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Solar One Solar Thermal Central Receiver Pilot Plant 1982 Meteorological Data Report

McDonnell Douglas Astronautics Company

Prepared by Sandia National Laboratories, Albuquerque, New Mexico 87185 and Livermore, California 94550 for the United States Department of Energy under Contract DE-AC04-76DP00789.

Printed June 1983

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Printed in the United States of America
Available from
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161

NTIS price codes
Printed copy: A08
Microfiche copy: A01

PREFACE

This document is provided by the McDonnell Douglas Astronautics Company in accordance with Sandia Contract 84-4690. The data contained in this document were recorded as part of the Solar One Startup and Initial Evaluation Test Program being conducted for Sandia under Contract 84-8173.

ABSTRACT

Meteorological data recorded at the Solar One 10 MWe Pilot Plant during a Startup and Initial Evaluation Test Program during 1982 are presented. Additionally, a General Plant Description is provided, plus specific information on the type, quantity, and location of meteorological equipment and instrumentation at the Power Plant which are being used to record the meteorological data.

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SECTION 1

INTRODUCTION

This report contains meteorological data which were recorded during the April 16 - December 31, 1982 time period at the Solar One site in parallel with the startup and initial evaluation program.

The contents of this report are organized to contain: a plant description for general orientation, an identification, location, and description of meteorological equipment and instrumentation used at the Solar One site, a description of summary data tapes being developed in parallel with this report, and finally, presentation and discussion of the meteorological data.

The intent of this report is to provide a description of the meteorological data system and of the data that is available on data tapes. Summary data is included for temperature, wind, rainfall, and direct normal insolation. Rainfall data for the years 1956 through 1970 is included for comparison with 1982, which shows that 1982 had higher than average rainfall and more than the average number of occurrences of rain. Barstow insolation data for 1976 is compared to the available 1982 data, which shows that 1982 was a bad year for total insolation and that the peak values are also lower. The average peak insolation values for 1982 are not that much different than for 1976.

Insolation data plots are included for two partially cloudy days as measured by pyranometers located throughout the field. These plots show the type of data that is available if someone wishes to make cloud passage studies. Direct normal insolation data plots are shown for 89 days between April 16 and December 31, 1982. Although the plots are not complete, they show that there were few days when the peak direct normal insolation reached 900 W/m^2. These plots also show the type of cloud passage transients that the plant must operate through. The meteorological instrumentation will be kept in proper working order during 1983 and the data acquisition system will be on-line much more of the time than during 1982, therefore, the meteorological data for 1983 will be more complete than in this report.

Wind data from the Daggett airport is included as representative data for Solar One, since the site wind data was not complete and in many cases inaccurate, due to instrumentation problems. The wind data shows that the predominate wind direction is from the west. The number of days during each month when the wind speed exceeded 30 mph is also shown.

The range of high and low temperatures for each month is included. There were four months when the maximum temperature exceeded 100° F and two months when it was below 32° F.

SECTION 2
PLANT DESCRIPTION

2.1 GENERAL

Solar One is a 10 MWe Solar Thermal Central Receiver Pilot Plant which generates electricity exclusively from solar energy. The pilot plant is a joint undertaking between the U.S. Department of Energy and the Utility Associates, which consists of the Southern California Edison Company, the Los Angeles Department of Water and Power, and the California Energy Resources Conservation and Development Commission.

Since this pilot plant is the first large scale demonstration of the generation of electricity using a solar central receiver, the pilot plant design, construction, and operation activities are intended to support the program objectives as defined by the Department of Energy and the Utility Associates. These program objectives are:

1) To establish the technical feasibility of a solar thermal power plant of the central receiver type, and to identify areas where research and development may lead to significant performance improvements and increased capabilities.

2) To obtain development, production, operating, and maintenance cost data to (a) support private sector decisions to invest in solar central receiver energy systems, and (b) identify areas where research and development may most effectively be applied to reduce costs and extend areas of application of such systems.

3) To determine the environmental impacts of the construction, operation and maintenance of solar thermal central receiver plants.

The plant is designed to produce at least 10 MWe of electrical power to the utility grid (after supplying the plant parasitic power requirement) for a period of 4 hours on the plant "Worst Design Day" (Winter solstice) and for a period of 7.8 hours on the plant "Best Design Day" (Summer solstice). The "Worst" and "Best Design Days" are based on assumed insolation (solar intensity) conditions which have been developed from actual site insolation measurements. During actual plant operation, the plant capability and electrical output will depend on the current sun and atmospheric conditions. During certain periods of the year (near noon from March through September), the plant energy collection capability can exceed the 12.5MWe turbine-generator rating.

An aerial photograph of Solar One is shown in Figure 1.

2.2 LOCATION

The pilot plant is located on a 130-acre site of Southern California Edison property near the Coolwater Generating Station which is located east of Daggett, California and approximately 12 miles east of Barstow, California. The site is at a latitude of 34.8 °N and longitude of 116.83°W. The site is contained in the western half of Section 13, Township 9N - Range 1E, San Bernardino County: San Bernardino Meridian. The reference location for the pilot plant is the receiver tower vertical centerline with coordinates N 501, 260 and E 2, 349, 950. The nominal elevation of the site is 1,946 feet above mean sea level. A vicinity map is shown in Figure 2.

2.3 GENERAL ARRANGEMENT

A general arrangement of the pilot plant site is shown in Figure 3. The site boundary, excluding the main parking area, is established by a perimeter security fence shown as a dashed line in the Figure.

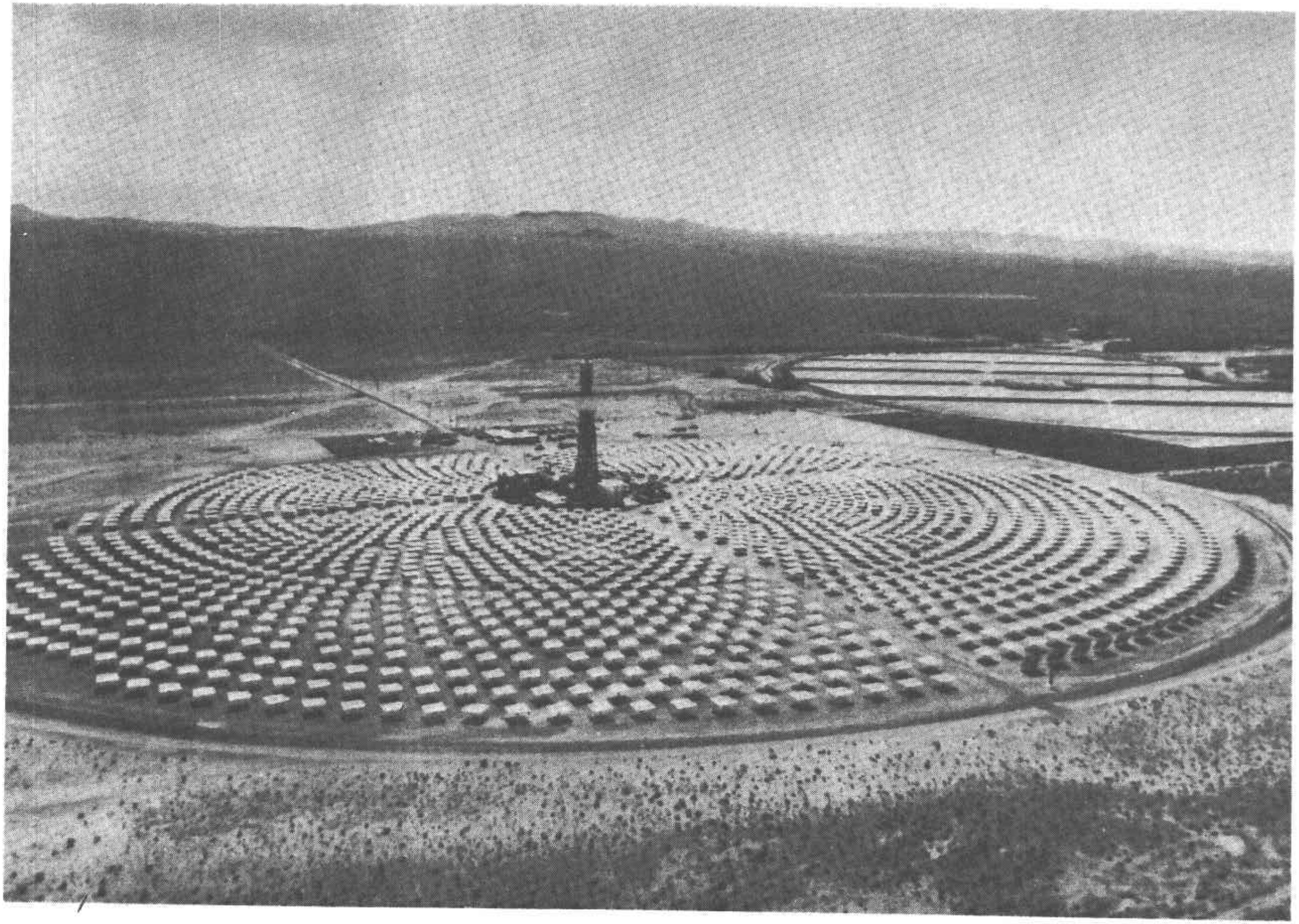

FIGURE 1. AERIAL PHOTOGRAPH OF SOLAR ONE

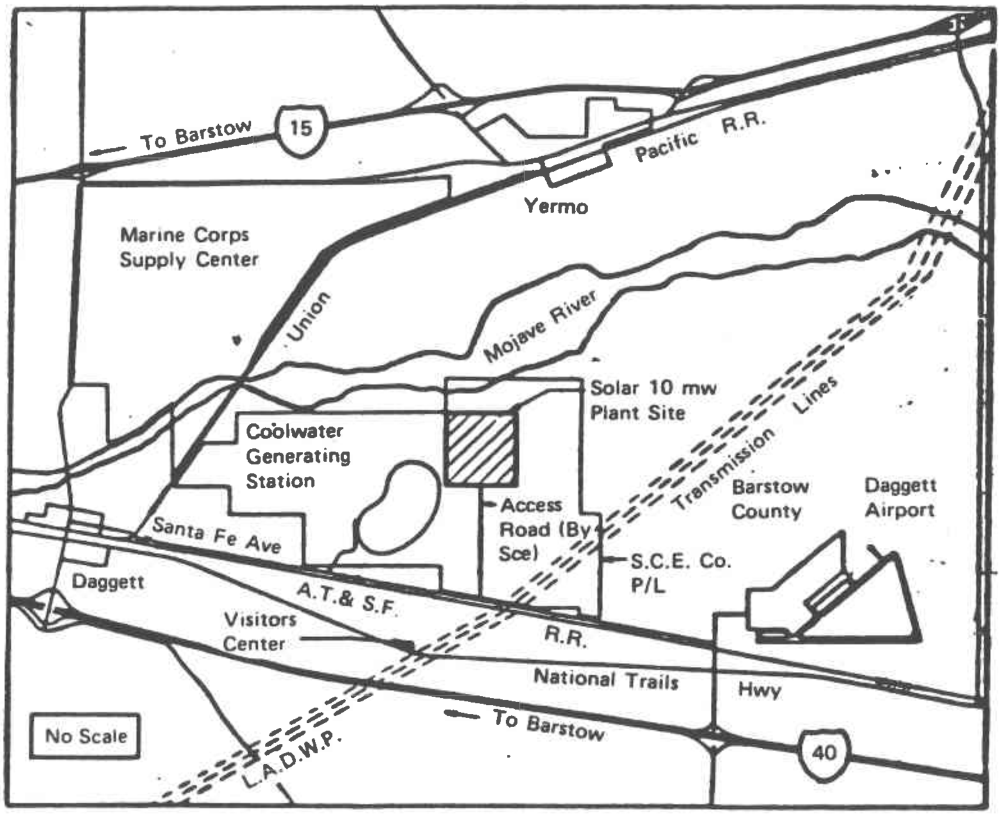

Figure 2 **Vicinity Map**

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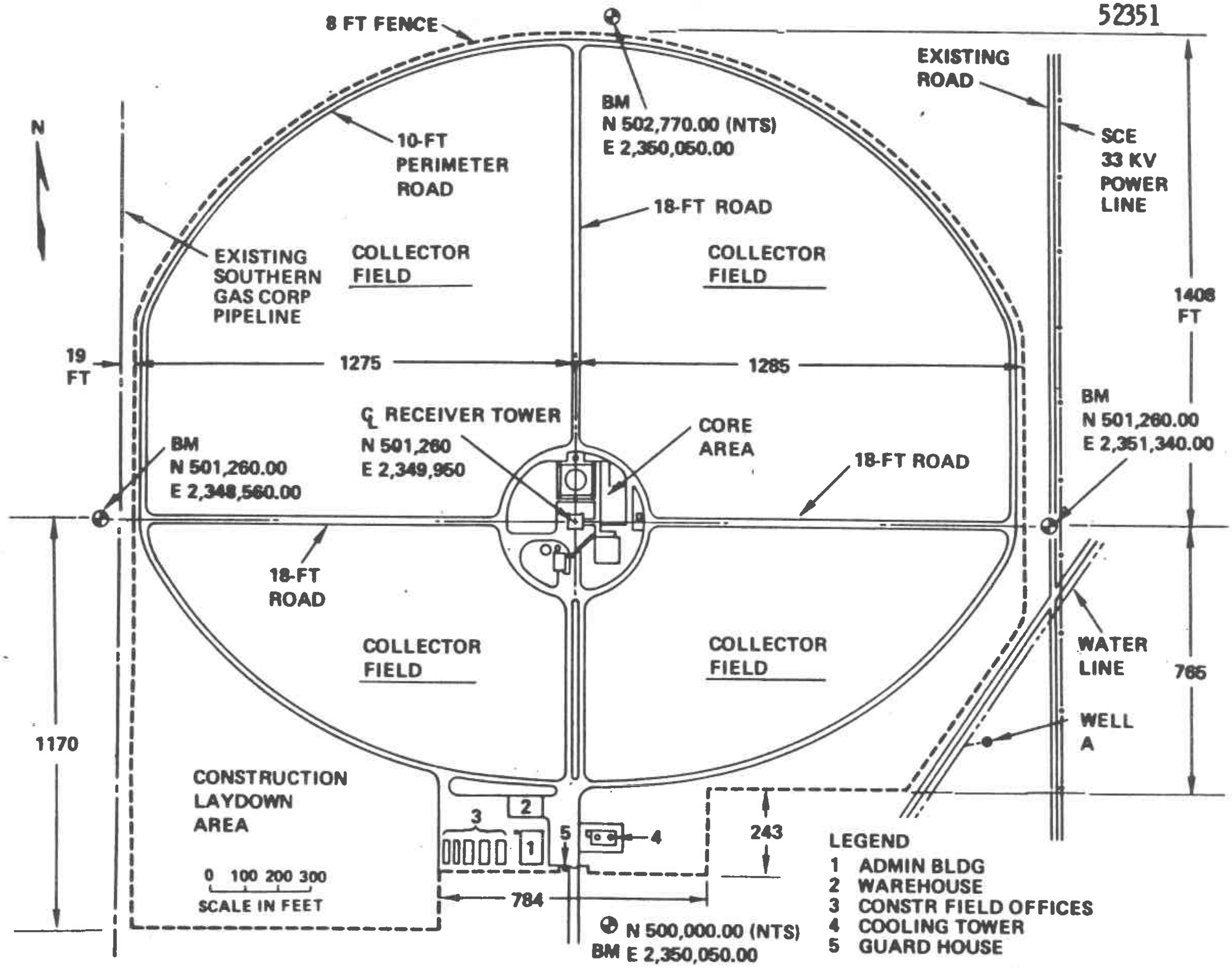


Figure 3 General Arrangement

A central core area of approximately three acres is utilized for the receiver tower and the support equipment for the solar system, such as the receiver system, thermal storage system and electrical power generating system, as well as other necessary support systems. The core area also contains electrical power generation equipment, related peripheral equipment and a plant control room. The core area has a radius of 201 ft, with its center coincident with the tower centerline. The center of the receiver tower is located at coordinates N501, 260 and E 2, 349, 950. The center of the receiver panels is at an elevation of 260 feet above the theoretical intersection of the collector field planes with the receiver tower centerline.

A 75-acre collector field surrounds the receiver tower. The northern field boundary can be described by an arc of 1,390 feet radius from the receiver tower centerline. The southern field boundary can be described by an arc of 2,145 feet radius whose center is 1,395 feet north of the receiver tower center. An area 243 feet by 784 feet within the perimeter fence and near the (southern) main entrance has been utilized for placement of the administrative building, warehouse, cooling tower and other service equipment not required in the central core area.

The collector field occupies 75 acres and contains 1818 heliostats in an optimized arrangement around the tower. The heliostat locations are depicted on Figure 4. In addition, numerous monitoring and measurement devices are located in the collector field, as shown in Figure 5. The collector field is graded to provide adequate drainage and to minimize elevation differentials between heliostats. It is also compacted to permit vehicular access to the heliostats and ancillary electrical equipment for installation, maintenance and washing functions.

2.4 TOWER AND BUILDINGS

2.4.1 Tower

The receiver tower is designed to support the receiver assembly at the required elevation above the collector field. In addition to the receiver panels, the tower supports a heliostat beam characterization system (BCS) target as well as the piping and auxiliary equipment for the receiver.

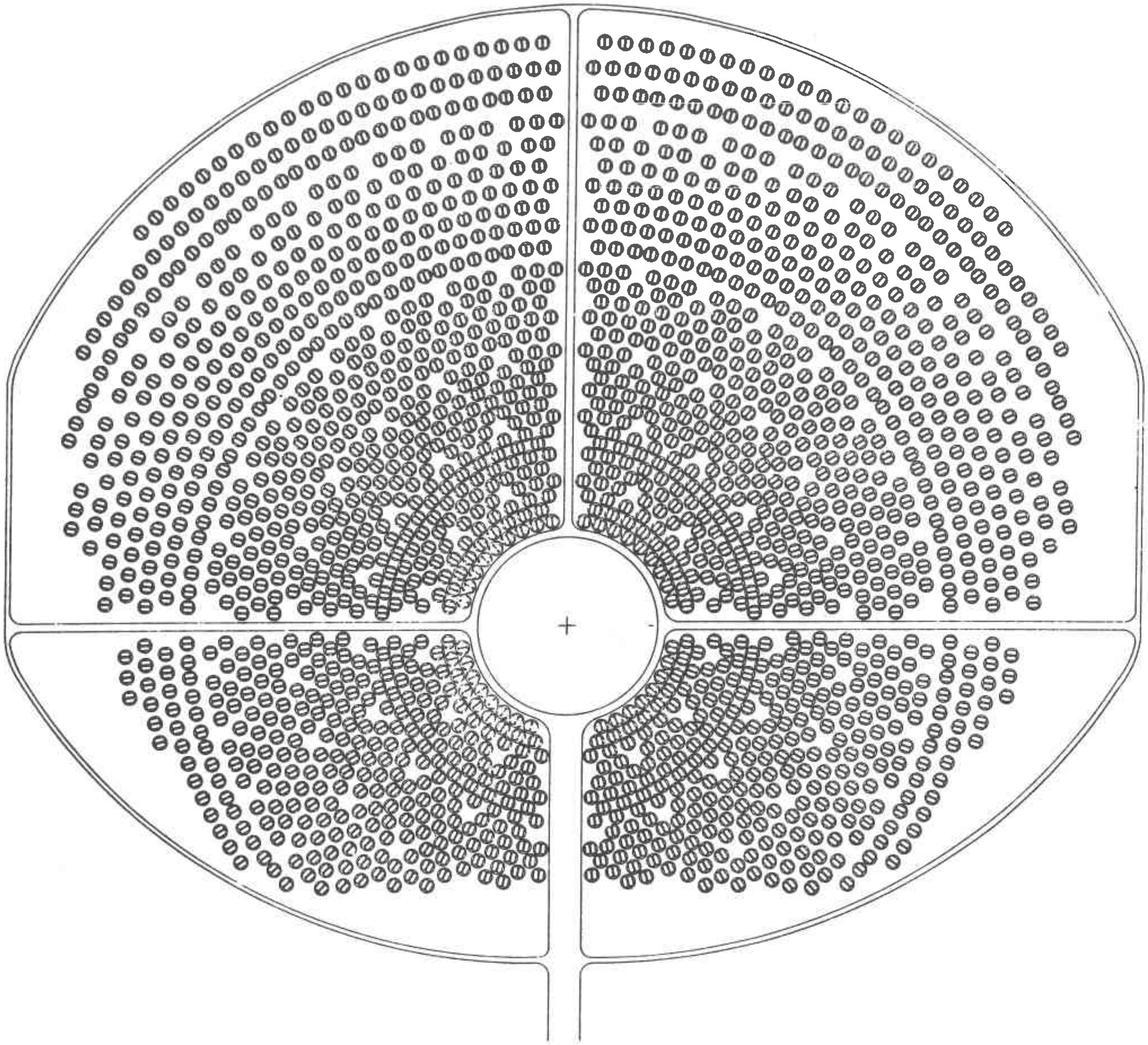


Figure 4 **10 MW Central Receiver Collector Field Layout**

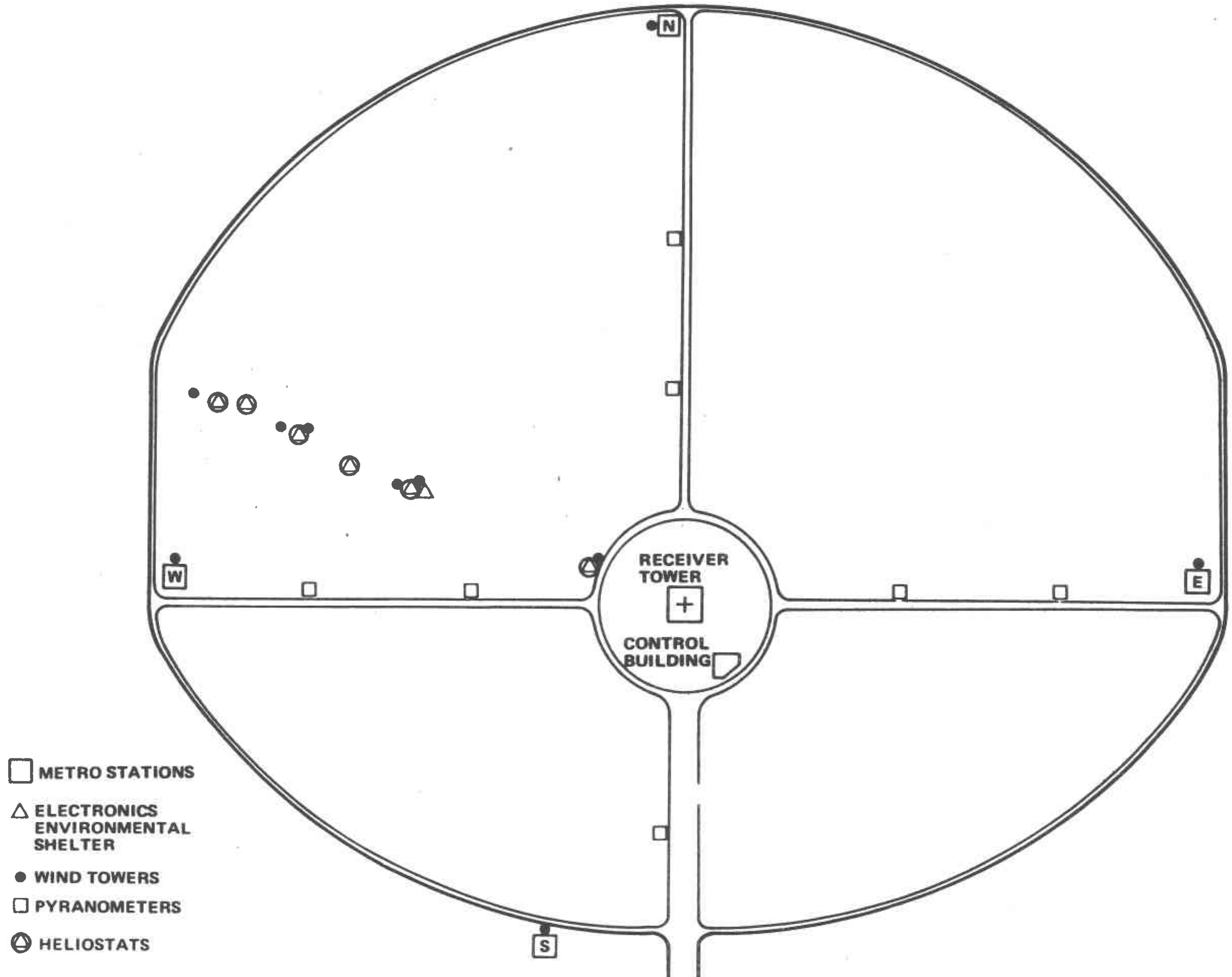


Figure 5 Collector Field Instrumentation and Meteorological Equipment

The tower (depicted in Figure 6) has a total height of approximately 295 feet above ground level, including 22 working levels above ground. It is an open, four-sided steel structure resting on a reinforced concrete foundation. At the base, the tower is 39 ft. 11 in. square, and tapers to 15 ft. 1/2 in. square at the 15th level (211 ft above ground level). However, at that level, the structure extends to support the BCS target, and is 47 ft. 8 in x 37 ft. 8 in. The tower has a stairway up to the base of the receiver and an elevator to transport three personnel and/or small parts to a working level near the top of the tower and other appropriate working levels. Ladders are provided from the base of the receiver to the top of the receiver assembly. A photograph of the receiver and tower assembly is shown in Figure 7. The heliostat beams are reflecting moisture droplets in the air, with the concentrations of the beams shown as bright spots at the collector field standby points.

2.4.2 Control Building

The control building is a two-story reinforced masonry block structure shown at the base of the tower in Figure 7. The Plant Control Room, Equipment Room and Personnel Office space are located on the second floor, with the electrical switchgear and battery rooms located on the first floor. Building plan dimensions are approximately 45'-0" by 7'-0". The elevation of the second floor is 20'-0" to allow direct access to the Auxiliary Bay structural deck. The roof is of timber construction and the second floor is a reinforced concrete slab supported by structural steel members.

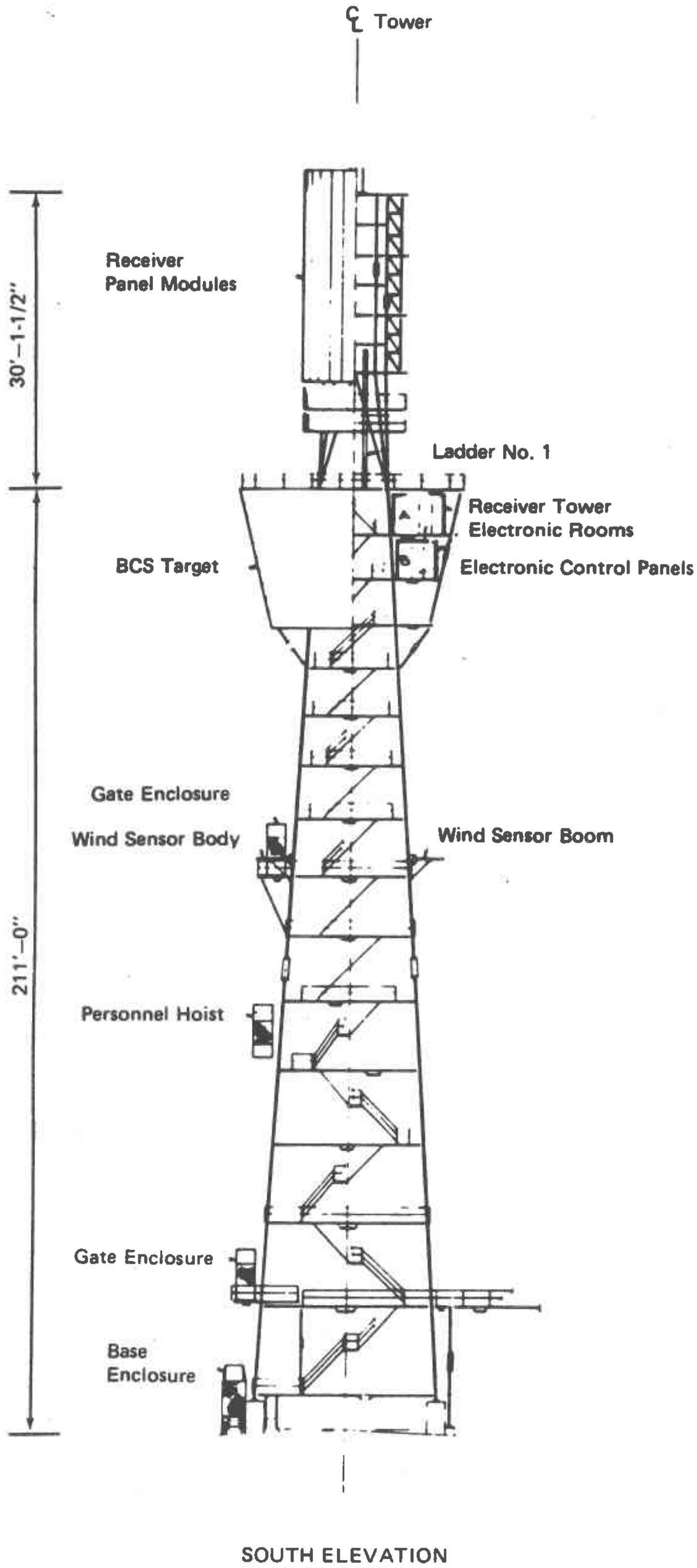


FIGURE 6 **RECEIVER TOWER**

FIGURE 7. RECEIVER TOWER ASSEMBLY

SECTION 3

METEOROLOGICAL EQUIPMENT AND INSTRUMENTATION

The meteorological measurements equipment consists of wind velocity and direction devices, fixed position pyranometers (measures total insolation), normal incidence pyrheliometer (NIP), which measures direct insolation, hail cubes (measure size and velocity of hail impact), rain gages, various temperature, pressure and humidity measurement devices, and a nephelometer. This equipment is placed in various stations throughout the site, as follows:

- South Station
- West Station
- North Station
- East Station
- Receiver Station (7th level)
- WNW Station
- Control Room Roof

3.1 LOCATION

Figure 8 shows the locations of the meteorological instrumentation for the Solar One Site. There is one meteorological station (shown as a hexagon) at each compass point of the field, at the central receiver tower, and at the Control Room roof. There are wind towers plus an environmental enclosure within the field in the West-North-West (WNW) direction adjacent to heliostats instrumented for structural, thermal and power studies. One hail cube is in the middle of the northwest field and one in the middle of the northeast field. These are shown as HC in the figure. In addition, there are seven pyranometers distributed along the spoke roads for cloud obscuration studies.

3.2 DESCRIPTION

Figure 9 provides a schematic of the overall system, including the sensors, the remote acquisition systems (RAS) at the various stations, the collector field interface cabinet, and the interfacing hardware connecting the meteorological system with the data acquisition system (DAS). Dashed lines also indicate the physical locations of the various equipment. The displays available in

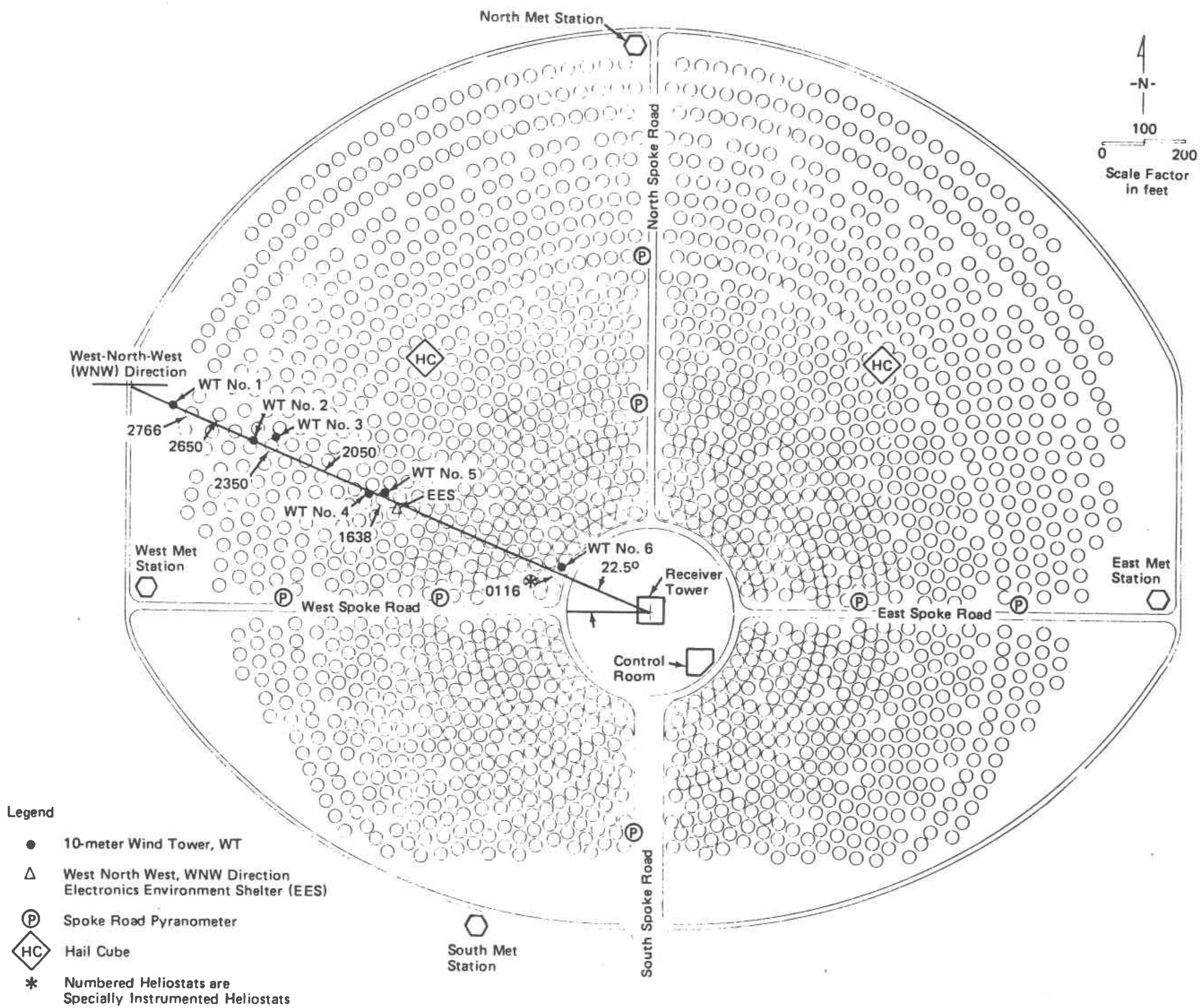


Figure 8 Collector Field Locations of Meteorological and Specially Instrumented Heliostats Measurements

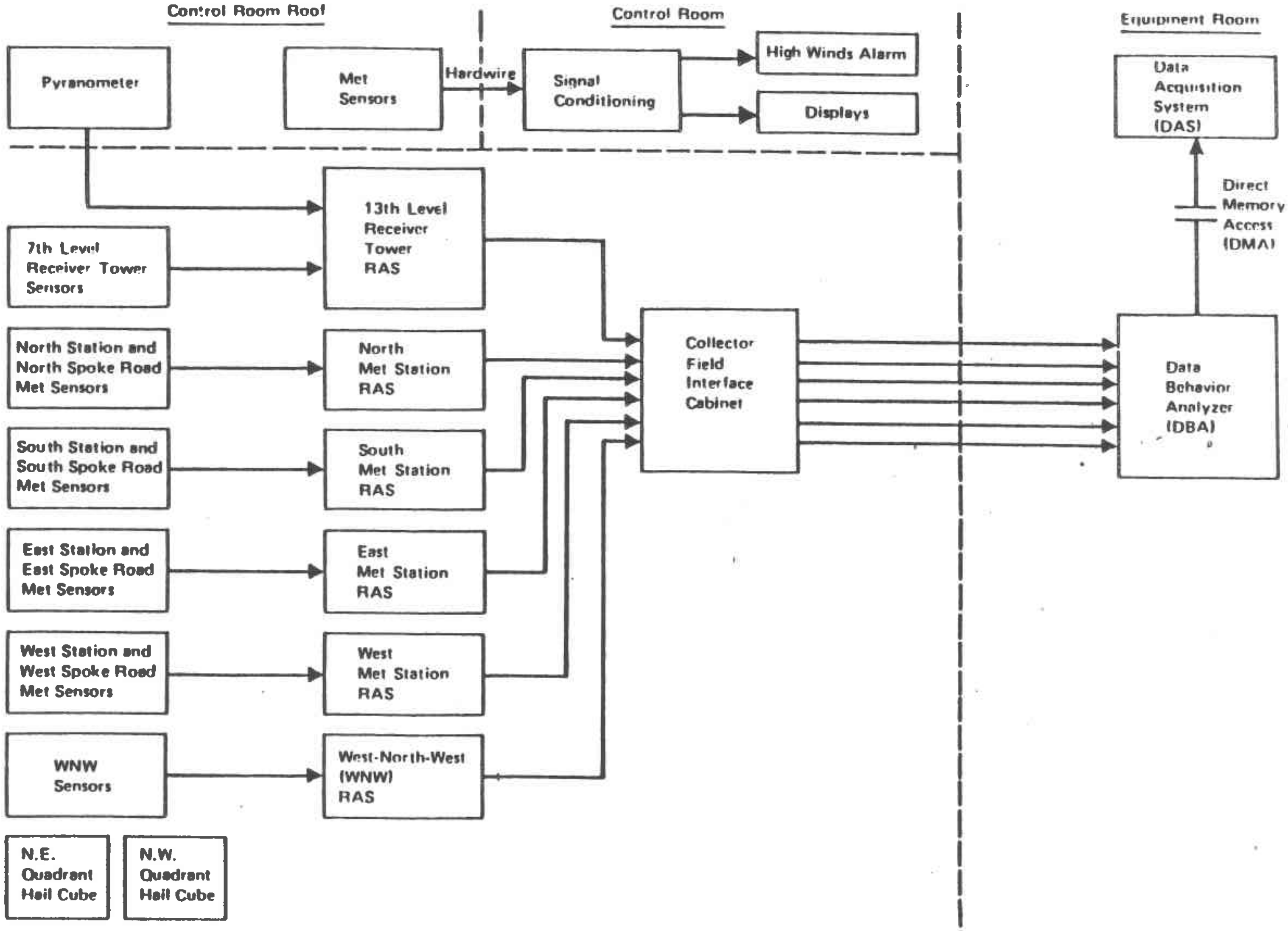


Figure 9 Overall System Description

the control room are the normal incidence pyrheliometer (NIP) readings, plus wind speed and wind direction.

3.2.1 General

Each compass point station has a concrete base to provide the stability and levelness required by the instruments. The base is at least 2 inches above the surrounding finished grade.

On top of each compass point station base is an environmental enclosure for sensitive equipment such as power supplies, signal conditioners, and the remote acquisition system (RAS). The enclosure is designed to maintain the enclosure area temperature and dust level within the most sensitive temperature and dust range dictated by the electronics hardware environmental specifications. The enclosure is capable of easy access and removal of the electronic equipment.

A power/signal cable distribution panel is mounted within the enclosure. A two-panel door is located at one end for easy access to the front of the electronic packages. A lock is provided on the door to allow access to the equipment for authorized personnel only. All power and signal cables running to and from the enclosure are environmentally protected.

3.2.2 South Station

The south station (see Figures 10 and 11) is the main meteorological station, and it is located south of the collector field perimeter road and west of the main entrance road to the core area. The specific XY coordinates are: X = +725 $\pm$ 3 ft, Y = -450 $\pm$ 3 ft. (It should be noted that the coordinate convention used for the Solar One Site has the origin (0,0) located at the tower vertical center line, with the +X direction due south and the +Y direction due east.) The station is equipped with instrumentation for measuring rainfall, wind speed, wind direction, barometric pressure, temperature, and dewpoint. Additionally, the signal conditioning for the south spoke road pyranometer is done here, and there are provisions for a circumsolar telescope (CT) installation and a portable precision spectral pyranometer (PSP), as indicated in the schematic of Figure 10 and the general arrangement of Figure 11. These instruments are not currently installed and operating.

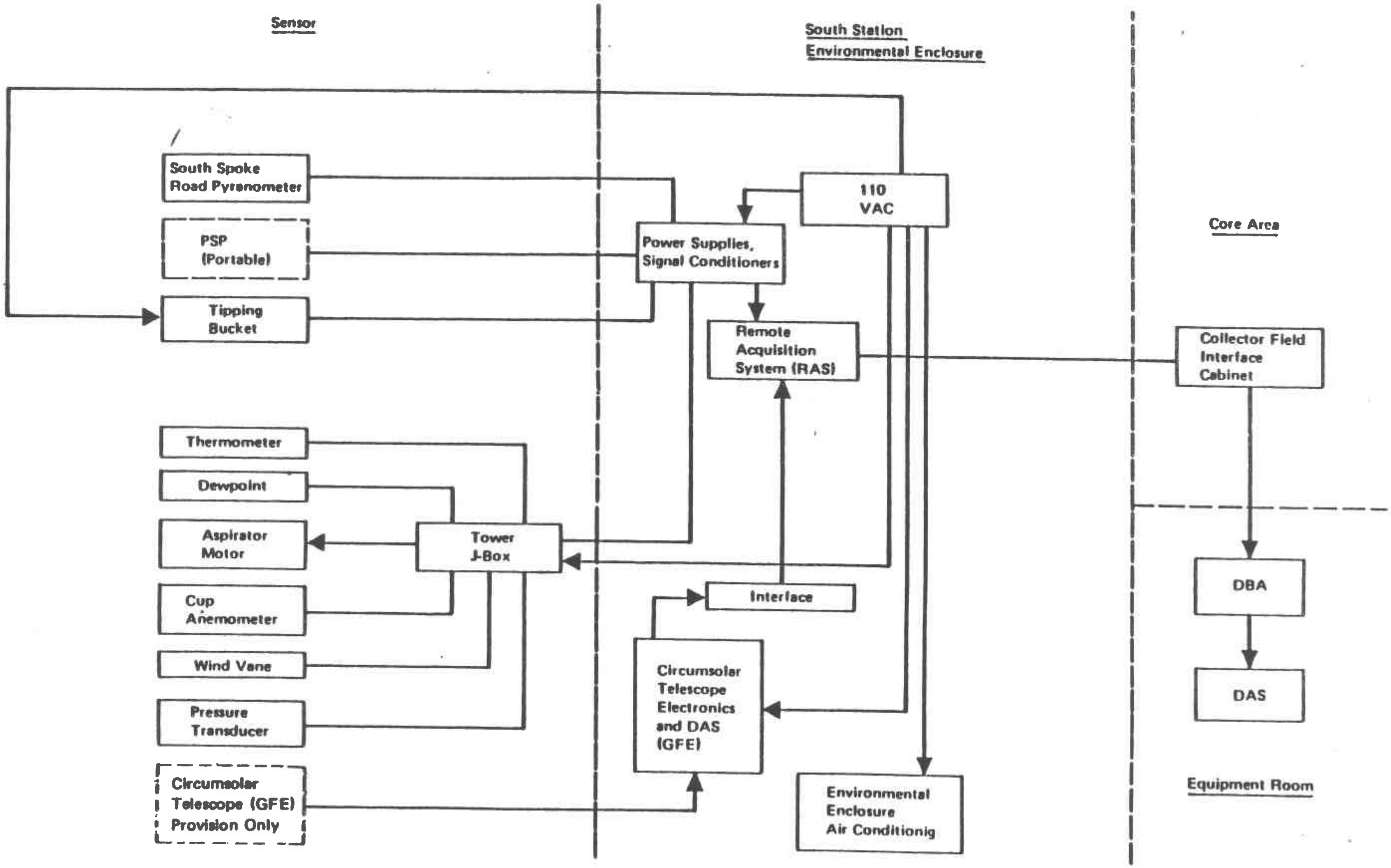


Figure 10 South MET Station (Main Station) System Schematic

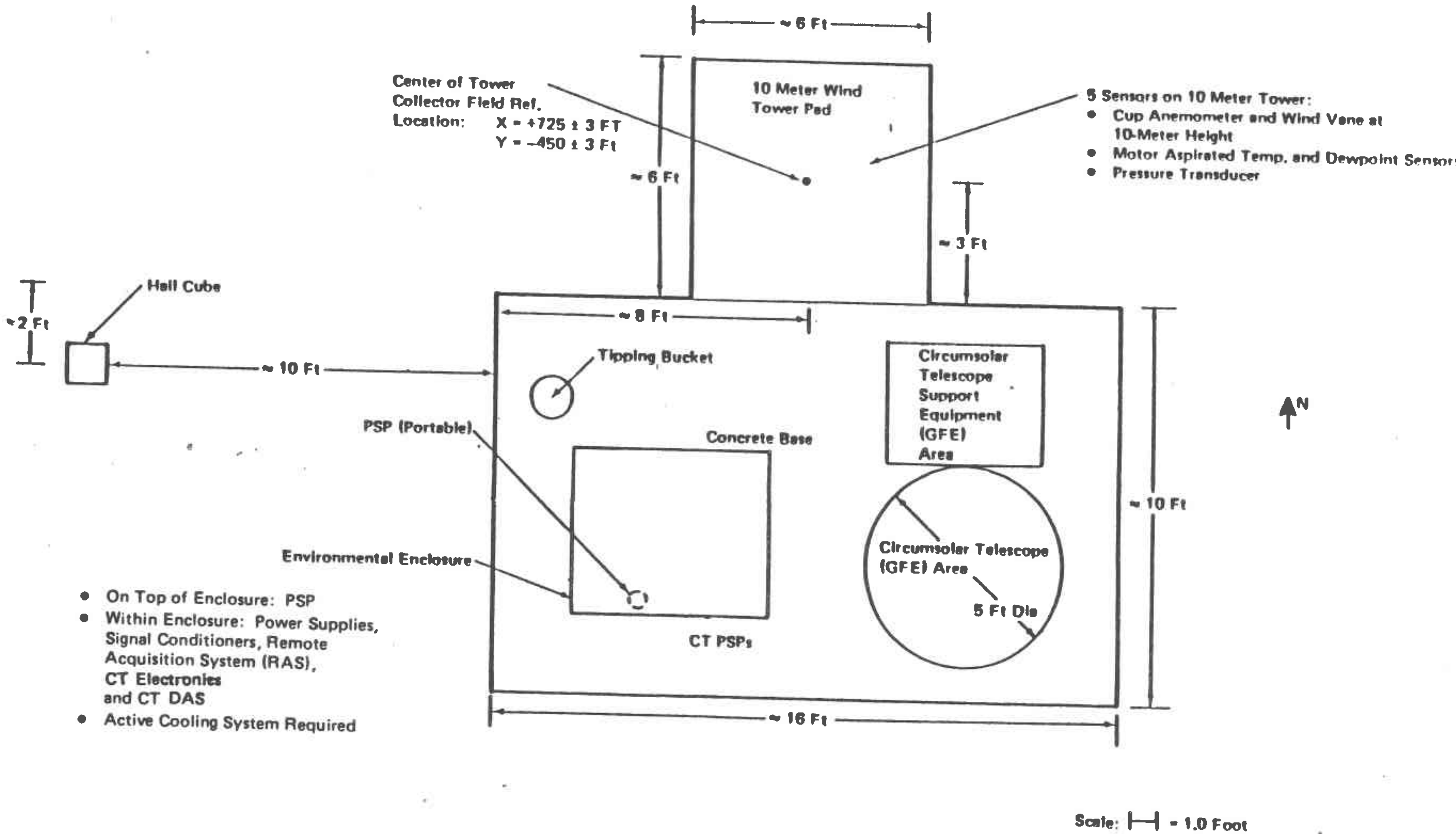


Figure 11. SOUTH STATION GENERAL ARRANGEMENT

The south station has a concrete slab base of approximately 16 by 10 ft, as indicated in Figure 11. A rigid environmental enclosure is sized to accommodate all instrumentation electronics (power supplies, signal conditioners, RAS electronics, CT electronics and CT data acquisition system (DAS). The approximate size of this enclosure is 80 inches wide by 96 inches high by 72 inches deep. It is located on the southwest end of the concrete base, 2 feet away from the base's edge with the long dimension in the east-west direction.

The CT electronics and CT DAS would dissipate approximately 1 kW of heat during operation and it requires a dust-free operational environment at a temperature of 70 $\pm$ 10°F. This dictated the major cooling capacity requirement of the enclosure's cooling system. The top of the enclosure has provisions for mounting one portable PSP. Figure 12 shows a photograph of the south station, as viewed from the west.

On the southeast corner of the base is a 5 foot diameter vacant area where the circumsolar telescope could be located. The 5 foot diameter vacant area is at least 1 foot from the base's edge and at least 2.5 feet from the environmental enclosure.

North of the circumsolar telescope area is a 3 by 4 foot area reserved for the circumsolar telescope support equipment.

A tipping bucket rain gauge is located on the west end of the base and at least 1.0 foot in from the edge of the base. Figure 13 shows the instrument.

Adjacent to the base (north of base) is a 6 by 6 foot square concrete area where a 10 meter tower is located. On the tower at the 10 meter level is a cup anemometer and wind vane mounted on a cross arm. (See Figure 14) A motor aspirated temperature and dewpoint sensor is mounted just below the wind sensors (see Figure 15). A pressure transducer is mounted at the 6 foot level of the tower. A hail cube is mounted on a pole 10 feet from the concrete base in the westerly direction. This installation can be seen in Figure 12.

3.2.3 West Station

The west station (Figures 16 and 17) is located per collector field reference XY coordinates as indicated in Figure 17. It is a 9 by 6.5 feet concrete slab base with the long end in the east-west direction. The surface of the base is at least 2 inches above the surrounding finished grade.

