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SANDWICH PANEL CONSTRUCTION

Filed Sept. 27, 1961 2 Sheets-Sheet 1

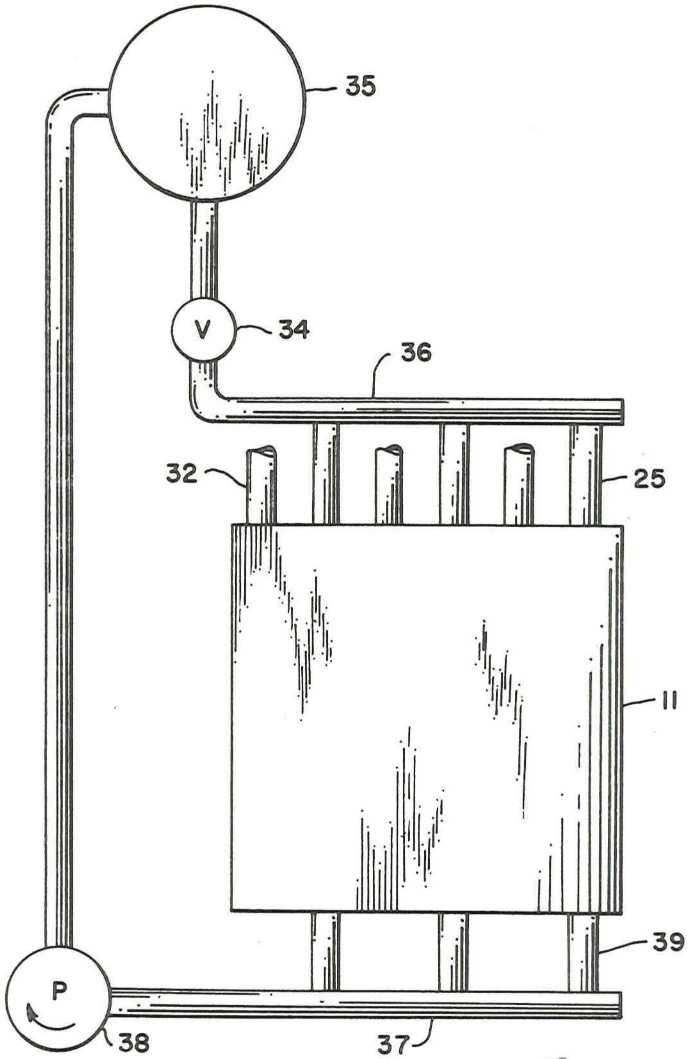

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FIG. 1

INVENTORS
ROGER A. ANDERSON
ROBERT T. SWANN

BY G. D. O'Brien
J. M. Carson, Jr.
ATTORNEYS

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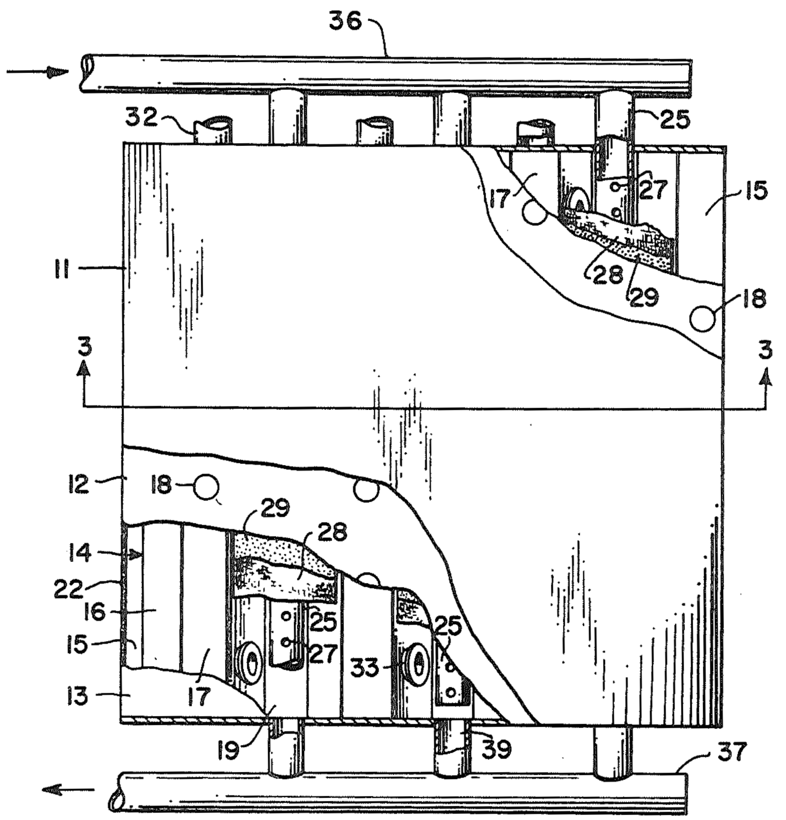

