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(54) Title: FOCUSING COLLECTOR OPTICAL AND ENERGY SYSTEM

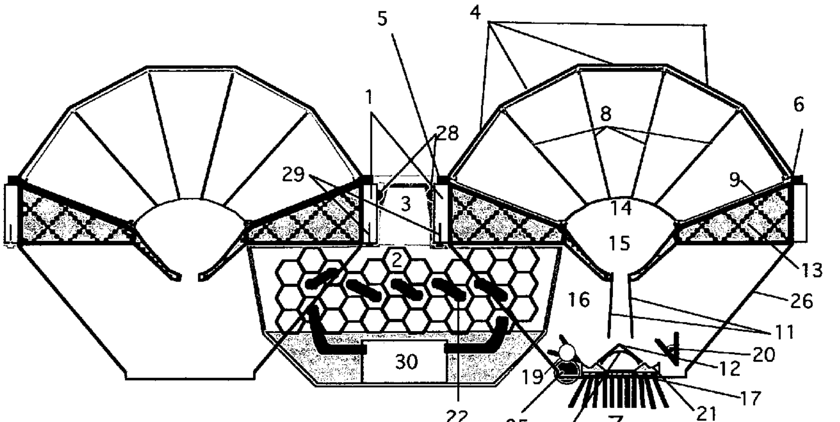

Figure 1

(57) Abstract: For terrestrial or marine human occupied structures, the invention provides an improved concentrating solar energy collector that is fixed and storm resistant, makes electricity from infrared radiation, uses two stages of concentration to provide concentration of light without need for tracking, and adds a variable partly reflective or refractive means • for dividing or redirecting the concentrated radiant energy between multiple uses in response to real time demand signals, user priority signals, and/or timer system. The invention also includes two or more optical interfaces enabling convenient and efficient integration with either heat exchanger slide-in unit(s) or other adaptive modules adding electrolysis of hydrogen or hydroxy gas, air dehumidification, solar powered air conditioning, and/or light delivery systems to the collector's functions. The invention enables the production of electricity and heat in a variable ratio or timing from sunlight, and integrates into or onto a roof or facade structure, using a specially designed truss system where desirable.

Patent Application

Title: Focusing Collector Optical and Energy System.

Inventor: Carl Brent Andrews

International Patent Classifications: H01L31/058, H01L31/052, H01L31/042, G02B6/42, H01L31/052B, H01L31/04B, H01L31/058C, H01L31/ 0232

1) An object of the invention is to produce a hybrid solar concentrating collector system that can be either integrated into a roof structure or mounted securely on an existing roof, that is practical for builders to install and resistant to stormy weather.
2) Another object of the invention is to dynamically apply solar radiation to two or more different energy conversion units or light conducting channels, so that multiple outputs can be controlled by demand signals.
3) Another object of the invention is to provide for the visible component of collected solar radiation to be directed to photovoltaic cells, or to a heat exchanger, alternately, by means of an automatically controlled movable reflective or refractive panel.
4) Another object of the invention is to provide a means whereby collected solar radiation is absorbed into a water-fed heat exchanger system when a hot water demand signal is positive, and absorbed by separate arrays of photovoltaic and thermovoltaic cells for electricity conversion when hot water demand signal is negative.
5) Another object of this invention is to provide solar radiation in different concentrations and different total flux quantities to different energy conversion units or light conducting channels.
6) Another object of the invention is to provide a means whereby collected solar radiation is conducted into a daylighting channel for lighting the interior of a building. This could be done by means of a bundle of optical fibers, or by means of a channel lined with reflective surfaces.
7) Another object of the invention is to provide a means whereby a maximum amount of solar radiation is collected and used per roof area required by the collection devise.
8) Another object of the invention is to conduct concentrated solar radiation to an air heating manifold, attached to an adjacent dehumidifier that uses the hot air to evaporate humidity from an absorber, and to use the DC power produced to run a ventilation fan.
9) Another object of the invention is to provide a stand-alone collector producing electricity only, using only the core unit of the invention (claim 3) with an array of thermovoltaic cells and one or more arrays of photovoltaic cells, the latter receiving radiation at lower concentrations than the former. (claim #41)
10) Another object of the invention is to provide an electrical conversion, storage, and control system, comprising the combination of a storage battery, a digital timer, and a sensor-based electronic programmed controller all attached to a multiple output solar collector as described herein, thereby achieving the following: 1) maximum electrical output during the peak hours of the grid, if the unit is grid-connected 2) light output when an interior building switch asks for lighting to the internal space, if daylighting option is employed, 3) heat

output when a call for heat exists from a thermostat on the connected heat storage unit or end use space 4) method of prioritizing the three, 5) method for dynamically locking and unlocking the system in full electrical production mode, in the case where the sales of the collector is subsidized by the government or power distribution company, 6) operation independent from the power grid, 7) channeling the solar energy to a storage medium when not required immediately by the end uses.

11) Another object of the invention is to provide a means whereby an attached electrolyzer chamber uses the DC electricity produced, and optionally the heat produced, to split water into hydrogen and oxygen, and channel the byproducts to an end use or storage tank for later use.

12) Another object of the invention is to provide a means whereby an attached air conditioner is substantially driven by solar radiation, using the DC electricity produced to drive a fan, and the heat produced to drive a heat-driven refrigeration cycle.

13) Other objects and advantages of the present invention will become apparent from the following description and accompanying drawings.

BACKGROUND

14) **Field of the invention**: solar power conversion / generation, or co-generation of electrical power, heated water/ fluid, solar space heating, solar dehumidification cooling, electrolysis of hydrogen, & interior daylighting, heat transfer methods, and optics.

15) This invention could be used in any of a large number of conditions where there is a need for power, for both heat and power, or for both light and power. Because the invention is modular, the core unit could be used effectively to generate power only. These conditions include, but are not limited to, commercial and residential buildings, industrial buildings with high-heat processes, ocean water desalination plants, solar power plants, solar powered air conditioning systems, hydrogen fuel generating plants, and marine vessel hybrid power generation systems.

Concentration of solar: how much ?

16) A solar energy system that provides electricity to a grid needs to use a large amount of land in order to produce in the megaWatt range of power. Higher power output per area of land used is an advantage in requiring lower real estate costs.

17) Most experimentation by scientists and engineers in concentrating collectors has been based on the assumption that high concentration ratios are preferable (50+ suns). But this level of concentration is unsuitable for making hot water, as it is too high a temperature and will flash the water to steam easily. Also, highly concentrated solar energy carries other disadvantages, such as fire hazards, the need for special, expensive materials, close optical tolerances, and more heat loss.

18) Driving different energy conversion units from the same concentrating collector could be problematic because the different units work optimally with different concentrations and different total flux quantities of solar radiation. Semiconductor cells have limitations as to how much concentration of solar energy they can practically handle.

19) For Photovoltaic cells, the limit is lower than for Thermovoltaic cells. For instance, in the case of GaAs photovoltaic cells, maximum conversion efficiency is about 30% at about 330 mW/cm2: about 4 suns' concentration. At 18 suns' concentration (1500 mW/cm2), efficiency is less than half, at about 13%. Furthermore, the life expectancy of these cells

reduces as the concentration factor increases. Silicon based photovoltaic cells have even harsher limits on practicality of concentrating solar energy. GaAs cells are preferable for concentrated sunlight.

20) For thermovoltaic cells, operating off of infra-red radiation rather than visible light, efficiency peaks at 100-200 SUNS, depending on the cell manufacturing methods used. Concentration levels affect their life expectancy to a lesser extent, especially at concentrations < 50 suns.

21) For water heating, it takes a great deal of copper tubing to absorb non-concentrated solar energy at a flux rate capable of replenishing a standard 230-liter hot water storage cylinder for a residential household. By increasing the concentration to about 4-5 suns, a much smaller heat exchanger can be used, less heat insulation material is needed, and the heat exchanger rate is increased, so that the hot water cylinder can be replenished at approximately the same rate or quicker than a natural gas powered water heater would replenish the same cylinder.

22) Another concern is active cooling versus passive cooling. Passive cooling systems are very reliable over time, while active cooling systems are prone to interruptions and maintenance needs. Since a failed cooling system can mean the ruin of the expensive cells at the heart of the system, a passive cooling system is much preferred for reliability and low-maintenance sake. Thus a more practical limit for the thermovoltaic cells is between 10 and 20 suns, whereby a passive cooling system can protect them.

23) Therefore, a design for a concentrating collector would be maximized by separating the infrared and the visible light, and producing the visible light at around 3-6 suns, a low concentration factor, and the infrared light at higher, but medium concentration factors. In the invention, the means of splitting the beam into multiple beams also provides the advantage of enabling the yield of different concentrations and different total flux quantities in the resulting beam forks of radiation. The higher concentration (still in the medium range, 8-20 suns) is more suitable for semiconductor conversion of radiation to electricity, and the lower concentration, (3-7.5 suns) is more suitable for heating water for domestic or space heating use.

24) In practice, it is also much preferable to make the collector stationary rather than tracking. To do this requires two stages of concentrator optics before the beam is split. After the beam is split, a third stage of concentration can yield the optimum concentration for the thermovoltaic cells.

25) Alternating the direction of some portion of a beam enables the system to adapt to changes in demand for end-uses. The beam for photovoltaic cells has been chosen to be the alternating one. The spectral distribution of direct solar radiation changes significantly over the day, while the spectral distribution of diffuse solar radiation remains nominally the same. The change is mainly in the visible part of the spectrum. Therefore, using a collector with good acceptance of diffuse light and using the thermovoltaic cells as the consistent source of electricity means a much more consistent delivery of electricity throughout the solar day.

26) A solar energy system that will provide most of the hot water and space heating for a human occupied structure in a moderate climate typically requires the use of approximately 12 square meters of solar collector aperture per 100 square meters of floor space, and 800

liters of hot water storage per 12 square meters of collector. During the summer months, no space heating is required in most locations, and the hot water domestic use of a family typically requires 2-3 square meters of solar collector. This means that 9-10 square meters of solar collector aperture and the extra water storage above the normal 280 liters used for domestic hot water are typically unused for a majority of the year in these applications. The 2-3 square meters that are used for Domestic hot water all year, are typically used only intermittently, when end use of hot water depletes the storage cylinder. The surplus solar energy that could theoretically be collected and delivered by such a system would therefore be significantly greater than the amount of energy delivered to end uses. (typically 8-90 X !).

27) This is necessary because current systems only make hot water, and are designed to match the timing of demand, which peaks during the period of lowest solar energy availability, not the timing of supply from the sun. A smaller system is possible, with fewer collectors, storing much summertime surplus energy as hot water over long periods of time. But this requires more storage volume than is available or cost-effective within constraints of residential building economics. Converting this surplus collected energy to electricity and/or hydrogen has many advantages. Typically, a residential roof system does not have enough space to accommodate the 12 square meters of hot water collectors mentioned as well as enough photovoltaic panels to provide a significant part of the electric load. Residential and commercial building practices both show a trend towards more density, resulting is less roof area per floor area. These facts suggest that a superior design collects the maximum solar energy per area of roof (or wall) space required by the collector. If the same collectors could be used for electricity conversion, it would enable combined heat and power to be fit into a small enough footprint for many standard roof systems. Yet no commercial system to accomplish this has been on the market.

28) Typically, Hot water systems are installed by plumbers and photovoltaic systems are installed by electricians. This perhaps is one reason why the installation of combined systems has not been developed on a commercial scale for residences. It is therefore important to design a CHP system for easy installation. For commercial buildings, Combined Heat and Power systems have a long history and an established value. They typically involve diesel generators, inverters, power conditioners, voltage regulators, air conditioning systems, and space heating, perhaps with some solar assistance. The cost of these systems is quite high, when all is added together. Therefore, a system that runs on solar energy and can be mass produced in core modules that could be differentiated in several ways for differing applications and demand profiles could be commercially viable on many residential buildings as well as many commercial buildings. Adding economical energy storage will reinforce and amplify this viability.