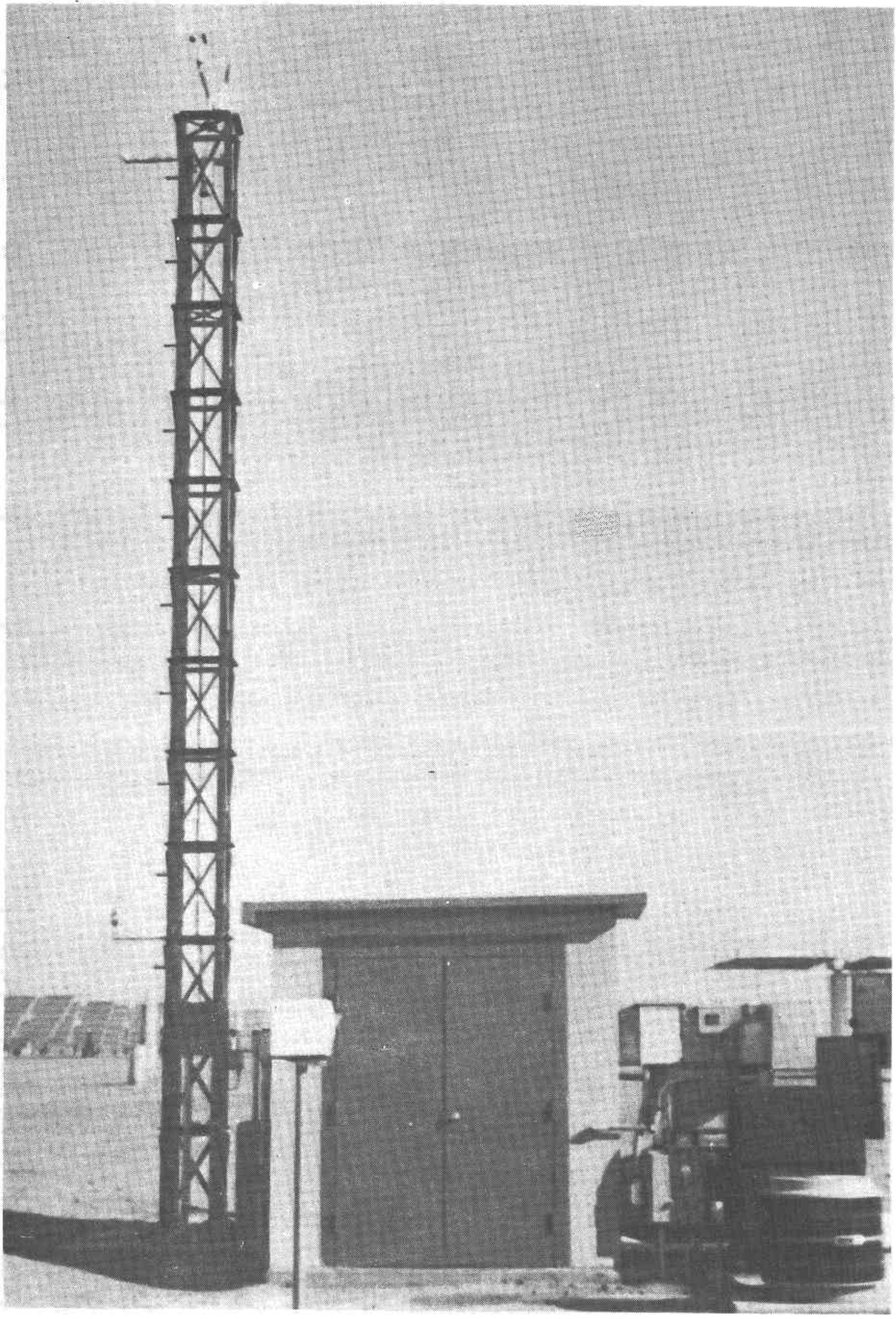


FIGURE 12. SOUTH STATION - VIEWED FROM THE WEST

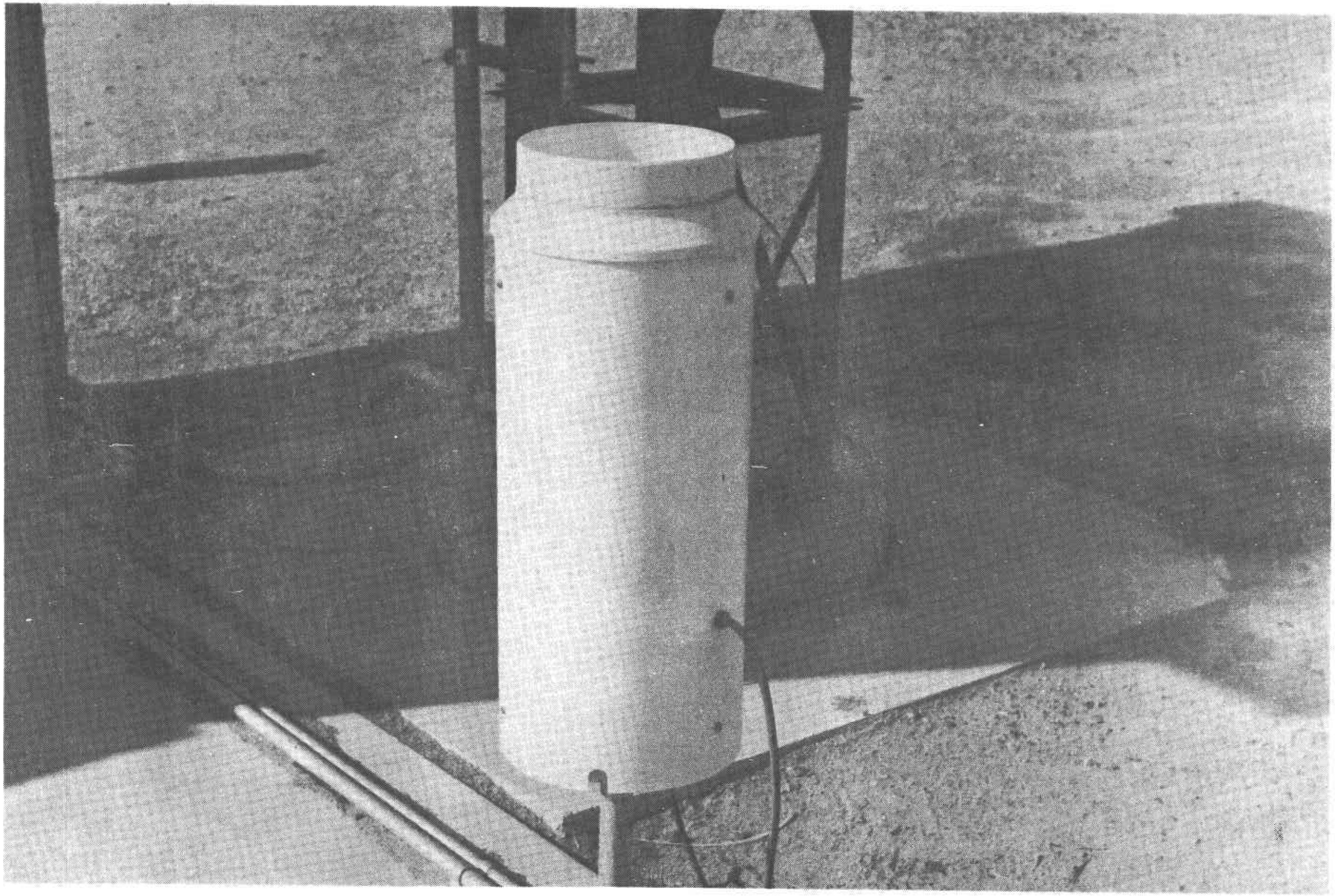


FIGURE 13. TIPPING BUCKET RAIN GAUGE INSTALLATION

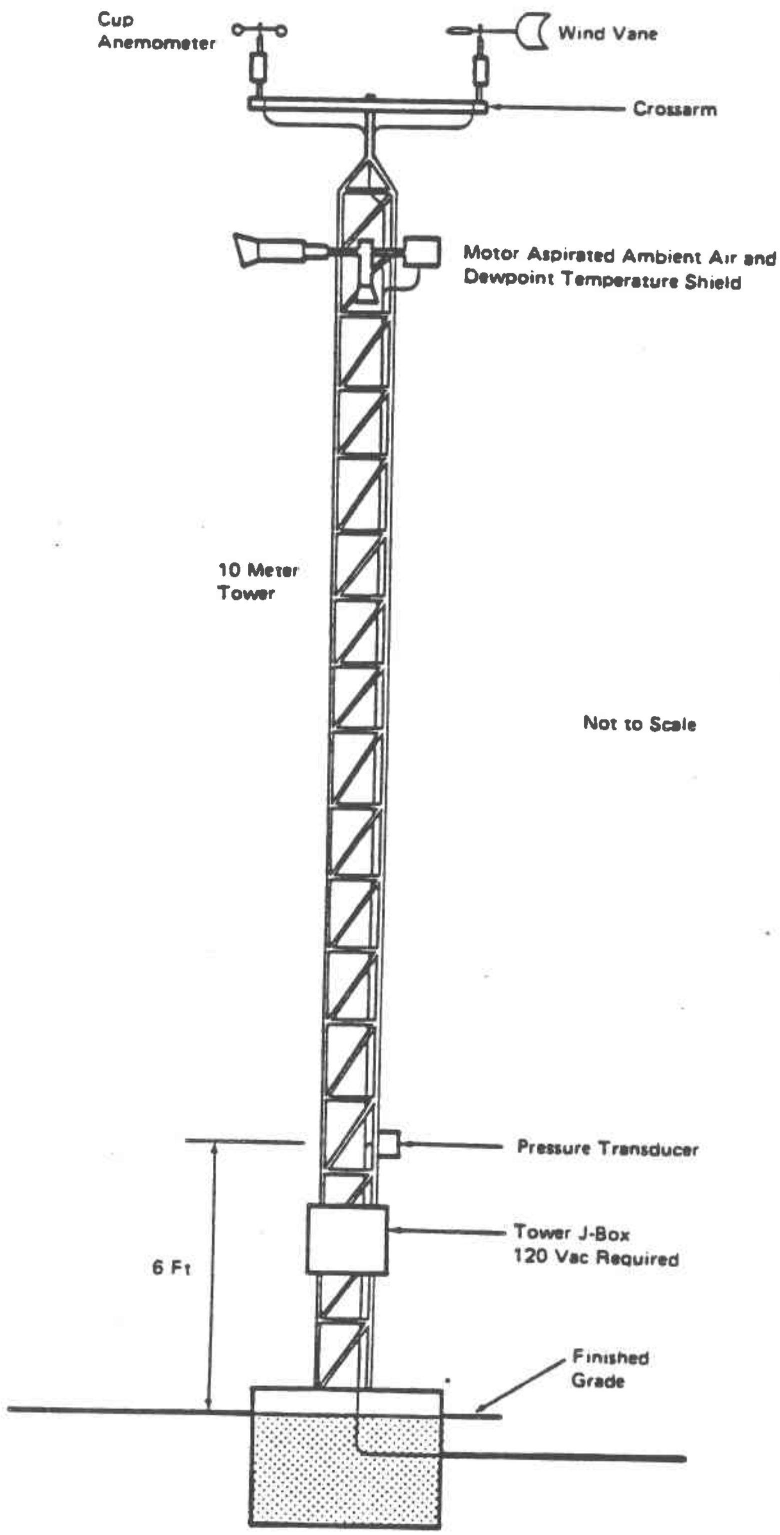


Figure 14 Mounting Location of Meteorological Sensors on 10-Meter Tower

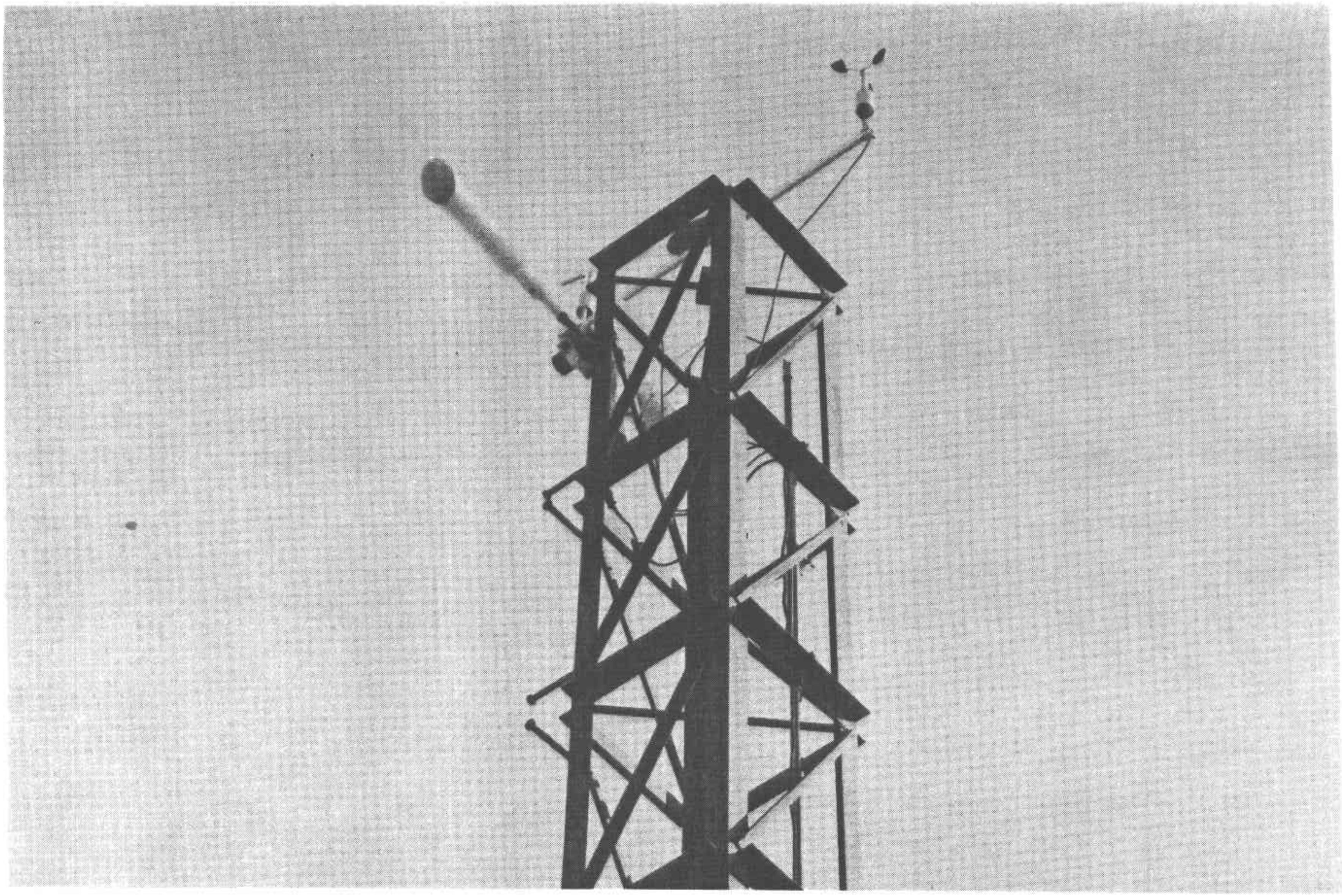


FIGURE 15. SOUTH STATION TEMPERATURE AND DEWPOINT SENSOR

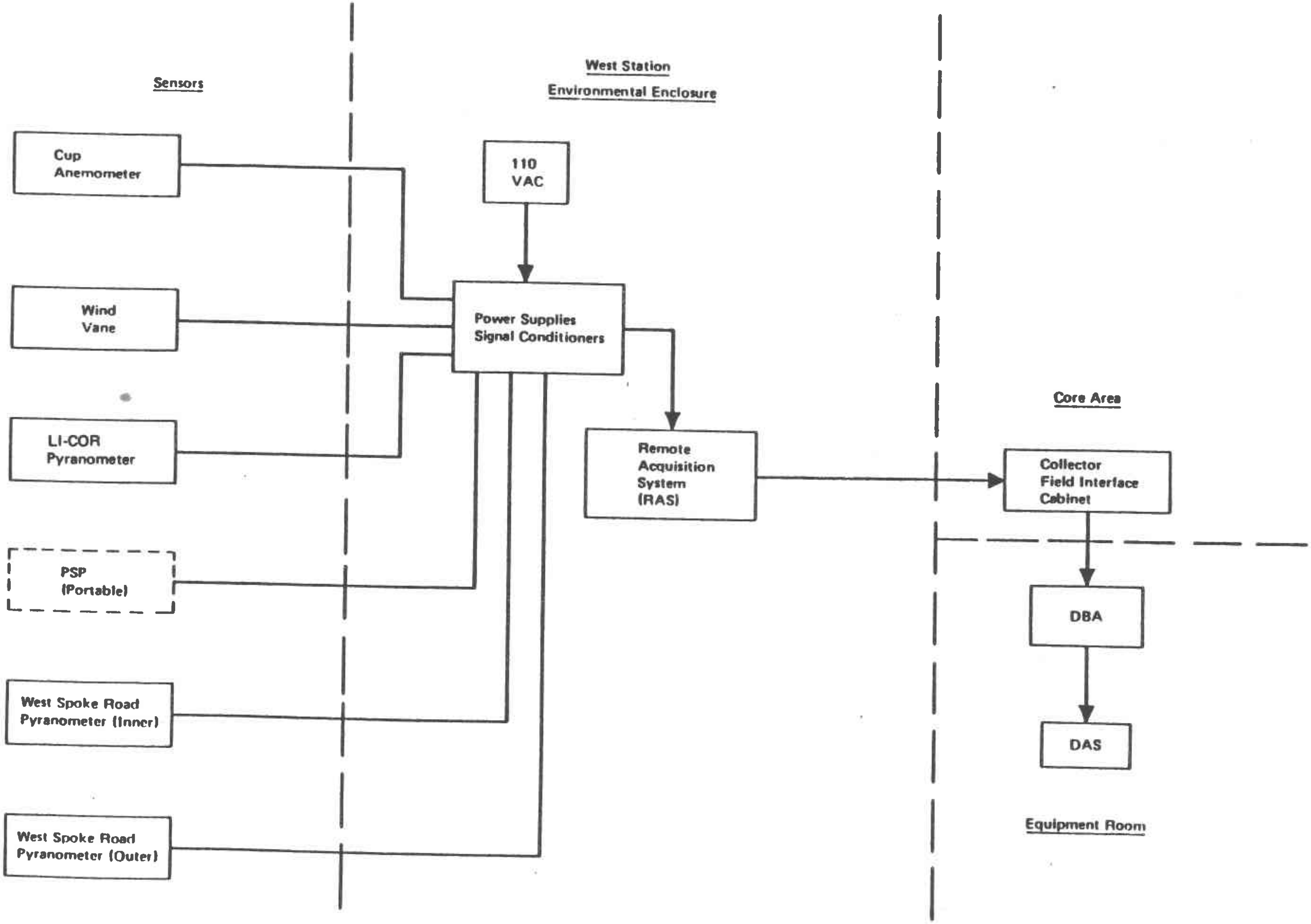


Figure 16 West MET Station System Schematic

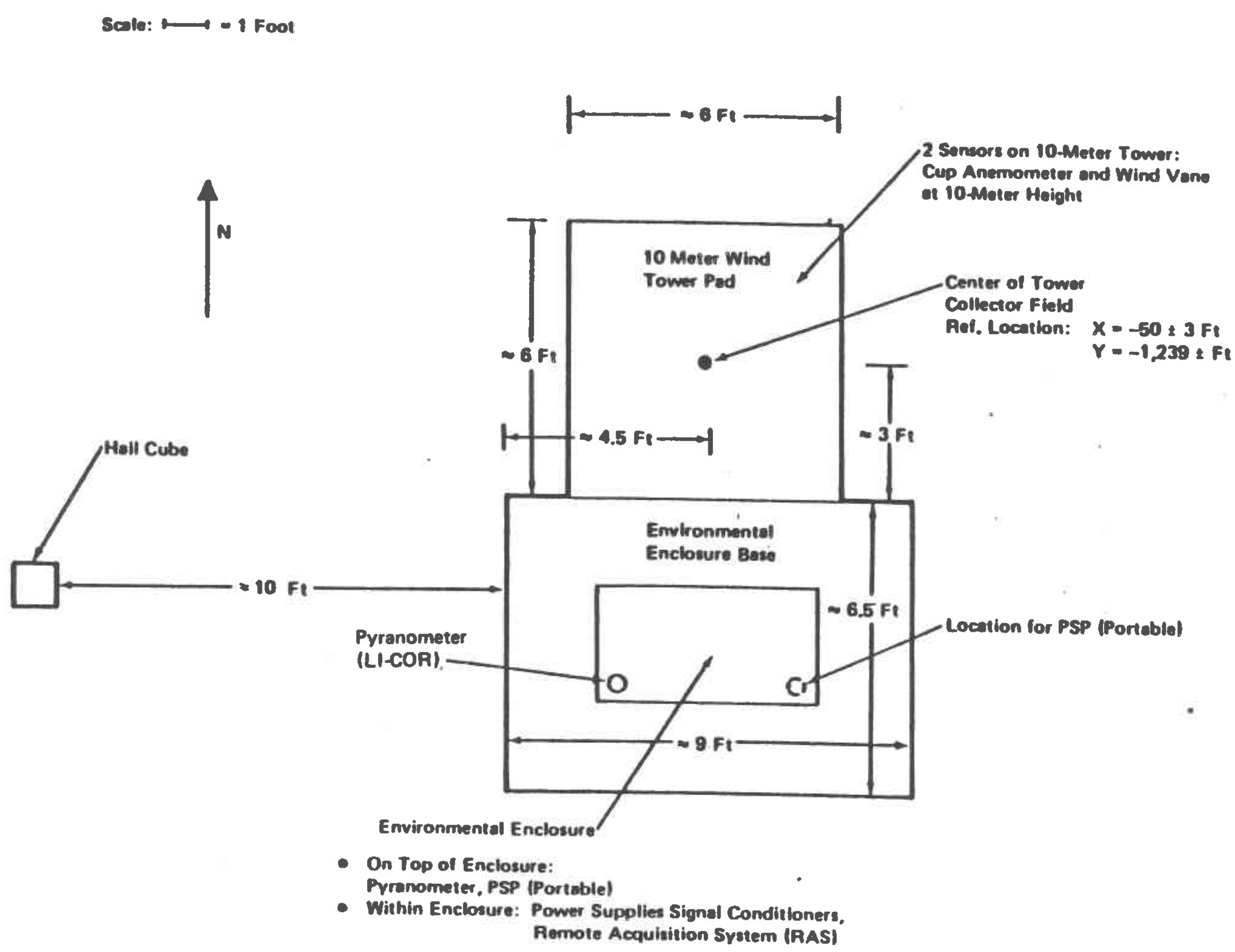


Figure 17. WEST MET STATION GENERAL ARRANGEMENT

An environmental enclosure approximately 24 inches wide by 72 inches high by 30 inches deep to accommodate all station electronics is located at the south side of the base. A pyranometer is permanently located on top of the enclosure, as well as cabling provisions for the portable PSP. Requirements for electronics environmental protection, access, drainage, cable connections, and safe guarding are the same as that for the south station environmental enclosure. An active cooling system is provided.

A 6 ft by 6 ft wind tower base is located north of the environmental enclosure base. A cup anemometer and a wind vane are mounted on a crossarm at the 10 meter height. A hail cube is located 10 feet west of the concrete base. The environmental enclosure, wind tower, and hail cube can be seen on Figure 18.

3.2.4 North Station

The north station (Figures 19 and 20) is located per collector field reference XY coordinates as indicated in Figure 20. The specifications of the base, environmental enclosure, wind sensors and 10 meter tower are identical to that of the west station. There is a pyranometer on top of the environmental enclosure, as well as provisions for a portable PSP. A NIP is mounted on a solar tracker on a table adjacent to the environmental enclosure. Space for an active cavity radiometer (ACR) is also provided. A hail cube is located 10 feet north of the base. The NIP installation and the environmental enclosure for the north station are shown on Figure 21.

3.2.5 East Station

The east station system schematic is identical to that of the west station, as depicted on Figure 16. The general arrangement for the east station is shown in Figure 22, including the collector field coordinates. The station characteristic dimensions and requirements are identical to those of the west station, except for the hail cube, which is located 10 feet east of the concrete base. Figure 23 shows the east station environmental enclosure, the wind tower, and the hail cube pedestal.

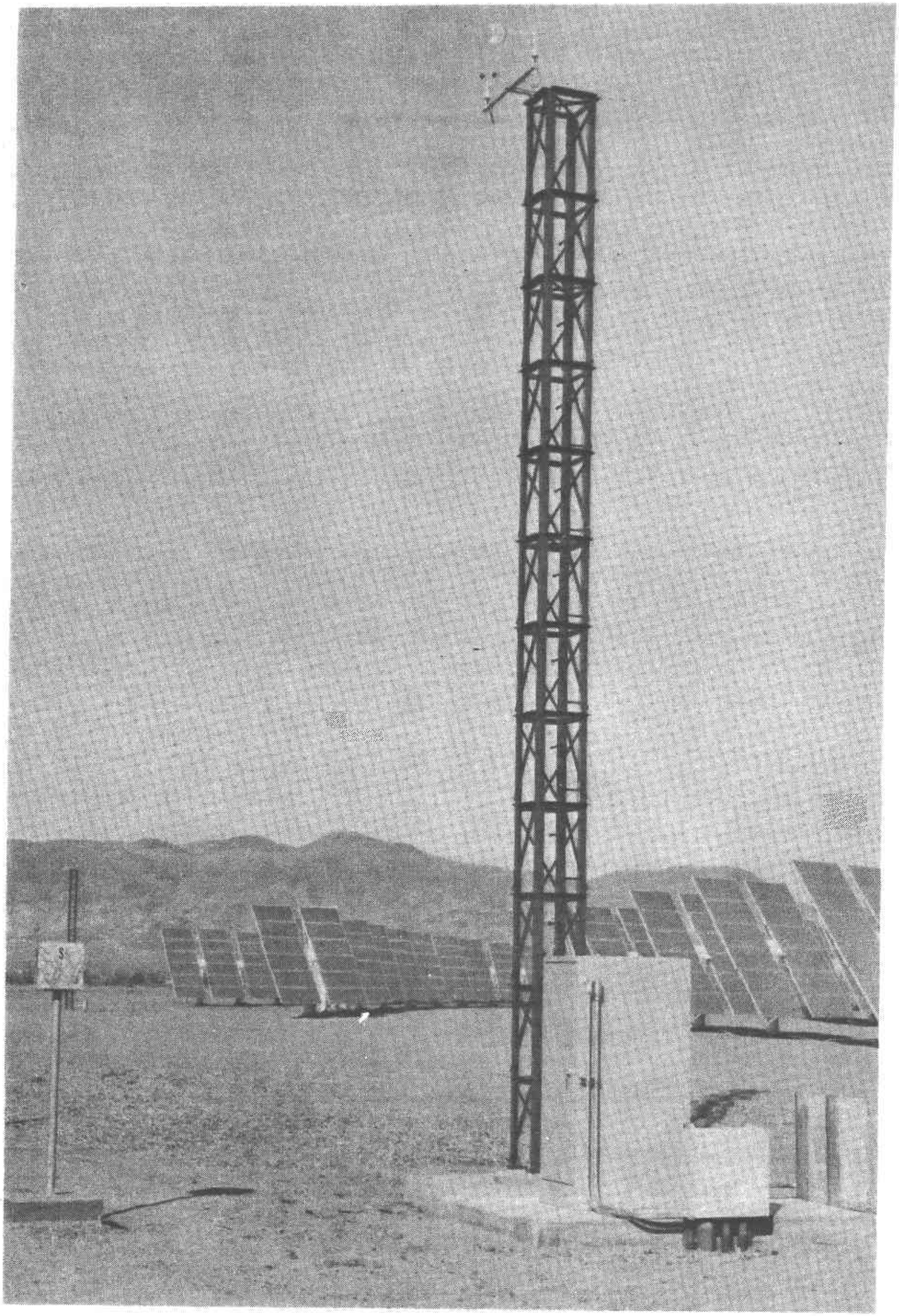


FIGURE 18. WEST STATION INSTALLATION

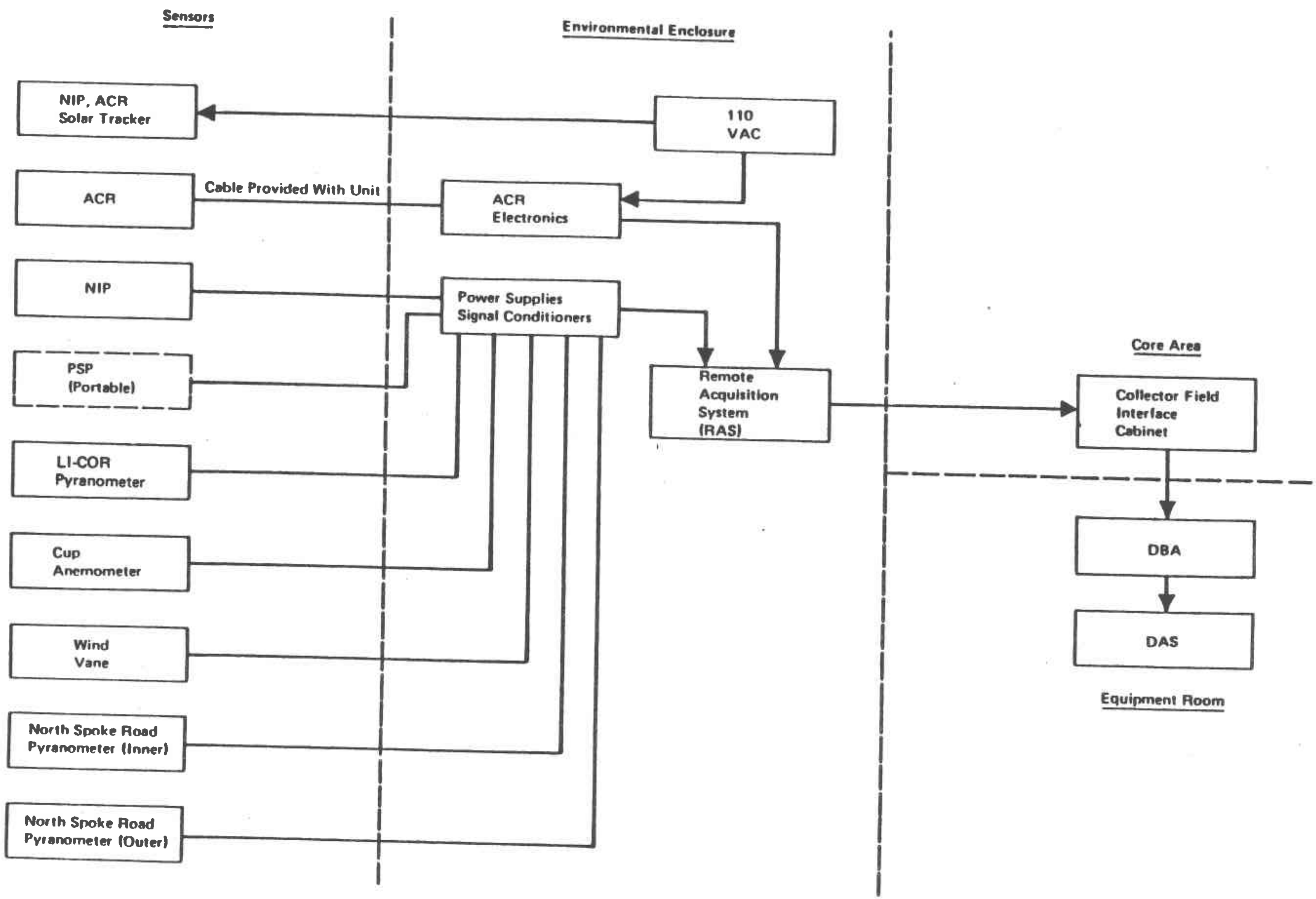


Figure 19 North MET Station System Schematic

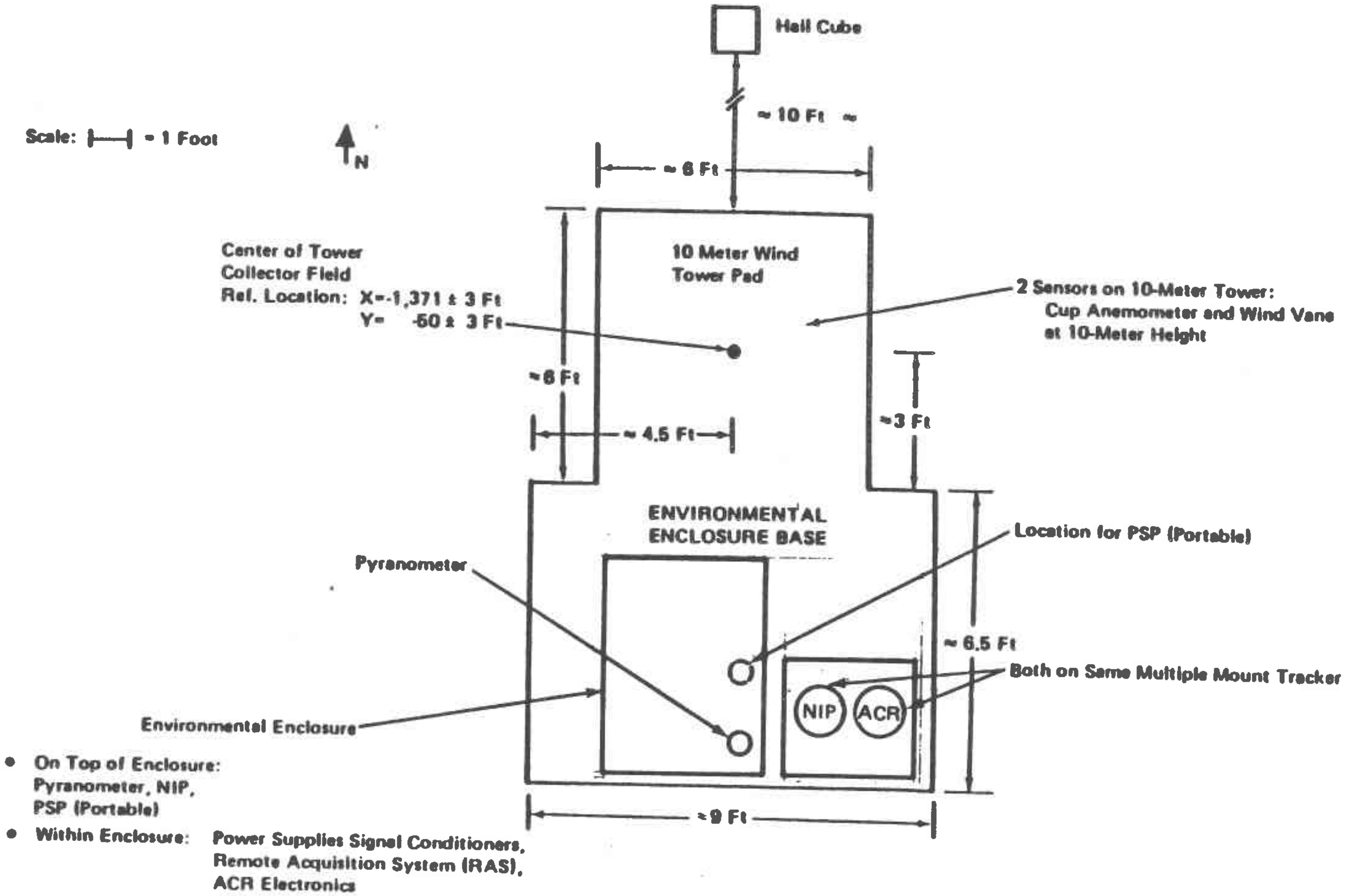


Figure 20. NORTH MET STATION GENERAL ARRANGEMENT

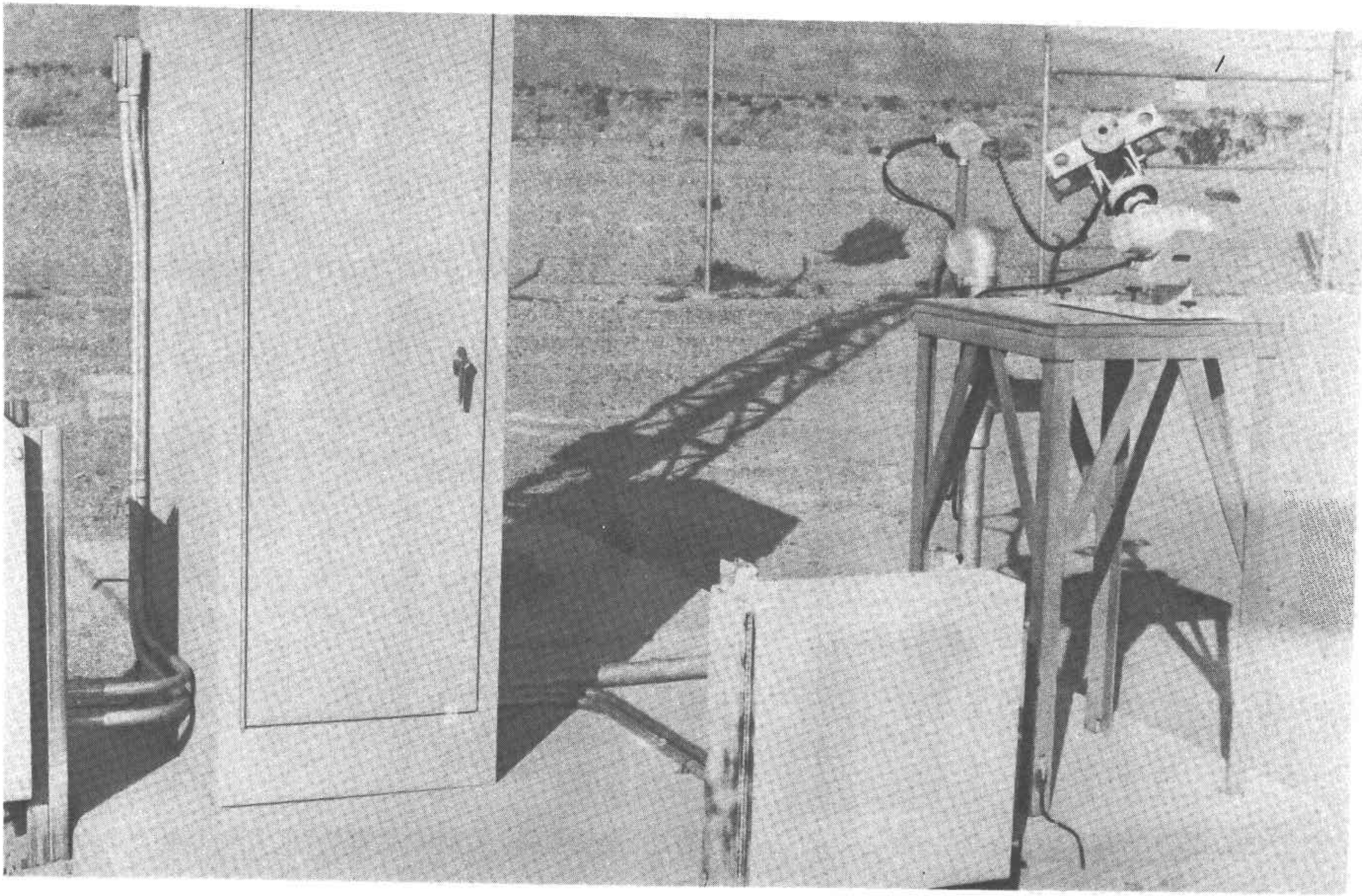


FIGURE 21. NORTH STATION NIP INSTALLATION

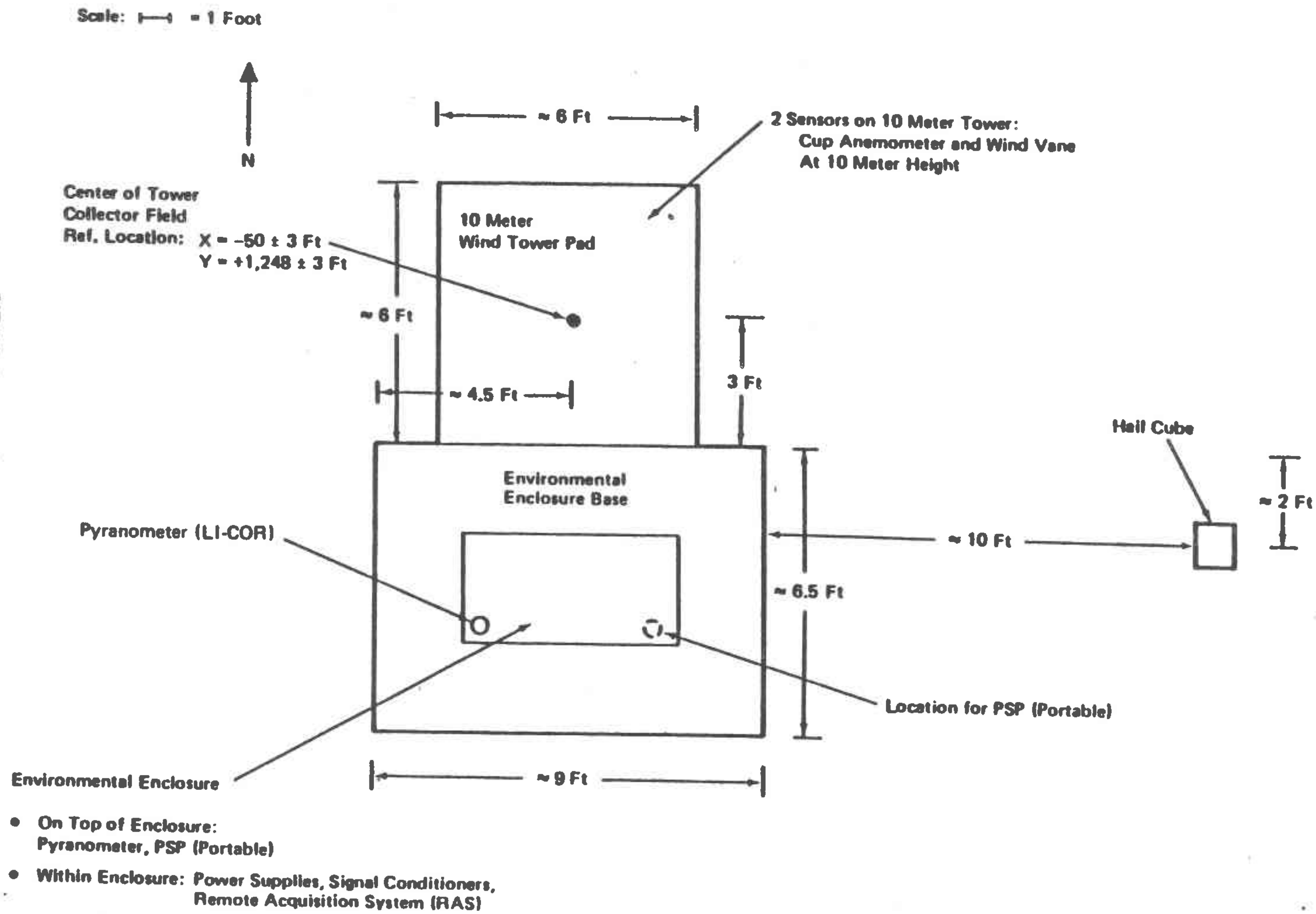


Figure 22. EAST MET STATION GENERAL ARRANGEMENT

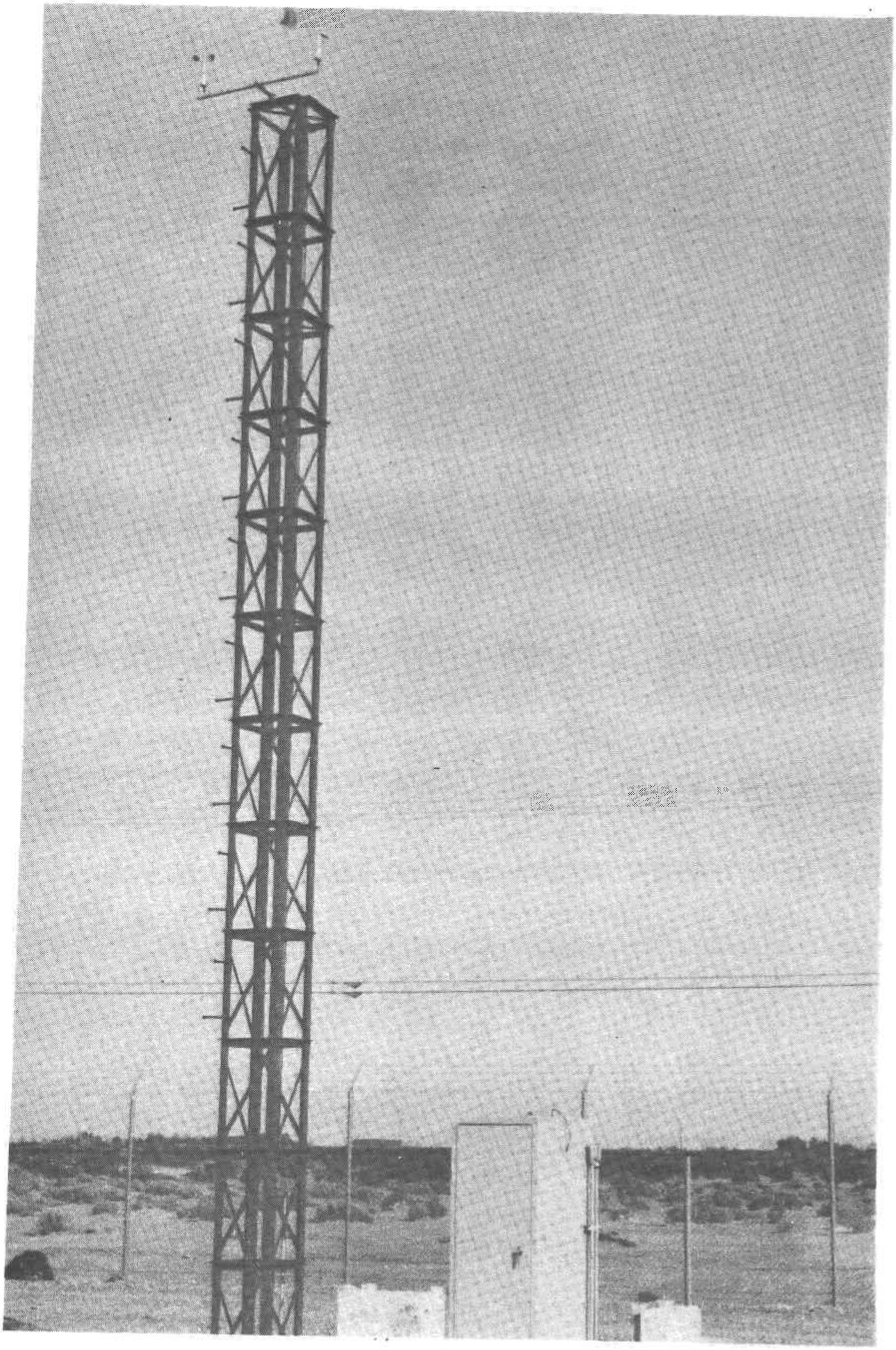


FIGURE 23. EAST STATION INSTALLATION

3.2.6 Receiver Station

Two sets of wind measuring sensors, each set consisting of a cup anemometer and a wind vane mounted on a crossarm which in turn is mounted on an 8 foot boom, are located in the easterly direction on the east side and also in the westerly direction on the west side of the receiver tower at level 7. The tower MET station system schematic is shown in Figure 24. The instrument and electronics locations are shown in Figure 25, and the eastern and western installations are shown in Figures 26 and 27, respectively.

A nephelometer, motor aspirated temperature, and dewpoint sensor are located within the tower structure on the same level as the wind sensors. The nephelometer is mounted in the environmental enclosure in a vertical position with the sample inlet port down. The nephelometer electronics are located not more than 6 feet from the sensor and are environmentally protected. Power supplies, signal conditioning, and the RAS are located in the environmentally protected area on the 13th level of the receiver tower.

3.2.7 West-Northwest Station

A system schematic of the west-northwest station is shown in Figure 28. Six 10 meter towers are located at the designated spots in the west-northwest (WNW) direction in the field. These towers are adjacent to the heliostats that are instrumented by SNLL for wind loading and temperature studies. Each tower (Figure 29) has four sensors: one cup anemometer on a 2 foot boom in the WNW direction at the 10 and 20 foot levels, and one cup anemometer and a wind vane mounted on a crossarm at the 32.8 foot (10 meter) level. The boom mounted cup anemometers are in the WNW direction, i.e., 292.5° (0° is north, angle measured clockwise). The crossarm is mounted perpendicular to the boom. Two of the tower installations are shown in Figures 30 and 31.

An electronics environmental shelter used to house power supplies, signal conditioners, and RAS is located adjacent to wind tower 5 as shown in Figure 32. The shelter has an active cooling system to maintain the temperature limits required by the electronics housed. The shelter is on a concrete base designed to accommodate a light load. The shelter is oriented with the long axis parallel to the circle radius and has double doors and a lock which will permit access only to authorized personnel.

