Paper No. 64

A UNIQUE HIGH INTENSITY SOLAR SIMULATION SYSTEM

Leo Romanowski, Jr. and Ignatius N. Serafino, *Northrop Services, Inc., Goddard Space Flight Center, Greenbelt, Maryland*

ABSTRACT

This simulator is unique in that it is capable of producing intensities up to 16.0 solar constants (25 solar constants without spectral filters) and closely simulates the solar spectrum over a 12 inch diameter area. The paper describes the simulator and discusses the capabilities, calibration, operational experiences, data collection, and safety considerations associated with this simulator.

INTRODUCTION

Within the past decade an increase in sun orbited missions has emphasized the need for more sophisticated solar simulation techniques. An example is the Helios spacecraft which must fly within 28 million miles (.3AU) of the sun. During its 18 month mission, it will experience solar intensities varying from one to eleven solar constants. A simulator capable of exceeding these intensities recently passed NASA acceptance tests at Goddard Space Flight Center.

This High Intensity Solar Simulator is interfaced with either of two adjacent thermal-vacuum chambers. It is presently being utilized in the environmental testing of several Helios experiments in material degradation and thermal balance studies.

This report describes the unique simulator, its various systems and modes of operation, and discusses its application in a major thermal-vacuum testing program.

DESCRIPTION

The High Intensity Solar Simulator consists of six modular components interrelated as shown in Figure 1 and described as follows:

1. Source Box

The source box shown in Figure 2 is a large rectangular box 170 inches long, 44 inches high and 31 inches wide. It is constructed of steel, weighs 1800 pounds and houses the components of the optical train as shown in Figure 3. It also serves as an environmental envelope to control the damaging effects of excessive heat, ultra-violet radiation, and ozone resulting from the operation of the xenon arc lamp. The sealed enclosure also protects the optics from the dust and moisture contained in normal room atmosphere. Two systems are provided for circulating water through separate plumbing networks within the enclosure. A flow of GN_2 is also maintained within the box so that the ultra-violet radiation will not produce ozone. Two access panels provide openings into the enclosure for servicing components of the system. Electrical, water and GN_2 connections are located near the bottom of the rear panel. In addition to housing the negative lens, attenuators, and douser the enclosure provides an attachment area for the source module and transfer optics. The following is a description of the negative lens, attenuators, and douser.

a. Negative Lens

The negative lens as shown in Figure 4, is a concave quartz lens 13 inches in diameter. It is factory aligned and installed on an adjustable mounting plate. Surrounding the lens are coils of copper tubing circulating water for cooling the assembly which serves as the lens holder and energy absorber. Plumbing disconnects are provided so that the negative lens assembly and mounting plate can be removed from the source box. To ensure proper alignment when replacing the lens assembly, the mounting plate must be indexed with the source box support framing and all shims must be positioned at each of the four anchoring points exactly as they were removed.

b. Attenuators

Two attenuators are mounted within the source box to provide a means of changing the beam intensity. Each attenuator can be positioned "in" or "out" of the beam by means of pneumatic cylinders which are actuated by switches located on the control console. The two units are interlocked so that only one can be positioned in the beam at a time. Each is cooled by demineralized water which is circulated through copper tubing welded to its frame. Attenuator #1 which is also fan-cooled, is so constructed to provide variable attenuation to reduce the final intensity by 68 to 99 percent. This is accomplished by closing the wedge-shaped spaces with the adjustable vanes of the attenuator as shown in Figure 5. The adjustable vanes are driven by a small electric motor in response to the electrical signal controlled by the attenuator transmission knob located on the control console. As shown in Figure 6, attenuator #2 is a grid-like light baffle with no moving parts; it reduces the beam intensity by a fixed percentage of 34% of the total beam output. Both attenuators can be positioned "out" of the beam to permit full unobstructed light transmission when required. Neither attenuator changes the spectral quality of the beam.

c. Douser

The douser, Figure 7, provides a method of shutting off the beam transmission completely without turning off the lamp. It is an optically dense metal plate, cooled by circulating de-mineralized water. An air-operated control cylinder positions the douser "in" or "out" of the light beam in response to the electrical signals from the control switches on the control console.

2. Source Module

The source module as shown in Figure 8 is the light source for the simulator. The source module is removable from the basic enclosure and consists of several individual components. The major components are:

a. 32KW short arc xenon lamp
b. Automatic lamp starter
c. 100 cfm blower for circulating GN_2
d. Aconic collector
e. Lamp adjustment mechanism
f. Energy absorber

The source module is mounted on a flat circular plate, machined and drilled to fit into an opening at the rear of the source box. A special RFI sealing gasket is installed between the source module and source box. Electrical and water connections for the source module are located on the circular mounting plate. A removable box-like insulated metal cover is attached to the rear of the source module to protect the operator from high voltages.