Weather resistance and building aesthetics require a new optical design

29) Although the prior art contains examples of concentrating collectors that divide the radiation beam up and absorb the infra-red into a conversion devise, these examples are not practical from the point of view of builders. Professional builders will not install anything on a roof unless it is highly weather resistant, and looks OK to the potential buyer or pre-existing owner of the building. The examples in the prior art consist of dishes and

troughs which track the sun. But what is needed is a fixed, continuously convex envelope on the roof that will not catch the wind, get clogged up with blowing leaves, or protrude very far, causing an eyesore. Tracking dish or trough collectors that can not meet these specifications.

30) Therefore the inventor designed a new optical system that accomplishes the concentration and the tracking of the sun's arc through the sky without any external moving parts. Since the solar radiation supply moves in a tilted arc, the optimum surface to immovably collect that radiation throughout the solar day would be shaped substantially similar to a cylinder perpendicular to the plane of the sun's arc. The invention uses such a shape, and combines heat and power, giving maximum collection capacity. In fact, for reliability, it was designed with as few moving parts as possible, and those that do move should be well protected and as small as possible to conserve energy.

ENERGY STORAGE

31) Storage of energy as generated Hydrogen gas has many advantages. It does not need heat insulation. It can be readily turned into either heat or electricity by means of a burner and a fuel cell. It burns with no carbon dioxide emissions, or dangerous air pollutants. It can be stored at room temperature. And it can be used to fuel a car, via fuel cells. Therefore, many people in the future will want hydrogen at their homes. Until recently, the storage of hydrogen in useful quantities was a problem, due to the safety issues and the size of storage container required. We now have a safe means to store hydrogen in compact form, by sublimating it into Hydrides, within a standard pressurized tank such as is used with propane gas.

Hydrogen electrolysis

32) The current cost of hydrogen by electrolysis is some $4.75 to $5.15 per gallon of gasoline equivalent (delivered) on average. However, SRI international is expected to release by 2009 a design for steam electrolysis to generate ultra-pure hydrogen at a cost of $2 to $3 per gallon gasoline equivalent.

33) Also, Argonne National Laboratory is working on another approach to the same goal. This technology will also be used with nuclear power plants, so it's development is well funded. The reason steam electrolysis is preferable is that from the thermodynamic viewpoint, it is more advantageous to electrolyze water at high temperature. In addition, the high temperature accelerates the reaction kinetics, reducing the energy loss due to electrode polarization and increasing the overall system efficiency. Having a solar collector that produces a variable ratio of heat and electricity is highly beneficial to facilitate steam electrolysis, because the energy can be supplied in the form of electricity and heat and in the RATIO of the two required. Providing heat and power in the proper ratio for steam electrolysis is very challenging. No prior art accomplishes this in a solar collector system. One problem is that the solar energy is unpredictable. Another is that heat builds up and dissipates slowly, while photovoltaic and thermovoltaic cells respond very quickly to variance in solar energy supplied.

34) The invention herein solves that problem by two methods: 1) the design allowing it to vary the ratio of heat and power output, and 2) incorporating one or more magnetic flywheel batteries to provide power for up to thirty minutes after solar irradiation has subsided, in order to better match the heat/ steam availability. Therefore:

35) An optional object of the invention is to provide solar heat and solar-generated power in a ratio suitable for steam electrolysis of hydrogen from water, and provide a storage tank containing hydrides, as a means of energy storage over time.

36) Another optional object of the invention is to include specially designed water-to-hydrogen electrolysis modules, which can produce hydroxy gas, as the need requires.

37) The exact method used for electrolysis will be left up to individual manufacturer licensees. The important aspect is that the invention provides for either DC current alone or combined DC current and heat to be provided to a plug-in unit attached to the collector assembly.

38) Another object of the invention is to provide phase change material encapsulated in storage containers and/or a liquid heat storage compartment conductively attached to a heat absorbing surface, facing the solar radiation beam, and a means for circulating water or liquid solution or refrigerant, causing the transfer of heat to a storage cylinder or air conditioner or dehumidifier or other end use.

39) Another object of the invention is to integrate a flywheel battery into the solar collector. Such capacity for energy storage makes more applications feasible for this invention.

Combined Heat and Power for off-grid applications

40) In the world there are many remote areas without grid power, and many rural buildings that do not have grid connection, or who will be losing grid power in the near future. All of these buildings would benefit from some form of CHP plant. Because of the ability of the invention to adjust the ratio of power-to-heat output, to make hydrogen at high efficiency, and to store excess energy as Hydrogen, there are many applications suitable for such a system, beyond those that have been candidates for CHP traditionally. The added cost savings of a combined system and the added flexibility to meet the desired outputs would make it attractive to building owners. This is due to the modular nature of the design and the ability to "toggle" energy conversion between up to three different plug-in conversion modules in addition to the electrical conversion built into the collector.

41) Further benefits are available in the invention due to the design of an optional advanced 3-stage solar concentrating optics section. Typically photovoltaic panel collectors perform poorly in the early and late hours of the solar day. Being flat, the geometric ratio of the cosine reduces the flux density on the panels at these times unless they are on active tracking devises. But tracking devises are problematic in severe weather and tend to need a lot of maintenance. Builders will not install them because they are deemed unsightly. In the invention herein, a design is used that remains stationary and quite protected from the weather. However, it protrudes external to the regular roof covering in a quasi-cylindrical shape, so that early and late sunshine irradiates a more 'normal' interface than it does on flat panels. This increases the efficiency and the practical functionality of the solar collector, especially since most of the need for both electricity and power in residential buildings happens during these extreme hours of the solar day or just after them.

42) A CHP system that can be accommodated to an attic space and roof system of a standard building while incorporating any of the above plug-in modules is another unique feature of the invention, and this has very valuable advantages for practical applications, in that

one may avoid installing electrical equipment, flammable gas apparatus, and storage battery banks within the occupied space of said building. These aspects are what have discouraged developers from installing solar system in the past, as they profit proportional to the quantity of safe living space they produce within a given structure.

43) The supply of natural interior lighting could add more value to solar products, and in the case of this invention, the day-lighting option, when implemented, comes with minimal heat gain, since the infra-red waves have been separated out of the sun light before delivering the visible light to the occupied space. Therefore, the building will enjoy a cooling load credit for light not generating heat. The typical transmittance of state-of-the-art tubular, domed skylights varies widely, depending on lighting requirements, but for commercial applications is typically well under 50%, and that light comes with heat gain. Second, skylights are typically not designed based on the maximum amount of light that can be supplied but rather designed to approximate that which is produced by the electric lighting system when the total exterior illuminance is 3000 foot-candles. Because of this, all light produced by skylights beyond this value is not functional. As such, preliminary estimates suggest that on average, depending on location, approximately 30% of the total visible light emerging from skylights is excess light that does not displace electric lighting. Daylighting from the invention herein is more concentrated, and subject to less losses, and is inherently more controllable than sky-lighting or "solar tubes".

44) The invention collects and concentrates light preferably in long thin channels, and therefore can easily deliver that light to an occupied space in a more distributed and diffuse pattern than skylights or tubular domed skylights with point focus could deliver directly.

45) Also, said beam pathways may contain large core optical fibers, providing a way to direct the light to a critical part of the building. For emergency lighting during a power outage.

46) When there are a series of heating, ventilation, air conditioning and hot water systems all separately installed, there are few ready opportunities to save energy or money by controlling the scheduling of their use of electricity. With a solar collector that generates electricity, and is tied to the electrical grid, there is often a financial advantage in being able to make more electricity at certain times of the day. Utility companies typically charge much higher rates for electricity during peak hours, and so producing one's own electricity during these hours eliminates a higher fee if the building is using electricity, or builds a larger credit if the building is not using electricity and it is instead being selling it back to the utility at peak rates. This financial advantage has made certain areas where peak usage coincides with peak solar input financially fruitful for investment in solar electricity. In this specification it is shown how having an integrated system of solar produced Heating, hot water, ventilation, and/or air conditioning, affords much greater possibilities for energy efficiency, both for the grid and for the building where it is installed, and therefore affords financial advantages. It involves the access of a central control system to the simple pivoting optical system in order to choose intelligently which outputs to select for each period of time.

47) There are four types of solid state devises posited for achieving conversion of infra-red radiation to electricity:

48) Thermoelectric devises

49) • These are a commercialized technology with a known track record and known limitations. The efficiency is generally between 2-6%. Therefore, while they have many useful applications, they are not capable of maximizing the electricity conversion from solar collectors.

50) Thermionic emission devises

51) • These are used in space applications only at this time. There are attempts currently underway to develop them for commercial use, but at this time, such devises in an affordable package for terrestrial consumers are "vapor-ware". (non- existent)

52) Thermovoltaic devises

53) • These are based on a time tested fabrication technology of optoelectronic semiconductors. Similar semiconductors of same materials and higher grade are used commonly in mobile phones, cameras, etc. As solar-electrical supply devises, they are proven and prototyped, but not fully qualification tested in the solar configurations that have been designed so far. They have been shown to be around 16% efficient by themselves.

54) Thermovoltaic Devises with infrared filters, concentrators, and/or recycling channels

55) • Prototypes have proven that the efficiency and power density can be raised to over 20% with these innovations. But a suitable package design that makes them affordable, safe, serviceable, and reliable has not been developed to date. However, there has been more than ten years of testing of these devises in other terrestrial applications, and 15 years in space applications, which provides reliable data on their potential. Therefore, it is this last category of devises that the inventor chose for his preferred embodiment.. However, as thermionics or other technology is developed, it can be substituted for thermovoltaic cells in essentially the same invention.

PRIOR ART DISCUSSION

Canadian Patent # CA 2399673 claims the collection of solar energy to an emitter, and then the emission received through a filter or spectral processor, and then the infrared emission being received by thermovoltaic cells, and the waste heat removed by heat sink means. In the present invention, no emitter, glass tube filter or evacuated insulation chamber is used. The remaining part of the configuration, without these elements, is not patentable because it follows from common sense that in order to protect thermovoltaic cells from damage when exposed to an intense focused radiation beam, there would need to be a filter to remove the frequencies of radiation that are not convertible to power in the cells, and a heat sink also would be necessary. Thermovoltaic cells themselves have been known in Russia for over thirty years, as have spectral filters and the ability of quartz glass to reflect infrared radiation. Therefore, this patent is not a parent to the invention herein.

1) Solar thermophotovoltaic system with high temperature tungsten emitter;

31st IEEE Photovoltaic Specialists Conference and Exhibition, 2005, Florida V.M. Andreev, V.P. Khvostikov, O.A. Khvostikova, A.S. Vlasov, P.Y. Gazaryan, N.A. Sadchikov, and V.D. Rumyantsev Ioffe Physico-Technical Institute, 26 Polytechnicheskaya, 194021, St.Petersburg, Russia

- This material describes a collector for concentrating solar radiation onto an array or thermophotovoltaic cells, in which infrared radiation enters an essentially closed container and illuminates the array of TV cells.
- In this prior art, no means of integrating the design with a solar water heating system has been proposed or designed for. In fact, this prior art design proves to be commercially untenable, not only for integrating with a solar water heating systems, but for commercial use at all, as it is too dangerous a devise and too expensive for sale to the public.

DISADVANTAGES OF THE ANDREEV DESIGN

Requires active tracking system making it vulnerable to weather or avian-caused malfunction

Does not integrate well with any commercial hot water collectors

Requires specially fabricated vacuum

Requires precision optical alignment- making it vulnerable to weather-caused warpage

Requires expensive Quartz Lenses

Only works with beam radiation sun light- virtually no concentration of diffuse light

Requires high temperature housing

Requires foolproof active cooling system

Requires replacing a whole assembly to Access or replace solar cells

Requires high-temperature tungsten/ ceramic emitter and absorber

Loss of vacuum ruins the expensive emitter and possibly the cells very quickly

Loss of cooling ruins the expensive cells very quickly

Repair requires dismounting the entire system from the roof and transporting it down to a repair facilitated area.(Not modular)

Requires active water cooling because cells are tightly packed together.