The collector field coordinates for the wind towers and the electronics

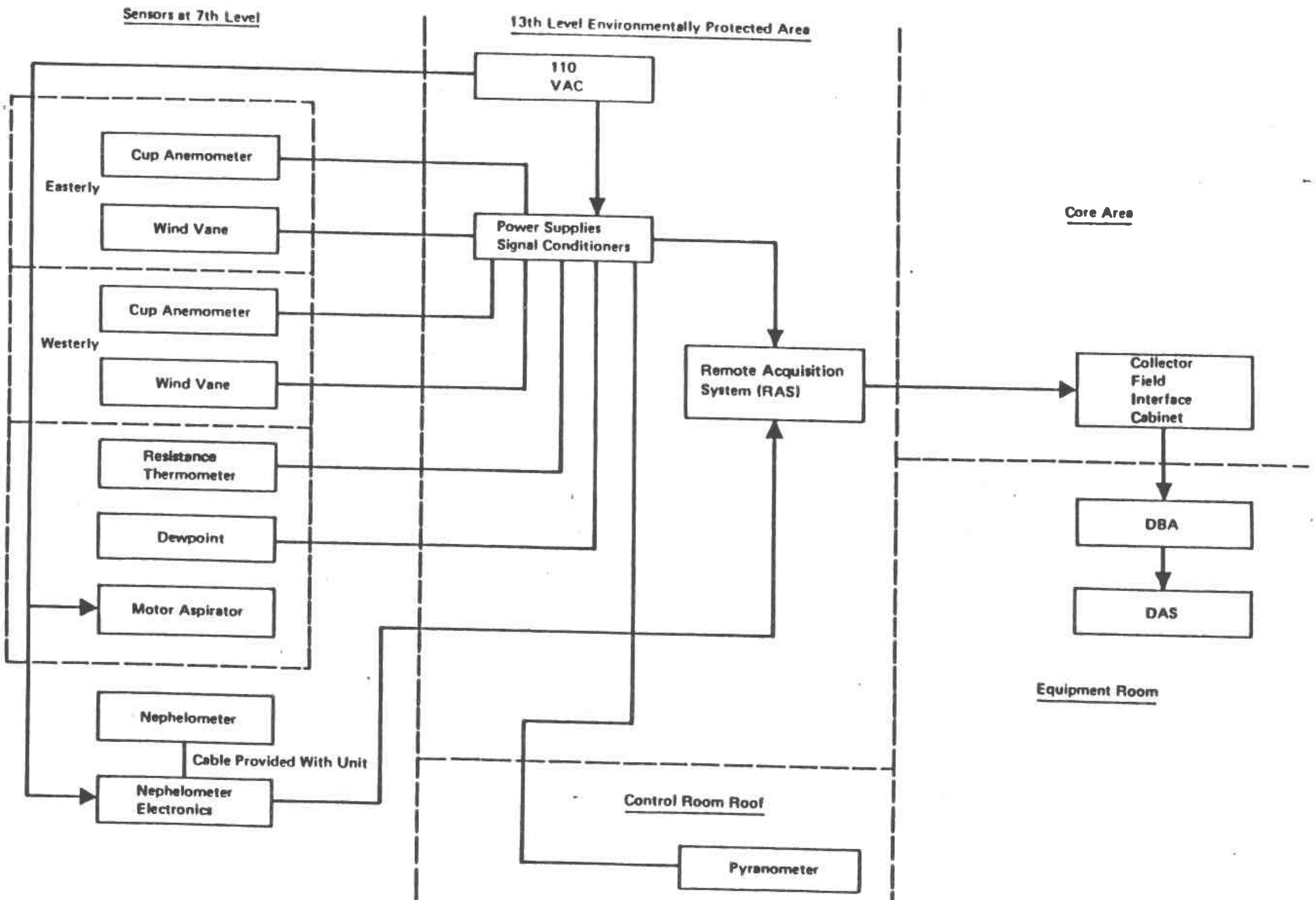


Figure 24 Central Receiver Tower MET Station System Schematic

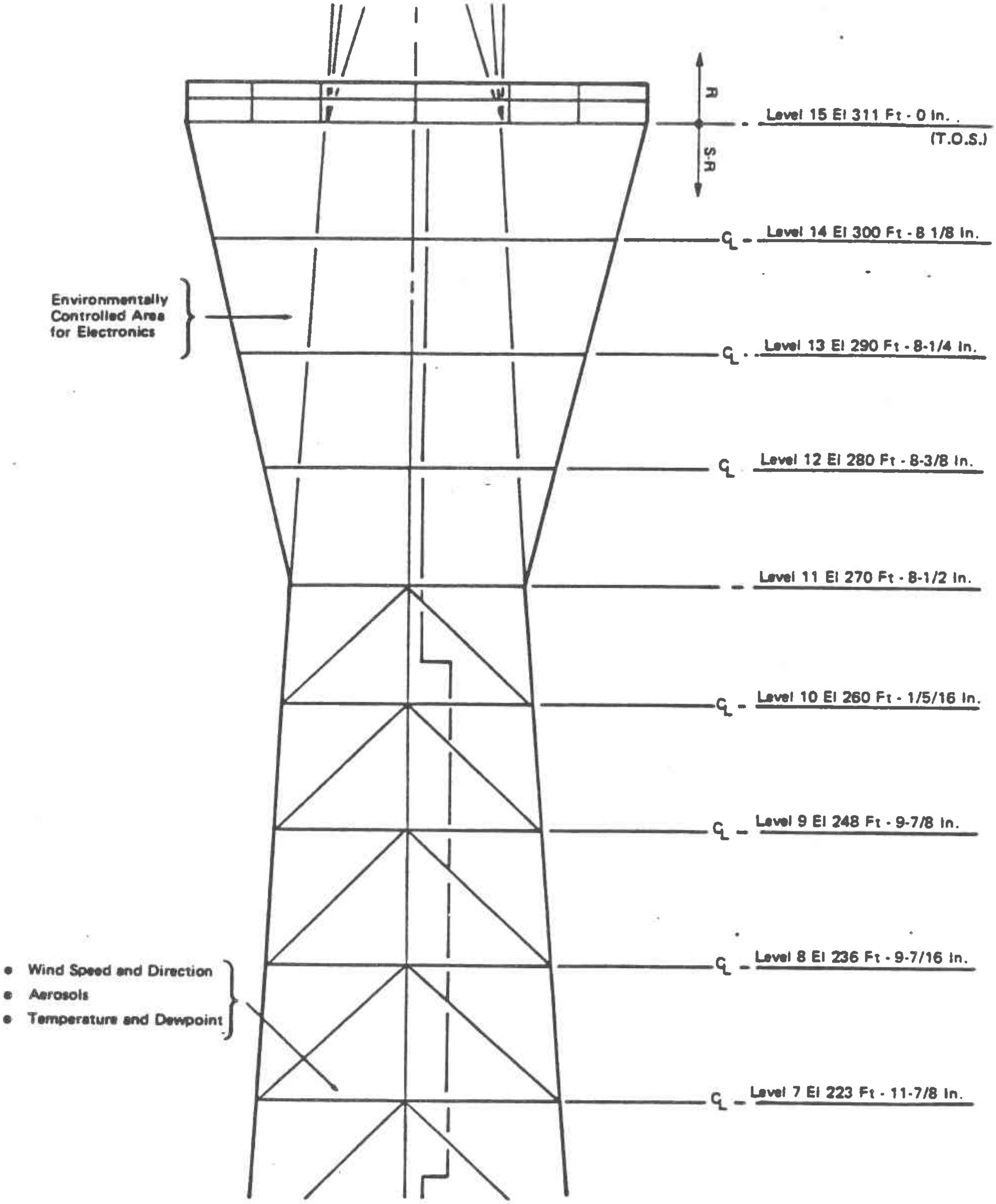


Figure 25. TOWER MET STATION LOCATIONS

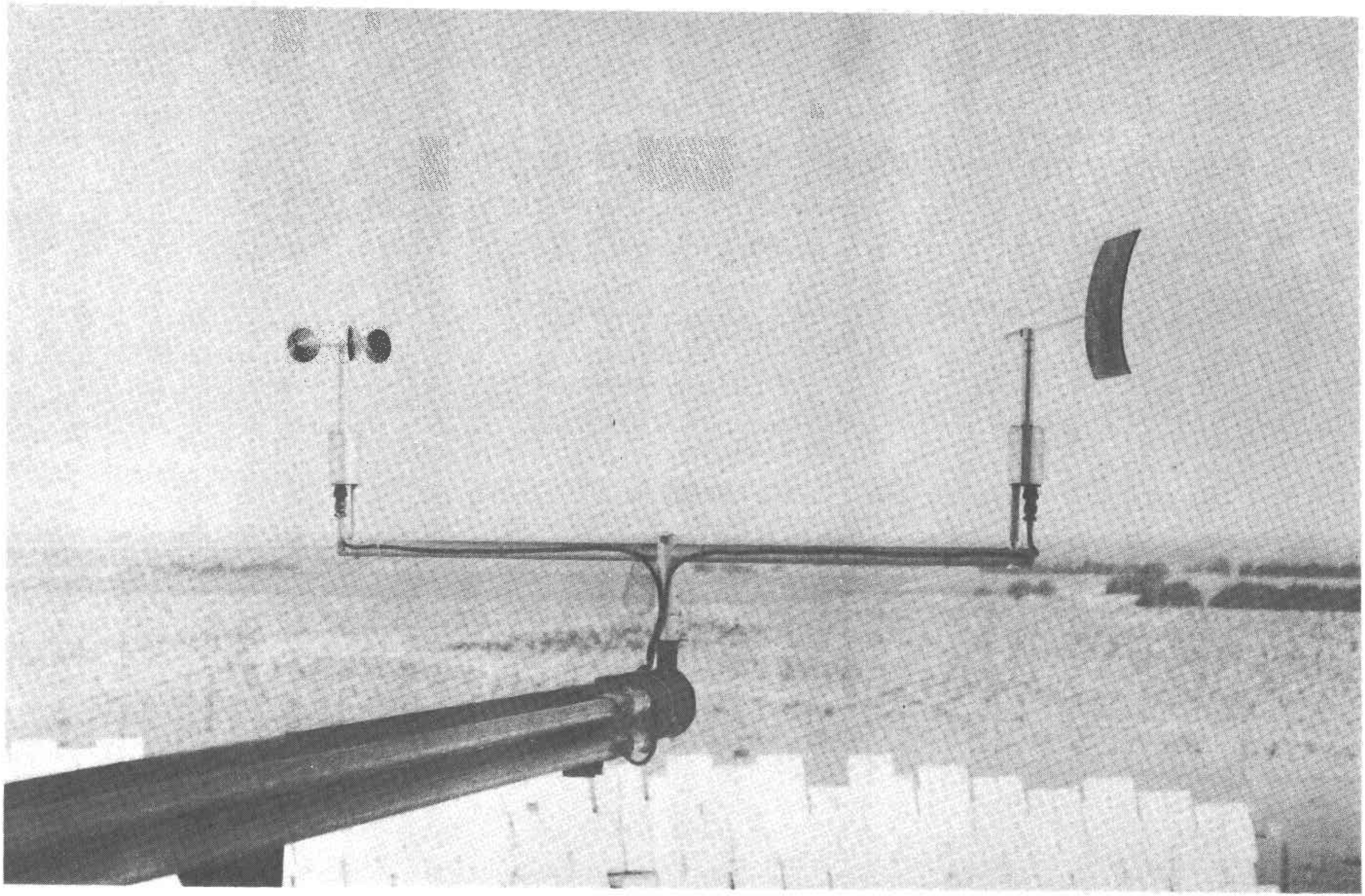


FIGURE 26. EAST SIDE INSTALLATION

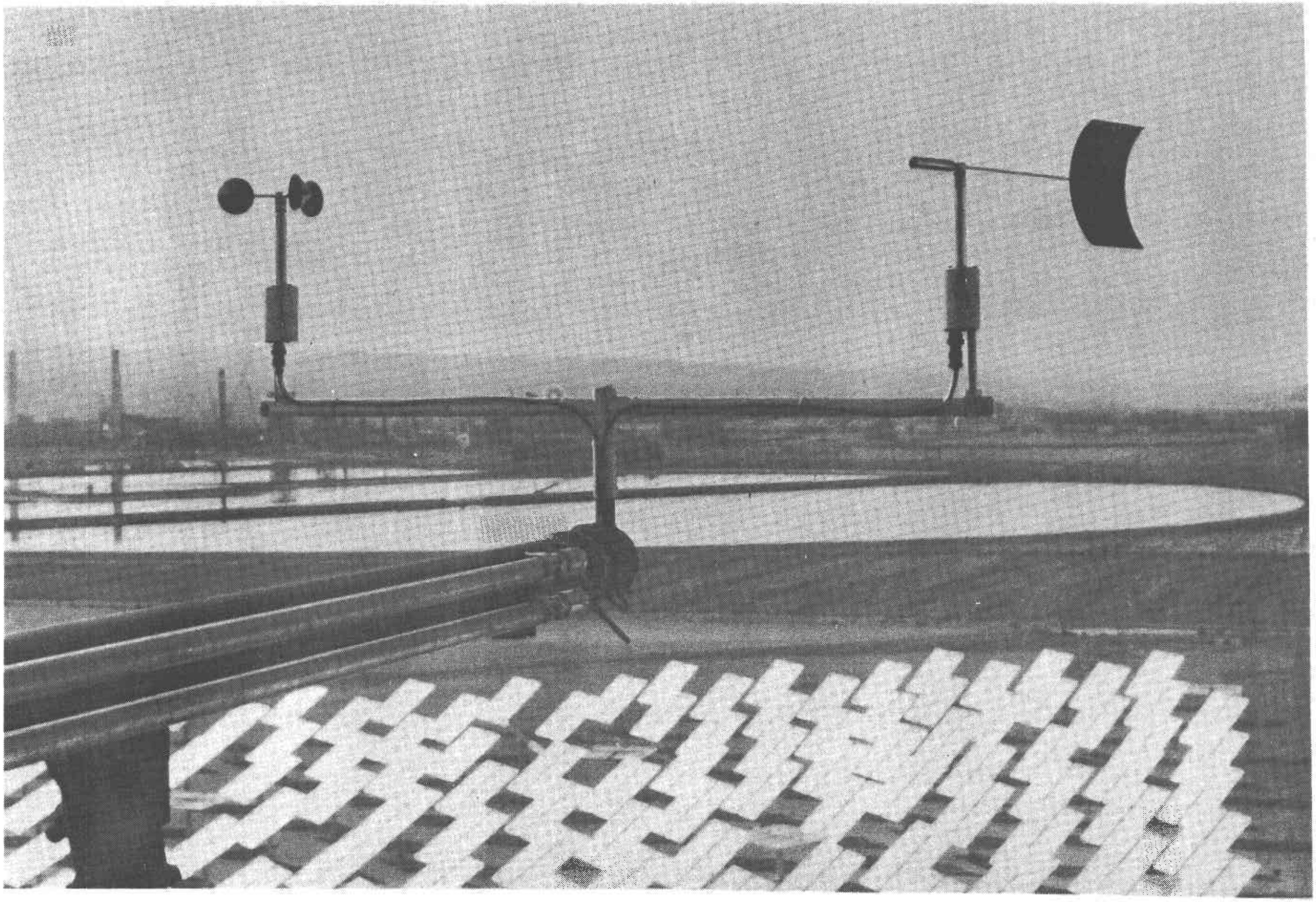


FIGURE 27. WEST SIDE INSTALLATION

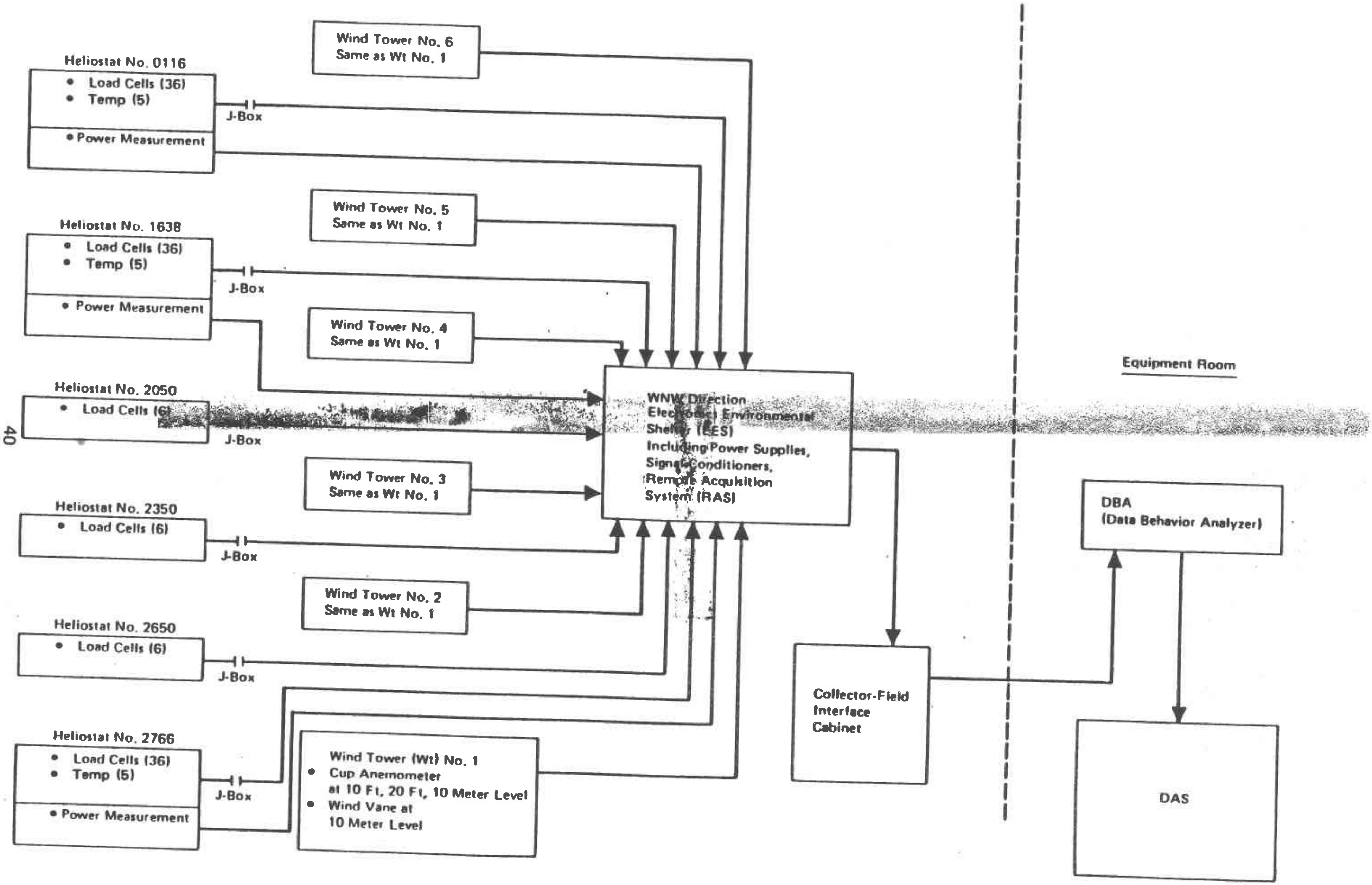
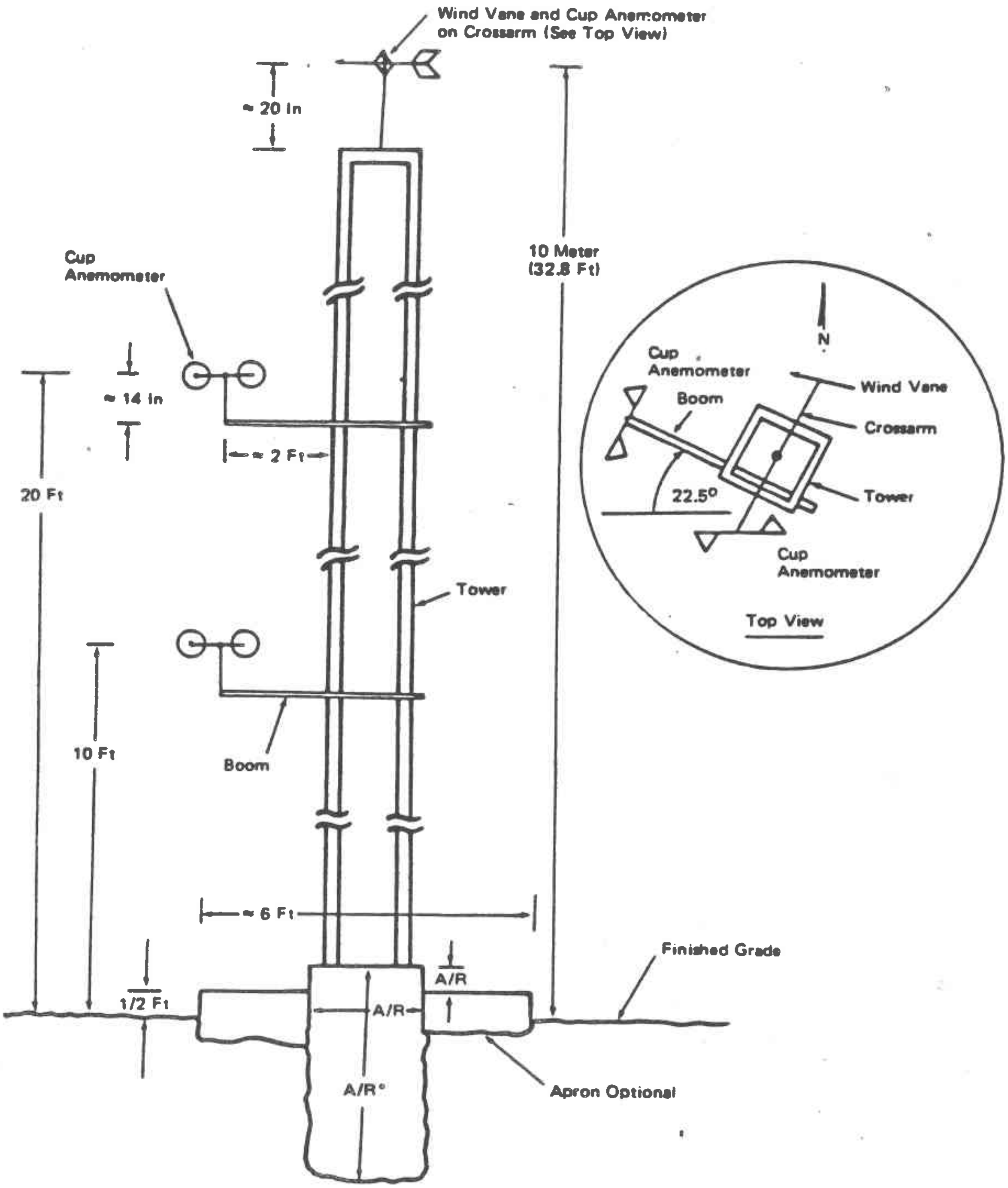


Figure 28 West-North-West (WNW) Direction Meteorological and Special Heliostat Measurements System Schematic



* As Required to Withstand Moment from 90 MPH Winds with Iceload

Figure 29 In Field Wind Tower (WNW Direction)

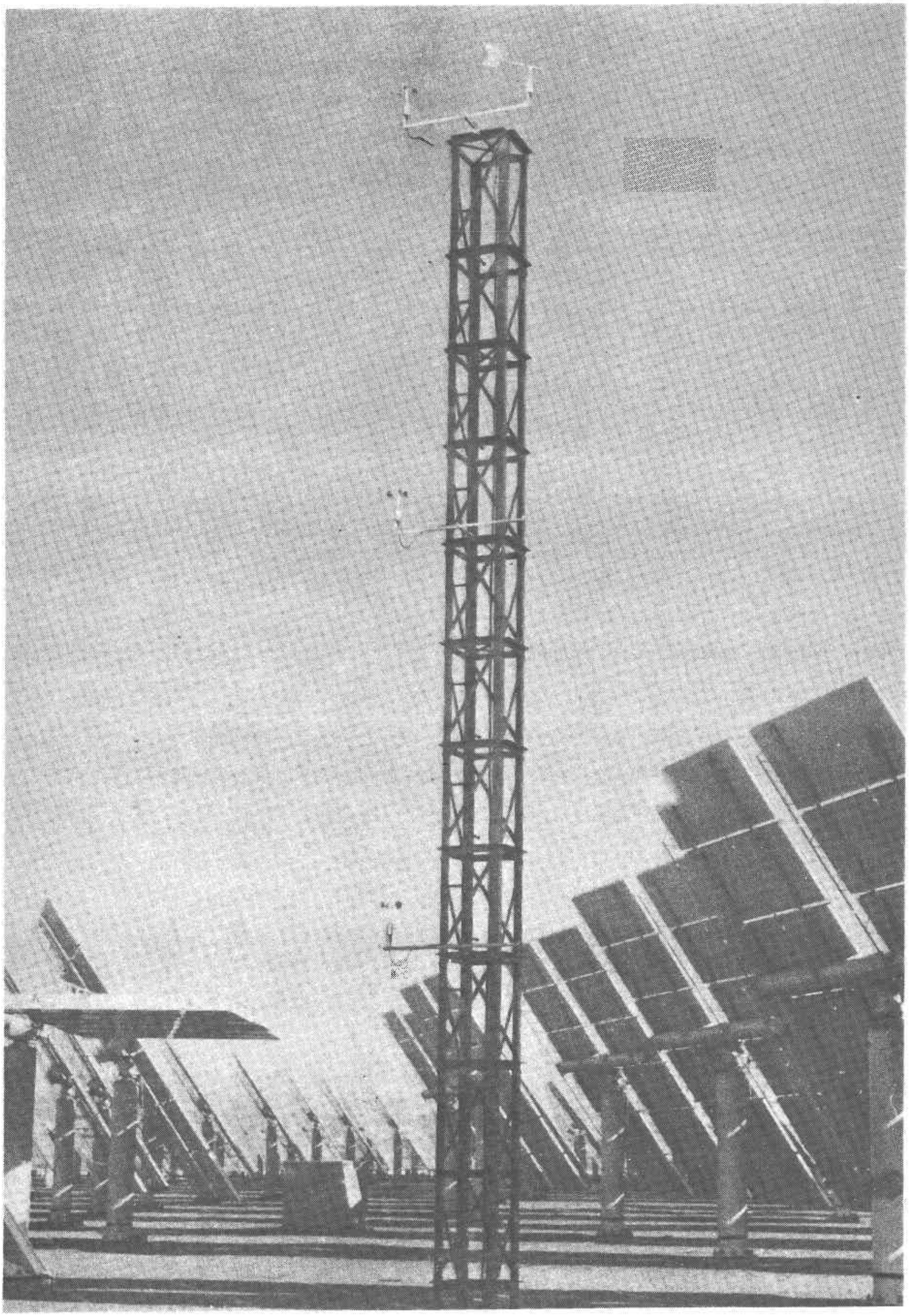


FIGURE 30. WNW WIND TOWER INSTALLATION -1

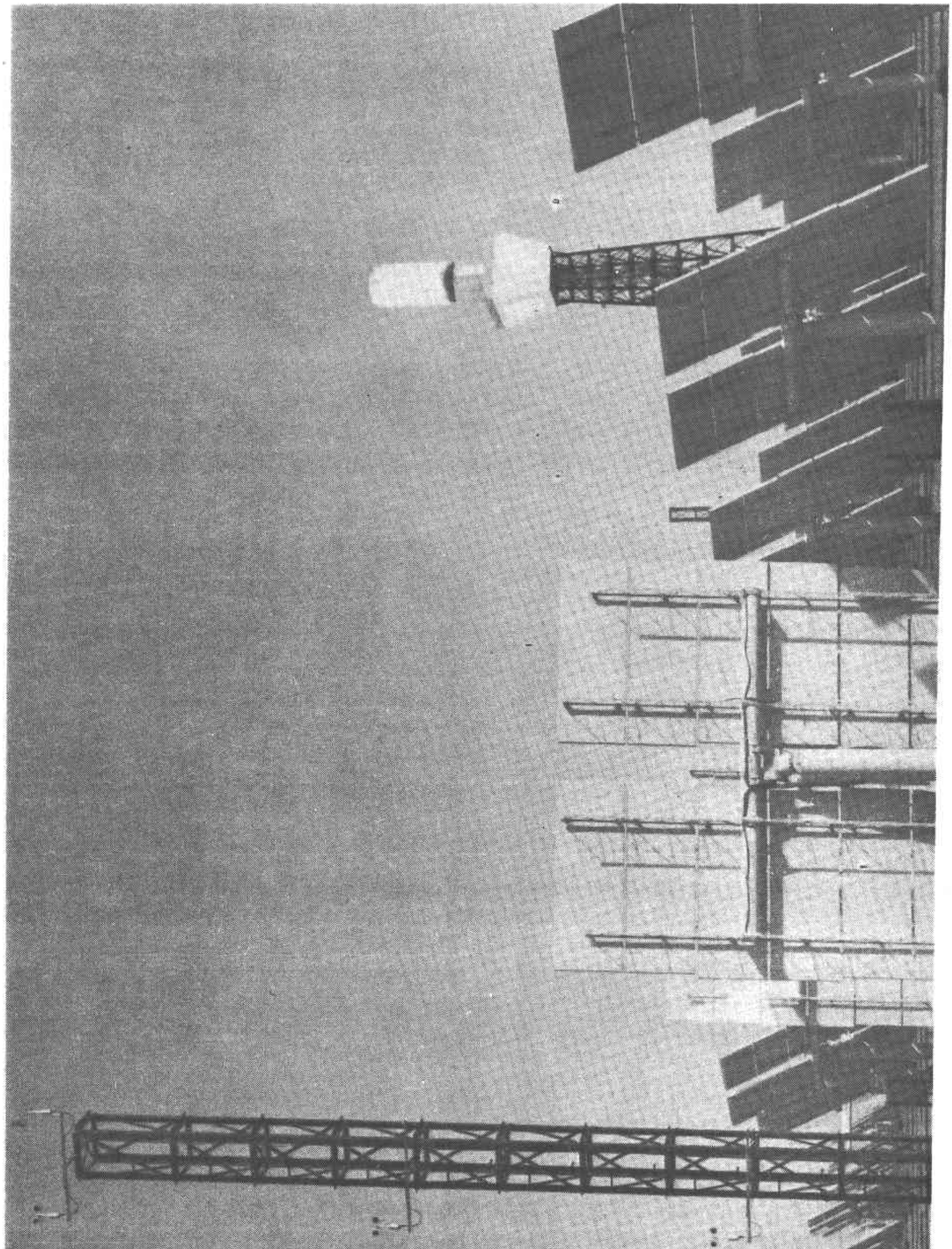


FIGURE 31. WNW WINDTOWER INSTALLATION -2

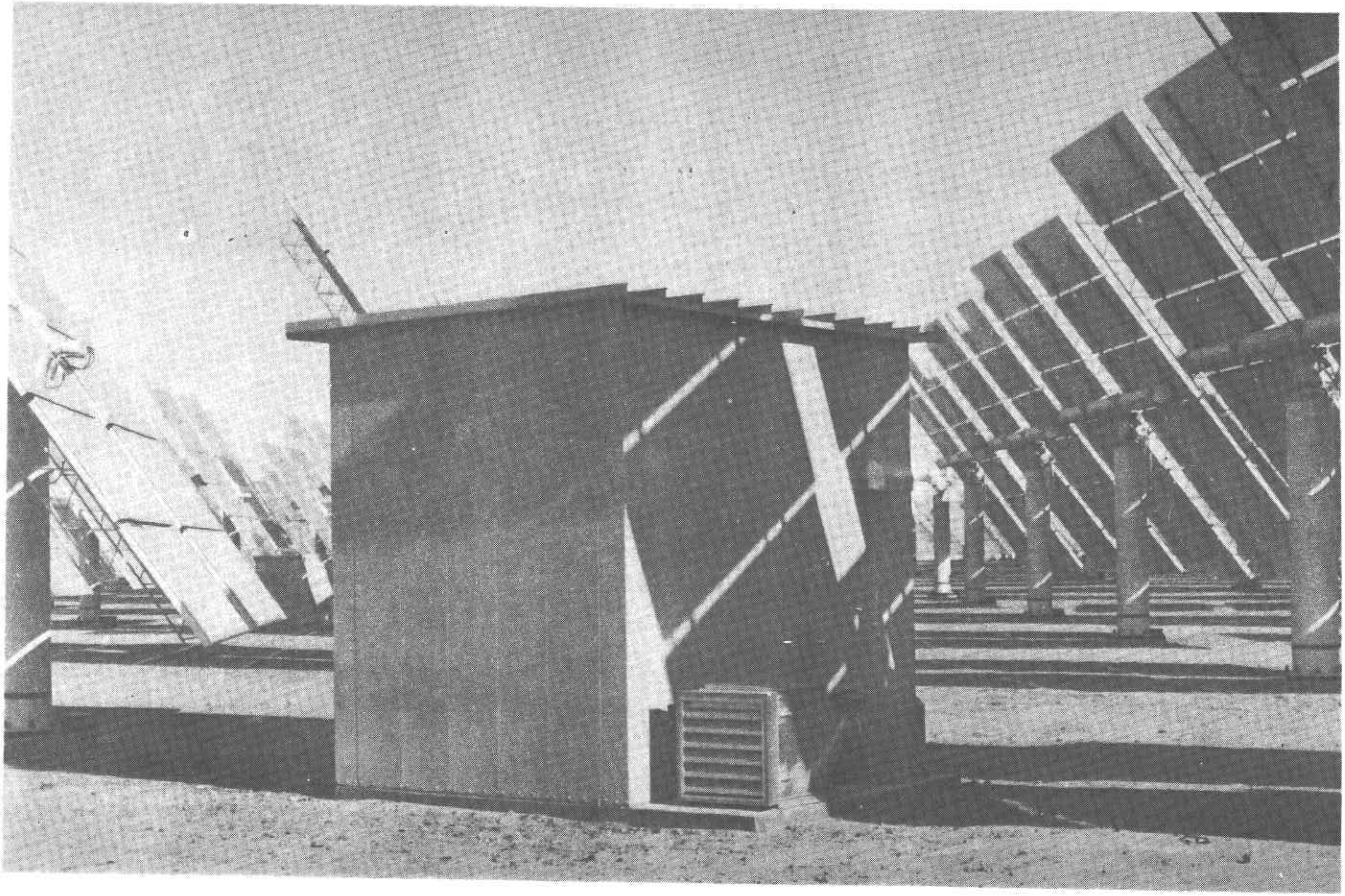


FIGURE 32. WNW ELECTRONICS ENVIRONMENTAL SHELTER

environmental shelter (EES) are shown in Table 1.

Table 1. WNW Wind Towers and EES Collector Field Location Coordinates

TOWER No. or EES	Collector Field Coordinates (Ft)	
	X	Y
1	-481.72	-1162.98
2	-405.54	-958.82
3	-408.75	-906.75
4	-275.25	-680.87
5	-281.84	-639.15
6	-105.75	-214.53
EES	-247.07	-614.47

3.2.8 Control Room Roof

Four sensors are located on the control room roof: a normal incidence pyrheliometer (NIP), a pyranometer, a cup anemometer, and a wind vane. The pyranometer and the NIP are placed on a rigid table of approximately 40 inches in height and 3 feet square in table top dimensions. Figure 33 shows the design of the table. The pyranometer is located on the southwest corner of the table and the NIP on the northeast corner. The pyranometer installation is shown in Figure 34. The NIP is mounted on a solar tracker, as shown in Figure 35. The table is located within a 10' by 10' square 10' away from the edge of the building.

The cup anemometer and wind vane are mounted on a crossarm at least 5 feet above the roof floor. Figure 36 shows the design of the sensors and the mount. The assembly is located within the 10 foot by 4 foot area 20 feet north of the south face. The actual installation is shown in Figure 37.

3.2.9 In-Field Hail Cubes

Two hail cubes are located within the field in addition to the four at the weather stations. One is in the northwest quadrant of the collector field in heliostat row 19, between heliostats 1930 and 1932. The other is in the northeast quadrant of the collector field in heliostat row 19, between heliostats 1929 and 1931. The collector field layout reference XY coordinates

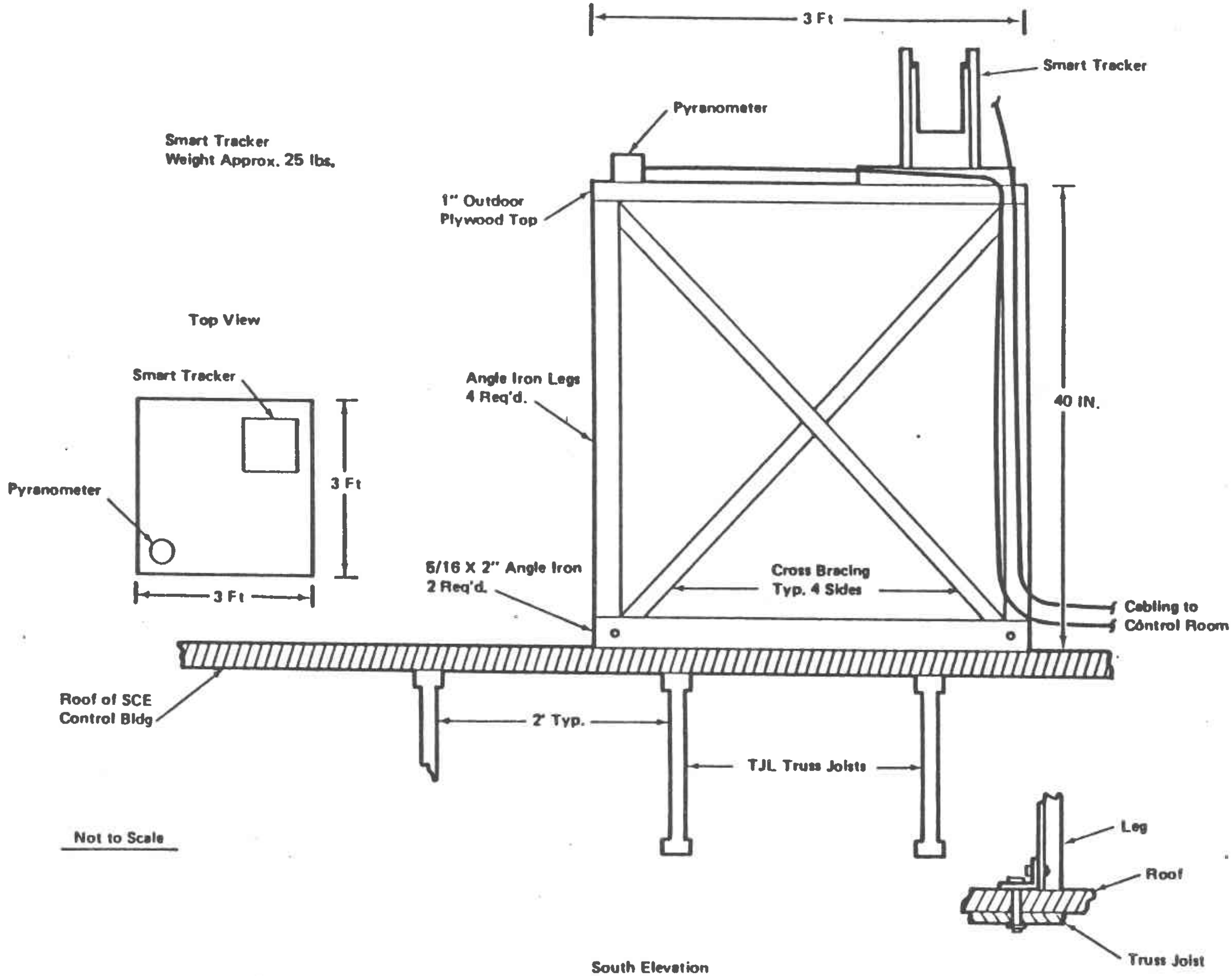


Figure 33 Smart Tracker Support Installation

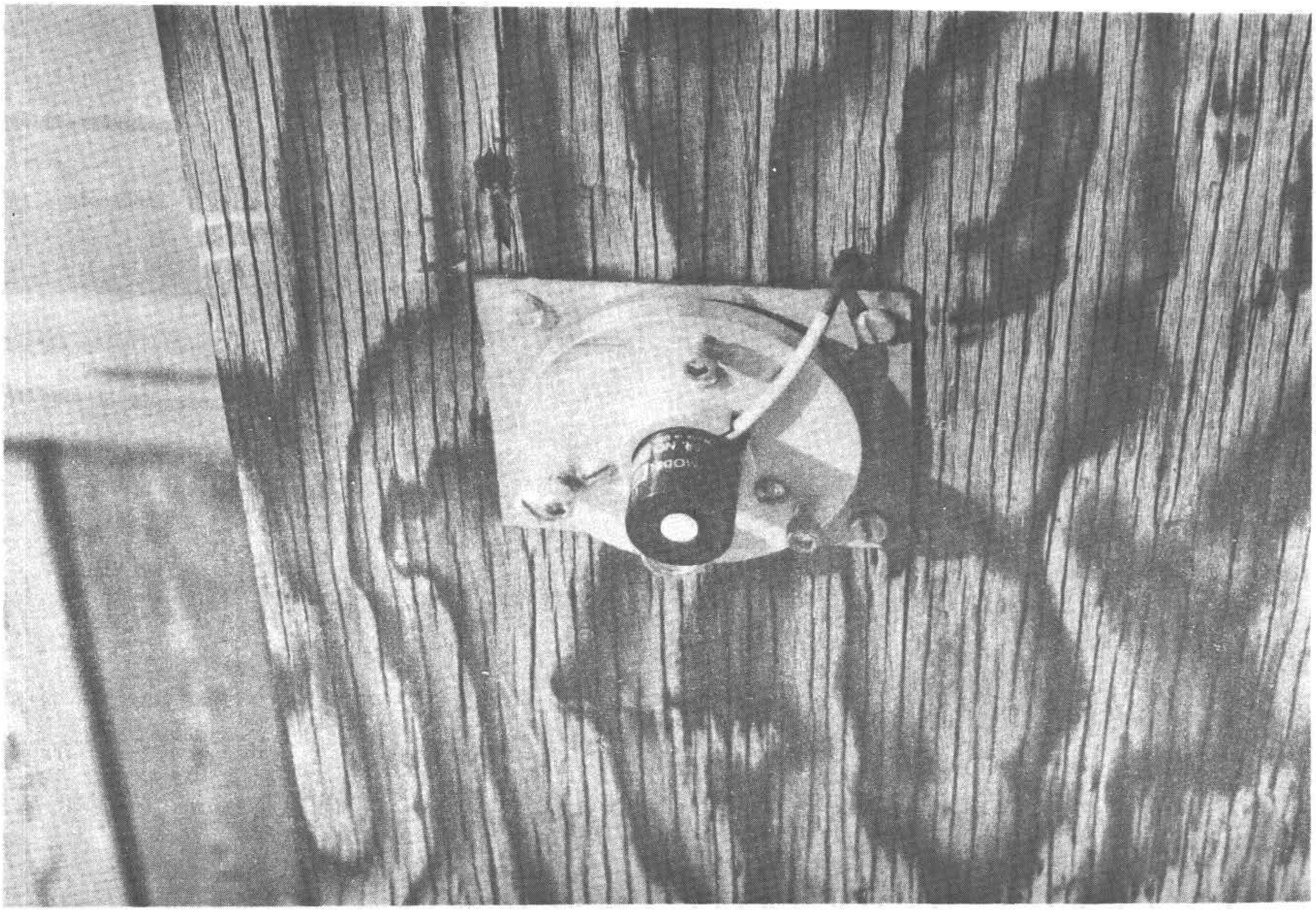


FIGURE 34. PYRANOMETER INSTALLATION - CONTROL ROOM ROOF

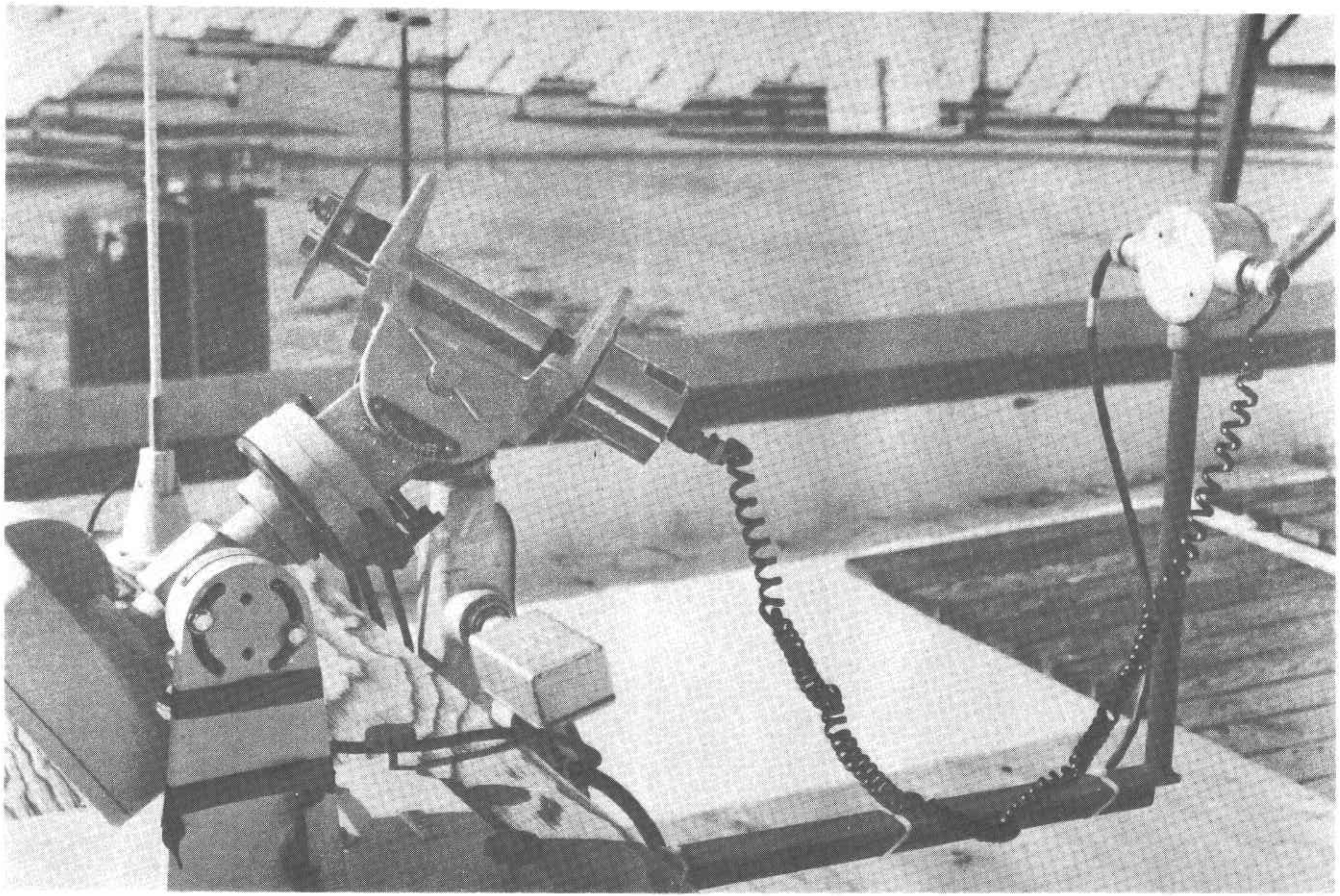


FIGURE 35. NIP-TRACKER INSTALLATION - CONTROL ROOM ROOF

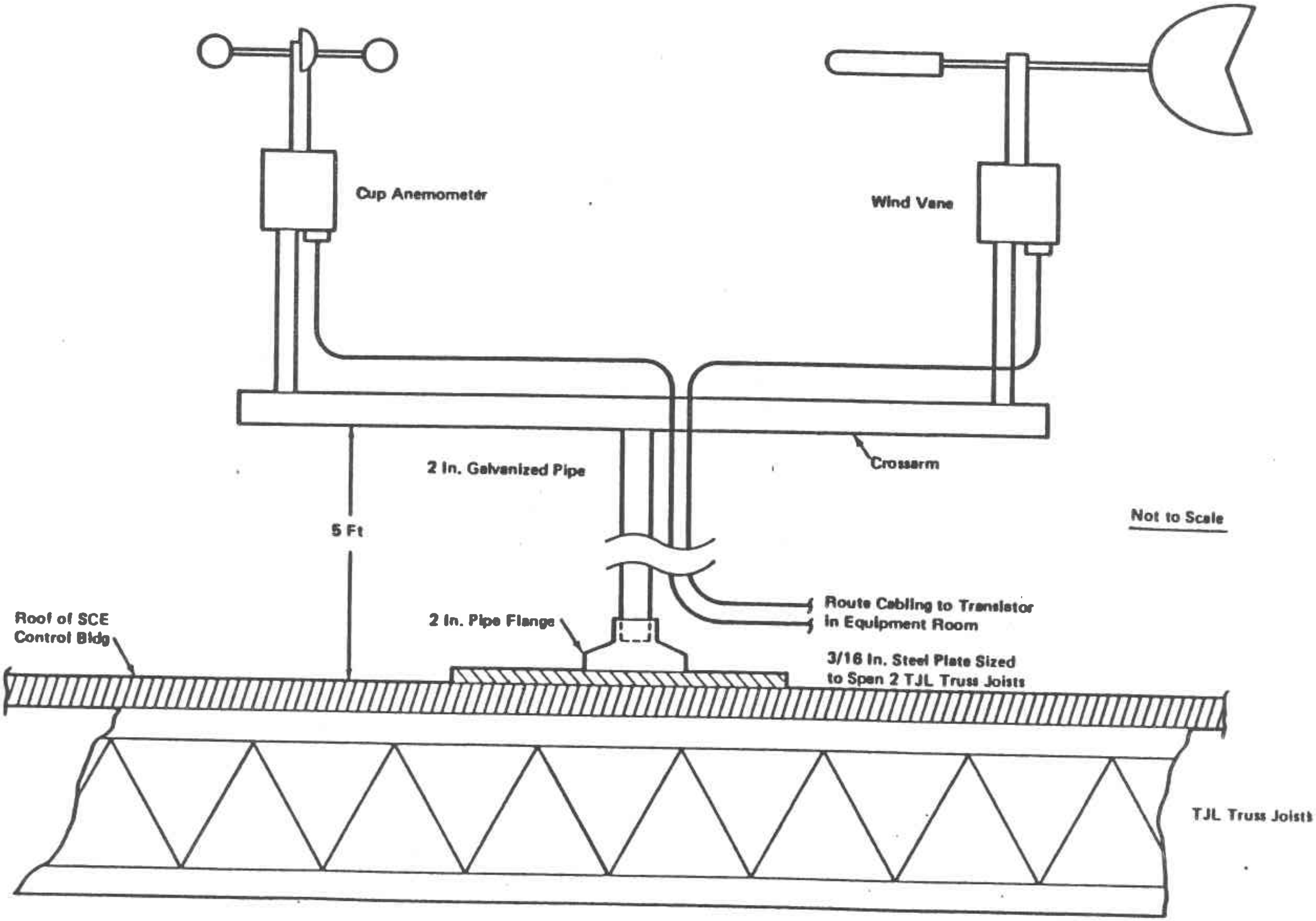


Figure 36. WIND SENSOR DESIGN - CONTROL ROOM ROOF

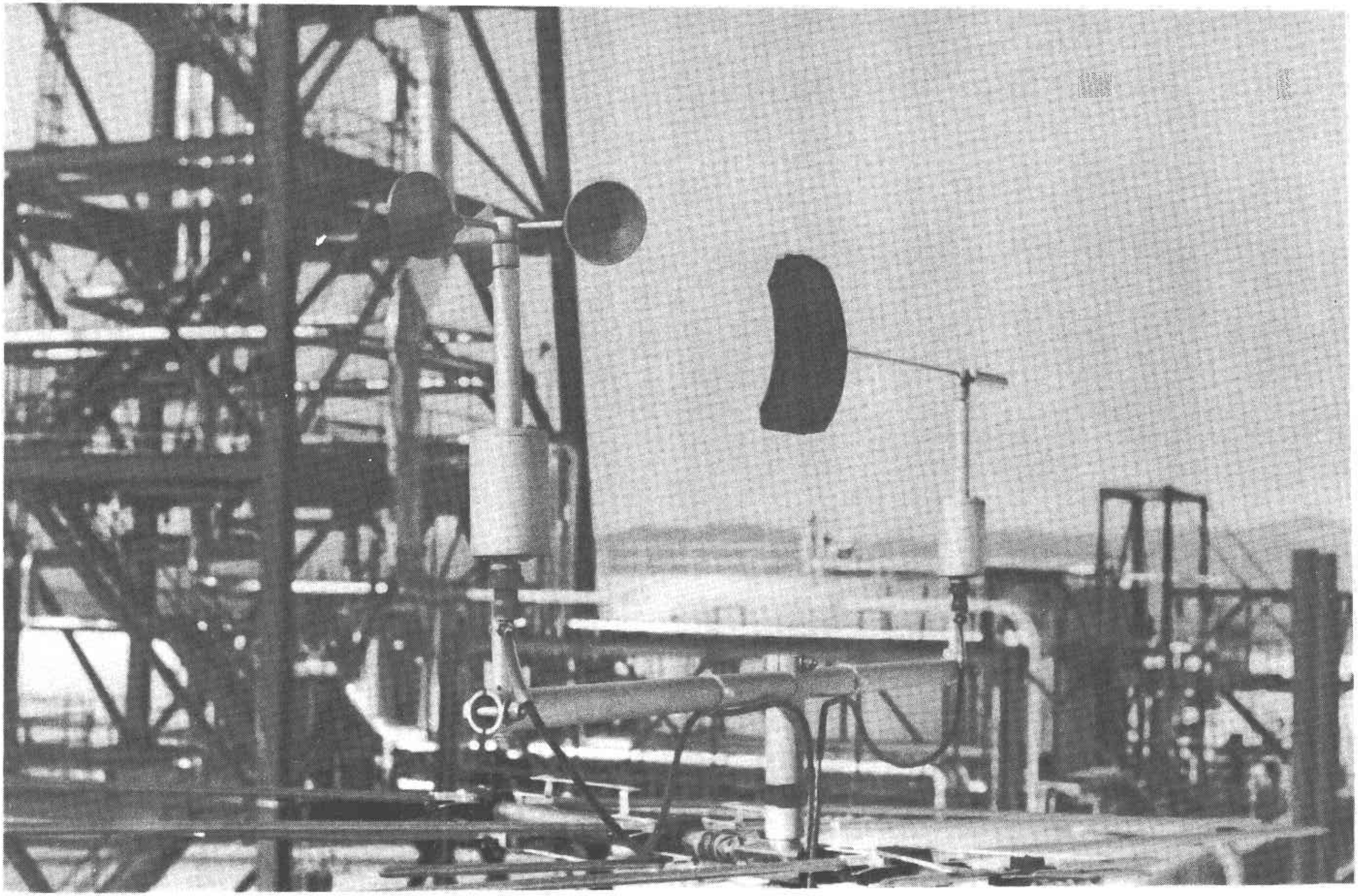


FIGURE 37. WIND SENSOR INSTALLATION - CONTROL ROOM ROOF

are:

	X	Y
Hail Cube No. 1 (NW)	-476.473 ft	-650.038 ft
Hail Cube No. 2 (NE)	-476.473 ft	+650.038 ft
(tolerance of ± 2 feet)		

The cubes consist of five 1 ft by 1 ft faces of 1 inch thich polystyrofoam which are covered with 1.5 mil thick aluminum foil. A closeup of a hail cube is shown in Figure 38.

3.2.10 Pyranometers

Seven pyranometers are located on the four spoke roads for cloud obscuration studies, as shown previously in Figure 8. The specific collector field coordiantes for the pyranometers are shown in Table 2.

Table 2. Pyranometer Collector Field Location Coordinates

Pyranometer	Collector Field Coordinates	
	X	Y
South Spoke Road	503.556	-30
West Spoke Road (inner)	-20	-502.282
West Spoke Road (outer)	-22.0	-864.00
North Spoke Road (inner)	-500.701	-20
North Spoke Road (outer)	-853.478	-20
East Spoke Road (inner)	-20	502.282
East Spoke Road (outer)	-22.0	864.00

The pyranometers used are identical to the one installed on the control room roof, as shown in Figure 34. They are each mounted on a tower which is identical to the wind tower design. A spoke road pyranometer tower installation is shown in Figure 39.

3.2.11 Instrument Data

The pertinent data for each of the types of meteorological instruments used at the Solar One Site are shown in Table 3.

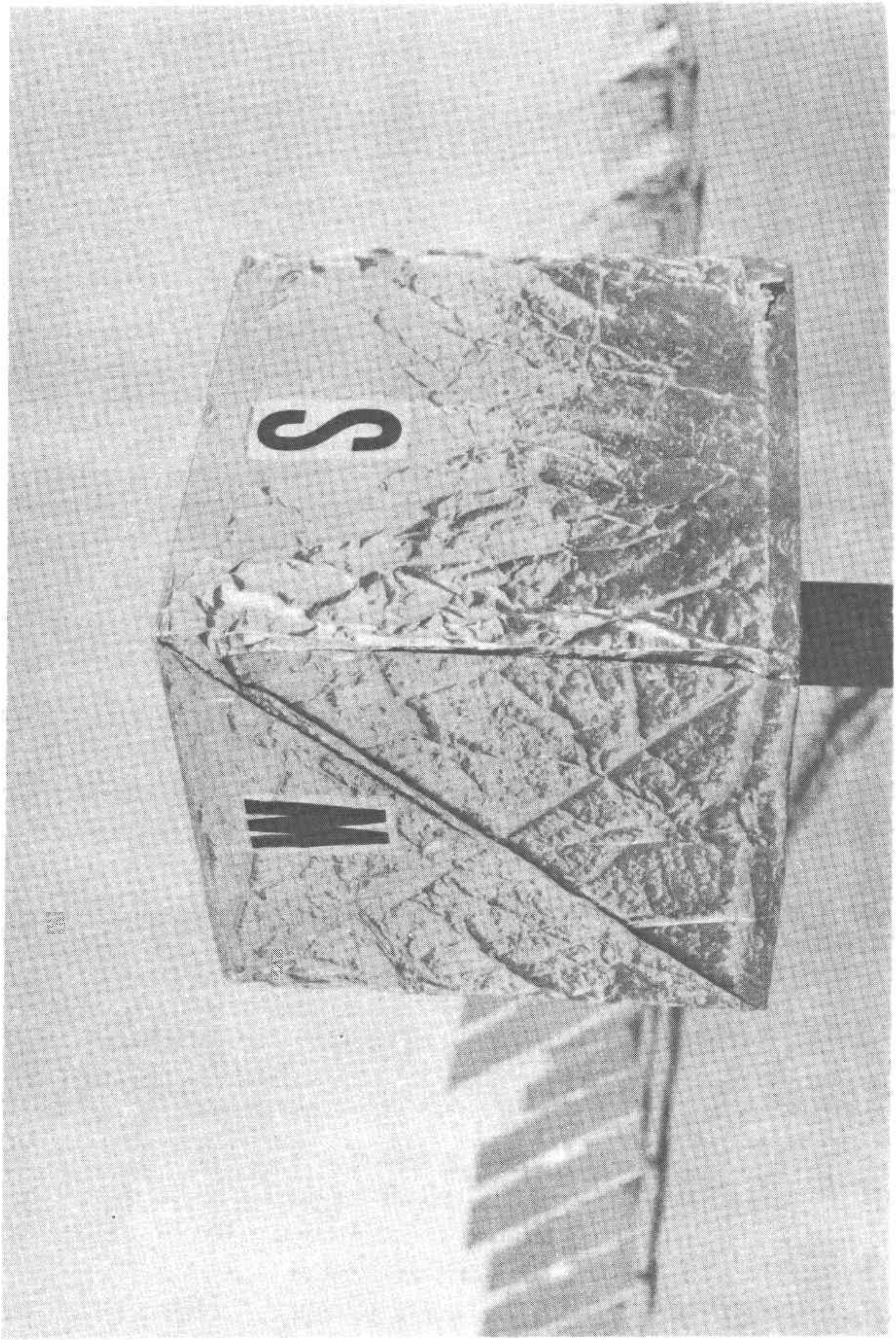


FIGURE 38. HAIL CUBE

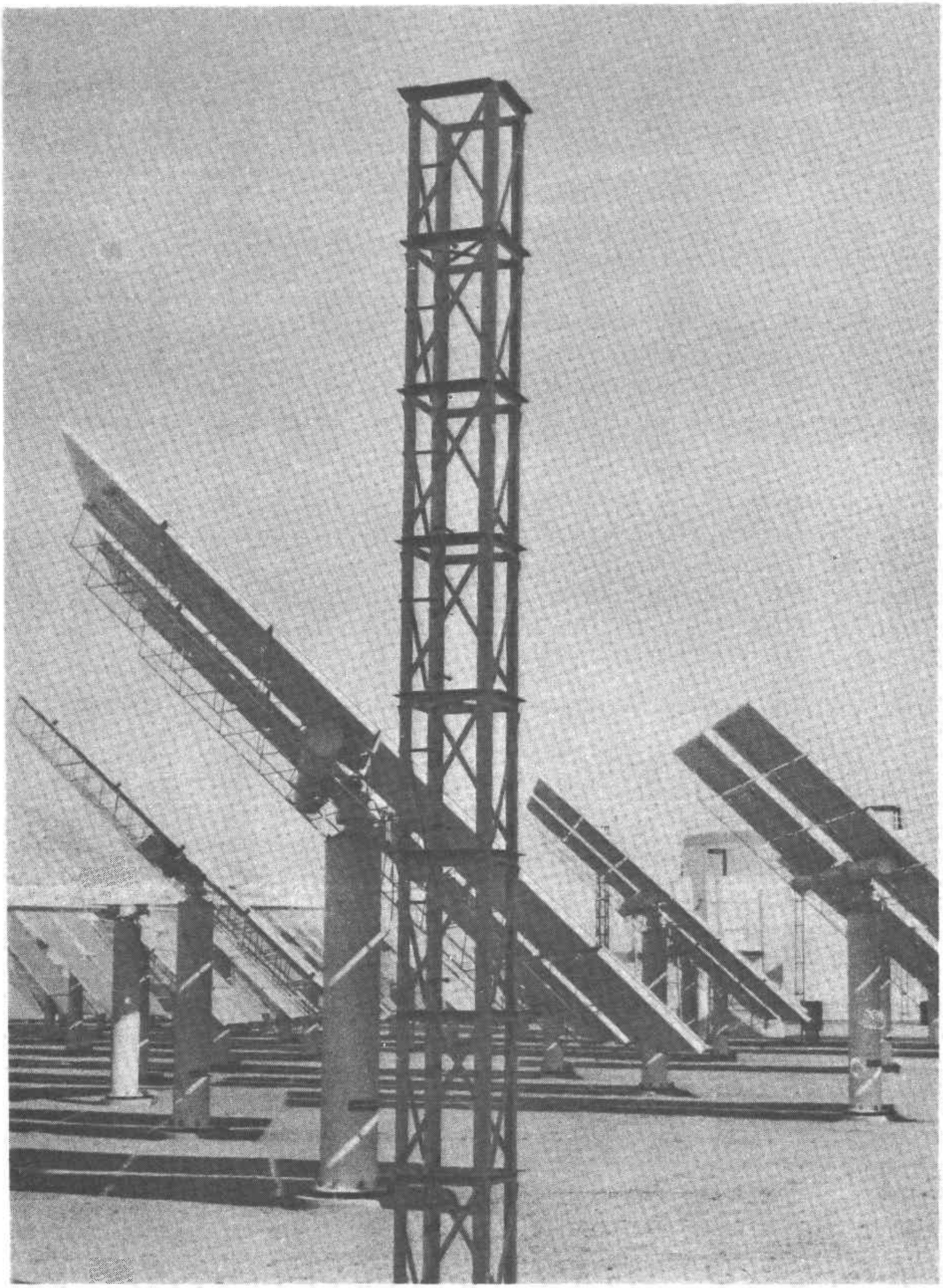


FIGURE 39. SPOKE ROAD PYRANOMETER TOWER INSTALLATION

Table 3

METEOROLOGICAL INSTRUMENT DATA

INSTRUMENT	MANUFACTURER	RANGE	SYSTEM ACCURACY
• NORMAL INCIDENCE PYHELIOMETER (NIP)	THE EPPLEY LAB, INC. 12 SHEFFIELD AVE. NEWPORT, RI 02840	0-1394 WATTS/m^2	± 0.6%
• PYRANOMETER	LI-COR, INC. BOX 4425 LINCOLN, NEBRASKA 68504	0-1250 WATTS/m^2	± 12 1/4%
• TIPPING BUCKET RAIN GAUGE	METEOROLOGY RESEARCH INC BOX 637 464 W. WOODBURY RD ALTADENA, CA 91001	1/100 IN PER TIP 3 IN/HR 10 IN/HR	 ± 1% ± 5%
• NEPHALOMETER	METEOROLOGY RESEARCH INC BOX 637 464 W. WOODBURY RD ALTADENA, CA 91001	40 MILES	± 10%
• DEW POINT SENSOR	CLIMET INSTRUMENT CO. P.O. BOX 151 1320 W. COLTON AVE REDLANDS, CA 92373	0-120°F	± 4%
• CUP ANEMOMETER	CLIMET INSTRUMENTS CO. P.O. BOX 151 1320 W. COLTON AVE. REDLANDS, CA 92373	0-100 MPH -50° - +115°F OPERATING TEMP.	+ 1% OR 0.15 MPH (WHICHEVER IS GREATER)
• WIND VANE	CLIMET INSTRUMENTS CO P.O. BOX 151 1320 W. COLTON AVE. REDLANDS, CA 92373	0-360°	± 3.2%
• HAIL CUBE	NONE (LOCAL FABRICATION)	--	--
• PLATINUM RESISTANCE TEMPERATURE SENSOR	ROSEMOUNT, INC. P.O. BOX 35129 MINNEAPOLIS, MINN 55435	0-120°F	± 1/2%
• BAROMETRIC PRESSURE SENSOR	YELLOW SPRINGS INSTR. CO. INDUSTRIAL DIVISION YELLOW SPRINGS, OHIO 45387	24.6-31.5 IN HG -30°F - +180°F OPER. TEMP.	± 0.4%

FOR MORE DETAILS ON THE OPERATION AND MAINTENANCE OF THIS EQUIPMENT, PLEASE REFER TO THE PLANT MAINTENANCE MANUAL, RADL ITEM 2-37, SECTION 8

SECTION 4

DATA TAPES

4.1 DESCRIPTION

Summary data tapes are being prepared at McDonnell Douglas for delivery to Sandia, for a limited number of tag identifications (ID's), including all of the meteorological measurements of interest, and these data can be used for additional analysis by interested parties. The description of the data tapes is as follows:

- Data will be taken from the archive tapes which contain information for all tag ID's and for the actual data scan rates in effect at the time of the test. The data tapes will contain information for approximately 300 tag ID's of particular interest. The data will be written to this tape at 3 minute intervals, with no time averaging.

