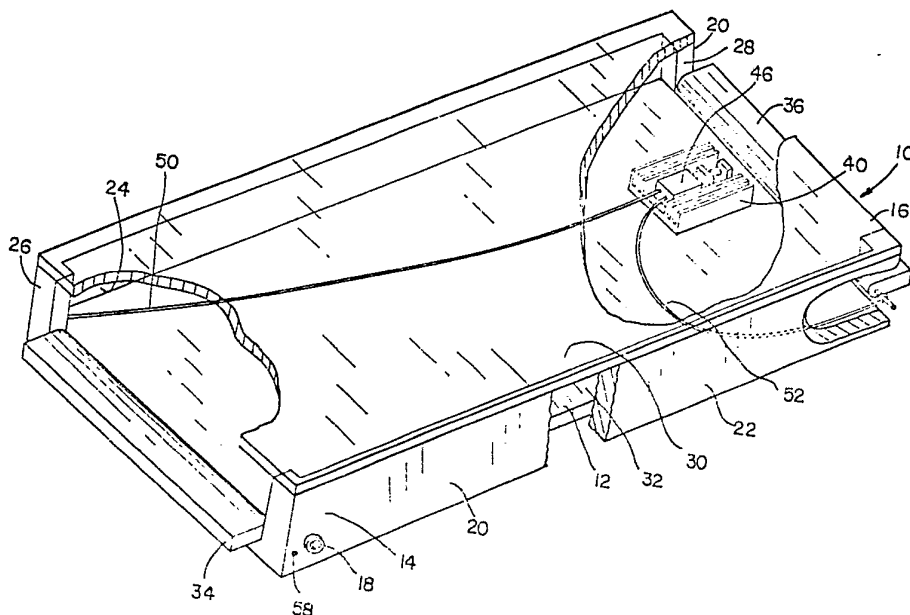




EP. 00 41061

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification³: F24J 3/02	A1	(11) International Publication Number: WO 81/00613 (43) International Publication Date: 5 March 1981 (05.03.81)
(21) International Application Number: PCT/US79/00633 (22) International Filing Date: 21 August 1979 (21.08.79) (71) Applicant: THE DAVID W. PALMER PARTNERSHIP [US/US]; 4729 James Avenue, Racine, WI 53402 (US). (72) Inventor: PALMER, David, W.; 109 Phillips Avenue, Rockport, MA 01966 (US). (74) Agent: JANSSON, Peter, N.; 4729 James Avenue, Racine, WI 53402 (US). (81) Designated States: AT (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, LU (European patent), NL (European patent), SE (European patent).		Published <i>With international search report</i>

(54) Title: IMPROVED VENTED SOLAR PANEL**(57) Abstract**

A solar panel (10) having venting gates (34, 36) at opposite ends of an air plenum defined between a collector element (12) and a protective, light-transmissive cover (30) and having a wax thermal actuator (46) for both the gates and flexible force-transmitting linkages (50, 52) between the actuator and each gate to operate the gates simultaneously. Preferred embodiments include certain linkages, gates and gate control apparatus, and certain structural relationships of the actuator with the collector element to achieve desired heat transfers. In certain embodiments, the actuator is part of a heat-sensing module which receives a multiplicity of heat inputs. The collector element (12) in certain highly preferred embodiments is of plastic. A glazed solar panel (10) having a venting gate controlled by a temperature-responsive wax thermal actuator (46) linked thereto by a flexible force-transmitting linkage.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	KP	Democratic People's Republic of Korea
AU	Australia	LI	Liechtenstein
BR	Brazil	LU	Luxembourg
CF	Central African Republic	MC	Monaco
CG	Congo	MG	Madagascar
CH	Switzerland	MW	Malawi
CM	Cameroon	NL	Netherlands
DE	Germany, Federal Republic of	NO	Norway
DK	Denmark	RO	Romania
FI	Finland	SE	Sweden
FR	France	SN	Senegal
GA	Gabon	SU	Soviet Union
GB	United Kingdom	TD	Chad
HU	Hungary	TG	Togo
JP	Japan	US	United States of America

IMPROVED VENTED SOLAR PANEL

This invention relates to solar panels, such as panels for heating water and the like, and, more particularly, to solar panels which have vented air plenums, typically above the collector element, to
5 eliminate overheating.

Background of the Invention

Solar panels have been used to collect solar energy for space heating, water heating and a variety of other applications requiring heat energy. Solar panels
10 of this type typically have a collector plate or other collector element which is of a color (black or other dark color) and/or texture to maximize absorption of solar radiation. Such collector elements have fluid conduits, often a large number of parallel conduits,
15 disposed in efficient conductive heat-transfer relation thereto. Often the conduits are formed integrally with the collector element. A fluid, usually a liquid, flows (aided normally by a remote pump or fan) through the conduits and is heated by taking heat from the collector
20 element. This heated fluid may be used in a variety of ways, either directly (for example as domestic hot water) or for a subsequent heat transfer for some other purpose such as space heating. The fluid passing



through such conduits may be referred to as the "working fluid".

Often, particularly in cold climates, a glazing, that is, a solar energy-transmitting cover, is placed
5 over the collector element in closely spaced relation thereto. This cover is usually supported by a frame of some sort, and forms an air plenum chamber which isolates and insulates the collector element from the environment to minimize undesirable heat loss. The
10 instant invention is applicable to solar panels of this general type and to any solar panel which has an air plenum adjacent to a collector element. The invention relates to the need to vent such air plenum whenever destructive overheating must be prevented.

15 Such solar panels may be mounted on a roof or other structure in position to receive solar radiation. Panels of this type are often generally flat and rectangular, and are often mounted at a substantial tilt or angle with respect to the horizontal to be facing the
20 sun as directly as possible. In many cases, several panels may be ganged together to increase collection of solar radiation.