3. Transfer Optics

The transfer optics module is mounted at an opening in the front panel of the source box. The optical components of the transfer optics include a quartz plano-convex tipping lens, a field lens assembly, spectral filters and a projection lens assembly as shown in Figure 9. The light beam transmitted thru the source box is centered on the field lens by the tipping lens. Nineteen pairs of biconvex lens of the field and projection lens assemblies divide the light beam into nineteen separate beams each of which covers the target area, thus integrating the various portions of the beam. The spectral content of the simulated solar energy is maintained by placement of the spectral filters in each of the individually projected beams. The transfer optics assembly is cooled by two blowers that circulate ambient air.

4. Coolant Conditioning Unit

The coolant conditioning unit is installed at a selected location on the laboratory floor best suited to serve the simulator at either of its operating locations. The compact, cabinet-mounted module supplies de-mineralized filtered water for cooling the modular components of the simulator. The CCU contains a circulation pump, filters, de-mineralizers, storage tank and heat exchanger. Sensors in the internal plumbing system and associated electrical circuitry provide protection against high temperature, high and low pressure and low supply of the processed cooling water.

5. Power Supply

The power supply as shown in Figure 10 is installed next to the CCU. This unit supplies and controls the direct current electrical power required to operate the lamp within the range of 11 to 32KW. The automatic control circuit maintains the lamp output stable throughout the operational range. This control is obtained by either a light-sensing system or current-regulating circuit. Commercial power, 480 V.A.C., 3 phase, is rectified to direct current for lamp power. The control circuit uses 115 V.A.C., 1 phase commercial power. The power supply is cooled by the processed water supplied by the coolant conditioning unit; it is operated from the control console. The unit weighs 1300 pounds, excluding cables, and is 60 inches high, 24 inches wide and 26 inches deep.

6. Control Console

The control console is a compact, cabinet-mounted module that provides operating controls, performance monitoring instruments and performance display indicators for the simulator. The unit is 48 inches high, 30 inches wide and 32 inches deep and is installed on the laboratory floor next to the power supply. The three basic components of the control console are: the Module Controller, Auxiliary Module Controller and a twelve point strip recorder. The monitoring instruments provide the operator with critical data such as lamp intensity, power and system temperatures. The

522-137 O - 73 - 51

display indicators show the status of the operational equipment in addition to displaying any malfunctions of the system. Interlock circuits, combined with the performance display indicators also aid in the diagnosis and location of the system failures.

The simulator is equipped with many interlocks that will turn off the lamp if there is a malfunction. Most of the interlocks are thermal and the temperatures can be observed on a strip chart recorder as they approach the cut-off limit. However, interlocks such as high current, low water flow and low GN_2 flow do not give the operator any previous warning and turn off the simulator immediately. This could be detrimental to the experiment if the cause of the failure cannot be determined in a short period of time.

CAPABILITIES

The projection distance is 74 inches from the front surface of the transfer optics package and the light beam produces a target of hexagonal shape that measures 12 inches across the flats.

The beam intensity is variable from 1 to 16 solar constants with spectral filters in place. If the filters are removed an intensity of 25 solar constants can be obtained. Due to test schedules the authors have not had experience with intensity levels greater than 16.0 solar constants.

The beam uniformity over the target area was ±2.5% as measured during acceptance tests at Goddard with a total irradiance sensor at an intensity level of 1.0 solar constant. At 16.0 solar constants the uniformity measurement was ±2.3%.

Irradiance stability as measured with a solar cell at an intensity of 16.0 solar constants was 1.8% R.M.S. over a period of 100 seconds. The long term stability over a 48 hour period was ±3.9%.

During the acceptance test the beam subtense angle was measured to be ±3.0 degrees which meets the specification.

CALIBRATION OF THE SIMULATOR

Before each test the lamp is adjusted in relation to the aconic collector to minimize the non-uniformity. Because the uniformity has a negligible variance up to 16 solar constants, the simulator is frequently calibrated only at 1.0 solar constant.

This calibration is performed by directing the light beam into a 10' x 11' x 6' black interior calibration booth, where intensity measurements are taken by either of two methods. One method involves taking approximately 50 radiometer readings 1½ inches apart by manually moving a 1 inch diameter sensor over the 12 inch hexagonal pattern which is projected onto a water-cooled, black, copper plate. The other method incorporates a multi-solar-cell X-Y scanner which is computer-interfaced to generate intensity profiles as shown in Figure 11.

OPERATIONAL EXPERIENCE

The High Intensity Solar Simulator has been in use at Goddard Space Flight Center since May, 1972. Since that time there have been 450 hours of operation on the simulator. As previously mentioned the simulator has been operated at intensity levels from 1.0 solar constant to 16.0 solar constants.

The power required to obtain 1.0 solar constant has been averaging 12.9KW. Due to the design features of the system the lowest power level obtainable is 11.5KW. So, to achieve 1.0 solar constant attenuator #1 or #2 must be inserted into the beam.