FIG. 2

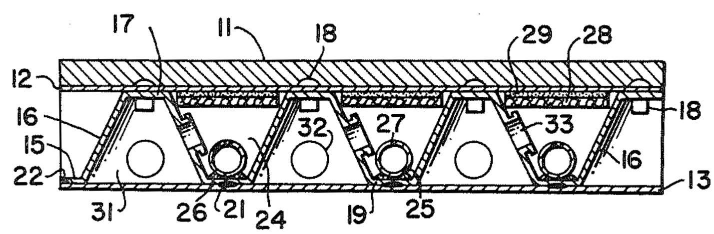

FIG. 3

INVENTORS
ROGER A. ANDERSON
ROBERT T. SWANN

BY

G. D. O'B...
J. M. Carson, Jr.
ATTORNEYS

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3,090,212
SANDWICH PANEL CONSTRUCTION

Roger A. Anderson, Newport News, and Robert T. Swann, Hampton, Va., assignors to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

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12 Claims. (Cl. 62—467)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates generally to a system for the removal of heat accumulating in a heat shield panel or barrier positioned between an area of high heat concentration and an area of lower heat concentration, and more particularly to a sandwich panel construction including the provision of means for maintaining the temperature in the area of lower heat concentration at a predetermined level independent of the amount of heat applied to the heat shield in the area of high heat concentration.

It will be appreciated that the sandwich panel construction of the present invention is applicable to any type of furnace wall construction, heat shield, or the like, where it is desirable to protect an area or space from excessive temperatures prevailing in an adjoining area or space, such as, for example, in the protection of various mechanisms or individuals required to work adjacent areas of excess heat, or in aerospace vehicles adapted to fly at high speeds.

One heretofore proposed system for obtaining these desired results called for the provision in a wall construction of closed loop recirculating systems carrying heat to a water boiler or storage tank. Such a system is conventional in the cooling of stationary furnace walls, as illustrated by U.S. Patent 2,981,241, to Barton. This prior art system, however, is not considered to be capable of handling the extreme heat loads of the present system, even when the cooling channels are positioned closely adjacent to each other. In addition, this prior art system relies on conduction in the wall materials to carry heat to the cooling channels, and thus restricts the choice of materials to those of high thermal conductivity. The operation of this particular system is also sensitive to small leaks, and is quickly disrupted if any one cooling channel is blocked or ruptured.

Another prior art system for removing heat from a heat barrier structure contemplates the provision in a panel wall construction of a water evaporation system utilizing wicking material for water stowage within the panel wall. Such an evaporation cooling system is illustrated in U.S. Patent No. 2,908,455 to Hoadley and in U.S. Patent No. 2,922,291 to Fox et al. Such a system, however, involves stowage of the water or other coolant in the panel wall, and relies on capillary action in a wicking material to distribute coolant over short distances. Stowage is difficult to accomplish when the coolant requirement is large, and either requires foreknowledge of the total heat load to be imposed on the various areas to be cooled or requires that excessive coolant be stowed at all areas to handle heat loads not readily predeterminable by the designer. This system is further considered impractical for high speed aerospace vehicles, since a fluid-tight double-wall structure compartmented into numerous panels would be required to minimize acceleration force effects on coolant distribution. Further, a micrometeoroid puncture during the space flight portion of a vehicle mission could lead to serious loss of coolant stowed adjacent the vehicle surface.

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The present invention combines the advantageous features of both of the aforementioned prior art systems while minimizing the disadvantages thereof. Accordingly, an object of the present invention is the provision of a new and improved cooled wall panel structure.

Another object of the instant invention is the provision of a new and improved system for the removal of heat in a wall panel construction.

A further object of the present invention is the provision of heat barrier means for preventing excessive heat accumulation within a selected area.

Still another object of the instant invention is the provision of an improved form of heat exchange panel structure particularly adapted for the thermal protection of human life and equipment.