A major problem with covered solar panels of the type described is excessive heating. If the temperature
25 of the solar collector and/or the entire panel rises above certain levels, a great deal of damage can occur. Of course, the temperatures which are tolerable depend on the materials and construction of the panel. Differing thermal expansion coefficients of materials
30 used in the panel may result in the breaking of bonds and joints. And, if the working fluid in the conduits vaporizes, the pressure may increase to the point of rupturing the conduits, thus causing leakage in the system. Very high temperatures for long periods of time
35 may cause permanent distortions in the collector element



(particularly metal collector elements) and related parts and can even cause melting of plastics and combustion of combustible materials.

Overheating of a solar panel can arise from
5 several failures in the system, such as blockage or other failure in the circulation of the working fluid, pump failure, power failure, or malfunctioning of the solar panel control system. Various systems have been made to protect solar panels from overheating. However,
10 many of these systems have failed because of electrical power outages or other problems.

Attempts have been made to develop means of venting the air plenum between the solar collector and the cover when overheating occurs to allow the hot air
15 adjacent to the overheated collector element to escape from the air plenum and be replaced by cooler air from the atmosphere, thus retarding heat buildup and allowing the collector element to cool to acceptable temperature levels. None of the efforts prior to the instant
20 invention, however, have resulted in a practical and effectively operating vented solar panel.

In certain solar panels of the prior art, temperature-responsive bimetal valves or dampers have been placed at opposite ends (the lower and upper ends,
25 considering panel tilt) of the panel. Such arrangements have been unsatisfactory for several reasons. In such panels, the temperature-responsive valves at either end operate separately rather than in a coordinated manner.

The opening of such valves at widely differing
30 times occurs because of the temperature differences between the lower and upper ends of the panel. In many cases, the isolation of the collector element of such a vented panel would be breached without allowing proper venting; such breach, while serving no useful purpose,
35 would allow some unwanted ingress of dirt or dust, par-



ticularly near the opened valve. In other cases, venting would stop prematurely because of premature closing of one of the temperature-responsive valves, before sufficient cooling occurs. While the lack of
5 coordination of separately operable venting valves at opposite ends of the solar panel could be avoided by leaving one end of the solar panel open at all times, such would only reduce the efficiency of panel operation and exacerbate the problem of ingress of dust and dirt.

10 A further problem with some of such temperature-responsive valves is that, even when valves at both ends are open, the venting is insufficient to allow flow of air across substantially the entire width of the solar panel. Instead, flow may occur primarily near the line
15 extending between the bimetal valves at either end of the panel, leaving other portions of the panel substantially uncooled.

Another drawback of the bimetallic valve venting devices is that the bimetallic temperature sensors are
20 at or near the opening, normally an integral part thereof. No flexibility of sensor placement is available.

Another major problem of prior glazed solar panels is their high cost. Glazed solar panels are generally
25 of expensive materials and construction. The collector elements are often expensive metal materials chosen to avoid corrosion. Some glazed solar panels of the prior art have complicated, powered control systems to prevent problems. Such systems are generally quite expensive,
30 and are also subject to failure because of power outages.

To reduce high panel cost, plastic collector elements could be used. Plastic collector elements,
35 however, undergo much greater dimensional changes



than similarly shaped metal elements, and use of such elements would place constraints on panel construction, and on any control systems forming a part thereof.

In summary, there has been need for a relatively
5 low-cost, efficiently operating, and practical vented solar panel. There has been need for a vented solar panel with a reliable heat-sensing device and vent control system.

Brief Summary of the Invention

10 This invention solves the problems and fills the needs mentioned above, providing an efficiently operating, practical vented solar panel. The solar panel of this invention has a reliable heat-sensing device and vent control system, which is totally sun-powered. The
15 solar panel of this invention, particularly certain preferred embodiments, is a relatively low-cost and trouble-free device.

The invention includes the use of a wax thermal actuator as the control for all required venting gates
20 in the panel. In a highly preferred embodiment, a wax thermal actuator is in heat-transfer relation with the collector plate and controls gates at opposite ends of the air plenum by means of flexible force-transmitting linkages extending between the actuator and each of the
25 gates.

The actuator and linkages serve to operate the gates simultaneously, to eliminate substantial problems and disadvantages of vented panels of the prior art. The wax thermal actuator generates sufficient force to
30 operate two large gates extending substantially across the width of the panel at either end thereof even though the actuator is remote from the gates. The force-transmitting linkages must be flexible to accommodate dimensional variations in the panel between the
35 actuator and the gates due to thermal expansion



and contraction. Control cables (that is, sheathed mechanical cables such as bicycle cables), can accommodate great dimensional variations, making possible effective operation of gates which are remote from the
5 actuator, even in panels having collector elements of highly expandable plastics.

In preferred embodiments of the invention, the gates are pivotable with respect to the remainder of the structure and operate as torque is applied by means of
10 the linkages. A linkage is secured relative to its gate at a radial position near the axis of the pivot for the gate. This serves to amplify the gate-opening movement available from lineal movement of the linkage. It has been determined that wax thermal actuators have suf-
15 ficient force to reliably move the gates in this manner through flexible linkages.

Certain preferred embodiments include one or more springs or other means to bias the gates toward the positions closing the air plenum. In such embodiments,
20 the wax thermal actuator and linkages are arranged to pull the gates moving them toward the open (or venting) positions. Such biasing means, sometimes referred to herein as first biasing means, may be two or more separate springs or the like at the gates, but is
25 preferably a single coil spring or the like arranged in relation with the actuator to act on the gates through the linkages. Some embodiments have, as an additional feature, second biasing means, which is (are) weaker than the first biasing means, to move the gates to
30 the open venting position when the flexible force-transmitting linkages (between the actuator and the gates) are disconnected or broken. The second biasing means serve(s) as a fail-safe system against overheating of panels should the linkages break.



