The Solar Hologram

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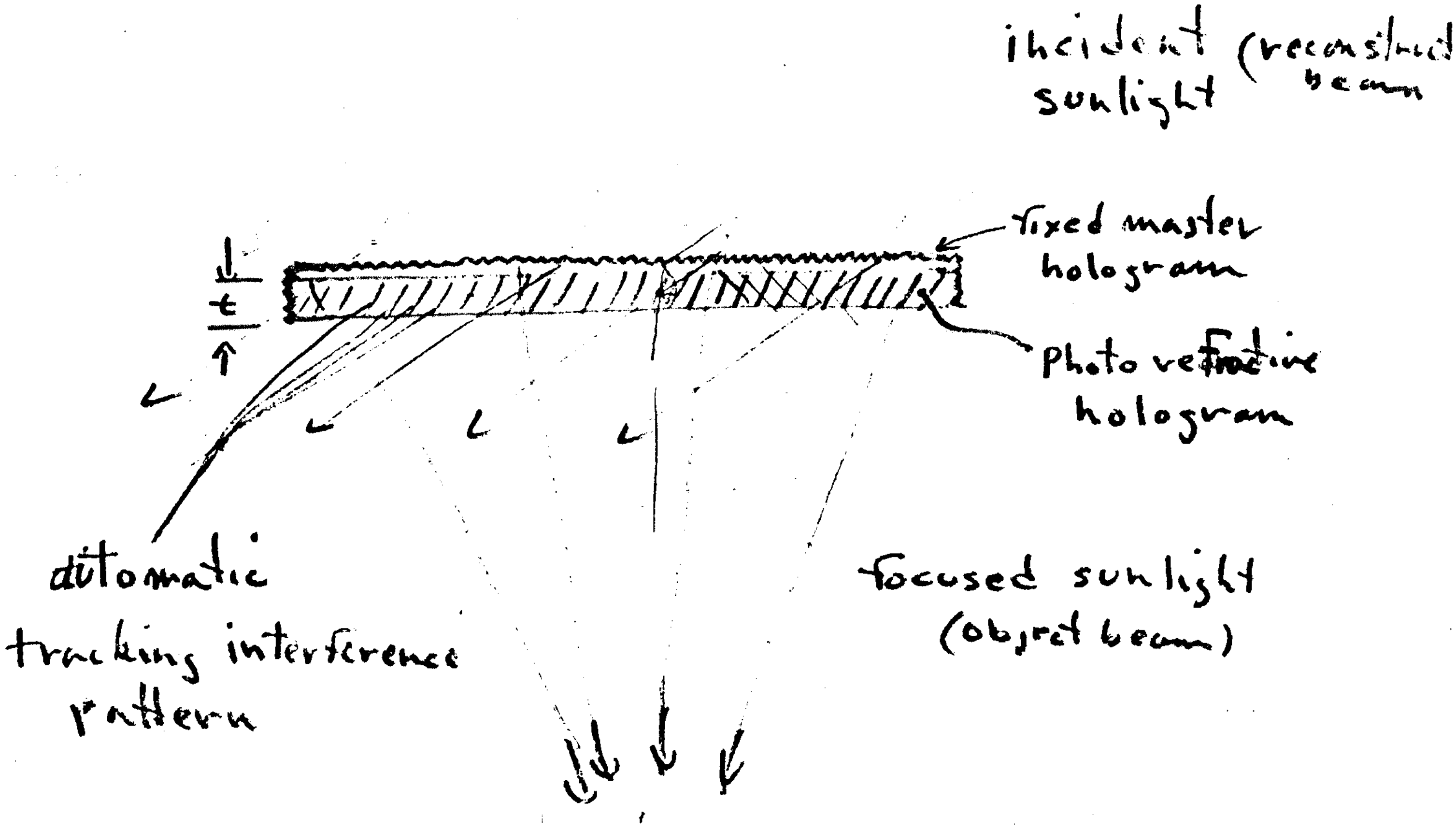

1. the fixed master hologram has multiple reference beams for the same object beam to accomodate a practical range of sun angles, at relatively low efficiency η_m
2. the photo refractive tracking hologram is continuously generated by the transmitted sunlight, as reference beam, and the object beam from the f.m.h. to an efficiency determined by the Δn and thickness, t approaching 100%

This concept was discussed by Mr. Cross at a seminar presented to the Optical Sciences Center on May 6, 1975.

