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COOL CELL™ ARCHITECTURAL CLIMATE-CONTROL*

Introduction

Cool Cell™ architectural climate-control uses water flowing within the skins of structures to heat and cool. The sun raises the temperature of dark surfaces 60° F to 100° F above ambient air temperature and the night sky drops the temperature of all surfaces 5° F to 15° F below ambient: this is the source of heat and coolth used by Cool Cell systems. Reservoirs of water in the ceiling connect to roof-mounted radiator/absorbers for summer cooling at night and winter heating by day.

Past Work

Engineers have long known about such heat and coolth - sections 28.5 and 28.6 of the ASHRAE Handbook titled 'Sol-Air Temperatures' explain it thoroughly. Cramer and Neubauer studied white and black panel temperatures in 1965. Plastic collectors manufactured for swimming pools have been demonstrating the use of sun and night-sky radiation to heat and cool for 25 years. Shawn Buckley introduced passive wall-modules to capture heat and coolth; Harold Hay used roof-ponds; Tim Maloney used rotational-molded water-walls. In his book Passive and Low Energy Cooling of Buildings (1994), Baruch Givoni outlines a system similar to Cool Cell™ which uses concrete for thermal mass instead of water and relies on pumped circulation.

Water

Water is excellent for heat storage: it weighs half as much as masonry and stores twice the heat in the same volume. Plain water recommends itself because it is non-toxic, non-flammable, readily available and almost free. It flows easily, is dense and thermally conductive and has a high specific heat. Its high heat of vaporization allows cooling to be 'supercharged' by evaporation from a wet radiator.

Water's high heat of fusion is a disadvantage, as is its expansion on freezing: frozen heat collectors are slow to thaw from morning sun and so reduce thermal profits. However, given the expense and toxicity of antifreeze, we have chosen to accommodate ourselves to these disadvantages for certain applications.

***Patent # 6357512 B1**

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Climate

Cool Cell systems work best in dramatic climates such as the West and Southwest of the United States, where cool nights divide hot days and winter is sunny. Cool Cell can meet the demands of colder climates with the addition of a south-wall absorber that circulates warm water to the interior by convection. Glazing and selective surfaces can also be used.

Storing Heat and Coolth Overhead

The advantages of interior storage of heat and coolth overhead have been explained by Norman Saunders in Bill Shurcliff's book, Super Solar Houses. Heat and coolth from overhead pass to the space below in different manners. In summer, warm air rises to the mass of water in the ceiling and cool air returns. In winter, heat descends by radiation and can be blocked with aluminum louvers: heat radiates to the space below only when the louvers are open. The mass of water in the ceiling has been located to 'shine' on the space below, and opening the louvers doubles or even triples radiant flux. Unlike trombe or drum walls, direct-gain systems and radiant floors, Cool Cell systems with louvers provide a source of heat that does not automatically flow into the space at a free rate but can be controlled as desired for comfort. If radiant heat alone is not enough, a fan may be used to pull down warm air - the heat so delivered vastly outweighs the energy to run the fan.

Circulation

The least expensive, most reliable circulation of water from reservoir inside to radiator/absorber outside occurs by convection. Convection causes gases and liquids to rise when warm and settle when cool, and is governed by many factors: thermal conductivity, density, viscosity, temperature, specific heat. Cool Cell systems cool in summer by convection-driven circulation and heat in winter by pumped, drain-back circulation or convection-driven circulation from a south-wall absorber. The Cool Cell's water-level is lowered each winter so drain-back will prevent freezing of the roof-mounted radiator/absorber. Since a south-wall absorber is below the mass of water inside, drain-back is precluded and that absorber must be freeze-tolerant.

Simplicity

Unlike most modern technology, Cool Cell systems are transparent in function. Flow patterns explain themselves. Every part is simple, every connection easy. No anti-freeze, no heat exchangers, no glass, no collector boxes, simple controls. Rubber connectors can be pushed on by hand. Cuff connectors self-seal and need no tools. Temperatures can be read from color-coded strip thermometers.