The wax thermal actuator, which is in heat-transfer relation to the collector element, is preferably in heat-conductive relation thereto, either in direct contact herewith or through a preferably
5 metallic module of which it is a part. When the collector overheats, the heat is conducted into the wax thermal actuator. When unacceptable temperatures are reached, the actuator will move with force, as will be more fully explained hereinafter, and act on the gates
10 through the flexible linkages.

While major heat input to the wax thermal actuator may be by conduction, in some embodiments the actuator is part of a heat-sensing module which includes heat-transfer fins within the air plenum. The fins increase
15 the amount of heat which may be transferred to or from the module by convection as air within the plenum contacts the module. With such an arrangement, actuation of the wax thermal actuator to open the vent gates can readily occur even though the portion of the solar panel
20 including the module may be shaded. And, when the venting gates are open, the fins will facilitate cooling of the actuator, thus preventing the solar panel from cooling so much that efficient operation is impaired.

The increase in convective heat transfer is
25 usually of greater importance when a plastic collector element is used, because of the lower thermal conductivity of plastics (compared to metal). The module itself, in most arrangements, shades a small portion of the collector, and conductive heat transfer from the
30 hotter, unshaded portions of the collector to the module through the shaded portions of the collector in contact with the module would be somewhat limited. Thus, with the venting gates closed, circulation of hot stagnant air within the air plenum is an important means of
35 heating the module and its wax thermal actuator.



In some preferred embodiments, the heat-sensing module may be adapted (such as by darkening its surface) for substantial absorption of solar radiation. This may be useful, particularly in solar panels having plastic
5 collectors, for substantially the same reasons as mentioned above.

The heat-sensing module, when it is adapted to absorb solar radiation, has fins for convective heat transfer from the air plenum, and is in conductive heat-
10 transfer relation to the collector, functions as a summing integrator of conductive, convective, and radiative heat transfer to the actuator. This arrangement functions well in sensing overheating at any portion of the solar panel and responding by ready venting
15 and closing of vents when and to the extent required to protect the solar panel.

The heat-sensing module may be located on the collector plate at whatever point is deemed advantageous. However, the module is preferably located near the upper
20 end of the solar panel, which is normally the hottest part of the panel.

Objects of the Invention

It is the primary object of this invention to provide a vented solar panel overcoming problems and
25 deficiencies of panels of the prior art.

Another object of this invention is to provide a vented solar panel which is totally sun-powered and thus not subject to power failure.

Another object of this invention is to provide a
30 low-cost, glazed solar panel which is reliable in operation.



Yet another object of this invention is to provide a vented solar panel which remains substantially closed except when venting is required to counteract overheating.

5 Still another object of this invention is to provide a vented solar panel with a heat-sensing device which controls gates at opposite ends of the panel simultaneously.

10 Another object of this invention is to provide a vented solar panel having a single temperature-responsive control for two widely separated venting gates.

Yet another object of this invention is to provide
15 a vented solar panel which allows cooling across substantially the entire width of the collector plate.

Still another object of this invention is to provide a vented solar panel with a temperature-responsive control having sufficient forcefulness to operate
20 venting gates extending across the width of the panel.

A further object of this invention is to provide a vented solar panel having a temperature-responsive gate operator which undergoes substantial heat transfer by conduction, convection and radiation to overcome certain
25 problems and provide reliable and efficient venting.

Brief Description of the Drawings

These and other objects of the invention will be apparent from the following description of preferred embodiments wherein:

30 FIGURE 1 is a partially cutaway perspective view of a solar panel according to this invention.



FIGURE 2 is an enlarged, partially cutaway perspective view of a portion of the device of FIGURE 1, specifically, the heat-sensing module.

FIGURE 3 is an enlarged, perspective view of
5 FIGURE 1, showing details of the gate-operating mechanism not shown in FIGURE 1.

FIGURE 4 is a sectional, partial top view of FIGURE 2, illustrating that portion of the device when the solar panel is below a predetermined unacceptable temperature.

10 FIGURE 5 is a view similar to FIGURE 4, differing only in that it illustrates the device when the panel is at or above a predetermined unacceptable temperature.

Description of Preferred Embodiments

FIGURE 1 illustrates a solar panel 10 according to
15 this invention. Solar panel 10 includes a collector element 12 which is a flat rectangular plate extending across nearly the entire solar panel structure. Collector element 12 has working fluid conduits formed therein which are not shown. The conduits run parallel
20 one to another from a first or lower end 14 of solar panel 10 to a second or upper end 16. The working fluid conduits are joined at either end in manifolds for circulation away from the panel for any desired purpose as previously mentioned. The manifold outlet 18 for lower
25 end 14 is illustrated in FIGURE 1; the manifold for upper end 16 is not shown.

Collector element 12 is mounted on a frame 20 which includes parallel side members 22 and 24, lower end member 26 and upper end member 28. All of the frame
30 members 20 are suitably insulated. Extending across the



top of frame 20 and spaced from collector element 12 is a solar radiation-transmitting cover 30, which is often referred to as a glazing. Cover 30 serves to isolate collector element 12 from the atmosphere, protecting it
5 against unnecessary heat loss while allowing radiant heat to enter.

Cover 30 defines, with frame 20 and collector element 12, an air plenum 32. Under working conditions, the air in air plenum 32 does not circulate, but remains
10 in place isolating and insulating collector element 12 from the atmosphere.

Lower end member 26 and upper end member 28 include gates 34 and 36, respectively. Each of gates 34 and 36 is pivotally movable about an axis defined
15 by rotation pins, such as rotation pin 58 shown in FIGURE 1. Gates 34 and 36 are movable between first positions closing air plenum 32 and second positions venting plenum 32. FIGURE 1 illustrates the venting position, in which the gates are wide open. When the
20 gates move through a 90° rotation from the positions illustrated in FIGURE 1, the gates would close the air plenum thus ending venting therethrough. FIGURE 3 shows gate 34 in the closed position.