To obtain 16.0 solar constants the power has been approximately 25.0KW. This power level is required when utilizing a new collector and a new lamp. However, the present collector and lamp with approximately 200 hours of operation time requires approximately 28.5KW to obtain the 16.0 solar constants.

There are two modes of control for the simulator, current and light. When operating in the current mode the power is controlled at a value that is proportional to the setting of the intensity control potentiometer. When the simulator is operated in this mode for a long period of time the intensity level may decrease due to the degradation of optical components. However, with an intensity monitoring device such as a radiometer at the target plane, the power level can be increased as the intensity decreases by manually resetting the control potentiometer. This mode of operation is preferred when the simulator is operated for a short period of time. It has also been determined that this mode is more stable than the light mode.

There are two methods in which one may operate the simulator in the light mode, internal and external. In the internal mode, there is a light sensor mounted in the source box where it receives light from the source module. The signal from this sensor which is fed into the control circuit is proportional to the setting of the intensity control potentiometer. In the external mode, a light sensor is located at the target plane. This signal which is also fed back to the control circuit will change the power if there is a change in intensity.

When operating the High Intensity Simulator at any intensity level the cooling conditioning unit is capable of cooling the components within a safe limit. As can be seen in Table 1 there is no drastic change in temperature as the intensity level increases. Since the most critical component is the lamp, the water temperature in and out of the lamp is monitored very closely.

During the acceptance test, the spectral irradiance was measured. To make these measurements at 16 solar constants, a quartz beam splitter was used to reflect approximately 10% of the light into the Perkin-Elmer spectrometer. The spectrum was scanned at several points in the target plane, 74" from the transfer optics and the results are shown in Table 2. The spectrum is within specification limits in all but five of the 14 wavelength bands.

OPERATIONAL REQUIREMENTS

One man per shift is normally required for monitoring the performance of the simulator during a routine test. These tests average about 15 hours of continuous lamp on-time with a facility engineer overseeing the operation and interfacing the simulator with the thermal vacuum chamber to meet the required solar intensities. The engineer is also responsible for calibrating and aligning the simulator, directing maintenance and the training of personnel.

An operational check is performed before each test and requires about 16 manhours to complete. It covers such items as a functional check of each module in the system, alignment with the calibration booth, check and adjustment of beam size, intensity and uniformity at each of the required test levels. However, if any optical component such as the lamp or collector have been replaced approximately 32 manhours must be spent to realign and calibrate the simulator.

To effectively operate the simulator five utilities must be available: they are, additional cooling water (other than the de-mineralized water), 115 VAC and 480 VAC, GN_2 and air.

DATA COLLECTION

The central data collection system continuously monitors the High Intensity Solar Simulator and prints out a listing every 100 seconds. This data which is accumulated in each 8 hour shift is printed in a summary report as shown in Table 3a. The critical parameters of the simulator are listed here.

Table 3b is an Accumulation Report for the lamp, collector, and filter. The time, kilowatt hours and starts are accumulated until there is a failure or a replacement of the component. When this occurs the data for that part is shifted into a Replacement Report as seen in Table 3c.

Table 3d is a plot of the number of starts (S), and kilowatt hours (P) vs. time. This data is accumulative. The scale for each parameter automatically changes whenever the new data exceeds the previous limit.

SAFETY CONSIDERATIONS

Probably the greatest personnel hazard associated with the High Intensity Solar Simulator is the explosive potential of the 32KW short arc xenon lamp. Serious damage to both personnel and equipment can result from flying fragments of glass upon failure of the quartz envelope. Therefore, the wearing of proper safety gear such as a helmet with face shield, gloves and apron is mandatory when handling or even observing the xenon lamp. Fortunately, an explosion which might occur with the lamp mounted in the source module, whether operating or not, will be confined and will not involve personal injury unless the access panels are removed.

In addition to these explosive dangers, there are hazards dependent on the operation only. They are radiation, chemical, and electrical. The simulator emits radiation with wavelengths from .2μm in the ultraviolet to about 2.5μm in the infrared. However, the ultraviolet radiation is the most harmful to the eyes and skin. The reflected U.V. is potentially more hazardous than the direct U.V. due to ignorance and carelessness on viewing these reflections. Permanent damage to unprotected eyes could result with extended exposure but the most frequent injury is an irritating inflammation of the mucous membrane which covers the eyeball. This condition is caused by U.V. wavelengths below .32μm and is not directly detected until a few hours after exposure. Dark sun glasses or goggles made of glass with side shields easily eliminate this persistant hazard for operating personnel.

