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Lewis Research Center

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A Low Cost "Air Mass 2" Solar Simulator

The Problem:

Much of the development and testing of Earth based solar collectors has been done by exposure to the Sun itself. Obvious disadvantages of depending on the Sun, however, are limited daylight and inclement weather. One alternative to such dependence is to use a solar simulator capable of duplicating most of the Sun's characteristics as they might appear to a solar collector on the Earth's surface. On a clear day when the Sun angle is 60° from the zenith, the optical path of the Sun's radiation to the Earth's surface produces the air mass 2 (AM2) solar curve or spectrum. This spectrum best represents the average North American sunlight. It is different from the air mass 1 (AM1) spectrum, when the Sun is located at its zenith (directly overhead), or the air mass zero (AM0) spectrum, which is obtained when the collector is located outside the atmosphere in Earth orbit. A low cost solar simulator (AM2) was required for testing flat-plate solar collectors.

Most commercial solar simulators use expensive high pressure arc lamps which, because of explosion possibilities, require safety equipment during handling. These commercial units use direct current and therefore require separate power supplies. They also use expensive quartz optics.

The Solution:

A solar simulator constructed of low cost commercially available components consisting of tungsten halogen projection lamps each having an integral ellipsoidal reflector, and hexagonal shaped plastic Fresnel lenses. The reflector is dichroic coated to reduce the infrared content of the reflected radiation. An array of these lamps and lenses produces a uniform collimated beam having a near AM2 spectrum and intensity that can be used for testing flat plate solar collectors.

How It's Done:

A cutaway view of the simulator is shown in Figure 1. The simulator consists of an array of 143 tungsten halogen 300 watt 120V lamps, each having integral-dichroic-coated reflectors. The square frontal section is covered with 143 hexagonal shaped Fresnel lenses in a closely fitted array. The optical axis of each lamp is coincident with that of its respective lens.

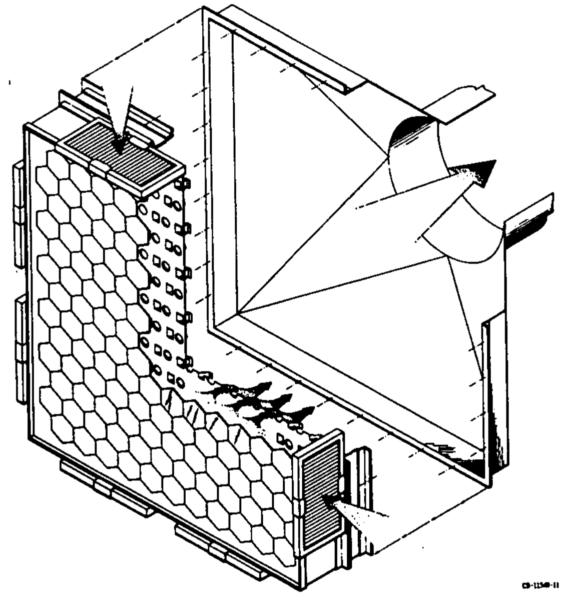

Figure 1

Power requirements are approximately 44 kilowatts of 120-volt, single-phase electrical power for the lamps and 1.1 kilowatts of 208-volt, three-phase power for the exhauster motor.

Power to the lamps is controlled through two switches at the console. Each switch operates a motor driven bank of autotransformers, and the output voltage of each bank is directed to half the lamps of the simulator. This wiring plan effectively divides the load between two 200-ampere capacity mains. Although other wiring and control schemes exist, this multiple autotransformer arrangement was used because the components were available.

The simulator produces a uniform collimated beam covering an area of 1.2 x 1.2 m (4 x 4 ft). Since the simulator uses readily available standard components and is modular in design, the area coverage can be scaled up or down by the addition or deletion of lamp-lens combinations.

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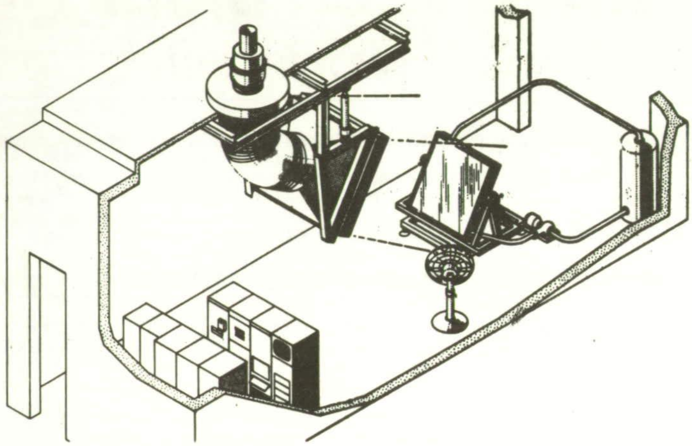

FIGURE 2

In Figure 2, the solar simulator is suspended to irradiate the collector on the floor below at zero incidence angle and at a separation distance of 4.6 m (15 ft). This position is adjustable through angles of 25° to 72° from the horizontal to accommodate different collector tilt angles.

Notes:

1. Capital cost of the (AM2) simulator is less than \$10,000/sq meter (\$1000/ft^2) compared to costs of from \$133,000 to \$291,000/sq meter (\$12,000 to \$27,000/ft^2) for conventional (AM0) simulators.
2. In addition to testing flat plate collectors, the simulator can also be used for testing paint, glass and other materials.
3. For testing restricted to small areas, an inexpensive simulator using a minimum of 12 lamps (in order to give uniform coverage) can be constructed from plywood and sheet metal.
4. Further information is available in the following report:
   NASA TM-X-3059 (N74-27719), Low-Cost, Air Mass 2 Solar Simulator

   Copies may be obtained at cost from:
   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10086
5. Specific technical questions may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
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Patent Status:

NASA has decided not to apply for a patent.

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