity and emissivity of the other surface finishes to control the rate and direction of radiant thermal energy passing through the panel structure, and openings at the upper and lower ends of said air spaces communicating same with the atmosphere, said openings having their width and depth at least equal to the width and depth of the cross-sectional area of said air spaces, whereby air may enter said lower openings and flow through said air spaces by natural convection to exit through said upper openings when the temperature of one of said sheathings is above the ambient temperature of the incoming air thereby substantially eliminating thermal conduction across said air spaces.

2. In a building, a planar panel structure inclined from the horizontal, said panel structure comprising an inner substantially imperforate sheathing, upstanding horizontally-spaced spacer members secured to the outer surface of said sheathing, an outer substantially imperforate sheathing secured along its inner surface to said spacer members thereby defining upstanding air spaces between said sheathings having substantially uniform cross-sectional areas throughout their lengths so that the outer surface of said inner sheathing faces the inner surface of said outer sheathing and the outer surface of the outer sheathing and the inner surface of the inner sheathing are non-facing, said outer surfaces of said outer sheathing and said inner sheathing having finishes with an absorptivity and emissivity substantially greater than the absorptivity and emissivity of the inner surface finishes of said inner and outer sheathings, whereby the absorptivity and emissivity of the outer surface finish of the outer sheathing coacts with the absorptivity and emissivity of the other surface finishes to control the rate and direction of radiant thermal energy passing through the panel structure, and openings at the upper and lower ends of said air spaces communicating same with the atmosphere, said openings having their width and depth at least equal to the width and depth of the cross-sectional area of said air spaces, whereby air may enter said lower openings and flow through said air spaces by natural convection to exit through said upper openings when the temperature of one of said sheathings is above the ambient temperature of the incoming air thereby substantially eliminating thermal conduction across said air spaces.

3. In a building, a planar panel structure inclined from the horizontal, said panel structure comprising an inner substantially imperforate sheathing, upstanding horizontally-spaced spacer members secured to the outer surface of said sheathing, an outer substantially imperforate sheathing secured along its inner surface to said spacer members thereby defining upstanding air spaces between said sheathings having substantially uniform cross-sectional areas throughout their lengths so that the outer surface of said inner sheathing faces the inner surface of said outer sheathing and the outer surface of the outer sheathing and the inner surface of the inner sheathing are non-facing, said outer surface of said outer sheathing and said inner surface of said inner sheathing having finishes with an absorptivity and emissivity substantially greater than the absorptivity and emissivity of the inner surface finish of said outer sheathing and the outer surface finish of said inner sheathing, whereby the absorptivity and emissivity of the outer surface finish of the outer sheathing coacts with the absorptivity and emissivity of the other surface finishes to control the rate and direction of radiant thermal energy passing through the panel structure, and openings at the upper and lower ends of said air spaces communicating same with the atmosphere, said openings having their width and depth, at least equal to the width and depth of the cross-sectional area of said air spaces, whereby air may enter said lower openings and flow through said air spaces by natural convection to exit through said upper openings when the temperature of one of said sheathings is above the ambient temperature of the incoming air thereby substantially eliminating thermal conduction across said air spaces.

4. In a building, a planar panel structure inclined from the horizontal, said panel structure comprising an inner substantially imperforate sheathing, upstanding horizontally-spaced spacer members secured to the outer surface of said sheathing, an outer substantially imperforate sheathing secured along its inner surface to said spacer members thereby defining upstanding air spaces between said sheathings having substantially uniform cross-sectional areas throughout their lengths so that the outer surface of said inner sheathing faces the inner surface of said outer sheathing and the outer surface of the outer sheathing and the inner surface of the inner sheathing are non-facing, said outer surface of said outer sheathing and said inner and outer surfaces of said inner sheathing having finishes with an absorptivity and emissivity substantially greater than the absorptivity and emissivity of the inner surface finish of said outer sheathing, whereby the absorptivity and emissivity of the outer surface finish of the outer sheathing coacts with the absorptivity and emissivity of the other surface finishes to control the rate and direction of radiant thermal energy passing through the panel structure, and openings at the upper and lower ends of said air spaces communicating same with the atmosphere, said openings having their width and depth at least equal to the width and depth of the cross-sectional area of said air spaces, whereby air may enter said lower openings and flow through said air spaces by natural convection to exit through said upper openings when the temperature of one of said sheathings is above the ambient temperature of the incoming air thereby substantially eliminating thermal conduction across said air spaces.