A potential chemical hazard is the ozone formed by exposing oxygen in the air to ultraviolet light. This strongly oxidizing gas attacks metal and rubber rapidly and will cause discomfort to individuals in the form of headaches and dryness of throat, nose and eyes even at low concentrations. Fortunately, the problem can be reduced by introducing gaseous nitrogen into the simulator to displace the ambient air present, thus miminizing generation of ozone. Concentrations of .02 PPM have been recorded at the source module when the simulator was operated at the maximum of 16 solar constants. This concentration offers little danger since exposure levels up to .06 PPM are safe for any two consecutive hourly measurements.

Electrical precautions are noteworthy because the ignition voltages are as high as 70KV and contact with them can be lethal. A large residual charge also remains in the power supply capacitors long after shutdown. Consequently, the grounding of this charge is necessary before attempting any maintenance.

CONCLUSION

Solar irradiation is being routinely simulated from 1.0 to 16.0 solar constants over a one foot diameter target area for the testing of spacecraft equipment for near sun missions. Although this simulator, manufactured by Spectrolab, Textron Inc., adequately meets the present needs for high intensity solar simulation at Goddard Space Flight Center, it has the potential for increased utilization. The purchase of a different transfer optics system would increase the pattern size and using 20KW lamps would decrease the operating costs (wherever lower intensities are required).

REFERENCES:

1. "Operation and Service Manual," Spectrolab-A Division of Textron, Inc., Sylmar, California, April 1972.

2. "High Intensity Solar Simulator Operating Procedure," R. Lange, Northrop Services, Inc., Goddard Space Flight Center, May 1973.

3. "Acceptance Test Report - High Intensity Solar Simulator," I. Serafino, D. Orbock Northrop Services, Inc., Goddard Space Flight Center, August 1972.