Very vulnerable to dirt on the quartz lens

Needs cleaning of the concentrator dish often.

Debris blown onto the lens could catch fire, at 2000 suns !

Does not provide for heat storage on board

Does not provide for channeling concentrated daylight to an interior space

Does not provide for easily and economically attaching a dehumidifier option

Does not provide possibility to incorporate an electrolyzer into the collector assembly and still fit with the confines of an attic/ roof installation.

2) Rheem/ SolaHart hybrid collector

Combined heat and power collectors are under development ***by Rheem/ Solahart*** *at the Australian National University. Called CHAPS, an acronym for Combined Heat and Power System, it involves a parabolic trough that tracks the sun and has in it's focal line a strip of photovoltaic cells that are cooled by a piped water system. They have a working prototype on the student dormitory building.*

Solar Electricity: It is estimated that the photovoltaic array will contribute around 60% of the annual electricity consumption by residents in the new Bruce Hall building. The solar cells convert around 15% of the sunlight into electricity, which is delivered to the building and the outside world through a 40 kW grid-connected inverter.

Solar Hot Water: It is estimated that the experimental CHAPS collectors will contribute between a third and two thirds of the annual hot water consumption for the new building. The hot water is used to power a hydronic heating system and supply the domestic hot water needs of the individual bathrooms and kitchenettes. Also under development is a residential model unit. Although I can get very little information about it, I did retreive a photo of the unit. From the photo I can see that it uses a similar design to the commercial unit, and is far too vulnerable, and "ugly" to be attractive to most wealthy homeowner/ home buyers. It requires direct sun to operate well, and ours does not.

Disadvantages of the* Rheem/ SolaHart *system:

• *These collectors are also tracking troughs. Not suitable for general installation on sloped roof buildings by builders. Vulnerable to weather and avian- caused malfunctions. • Each square meter of collector mirror surface produces about 43 litres of hot water per day in a storage tank, perhaps several times a day. Azzuro Evacuated tube systems, by comparison, provide about 90 litres of hot water per square meter of collector surface. Therefore the CHAPS collectors are very significantly less efficient at producing hot water than current commercial stand-alone hot water collectors. Since hot water production is the least expensive form of solar energy conversion, it seems a mistake to produce a system that sacrifices about 50% of the hot water production efficiency for the sake of producing electricity. Also, the solar cells they are using are heat sensitive in that they are much less efficient at high temperatures. This combined with a low efficiency and high cost and very low power density for photovoltaic cells to start with means they are depending on the cooling system to work within a narrow set of parameters in order to produce a profitable amount of electricity.*

- *The two outputs, hot water and electricity, appear to be statically mismatched. That is, adjusting the ratio of the outputs would require re-designing the entire system. Far better to have a modular system, such as the invention described herein, which contributes to a system that can be easily adjusted to make varying amounts of hot water and electricity.*
- *The sun-tracking devise required in both the commercial and the residential designs is likely to cause noise and maintenance problems that upscale home owners will find rather unpleasant, if not unacceptable.*
- *Only works with beam radiation sun light- virtually no concentration of diffuse light*
- *Does not provide a closed loop system for use with a domestic hot water system.*
- *Does not provide for heat storage on board*
- *Does not provide for channeling concentrated daylight to an interior space*
- *Does not provide for easily and economically attaching a dehumidifier option*
- *Does not provide for integrated electrolysis of water to store energy as hydrogen*
- *Repair requires dismounting the entire system from the roof and transporting it down to a repair facilitated area. (Not modular)*

3) Oak ridge Hybrid Lighting System with IR conversion (now commercialized)

In this system the design involves a tracking parabolic dish collector with a secondary reflector that comprises a cold mirror, with thermovoltaic cells located behind the cold mirror.

The reflected light then goes through a hole in the center of the dish and enters large core optical fibers, that distribute the filtered concentrated sunlight to various lighting fixtures in the building.

Disadvantages of this prior art compared to the present invention:

There is no option of generating hot water, nor an easy way to adapt the devise to do so.

There is no option of generating electricity from the visible spectrum of the sunlight.

The visible sunlight is always directed to lighting fixtures, whether or not lighting is desired. The delivered light intensity varies greatly with the sun and clouds.

The tracking dish collector is inefficient on cloud-covered days.

The system presently retails for $24,000 USD per dish, and generates only 70 watts of electricity and 50,000 lumens of daylighting. Price per watt is unacceptably high.

The system does not integrated into the building facade structure or roof structure, but sits on top of the roof, creating considerable vulnerability to weather and making it unsightly.

The system requires close tolerances in manufacturing and adjustment, making it expensive and vulnerable to becoming mis-aligned.

The system does not provide for integrated electrolysis of water to produce hydrogen

Repair requires dismounting the entire system from the roof and transporting it down to a repair facilitated area. (Not modular)

1) **Unobvious and unique aspects of the invention herein are:**

2) The design allows one or more liquid medium heat exchangers to be mounted in exposure to the same light beam that sometimes exposes the photovoltaic array.

3) Addressing the needs of a commercial building-integrated system by NOT using a tracking parabolic dish or trough to concentrate the solar energy, but instead using a stationary slotted trough interceded with converging mirrors radiating axially along the trough axis, and truncated near the slot.

4) Employing a barrel vault shaped Fresnel lens as a secondary stage concentrator, in order to increase concentration and coherence of solar radiation in a fixed collector. This feature has been used on tracking collectors, but never on stationary collectors, and never as a secondary optical processor in a hybrid collector, protected from the weather.

5) Using a collimating mirrored channel that enables the use of a smaller size beam splitter while providing a gap/ channel for reflected light to transit through, thus positioning the absorbers deep within the collector module where they are insulated from the ambient weather.

6) Using self-cleaning glass and positioning the glass at a sloping angle when the collector is mounted on a sloping roof, thus enabling the collector to remain optically transparent over a long period of use and through many weather conditions, and to shed water and snow effectively.

7) Using self-cleaning glass on the exposed surface of the collector, divided into long narrow panels, which may be made from off-cuts from larger sheets, and purchasing said off-cuts from the factory at less expense.

8) Designing the collector and a special roof truss system together to enable an array of quasi-cylindrical collectors to be configured with spacing between them of approximately 16", thereby avoiding shadows from one collector interfering with another collector. This spacing happens to also be great for positioning heat storage plug-in units in between two collectors. The heat storage units will therefore be approximately 44" wide, and the collectors approximately 46" wide. This designs enables easy loading and stacking of collectors and

plug-in units in vans and trucks, efficient packing and shipping of units, etc. It also enables a truss system to be reinforced to hold the extra weight, using cross bracing designed for standard 16" on-center stud framing.

9) Using Phase Change Materials to produce heat storage plug-in units of a weight that a code-designed roof truss system with steel plate reinforcement and standard cross bracing can support, and providing a method of meeting the end-use demand for heat without requiring a significantly over-sized hot water cylinder. Therefore space is used to maximum efficiency, having a compact arrangement fitting entirely into an attic space, while the heat storage per volume is increased by the use of phase change materials.

10) Designing a core unit that can be mass manufactured and configured in several different ways after manufacture by means of specially designed slide-in snap-lock ancillary units that add different output functions using the energy captured by the collector, thereby making the manufacturing, distribution, and installation process very efficient, and making the core unit useful for many functions, including integrating with hydronic heating, stove/ wetback technologies, hydrogen production electrolyzers, dehumidifiers, solar powered air conditioning, and other plug-in modules.

11) Using aerogel as an insulating medium enables the above design advantages because it herein provides the dual function of providing structural integrity while insulating the heat exchanger, thus decreasing the overall volume and surface area of the collector package, making possible the compact and configurable design,

12) Using a pivoting 'V' shaped extrusion with photovoltaic cells on one side and mirror on the other side, positioned for absorbing or bending the channel light transmission provides a unique method of alternating on demand between heat, power conversion, and optionally day–lighting within the collector, by use of a simple actuator such as a standard stepper motor arrangement. It also provides a means for preventing overheating of the PV cells, by simply moving them out of the radiation path based on a temperature sensor.

13) Integrating into the collector housing a compartment suitable for installing a DC pump for pumping hot water, flywheel battery, and charge controller, so that Solar hot water is not using external power and will continue to function during temporary power outages at the building's supply side.

14) Providing a unique set of optical processing components (converging mirrored cells, Barrel-vault shaped Fresnel lens, collimating channel, and particularly a peaked cold mirror), for optimum concentration ratio differential between separate photovoltaic cells and the thermovoltaic cells. This also minimizes the size and expense of the thermovoltaic array, which is more expensive at present than photovoltaic arrays, and more tolerant of high concentration radiation.

15) The angled bottom of the collector enables it to fit into a roof structure just above the ceiling layer of the attic, or to be mounted externally onto a sloped roof, while achieving a slope angle appropriate for solar exposure.

16) Sharing a heat transfer manifold with an adjacent collector, thus requiring only one heat exchanger between the two, needing fewer plumbing connections, and producing less flow resistance in an array of collectors heating hot water.

17)

18) Sharing it's optical channel and mirrors between three functions: 1) providing a beam collimator

and splitter, 2) insulating a heat exchanger by reflecting heat and light back to it's surface while highly resisting air convection, and 3) channeling light towards the insulated converter cells and if desired, towards the occupied space.

19) A thermovoltaic strip array is positioned preferably below a specially lined optically closed channel, such that it can receive infra-red radiation from the concentrating solar collector. Due to the back side reflectance of infrared of the peaked infrared splitter (cold mirror) infra-red radiation from the Collector essentially cannot escape the channel except by absorption into the TV cells or other interfaces. Therefore, unabsorbed radiation is recycled until it gets absorbed, thereby increasing the efficiency and power density of the devise.

20) Using a peaked cold mirror to split the light beam into three beams, one of the full component of Infra-red and two of half the component of visible light, allows photovoltaic cells which tend to be more sensitive to heat to be positioned on long narrow strips for quicker heat dissipation and high current-to-voltage ratio.

21) Making use of means for switching a focused light beam between outputs in response to a real time demand signal and/or timer system enables the usefulness of the solar energy to be maximized for the technology currently available and the uses desired.

22) Designing a solar collector so that it can be preset to give maximum electrical output at times of peak grid demand makes it attractive for utility companies to help market.

23) Being a focusing collector yet operating below the melting point of the solder on the thermovoltaic and photovoltaic arrays by design, without active cooling systems. It therefore loses no energy for cooling, and in fact USES some of the excess energy, normally rejected by cooled collectors, for other outputs, by pivoting the V-strip mirror/ PV array and thereby absorbing it for a useful function.

24) Having means for electrolysis of hydrogen to be integrated into the system chassis and receive power from the photovoltaic and/or thermovoltaic arrays.

25) Having means for the integration of an electrolyzer allows the invention to produce hydroxy gas ($H2 + O2$) directly from DC current, avoiding the need for inverters, regulators, and conditioners of power, thus providing a thermal fuel source as a more economical means to store energy. An external electrolyzer would require thick wiring traversing the distance from the attic or roof to the location of the external electrolyzer in order to get equivalent current density at low DC voltage as does the included electrolyzer. Since electrolysis efficiency is independent of voltage and proportional to current provided, the inclusion allows for connecting the arrays at very low voltage (5-13 Volts) and high current density, using only very short lengths of thick copper wire. Being a modular system, one electrolyzer can run off of two or more neighboring collector systems and get high current density with very little heat and current loss over the relatively short wires

BRIEF DESCRIPTION OF THE INVENTION

26) The invention is an improved process of utilizing solar energy, by causing a radiant light/heat source such as solar radiation to be passively concentrated, preferably in two stages of stationary optics, conducted thereafter into an essentially optically closed channel, split into two, three, or more directions by a preferably movable panel with a reflective or refractive quality, and directing each resulting light beam at an absorber, a semiconductor conversion technology, or a light conductor attached to a remote end use or energy conversion means.