Energy Savings versus System Sizing

A Cool Cell system serving a storage building or warehouse offers optimal energy savings, because the permissible temperature range is greater than for an inhabited space. Close temperature-regulation as for houses requires radiator/absorbers as large as the roof to be effective in marginal weather. Temperatures in a storage building or warehouse can fluctuate more widely and the Cool Cell system can be smaller and less expensive, because high-temperature heat radiates easily during summer nights and low-temperature heat is easily collected during winter days.

A system for a storage building allowed to reach 95°F in summer and 40°F in winter has about twice the rate of payback of a system which typically maintains a much tighter temperature range. Compared to a standard electric system that holds the same temperature limits as Cool Cell, the Cool Cell system in such an application could save 10 kilowatt hours per square foot during the cooling season and 25 kilowatt hours per square foot during the heating season. At ten cents per kilowatt hour, the overall savings would be $3.50 per square foot per year.[1] Without any means of heating or cooling, temperatures in this example might reach 120°F in summer and 25°F in winter.

Summer versus Winter

Earth's heat gain and loss balance one another. Solar gain occurs when the sun is shining and radiant cooling occurs constantly. While radiant cooling is actually greatest during the day, when the sun is heating the earth, net coolth is really only available at night in the absence of solar gain. Since night is never more than 12 hours away, coolth can be replenished on a reliable 24-hour cycle, for daily comfort during the summer.

Solar gain is not as reliable as radiant cooling, the winter sun can disappear for days, so heat storage must be greater for winter comfort to compare to summer coolth. By blocking radiation to the space below, aluminum louvers allow Cool Cell systems to absorb maximum solar gain[2] for heat storage, without overheating the space below and dissipating heat before needed. Back-up heating is recommended for colder climates.

Swimming Pool Collectors versus Cool Cell Radiator/Absorbers

Swimming pool collectors made of polypropylene have been in use for over 20 years. In New Mexico they last about 10 years, and we expect a similar service-life from our polypropylene radiator/absorbers for Cool Cell systems. Conventional pool collectors, intended to be used only with pressurized pumping, are not well-suited for Cool Cell applications due to typical restrictions at their headers and risers. Because Cool Cell systems circulate water by natural thermosiphon (convection), their radiator/absorbers have been designed to minimize flow-resistance.

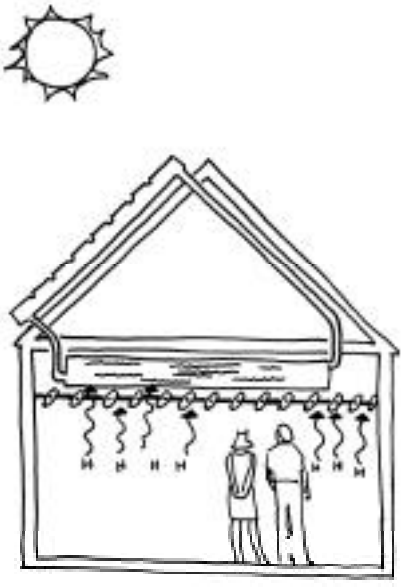
[1]Because Cool Cell systems cost almost nothing to run, savings are considered to be the total cost of energy required to run an equivalent conventional system.

[2]Recall that the sun raises the temperature of dark surfaces 60° F to 100° F above ambient.

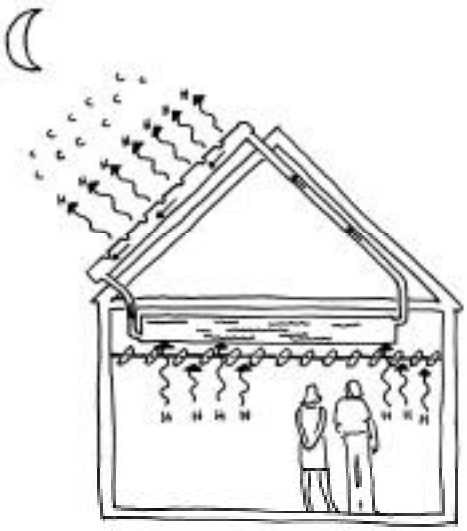
Conclusion

There are experimental roof shingles that double as photovoltaic panels, and special windows that make electricity. Yet, for all this fascination with converting sunshine into electricity, a simple low-tech radiator/absorber can collect three times the energy of photovoltaics, at one-tenth the cost per area and one-thirtieth the cost per BTU. Whether by convection over summer nights or pumped, drain-back circulation winter days, Cool Cell systems transfer thermal energy to and from a building's interior with elegance and ease, providing comfortable overhead radiant cooling and heating at a small fraction of the annual energy cost of standard systems. Cool Cell systems for architectural climate-control renew a long-standing interest in the passive use and management of natural thermal energy. Designers who already make use of climate will be ready customers for Cool Cell; designers who wish to use climate will find that Cool Cell makes passive design simple, practical and cost-effective.