Peter Franken

The application of solar holograms can be divided into three basic categories, depending upon the conversion technique used to apply or harness the radiation. The solar holograms will be developed in each one of these three areas, all using basically the same camera and techniques, but having slightly different optical or material characteristics--depending on the specific application. Each application area will result in a number of products--immediately or in the projected future.

The three application areas are 1) direct electrical conversion of solar radiation through the use of solar cells or photovoltaic cells--solid state devices that directly convert radiant energy into low voltage high current electricity; 2) thermal electrical conversion, such that the sun's energy will be used to heat a working medium, such as a steam turbine, and consequently either provide direct work applications or, more likely, be used to generate electrical power through driving an electrical generator; 3) application in this area involves the use of direct sun radiation concentrated into a diffuse, soft or appropriately shaped focus. Initially, the units produced will be experimental in nature, although they should quickly evolve into hard products.

DIRECT ELECTRICAL CONVERSION UNITS

The first actual product will be developed and made available for sale within the first three months. It will be a small 16 inch diameter solar hologram utilizing a directing radiation into a small array of conventional solar cells. This unit will provide a 12 volt dc charging voltage to recharge small battery-powered equipment of any kind using rechargeable batteries. The unit will put out power in the range of 1/5 to 1 watt initially, and as the solar cells are developed or improved in efficiency, could potentially put out 5 watts of power.

Even this first small unit will provide a capability for people to utilize electronic devices in remote locations for definite periods of time. The second unit of this type will be a 5 x 4 foot solar screen or array of screens to convert sunlight into electricity directly, and will generate 12 volts dc, in the range of 10-50 watts and with an improved efficiency probably as much as 100 watts of electrical power.

The small unit(as shown in figure 1)will be of such a shape and size that can be easily backpacked and carried into remote locations. A 5 x 4 foot unit could also be made in a sectioned panel as shown in figure 2a, and could be carried into remote locations without difficulty. This unit could easily provide enough charging power to operate remote radios, telephones, provide a significant amount of useable light at night, recharge lamp batteries, sound system batteries, as well as a vast array of electrical appliances.

The third unit in this series will be approximately 6 x 9 feet in size. The first units will generate between 100 and 500 watts, with a potential of 1,000 watt direct electrical generation from a unit using improved cells. This unit will have a capability of generating 12, 24, or 110 volts dc or ac. The unit could be mounted easily on the roof of a car or a larger vehicle, and taken to any location accessible to the vehicle; it could be airdropped into remote areas, and provide a continuous source of electrical power for significant installations of all types. Certainly it would be sufficient for powering a house in a remote location operating on a minimal electrical economy basis.

This unit would also provide enough power to directly drive an electric vehicle, which will also be developed within the first year. This vehicle will be extremely light-weight, basically built from two conventional bicycles carrying a solar screen as its roof, providing approximately 1 horsepower of essentially cost-free travel at cruising speeds up to 50 miles per hour.

Figure 4 shows a preliminary sketch of the solar car, in which the solar screen is mounted on top. The solar cell unit is mounted directly under the screen, and a nicad battery system is located beneath the rear seat. This car will carry 2-5 people, with an additional luggage payload on the back as well as a large basket or tray in front. The power control unit would direct that portion of the power not used to drive the vehicle into the battery charging system, so that potentially the car could be driven all day at a phenomenal cruising speed and then all night on the charge built up in the batteries from the excess power.

The advantages of using a solar hologram to collect energy for an array of solar cells are 1) that the direction of the orientation of the entire unit can remain constant throughout the day--designed to lie approximately horizontal, depending on the time of year and the lattitude of use. Once a simple adjustment is made for these factors, the unit can remain in one position at all times, and not have to be moved during the day; and 2) another obvious advantage is that the area and number of solar cells used would be reduced by a factor of 10, which is a significant cost reduction.

In fact, the primary cost of the whole unit would be in the solar cells. These two factors together--that the unit would not have to be revolved to follow the sun, and that the actual number of solar cells required would be substantially reduced--provides a very significant commercial advantage over any other existing or conventional optical type of direct solar converter.

THERMAL ELECTRICAL CONVERSION UNITS

The first year effort in thermal electrical conversion will begin with the construction of a 25 x 40 foot platform which will mount a solar screen which eventually may be as large as 40 x 20 feet in width and height. The first solar screen built will be considerably smaller, however. The entire project will procede in three stages: the first stage will be used to drive a small steam generator, generating between .1 and 1 kilowatt. The screen size for this unit will be approximately 5 x 4 feet. Then the second unit of this type will be a screen nearly ten times larger, generating from 1 to 5 kilowatts initially and with a final projected output of 10 to 50 kilowatts.