27) In one species, the movable panel allows infrared radiation to go through it when in one or more positions, under which an array of thermovoltaic converting cells are located, after preferably a third stage of concentration and/or filtering optics. In this case the visible light is reflected by the movable panel and directed at one or more energy conversion devises or at pivoting two-sided assemblies which depending on their position either

i) absorb the visible light into photovoltaic cells on one side or

ii) reflect it onto a detachable optical black heat absorbing surface, or

iii) reflect it into light conducting channel(s) where it is entrained into the occupied building space or to a remote energy conversion devise by either reflective conduits or optical fibers. The invention additionally comprises an electronic or electro-mechanical means for automating the movement of said movable panel, in response to real time signals from the user, from sensors, and from a programmable 7-day timer circuit; in other words, signals similar to those found in many modern thermostats.

28) Variations of the invention include:

A) placing thermophotovoltaic cells at the interface with higher concentration (9–20 suns) and a water heating or heat-driven plug-in unit at a lower concentration interface.

B) placing thermovoltaic cells at the interface with higher concentration (9–20 suns) and alternately photovoltaic cells or a water heating or heat-driven plug-in unit at lower concentration interfaces (3-6 suns), and splitting the beam's spectrum so that the thermovoltaic cells receive primarily infrared radiation and the photovoltaic cells do not receive any substantial infrared radiation.

DETAILED DESCRIPTION OF (The preferred embodiment of) **THE INVENTION**:

29) Arranging a concentrating solar collector with two or more stages of means for concentration of light, preferably employing a plurality of reflectively lined gradually converging cells or sections, adjacently oriented, like radial sectors of a cylinder or sphere, with open tops and bottom edges truncated before the convergence line, as the primary concentrator stage (see figure 3), and adjoining a second stage concentrator or a channel with substantially parallel walls leading to a second stage concentrator.

30) Arranging the second stage concentrator preferably with an essentially barrel–vault shaped Fresnel lens whose convex surface is facing the light receiving side, under which is positioned another tapered reflective trough with a slot opening positioned at it's (narrower) bottom, such that light channeled through said concentrating collector is focused onto and through said slot opening,

31) Positioning said collector, beam pathways, absorbers, and arrays within a frame suitable for stationary mounting on or in penetration of a roof or building facade structure, with the collector system facing preferably within ±25º of the equator and inclined within 45-65º from the horizontal,

32) Mounting said Fresnel lens so as to create a water-tight and essentially air-tight seal over the light transmission channel and absorbers beneath it,

33) Providing a forked light transmission channel, preferably folded, positioned to receive light into the channel through said slot opening in said collector, said channel being essentially optically closed due to it's reflective and folded characteristics, so that radiation cannot for the most part escape once entering inside said channel from the collector, except through a multiplicity of designed interface gaps in said channel's walls.

34) Optionally attaining optical closure also by use of a narrow slot opening, descending into a collimating reflective channel, (see figure 1), said channel having converging walls so as to deflect radiation away from said slot opening and toward the end opposite the receiving end, that being the position for a light-absorbing, reflecting, or transmitting function.

35) Providing a movable partly reflective devise (f. In figure 9) operable on command from a digital control center, which can redirect the light beam towards one or another interface positioned in the beam pathway.

36) In one species of the invention, said optical devise is a pair of cold mirrors joined like a peaked roof and positioned at the bottom of said light transmission channel, each side of said peaked roof reflector positioned at an angle near 45º to the incident light path, thereby reflecting visible light to either side into beam pathway forks, while allowing infra-red (IR) radiation to pass through said cold mirror substantially unblocked, and optionally, positioning a spectral filter underneath said cold mirror, filtering out the IR light that is below the band gap of an included thermovoltaic conversion devise.

37) In this same species of the invention, providing a thermovoltaic conversion devise (e.g.heat-converting semiconductor cell array or thermionic panel), mounted underneath said cold mirror and facing said cold mirror, such that they absorb the IR radiation from the channel, said array being wired to a circuit that receives their electrical output.

38) In another species, providing a pivoting reflective panel with a hinge on one side along the edge, positioned to intercept said beam pathway. The nominal position is perpendicular to said channel. In the nominal position the glass filter allows the concentrated light to essentially pass by it. The activated position is an angle of approximately 45º or more to the light beam. In the activated position, the panel reflects the light beam aside to one or more light absorbers attached to the collector system. In this species, an array of thermophotovoltaic cells (multi-layer multi-junction semiconductors) is positioned underneath the pivoting reflective panel, suitable for converting full spectrum light to electricity. A heat sink is mounted to the thermophotovoltaic array, and said array is wired to a circuit that receives ~~their~~ the array's electrical output.

39) In conjunction with either of the above species, providing a pivoting 'V' shaped extruded 'PV bar' lined on one side with special photovoltaic cells capable of converting high density light to electricity and lined on the other side with a mirror, positioned in a bending channel of light transmission, such that upon alternating demand between heat, power, cooling of the photovoltaic cells, and optionally day-lighting, the visible light may be absorbed into the photovoltaic array, reflected onto a heat exchanger, or reflected into a day-lighting channel, by use of a stepper motor actuator as known to the HVAC industry. This component may be used on both sides in the species with the peaked cold mirror.

40) Providing an electronic sensing and control means for pivoting the orientation of the V-shaped mirrors/ photovoltaic conversion devises or the hinged reflective panel, having functions for deciding whether the critical demand is for heat, power, or other functions as may be attached. This system has an interface so that it can optionally communicate with a meter and/or a radio frequency signal receiver. Thus it could be configured to be controlled by a utility company, so that full power generation mode could be called up during critical shortages on the power grid or micro-grid.

41) Providing two curved overflow reflector strips adjacent the thermovoltaic array on either side, to reflect light back up the second fold of the beam pathway to illuminate a heat exchanger surface placed at the termination of the beam pathway.

42) Providing a detachable liquid medium heat exchanger system positioned with one surface interfacing a light beam pathway, said surface having a selective coating for absorbing light, and attached to a liquid medium circuit, such that liquid medium will enter the heat exchanger system, absorb heat from said light communicating channel, and leave the heat exchanger system, for the purpose of delivering said absorbed heat to an end use, said liquid medium thereafter being recycled back through said heat exchanger system.

43) Providing two or more insulation slabs composed of a highly insulating rigid material such as aerogel, said insulation fitting onto the exterior sides of said heat exchanger system, an any other place in the assembly where both structural strength and thermal insulation are needed.

44) Providing an optional water electrolysis devise that fits onto the collector system chassis, and optionally supplying heat to it via a heat exchanger fitted into one of the gaps in the light collecting channel, and connecting DC current from either the thermovoltaic array or the photovoltaic array or both arrays to the electrolysis devise, so that water is heated and then split into hydrogen and oxygen, the products having means for traversing to an end use or storage tank.

45) Providing an optional heat exchanger for pool water, which is shaped so as to fit in the same gap and slots as the previously mentioned heat exchanger, as another option, and extending across the gap between two collector units and the other end fitting into the gap of an adjacent collector unit,

46) Providing a heat sink mounted behind the Thermovoltaic conversion devise and exposed to a freely convecting air pathway, such that heat is dissipated from said conversion devise, thereby keeping the Thermovoltaic devise below its maximum operating temperature.

47) Providing a mounting system that connects the entire collector assembly directly onto the roof trusses, or in the case of retrofits, onto a stand-off frame securely fastened onto a roof or wall structure, in any case enabling sloped mounting suitable for maximizing solar energy collection,

48) Providing an optional snap-in module that adds a micro-inverter to the collector to make AC power from the DC power generated in the collector.

49) Providing an optional snap-in module that adds a flywheel battery to the collector to store the DC power generated in the collector.

50) Providing means for attaching an accessory that draws heat from the heat store and uses it to evaporate water from an absorber in order to dehumidify ventilation intake air, thereby cooling the air as well. (accessory not shown)

51) Providing a control circuit for an array of multiple invention units, capable of deciding which of the outputs are activated according to complex algorhythms. For instance, when the collector is used in a grid-tied electrical system and there is an attached PCM heat storage reservoir and PV array included, it can decide to heat up the reservoir in the early hours and again in the late hours of the solar day, scheduling it so as to concentrate on making electricity with the PV array during the peak electricity usage times. For an array of four or more units of the invention, there can be multiple energy processing units plugged into various core units and the control system will determine the priority of each output throughout the whole collector

and plug-in system. Such a system will be programmable and able to prioritize outputs contingent upon the values entered on site by the end user or commissioner of the system.

52) Providing a roof truss system for mounting said collectors, with trusses spaced approximately 16 inches and 46 inches apart alternately, and with roof slope of approximately 50-60º from the horizontal on the collector-bearing face, and approximately 25-35º on the opposing face.

53) Providing two sizes of collectors, with longitudinal length being approximately double in the larger size, while the widths are the same, so that they fit in the same truss system and can be stacked upon each other in arrays, as means of covering different sizes of roofs (figure 10).

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a sectioned elevation view of the collector

Figure 2 shows an exploded view of a collector with one heat exchange/storage plug-in module.

Figure 3 shows a 3D left-side view of the invention core unit, "FC3L"

Figure 4 shows an elevation section view of a roof with 2 peaks, large & small FC3 collector arrays, in the upper section of the page, and a roof with stacked array, large collectors on the bottom, & small FC3 collectors on the top, in the lower section of the page.

Figure 5 shows a schematic of a building energy system with the collectors connected to building energy components.

Figure 6 shows a collector assembly from the top view with converging heat and light vents for delivering heat and light to a building through it's ceiling.

Figure 7 shows in elevation view a roof truss system with outlines of the collectors mounted therein.

Figure 8 shows a retro-fit solar system on a pre-existing building/ roof.

Figure 9 shows a schematic of the core unit of the invention in claims 1-3.

Figure 10 shows another species of the invention, cut-away view, showing an optical devise that is operable to change the light beam direction.

Figure 11 shows a schematic of an alternative core unit of the invention.

Legend; meaning of label marks in figures:

Figures 1 & 2

1= truss beams
2= Honeycomb PCM heat store/ heat exchanger
3= Heat store slide-clamp bar
4= glass cover strips, preferably self-cleaning glass
5= flanged set frame
6= collector frame truss arm
7= heat sink
8= aperture divider mirrors
9= trough side mirrors
10= End mirrors (not shown in end view)
11= Collimator mirrors
12= Dichroic (cold) mirror
13= Aerogel rigid insulation slabs
14= Fresnel lens
15= slotted trough
16= folded beam pathway
17= thermovoltaic strip array
18= optional Spectral filter
19= PV bar
20= actuator gear for PV bar
21= overflow curved reflector strips
22= heat exchanger tubing
23= electronic control circuit (not shown)
24= stepper motor
25= sensors (not shown)
26= end plate
27= slide-in flange
28= spring-ball snaps
29= end plate lag screws
30= DC Water pump/ battery/ charger unit

Figure 3

a) first stage concentrator
b) slide-in energy processing unit
c) heat rejection unit (multi-flanged heat sink)
d) Thermovoltaic conversion devise
e) Photovoltaic conversion devises
f) collimating channel
g) third stage (converging trough) concentrator
h) curved Fresnel lens concentrator

Figures 3, 4, 5 & 7

FC3L= focusing collector assembly, large version

FC3S= focusing collector assembly, small version

Figure 6

1) Infrared bleed-through vent
2) Lighting vent
3) heat rejection outlet
4) pivoting mirrors (2)
5) heat and light delivery channel
6) top view of collector assembly

Figure 9:

a. interface
b. absorber plate or thermovoltaic conversion devise
c. secondary concentrator
d. primary concentrator
e. divided beam channel
f. optical devise: peaked roof reflector

Figure 10:

b. absorbers

movable partly reflective devise: pivoting optically coated glass panel: j, k

j - optical coated glass in cleared position

k - optical coated glass in reflective position

Figure 11:

e. diverted beam channel
c. secondary concentrator
d. primary concentrator
g. pivoting mirror
h. thermophotovoltaic conversion devise
J. slide-in energy processing unit, such as steam electrolyzer, heat exchanger, phase change material heat storage unit, pool water heat exchanger, electrical and heat-driven air conditioning unit, or electrical & heat-driven dehumidification unit.