Near to upper end member 28 and mounted in heat-
25 conductive contact with collector element 32 is heat-sensing module 40. Module 40 is illustrated in detail in FIGURE 2. Heat-sensing module 40 includes a base plate 42 in full contact with collector element 12 and a wax thermal actuator resting on base plate 42. The
30 wax thermal actuator is the heart of the control system for both gates 34 and 36.



As used herein, the term "wax thermal actuator" means a device which uses the change of volume of a material undergoing a reversible solid-liquid phase change to generate displacement of a piston (usually a rod-like piston). Operation of a wax thermal actuator is illustrated in sufficient detail in FIGURES 4 and 5. Wax thermal actuator 46 includes a rigid metal block 72 which defines a chamber 74 filled with wax. Also in chamber 74 is a piston 48 including proximal end 78 in contact with wax 76 and distal end 80 extending outside chamber 74. In FIGURE 4, wax 76 is in the solid state since its temperature is below the phase change range. In FIGURE 5, all or some of the wax in chamber 74 has melted, and, consequently, increased in volume. By its increase in volume, the wax has displaced piston 48 outwardly, generating great force. When wax thermal actuator 46 and hence its wax have cooled, wax 76 will solidify, decreasing in volume and allowing piston 48 to be returned to some extent into chamber 74.

Wax thermal actuators may be obtained from a variety of sources. Such actuators are used in automobile cooling systems and in a variety of other applications, and may be obtained from the same suppliers used in such other cases. Wax thermal actuators which utilize materials having a variety of phase-change temperature ranges may be obtained. For example, wax can be formulated to melt at a temperature anywhere within the range of about 20°C. to 150°C. Usually, a wax mixture will melt at a chosen temperature or within perhaps 3°C. over or under such temperature. As melting occurs, piston 48 will be displaced by an amount proportional to the amount of wax melted. The phase-change material should be chosen with reference to a predetermined unacceptable temperature for the construction and materials chosen for the solar panel.



As previously indicated, the movement of piston 48 is accomplished with great force, and provides the work necessary to move gates 34 and 36 from the first or closed positions to the second or open positions simultaneously. The movement provided by actuator 46 is transmitted simultaneously to gates 34 and 36 by means of flexible force-transmitting linkages 50 and 52, respectively. The term "flexible force-transmitting linkage" as used herein means a linkage which can transfer the strong force of the wax thermal actuator to the gates and do so effectively in spite of dimensional variations between the actuator and the gates it controls. Such linkages include slack accommodating varying distances between the actuator and the gate or gates. In the highly preferred embodiment shown in the drawings, linkages 50 and 52 are control cables. The term "control cables" as used herein refers to the sheathed coaxial mechanical cables 50 and 52. A variety of other flexible force-transmitting linkages could be used effectively.

As shown best in FIGURES 2, 4 and 5, the sheathings 54 of control cables 50 and 52 are secured to mounting block 72 at one end of each of the cables 50 and 52. The movable inner portion of cables 50 and 52 at that end are secured to a yoke 56 which is attached firmly to distal end 80 of piston 48. The other ends of cables 50 and 52 are secured relative to gates 34 and 36, respectively, and apply a torque thereto in a manner not shown fully in FIGURE 1.

The connection of the cables with respect to the gates is fully illustrated in FIGURE 3. As shown in that figure, cable 50 is secured relative to gate 34 at a radial position near the axis of pivot pin 58 such that linear movement of the inner portion of cable 50 is amplified in the gate-opening movement. Sheathing 54 of



cable 50 is firmly attached to mounting bracket 60 which is secured in turn to a portion of lower end member 26 adjacent to gate 34. The extreme end of cable 50 at gate 34 is wrapped partially around a rotation drum 62 which is fixed to pivot pin 58.

When an unacceptably high temperature is reached, piston 48 of actuator 46 moves outwardly (to the right as shown in FIGURES 1, 2, 4 and 5), causing the inner portion of cable 50 to be moved such that it is effectively unwound from rotation drum 62 to cause gate 34 to open to the venting position shown in FIGURE 1. At precisely the same time, the same action occurs with respect to cable 52 and gate 36 at upper end 28 of frame 20. (The structural details shown in FIGURE 3 with respect to gate 34 are the same with respect to gate 36.) Thus, when the temperature become unacceptably hot, the gates open simultaneously to allow venting of solar panel 10 and consequent cooling.

After solar panel 10 has cooled sufficiently to cause the wax of actuator 46 to solidify, piston 48 and thus yoke 56 undergo return movement under the action of a return compression spring 64 which is compressed between yoke 56 and compression spring buttress 66. (This return movement is to the left as shown in FIGURES 1, 2, 4 and 5.) This causes return movement of cables 50 and 52 and operates to close gates 34 and 36. Referring to FIGURE 3, the return movement causes, in effect, the rewinding of the inner portion of cable 50 onto rotation drum 62 and the consequent amplified closing movement of gate 34. Spring 64 forms the principal part of a first biasing means which urges gates 34 and 36 toward the positions closing air plenum 32. Wax thermal actuator 46, when heated, works against spring 64.



A torsion spring 68 is keyed at one end to pivot pin 58 and attached at the other end to mounting bracket 60. Torsion spring 68 serves as a fail-safe system to protect solar panel 10 from overheating in the event
5 that cables 50 and/or 52 are disconnected or break. In such cases, torsion spring 68 would rotate pivot pin 58 and thus gate 34 to the open position, allowing venting of solar panel 10. A similar torsion spring fail-safe system is installed with respect to gate 36 at upper end
10 of frame 20.