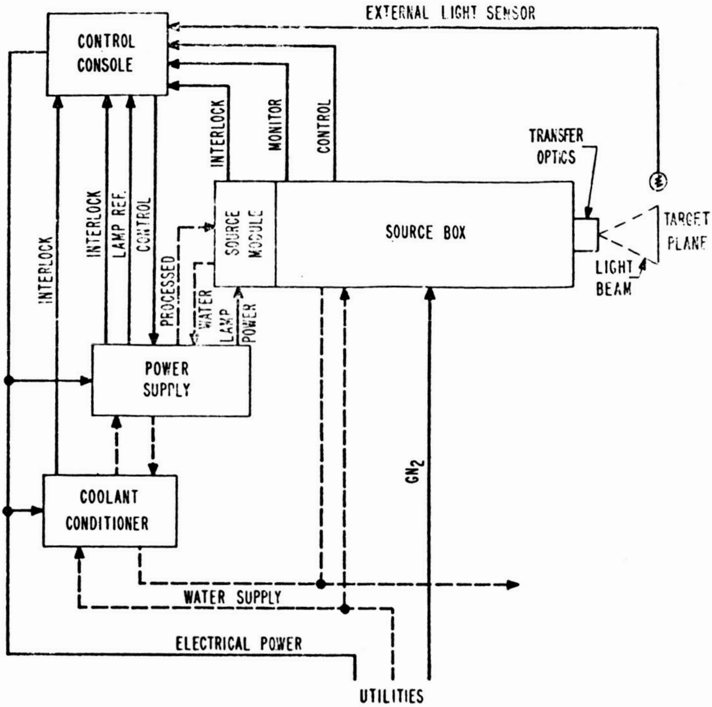


Fig.1 Solar Simulator Block Diagram

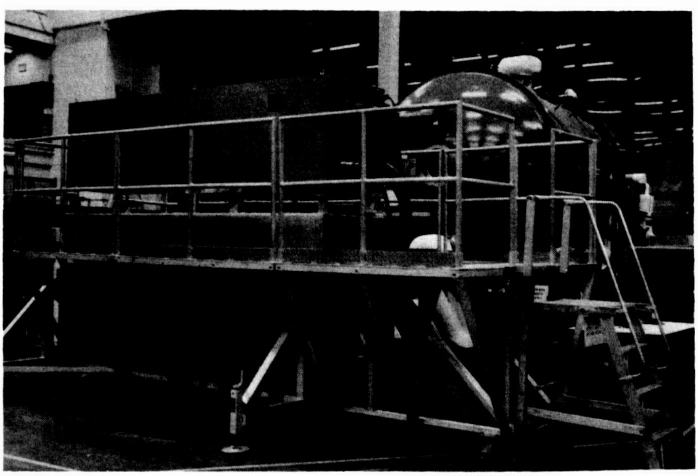


Fig. 2 High Intensity Solar Simulator

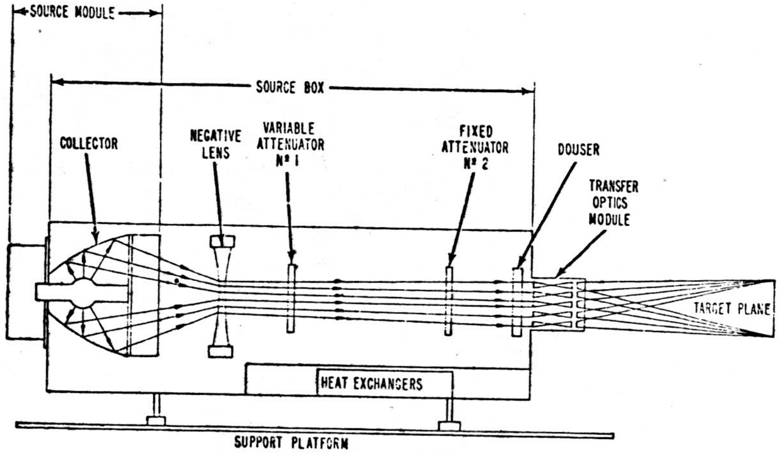


Fig. 3 Source Box Schematic

Fig. 4
Negative Lens

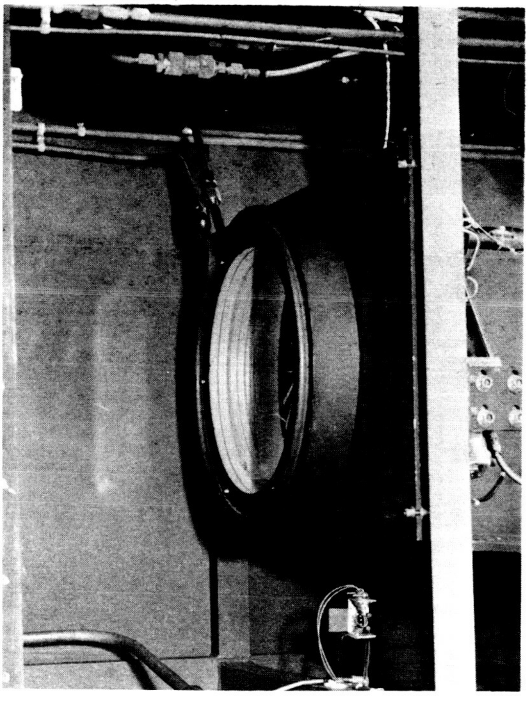
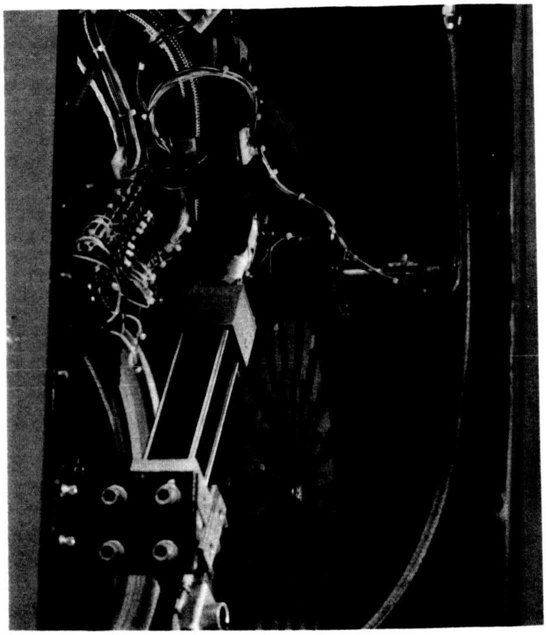


Fig. 5
Attenuator #1



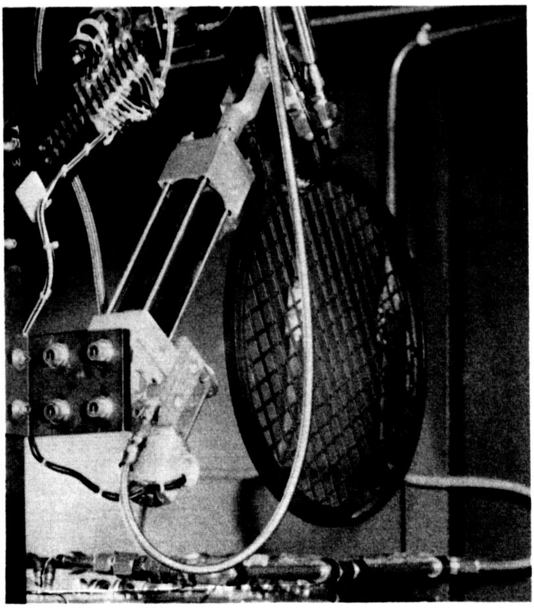
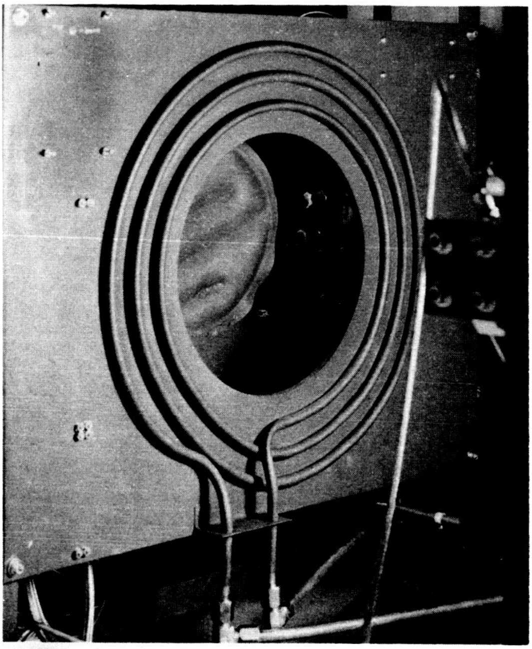