ADVANTAGES of the invention over the prior art

1. This invention has the unique advantage that it uses the same solar collector for both electricity and hot water or other energy conversion functions, and can therefore continue to use the collector during times when its output would normally be unused for making hot water, due to the mismatch between summer input and demand. This is very advantageous, as many buildings have limited sun-facing roof sections, and this allows maximum use of the area available. It also brings down the cost of installation by sharing installation of a PV system with a hot water system or other heat and power end uses.

2. Because of the ability of the invention to adjust the ratio of power-to-heat output, it can match the outputs to a building's energy demand profile dynamically.
3. This invention has the unique advantage that it houses a thermovoltaic conversion devise, such as an array of thermovoltaic conversion cells (TV), using a geometry that allows said array to be irradiated by concentrated IR radiation, separately from where the photovoltaic cells are irradiated. Instead of the IR array conducting waste heat in the Photovoltaic array which then must be rejected, negatively impacting the PV output performance, it rejects waste heat passively.
4. This invention has the unique advantage that liquid medium heat exchanger panel overheating can be prevented by a means which converts what would have been over–heat into electricity usable by the owner for work.
5. This invention has the unique advantage that it radiates concentrated light onto an absorber surface intermittently, achieving faster heat-up times than systems that use non-concentrated light, while allowing fluid to be heated to a variable demand-determined temperature and no higher.
6. This invention has the advantage that multiple solar collectors of both Liquid medium type and thermo– or photo–voltaic type can be positioned on a building roof truss or wall framing with a simple flanged mounting & fastening system, thus simplifying and speeding up the process of installation of combined function solar systems, while providing a weatherproof and consitsent covering for the area it occupies.
7. This invention has the unique advantage that plug-in units that generate hot water, hydrogen, or electricity can easily be installed to fit between two solar collectors, thus increasing the overall output and cost efficiency of such plug-in modules, and sharing any needed control system, sensors, valves, and pumps between two collectors.
8. This invention has the unique advantage that a TV, PV, or TPV cell strip or other TV or PV conversion devises can collect concentrated infra-red light from the sun during most of the solar day without need for an active mechanical tracking system. The invention tracks the sun passively, without use of moving parts to do so, when properly installed.
9. This invention has the unique advantage of an interface that is purely optical, enabling a sliding snap-lock insertion and removal of various adaptive modules that make hot water, electricity, etc. These modules can be slid into place from behind the collector when it is a built-in system, and the collector can tip-over for module insertion and removal when it is a retro-fit system. This protects the longevity and value of the collector, since servicing modules and adapting system functionality is quick and easy, normally not requiring removal of the collector itself.
10. This invention has the advantage that it can be used to create a self-sufficient (off-grid) hot water system at lower cost than existing non-integrated systems, by means of a DC powered pump, a battery, and a charge controller fitted into the collector assembly, thereby generating it's own pumping power, which in turn is used for pumping the water through the circuit.
11. This invention has the unique advantage that it provides a marketable use for simple TV cells by themselves that does not require also using specialized high-intenstity photovoltaic cells in order to get high efficiency conversion, nor using multi-junction or multi-layered cells, in a collector that absorbs a large portion of the solar spectrum.
12. This invention allows the TV cells to be protected from the weather, as they are positioned inside a rigid channel and separated from the outside environment by two sealed membranes and

by a large distance relative to flat plate collectors.

13. While in the prior art the hot water absorber depends on collecting heat in an open trough or parabolic dish at high concentration levels, where there will be a tendency for much heat loss, this invention has the heat captured primarily at less than twenty suns' intensity, so that there is less potential for heat loss.
14. This design has the unique advantage that by sensing the temperature of the photovoltaic conversion devises, and turning the V-shaped extrusion so that the cells leave the path of the light beam, overheating of the photovoltaic cells can be prevented without discarding potential solar energy.
15. This invention has the unique advantage that by sliding in a pre-fitted pool water heat exchanger plug-in (during the swim season only), one saves materials & money over other heat exchangers for pools, because only the pool water side of the heat exchanger needs to be supplied, along with an attached flat selective absorber surface. (Normally, pool heating requires two sides, the second one comprising serpentine tubing or a heavily insulated waterproof shell)
16. This invention has the advantage that no specially fabricated vacuum nor a tungsten emitter is required to achieve the isolation of the IR radiation for irradiating the TV conversion devise, as in evacuated tube collectors or thermovoltaic inventions by Lewis Fraas and Dr. Andreev. There is no vacuum used, decreasing it's vulnerability to leaks over time.
17. This invention has the advantage over other concentrating, tracking collectors that it operates within loose optical tolerances, so that in case weather, earthquake, or installation warps the concentrator it still works fine.
18. This invention has the advantage that it's Housing can be of standard materials- since it operates below 200º C
19. This invention has the advantage that it can operate with only passive cooling.
20. This invention has the advantage that it's conversion devises are easy to access/ replace.
21. This invention has the advantage that it's absorbers are medium temperature, and could be made by adapting known manufacturing techniques of spluttering used in inexpensive evacuated tube manufacture.
22. This invention has the advantage that complete loss of cooling is not probable as it is a physical heat sink. Neither fan nor water cooling is not required.
23. This invention has the advantage that it has a sealed concentrator trough, keeping the optics free of dust, dirt, water, and smoke.
24. This invention has the advantage that it's appearance is uniform, simple, elegant, and fairly low profile, unlike tracking collectors and other combinations of PV and Hot Water collectors required to accomplish the same output results.
25. This invention can be mounted either directly on the roof truss framing or on the roof covering, making installation simple, and making it good for a wide range of applications.
26. This invention has the advantage that it's concentrator is relatively easy to fabricate, having mostly flat optics, with in one instance a single plane of curvature, as compared to the reliance on curvature and often compound curvature of other concentrating collectors.
27. This invention has the advantage that it has relatively low concentration ratio of solar light, (9-18 x) which reduces the danger of fire compared to most concentrators.
28. This invention has the advantage that it is suitable for use of a combination of two types of solar

cells that have together proven to achieve maximum conversion efficiency– currently measured at 30+% by independent lab tests.

29. The invention herein collects light in long thin channels, and therefore can easily deliver that light to an occupied space in a more distributed and diffuse pattern than skylights or tubular domed skylights could economically deliver.
30. This invention has the advantage that it's thermovoltaic cells can be made without use of toxic gases, as are required for multi-junction thermophotovoltaic cells.
31. This invention has the advantage that it can be made to deliver maximum power generation at times when the connected grid is experiencing a critical shortage of supply power, by means of a storage devise and radio frequency or line signal control of the meter and/or control system. This makes the invention attractive to utility companies as a means of regulating their grid peaks and preventing brown-outs and black-outs.
32. Providing a Hydrogen Electrolyzer that plugs right into the collector enables the electrolyzer to attain high efficiency by using both the heat and the electricity generated within the collector body, avoiding extra copper wire to traverse a distance to a remote electrolyzer, avoiding heat losses in transmitting of heat to a remote electrolyzer, and avoiding floor space taken up by a remote electrolyzer.
33. Having the electrolyzer installed in a roof with the collector unit is safer than having an electrolyzer installed in a garage or basement, because if a fire starts, the fire will move upward, and only very slowly spread to the lower parts of the building.
34. Placing a separate electrolyzer in an attic space would be difficult because of the restricted space for brazing pipes, connecting wires, attaching bracing and brackets, etc as needed by a separate unit. The slide-in snap-lock interface design makes the installation much easier- no extra bracing or interface plumbing required. Once the plug-in is aligned, it just snaps in, with no need to measure and attach pipe fittings to-from the collector or provide an extra heat exchanger to connect to the collector.
35. This invention has the advantage that there are both a concentrating mechanism and 2 layers of sealed barrier between the TV and/or PV cells and the ambient, so that if the outer barrier is broken, there still is a layer of sealed protection and a trough protecting the valuable PV and TV cells, and the balance of the system, and light continues to be concentrated to some degree into the absorber receivers.

THE INVENTION CLAIMED IS:

1. In a process for receiving and concentrating solar radiation throughout the solar day, and employing an assembly with a storm resistant envelope fixed to a terrestrial or marine human occupied structure, therein converting some of the solar radiation to electricity, and delivering energy to two or more end uses, the improvement comprising:
employing a physical wave-diverting means to divide the beam pathway of the concentrated radiation, alternately receiving at least one part of the concentrated radiation at two or more interfaces, and converting at least infrared radiation within the beam to electricity by positioning solid state thermal-radiation-to-electricity conversion devises with attached means for heat rejection at one of said interfaces, and receiving a substantial part of the remaining visible light at two or more energy processing units.
2. The improvement of claim 1, further comprising,
employing one or more reflective panels fitted with an actuator means for automatic tilting along an axis, and tilting said reflective panels to direct radiation towards two or more interfaces in different beam pathways, and fitting one or more of said interfaces with means for slide-in attachment of various possible energy processing units.
3. The improvement of claim 1 or 2, further comprising,
arranging the concentrator optics, the physical wave-bending means, and the interface angles of incidence so that one interface receives solar radiation measured at mid-day in concentrations between 8 and 20 suns, and another receives radiation measured at mid-day at concentrations of between 3 and 7.5 suns. [One sun is taken herein to mean the flux density of whatever group of wavelengths exist in a beam that would equal the flux density of the same group of wavelengths found in sunlight at normal incidence.]
4. The improvement of claim 2, further comprising:
employing two different resting slope angles of said reflective panel, in addition to an angle clear of the radiation beam, thus redirecting the beam pathway alternately towards two such slide-in energy processing units, one unit having a heat absorber plate positioned substantially perpendicular to the redirected radiation beam, and flash-evaporating a liquid working fluid inside said energy conversion unit, and the other unit having a heat absorber plate positioned at an obtuse angle to the redirected radiation beam, heating a liquid working fluid inside the latter unit below its boiling point, due to lower density radiation flux on the latter heat absorber plate.
5. The improvement of claim 4, further comprising:
Supplying water as the main working fluid, and using the resulting steam for steam electrolysis in an attached processing unit, thereby producing hydrogen and oxygen gases.
6. The improvement of claim 2, further comprising:
sliding into an interface a radiation-to-water heat exchanger unit fitted with containers of phase change materials, storing heat in said containers, irradiating said heat exchanger with the concentrated solar beam by tilting said reflective panel, and fitting said heat exchanger with pipes and a pump causing water to be heated, using the on-board stored heat as well as currently generated heat, and circulating hot water to an external use,
7. The improvement of claim 2 or 3, further comprising:
sliding into one or more interfaces a heat absorber plate conductively attached to an air conditioning unit, thus driving an heat-driven refrigeration cycle substantially with the solar

radiation, and attaching a direct current conditioned-air supply fan motor to a circuit powered by said conversion technology of one or more units of the invention, thereby driving an air conditioner substantially on power and heat generated by the invention.

8. The improvement of claim 2, further comprising:
using a peaked (roof-shaped) cold mirror to separate out infrared radiation, converting infrared radiation with a thermovoltaic conversion devise placed beneath said peaked cold mirror, and directing subsequent visible light beam forks on either side of said cold mirror at photovoltaic conversion devises.