Wax thermal actuator 46 is in heat conductive relation to collector element 12 by means of its contact therewith through base plate 42 of heat-sensing module 40. Module 40 includes heat-transfer fins 70 extending
15 upwardly from base plate 42 in parallel, spaced relationship to one another. Fins 70 extend in a direction between lower end 26 and upper end 28 of panel 10. When gates 34 and 36 are open, "a chimney effect" air flow is established from gate 34 at the lower end of panel 10 to
20 gate 36 at the upper end of panel 10. The flow is caused by the hot air within plenum 30 rising through gate 36 causing cooler air to be drawn into air plenum 32 through gate 34. This air flow will move between fins 70, thus increasing effective heat transfer with
25 actuator 46. Fins 70 will also allow increased convective heat transfer when gates 34 and 36 are closed, as air circulates within air plenum 32. Thus, fins 70 provide the advantages described above.

Module 40 has its upper surface darkened or
30 adapted in other known fashion to absorb substantial amounts of solar radiation. Heat-sensing module 40, therefore, functions as a summing integrator of conductive, convective, and radiative heat transfer. Each of these heat-transfer relationships is significant for the



various reasons described above. Primary heat transfer to and from module 40, and thus actuator 46, can be by conduction from collector plate 12. However, the fins increasing convective heat transfer and the adaptation
5 of module 40 to increase absorption of solar radiation are preferred for more reliable and efficient functioning of the solar panel venting system.

Collector element 12 of solar panel 10 is preferably made of a plastic such as polycarbonate,
10 poly(2,6-dimethyl-1,4-phenylene oxide) (sold by General Electric Company under the trademark "Noryl"), polyethylene, polypropylene or acrylonitrile butadiene styrene. A plastic collector element 12 has certain cost advantages and the further advantages of being corrosion
15 free, unaffected by freezing, and compatible with present plumbing codes. Plastic collector plates may readily be extruded, thus contributing to their low cost when compared to higher-priced materials. However, plastic collector plates undergo substantial dimensional
20 variations as temperature conditions vary. Thus, flexible force-transmitting linkages are particularly required in solar panels having the preferred plastic collector elements. Substantial dimensional changes may be easily tolerated by flexible force-transmitting
25 linkages, particularly the control cables of the preferred embodiments.

The solar radiation-transmitting cover 30 may be made of wide variety of transparent or translucent materials including various plastics, glass or any other
30 material which serves to insulate collector element 12 from the atmosphere while allowing solar radiation to enter. Frame members 20, including gates 34 and 36 may be made of wood or various plastics or metal materials. Such frame members preferably have insulating qualities
35 which prevent unnecessary heat loss during operation of



the solar panel of this invention. The principal parts used in the solar panel are preferably chosen to be compatible in their coefficients of thermal expansion, to maintain structural integrity in the panel. Heat
5 sensing module 40 is preferably made of aluminum or other highly conductive metals.

While in the foregoing specifications, this invention has been described in relation to certain preferred embodiments, and many details have been set forth
10 for purpose of illustration, it will be apparent to those skilled in the art that the invention is susceptible to additional embodiments and that certain of the details described herein can be varied considerably without departing from the basic principles of the
15 invention.



WE CLAIM:

1. In a solar panel of the type having a collector element, a cover spaced from the element and defining an air plenum adjacent to the element, and
5 gates at opposite ends of the plenum movable between first positions closing the plenum and second positions venting the plenum, the improvement comprising:

--a wax thermal actuator for both said gates, said actuator in thermal transfer relation to the element;
10 and

--flexible force-transmitting linkages between the actuator and each of the gates for moving the gates between said first and second positions, whereby the gates operate simultaneously.

15 2. The device of claim 1 wherein the linkages comprise control cables.

3. The device of claim 1 wherein the collector element is of plastic.

4. The device of claim 3 wherein the linkages
20 comprise control cables.

5. The device of claim 1 wherein the panel is generally rectangular and the gates are along substantially the entire width of the panel at said opposite ends.

25 6. The device of claim 1 wherein each of the gates is pivotable and torque is applied thereto by means of said linkages.



7. The device of claim 6 wherein each linkage is secured relative to its gate at a radial position near the axis of the pivot for such gate, whereby to amplify the gate-opening movement available from lineal movement
5 of such linkage.

8. The device of claim 7 wherein the panel is generally rectangular and the gates are along substantially the entire width of the panel at said opposite ends.

10 9. The device of claim 8 wherein the linkages comprise control cables.

10. The device of claim 1 further comprising first means biasing the gates toward said first positions closing said plenum, and wherein the actuator acts
15 through the linkages to move the gates toward said second positions venting the plenum in response to a predetermined unacceptable temperature condition.

11. The device of claim 10 wherein said first biasing means acts on the gates through said linkages.

20 12. The device of claim 11 further comprising second biasing means to bias the gates to said second positions when said linkages are disconnected from the gates.

13. The device of claim 10 wherein the panel is
25 generally rectangular and the gates are along substantially the entire width of the panel at said opposite ends.

14. The device of claim 13 wherein the linkages comprise control cables.



15. The device of claim 11 wherein the panel is generally rectangular and the gates are along substantially the entire width of the panel at said opposite ends.

5 16. The device of claim 15 wherein the linkages comprise control cables.

17. The device of claim 1 wherein the actuator is in heat conductive relation to the collector element.

10 18. The device of claim 1 wherein the wax thermal actuator is part of a heat-sensing module including heat-transfer fins within the plenum, whereby to increase convective heat transfer with the actuator.

15 19. The device of claim 18 wherein said module has a surface adapted for substantial absorption of solar radiation.

20. The device of claim 17 wherein the wax thermal actuator is part of a heat-sensing module including heat-transfer fins within the plenum, whereby to increase convective heat transfer with the actuator.