- Data will be written to tape in 8-bit ASCIT. The tapes will be 9-track, and will be written at 1600 BPI density. 6254 BPI is a possibility.

- Tapes will contain two weeks of data; the time period of greatest interest initially is from November 1, 1982 forward to time now. Time periods between February 2, 1982 and October 31, 1982 will be added subsequently, as well as time period during 1983 from time now forward.

4.2 AVAILABILITY

The summary data tapes will be available from Sandia Livermore, with the initial tapes for the November and December 1982 time period being available after March 1, 1983.

SECTION 5

METEOROLOGICAL DATA

5.1 GENERAL

This section contains the meteorological data which were selected from the available data between April 16th and December 31st, 1982 for inclusion in this report. The data were principally derived through the computer-centered data reduction system being used at McDonnell Douglas to support the Solar One test program. This system uses a PDP-10 Computer in conjunction with data reduction programs and a tektronix 4014 printer to produce the plots and tabulations desired.

The plot format has a 10 x 10 grid, on which a maximum of five tag ID's can be plotted. They are identified at the bottom of the page, below the grid. The values of each of the elements of the vertical scale are equal to one-tenth of the range shown for the tag ID. The horizontal time scale is variable, with 1500 minutes being chosen to cover a full day plus, with each element equal to 2-1/2 hours. The reference time shown is the day of the year, with January 1 being day 1, etc. The start time is shown beside the day, with 00 signifying midnight. An Nth sample average of 1 indicates the data were plotted at 1 minute intervals. In addition to the PDP-10 system, data were obtained from the midnight readings of insolation recorded on the Beckman MV8000 system, and the rainfall data for this report were obtained from the Barstow-Daggett airport. Additional specific comments are included with the data packages in the following sections.

5.2 LIST OF TAG ID'S AND INSTRUMENT

The tag ID's and instruments of interest for the meteorological data report are shown below:

LTX	1806	Tipping Rain Gauge
TTX	1803	Air Temperature, South Station
MTX	1805	Dewpoint, South Station
MTX	1832	Dewpoint, Receiver Tower Level 7
ATX	1834	Pyranometer, Control Room Roof
ATX	1817	Normal Incidence Pyrheliometer, North Station
##ATX	1817A	Normal Incidence Pyrheliometer, Control Room Roof

ATX	1808	South Station Pyranometer
ATX	1809	South Spoke Road Pyranometer
ATX	1812	West Station Pyranometer
ATX	1813	West Spoke Road Pyranometer, outer
ATX	1814	West Spoke Road Pyranometer, inner
ATX	1819	North Station Pyranometer
ATX	1820	North Spoke Road Pyranometer, outer
ATX	1821	North Spoke Road Pyranometer, inner
ATX	1824	East Station Pyranometer
ATX	1825	East Spoke Road Pyranometer, outer
ATX	1826	East Spoke Road Pyranometer, inner
ATX	1834	Control Room Roof Pyranometer

Wind Speed

STX	1801	South Station
STX	1810	West Station
STX	1815	North Station
STX	1822	East Station
STX	1827	Receiver Tower Level 7, East
STX	1829	Receiver Tower Level 7, West
STX	1839	Wind Tower 1, 32.2 feet
STX	1840	Wind Tower 1, 20 feet
STX	1841	Wind Tower 1, 10 feet
STX	1843	Wind Tower 2, 32.2 feet
STX	1844	Wind Tower 2, 20 feet
STX	1845	Wind Tower 2, 10 feet
STX	1847	Wind Tower 3, 32.2 feet
STX	1848	Wind Tower 3, 20 feet
STX	1849	Wind Tower 3, 10 feet
STX	1851	Wind Tower 4, 32.2 feet
STX	1852	Wind Tower 4, 20 feet
STX	1853	Wind Tower 4, 10 feet
STX	1855	Wind Tower 5, 32.2 feet
STX	1856	Wind Tower 5, 20 feet
STX	1857	Wind Tower 5, 10 feet
STX	1859	Wind Tower 6, 32.2 feet

STX	1860	Wind Tower 6, 20 feet
STX	1861	Wind Tower 6, 10 feet

<u>Wind Direction</u>

OTX	1802	South Station
OTX	1811	West Station
OTX	1816	North Station
OTX	1823	East Station
OTX	1828	Receiver Tower Level 7, East
OTX	1830	Receiver Tower Level 7, West
OTX	1842	Wind Tower 1, 32.2 feet
OTX	1846	Wind Tower 2, 32.2 feet
OTX	1850	Wind Tower 3, 32.2 feet
OTX	1854	Wind Tower 4, 32.2 feet
OTX	1858	Wind Tower 5, 32.2 feet
OTX	1862	Wind Tower 6, 32.2 feet

5.3 SPECIFIC COMMENTS ON DATA

The data included in this report have been chosen by Sandia following an informal review and discussion of the total data processed. Data not published in this report have been submitted to Sandia separately. The total data base between 4/16/82 and 12/31/82 consists of 167 data days. Eighty-nine of these days have been processed and insolation data are included in the report. The remaining 78 days have not been processed as of this printing because of schedule and funding constraints. Twenty-three of the 89 days in this report had cloud activity, with 7 days of low and 16 days of high activity.

Specific comments about the data shown or not shown on the plots are as follows:

1) If a tag ID listing is followed by a tag ID not available, this tag ID was not on the scan list on the day the data were recorded. This may be the case even though the instrument is working.

2) If a tag ID listed on the plot shows no data, the instrument was not operating at all, or was operating and reading zero.

3) If the data for a tag ID show for only part of a day, the data acquisition system was very probably not archiving data for the missing time periods.

5.4 HAIL DATA

Six hail cubes are deployed at the Solar One site. The physical characteristics are as shown and described in Section 3. There were no occurrences of hail at the Solar One site during the test period covered in this report.

5.5 RAINFALL DATA

A tipping bucket raingauge (tag ID LTX 1806) is installed and operating at the south weather station of Solar One. Because the system was not operational initially in the test program, and because the system is not guaranteed to be recording when precipitation occurs, a summary of Barstow rainfall as recorded at the Barstow-Daggett airport is included as Table 4 to provide representative rainfall data for the Solar One site.

5.6 TEMPERATURE DATA

Daily plots of temperature data recorded at the Solar One site (air temperature and dewpoint data for the south station and receiver tower level 7) have been submitted to Sandia separately. Since the recorded data is not complete, a review was made of data from the weather station at the Daggett airport. The range of the high and low temperatures for each month is shown in Table 5.

5.7 WIND DATA

The wind data at the Solar One site was not complete in 1982 due to the higher priority given to startup and check-out of the plant, and much of the data is wrong because the instrumentation was installed incorrectly. Data from the weather station at the Daggett airport is included in Table 6 to provide representative wind data for the Solar One site. The airport data is recorded hourly, therefore many of the peak wind speeds were proably not recorded. All of the windy days are represented in Table 6, which shows the recorded peak wind speeds and the wind direction when these peaks occurred. The number of days during each month when the wind speed exceeded 30 mph is between 8-10 mph and 20-22 mph is shown in Table 7. At these lower wind speeds, the wind direction tends to be from the northwest at 8-10 mph and southwest at 20-22 mph wind speeds rather than from thw west like the higher wind speeds.

Table 4. BARSTOW RAINFALL SUMMARY

(All rainfall values are in inches)

	Month											
1956 - 1970 Data	J	F	M	A	M	J	J	A	S	O	N	D
Ave/Month	0.31	0.32	0.28	0.21	0.07	0.05	0.31	0.60	0.51	0.22	0.37	0.35
Max/Month	0.90	1.50	1.01	1.83	0.49	0.32	0.96	3.22	2.31	1.01	1.74	2.02
Max/24 Hours	0.73	0.70	0.88	0.65	0.37	0.32	0.96	2.06	1.11	0.66	1.08	1.01
Ave/Occur/Month	3.20	3.30	2.40	2.10	0.70	0.50	1.80	2.40	1.60	1.90	3.30	2.70
Months with no Rain	0	2	2	3	10	10	2	4	6	5	1	4
1982 Data												
Rainfall	0.90	0.51	0.16	0.61	0.05	0	1.40	1.02	0.31	0.16	0.35	0.85
Max/24 Hours	0.34	0.51	0.09	0.55	0.05	0	0.74	0.96	0.25	0.15	0.13	0.52
Number of Occurrences	10	2	13	3	2	0	5	5	5	3	3	4

Table 5

HIGH AND LOW TEMPERATURE RANGES AT THE DAGGETT AIRPORT

Month	Range of Low Temperatures (°F)	Range of High Temperatures (°F)
January	21 - 47	51 - 71
February	28 - 60	51 - 81
March	38 - 59	60 - 78
April	40 - 60	57 - 91
May	48 - 73	69 - 98
June	60 - 75	83 - 103
July	62 - 84	88 - 106
August	66 - 86	83 - 107
September	53 - 78	69 - 107
October	43 - 60	65 - 85
November	35 - 57	63 - 83
December	31 - 45	45 - 73

Table 6. DAGGETT AIRPORT WIND DATA

Month	Windy Day Peak Wind Speeds (mph)	Wind Direction (degrees)	No. of Days When Speed Exceeded 30 mph
January	38	290	7
	38	290	
	30	240	
	41	270	
	33	270	
	40	210	
	34	260	
February	34	280	3
	34	250	
	40	260	
March	34	290	8
	40	270	
	32	270	
	37	300	
	37	250	
	32	270	
	36	230	
	38	260	
April	34	250	6
	34	270	
	32	240	
	32	270	
	32	230	
	31	260	
May	34	230	6
	37	240	
	31	260	
	34	240	
	31	240	
	34	220	
June	32	250	4
	37	270	
	38	250	
	32	230	

Table 6 (cont'd)

Month	Windy Day Peak Wind Speed (mph)	Wind Direction (degrees)	No. of Days When Speed Exceeded 30 mph
July	32	260	2
	36	250	
August	22	240	0
	24	240	
September	29	90	3
	30	250	
	36	260	
	34	270	
October	34	260	2
	37	250	
November	28	150	3
	34	260	
	31	230	
	41	250	
December	34	230	4
	30	280	
	32	270	
	40	270	

Table 7

DAGGETT AIRPORT WIND DIRECTION VERSUS WIND SPEED

Month	Direction When Wind Speed 8-10 mph	Direction When Wind Speed 20-22 mph
January	260 - 305 degrees	245 - 275 degrees
February	285 - 320	220 - 245
March	245 - 280	250 - 265
April	285 - 310	250 - 270
May	260 - 300	240 - 250
June	255 - 275	255 - 270
July	250 - 285	250 - 265
August	270 - 310	no wind 20 -22 mph
September	280 - 310	275 - 355
October	280 - 315	260 - 275
November	270 - 315	240 - 260
December	270 - 300	235 - 250

5.8 INSOLATION DATA

The Solar One direct normal insolation data recorded at Solar One is shown on Table 8. Monthly totals and daily averages are tabulated for Southern California Edison Barstow data for 1976 and for three 1982 Solar One parameters, as follows:

NIP 1000 - The total integrated value of direct normal insolation from horizon to horizon, as recorded by normal incidence pyrheliometer (NIP).

NIP Hours - The useable portion of the total, with cutoffs at 500 W/m^2 on startup and shutdown.

NIP TIME - A total value of time, per day, as determined by a counter, when insolation levels were above 450 W/m^2. (The data not available for the April-September time frame means that the counter was not in operation until October.)

A comparison of the total direct normal values (NIP and NIP 1000) for 1976, 1982 and 25-year averages in Table 8 shows that the average daily insolation was much lower during 1982. This can be due to two things: 1) the insolation intensity is lower, and 2) there were more cloudy days in 1982. The rainfall data in Table 4 shows that there were more occurrences of rain and the plots of direct normal insolation, which are included later in this report, show that the peak insolation levels are lower than 1976. A comparison of the maximum and average peak insolation levels is shown in Table 9 for five months, for which 89 days of 1982 data have been obtained. The average peak insolation was higher in 1982 during April, May and June and lower in November and December. This may be due to the small number of days for which data is available, or April, May and June were hazy months in 1975.

Table 8. SOLAR ONE DIRECT NORMAL INSOLATION DATA - 1982

	NIP (Total) KW-HR/m²		NIP 1000 (Total) KW-HR/m²		NIP Hrs (Useable) KW-HR/m²		NIP Time (Time Above 450 W/m²) Hrs	
Month	1976 Daily Average*	25-Year** Daily Average	Monthly Total	Daily Average	Monthly Total	Daily Average	Monthly Total	Daily Average
April	8.00	8.01	217.307	7.244	194.968	6.499	Data not available	
May	8.95	8.69	230.267	7.428	201.008	6.484	Data not available	
June	10.56	9.39	246.113	8.204	206.266	6.876	Data not available	
July	8.23	8.76	243.820	7.865	205.126	6.617	Data not available	
August	10.13	8.32	193.405	6.239	146.992	4.742	Data not available	
September	5.78	7.59	171.441	5.715	129.669	4.322	Data not available	
October	7.47	6.65	178.677	5.764	144.269	4.654	211.920	6.836
November	7.19	5.52	139.605	4.654	95.884	3.196	171.130	5.704
December	6.40	4.83	119.500	3.855	82.524	2.662	150.128	4.843

*C. M. Randall, "Barstow Insolation and Meteorological Data Base," The Aerospace Corporation, Report ATR-78(7695-05)-2, March 13,1978.

**"Direct Normal Solar Radiation Data Manual," Solar Energy Research Institute, SERI/SP-281-1658, October 1982. (These direct normal insolation values are estimated from toal global data.)

Table 9

MAXIMUM AND AVERAGE PEAK INSOLATION VALUES FOR 1975-76 and 1982

	1975-1976		1982		
Month	Peak Insolation	Average Peak Insolation	Peak Insolation	Average Peak Insolation	Data Days
	1975				
April	990	780	940	889	6
May	985	800	970	887	12
June	990	810	920	871	8
	1976				
November	985	830	910	806	14
December	980	820	860	806	20

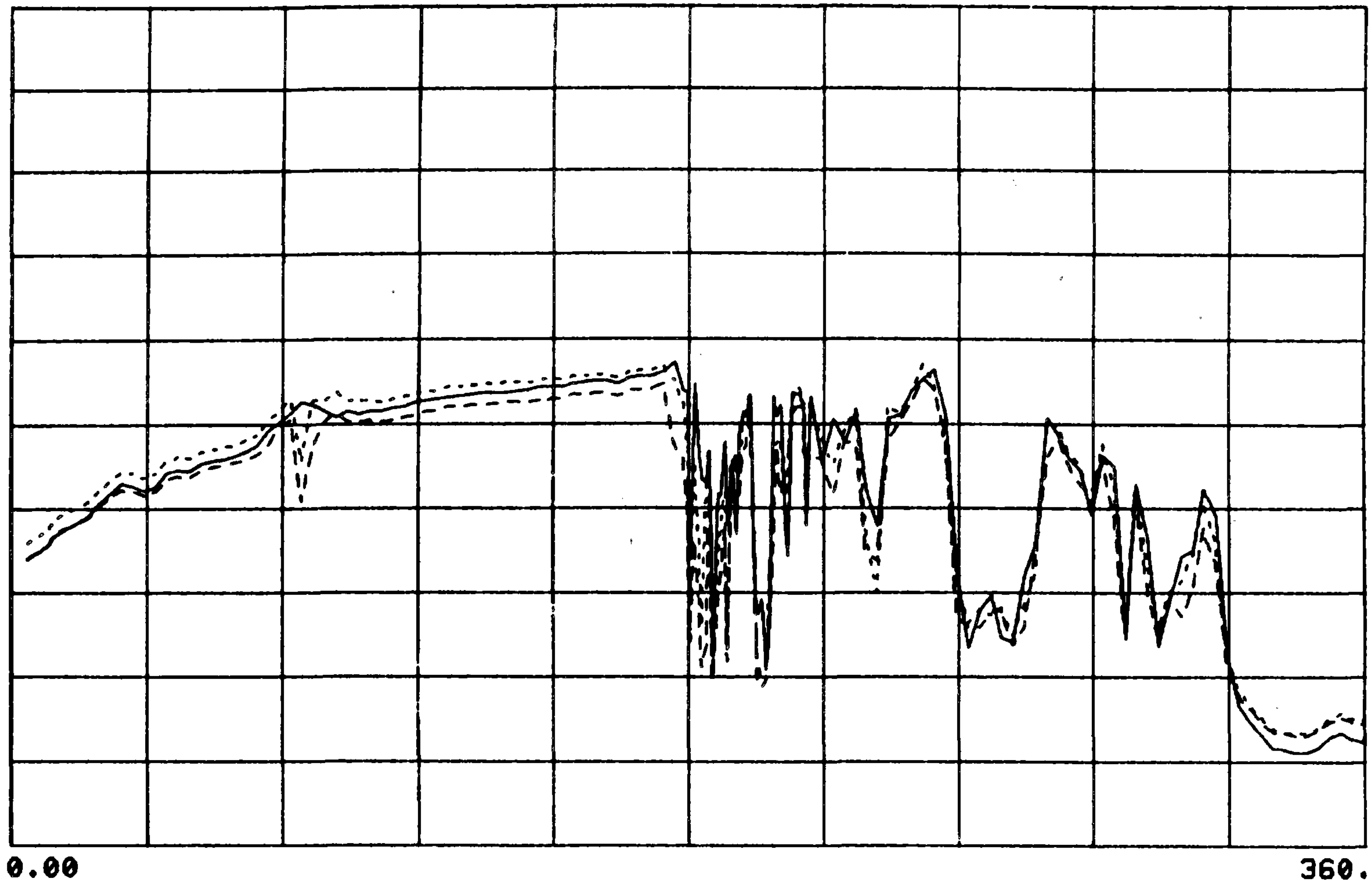
Pyranometer data are included on the following pages for two cloudy days of the total days processed. These pyranometers were installed for cloud passage studies and as a potential means of heliostat control during cloudy periods. The purpose of these plots is to show what type of data is available. The start time and date for each plot is noted as "Reference Time." The day of the year is listed first, followed by the time of day in hours, minutes, seconds, and milliseconds. For example, on page 74 the day is 341 (Dec 7) and the time is 9:00 a.m. Table 10 may be used to convert the day of the year to the date. The plot ends after 360 minutes (3:00 p.m.). The scale for the ordinate is shown on the bottom of the page. On page 74, full-scale is 1000 W/m^2.

Table 10

DAY OF THE YEAR AND DATE FOR 1982

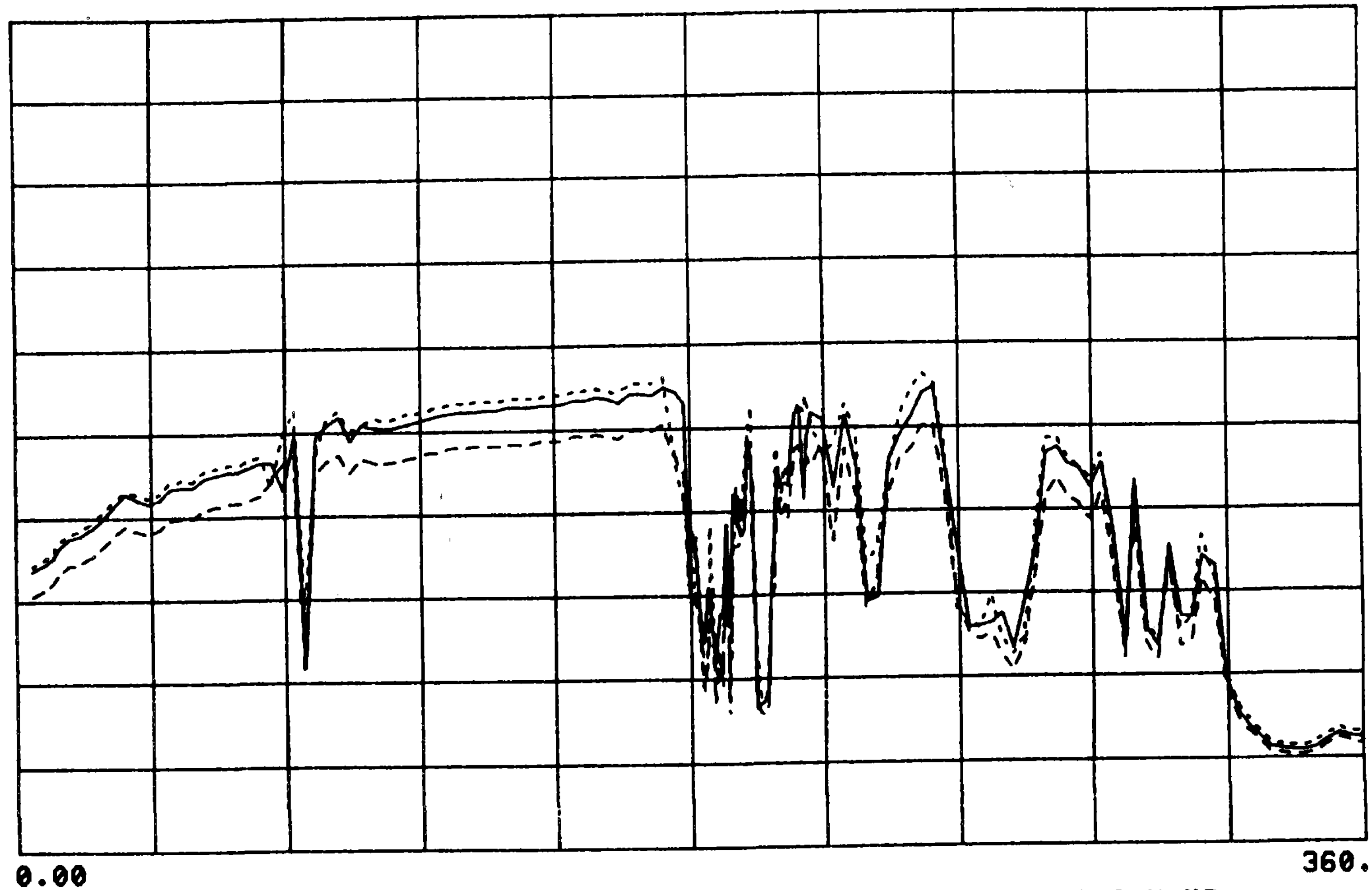
Day	Date	Day	Date
1	Jan 1, 1982	182	Jul 1, 1982
32	Feb 1	213	Aug 1
60	Mar 1	244	Sep 1
91	Apr 1	274	Oct 1
121	May 1	305	Nov 1
152	Jun 1	335	Dec 1

SOLAR DATA PLOT PLOT # MINS3 NTH SAMPLE AVERAGE = 6
REFERENCE TIME: 341 09 00 00.000 FOR 360.0000 MINUTE(S)



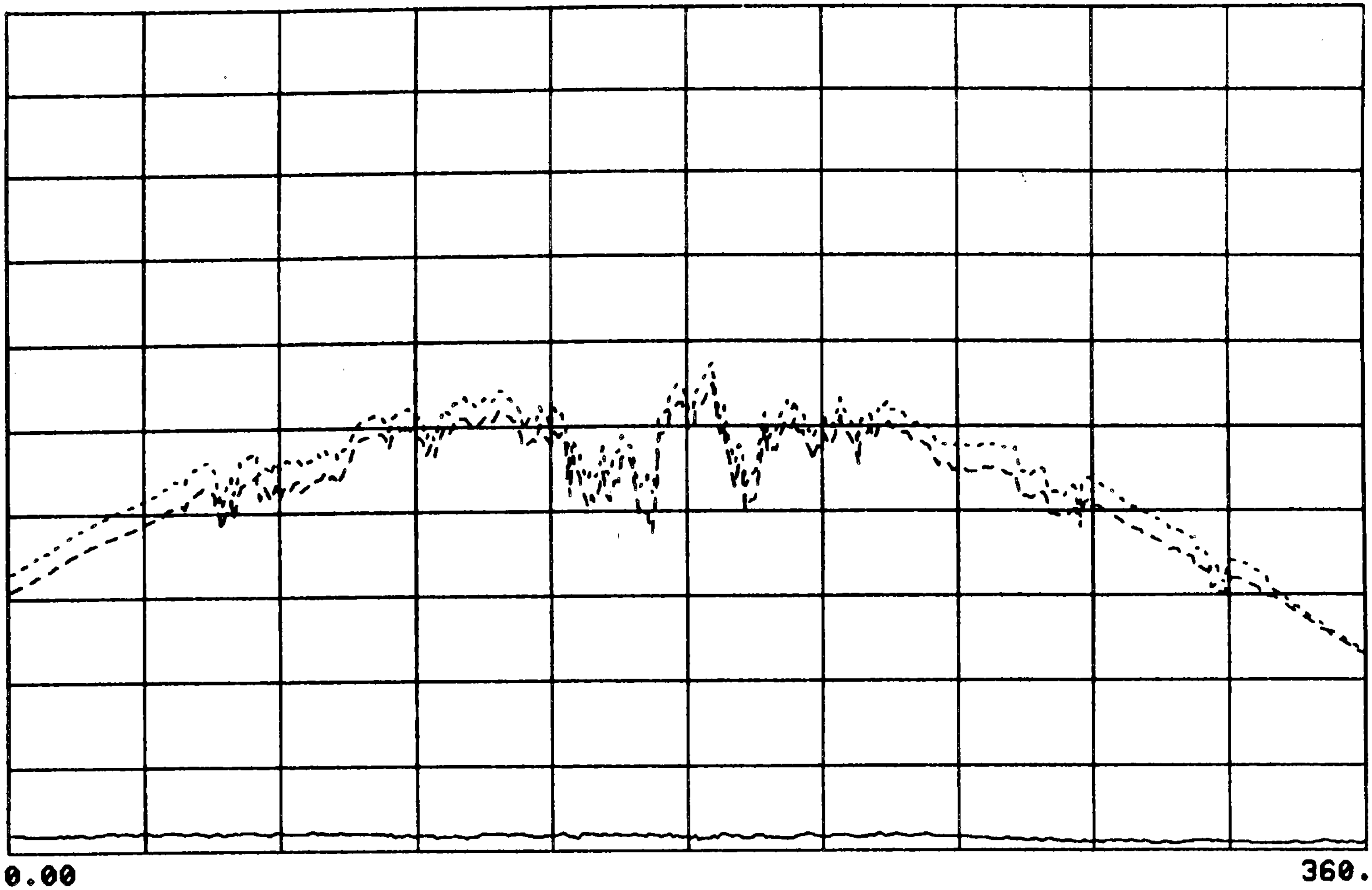
ATX1819	PYRAMTR (NORTH STATION)	0.0 -	1000.0 W/M2	___
ATX1820	PYRAMTR (NORTH SPOKE RD-OTR)	0.0 -	1000.0 W/M2	- - -
ATX1821	PYRAMTR (NRTH SPOKE RD-INNR)	0.0 -	1000.0 W/M2	_ _

SOLAR DATA PLOT PLOT # MINS2 NTH SAMPLE AVERAGE = 6
REFERENCE TIME: 341 09 00 00.000 FOR 360.0000 MINUTE(S)



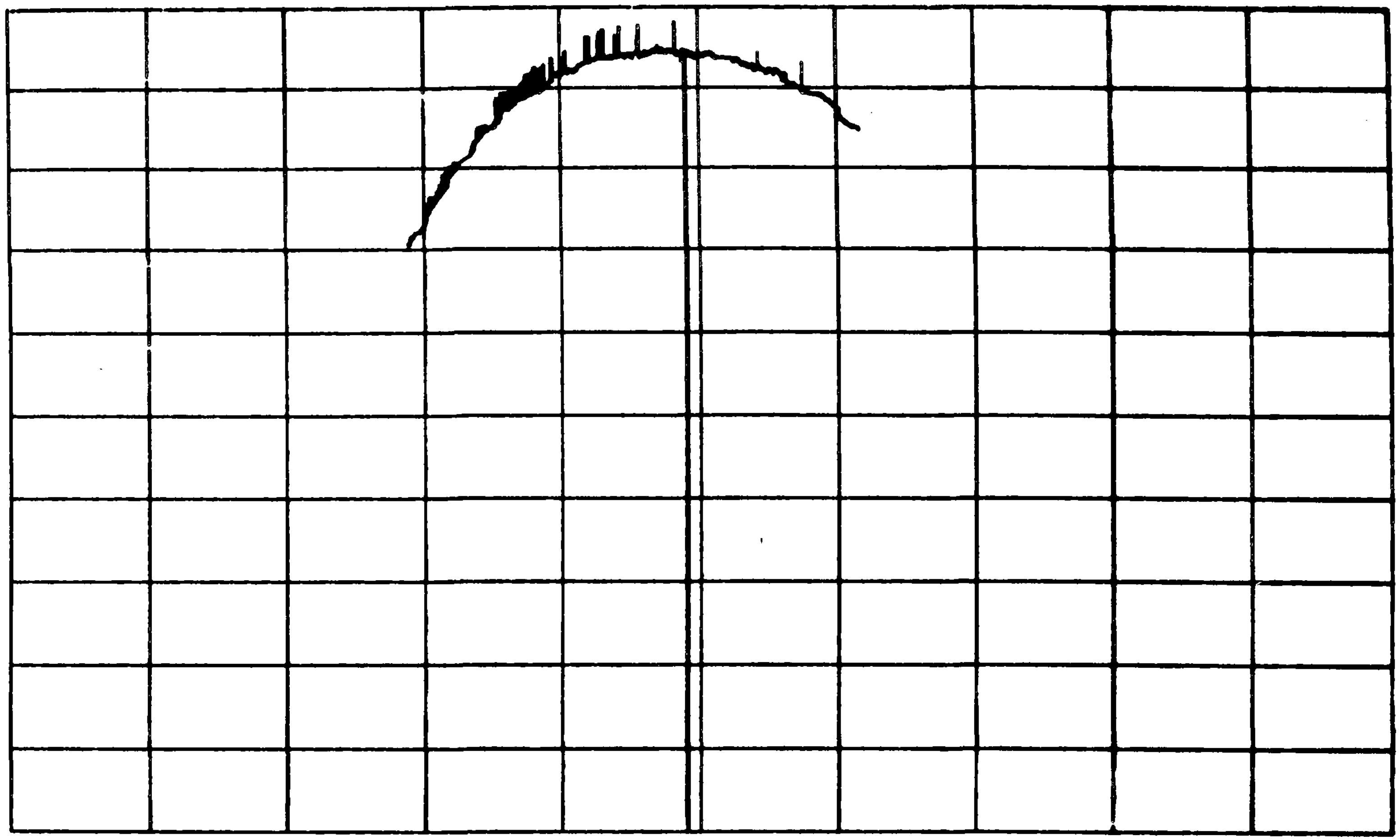
ATX1812	PYRAMTR (WEST STATION)	0.0 - 1000.0 W/M2	——
ATX1813	PYRAMTR (WST SPOKE RD-OUTR)	0.0 - 1000.0 W/M2	---
ATX1814	PYRAMTR (WST SPOKE RD INNR)	0.0 - 1000.0 W/M2	--

SOLAR DATA PLOT PLOT # MINS1 NTH SAMPLE AVERAGE = 2
REFERENCE TIME: 352 09 00 00.000 FOR 360.0000 MINUTE(S)

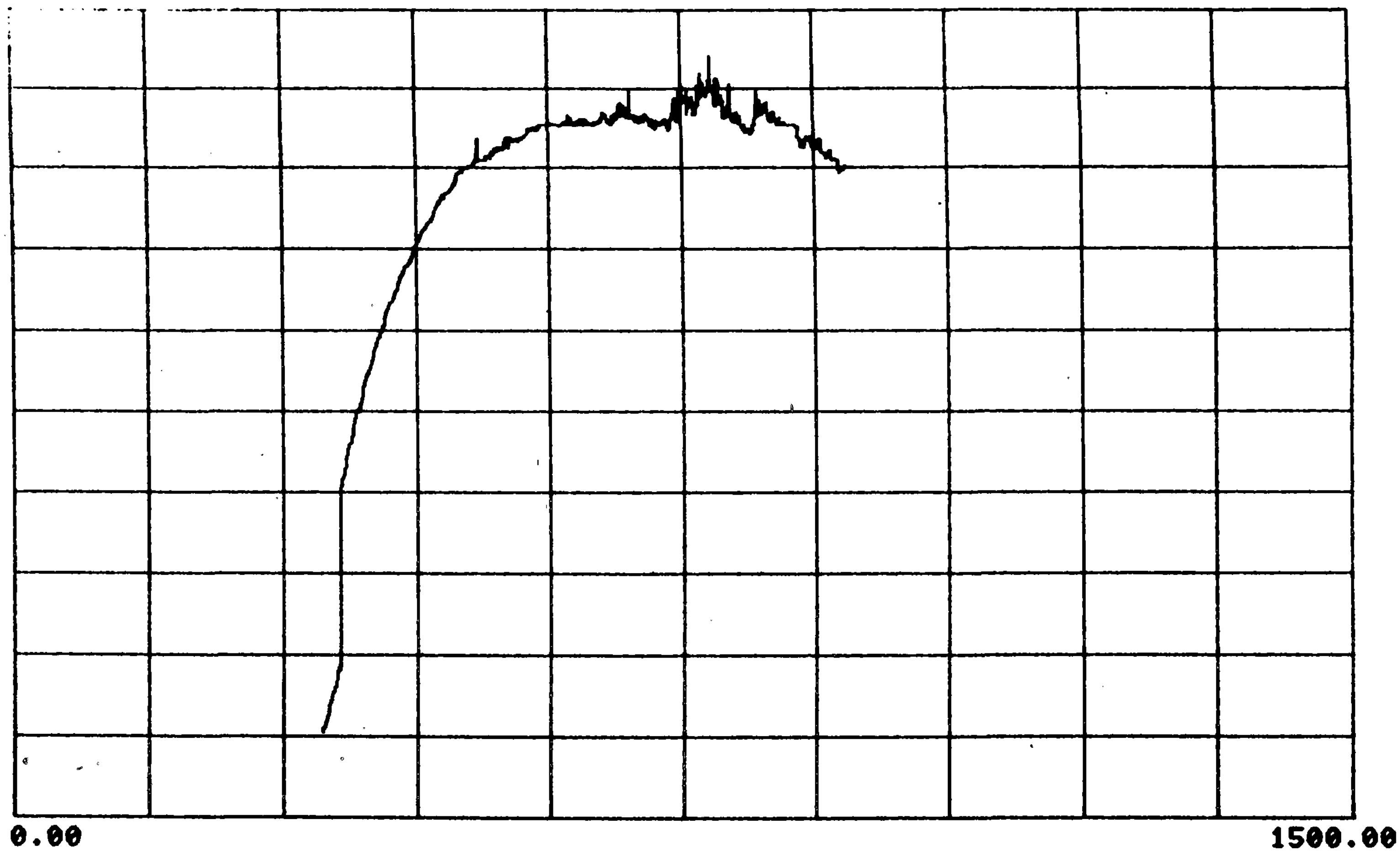


ATX1808	PYRAMTR (SOUTH STATION)	0.0 - 1000.0 W/M2	——
ATX1809	PYRAMTR (SOUTH SPOKE RD)	0.0 - 1000.0 W/M2	....
ATX1834	PYRA (CNTRL RM RF)	0.0 - 1000.0 W/M2	--.-

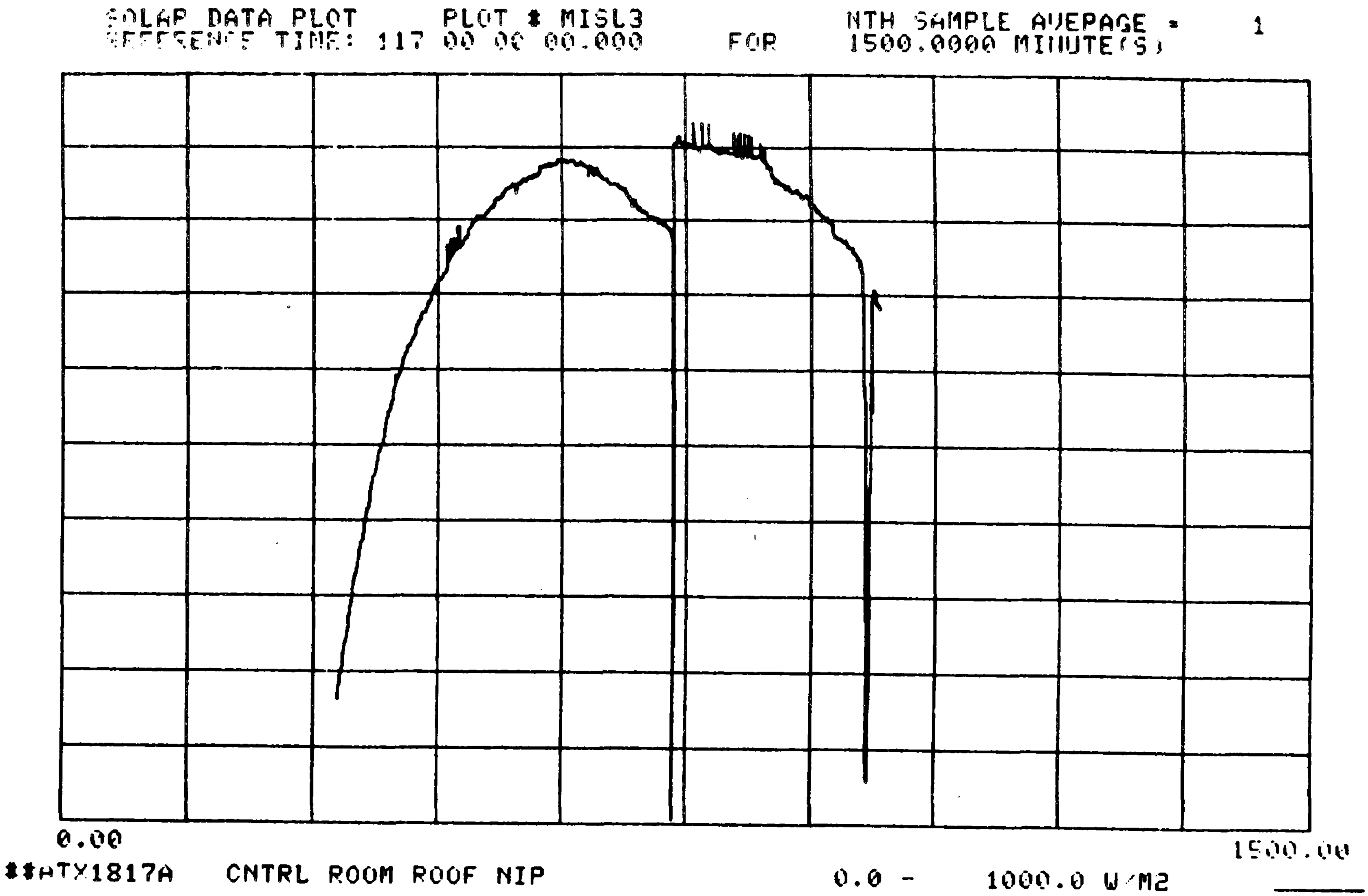
All of the available NIP data plots for 89 days are included on the following pages for the north station (ATX 1817) and the control room roof (##ATX 1817A). Starting with day 106 (April 16) and completing with day 365 (December 31). These direct normal insolation data plots show that there were few days when the peak normal insolation reached 900 W/m^2. Although the resolution on these plots is poor, they show the type of cloud passage transients that the plant must operate through. The data tapes that are available at Sandia could be read again to obtain much improved resolution if it is needed. The reference time (start time) for each plot is shown on the top of each page starting with the day of the year, followed by the time in hours, minutes, seconds, and milliseconds. For example, on page 75, the day is 106 (April 16) and the start time is midnight, and the stop time is 1500 minutes (25 hours) later. The scale for the ordinate is 0.0 to 1000 W/m^2.


SOLAR DATA PLOT
PLOT # NISL3
NTH SAMPLE AVERAGE = 1
REFERENCE TIME 106 00 00 00.000
FOR 1500.0000 MINUTE(S)
0.00
1500.00
**ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 113 00 00 00.000 FOR 1500.0000 MINUTE(S)

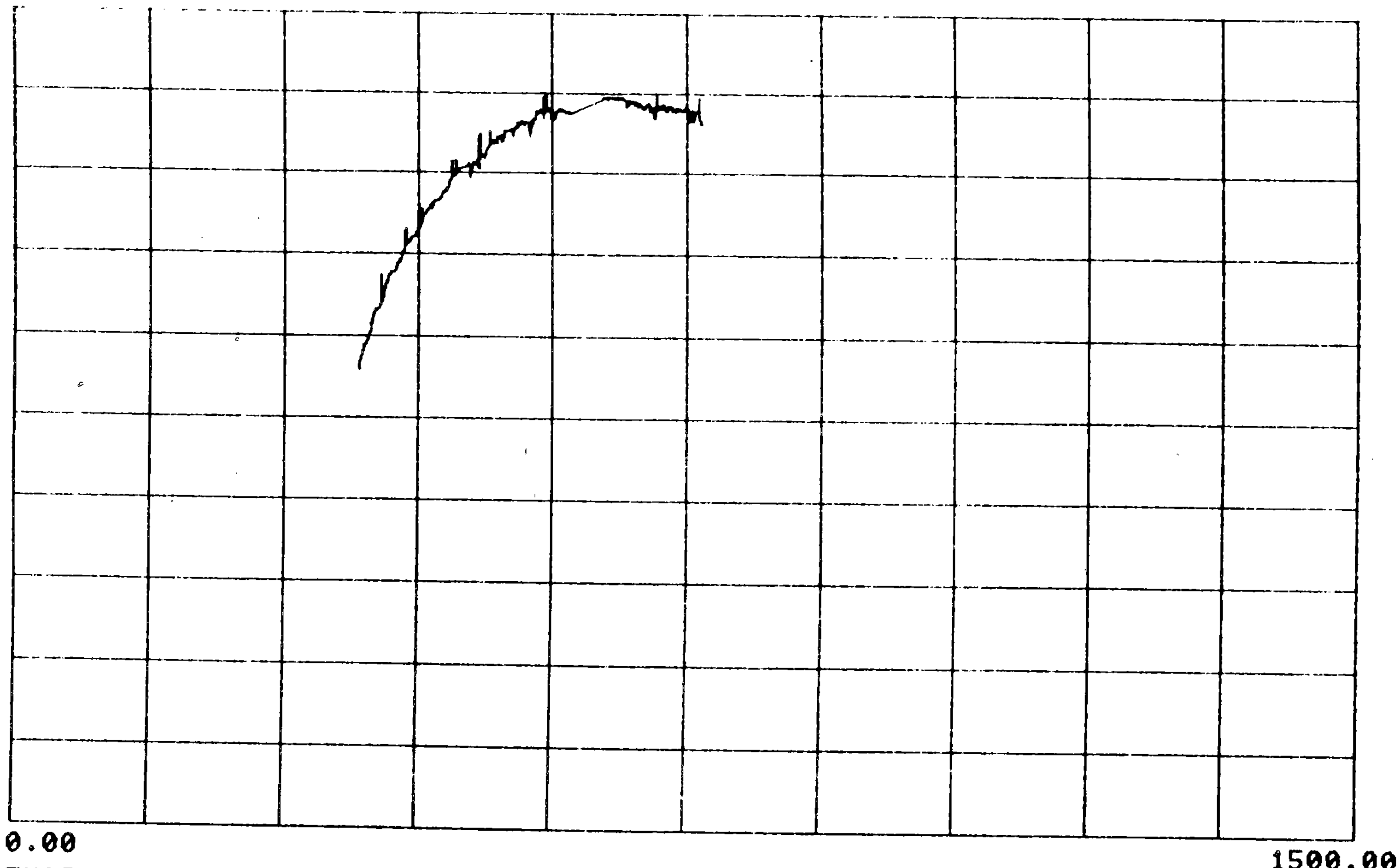


##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

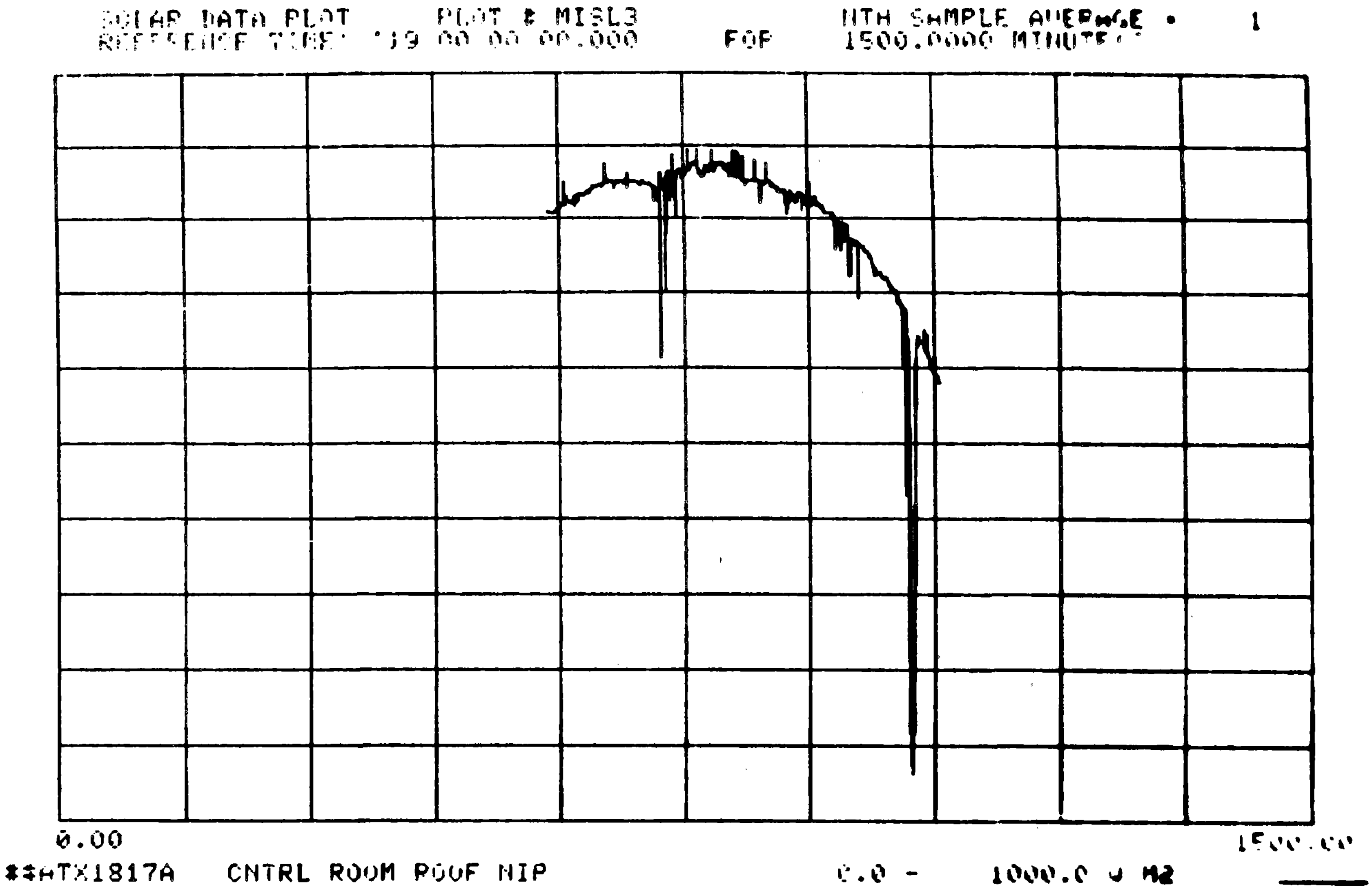


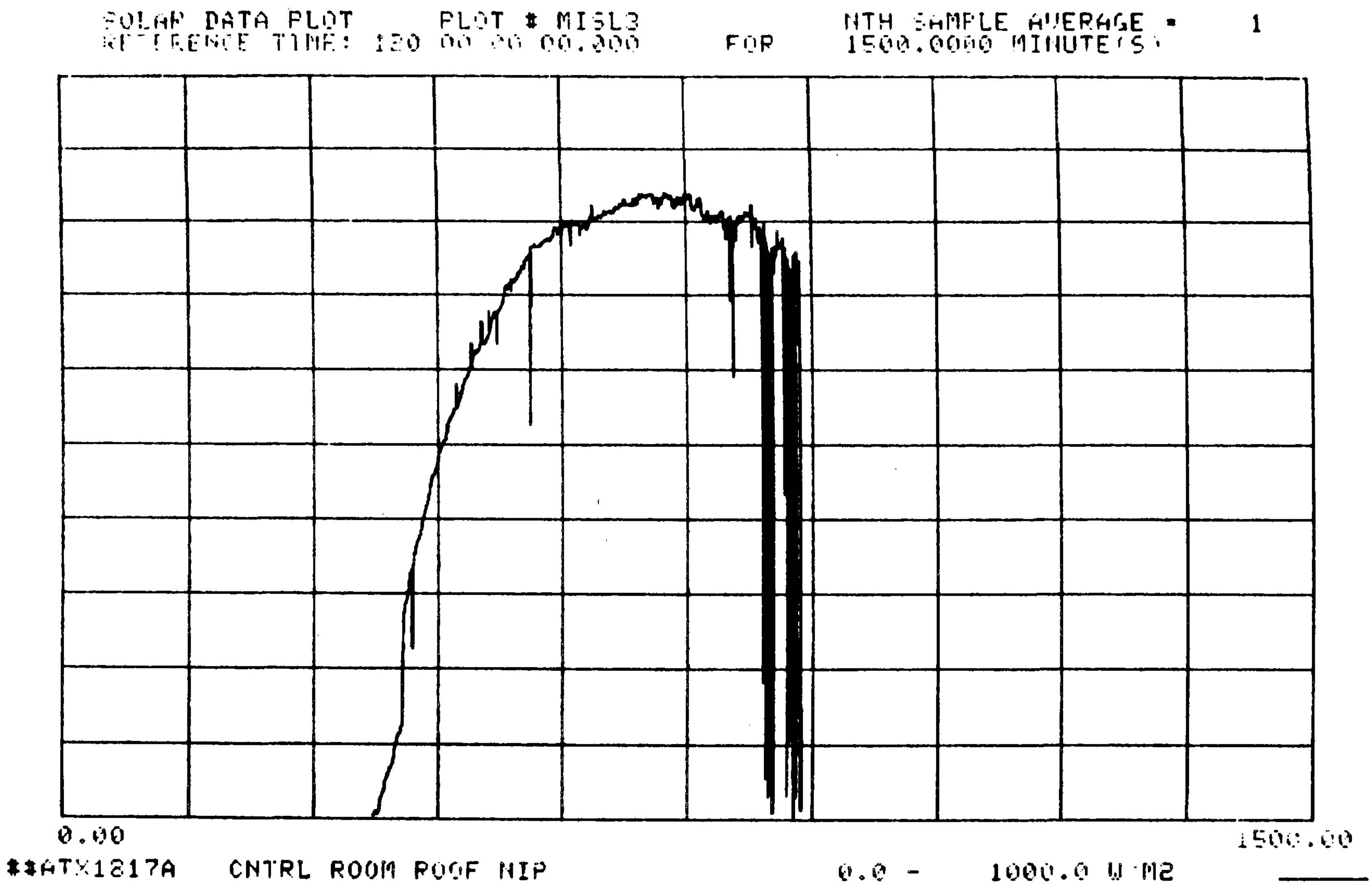
SOLAR DATA PLOT PLOT # MISL3
REFERENCE TIME: 117 00 00 00.000 FOR
NTH SAMPLE AVERAGE = 1
1500.0000 MINUTE(S)
0.00
1500.00
##ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 118 00 00 00.000 FOR 1500.0000 MINUTE(S)