9. In a process for receiving and concentrating solar radiation, converting some of it to electricity, and delivering it to one or more end uses, the improvement comprising:
using a longitudinally peaked "cold mirror" to separate out infrared radiation, converting infrared radiation to electricity with a thermovoltaic conversion devise positioned beneath said peaked cold mirror, directing subsequent visible light beam forks on either side of said peaked cold mirror towards pivoting panels with photovoltaic conversion devises on one side and a reflective panel on the other side, providing beam pathways for said forking light beams when pivoting panels have their reflective side facing said beams, and providing one or more interfaces in each of said beam pathways with means for sliding in one or more radiant energy processing units, and providing a digital control and actuator system for moving said pivoting panels to desired positions at desired times, thereby selecting on demand the energy processing units or the photovoltaic conversion devises as receivers of the radiation beams.

10. The improvement of claim 9, further comprising:
installing said collector assembly in a roof structure so that the main reflective walls within the first stage concentrator are distributed from essentially eastward to westward facings, and attaching said array of reflective panels to a trough and assembly with side walls and end walls tapered and converging inward sufficiently to enable the assembly to fit onto roof trusses with rise angle of 40 degrees or more, while penetrating inside an attic, (see figures 3, 4, 5) and with a slot opening in the bottom of said trough, thereby receiving and concentrating both direct and diffuse solar radiation throughout most of the solar day into a stationary roof-mounted assembly encompassing all elements in claimed 18, and arranging the concentrator optics, the physical wave-bending means, and the interface angles of incidence so that one interface receives solar radiation measured at mid-day in concentrations between 8 and 20 suns, and another receives radiation measured at mid-day at concentrations of between 3 and 7.5 suns.

11. The improvement of claim 9 or 10, further comprising sliding into one or more interfaces a radiation-to-phase change material heat exchanger unit, so that the redirected radiation beam can cause heat to be stored in the phase change material, and fitting said unit with pipes so that end use water can be heated at almost any time required, and supplying an integrated or attached pump attached electrically to the output of the thermovoltaic conversion devise(s), thereby producing hot water on demand and pumping it to an end use delivery system.

12. The improvement of claim 9 or 10, further comprising:
sliding into one or more interfaces a radiation-to-water heat exchanger unit, redirecting the radiation beam onto its surface thereby causing heat to transfer to water, supplying an integrated direct current powered pump attached electrically to a circuit powered by the output of the thermovoltaic conversion devise, and fitting said unit with pipes so that heated water can be delivered to an end use delivery system.

13. The improvement of claim 9 or 10, further comprising:
sliding into one or more interfaces a heat absorber plate connected to an absorption-type air conditioning unit, thus driving an absorption cycle with heat from the solar radiation, and attaching a direct current conditioned air supply fan motor to a circuit powered by said thermovoltaic and photovoltaic conversion devises of one or more units of the invention, thereby driving the air conditioner substantially on power and heat generated by the invention.
14. The improvement of claim 9 or 10, further comprising: using heat and electricity produced therein to drive an attached ventilation and dehumidification unit by placing a heat absorber plate in one or more interfaces driving a dehumidification circuit and powering a ventilation fan with direct current supplied by a circuit fed from the included radiation conversion devise(s) of one or more units of the invention.
15. The improvement of claim 9 or 10, further comprising:
sliding into one or more interfaces a heat absorber plate connected to an evaporation unit acting as a component of a steam electrolyzer, and attaching the electrodes of said electrolyzer to a circuit powered by said thermovoltaic devise, thus driving an electrolysis unit substantially on power and heat generated by the invention.
16. The improvement of claim 9, further comprising:
employing two different resting slope angles of said pivoting reflective panel, in addition to the angle that irradiates the photovoltaic conversion devise, allowing irradiation alternately of a slide-in energy conversion unit, and of the end of an optical fiber bunch, thus directing the radiation beam to another location via optical fibers for another end use.
17. The improvement of claim 2, further comprising:
creating the first stage of said concentration by forming an array of adjacent cells open at the front and back ends, whose walls are reflective, substantially planar, and gradually converging in the direction away from the radiation source, whose outer extremities follow the shape of a substantially semi-cylindrical surface whose arc is, upon proper installation, in substantially the same plane as the sun's arc across the sky through the daytime, and covering the external edges of said panels with a transparent weather resistant material, thereby forming a solar collector with a wide acceptance angle to the radiation from the sky while concentrating all collected radiation.
18. The improvement of claim 2, further comprising creating a subsequent stage of said concentration by using a convex Fresnel lens positioned transversely across the radiation beam.
19. The improvement of claim 17 or 18, further comprising providing a thermophotovoltaic conversion devise positioned at an interface facing the concentrated radiation beam, and using the reflective panel to alternately redirect the radiation beam onto one or more laterally positioned energy processing units other than electricity generation units, by slide-fitting said units into an interface to a beam pathway.
20. The improvement of claim 19, further comprising:
installing said collector assembly in a roof structure so that the main reflective walls within the first stage concentrator are distributed from essentially eastward to westward facings, and attaching said array of reflective panels to a trough and assembly with side walls and end walls tapered and converging inward sufficiently to enable the assembly to fit onto roof trusses with rise angle of 40 degrees or more, while penetrating inside an attic, (see figures 3, 4, 5) and with a slot opening in the bottom of said trough, thereby receiving and concentrating both direct and

diffuse solar radiation throughout most of the solar day into a stationary roof-mounted assembly encompassing all elements in claimed 18, and arranging the concentrator optics, the physical wave-bending means, and the interface angles of incidence so that one interface receives solar radiation measured at mid-day in concentrations between 8 and 20 suns, and another receives radiation measured at mid-day at concentrations of between 3 and 7.5 suns.

21. The improvement of claim 20, further comprising:
placing one or more spectral filters in front of said thermophotovoltaic conversion devise to reduce heating effects of the radiation on the conversion devise.

22. The improvement of claim 20, further comprising:
sliding into one or more interfaces a heat absorber plate conductively attached to an air conditioning unit, thus driving an heat-driven refrigeration cycle with heat from the solar radiation, and attaching a direct current conditioned–air supply fan motor to a circuit powered by said thermovoltaic and photovoltaic conversion devises of one or more units of the invention, thereby driving an air conditioner substantially on power and heat generated by the invention.

23. The improvement of claim 20, further comprising:
using heat and electricity produced therein to drive an attached ventilation and dehumidification unit by placing a heat absorber plate in one or more interfaces driving a dehumidification circuit and powering a ventilation fan with direct current supplied by a circuit fed from the included radiation conversion devise(s) of one or more units of the invention.

24. The improvement of claim 20, further comprising:
sliding into one or more interfaces a radiation-to-water heat exchanger unit, redirecting the radiation beam onto its surface thereby causing heat to transfer to water, supplying an integrated direct current powered pump attached electrically to a circuit powered by the output of the thermovoltaic conversion devise, and fitting said unit with pipes so that heated water is delivered to domestic supply of hot water, swimming pool heating, or space heating by means of hydronic heat distribution.

25. The improvement of claim 24, further comprising:
adding phase change materials in containers conductively attached to said heat exchanger and said heat absorber panel.

26. The improvement of claim 2, 17, or 18, further comprising:
providing thermovoltaic cells that are translucent to infrared, and providing a heat conductive channel underneath said thermovoltiac conversion devise as the passive heat rejection means, thereby conducting remaining infrared radiation into a building space.

27. The improvement of claim 17 or 18, further comprising:
providing a thermovoltaic conversion devise positioned underneath a cold mirror to separate out and convert infrared radiation, placing a beam collimating channel with reflective surfaces diverging towards the cold mirror, directing subsequent visible light beam forks on either side by pivot-tilting said cold mirror, placing photovoltaic conversion devises on at least one side and an energy processing unit on at least one side, connecting a digital control and actuator system to a pivoting means on said cold mirror, selecting on demand the energy processing unit or the photovoltaic conversion devise as energy receiver by moving light beams to desired positions at desired times, and connecting electricity generated by the solid state conversion devise(s) to one or more useful means via an electrical processing system.

28. The improvement of claim 27, further comprising:
placing one or more spectral filters in front of one or more conversion devises to reduce heating effects of the radiation upon said devises by removing frequencies of radiation that do not activate the devises' conversion functions.
29. The improvement of claim 27, further comprising:
using heat and electricity produced therein to drive an attached steam electrolysis unit, by absorbing heat at one or more interfaces and connecting current to an electrolyzer electrode.
30. The improvement of claim 27, further comprising:
installing said collector assembly in a roof structure so that the long axis of the collector system is essentially vertically facing Southward if located in the Northern hemisphere, but Northward if located in the Southern hemisphere, with at least one end wall tapered and converging inward at an angle of 40 degrees or less, attaching the collector assembly onto roof trusses with rise angle of 40 degrees or more, while penetrating inside an attic, (see figures 3, 4, 5) and with a slot opening in the bottom of said trough, thereby receiving and concentrating both direct and diffuse solar radiation throughout most of the solar day into a stationary roof-mounted assembly encompassing all elements in claimed 27, and arranging the concentrator optics, the physical wave-bending means, and the interface angles of incidence so that one interface receives solar radiation measured at mid-day in concentrations between 8 and 20 suns, and another receives radiation measured at mid-day at concentrations of between 3 and 7.5 suns.
31. The improvement of claim 30, further comprising:
sliding into one or more interfaces a radiation-to-water heat exchanger unit, redirecting the radiation beam onto its surface thereby causing heat to transfer to water, supplying an integrated direct current powered pump attached electrically to a circuit powered by the output of the thermovoltaic conversion devise, and fitting said unit with pipes so that heated water is delivered for a useful function.
32. The improvement of claim 31, further comprising:
adding phase change materials in containers conductively attached to said heat exchanger and said heat absorber panel.
33. The improvement of claim 30, further comprising:
sliding into one or more interfaces a heat absorber plate conductively attached to an air conditioning unit, thus driving an heat-driven refrigeration cycle with heat from the solar radiation, and attaching a direct current conditioned–air supply fan motor to a circuit powered by said thermovoltaic and photovoltaic conversion devises of one or more units of the invention, thereby driving an air conditioner substantially on power and heat generated by the invention.
34. The improvement of claim 30, further comprising:
using heat and electricity produced therein to drive an attached ventilation and dehumidification unit by placing a heat absorber plate in one or more interfaces driving a dehumidification circuit and powering a ventilation fan with direct current supplied by a circuit fed from the included radiation conversion devise(s) of one or more units of the invention.
35. The improvement of claim 30, further comprising:
conducting said forking light beams alternately, to an interior space as daylighting conducted by reflective-walled light conduit(s), and to the photovoltaic conversion devise.
36. The improvement of claim 27, further comprising:
using the electricity produced to power an uninterruptable power supply.

37. The improvement of claim 27, further comprising:

conducting said forking light beams alternately, to an interior space as daylighting conducted by reflective-walled light conduit(s), and to the photovoltaic conversion devise.

38. The improvement of claim 37, further comprising:

providing a daylighting channel to conduct forking light beams through an interface into a building space, and connecting said heat conducting channel to said daylighting channel with a movable deflecting baffle attached to heat rejection means to choose the amount of infrared radiation to add to said daylighting channel.

39. The improvement of claim 2, 9, 17, or 18, further comprising:

providing digital logic for real time control, responsive to sensor data, timed program data, and user programmed priorities & adjustments.

40. The improvement of claims 10, 17, or 18, further comprising:

providing a special roof truss system for mounting said collectors as a roof covering, avoiding shadows from one collector interfering with another collector while placing them as close together as 15 to 16 inches, leaving space between alternate trusses of approximately 46" for said collectors' lower bodies to penetrate through the trusses and into the attic space, providing truss materials sufficient to carry the weight of the collectors and their slide-in add-on units, including water-containing heat storage and heat exchanger add-on units, and fitting them for easy mounting of said collectors and for slide-in snap-lock of add-on units in the truss surfaces facing the 15 to 16 inch gaps.