Fig. 6
Attenuator #2

Fig. 7
Douser



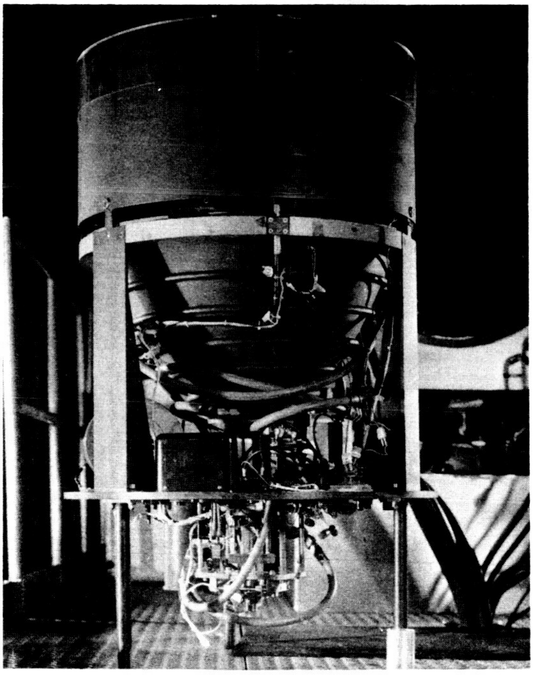


Fig. 8
Source Module

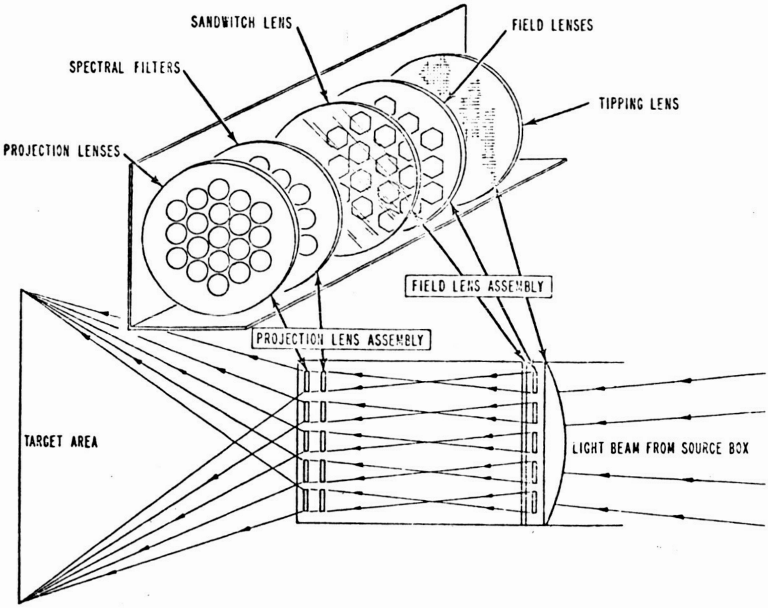


Fig. 9 Transfer Optics Schematic

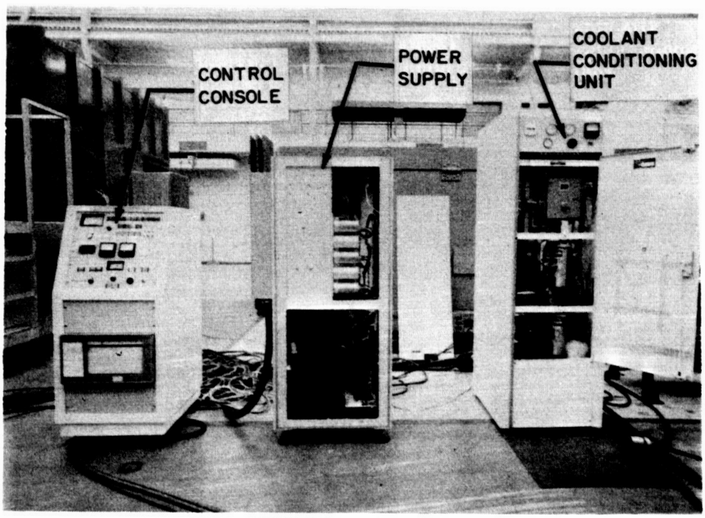


Fig. 10 Component Layout

X-Y SCAN PROGRAM

MSSR 2405 1419 1421

HORIZONTAL SCALE 1.0 = 6 PRINT CHARACTERS (ABOUT 5/8 INCHES)
IMPLIED DECIMAL PT. X.XX

	START TIME					END TIME				
	DAY	HOUR	MINUTE	SECOND		DAY	HOUR	MINUTE	SECOND	
	93	14	19	47		93	14	20	34	ZVAL = 44

Beam Diameter (Inches)