20 21. The device of claim 20 wherein said module has a surface adapted for substantial absorption of solar radiation, whereby the module functions as a summing integrator of conductive, convective, and radiative heat transfer.

25 22. The device of claim 4 further comprising first means biasing the gates toward said first positions closing said plenum, and wherein the actuator acts through the linkages to move the gates toward said second positions venting the plenum in response to a
30 predetermined unacceptable temperature condition.



23. The device of claim 22 wherein said first biasing means acts on the gates through said linkages.

24. The device of claim 23 further comprising second biasing means to bias the gates to said second
5 positions when said linkages are disconnected from the gates.

25. The device of claim 24 wherein the panel is generally rectangular and the gates are along substantially the entire width of the panel at said opposite
10 ends.

26. The device of claim 25 wherein each of the gates is pivotable and torque is applied thereto by means of said linkages.

27. The device of claim 26 wherein each linkage is
15 secured relative to its gate at a radial position near the axis of the pivot for such gate, whereby to amplify the gate-opening movement available from lineal movement of such linkage.

28. The device of claim 27 wherein the actuator is
20 in heat-conductive relation to the collector element.

29. The device of claim 28 wherein the wax thermal actuator is part of a heat-sensing module including heat transfer fins within the plenum, whereby to increase convective heat transfer with the actuator.

25 30. The device of claim 29 wherein said module has a surface adapted for substantial absorption of solar radiation, whereby said module functions as a summing integrator of conductive, convective, and radiative heat transfer.



31. A solar panel having a collector element, a solar radiation-transmitting cover above the element and defining an air plenum adjacent to the element, a gate movable between a first position closing the plenum and
5 a second position venting the plenum, and a temperature-responsive wax thermal actuator linked to the gate for moving the gate between said first and second positions in response to predetermined temperature conditions.

32. The device of claim 31 further including a
10 flexible, force-transmitting linkage between the actuator and the gate.

33. The device of claim 32 wherein the linkage comprises control cable.

34. The device of claim 31 wherein the actuator is
15 in heat-conductive relation to the collector element.

35. The device of claim 34 wherein the wax thermal actuator is part of a heat-sensing module including heat-transfer fins within the plenum, whereby to increase convective heat transfer with the actuator.

20 36. The device of claim 35 wherein said module has a surface adapted for substantial absorption of solar radiation, whereby the module functions as a summing integrator of conductive, convective, and radiative heat transfer.

25 37. The device of claim 31 further comprising means biasing the gate toward said first position, wherein the actuator moves the gate toward said second position in response to a predetermined unacceptable temperature condition.



38. The device of claim 37 wherein the panel is generally rectangular and the gate is along substantially the entire width of one end thereof.