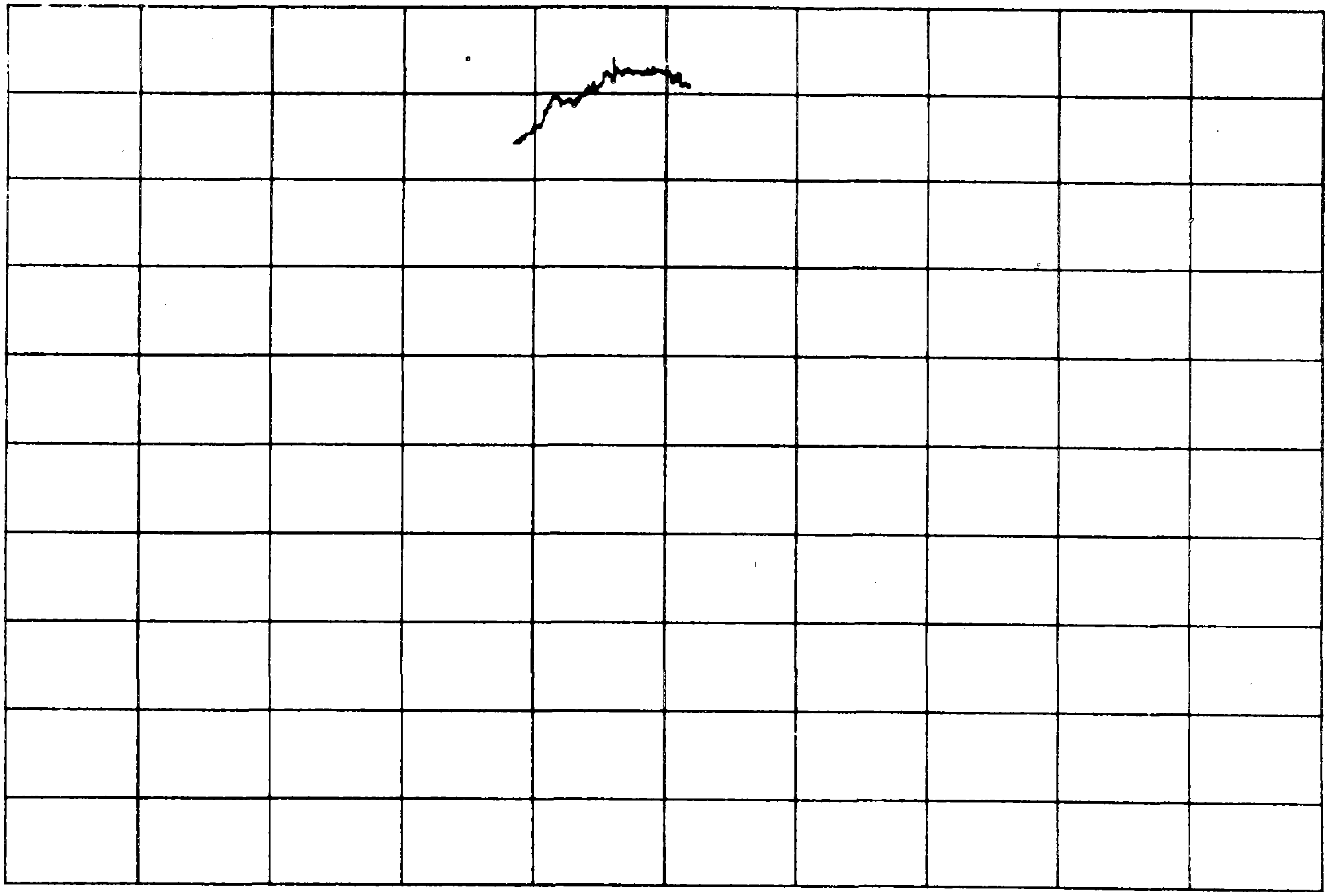


**ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2


SOLAR DATA PLOT
PLOT # MISL3
NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 19 00 00 00.000
FOR 1500.0000 MINUTES
0.00
1500.00
**ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W M2


SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 120 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.00
**ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W/M2

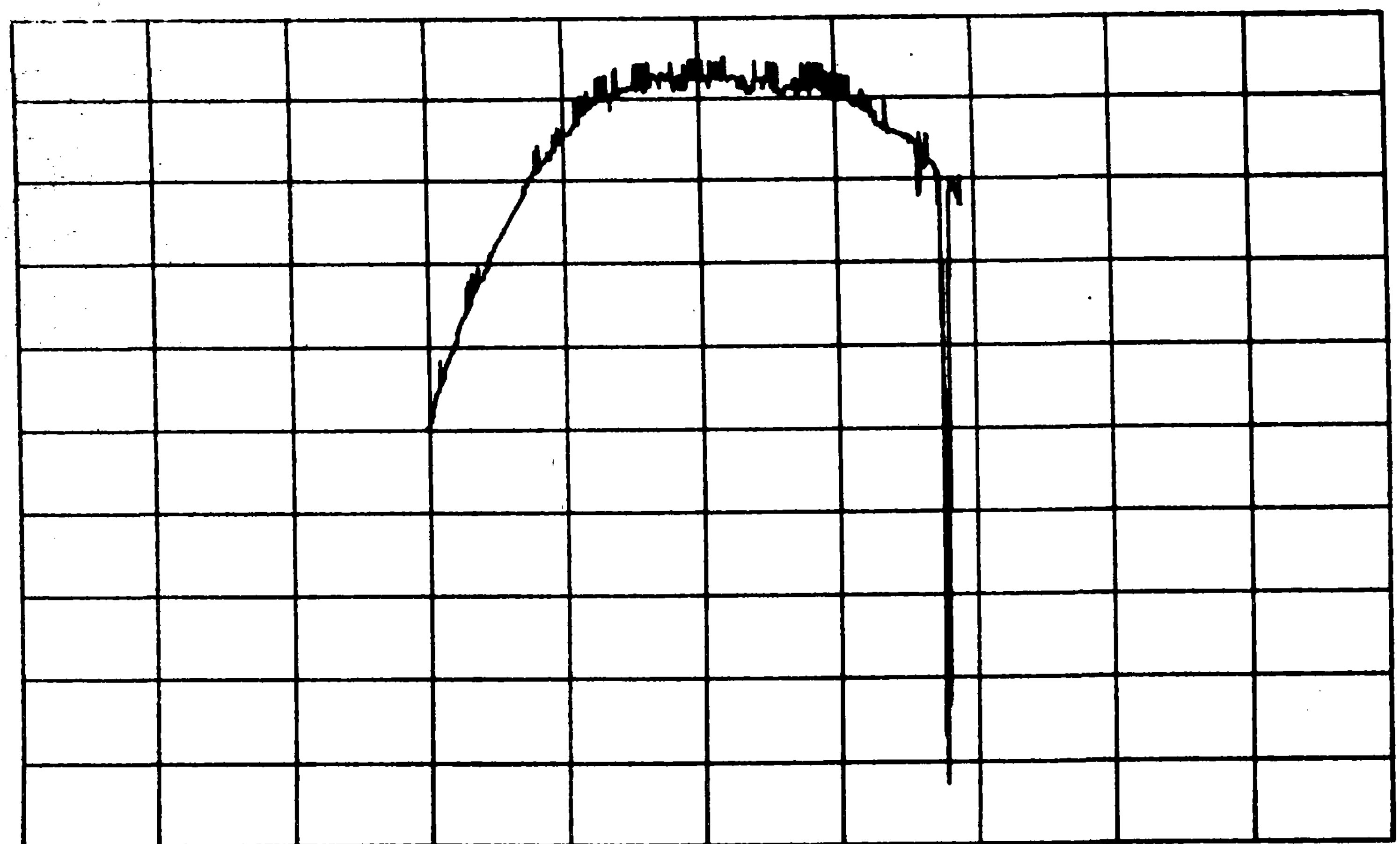
SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 123 00 00 00.000   FOR 1500.0000 MINUTE(S)



0.00   1500.00

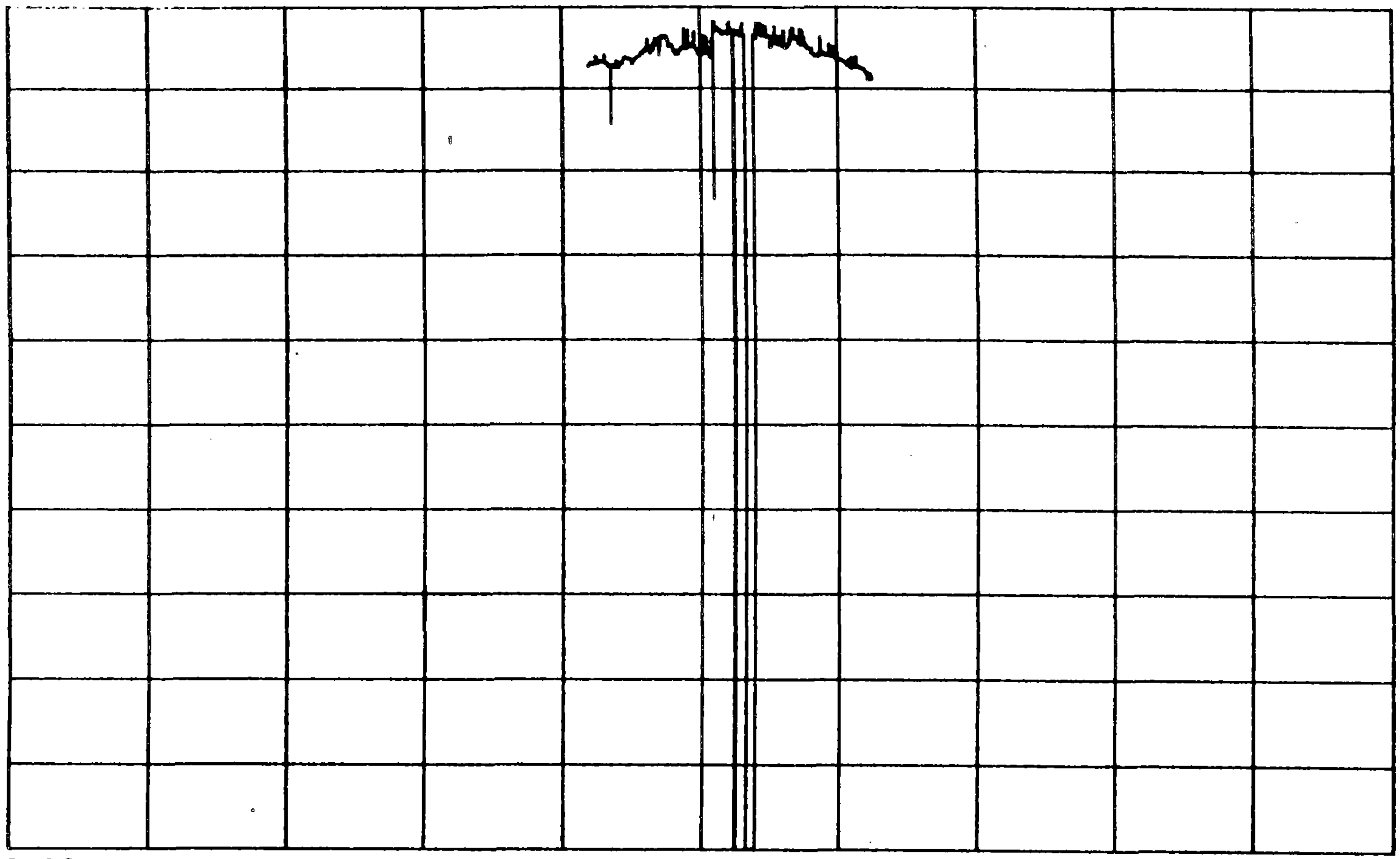
##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 125 00 00 00.000 FOR 1500.0000 MINUTE(S)



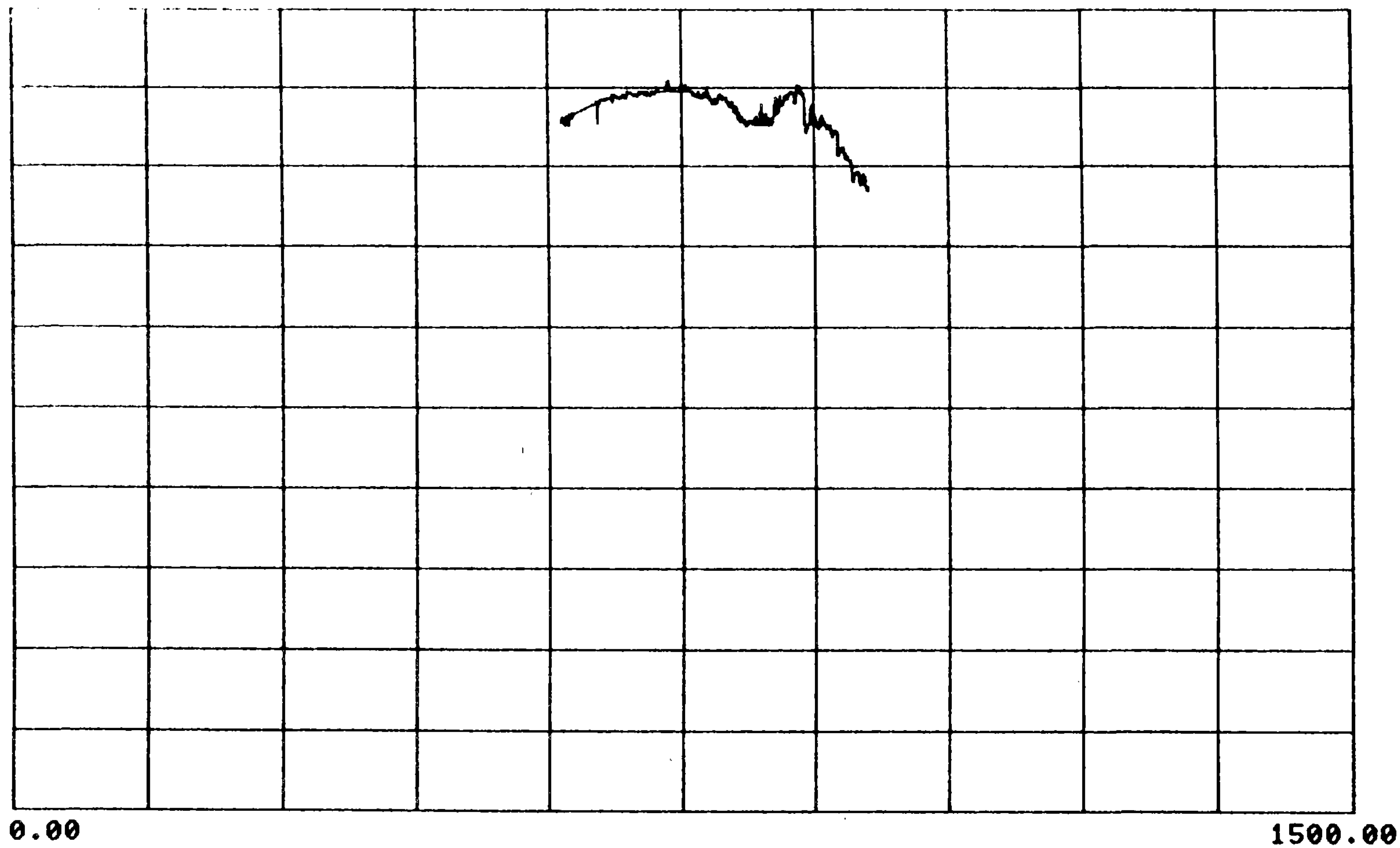
$$ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 126 00 00 00.000 FOR 1500.0000 MINUTE(S)



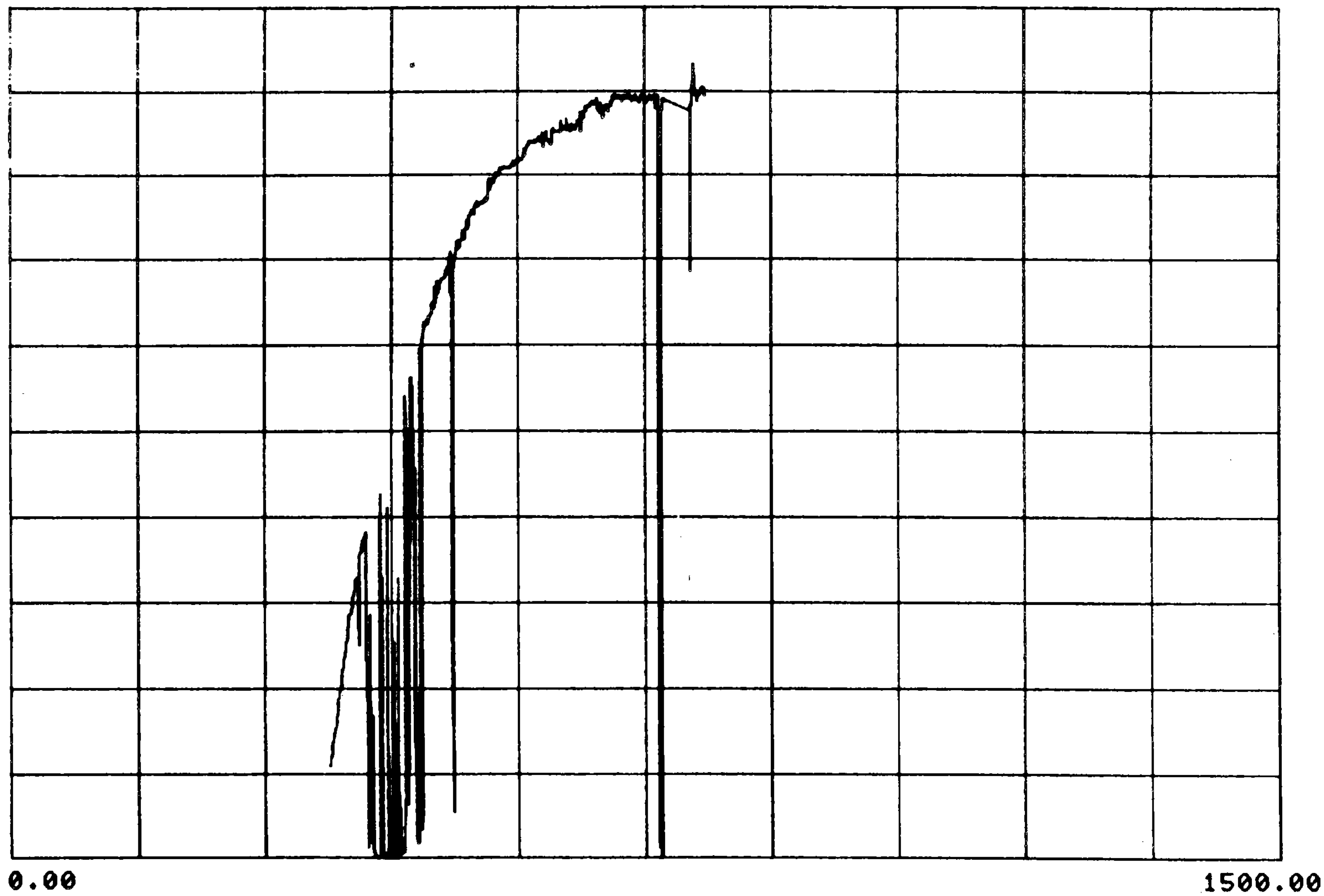
##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

OLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
ENCE TIME: 127 00 00 00.000 FOR 1500.0000 MINUTE(S)



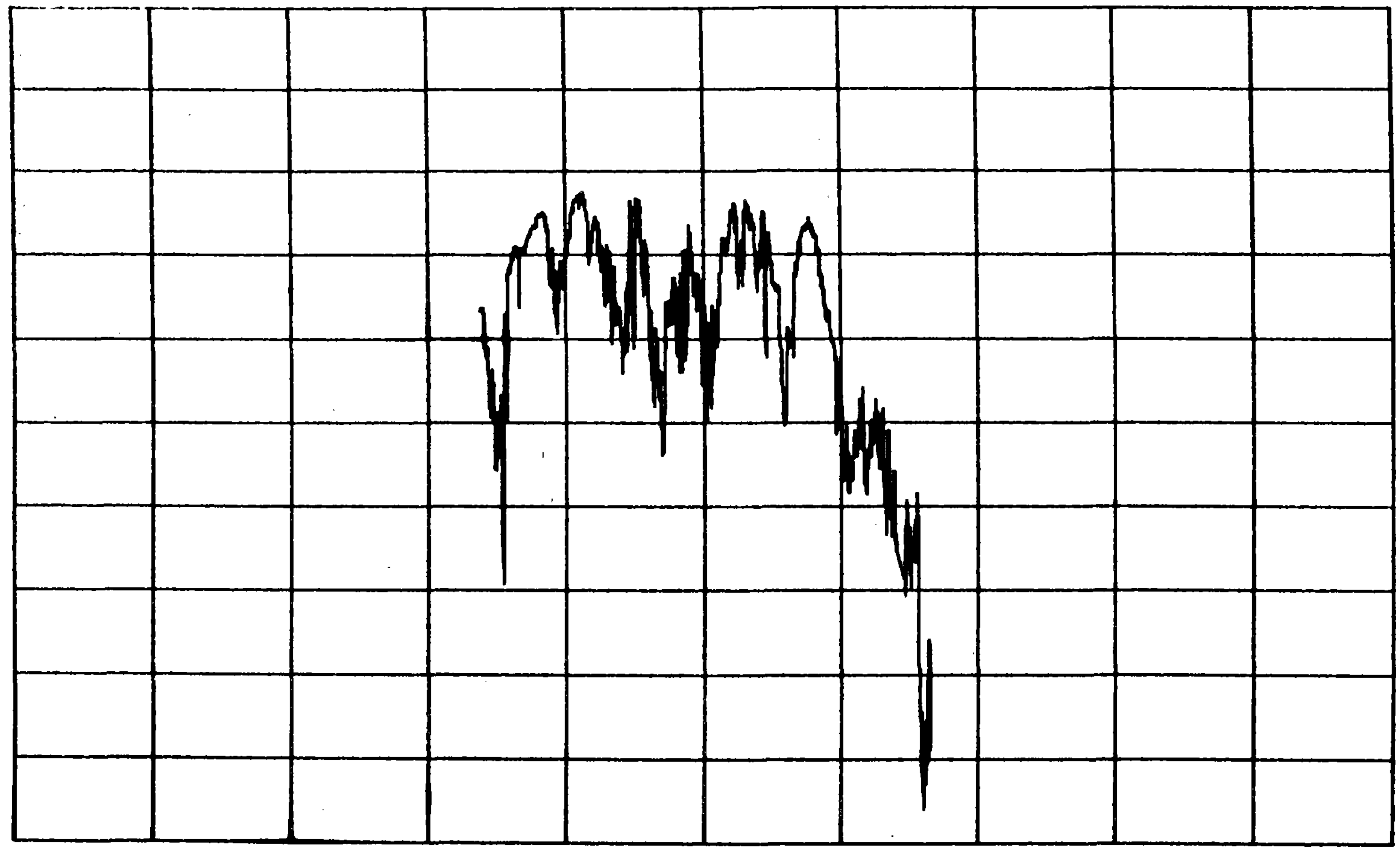
##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 130 00 00 00.000   FOR   1500.0000 MINUTE(S)

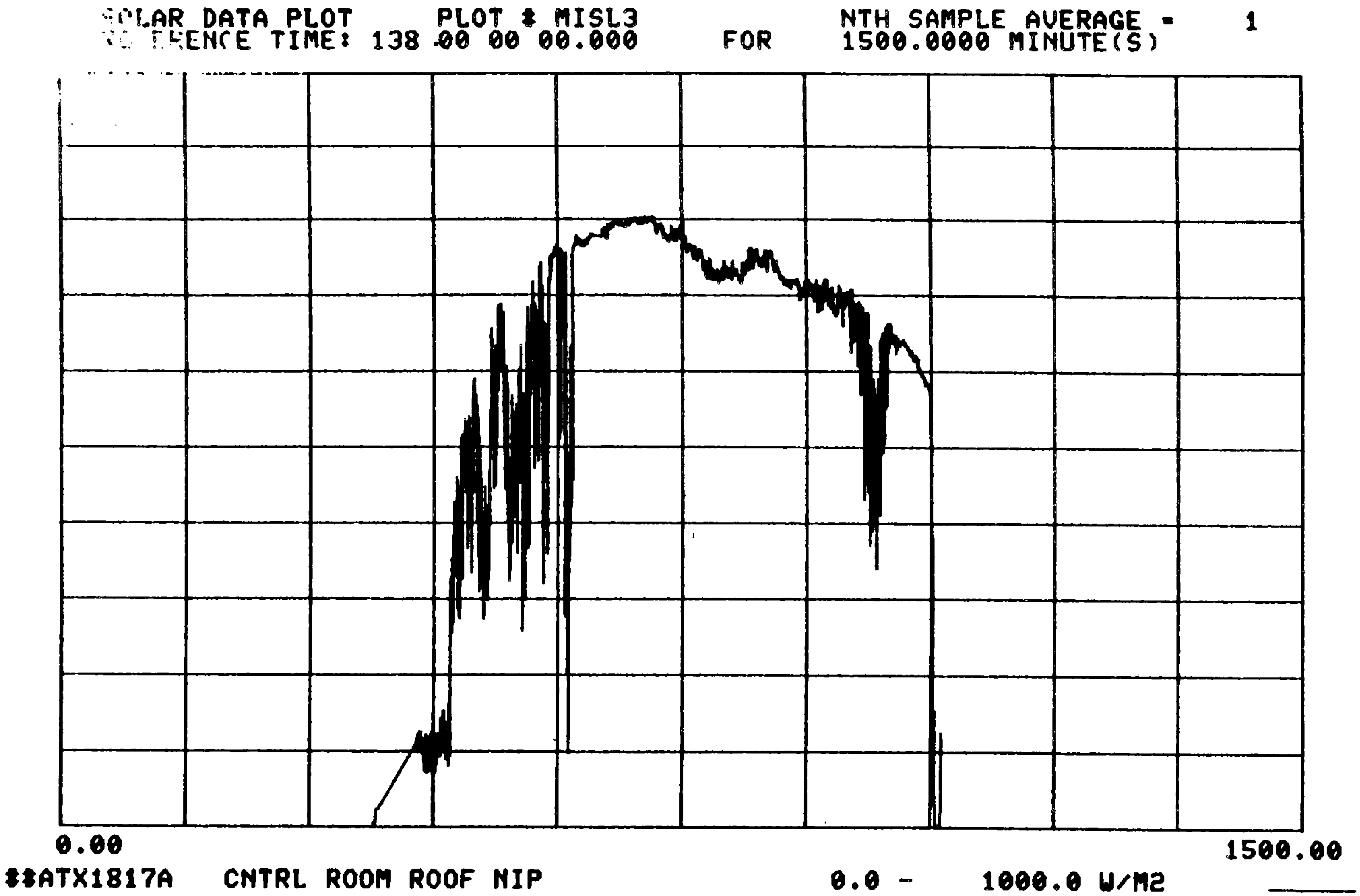


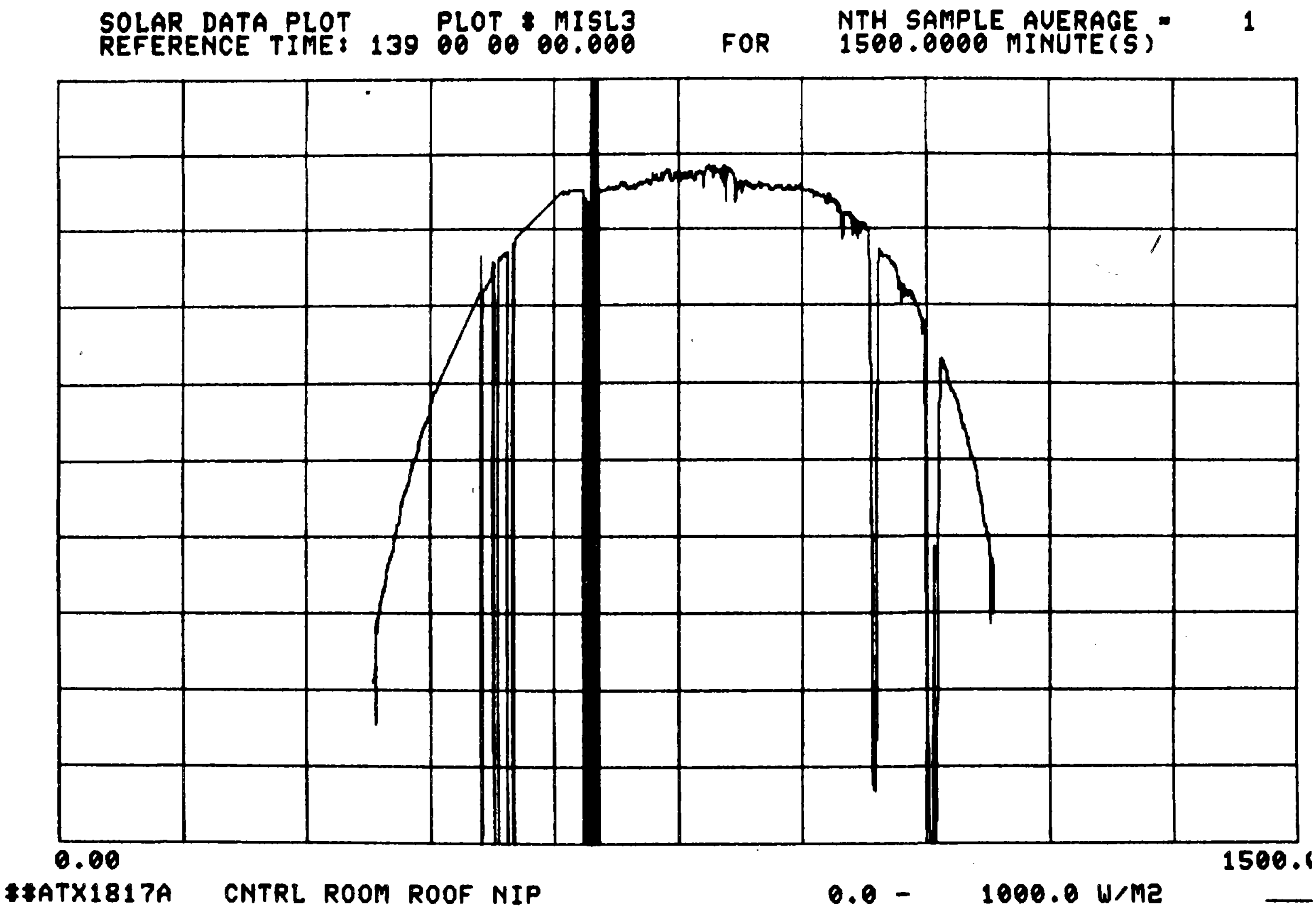
##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 137 00 00 00.000 FOR 1500.0000 MINUTE(S)

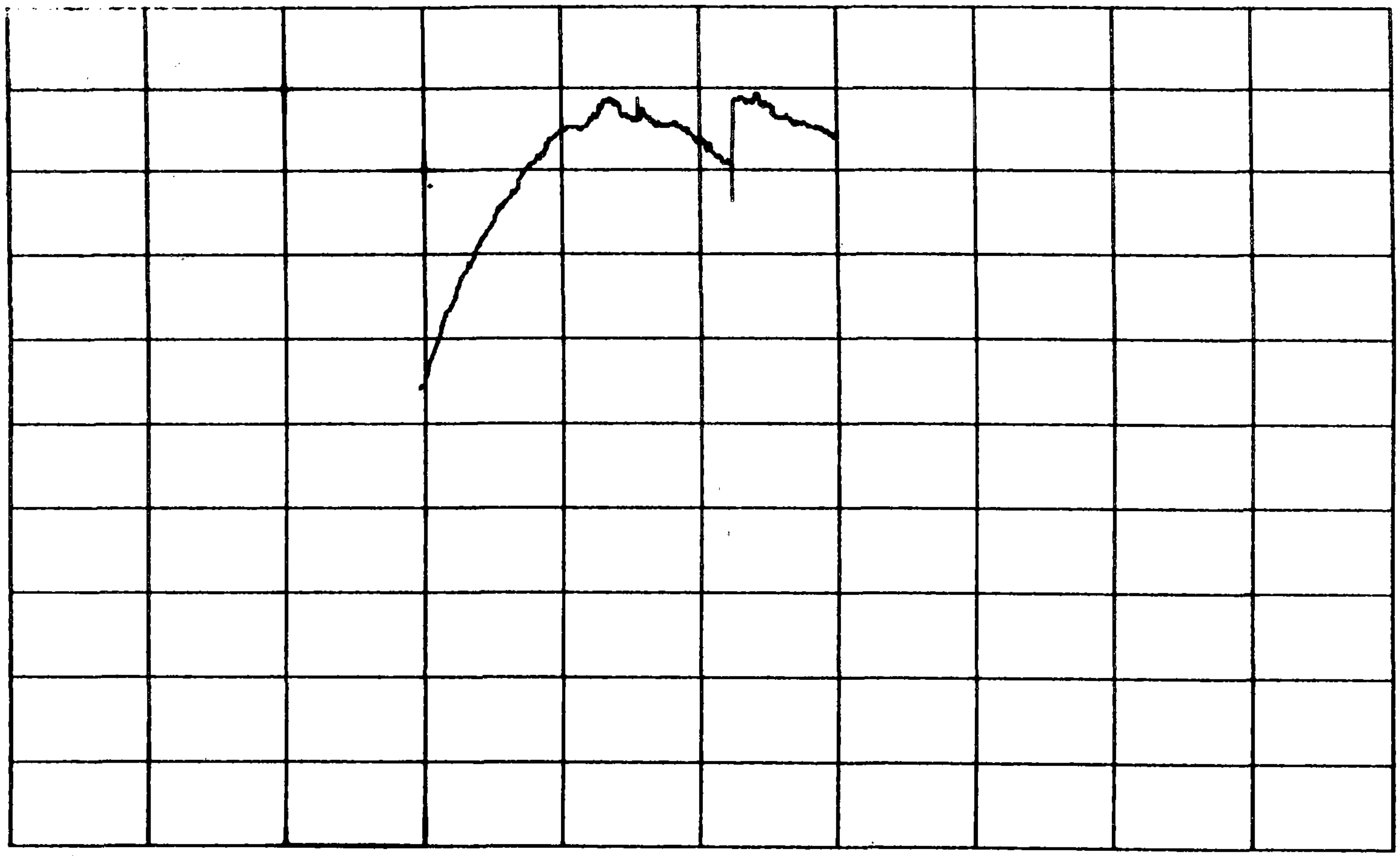


##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2


SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 138 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.00
##ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W/M2


SOLAR DATA PLOT PLOT $ MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 139 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.0
$$ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 140 00 00 00.000 FOR 1500.0000 MINUTE(S)

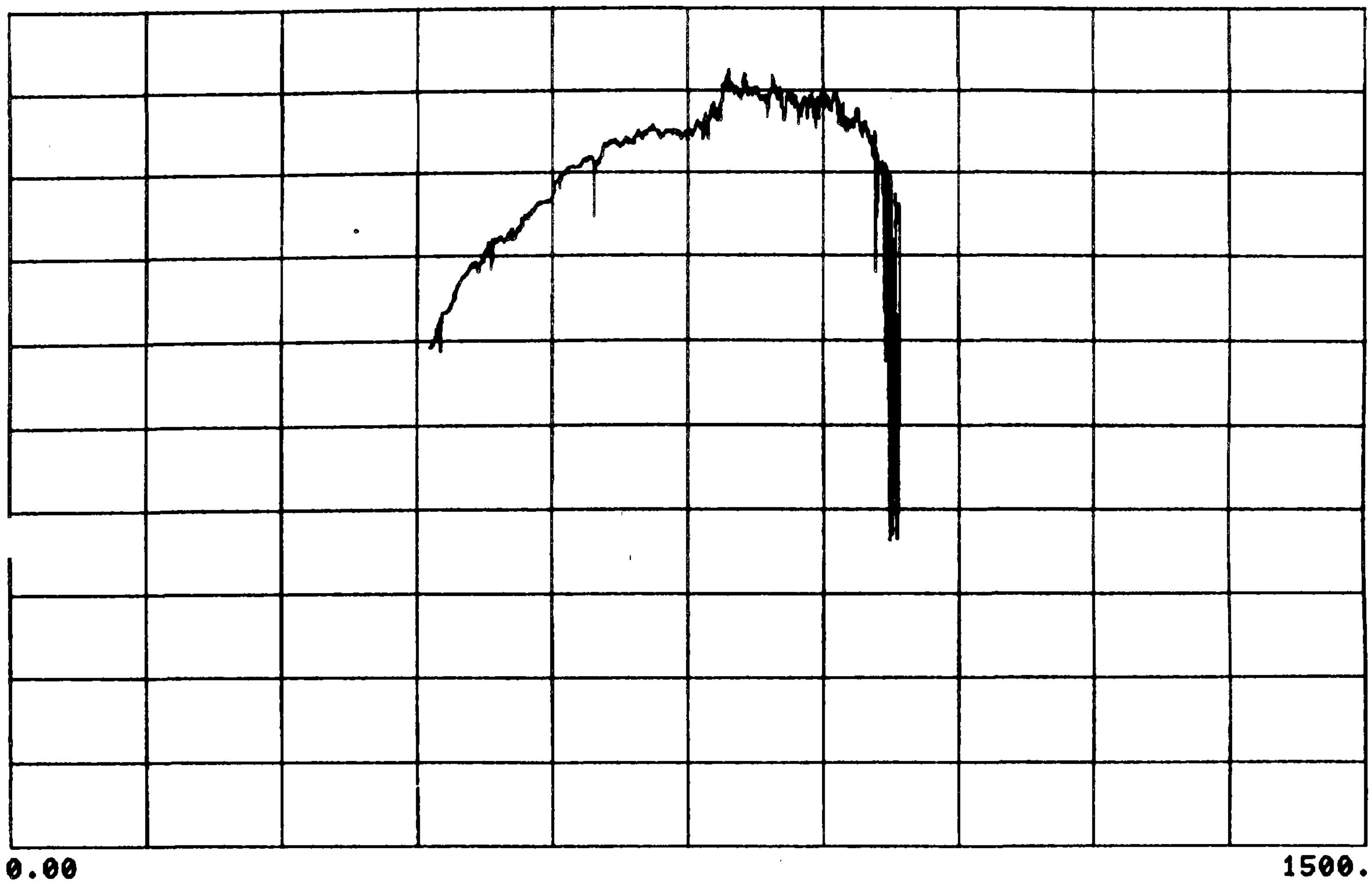


##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 144 00 00 00.000   FOR   1500.0000 MINUTE(S)

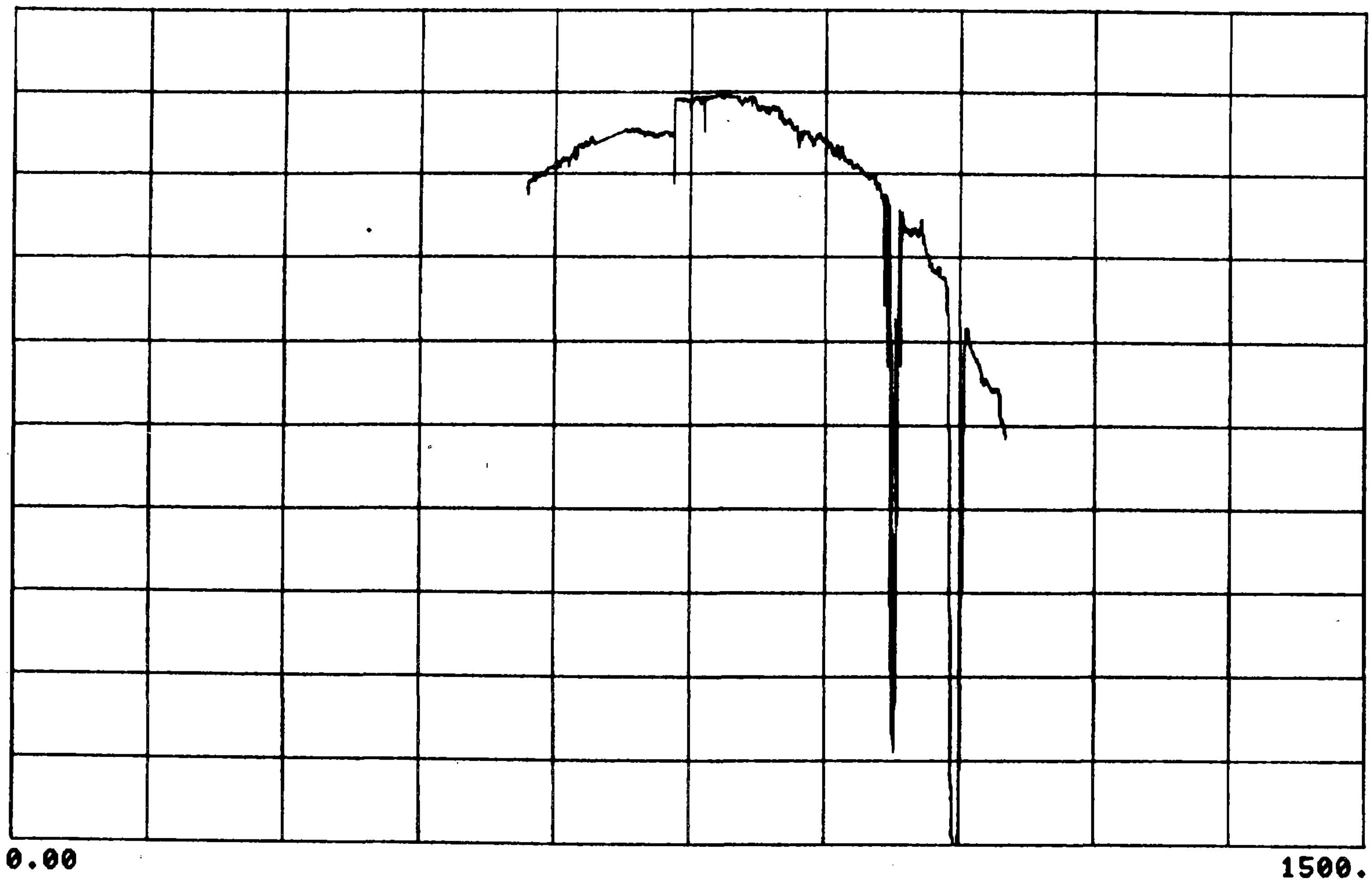
##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 147 00 00 00.000 FOR 1500.0000 MINUTE(S)



##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 148 00 00 00.000   FOR   1500.0000 MINUTE(S)

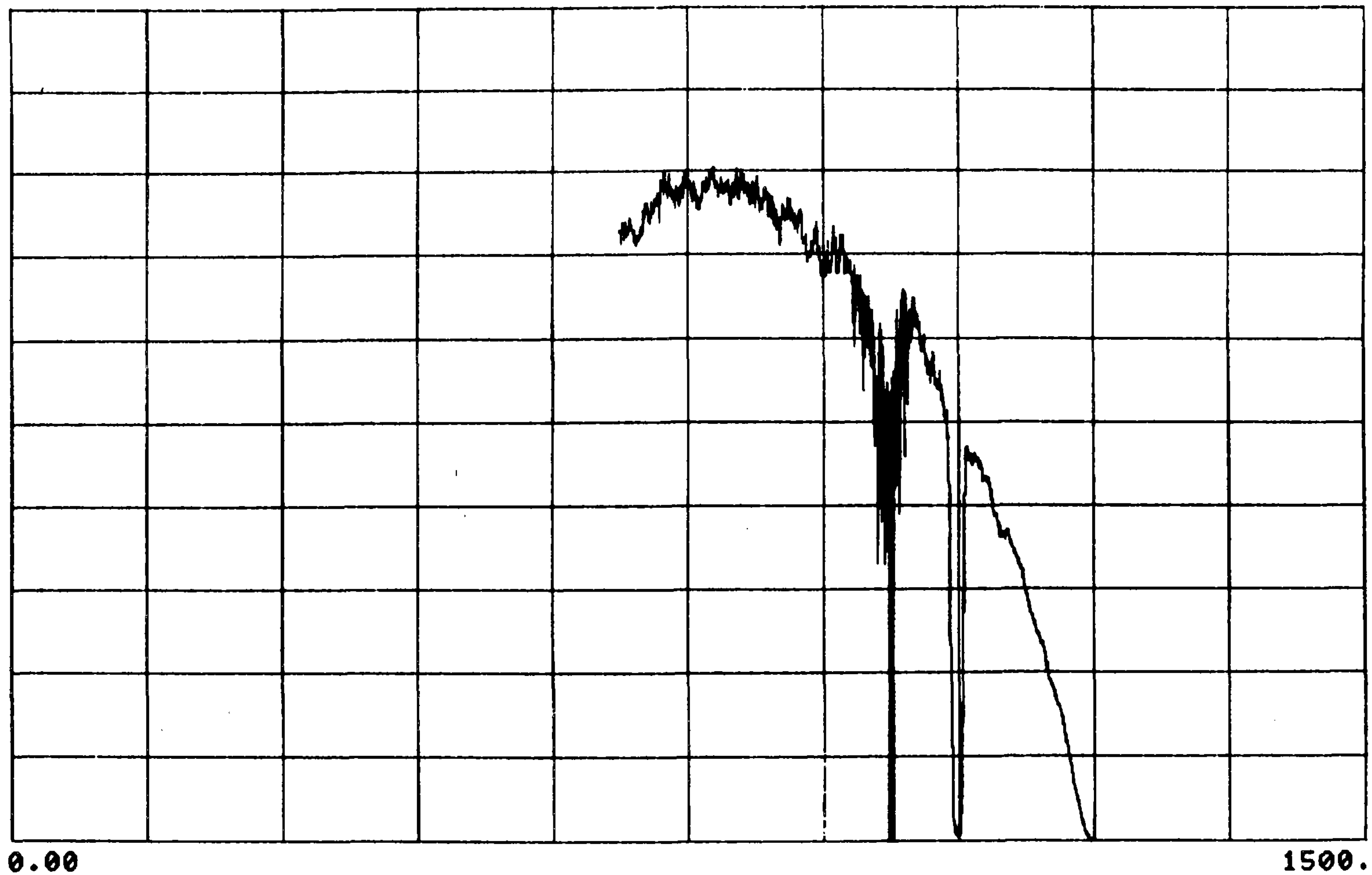


##ATX1817A   CNTRL ROOM ROOF NIP   0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 152 00 00 00.000 FOR 1500.0000 MINUTE(S)

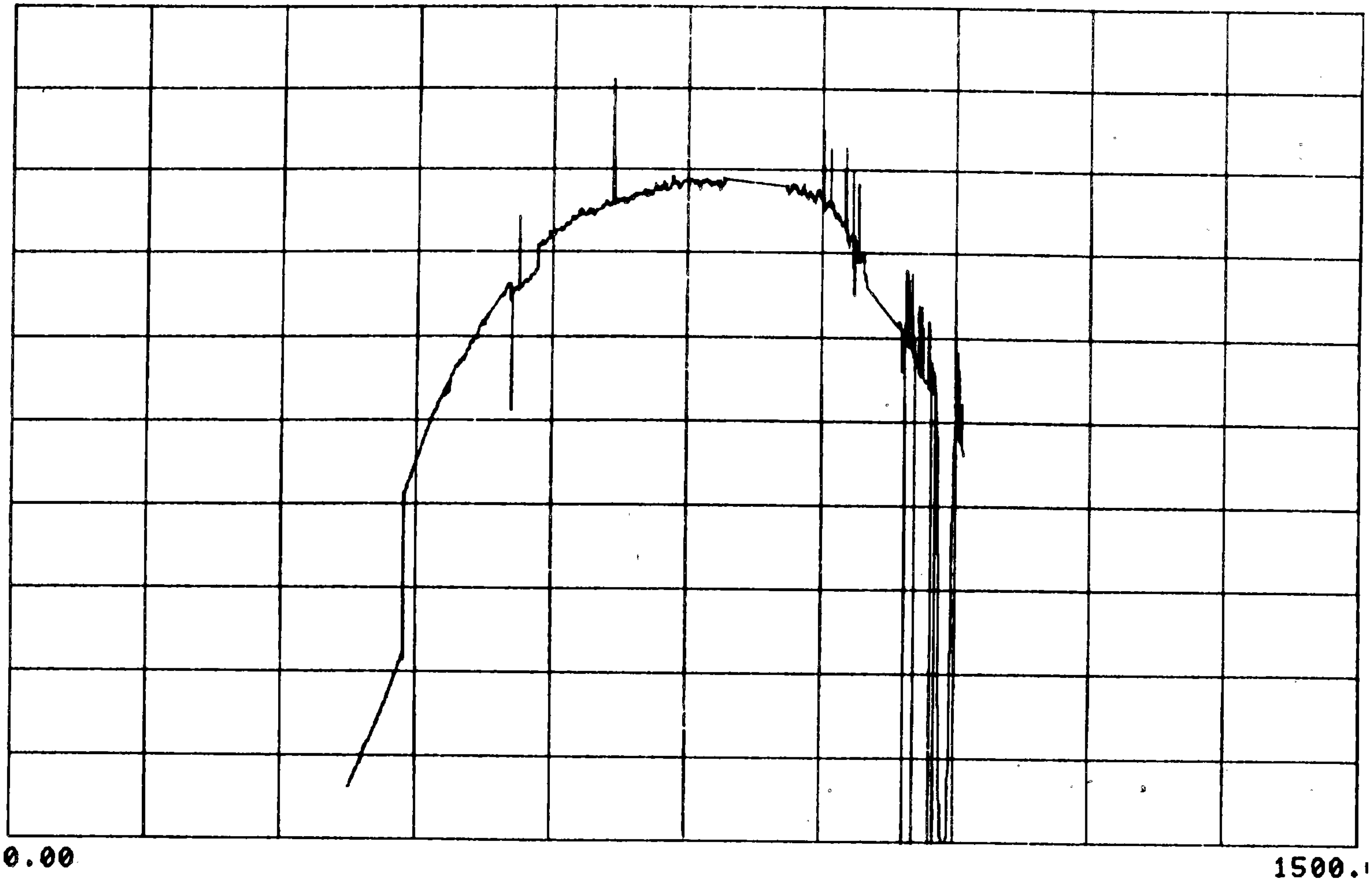
##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 153 00 00 00.000   FOR   1500.0000 MINUTE(S)



##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 154 00 00 00.000 FOR 1500.0000 MINUTE(S)