A still further object of the instant invention is the provision of a new and novel fire wall panel construction interpositionable between an area of high heat concentration and an area of lower heat concentration.

According to the present invention, the foregoing and other objects are attained by providing, in a heat barrier wall, sandwich panel units of the type including a corrugated core element. Spray tubes are positioned within alternate individual corrugations of the core element, and are adapted to spray water or other liquid coolant onto absorbent wicking material secured to the interior of an external surface portion of the panel. A heat shield element is operatively coupled with the exterior of this external surface portion of the panel and is positionable adjacent an area of high heat concentration. Heat impinging upon the shield leads to heat accumulation within the panel, causing evaporation of the coolant in the wicking material, and the evaporated coolant leaves the panel through exhaust conduits with the result that the temperature at the other external surface portion of the panel is maintained at or below a predetermined level.

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a schematic view of a typical heat barrier panel structure of the present invention interconnected with a liquid coolant supply system;

FIG. 2 is a plan view of the heat barrier panel structure with parts broken away to show the interior thereof; and,

FIG. 3 is a cross-sectional elevational view of the heat barrier panel structure taken along the line 3—3 of FIG. 2.

Referring now more particularly to the drawings, wherein like reference numerals designate identical parts throughout the several views, and more particularly to FIG. 1, there is shown a heat barrier or shield **11** operatively coupled with a circulatory cooling system. Heat barrier or shield **11** is preferably of metallic construction, although other suitable conventional materials such, for example, as ceramics or high temperature resistant plastics, may be utilized as found desirable. The heat barrier **11** is disposed between an area of high heat concentration and an area to be thermally protected, i.e., an area of lower heat concentration. Referring now more particularly to FIGS. 2 and 3, the heat barrier or shield **11** is shown operatively coupled with a sandwich panel unit including a metallic external wall or skin **12**, a metallic inner wall or skin **13**, and an intermediate corrugated metallic core element generally designated by the reference numeral **14**. Core element **14** is composed of a unitary sheet metal member including end flange portions **15**, diagonally disposed web portions **16**, and intermediate flange portions **17** and **19**. Alternate ones of the diagonal web portions **16** are parallel to each other and are disposed at approximately 45 degree angles to the skins **12** and **13**. The web portions **16** converging toward external skin **12** are joined by flange sections **17** adjacent and parallel to external skin **12** and attached thereto by suitable means such as, for example, rivets **18**. The web portions **16** which converge toward internal skin **13** are joined by bottom flange sections **19** adjacent and parallel to internal skin **13** and secured thereto by any suitable means such as, for example, welds **21**. End flange portions **15** of core element **14** are secured to the skins **12** and **13** by conventional means, such as welds **22** or rivets **18**. The space between inner wall or skin **13** and outer wall or skin **12** is thus divided by corrugated core element **14** into a plurality of longitudinally extending bulkheads forming parallel channels **24** and **31** which are substantially trapezoidal in cross-section. Rivet means **18** may also be extended through external skin or wall **12** to connect with shield **11** where so desired.

A plurality of longitudinally disposed spray tubes **25** extend into the sandwich panel unit at spaced intervals. These tubes **25** are attached by suitable welds or thermosetting adhesives **26** within the minor area portion of the parallel longitudinally extending channels **24**, adjacent inner wall or skin **13**, and extend substantially the entire length of these channels **24**. Each of spray tubes **25** is provided on one surface thereof with a row or rows of minute, closely spaced holes **27** adapted to direct a spray of water or other liquid coolant from the interior of the tube **25** onto absorbent wicking material **28** which, in turn, is fixedly secured by suitable adhesive or bonding means **29** to the major surface area of the internal surface of outer skin or wall **12** spaced from the spray tubes. The alternate channels **31** of corrugated core element **14** not occupied by spray tubing **25** are utilized as steam exhaust passages leading through pressure relief valves, not shown, to exhaust conduits **32** which, if so desired, may be directed to any desirable point on the exterior surface of heat shield **11** for the cooling of selected exterior areas of the heat shield. The corrugated core element **14** also is provided, on alternate ones of diagonal web portions **16**, with means forming furled holes **33** which permit the transfer of steam from channels **24** to steam exhaust channels **31** while hindering the flow of water therethrough. The excess water or other coolant not converted to steam is thus available for transfer back to a central water reservoir, or may be discarded as waste, as will be explained more completely hereinafter.