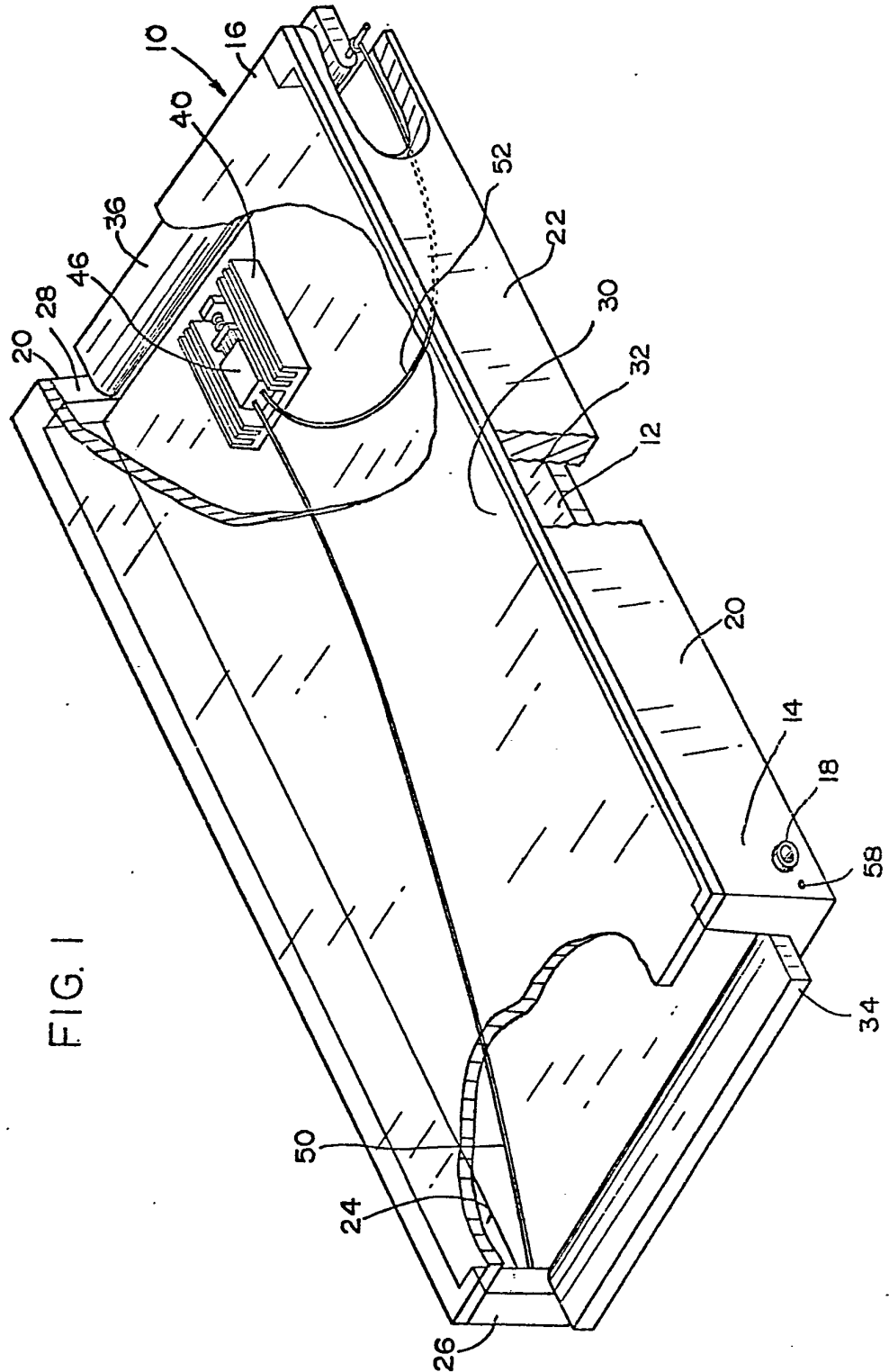
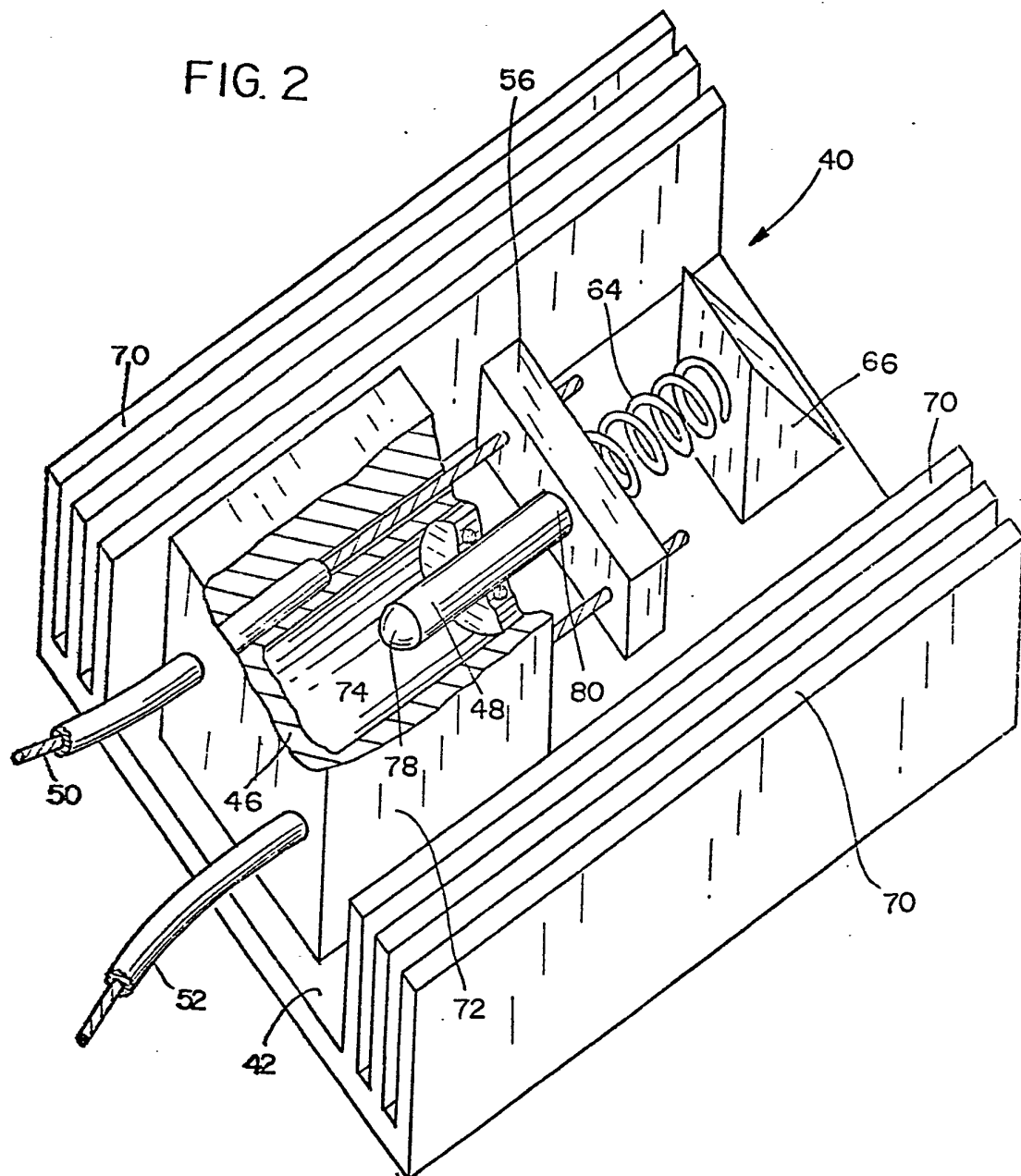
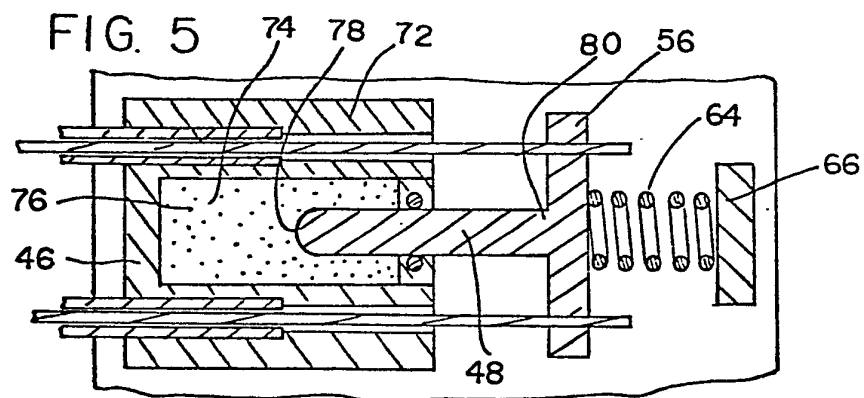
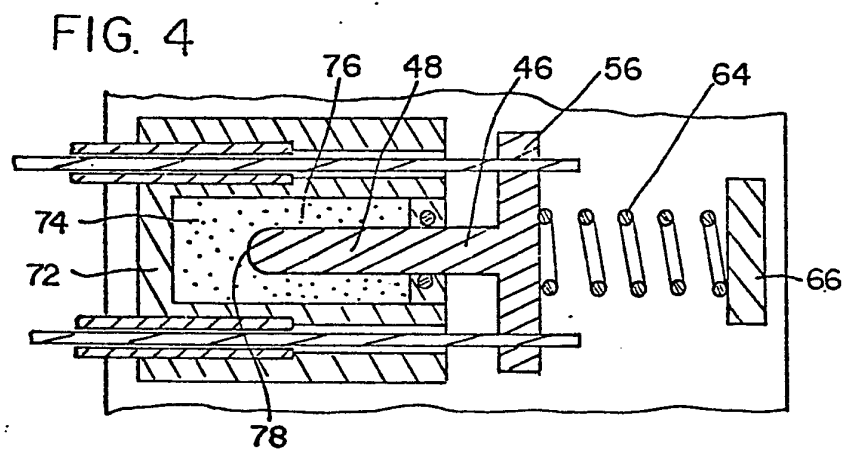
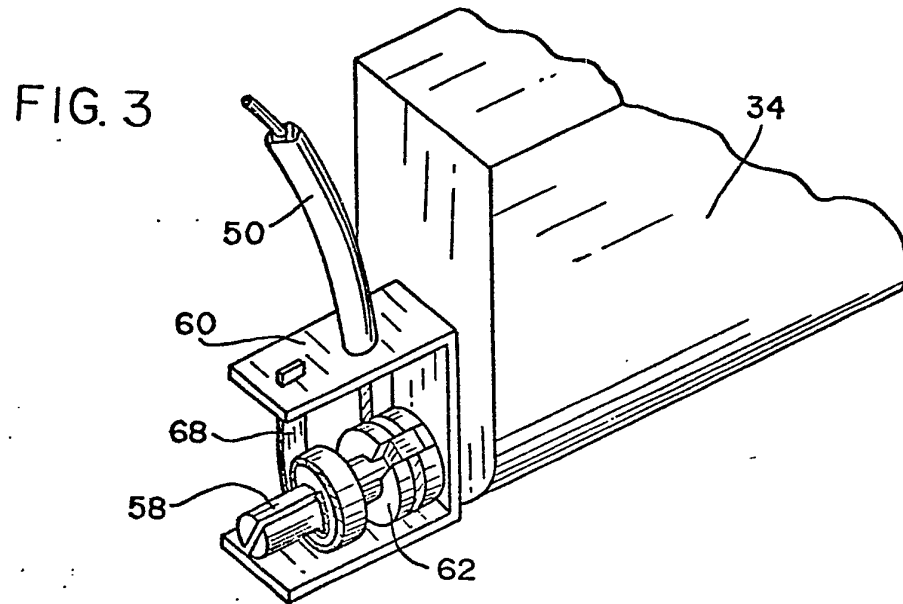