41. The improvement of claim 3, further comprising:

placing a thermovoltaic conversion devise at the higher concentration interface, and a photovoltaic conversion devise at the lower concentration interface.

42. The improvement of claim 17, further comprising:

Using glass that has been treated to repel dust and dirt particles on the outer surface as the external covering material of the collector assembly.

43. The improvement of claim 9, 19, or 27, further comprising:

mounting said elements into a stationary assembly, forming at least one end wall to converge inward at an angle of 40 degrees or less, mounting said assembly on top of an existing building's sloping roof so that the long axis of the collector system is essentially vertically facing Southward if located in the Northern hemisphere, but Northward if located in the Southern hemisphere.

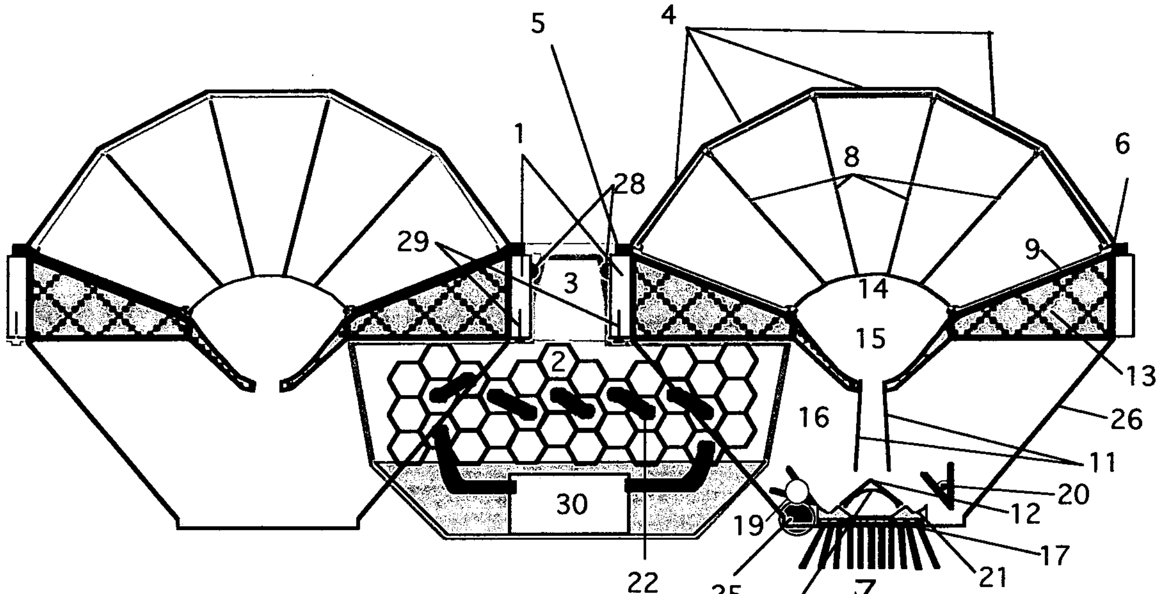

Figure 1

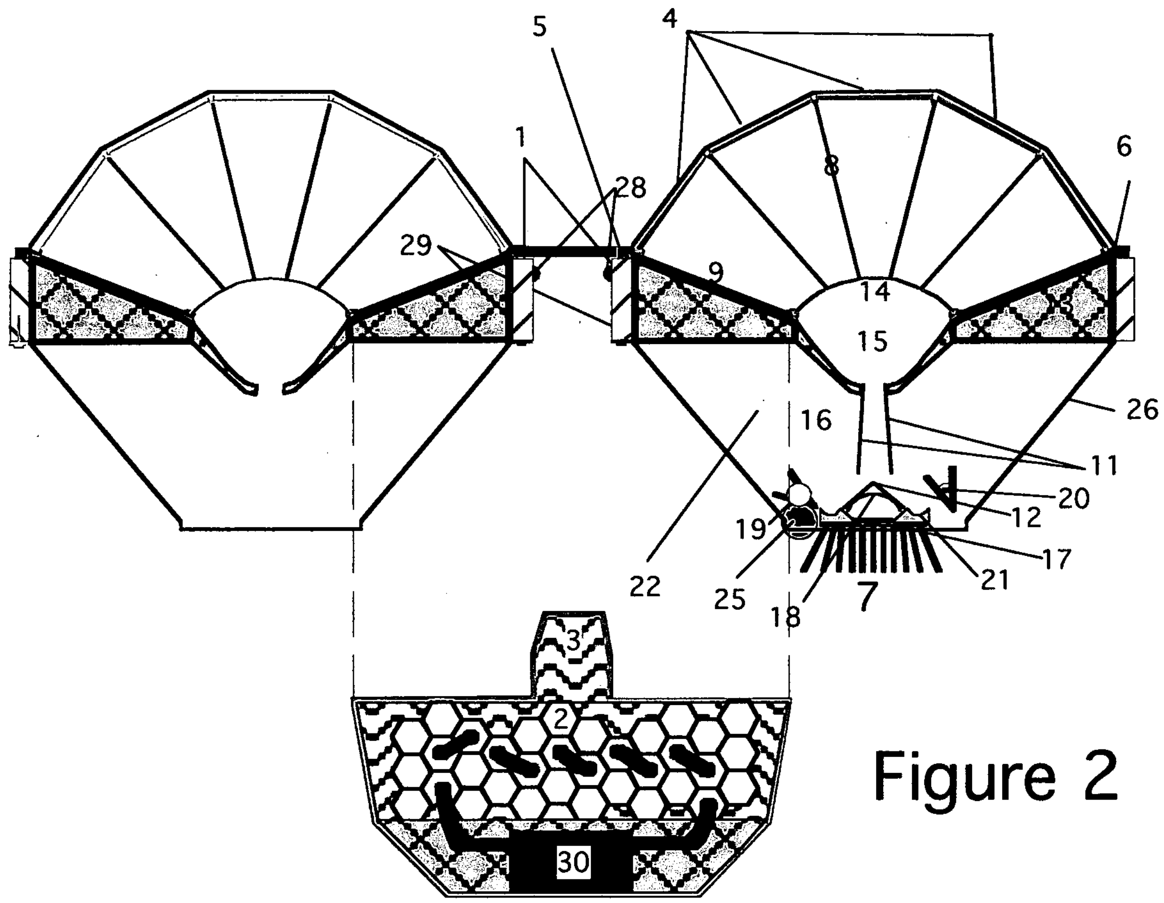

Figure 2

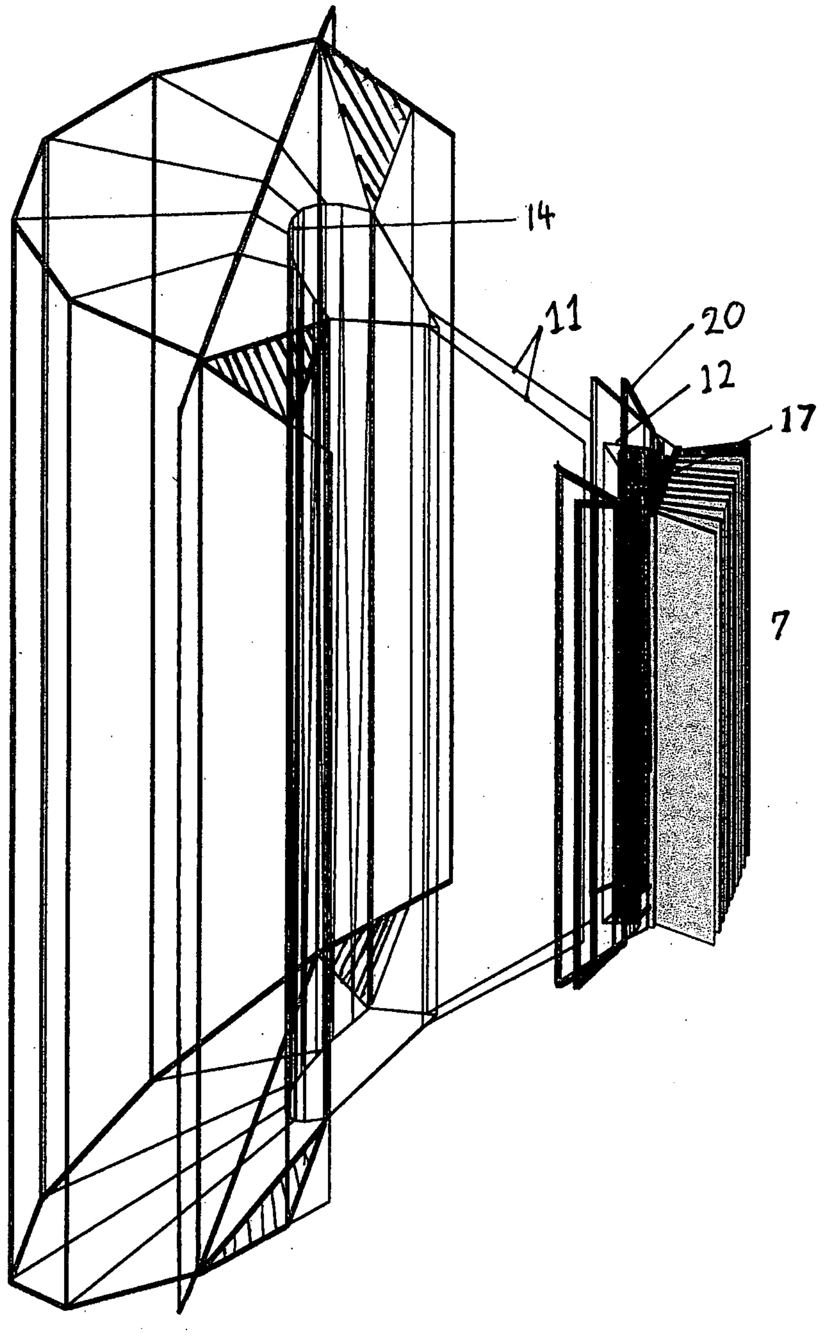

Figure 3

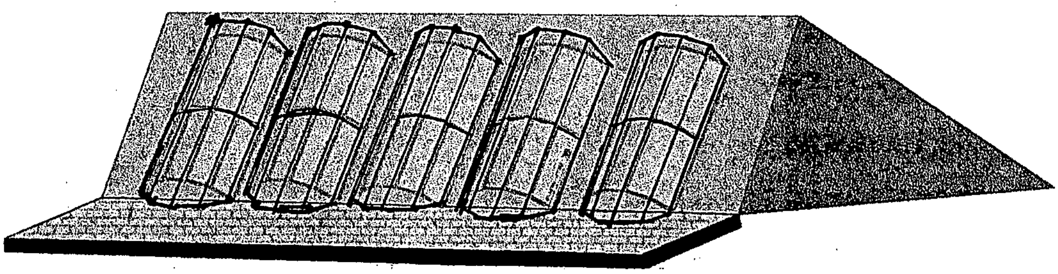

Figure 4

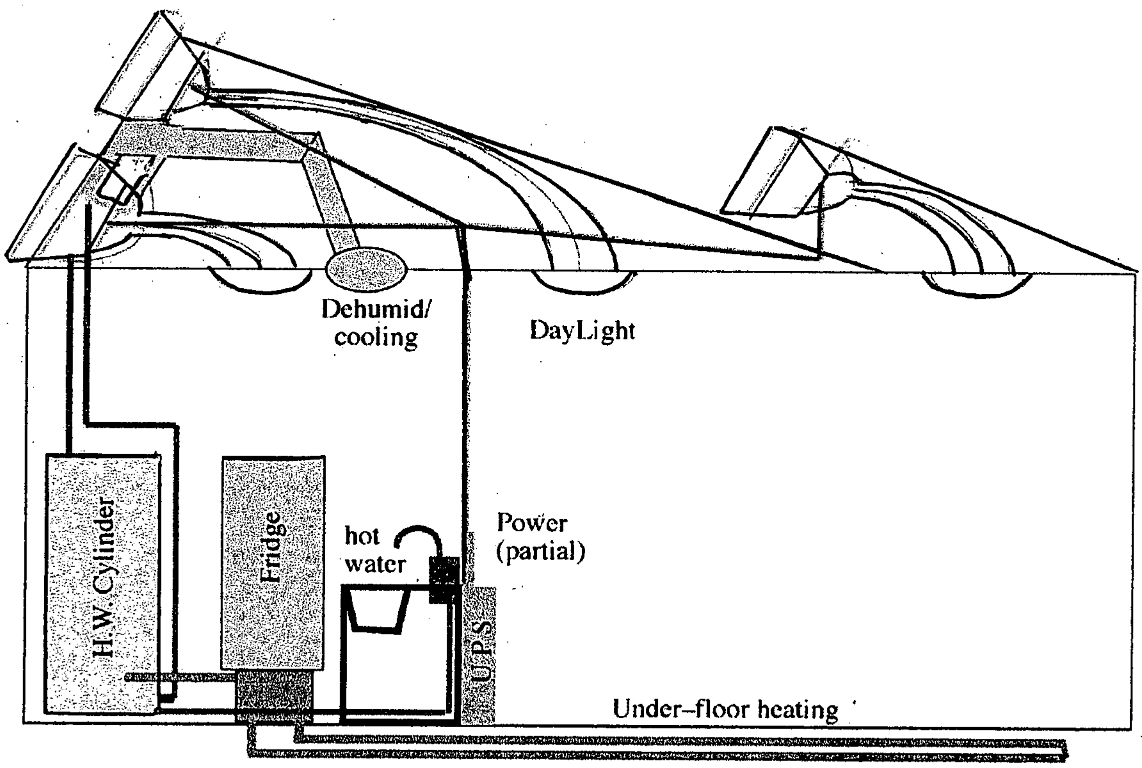

Figure 5

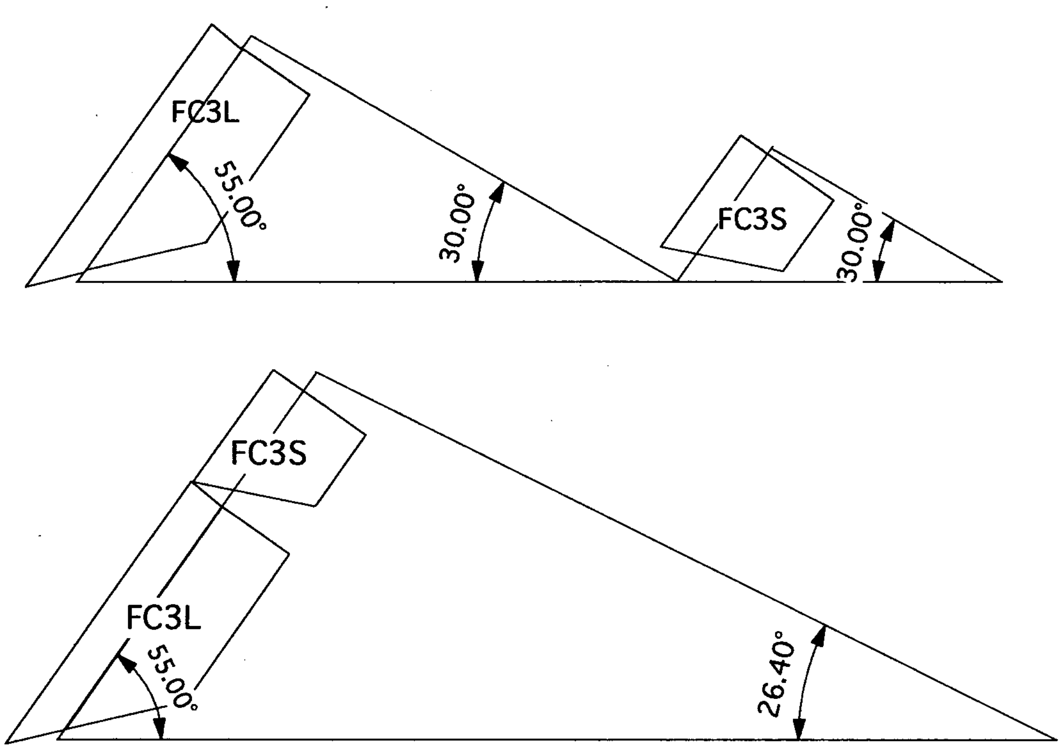

Figure 7

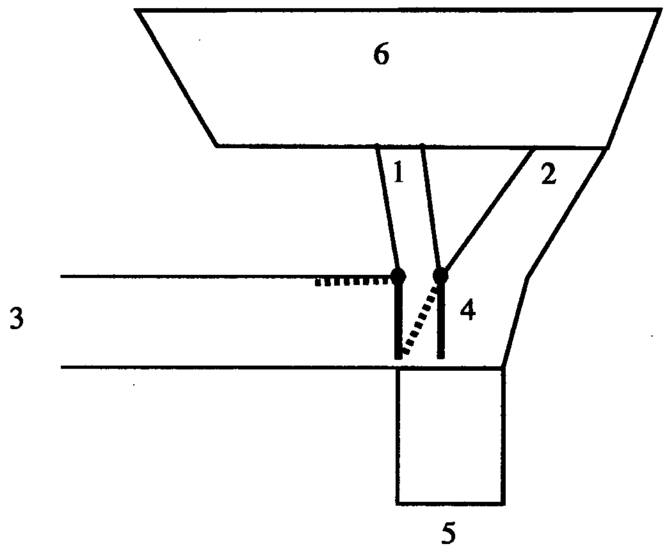

Figure 6

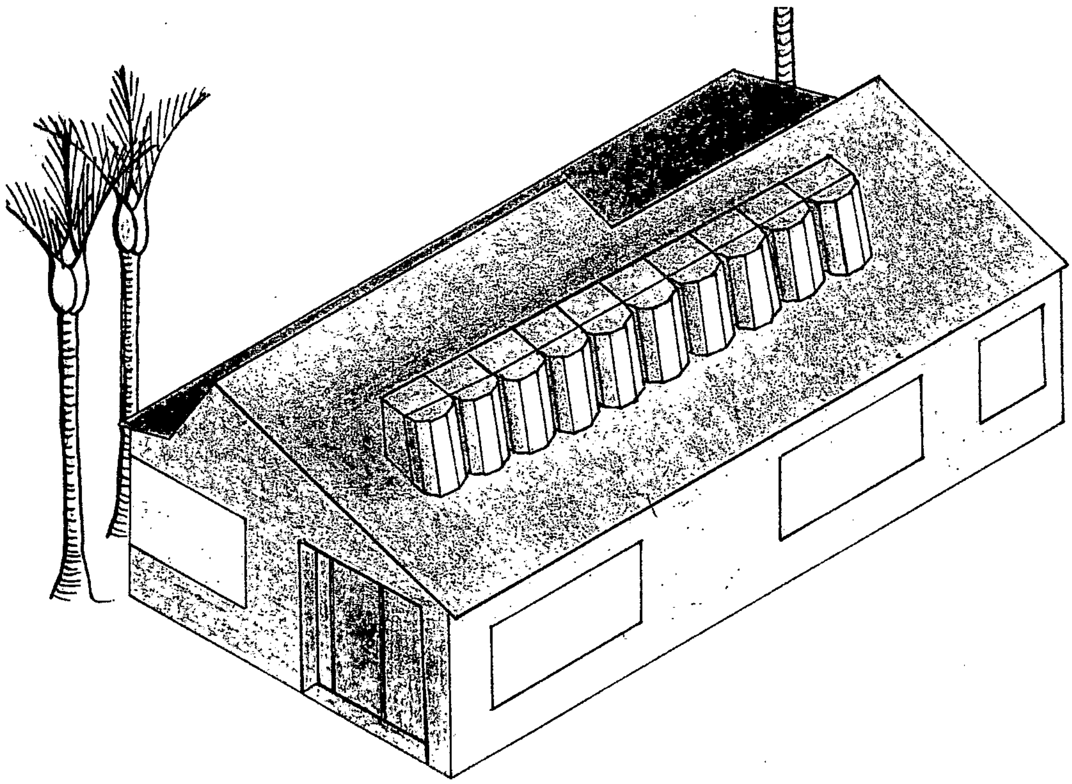

Figure 8

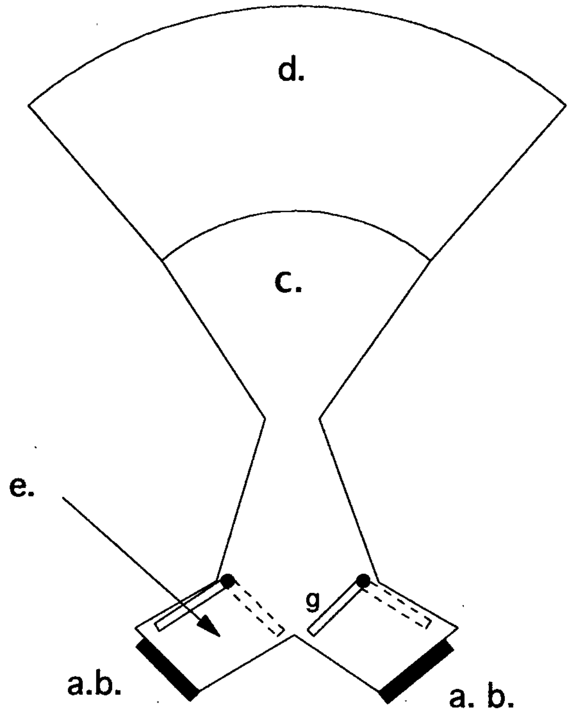

Figure 9

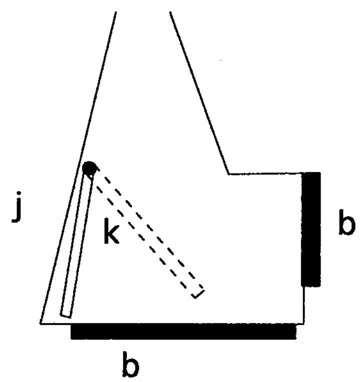

Figure 10

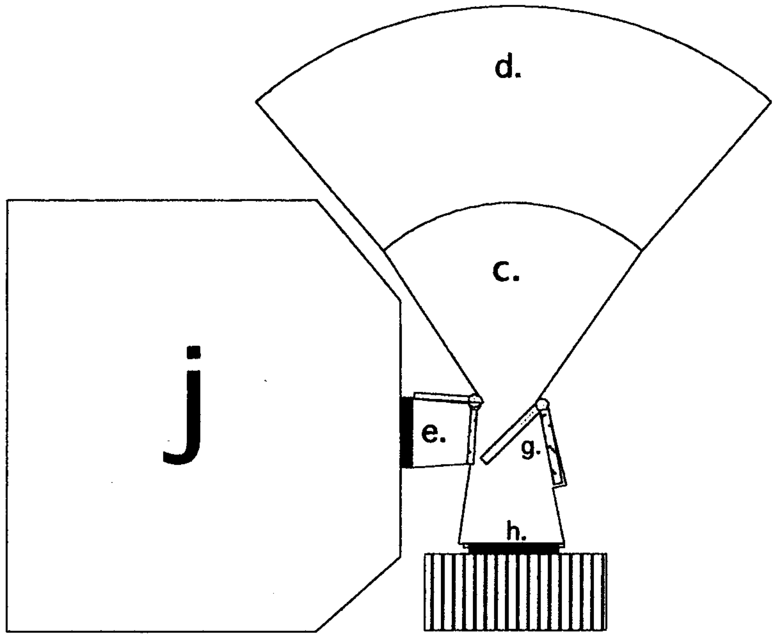

Figure 11