To assemble the above described structure, spray tubes **25** may be adhesively bonded, by any well known thermosetting adhesive **26**, or attached in any other suitable manner, to corrugated core element **14** which has been previously attached, as by spot welds **21**, to the exterior side of inner skin or wall **13**. Wicking material **28** is secured, by suitable bonding means **29**, to the interior side of outer skin **12**, which may then be fastened to corrugated structure **14** by rivets **18** or any other suitable equivalent means. The assembled structure may then be positioned adjacent heat shield **11**, which may be a separate structure or, as in furnace walls or stationary fire shields, may be assembled directly on and attached to the sandwich panel. It will readily be seen that a complete cooling system checkout may be accomplished prior to assembly of the outer wall to the corrugated structure and prior to the application of the heat shield to the outer skin.

In operation of the system, referring once again to FIG. 1, water or other liquid coolant is admitted through a valve **34**, which may be actuated manually, or automatically by means responsive to temperature, motion or time control, from a pressurized central coolant supply reservoir **35**, into inlet coolant supply manifold **36** and thence into spray tubes **25**. Obviously, the temperature of heat shield **11** when valve **34** opens would be somewhat higher than the maximum temperature to be maintained along internal wall or skin **13**. The water or other coolant is forced through inlet supply manifold **36**, spray tubing **25**, and onto wicking material **28**. As the temperature of wicking material **28** increases due to heat emanating from heat shield **11**, the water is evaporated and converted into steam which results in convective cooling of heat shield **11** and the maintenance of a maximum temperature level for internal wall or skin **13** by disposing of heat as collected on heat shield **11**. The amount of water forced into the cooling area is predetermined by the total heat load expected for the panel and, of course, varies with the size and shape of the panel and the amount of heat applied to shield **11**. The system is calibrated to assure that at least the minimum amount of water required to maintain the desired temperature level reaches the cooling area. Any excess water is returned to outlet coolant return manifold **37**, through return tubes **39**, and may be pumped back into central reservoir **35** by a suitable conventional pump **38**. Steam created by the heating of the water coolant helps maintain the desired temperature level of inner skin **13** and is exhausted through steam exhaust ports **32** to the exterior of the system. It is also contemplated that this exhaust steam can be directed to selected exterior areas of heat shield **11** for mass transfer cooling thereof, if so desired. It is further within the scope of this invention that any conventional source of water or other liquid coolant under pressure may be connected to supply manifold **36**, and that excess coolant from return manifold **37** may be discarded as waste when so desired.

From the foregoing description, it will be readily apparent that the present invention may be employed as a cooling system for any type of area where it is desirable that the temperature level adjacent internal wall or skin **13** be maintained below a predetermined maximum. Under the system of the present invention, using water as the coolant, it has been found possible to provide heat barriers capable of disposing of heat at rates from 0–5 B.t.u.'s/ft.^{2}-sec. with a capability in localized areas (about 1 in.^{2}) of 20 B.t.u./ft.^{2}-sec., and the system as thus designed provides a positive temperature cut-off at 150 degrees F. for inner wall **13** independent of the timewise and spatial distribution of heat applied to heat shield **11**. Although this temperature may be uncomfortable to humans when endured over a long period of time, no difficulty is experienced by individuals at this temperature level during relative short intervals of time. Further, even protracted exposure of instruments, mechanisms, or the like to such temperature levels is not expected to result in deleterious effects thereon.

Whereas the operation of the device according to the present invention has been described in connection with a specific structural panel barrier utilizing water as a coolant, it is not so limited and the use of any liquid coolant is contemplated, while the structure may vary from fire shields for individuals to entire building or vehicle cooling systems.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A sandwich panel heat barrier structure, comprising: an internal skin, an external skin spaced from said internal skin, a core element including a plurality of bulkheads disposed intermediate said internal and external skins and attached thereto to divide the space between said skins into a plurality of longitudinally extending channels, absorbent means fixedly positioned adjacent the inner surface of said external skin and a plurality of spray tubes individually secured within at least some of said channels and adapted to spray a liquid coolant onto said absorbent means.

2. A sandwich panel heat barrier structure, comprising: an internal skin, an external skin spaced from said internal skin, a corrugated core element disposed inter-

mediate said internal and external skins and attached thereto, absorbent wick material fixedly attached to the inner surface of said external skin over the major portion thereof, and a plurality of spray tubes attached to said corrugated core element at spaced intervals and adapted to spray a liquid coolant onto said absorbent wick material.