FIG. 2





INTERNATIONAL SEARCH REPORT

International Application No PCT/US79/00633

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
INT. CL. F24J 3/02		
U.S. CL. 126/422		
II. FIELDS SEARCHED		
Minimum Documentation Searched *		
Classification System	Classification Symbols	
U.S.	126/417, 418, 422, 452 236/93A 137/75 251/294	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category *	Citation of Document, ¹⁵ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
A	U S ,A, 246,626, PUBLISHED 6 SEPTEMBER 1881 MORSE	1,31
X	D E , A, 2,607,188, PUBLISHED 25 AUGUST 1977, RAETZ	1-5,8,17,31, 32,34
A	U S ,A, 2,109,114, PUBLISHED 22 FEBRAURY 1938 KERR, JR.	2,4,9,14,16, 33
A	U S ,A, 2,776,796, PUBLISHED 8 JANUARY 1957, MOSELY	1,31
A	U S ,A, 3,690,336, PUBLISHED 12 SEPTEMBER 1972, DRUM	1,31
A	U S ,A, 3,726,299, PUBLISHED 10 APRIL 1973, WHEATLEY, JR.	1, 31
A	U S ,A, 3,943,911, PUBLISHED 16 MARCH 1976, YU	1, 31
X	U S ,A, 4,026,267, PUBLISHED 31 MAY 1977, COLEMAN	18-21,35,36
X	U S ,A, 4,029,258, PUBLISHED 14 JUNE 1977 GROTH	1-11,13-23 32-38
* Special categories of cited documents: ¹⁶ "A" document defining the general state of the art "E" earlier document but published on or after the international filing date "L" document cited for special reason other than those referred to in the other categories "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but on or after the priority date claimed "T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention "X" document of particular relevance		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search *	Date of Mailing of this International Search Report *	
3 DECEMBER 1979 (12.03.79)	18 DEC 1979	
International Searching Authority ¹	Signature of Authorized Officer ²⁰	
ISA/US	LARRY JONES	

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

X	U S ,A, 4,043,317, PUBLISHED 23 AUGUST 1977, SCHARFMAN	1-11,13-23, 31-38
A	U S ,A, 4,046,134 PUBLISHED 6 SEPTEMBER 1977 SCOTT	1, 31
A	U S ,A, 4,058,109, PUBLISHED 15 NOVEMBER 1977, GRAMM	1, 31
X,P	U S ,A, 4,150,659, PUBLISHED 24 APRIL 1979, BUCKLEY	1, 31

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE ¹⁰

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers because they relate to subject matter ¹² not required to be searched by this Authority, namely:

2. ☐ Claim numbers because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out ¹³, specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING ¹¹

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.