	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	86	88	86	85	88	89	87	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	91	92	91	91	91	91	90	0	0	0	0	0	0	0	0
5	0	0	0	0	0	89	90	91	91	91	91	90	89	87	0	0	0	0	0	0	0
4	0	0	0	0	0	90	90	91	91	91	91	90	90	89	0	0	0	0	0	0	0
3	0	0	0	0	89	90	91	93	93	93	93	92	92	90	88	0	0	0	0	0	0
2	0	0	0	0	90	90	91	92	92	92	92	90	90	89	87	0	0	0	0	0	0
1	0	0	0	87	91	92	92	94	95	95	95	94	93	91	90	88	0	0	0	0	0
0	0	0	0	0	93	94	95	96	96	96	95	94	92	91	90	0	0	0	0	0	0
-1	0	0	0	0	94	94	95	95	96	97	96	95	94	93	91	0	0	0	0	0	0
-2	0	0	0	0	0	93	94	95	95	95	95	93	92	90	0	0	0	0	0	0	0
-3	0	0	0	0	0	0	99	109	102	99	99	99	98	89	0	0	0	0	0	0	0
-4	0	0	0	0	0	0	91	92	92	92	91	91	88	0	0	0	0	0	0	0	0
-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fig. 11 Calibration Profile

(note hexagonal pattern)

Table 1

COMPONENT TEMPERATURES

Intensity S.C.	PWR KW	Douser	Filter	Power Supply H_2O Out	Collector	Anode H_2O Out	Cathode H_2O Out	Atten. #1	Atten. #2
1.0 *	14.1	41	32	34	41	40	38	42	40
5 **	13.9	40	31	34	41	40	38	39	42
7	12.7	39	32	33	39	38	37	40	38
11	20.3	46	30	37	47	46	43	46	46
16	27.4	54	35	41	56	54	47	56	55

NOTE: All Temperatures °C

* Attenuator #1 in the beam
** Attenuator #2 in the beam

Table 2

SPECTRAL IRRADIANCE

(WAVEBAND) (MICRONS)	ENERGY (mw/cm²) SPEC. -	BEAM POSITION I	II	IV	ENERGY (PERCENT) BEAM POSITION I	II	IV	AVG. -	SPEC. ±	OUT OF SPEC.
.25 - .35	5.89	5.24	5.24	5.16	-11.0	-11.0	-12.4	-11.5	40	-
.35 - .40	5.69	5.28	5.44	5.24	- 7.2	- 4.4	- 7.9	- 6.5	25	-
.40 - .45	8.68	8.53	8.80	8.29	- 1.7	1.4	- 4.5	- 1.6	10	-
.45 - .50	10.09	8.44	8.76	8.45	-16.4	-13.2	-16.3	-15.3	10	-5.3
.50 - .60	17.70	17.49	17.99	17.83	- 1.2	1.6	0.7	0.4	10	-
.60 - .70	15.15	15.40	15.87	16.21	1.7	4.8	7.0	4.5	10	-
.70 - .80	12.37	13.84	13.80	14.18	11.9	11.6	14.6	12.7	10	+2.7
.80 - .90	9.93	12.20	12.06	12.31	22.9	21.5	24.0	22.8	15	+7.8
.90 - 1.00	8.28	10.72	10.96	11.11	29.5	32.4	34.2	32.0	15	+17.0
1.0 - 1.2	12.06	12.34	12.31	12.40	2.3	2.1	2.8	2.4	20	-
1.2 - 1.5	11.14	9.05	8.73	8.73	-18.8	-21.6	-21.6	-20.7	20	-0.7
1.5 - 1.8	6.70	5.78	5.45	5.49	-13.7	-18.7	-18.1	-16.8	20	-
1.8 - 2.2	4.38	3.78	3.32	3.49	-13.7	-24.2	-20.3	-19.4	30	-
2.2 - 2.5	1.98	1.89	1.29	1.14	-4.5	-34.9	-42.4	-27.3	30	-