3. A sandwich panel heat barrier structure according to claim 2 and further including outlet means within said corrugated core element for removal of excess coolant from said wick material.

4. A substantially hollow wall panel adapted to be exposed on one surface thereof to extreme heat, said hollow wall panel comprising at least an inner skin, an outer skin, and a core element positioned between said skins, said core element comprising a corrugated metallic sheet secured to said inner and outer skins, absorbent means fixedly attached to said outer skin and adjacent to said core element, and means to continuously supply a liquid coolant to said absorbent means to effect cooling of said outer skin.

5. A wall panel according to claim 4 wherein the space between said inner and outer skins is divided into a plurality of longitudinally extending channels by said core element.

6. A wall panel according to claim 5 wherein said absorbent means and said means supplying liquid coolant thereto are both positioned within alternate ones of said longitudinally extending channels.

7. A system for disposing of heat accumulating in a heat barrier adapted to be positioned between an area of high heat concentration and an area of lower heat concentration, comprising in combination a heat shield; a sandwich panel structure; said panel structure including, an external skin attached to said heat shield, an internal skin, and a corrugated core element disposed intermediate said internal and external skins and secured thereto at spaced intervals; said core element defining a plurality of longitudinally disposed channels between said internal and external skins, tubular spray means within alternate ones of said channels extending substantially the entire length of the respective channel, and a supply manifold disposed externally of said sandwich panel structure and connected to a central coolant supply reservoir and to each of said tubular spray means for the transfer of coolant from said reservoir to said tubular spray means.

8. A heat protective system for use between an area of high heat concentration and an area of lower heat concentration comprising heat shield means adjacent the area of high heat concentration, a sandwich panel cooling construction adjacent said heat shield means, said sandwich panel construction comprising an inner skin, an outer skin, and a core element, said core element comprising a corrugated metallic sheet secured between said inner and outer skins and defining a plurality of equally spaced parallel longitudinally extending channels, first alternate ones of said channels forming cooling channels and having fixedly secured therein longitudinally extending tubular means, said tubular means having at least one row of closely spaced minute holes on one surface thereof, an absorbent wicking material fixedly attached to the inner surface of said outer skin over the major portion thereof and spaced from said row of holes in each said tubular means, one end of each said tubular means being operatively connected to an inlet coolant supply manifold and the other end of each said tubular means being sealed and terminating within said cooling channel, means operatively connecting each said cooling channels to an outlet return manifold, second alternate ones of said longitudinally extending channels comprising steam exhaust channels, means providing for fluid communication between each of said cooling channels and an adjacent steam exhaust channel, and exhaust means operatively connected to each said steam exhaust channel, liquid coolant being forced under pressure into said inlet supply manifold and then through said tubular means, delivered as a spray through said row of holes in each said tubular means onto said wicking material from which it may be evaporated and converted into steam by heat emanating from said heat shield means, the excess steam passing from said cooling channels into said steam exhaust channels and then from said steam exhaust channels through said exhaust means to the atmosphere, excess coolant not absorbed by said wick material being received by said outlet return manifold.

9. A heat protective system according to claim 8 further including valve means actuatable to permit flow of coolant from a central coolant supply reservoir into said inlet supply manifold, and pump means associated with said outlet return manifold adapted to transfer excess coolant from said return manifold back to said central supply reservoir.

10. A heat protective system according to claim 8 wherein the means providing for fluid communication between each of said cooling channels and the adjacent steam exhaust channel comprises at least one furled hole in said corrugated core element separating each said cooling channel and said adjacent steam exhaust channel, whereby steam is freely transferred from said cooling channel to said exhaust channel and the flow of liquid coolant therebetween is obstructed.

11. A heat barrier structure, comprising: an inner skin; an outer skin; spacing means arranged between said skins and attached thereto to retain them in fixed spaced relation; absorbent means fixedly positioned at spaced points between said skins; and means to direct a spray of liquid coolant onto said absorbent means.

12. A structure according to claim 11 wherein said spacing means forms bulkheads dividing the space between said skins into a plurality of compartments; and said means to direct a spray of liquid coolant onto said absorbent means are positioned within selected ones of said compartments.

References Cited in the file of this patent

UNITED STATES PATENTS

2,576,843	Lockman	Nov. 27, 1951
3,013,641	Compton	Dec. 19, 1961

FOREIGN PATENTS

481,285	Italy	May 27, 1953