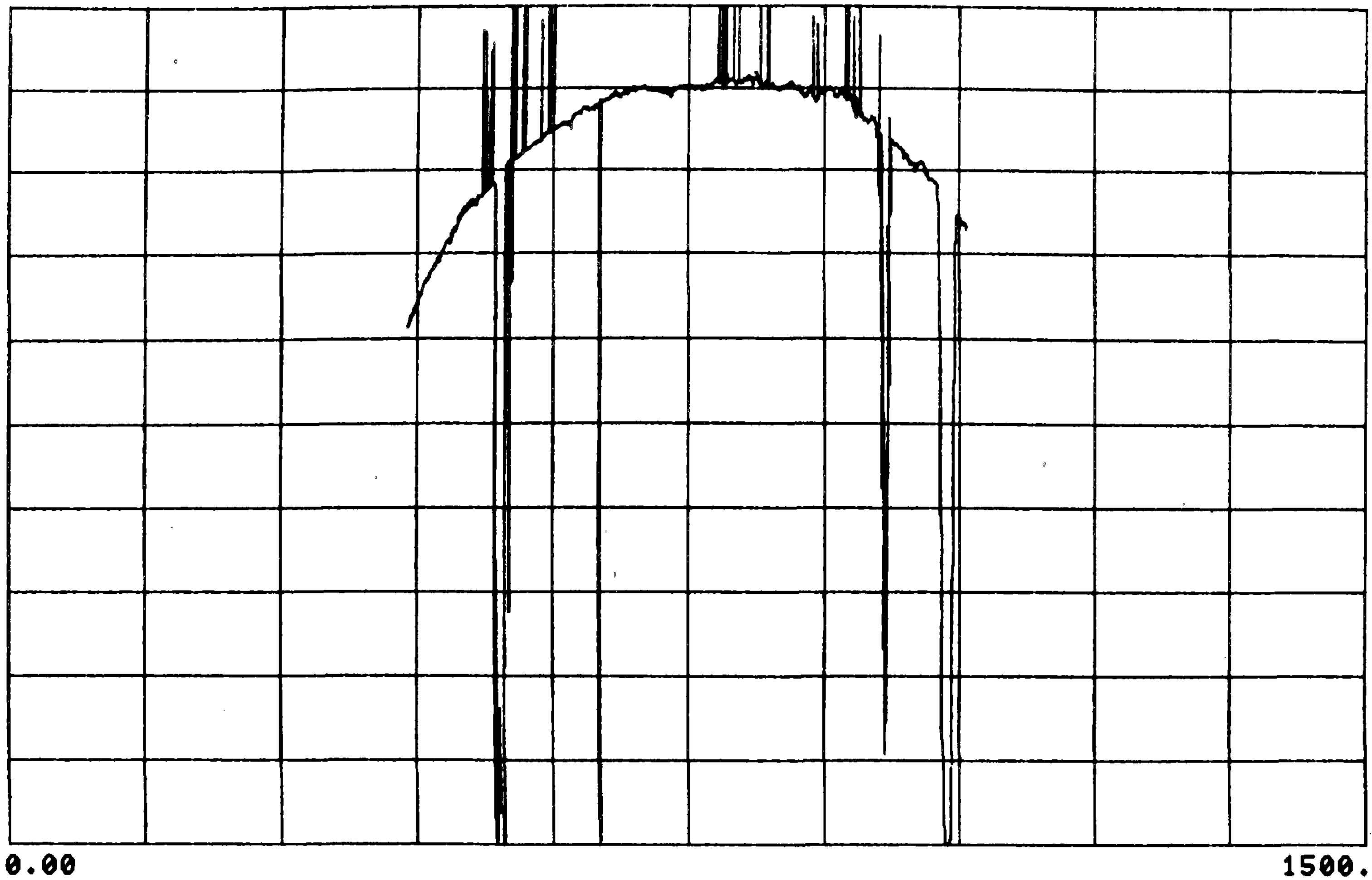
$$ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 158 00 00 00.000 FOR 1500.0000 MINUTE(S)

0.00 1500.0

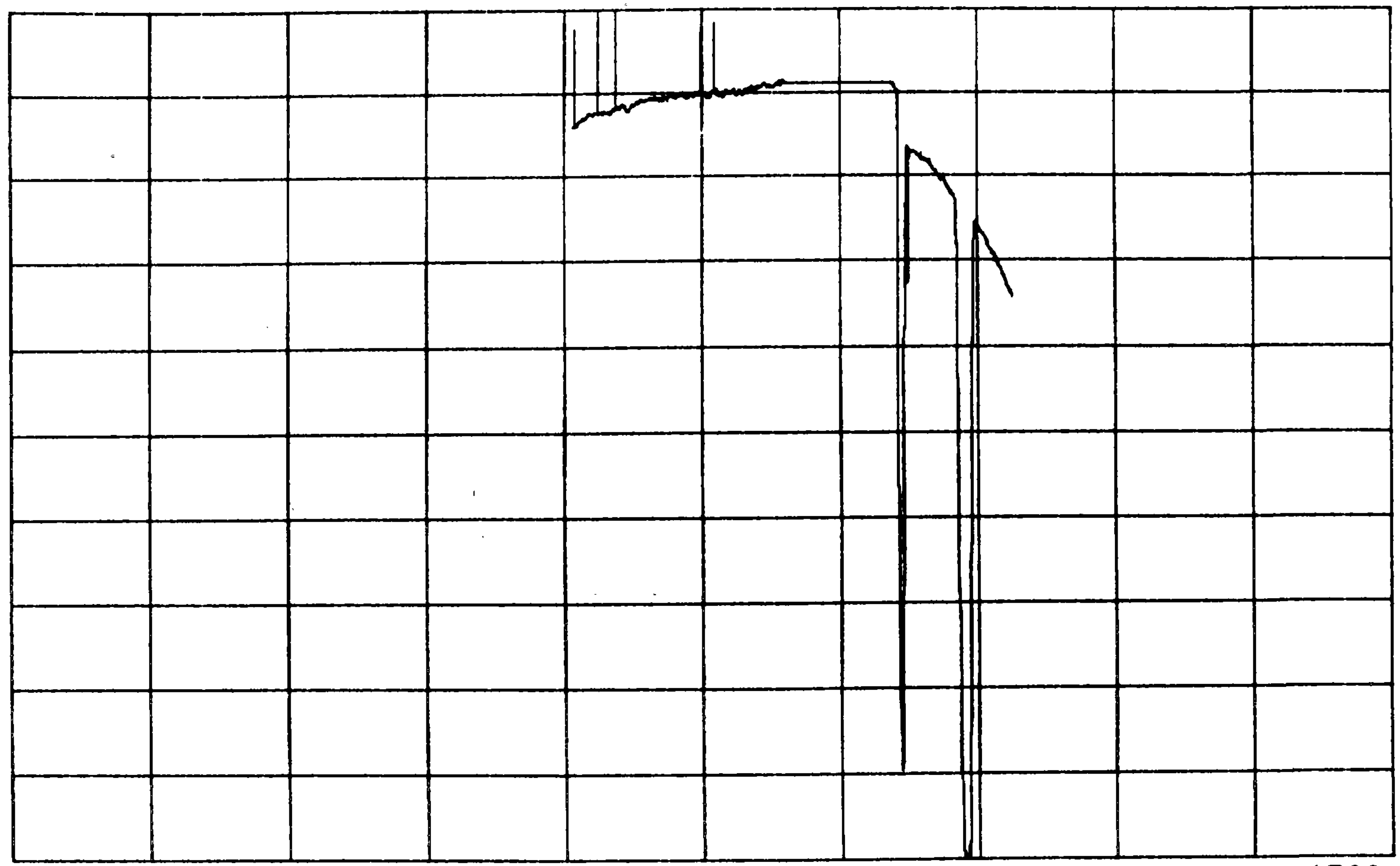
##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 159 00 00 00.000   FOR   1500.0000 MINUTE(S)



##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

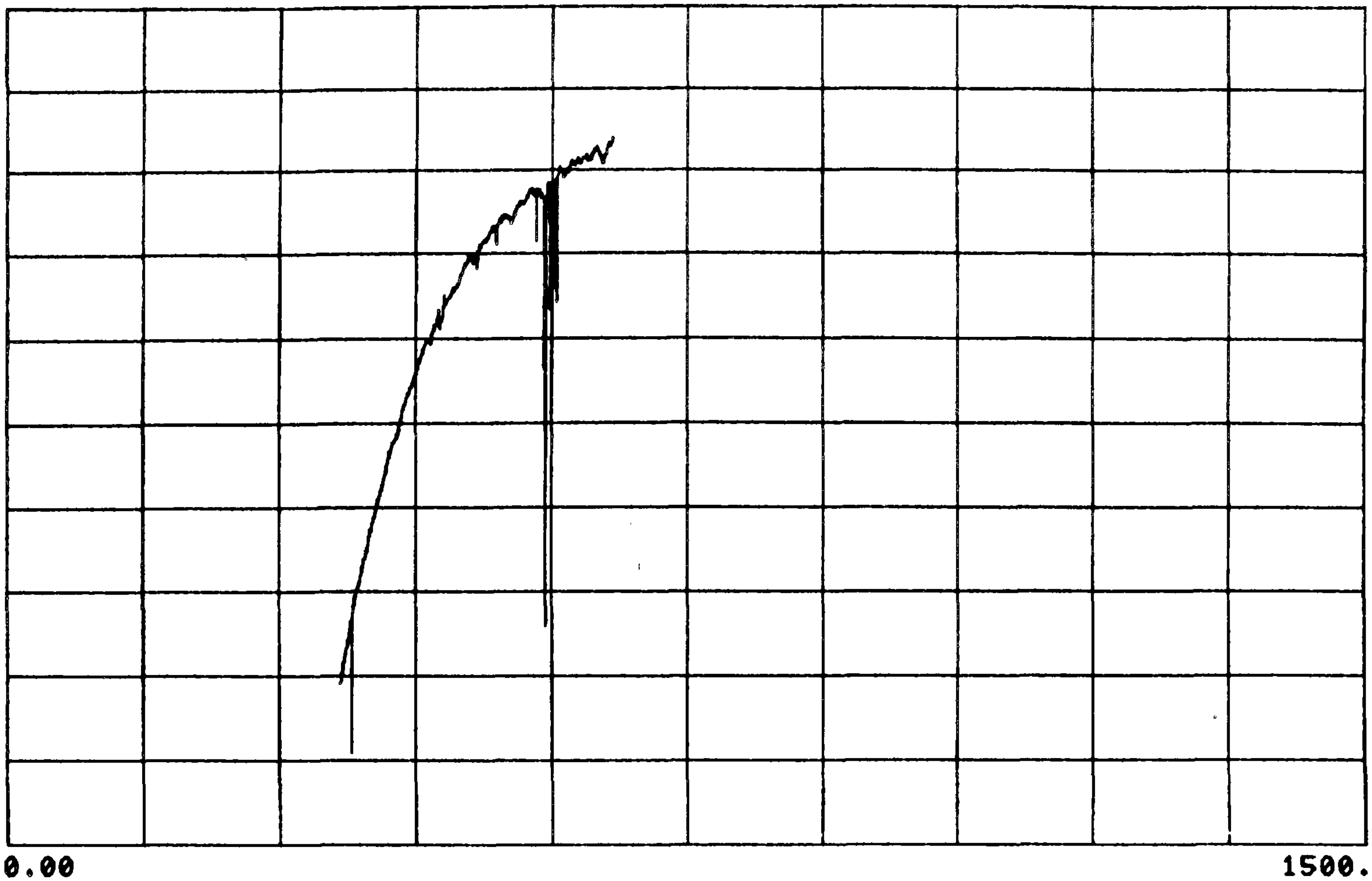
SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 166 00 00 00.000 FOR 1500.0000 MINUTE(S)



0.00 1500.

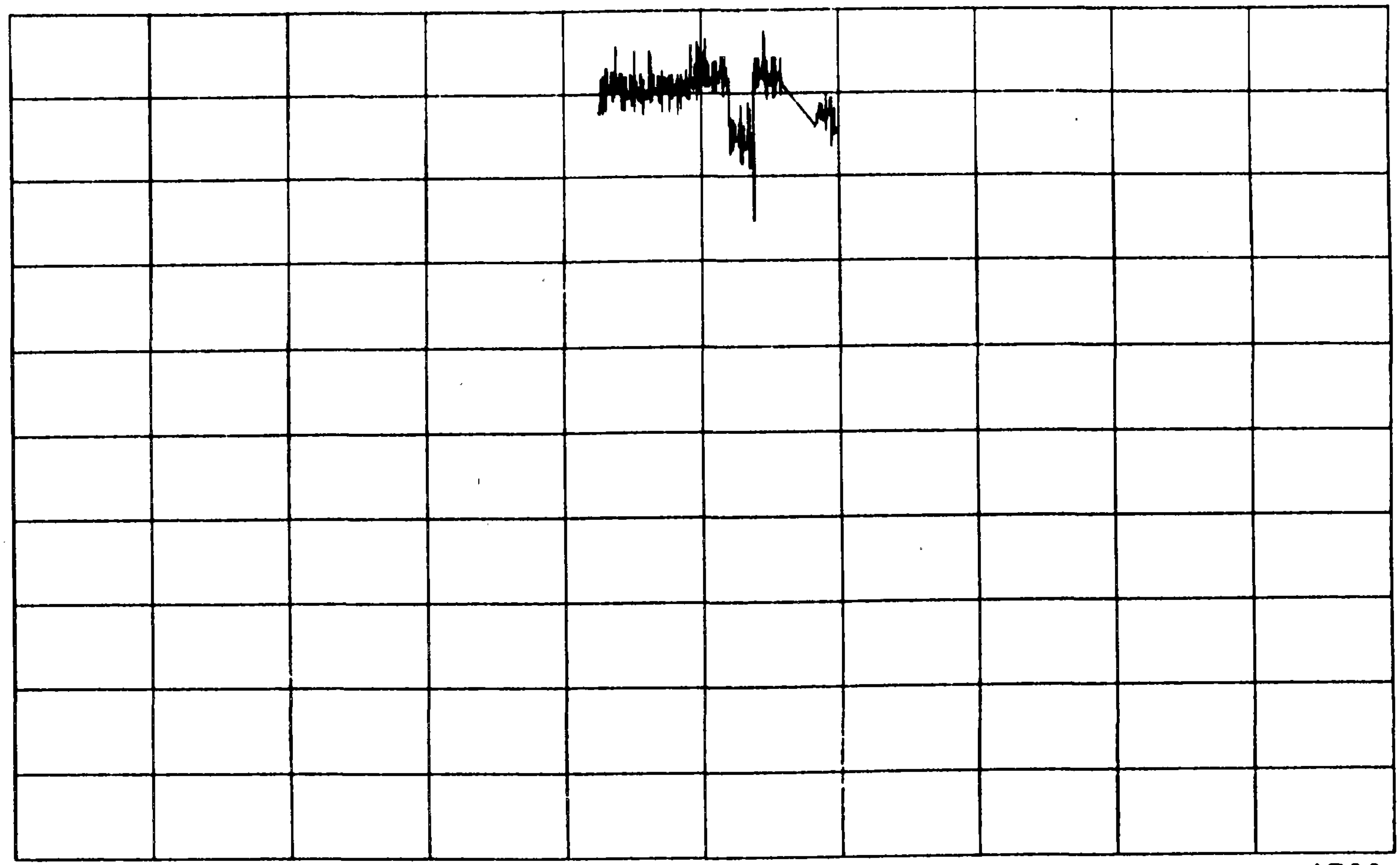
##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 167 00 00 00.000 FOR 1500.0000 MINUTE(S)

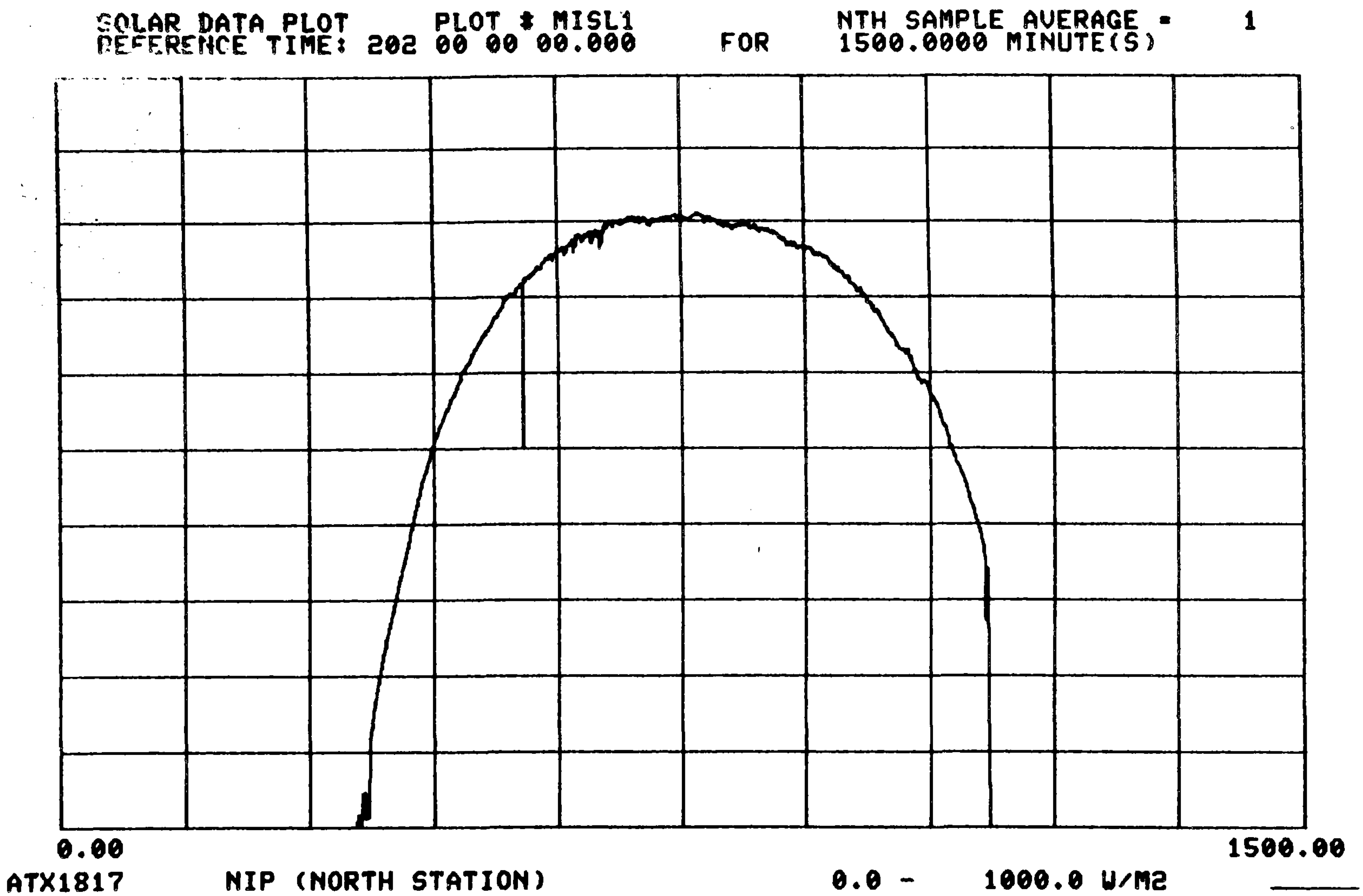


##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

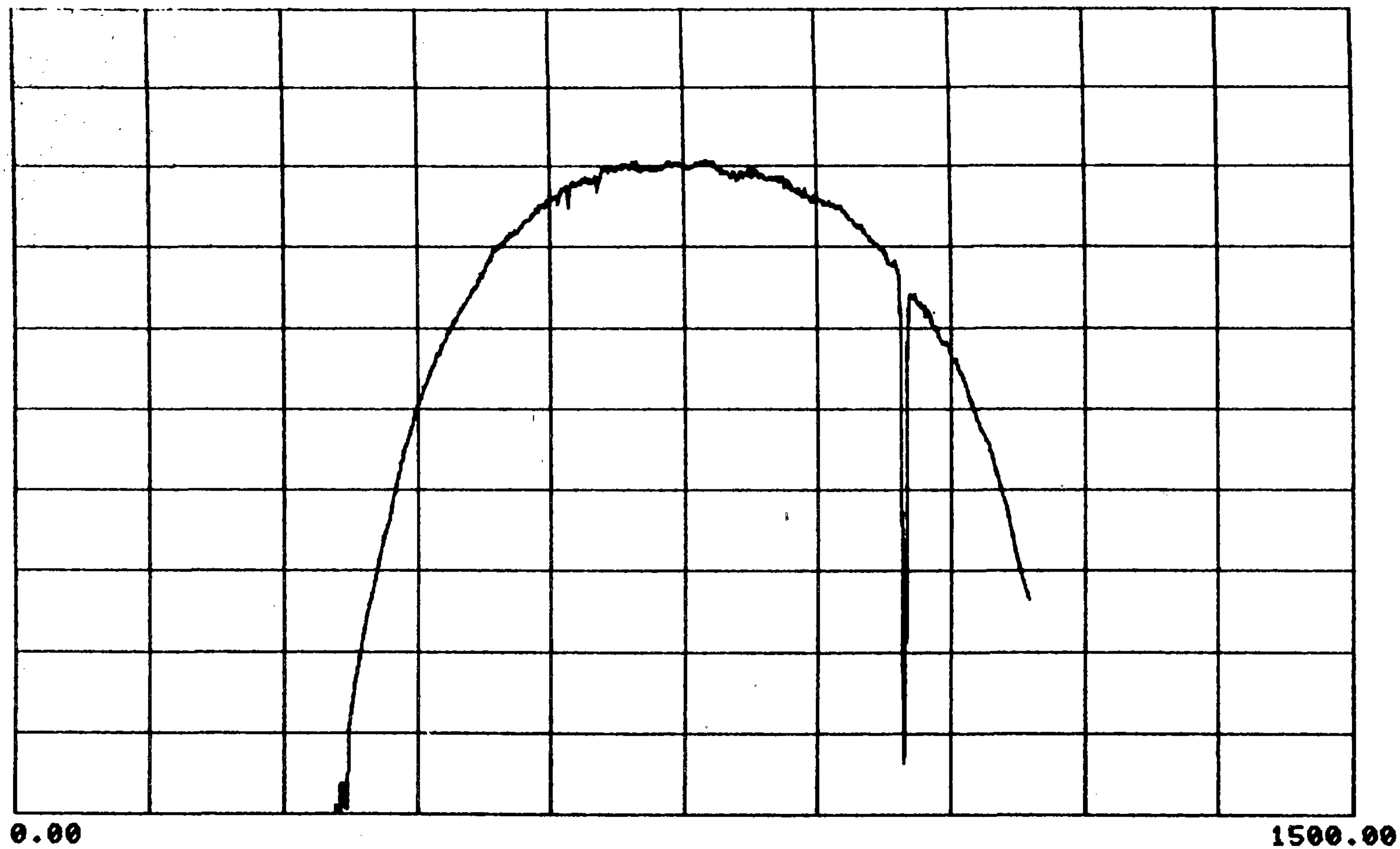
SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 179 00 00 00.000 FOR 1500.0000 MINUTE(S)



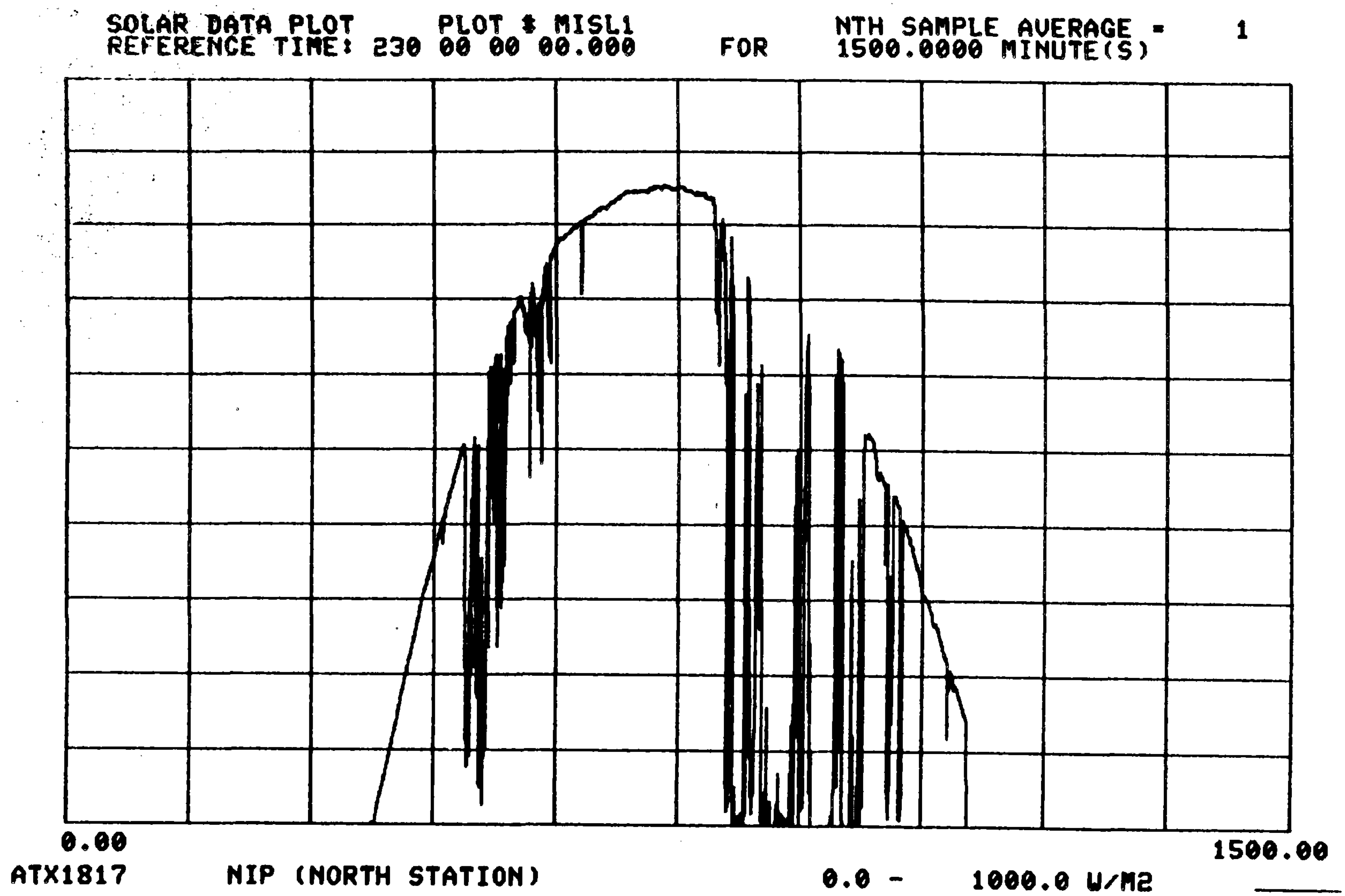
##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2


SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 202 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.00
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

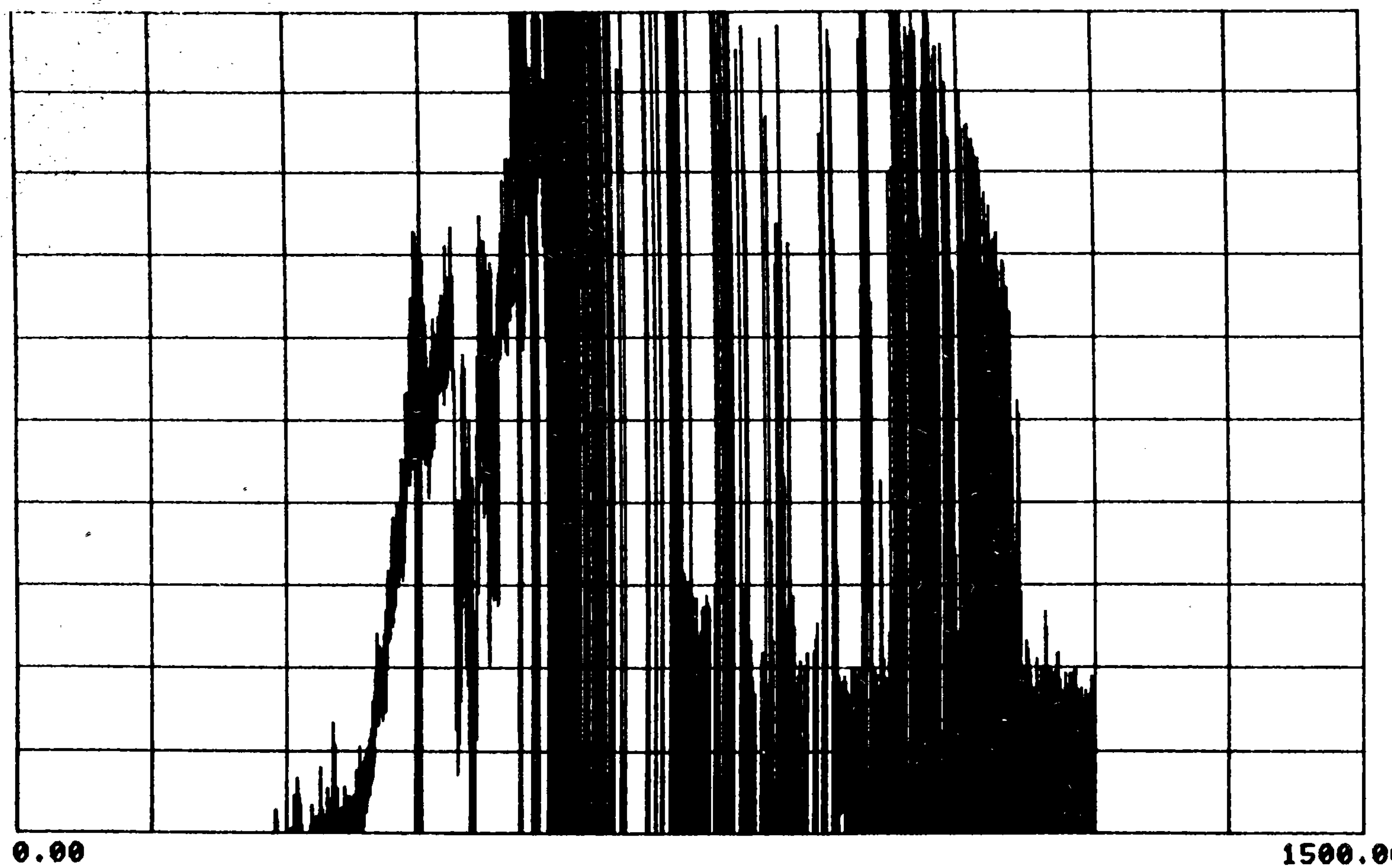
SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 202 00 00 00.000 FOR 1500.0000 MINUTE(S)



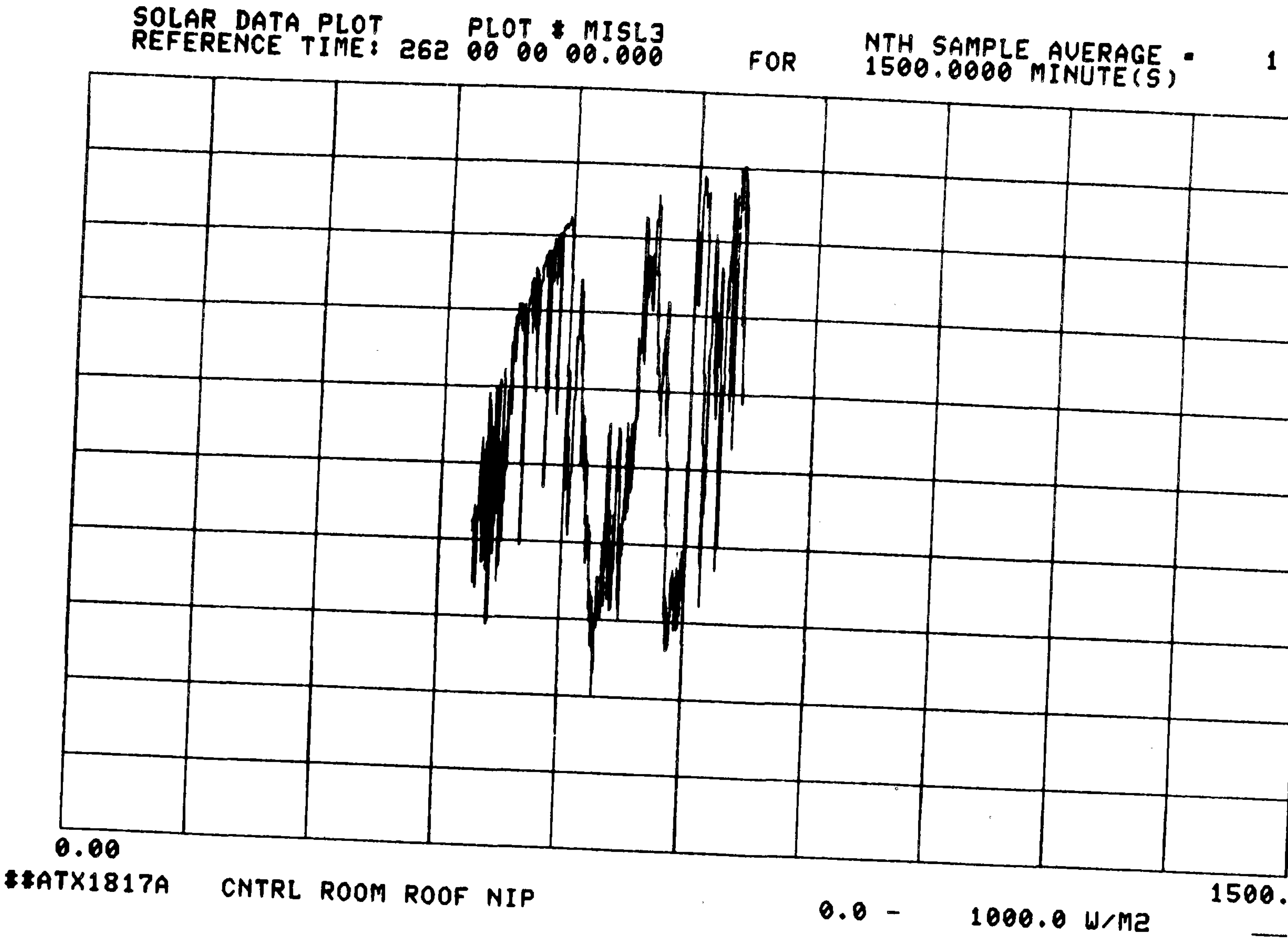
##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2


SOLAR DATA PLOT PLOT $ MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 230 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.00
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

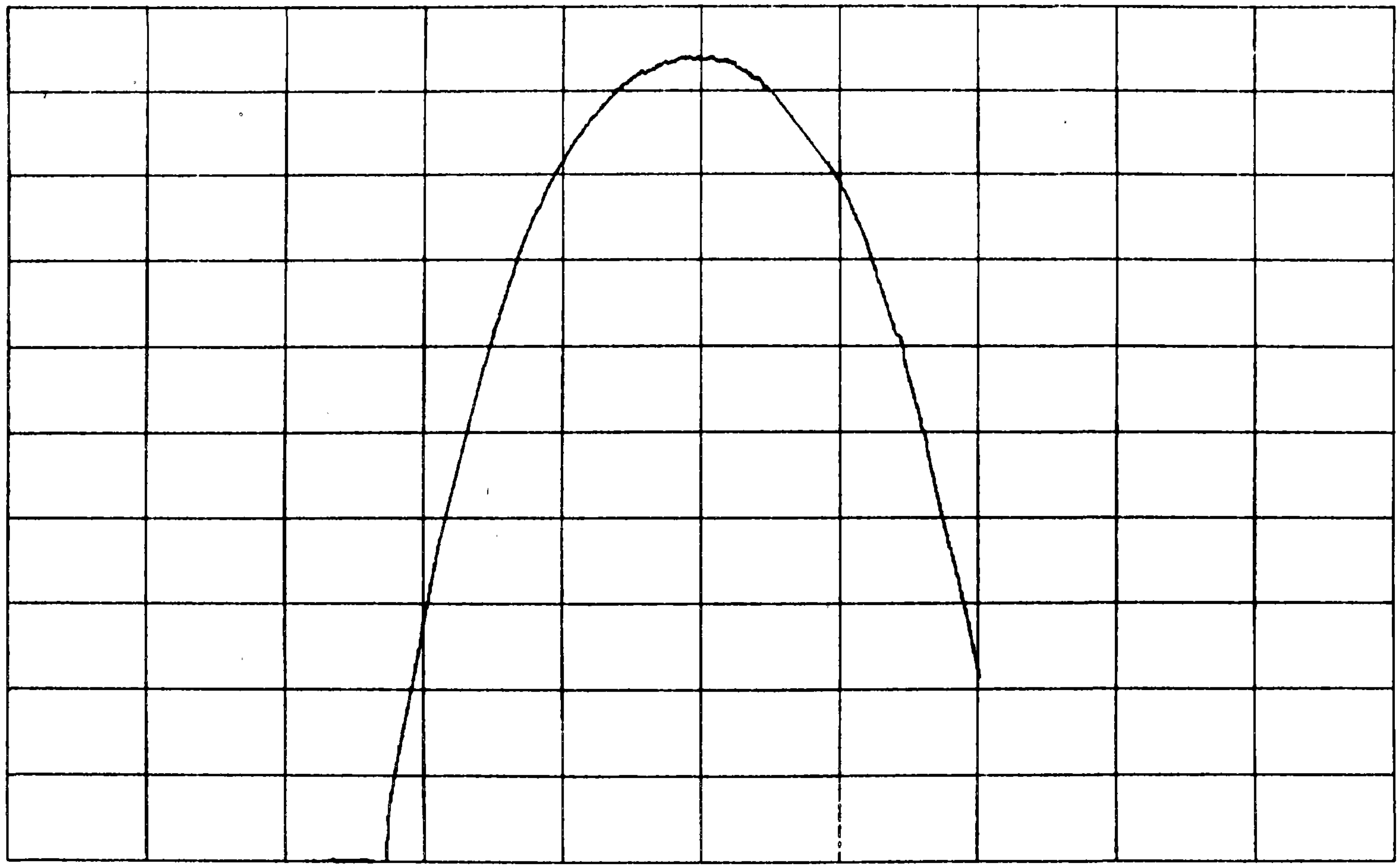
SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 230 00 00 00.000 FOR 1500.0000 MINUTE(S)



$$ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

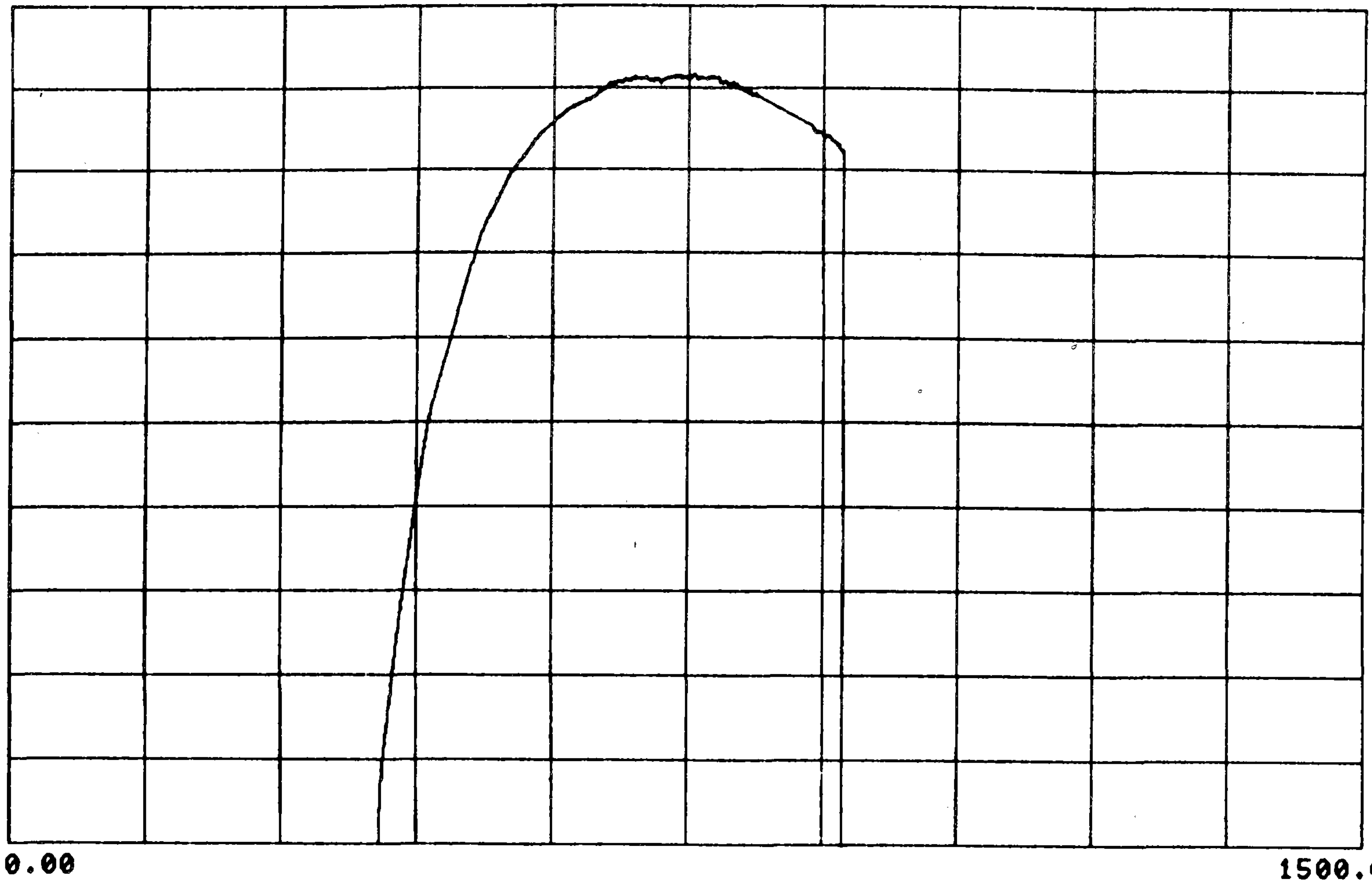

SOLAR DATA PLOT
PLOT # MISL3
REFERENCE TIME: 262 00 00 00.000
FOR
NTH SAMPLE AVERAGE = 1
1500.0000 MINUTE(S)
0.00
1500.
##ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 279 00 00 00.000 FOR 1500.0000 MINUTE(S)



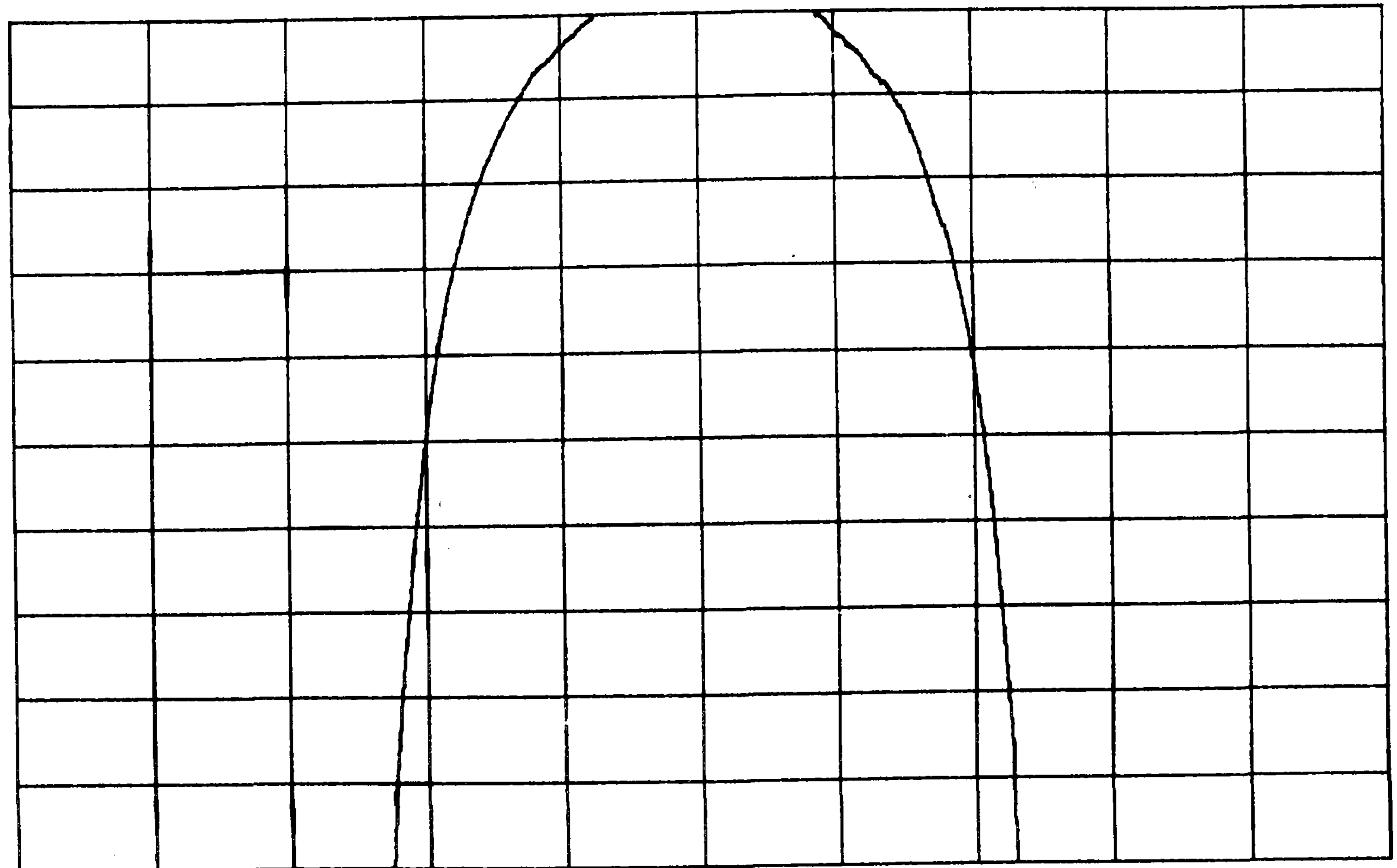
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 279 00 00 00.000   FOR   1500.0000 MINUTE(S)



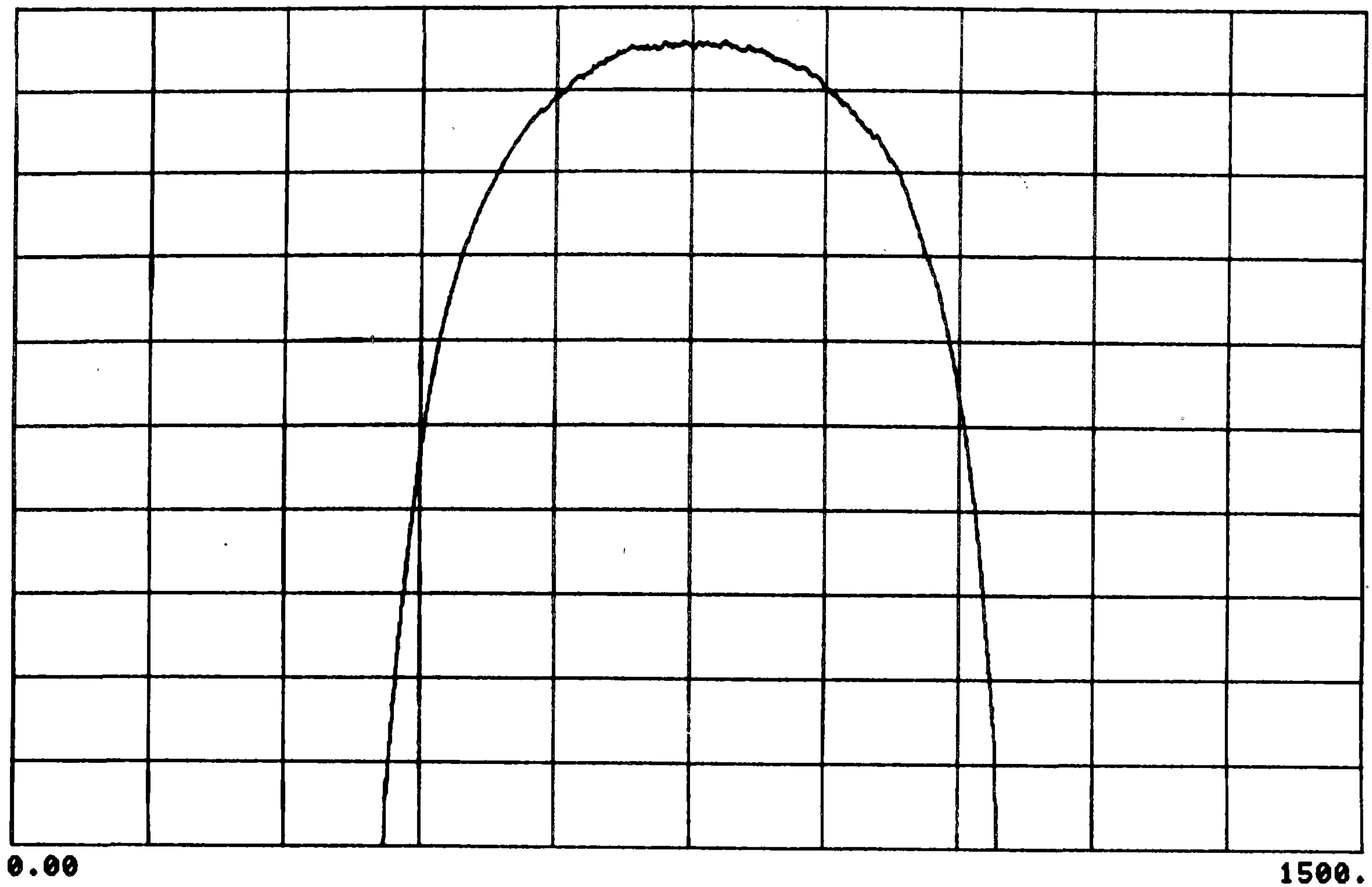
##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 283 00 00 00.000 FOR 1500.0000 MINUTE(S)



ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

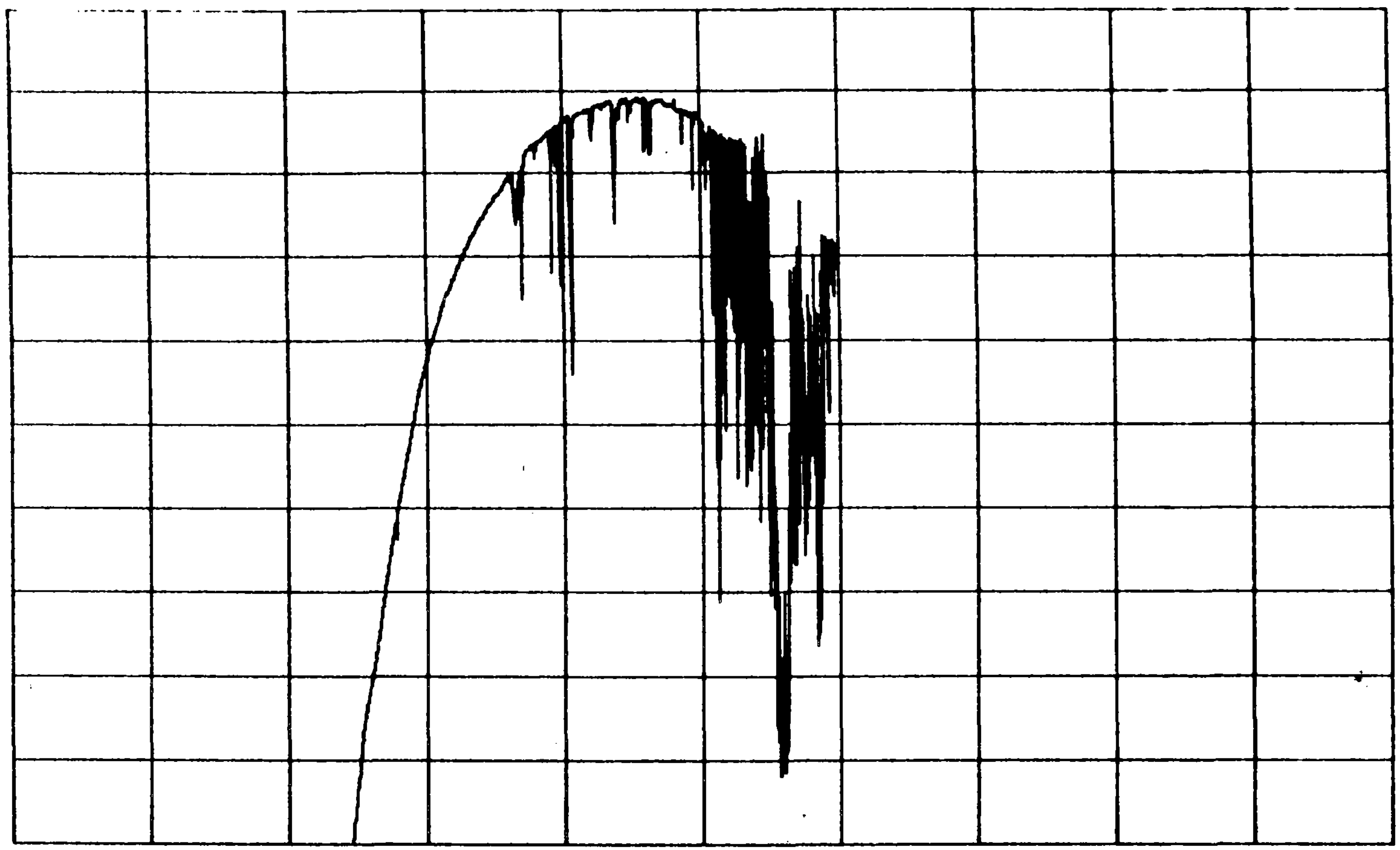
SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 283 00 00 00.000 FOR 1500.0000 MINUTE(S)