Table 3a

HI-INTENSITY SOLAR SIMULATOR

FACILITY 218

8 HOUR REPORT

LSDT	DATE	SHIFT	ON TIME	STARTS	KWATT AG POW	KWATT MX POW	LT DG	DOUSER	FILTER	PS H2O	COLLECT	CATHODE H2O IN	ANODE H2O OUT	ATTEN1	ATTEN2
8410	1/30/73	1	5.23	2	12	13	-0.010	45.0	34.8	38.9	45.8	44.7	42.5	45.0	44.5
8416	2/ 1/73	1	6.31	1	12	13	-0.009	43.0	35.3	36.9	43.9	42.8	40.4	44.9	42.7
8428	2/ 5/73	1	7.53	1	18	19	-0.008	48.5	39.8	39.9	50.2	48.0	44.5	49.3	48.4
8431	2/ 6/73	1	3.11	1	19	26	-0.008	55.9	44.7	43.7	58.3	54.9	49.9	58.6	55.8
8437	2/ 8/73	1A	0	0	0	0	0	0	0	0	0	0	0	0	0
8437	2/ 8/73	1B	.25	1	20	22	-0.007	48.6	28.3	38.7	48.7	47.6	43.8	37.7	47.8
8439	2/ 9/73	3	1.14	1	15	28	.002	55.6	39.8	42.5	55.3	53.3	48.4	43.6	53.7
8440	2/ 9/73	1	3.39	1	11	13	.003	43.3	39.8	36.6	43.4	42.7	40.4	41.6	45.1
8441	2/ 9/73	2	2.79	3	17	28	.001	59.1	46.5	45.8	59.0	57.1	52.2	54.1	58.0
8442	2/10/73	3	4.64	2	23	27	.001	57.3	35.6	44.5	58.2	56.0	51.0	56.3	57.1
8443	2/10/73	1	5.72	0	26	27	.000	59.1	48.6	45.9	58.8	56.8	52.3	56.7	58.1
8445	2/11/73	3	5.03	1	12	12	.003	40.5	39.8	34.6	40.9	40.3	39.6	41.7	40.4
8446	2/11/73	1	6.50	0	12	12	.002	41.1	32.7	35.2	41.5	41.0	38.7	42.5	40.7
8452	2/13/73	1	2.03	1	12	16	.003	42.7	30.9	35.4	43.0	42.2	39.3	41.5	45.1
8453	2/13/73	2	1.03	1	11	12	.003	39.8	29.3	34.2	40.1	39.6	37.4	40.5	42.0
8455	2/14/73	1	1.14	1	17	27	.001	50.9	30.9	39.4	51.5	49.4	45.0	43.4	50.3
8477	2/24/73	2	4.30	1	11	12	.006	39.4	30.1	33.6	39.8	39.3	37.1	41.1	39.0
8478	2/25/73	3	8.00	0	21	30	.003	55.2	31.4	42.3	56.1	53.7	48.8	54.7	54.9
8479	2/25/73	1	8.03	0	26	27	.003	55.2	54.1	42.3	56.0	54.9	52.5	55.9	55.5
8480	2/25/73	2	7.95	0	18	19	.006	45.5	44.4	36.8	46.2	45.0	43.6	47.2	45.9
8554	3/29/73	1	.29	1	13	20	.002	40.4	25.2	33.5	40.1	39.3	36.8	32.9	43.9
8557	3/30/73	1	2.55	1	16	27	-0.180	54.2	33.8	40.3	53.9	50.6	45.9	46.1	52.3
8560	4/ 2/73	1	1.81	1	17	22	-0.340	46.9	33.2	37.2	46.1	44.6	40.9	43.7	45.8
8563	4/ 3/73	1	1.89	1	15	26	-0.137	49.1	32.9	38.4	50.4	48.5	44.2	44.9	49.9
8567	4/ 4/73	2	1.59	2	11	11	-0.041	37.3	27.8	31.5	37.7	36.8	35.1	37.3	37.1
8568	4/ 5/73	3	3.27	1	14	18	-0.176	43.3	29.0	35.9	44.9	43.3	39.3	41.0	44.7

Table 3b

HI-INTENSITY SOLAR SIMULATOR

FACILITY 218

TOTAL ACCUMULATION REPORT

COMPONENT	SERIAL NO.	DATE INSTALLED	TOTAL ON TIME HRS.	TOTAL KILOWATT HOURS	TOTAL STARTS
LAMP	700A-5	2/ 7/73	225.8	4216.8	45
COLLECTOR	20151/02	2/ 7/73	225.8	4216.8	
FILTER		6/ 6/72	223.6	4196.8	

Table 3c

HI-INTENSITY SOLAR SIMULATOR

FACILITY 218

REPLACEMENT REPORT

COMPONENT	SERIAL NO.	INSTALLED	REPLACED	ON TIME HRS.	KILOWATT HRS.	STARTS	REMARKS
LAMP	700A-1	11/17/72	2/ 7/73	22.2	336.6	5	LAMP EXPLODED
COLLECTOR	3747/01	6/ 6/72	2/ 7/73	22.2	336.6		LAMP EXPLODED

NOTE: The simulator was operated an additional 100 hours prior to the use of this program.

Table 3d