5. In a building, a planar panel structure inclined from the horizontal, said panel structure comprising an inner substantially imperforate sheathing, upstanding horizontally-spaced spacer members secured to the outer surface of said sheathing, an outer susbtantially imperforate sheathing secured along its inner surface to said spacer members thereby defining upstanding air spaces between said sheathings having substantially uniform cross-sectional areas throughout their lengths so that the outer surface of said inner sheathing faces the inner surface of said outer sheathing and the outer surface of the outer sheathing and the inner surface of the inner sheathing are non-facing, said outer and inner surface of said outer sheathing having finishes with an absorptivity and emissivity substantially greater than the absorptivity and emissivity of the inner and outer surface finishes of said inner sheathing, whereby the absorptivity and emissivity of the outer surface finish of the outer sheathing coacts with the absorptivity and emissivity of the other surface finishes to control the rate and direction of radiant thermal energy passing through the panel structure, and openings at the upper and lower ends of said air spaces communicating same with the atmosphere, said openings having their

width and depth at least equal to the width and depth of the cross-sectional area of said air spaces, whereby air may enter said lower openings and flow through said air spaces by natural convection to exit through said upper openings when the temperature of one of said sheathings is above the ambient temperature of the incoming air thereby substantially eliminating thermal conduction across said air spaces.

6. In a building, a planar panel structure inclined from the horizontal, said panel structure comprising an inner substantially imperforate sheathing, upstanding horizontally-spaced spacer members secured to the outer surface of said sheathing, an outer substantially imperforate sheathing secured along its inner surface to said spacer members thereby defining upstanding air spaces between said sheathings having substantially uniform cross-sectional areas throughout their lengths so that the outer surface of said inner sheathing faces the inner surface of said outer sheathing and the outer surface of the outer sheathing and the inner surface of the inner sheathing are non-facing, said inner and outer surfaces of said outer sheathing and said inner surface of said inner sheathing having finishes with an absorptivity and emissivity substantially greater than the absorptivity and emissivity of the outer surface finish of said inner sheathing, whereby the absorptivity and emissivity of the outer surface finish of the outer sheathing coacts with the absorptivity and emissivity of the other surface finishes to control the rate and direction of radiant thermal energy passing through the panel structure, and openings at the upper and lower ends of said air spaces communicating same with the atmosphere, said openings having their width and depth at least equal to the width and depth of the cross-sectional area of said air spaces, whereby air may enter said lower openings and flow through said air spaces by natural convection to exit through said upper openings when the temperature of one of said sheathings is above the ambient temperature of the incoming air thereby susbtantially eliminating thermal conduction across said air spaces.

7. In a building, a planar panel structure inclined

from the horizontal, said panel structure comprising an inner substantially imperforate sheathing, upstanding horizontally-spaced spacer members secured to the outer surface of said sheathing, an outer substantially imperforate sheathing secured along its inner surface to said spacer members thereby defining upstanding air spaces between said sheathings having substantially uniform cross-sectional areas throughout their lengths so that the outer surface of said inner sheathing faces the inner surface of said outer sheathing and the outer surface of the outer sheathing and the inner surface of the inner sheathing are non-facing, said inner and outer surfaces of said outer sheathing and said outer surface of said inner sheathing having finishes with an absorptivity and emissivity substantially greater than the absorptivity and emissivity of the inner surface finish of said inner sheathing, whereby the absorptivity and emissivity of the outer surface finish of the outer sheathing coacts with the absorptivity and emissivity of the other surface finishes to control the rate and direction of radiant thermal energy passing through the panel structure, and openings at the upper and lower ends of said air spaces communicating same with the atmosphere, said openings having their width and depth at least equal to the width and depth of the cross-sectional area of said air spaces, whereby air may enter said lower openings and flow through said air spaces by natural convection to exit through said upper openings when the temperature of one of said sheathings is above the ambient temperature of the incoming air thereby substantially eliminating thermal conduction across said air spaces.

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