##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

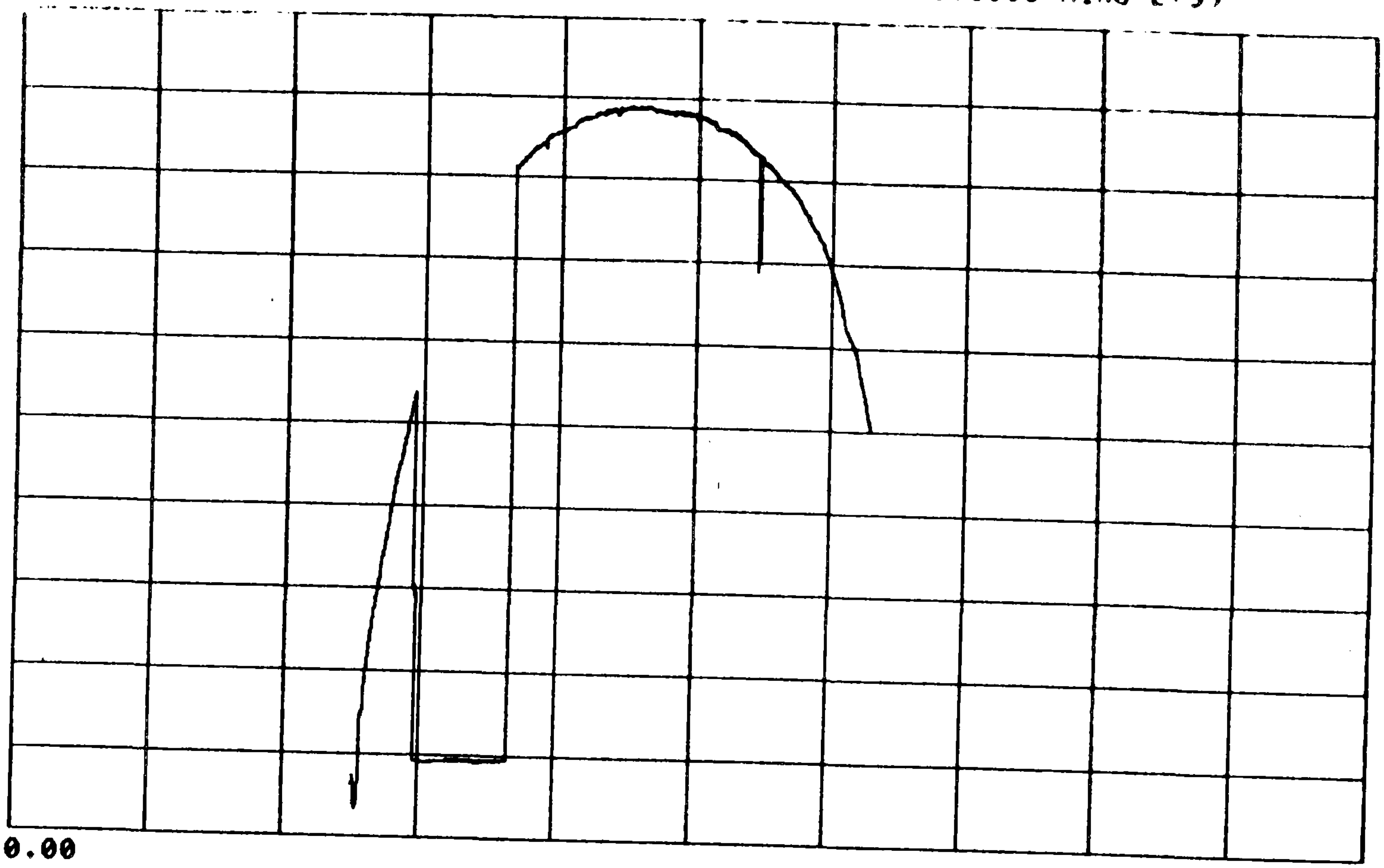
SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1

R…ENCE TIME: 305 00 00 00.000 FOR 1500.0000 MINUTE(S)



##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

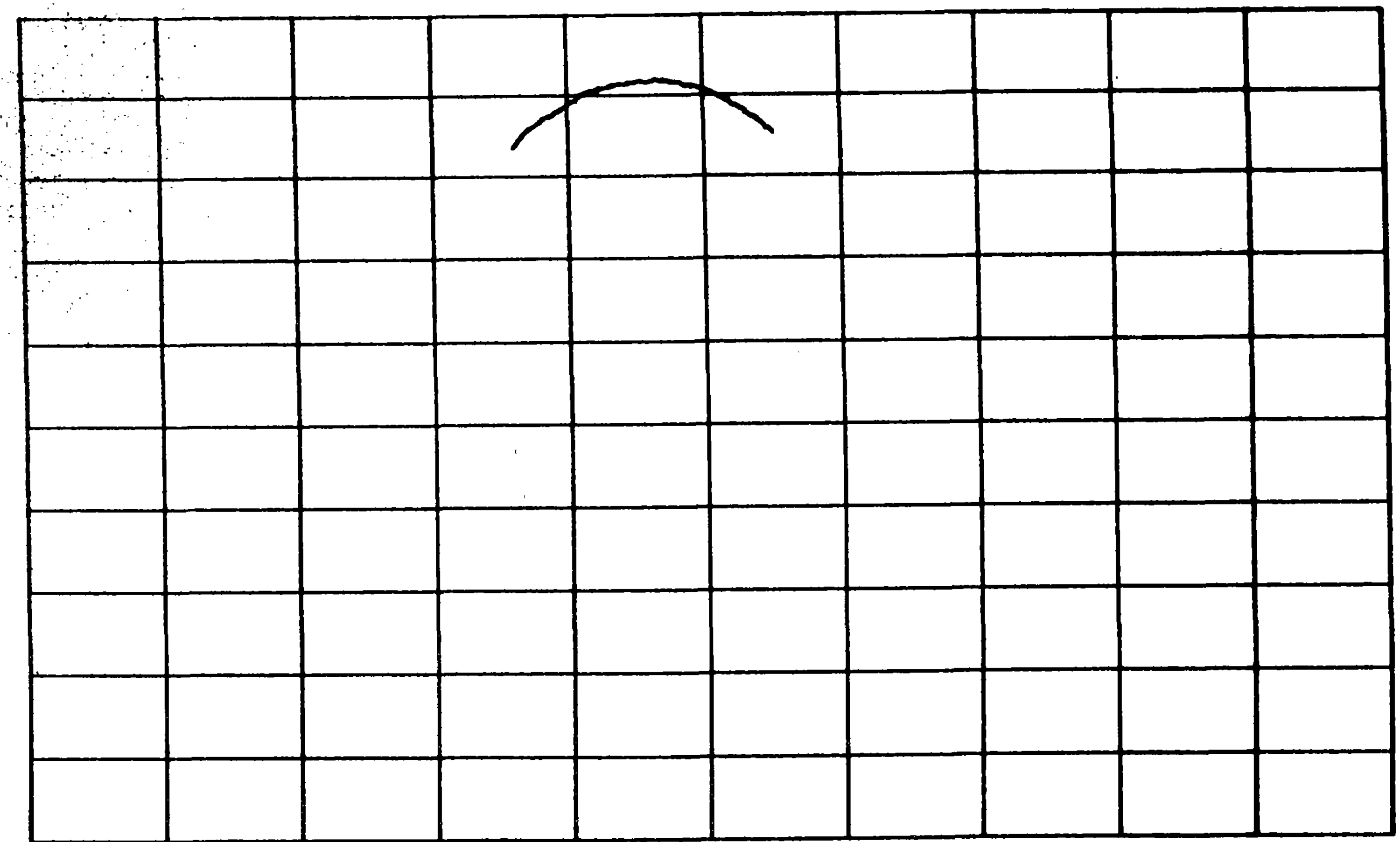
SOLAR DATA PLOT PLOT $ MISL3
FEFERENCE TIME: 306 00 00 00.000 FOR NTH SAMPLE AVERAGE = 1
1500.0000 MINUTE(S)



0.00 1500.00

$$ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 307 00 00 00.000 FOR 1500.0000 MINUTE(S)



ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

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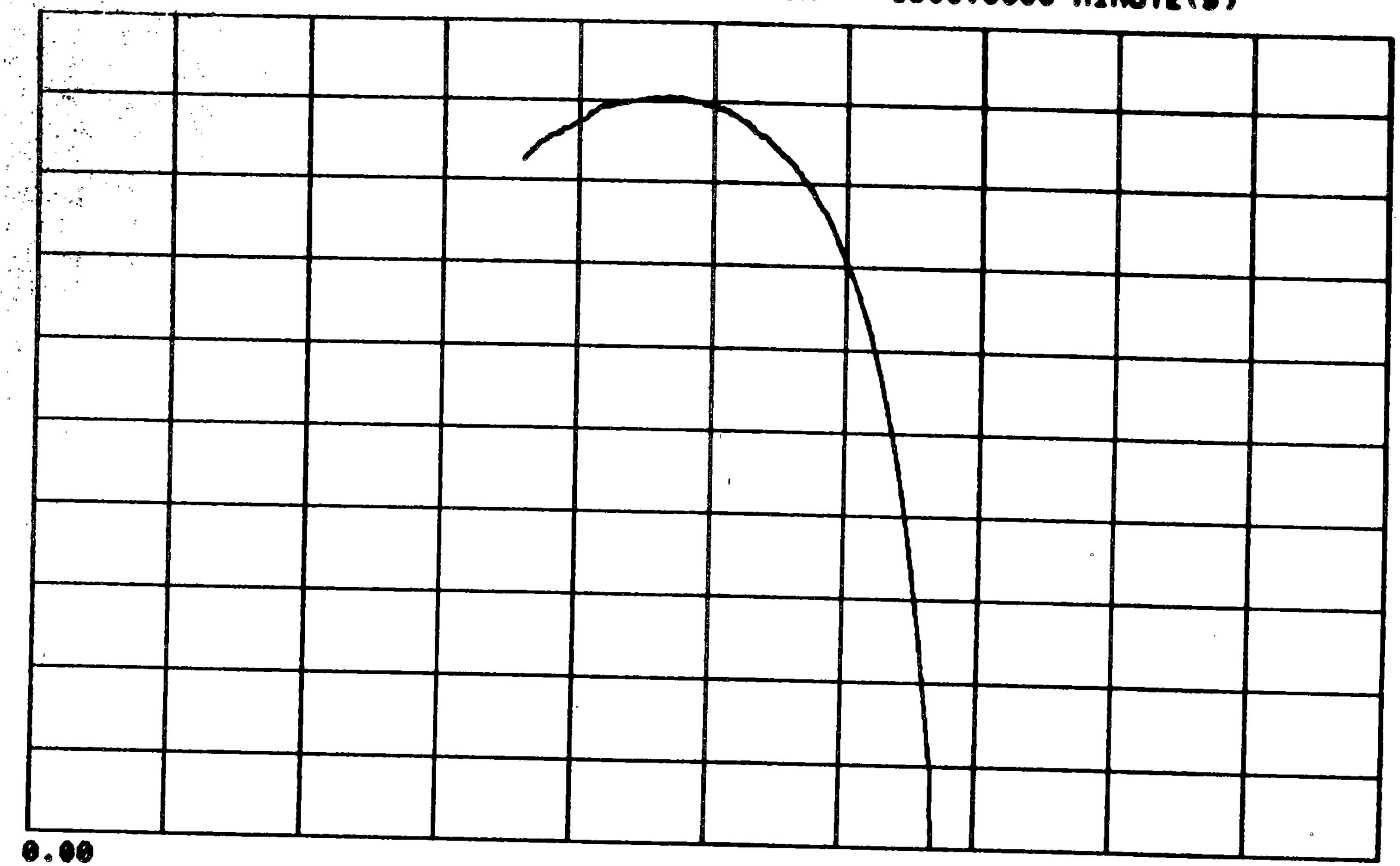
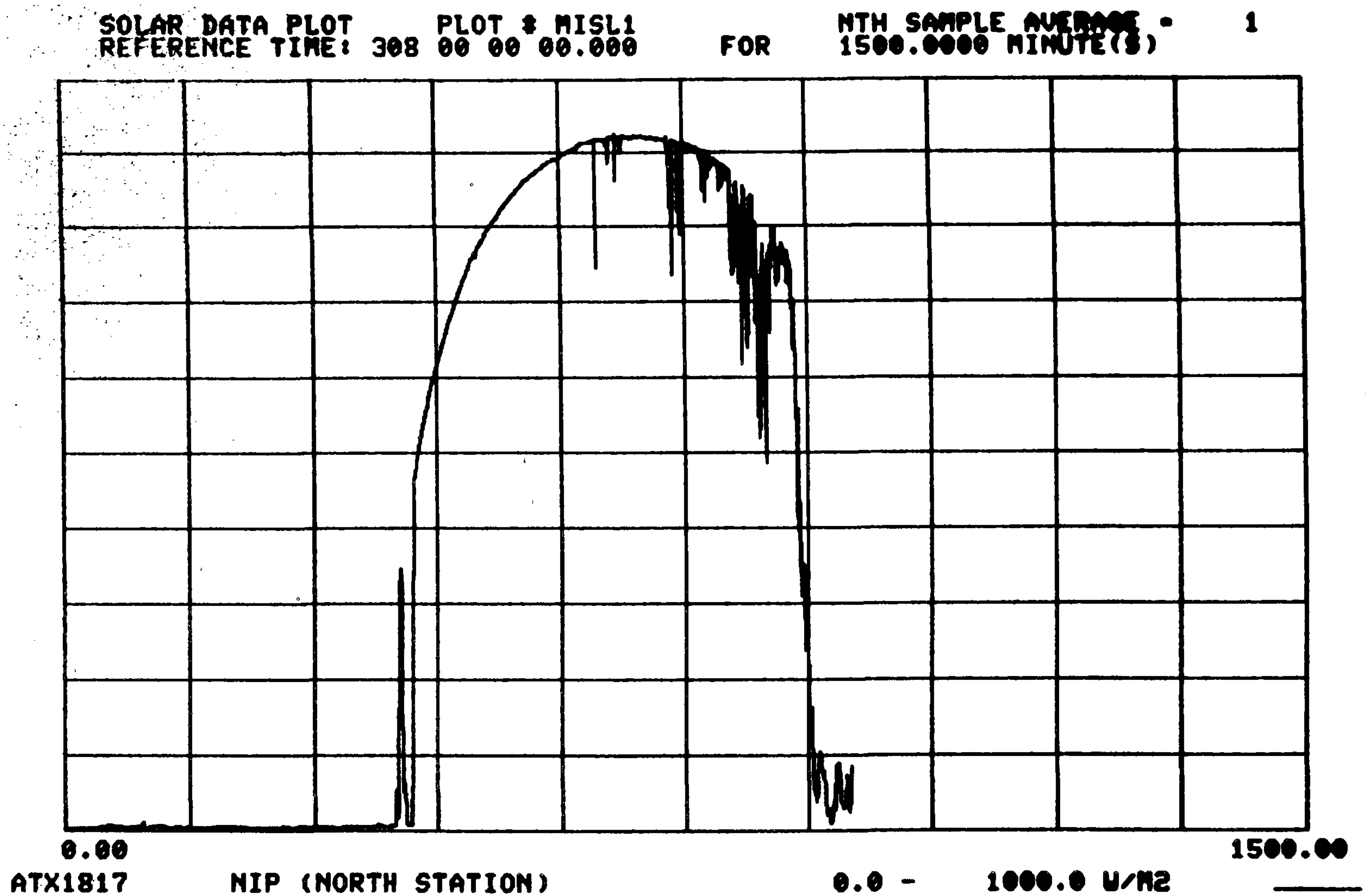
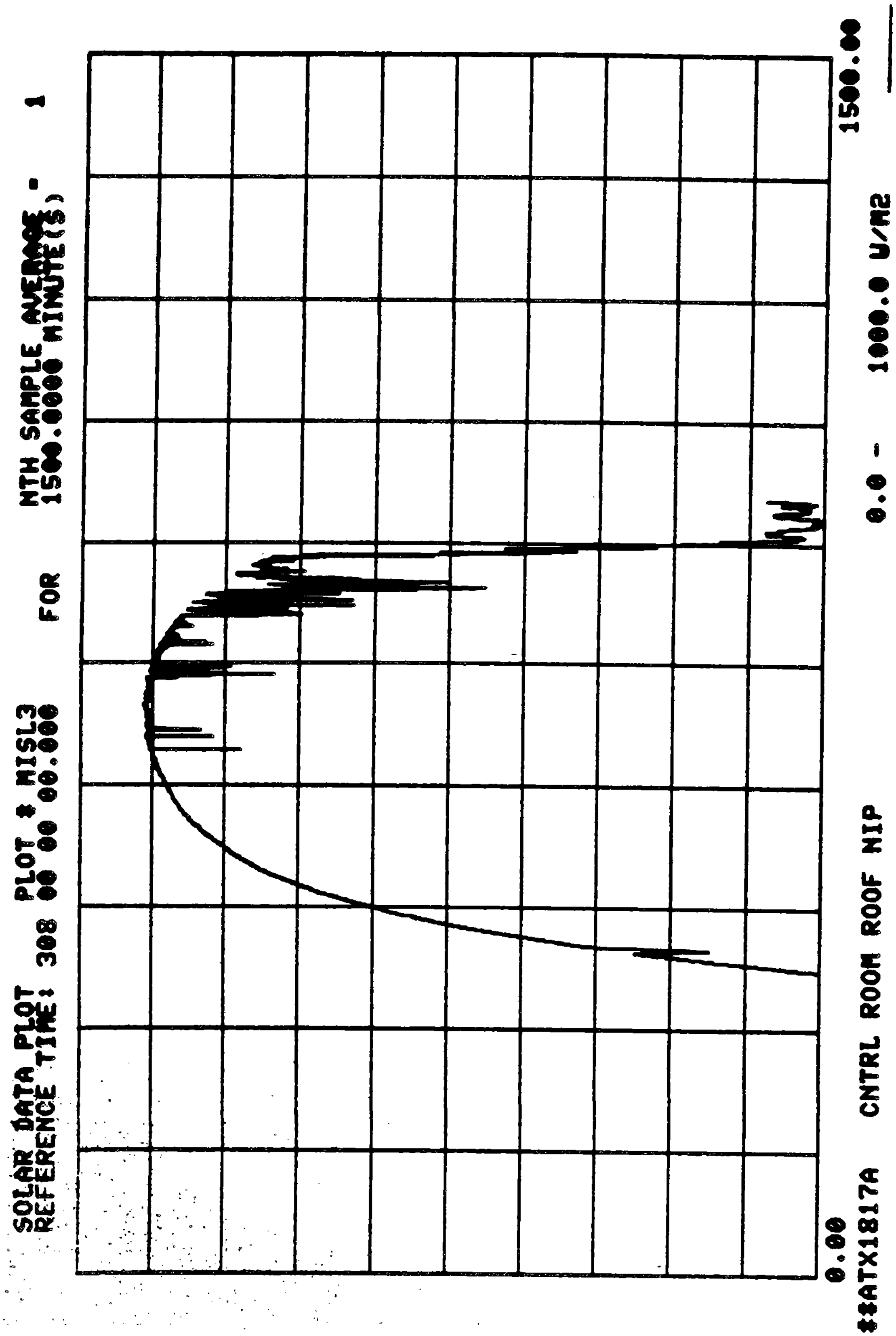
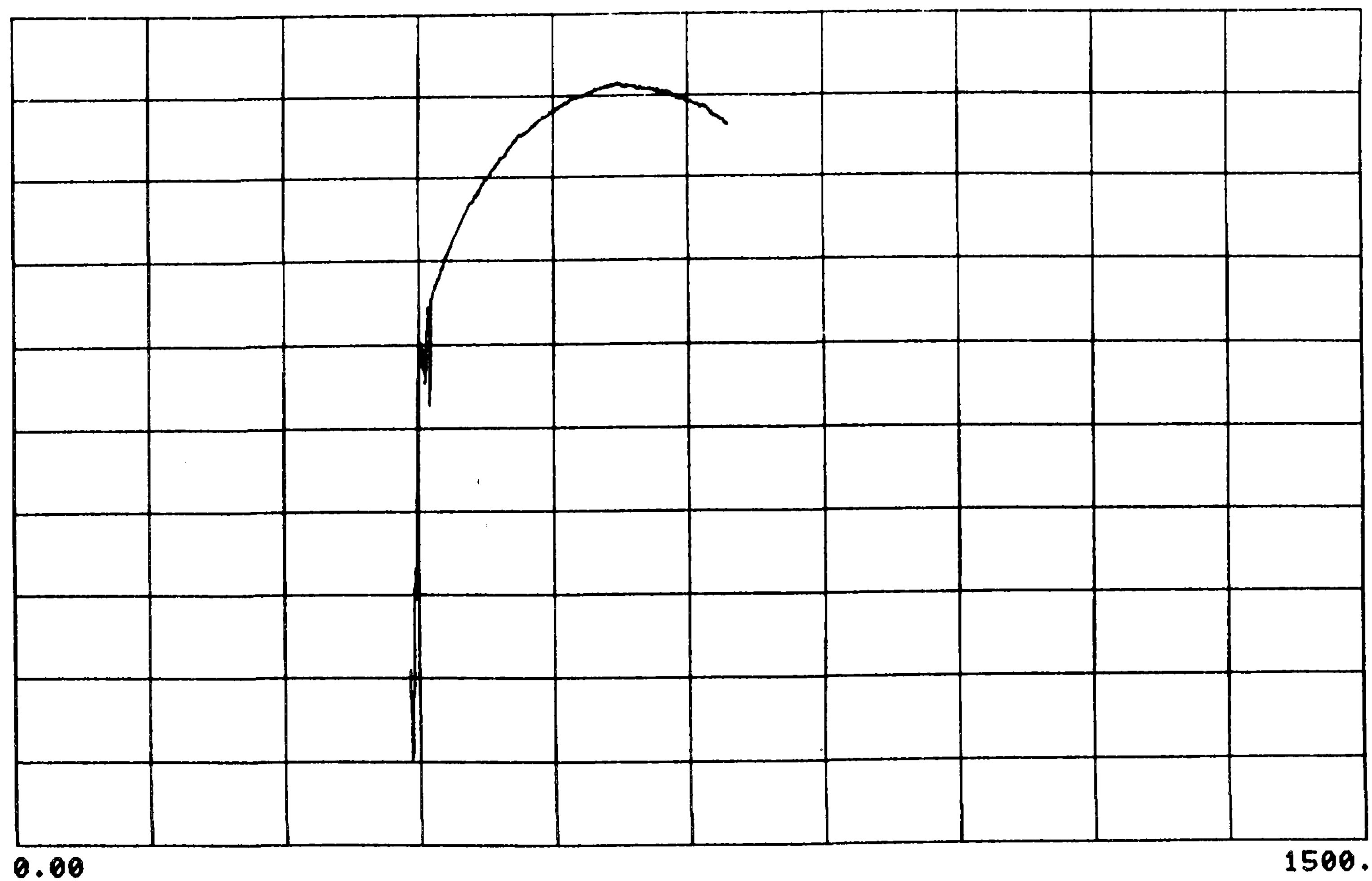


##ATX1817A　　CNTRL ROOM ROOF NIP　　0.0 - 1000.0 W/M2


SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 308 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.00
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

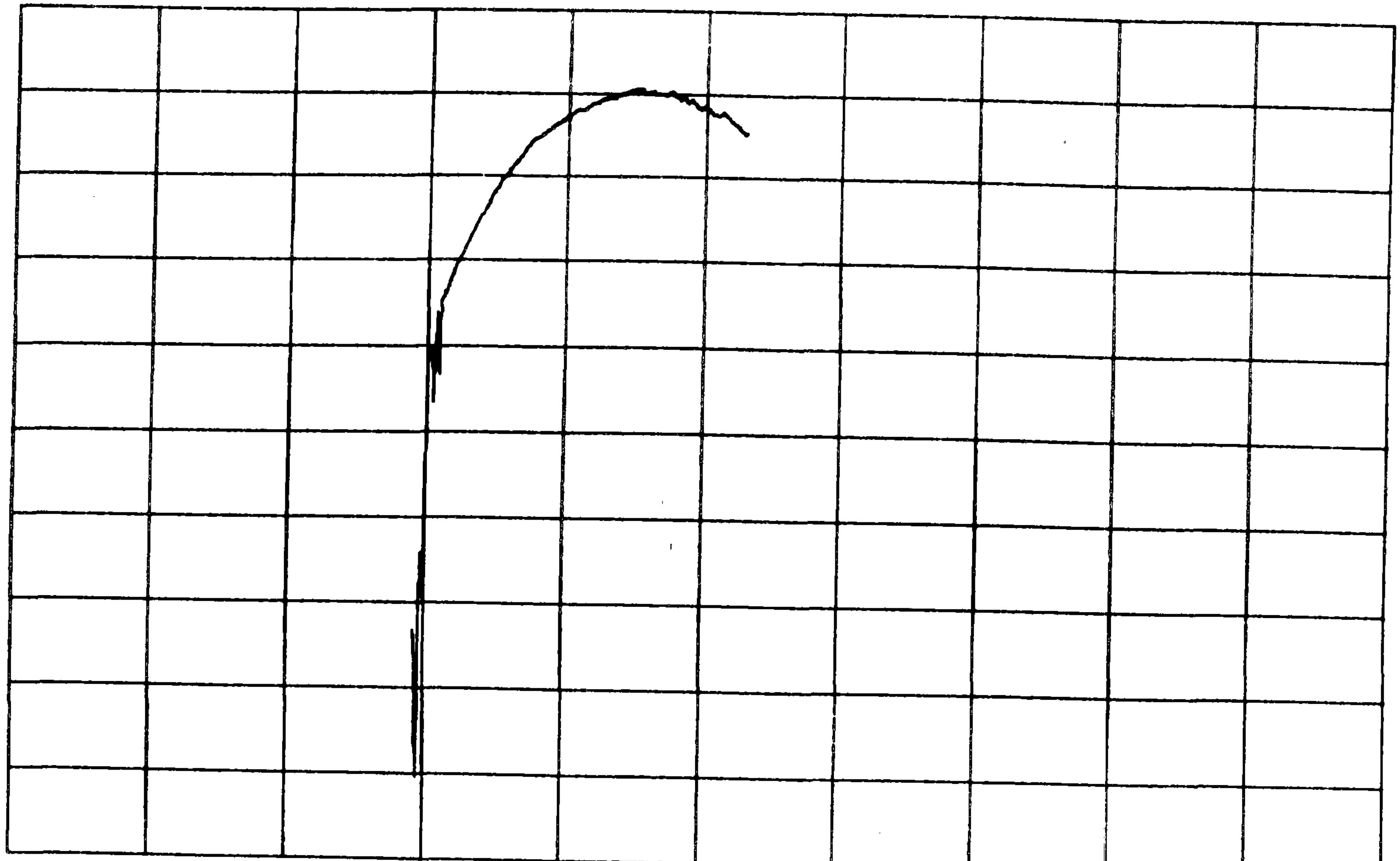

SOLAR DATA PLOT
PLOT $ MISL3
FOR
NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 308 00 00 00.000
1500.0000 MINUTE(S)
0.00
1500.00
0.0 - 1000.0 W/M2
$$ATX1817A
CNTRL ROOM ROOF NIP

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 309 00 00 00.000 FOR 1500.0000 MINUTE(S)



ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

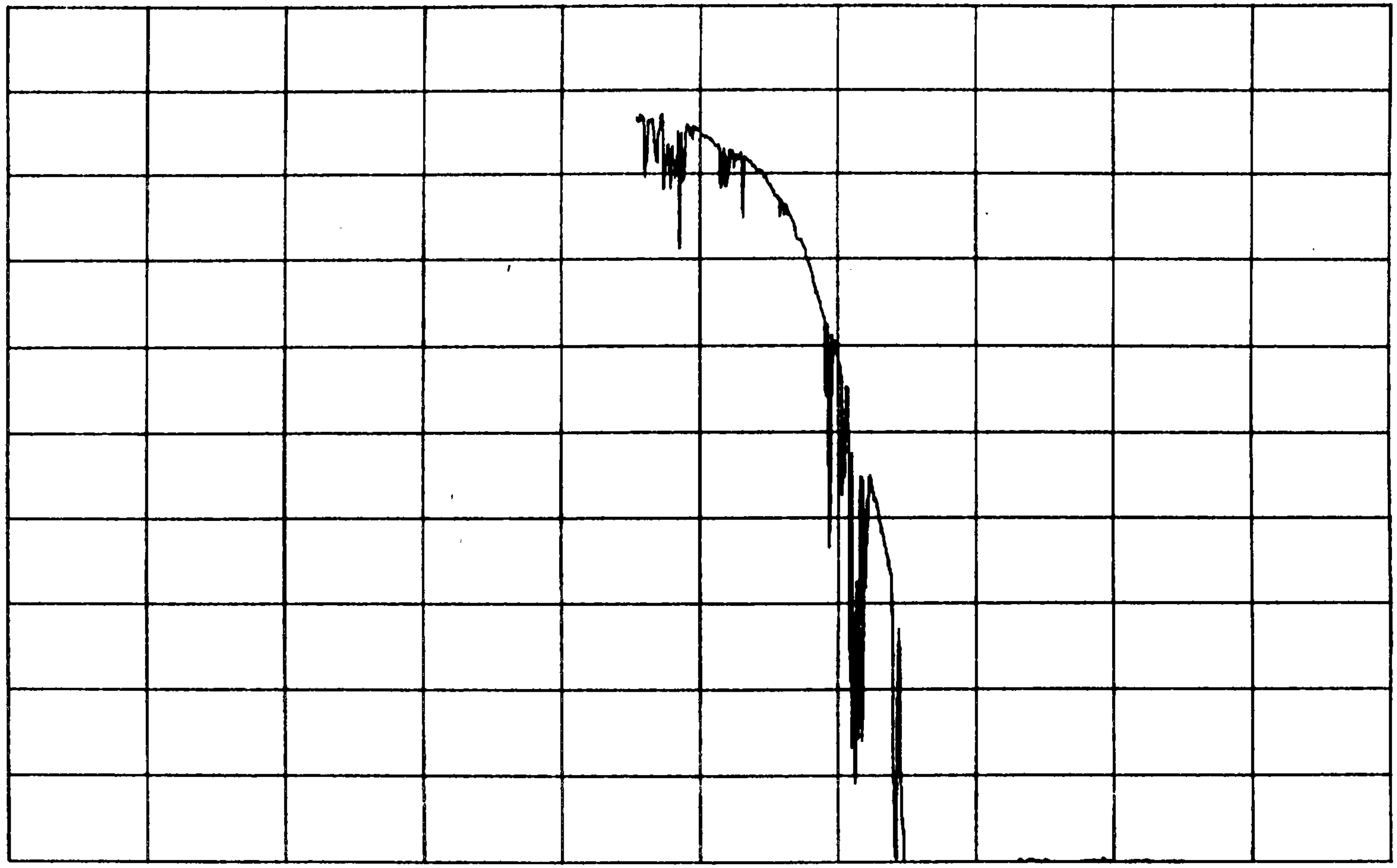
SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 309 00 00 00.000   FOR   1500.0000 MINUTE(S)



0.00   1500.

##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL1   NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 310 00 00 00.000   FOR   1500.0000 MINUTE(S)



0.00   1500.

ATX1817   NIP (NORTH STATION)   0.0 - 1000.0 W/M2

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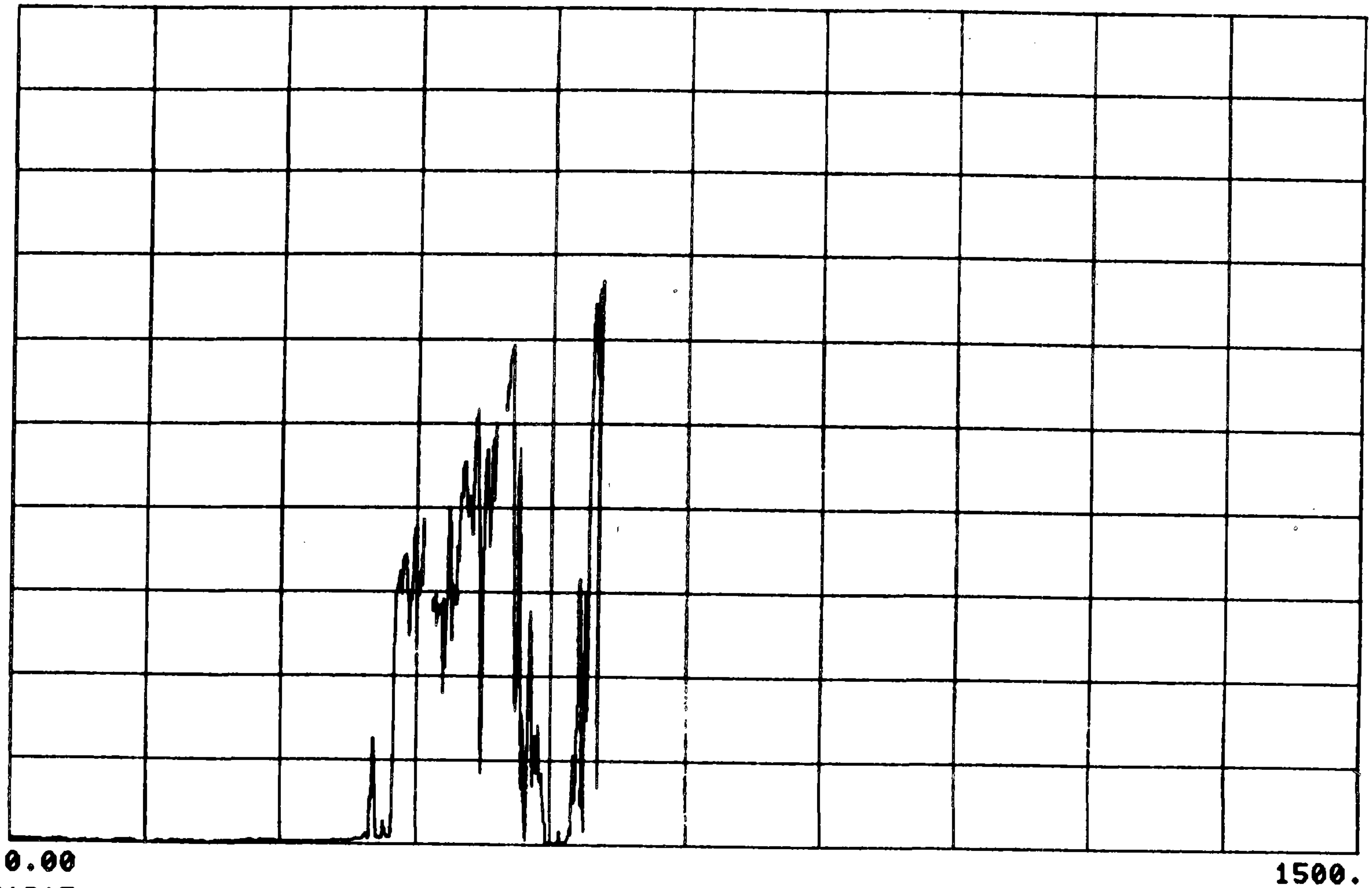

ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE = 1
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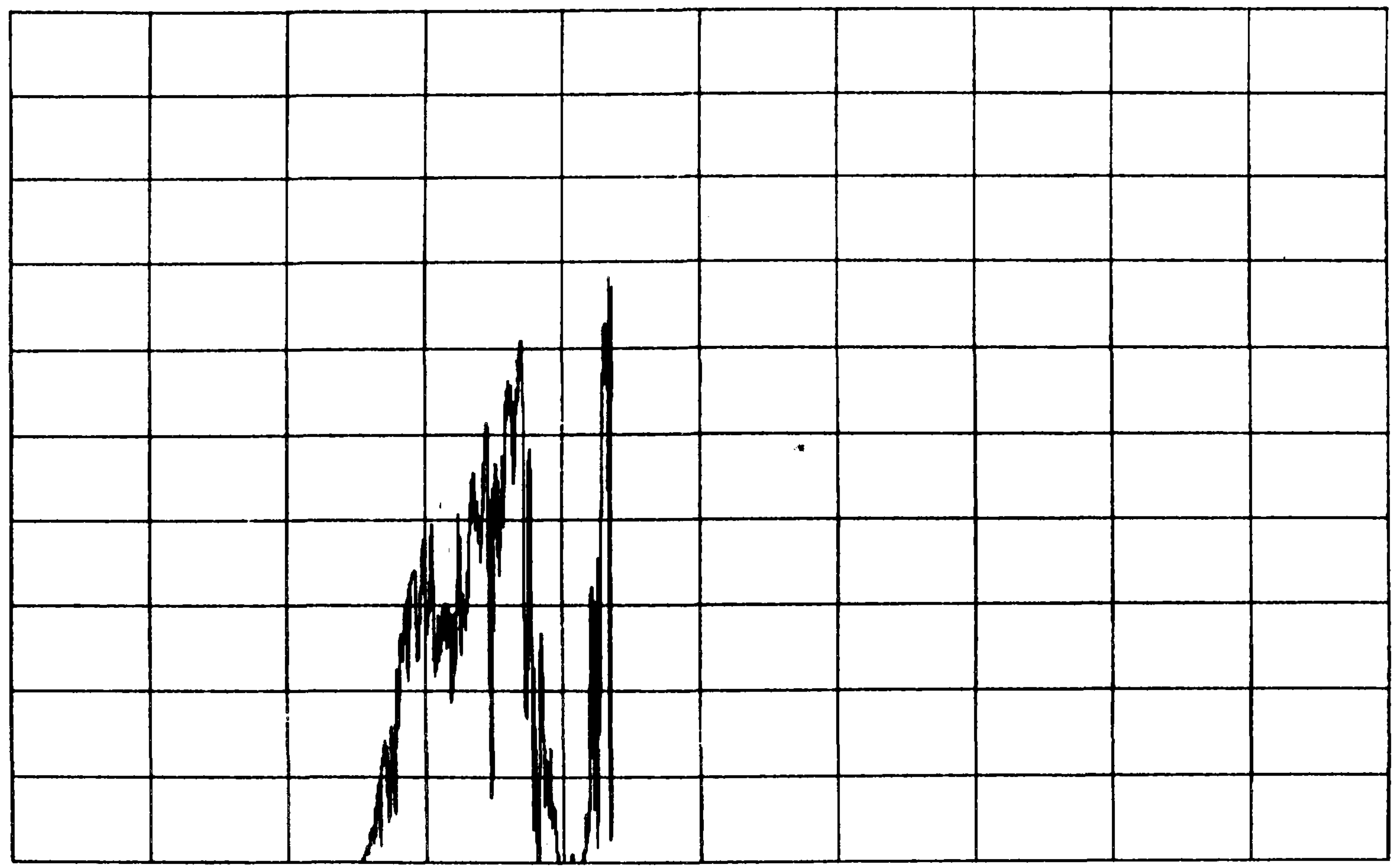

0.00   1500.

##ATX1817A   CNTRL ROOM ROOF NIP   0.0 - 1000.0 W/M2

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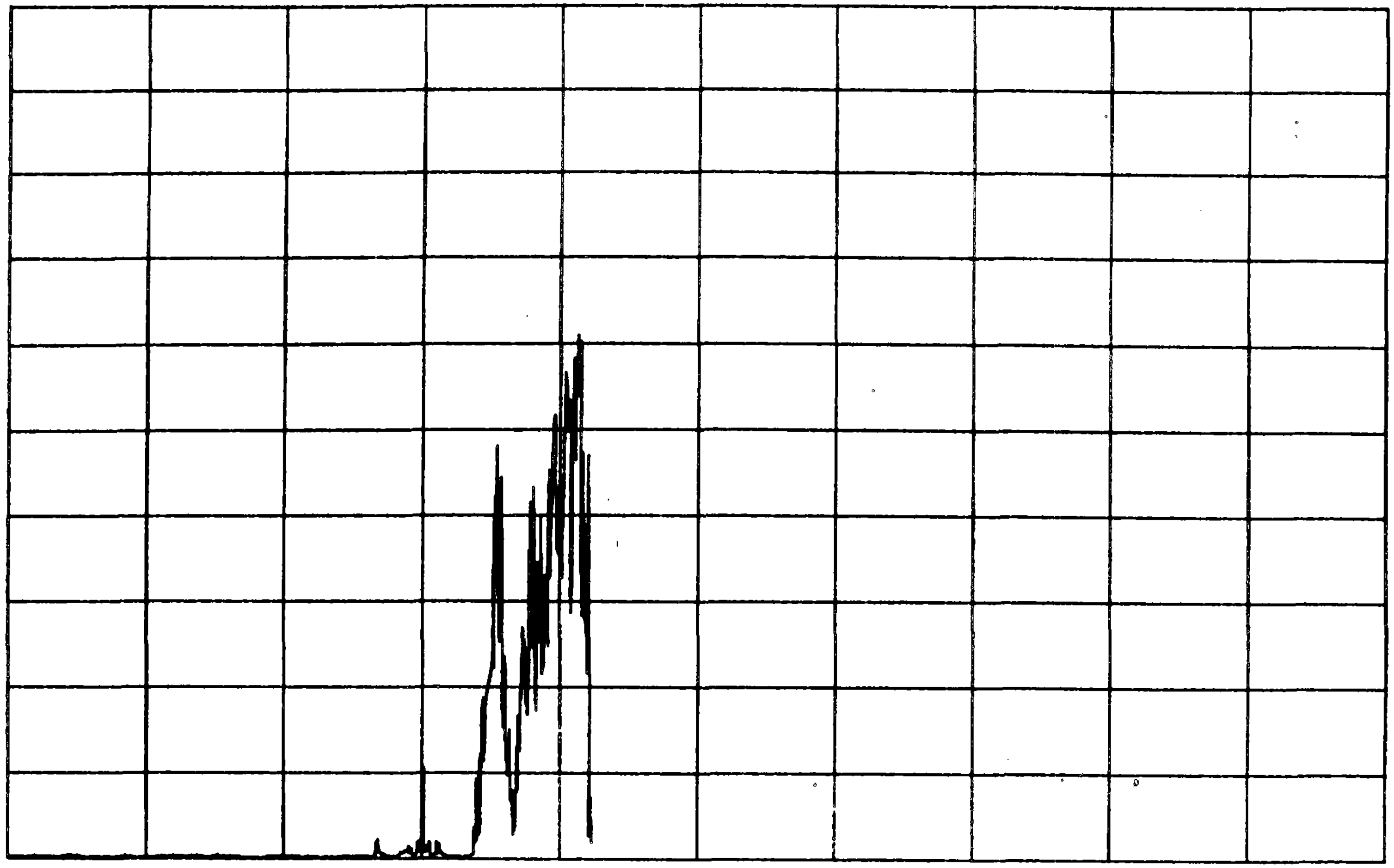

0.00 1500.

ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

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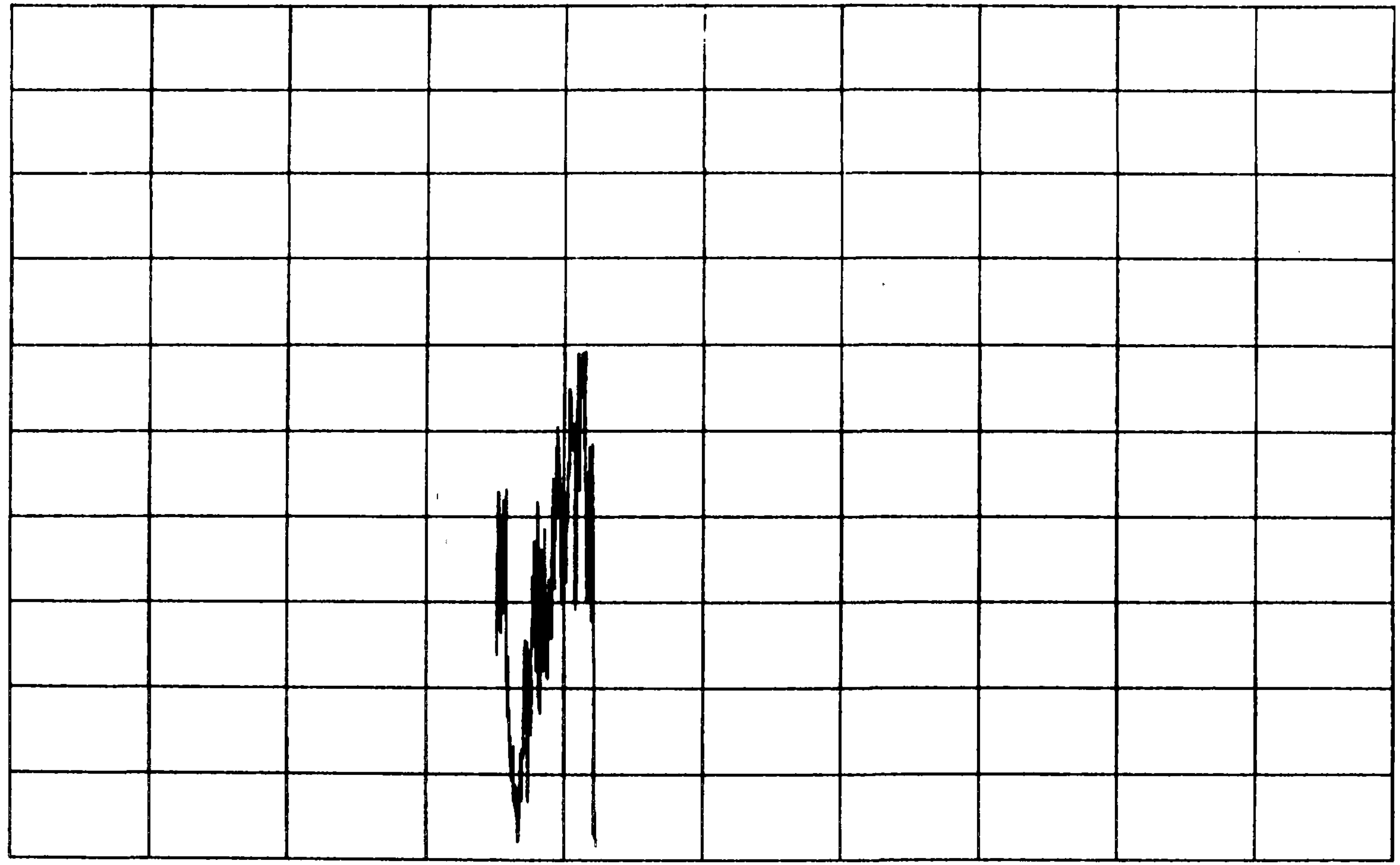

##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
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ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL3 NTH SAMPLE AVERAGE = 1
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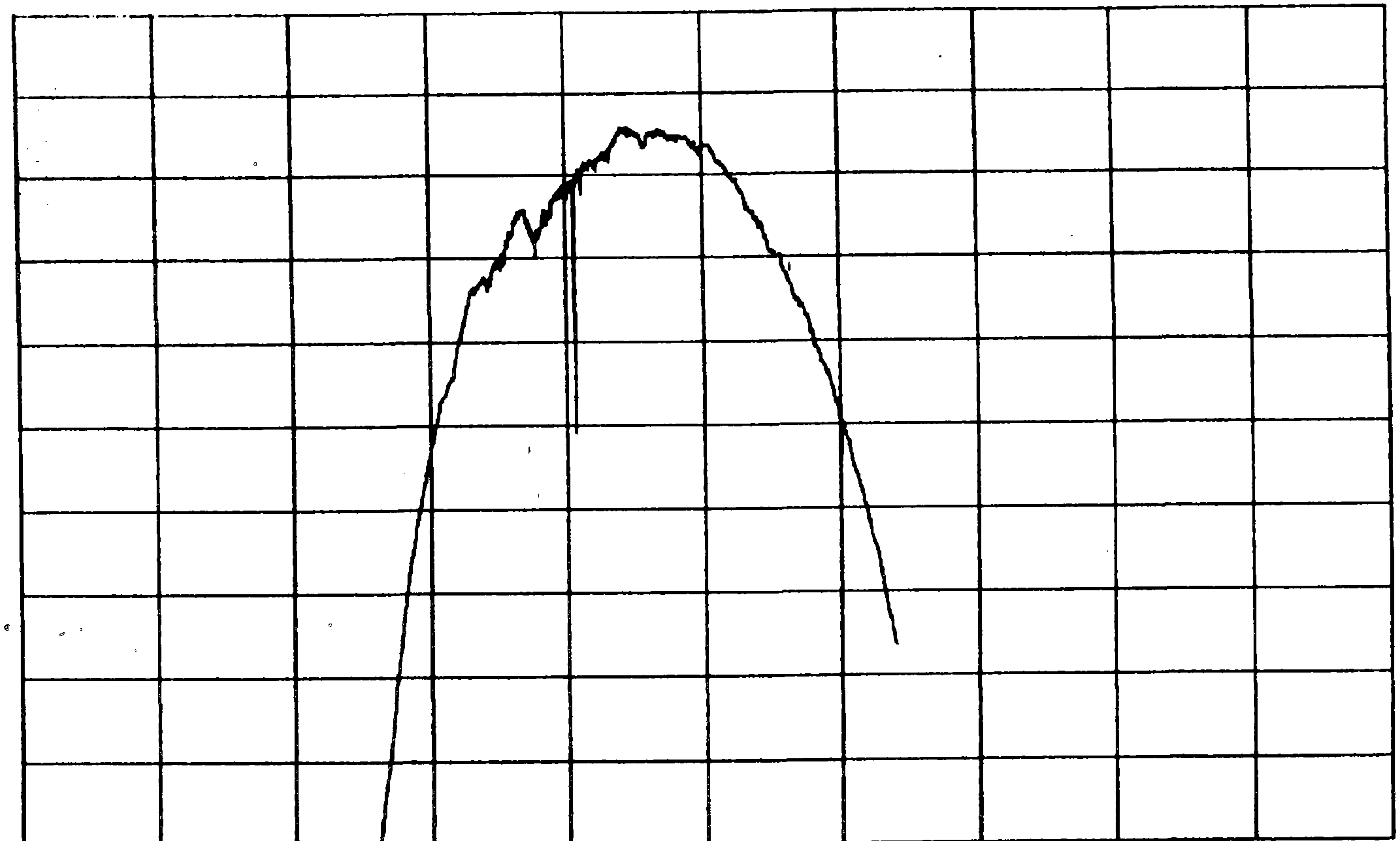
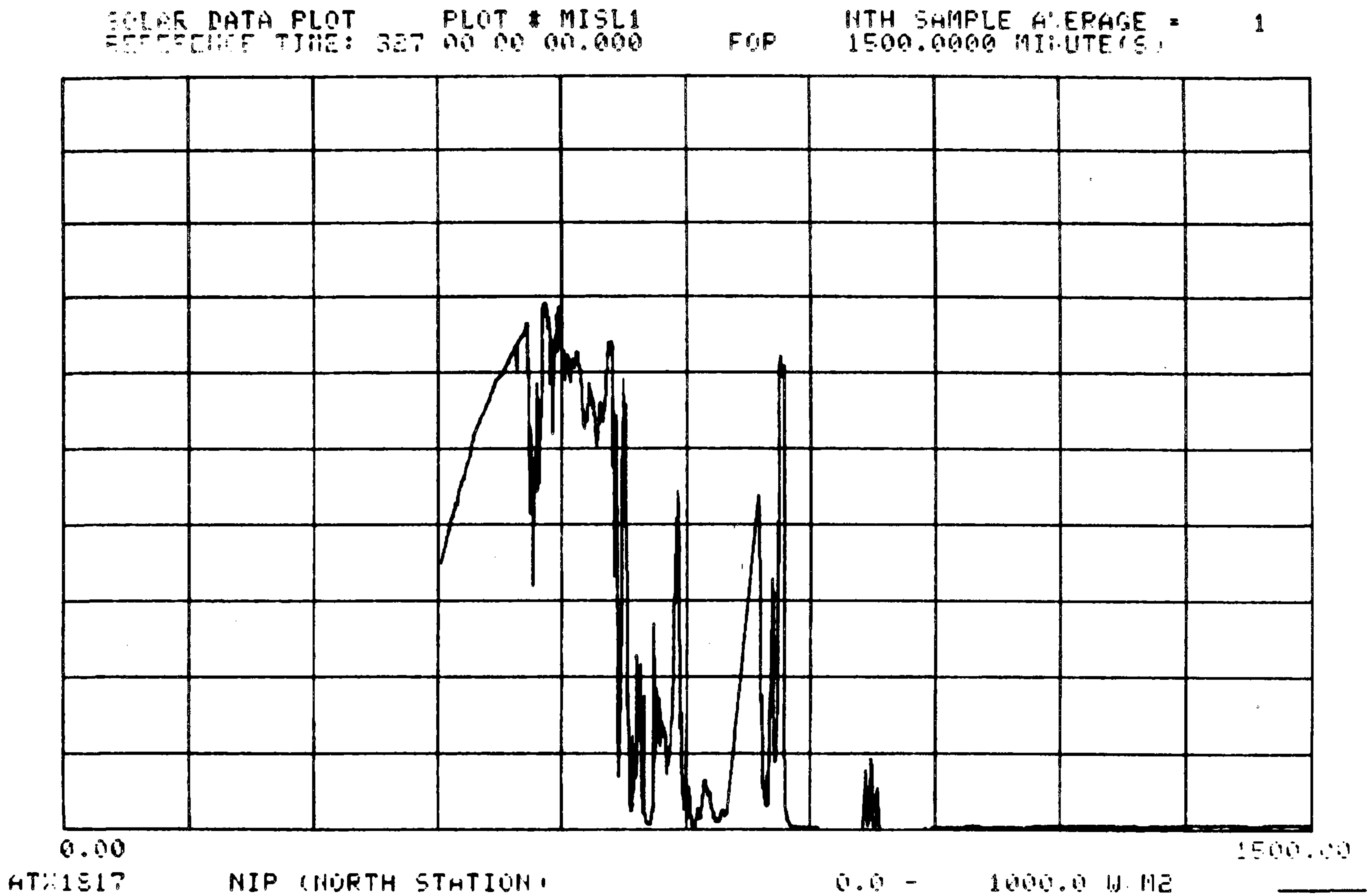
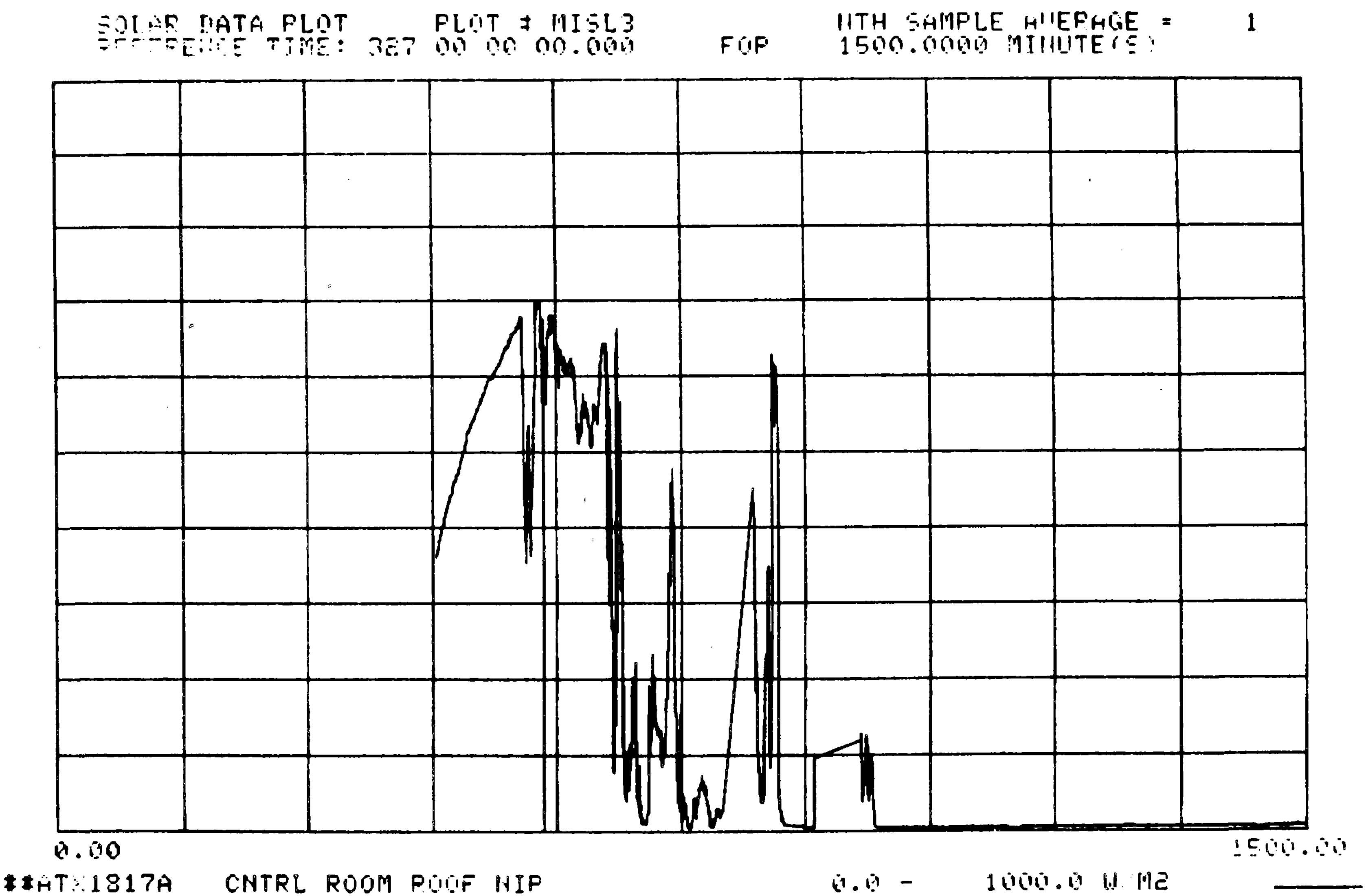