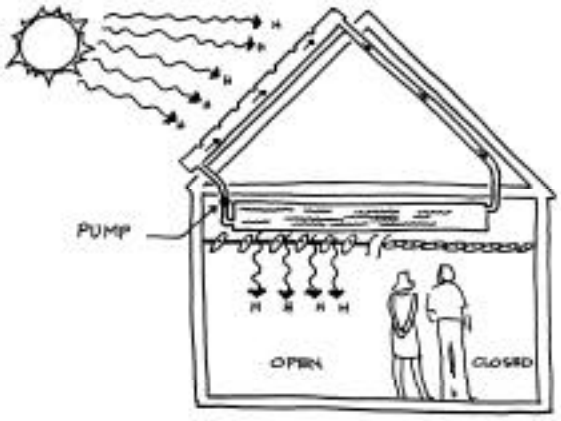
Heat Flow Diagrams



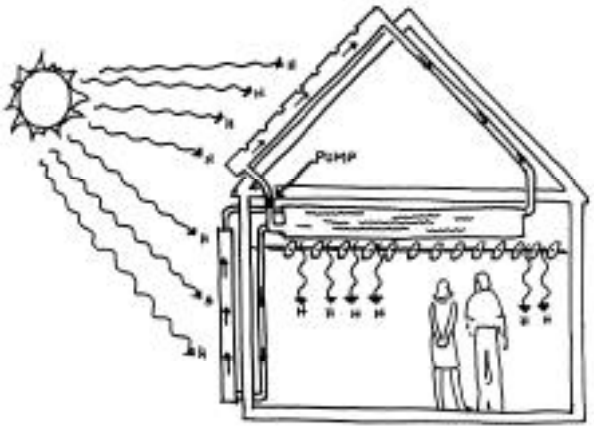
1. Summer cooling during the day: The water inside acts as a heat sink, absorbing heat through the day and thereby cooling the space. Because the water in the roof-mounted radiator/absorber becomes very hot from the summer sun, no thermosiphon circulation occurs and no solar gain is added to the system.



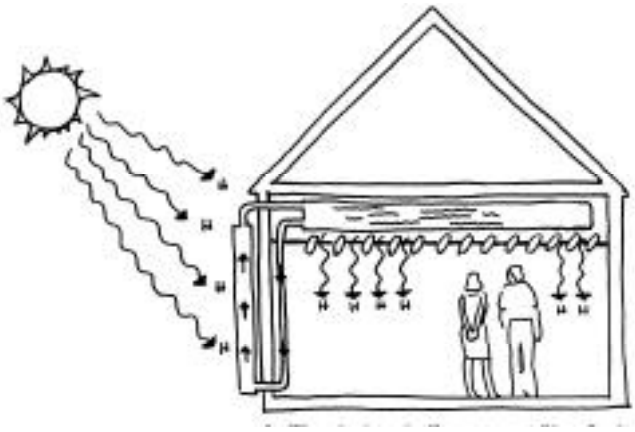
2. Summer cooling overnight: The water inside absorbs heat from below and thereby cools the space. The water in the roof-mounted radiator/absorber cools by radiation to the night sky, thermosiphon circulation and radiant cooling begin and continue overnight.



3. Winter heating during the day: A low-power pump circulates water through the roof-mounted radiator/absorber for solar gain during the day. Warm water returns and radiates its heat to the space below. Closing the louvers allows maximum solar gain for heat storage without overheating the space.



4. Winter heating with additional absorber: For colder climates, the addition of a south-wall absorber increases the system's heating capacity. Since it is below the mass of water inside, the south-wall absorber does not drain and must be freeze-tolerant. Circulation from this absorber occurs by natural thermosiphon and no pump is required.