The plan for the first year would be to develop a final power station unit through these stages, copies of which would then be available for sale. A 50 kilowatt unit could provide enough power for a small community, on an average power basis. By the conclusion of this project, enough data would have been obtained to determine the feasibility of designing even larger units, possibly of a magnitude capable of directly converting existing thermal electrical power stations, which presently burn oil to generate electrical power.

It is difficult to say at this time whether that final application would be immediately feasible, but unquestionably, after a few years of development, a solar holographic screen large enough to convert a 1-10 megawatt thermal powered generator directly to solar energy would be realizable. This could be accomplished without any further cost than the holographic screen and the modifications to the boiler and heat transfer systems. All the other existing steam, turbine, electric, generator and power control technology would remain intact and continue to function as it does presently.

The advantage of using solar holographic collection techniques for this application is enormous. The initial installation cost and maintenance of an optical collector requiring constant tracking would be staggering, especially compared to the cost of a solar hologram. And the long term maintenance and replacement costs for an optical system large enough to convert a 10 megawatt power plant is almost beyond calculation. The fact that no such system exists today speaks for itself.

DIRECT RADIATION AND HEATING UNITS

In this area there will be a number of experiments carried out throughout the year that may lead to immediate applications. The initial units, however, will all be experimental in nature, and not designed for sale. The first area of significance in the application of direct radiation will be a holographic solar roof for a small hot house or garden area. It will be capable of collecting light over 3 to 4 times of the actual planted area of the hothouse, and will softly focus this energy to create a tropical environment in a northern latitude.

The obvious advantage of a solar hologram used in this connection is that it will not require any motion in order to be effective; no mechanisms will be necessary to move the holographic panels, which will be fixed in place in the roof. Another advantage gained by the use of the holographic technique is that the actual area covered can be designed in the hologram so that there will be only a uniform increase of solar energy without any hot spots or focussing effects, as would occur with a conventional optical system. A third inherent advantage is that the light could be spectrally smeared over the garden area so that plants that thrive in specific areas of the visible spectrum, such as infrared or ultraviolet, could be appropriately planted and enhanced.

Some of the energy will be directly used to create appropriate temperature and humidity conditions inside the hothouse to simulate any tropical environment desired.

A second application in the area of direct radiation will be a solar cooking unit, involving a large, fixed holographic screen, as shown in figure 7. Radiation will be reflected from a sheetmetal or plastic-backed mirror onto a cooking surface, and could be used throughout the day. Again, the use of the solar hologram means that a fixed installation is possible, and no tracking is required. The temperature concentration of sunlight in various cooking areas, such as the high heat plates, lower heat grill areas, and uniform oven areas, can be easily be regulated by the appropriate design of the hologram itself, without any further diffusing or focussing optics. Basically, the holographic pattern would be of the stove top itself, with variation in the brightness of the hologram being directly related to the temperature of the respective cooking area.

A solar water heater will be designed which will have certain advantages over previous attempts in this area, such as a capacity of reaching higher water temperatures, and maintaining those temperatures constantly during the day. Earlier designs, which have been the only successful use of solar energy thus far, have had limited efficiency.

This unit will be designed to provide water at temperatures up to boiling, with an automatic flow regulator through the heat transfer area so that regardless of the sun's brightness or position, the temperature output can be maintained--although the flow may be reduced or increased with available sunlight. The addition of styrofoam storage tanks will be developed for storing this water for low sun periods.

The last experimental area in direct radiation uses will be in the development of solar windows using both reflection and transmission holograms. The main characteristic of the solar window will be that the design, given a specific orientation in a structure, will be capable of reflecting all or any part of the sun's energy, thus eliminating all direct heating through the window without imparing vision through it. The obvious applications of such a window in large buildings in connection with the reduction of the sun heat loading and the consequent reduction of air conditioning costs has immediate commercial implications.

Theoretically, there is no reason why such windóws cannot be produced at a lower cost than present day windows. The solar holographic window could redirect the radiation into any desired area, most simply directly back at the sun itself, or could, conceivably, be focussed into direct or thermo-electric collectors for direct power conversion of the sun's energy from reflections off the building itself. It is also possible that a large building could be constructed wherein all the electrical power required would be obtained from directed reflections from the window area itself without obstructing vision and at the same time reducing heat loading into the building. This may be the ultimate architectural application of the solar hologram.