5. Winter heating only: If summers are mild, cooling is unnecessary and heating is provided by a freeze-tolerant south-wall absorber which circulates by natural thermosiphon and requires no pump.

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Questions and Answers

Q - How long have you been working on developing this product?
A - The **Cool Cell™ architectural climate-control system*** has grown out of 31 years of design and manufacture of passive energy products. Earlier versions of the Cool Cell™ system used custom-molded polyethylene bottles, five-gallon water bags, and even two-liter soda pop bottles. Much of the foundation for Cool Cell™ architectural climate-control was provided by Zomeworks' development of Cool Cell™ temperature-regulating cabinets for stand-by batteries.

Q - Do you have other parties in this venture?
A - **Bill Mingenbach** of Architects Taos; Dick Bourne of **Integrated Comfort** in Davis, California, who is working with Zomeworks to increase cooling-capacity in extremely hot and humid climates, by spraying the roof-mounted radiator/absorbers with special sprinklers that recycle water collected from the building's gutters; **Nanopore Incorporated** of Albuquerque, New Mexico, which has invented and patented an ultra-thin super insulation which will be used in special applications of Cool Cell™.

Q - What is the market for Cool Cell™ systems?
A – That's the great part. Cool Cell™ systems can be put in any building.

Q - Can the apparatus be hidden or camouflaged?
A - The roof-mounted radiator/absorbers can be concealed behind parapets. The interior reservoirs can be placed above a drop-ceiling or covered with aluminum louvers.

Q - Can the Cool Cell™ system be installed in existing buildings or is it better to incorporate it into new construction?
A – Incorporating the system into new construction is best, but variations can be used in existing buildings.

Q – What type of climate is best for Cool Cell™ architectural climate-control?
A – The system works best in dramatic climates such as the West and Southwest of the United States, where cool nights divide hot days and winters are sunny. It can work in humid climates provided they are not too hot. Cool Cell™ systems are suitable for any climate in which evaporative cooling is presently utilized.

Q - Are there any downsides to this product?
A - The water adds an extra load of 25 pounds per square foot, which increases construction costs.

Q - When will you be in full production?
A - Our current timetable has us at full production within 12 months.

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Background

Since 1969, Zomeworks has specialized in the development of products that operate passively, conserve energy, and require no power. Zomeworks' customers range from homeowners and ranchers to telecommunications companies and utilities.

Three product lines have resulted from working with the sun, the natural properties of water, and the movement of heat:

1 **Mounting systems for solar panels**, including Zomeworks' patented Track Rack™, which tracks the sun through the day with no power and no moving parts, for maximum power output from its solar panels. Zomeworks' Track Rack™ is still the undisputed cadillac of the tracker industry.

2 **Architectural products**, including Sunbenderâ reflector shades, Skylidâ self-operating louvers, and Zomeworks' latest innovation, the Cool Cell™ architectural climate-control system, which is simple to install and costs almost nothing to operate.

3 **Cool Cell™ temperature-regulating cabinets**, for stand-by batteries and instrumentation. Development of the Cool Cell™ cabinet provided much of the foundation for Cool Cell™ architectural climate-control systems.

The 'Zome' name is derived from a combination of 'zonohedron', a technical term from geometry, and 'dome/home'. Zome System geometry kits now seen in toy stores incorporate geometry discovered and patented at Zomeworks 30 years ago. Playground climbers based on this geometry can be seen in Albuquerque-area parks. The Zome geometry kits are available from Zometool Incorporated of Denver, CO.

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How To Get Started

Should you or your client wish to install the Cool Cell™ architectural climate-control system*, Zomeworks offers the following services:

+ Design consulting:	Zomeworks provides a license and designs the system, in consultation with the architect and engineer, to match the building's requirements and the climate. Zomeworks provides static-load information to the engineer.
+ Materials:	Zomeworks provides materials.
+ On-site:	Zomeworks can send a representative from its architectural Cool Cell™ division to be present during installation.
+ On-going:	Zomeworks is available for on-going service after the system is installed.

Please call Steve Baer, architectural Cool Cell division, at 505 242 5354, ext 227, for further information.

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