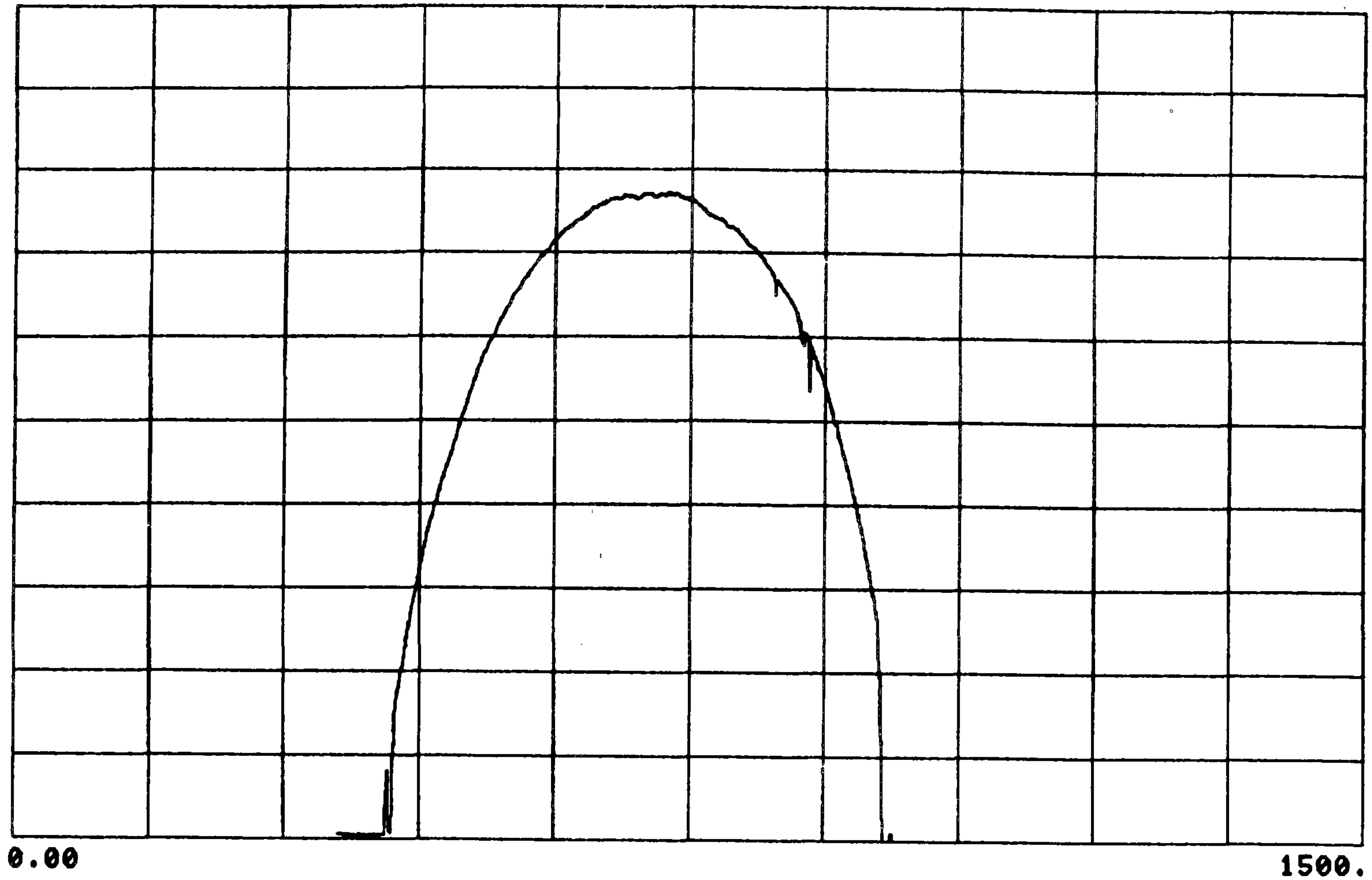
$$ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2


SOLAR DATA PLOT
PLOT # MISL1
NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 327 00 00 00.000
FOP
1500.0000 MINUTE(S)
0.00
1500.00
ATX1517
NIP (NORTH STATION)
0.0 - 1000.0 W/M2



SOLAR DATA PLOT
PLOT # MISL3
NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 327 00 00 00.000
FOP
1500.0000 MINUTE(S)
0.00
1500.00
**ATX1817A CNTRL ROOM ROOF NIP
0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 329 00 00 00.000 FOR 1500.0000 MINUTE(S)



ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
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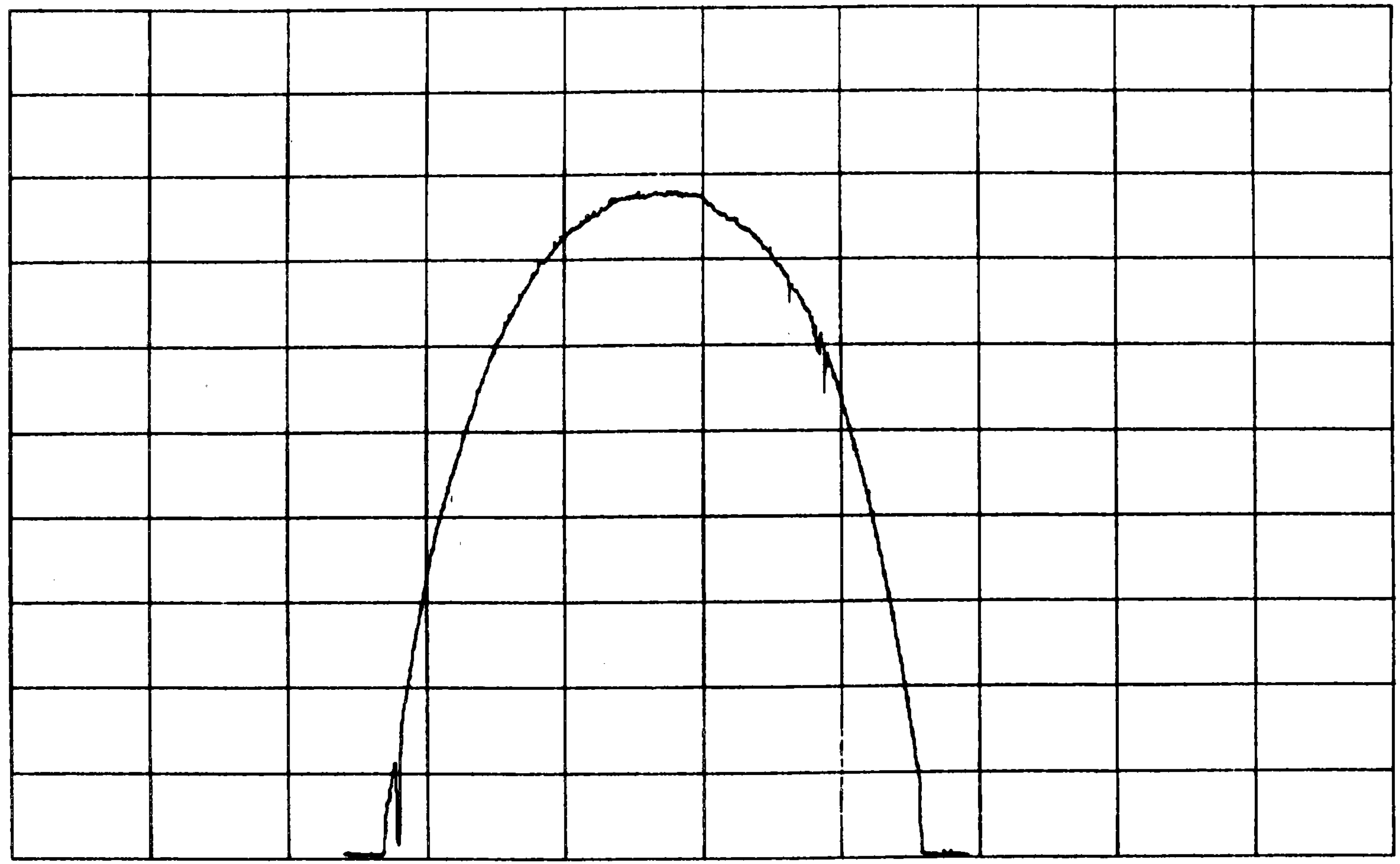
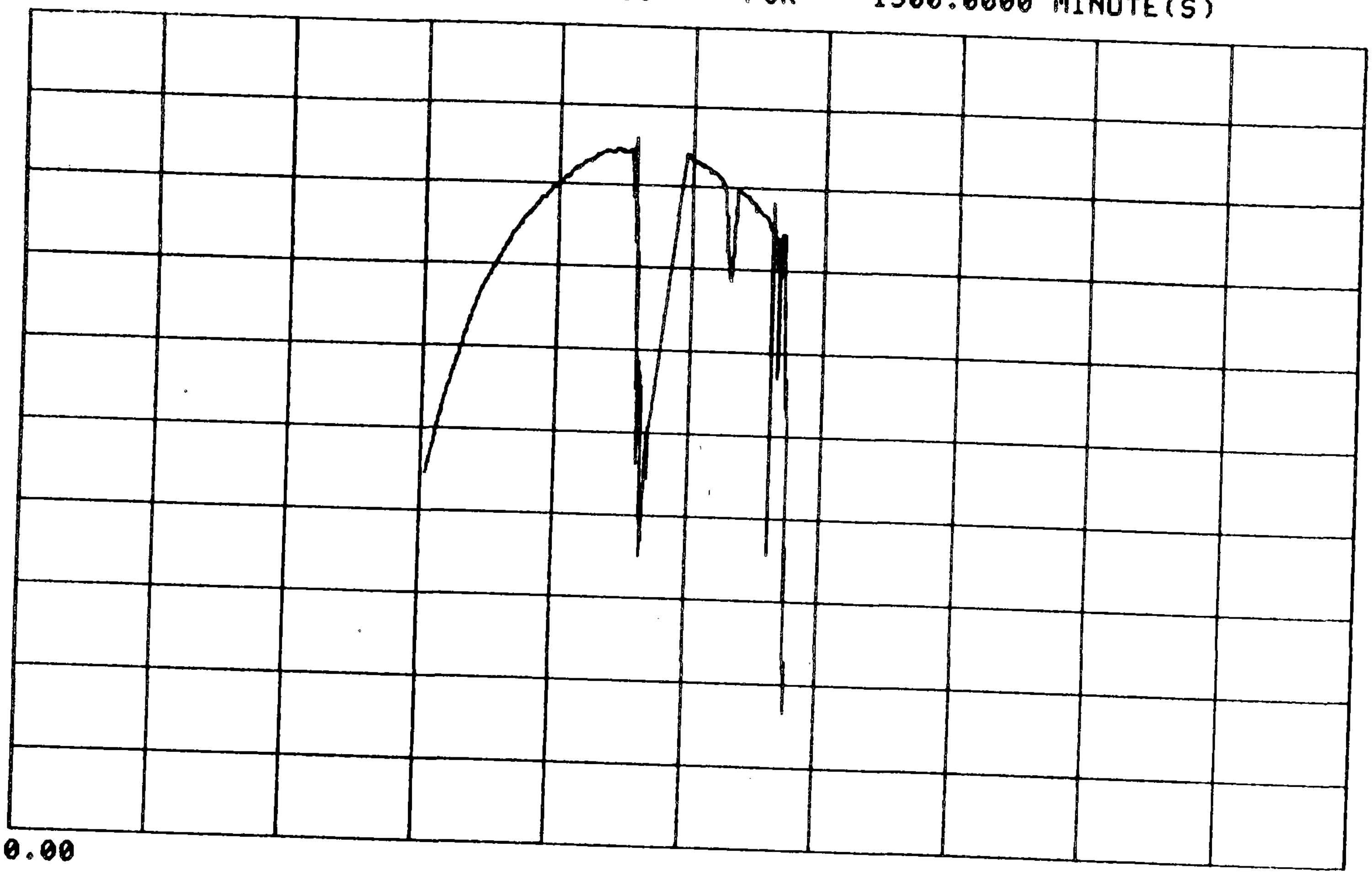


##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

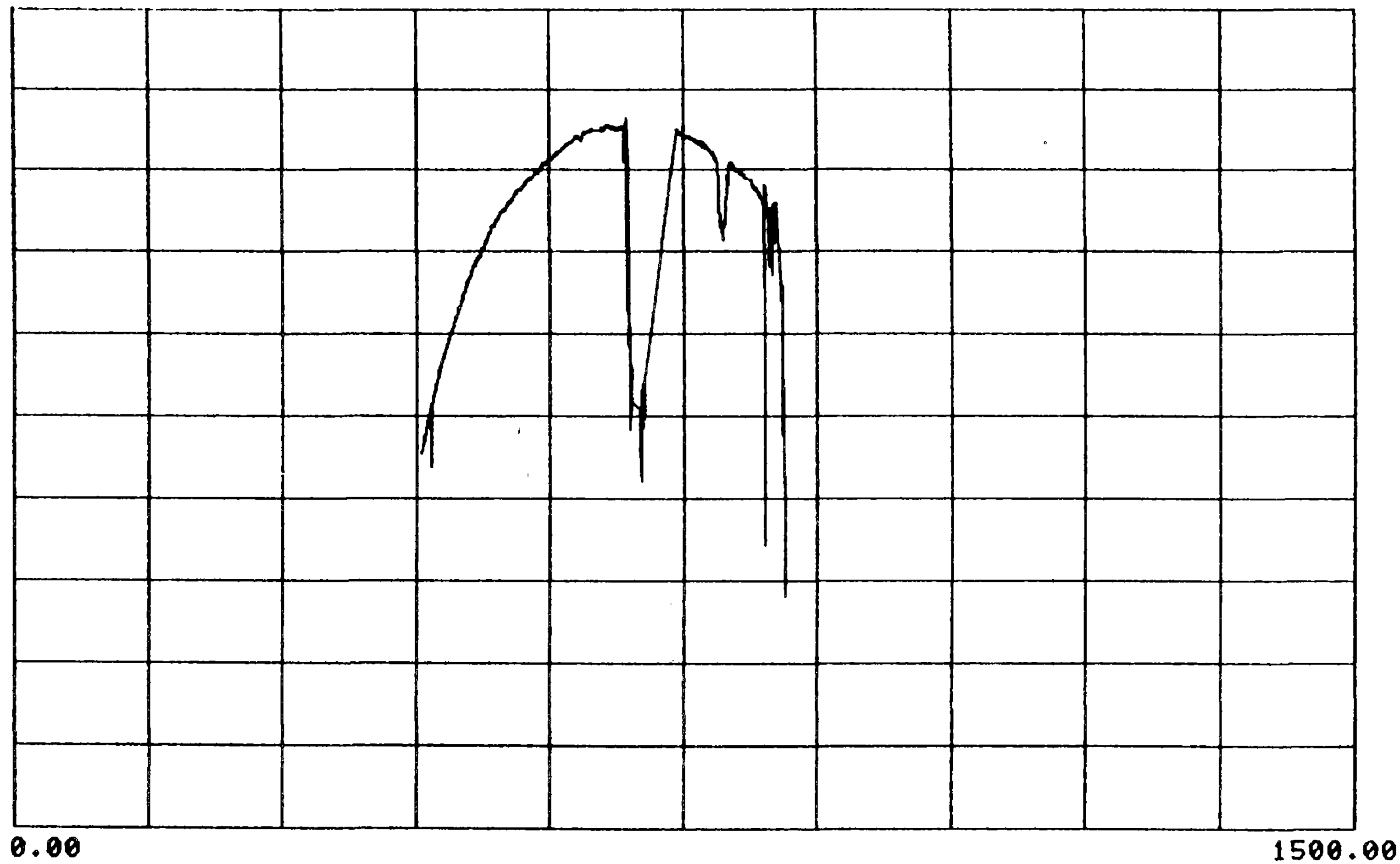
SOLAR DATA PLOT PLOT # MISL1
REFERENCE TIME: 330 00 00 00.000 FOR

NTH SAMPLE AVERAGE = 1
1500.0000 MINUTE(S)

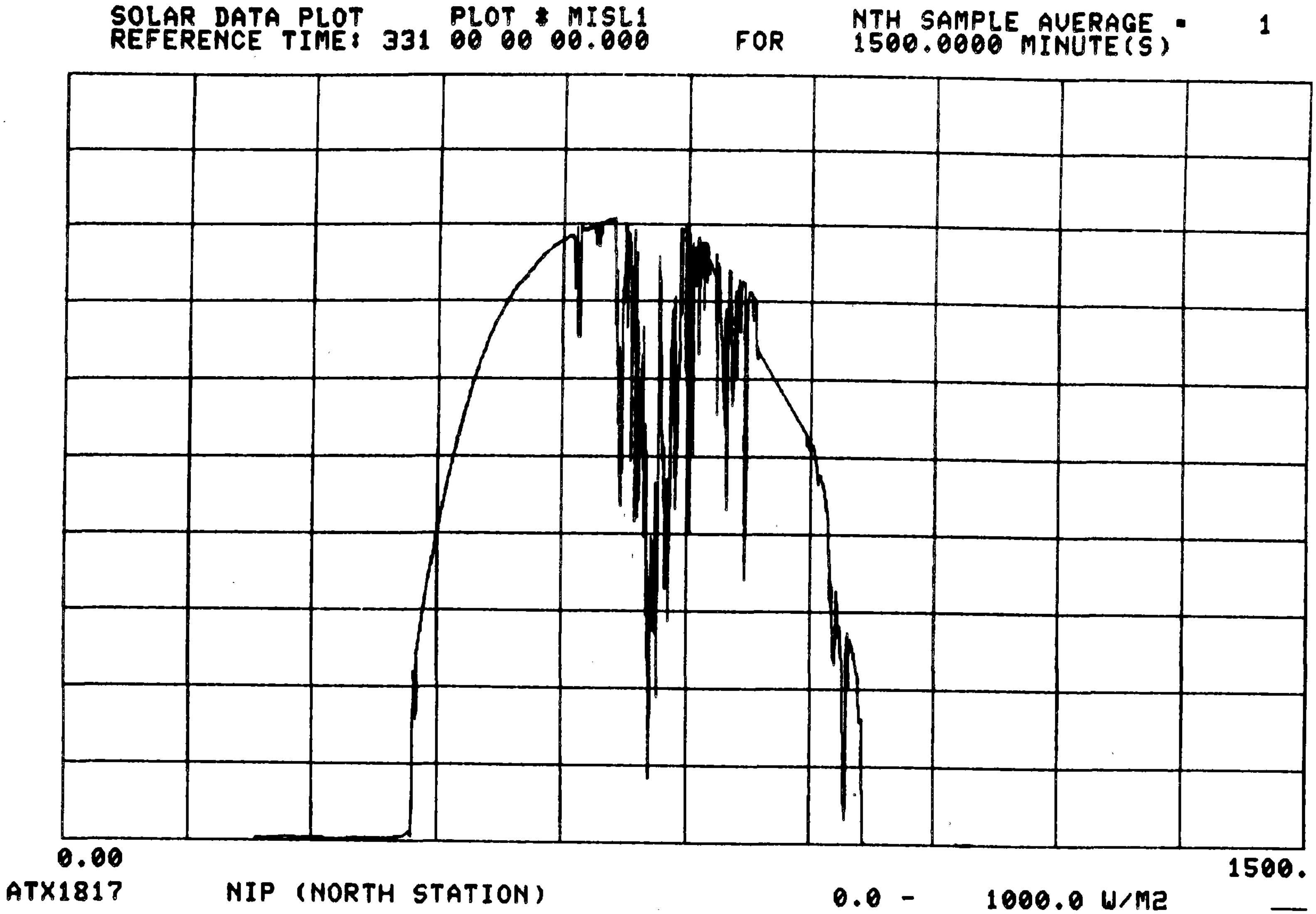


0.00
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2 1500.00

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 330 00 00 00.000   FOR   1500.0000 MINUTE(S)



##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2


SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 331 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
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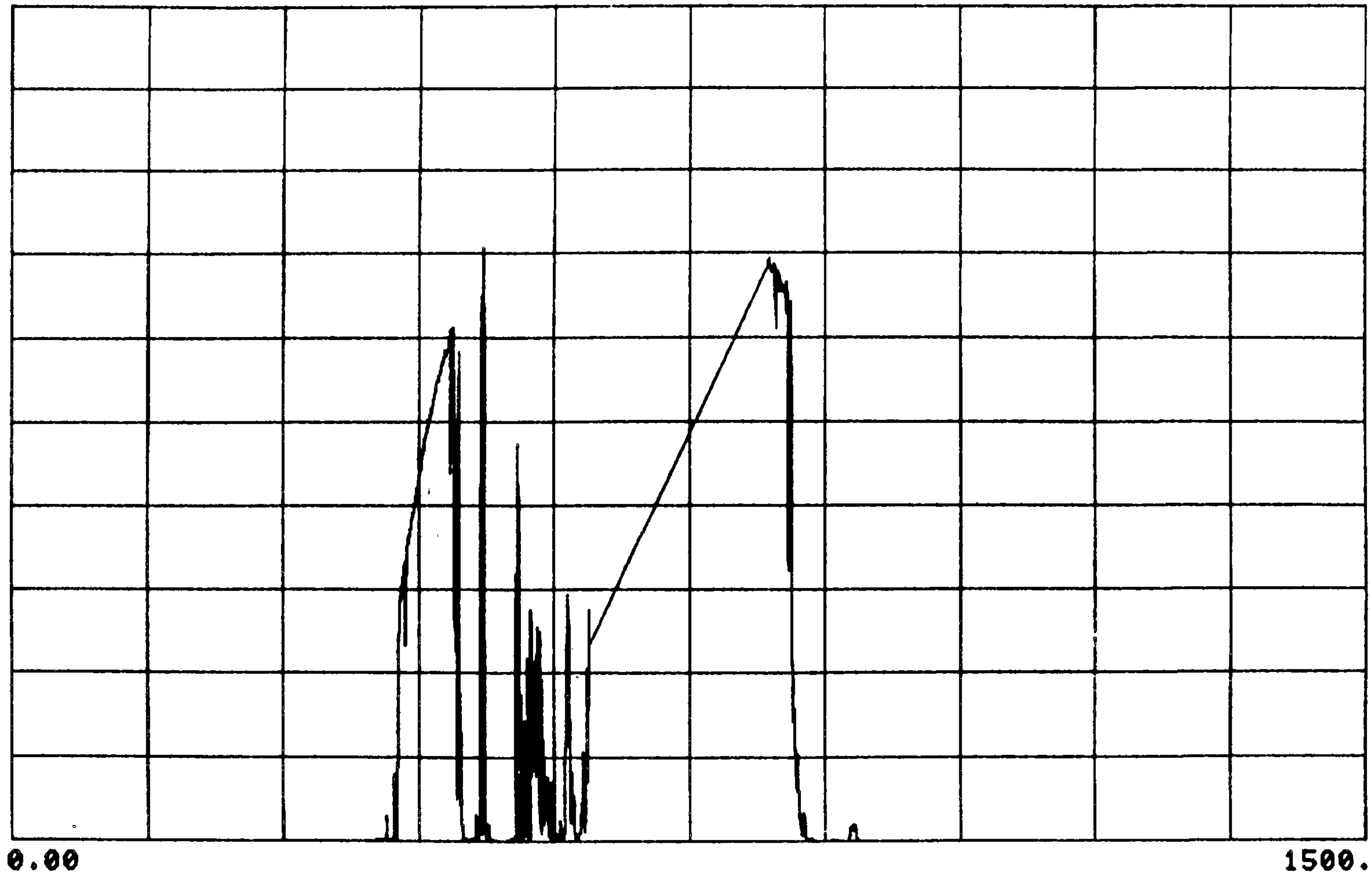
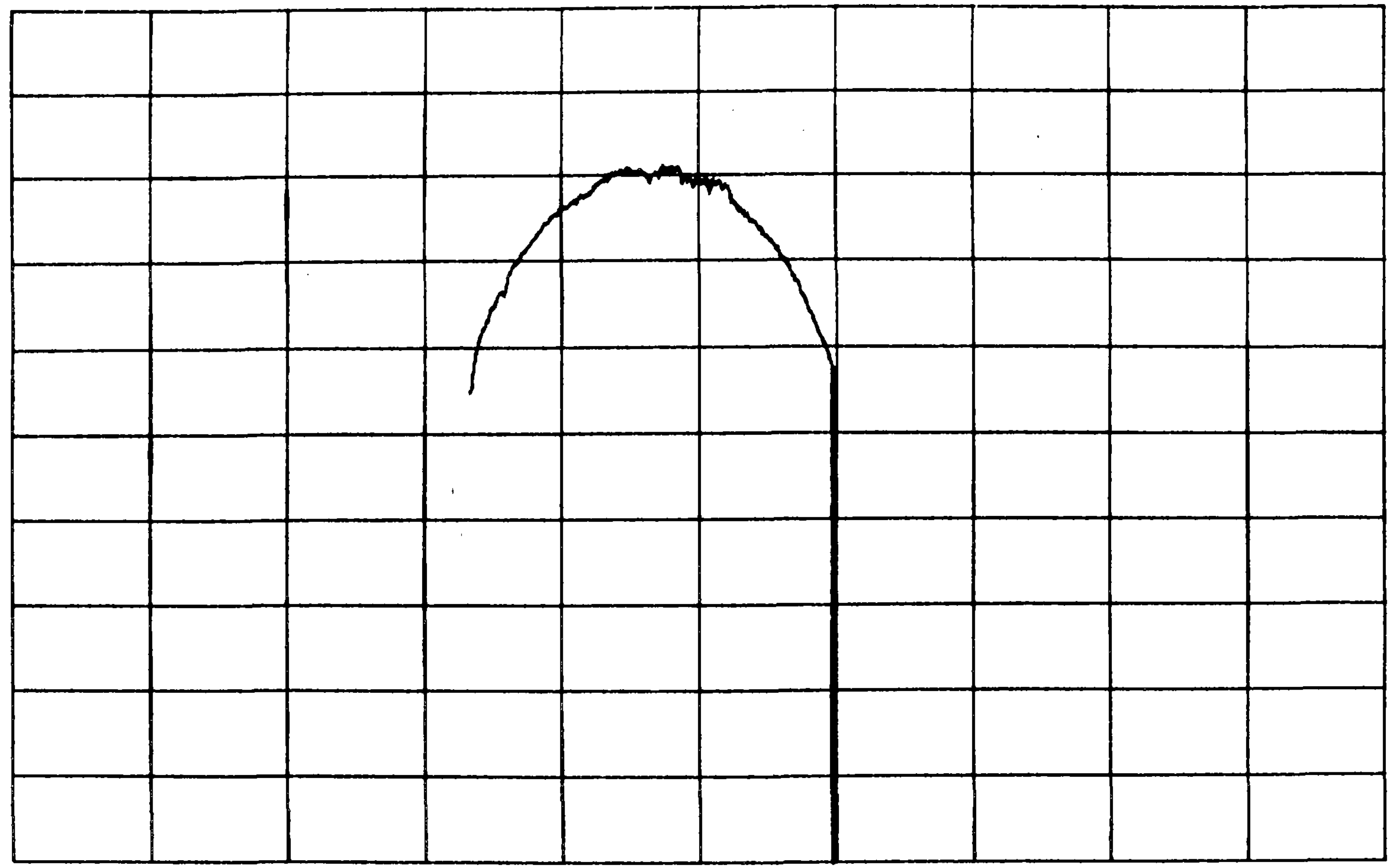


ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 333 00 00 00.000 FOR 1500.0000 MINUTE(S)

$$ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 336 00 00 00.000 FOR 1500.0000 MINUTE(S)

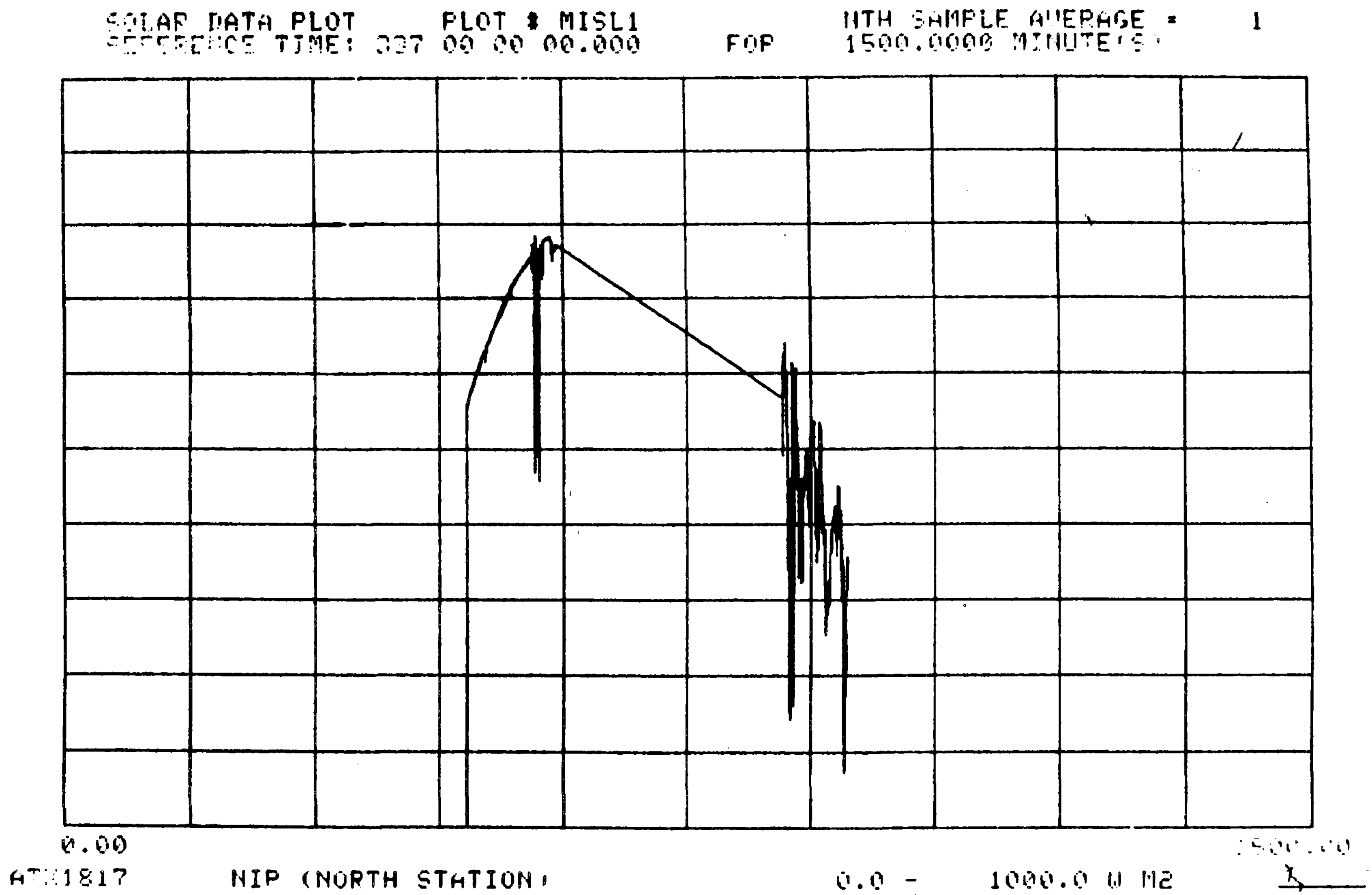


0.00 1500.

ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 336 00 00 00.000 FOR 1500.0000 MINUTE(S)

##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2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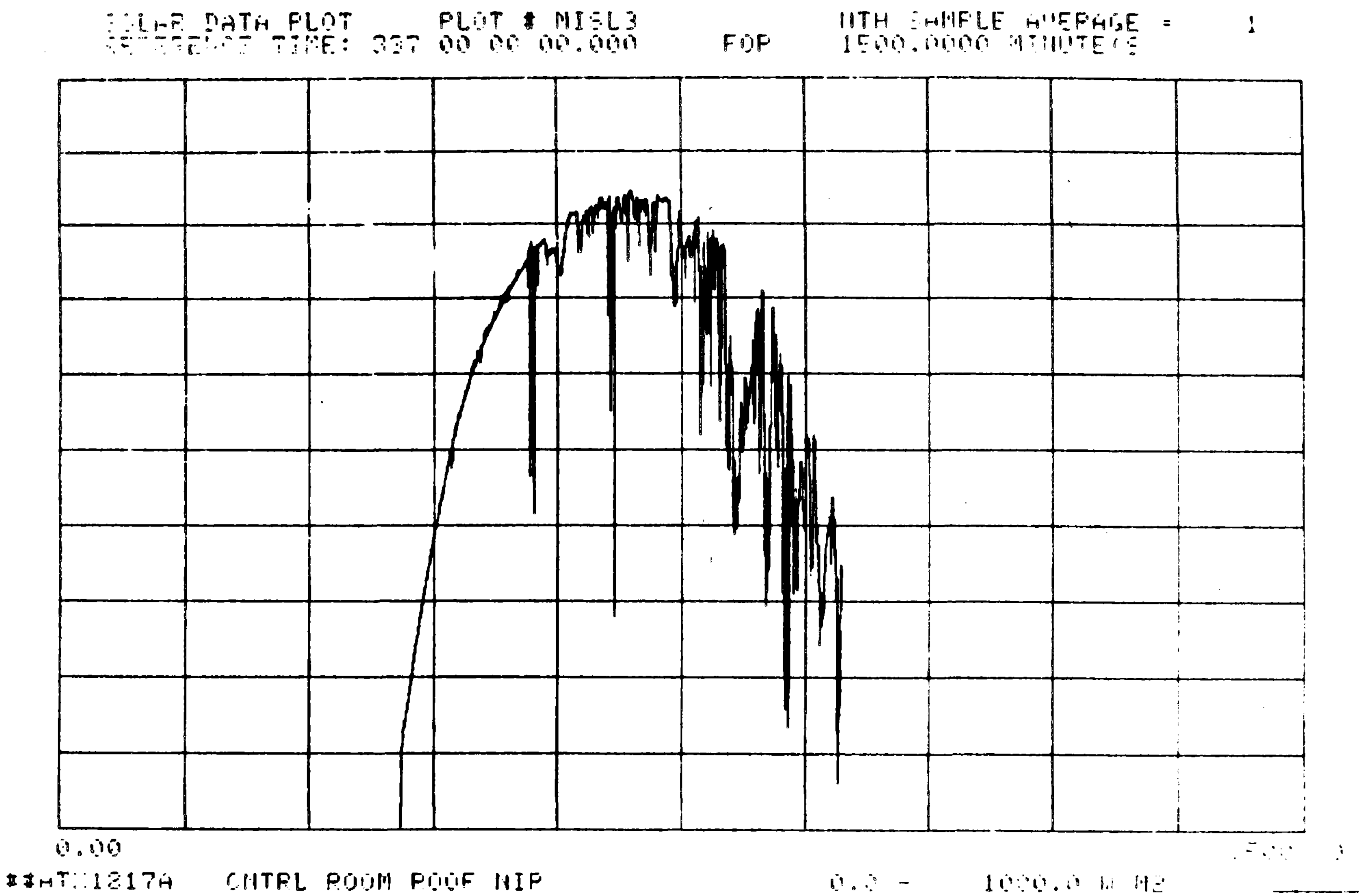
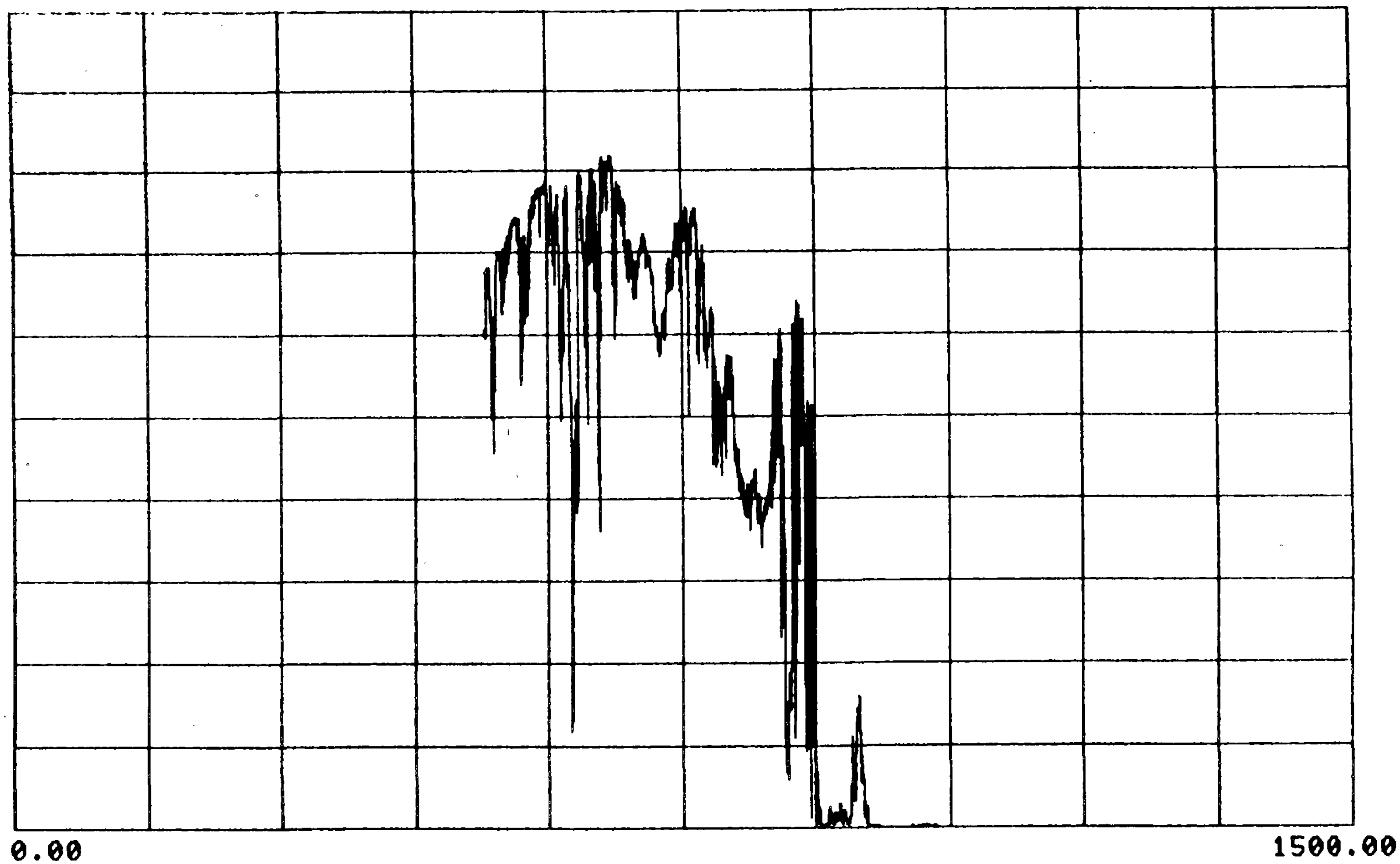
REFERENCE TIME: 337 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.00
AT11817 NIP (NORTH STATION) 0.0 - 1000.0 W M2

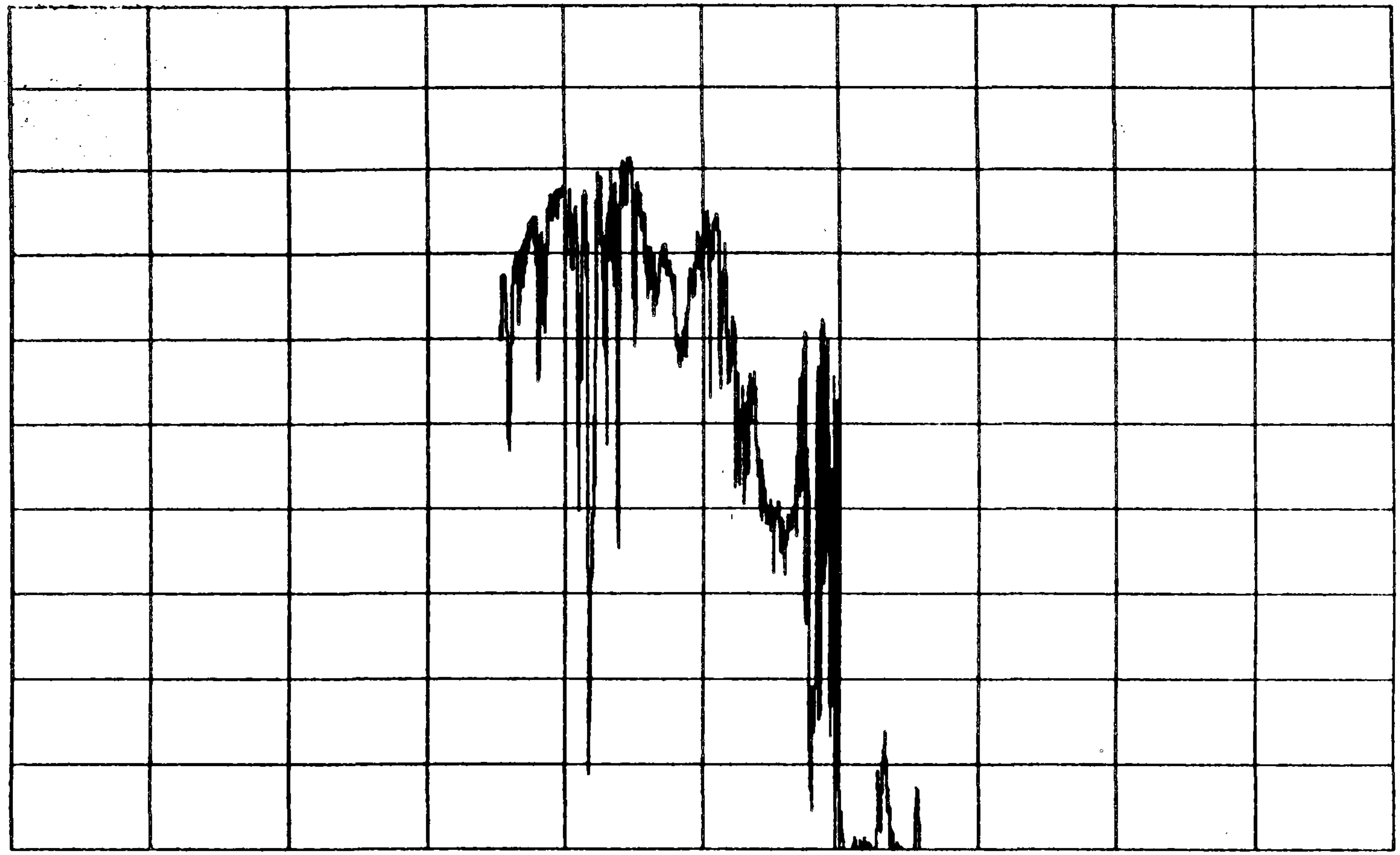

DATA PLOT
PLOT # MISL3
TIME: 337 00 00 00.000
FOP
NTH SAMPLE AVERAGE = 1
1500.0000
0.00
CNTRL ROOM ROOF NIP

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 338 00 00 00.000 FOR 1500.0000 MINUTE(S)

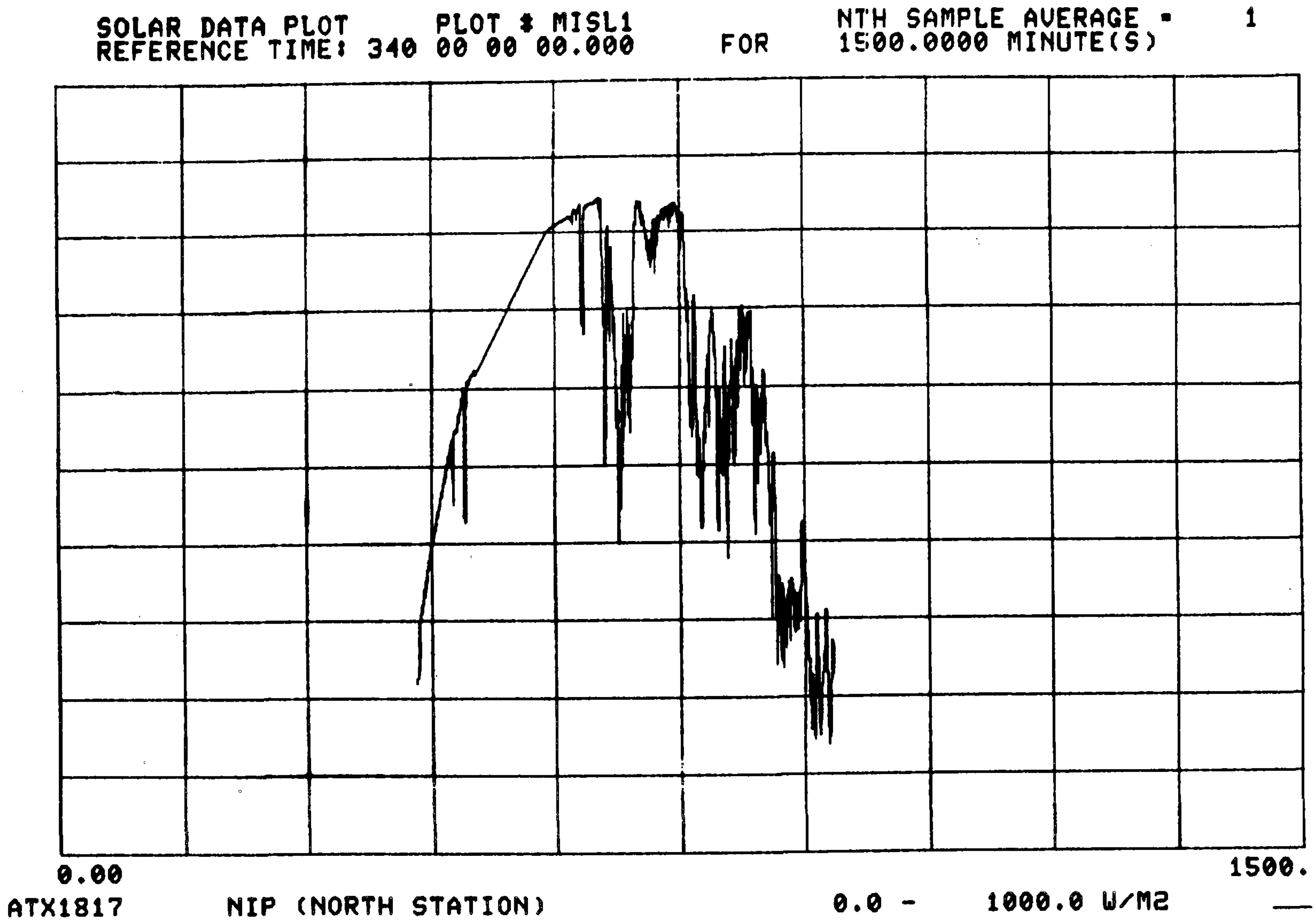


ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

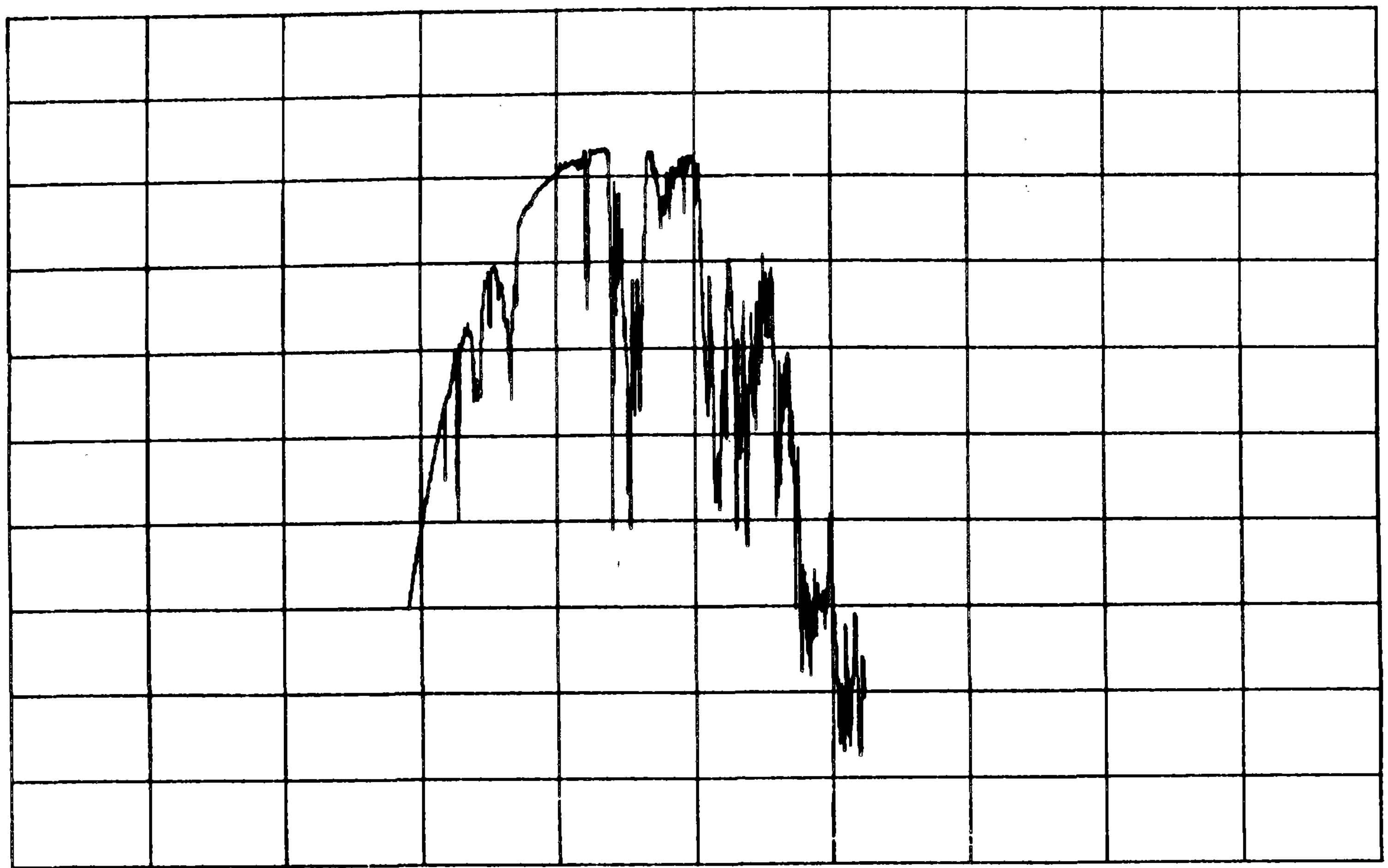
SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 338 00 00 00.000   FOR   1500.0000 MINUTE(S)



0.00   1500.00
##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2


SOLAR DATA PLOT PLOT # MISL1
REFERENCE TIME: 340 00 00 00.000 FOR
NTH SAMPLE AVERAGE = 1
1500.0000 MINUTE(S)
0.00
1500.
ATX1817
NIP (NORTH STATION)
0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 340 00 00 00.000 FOR 1500.0000 MINUTE(S)



0.00 1500.

##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

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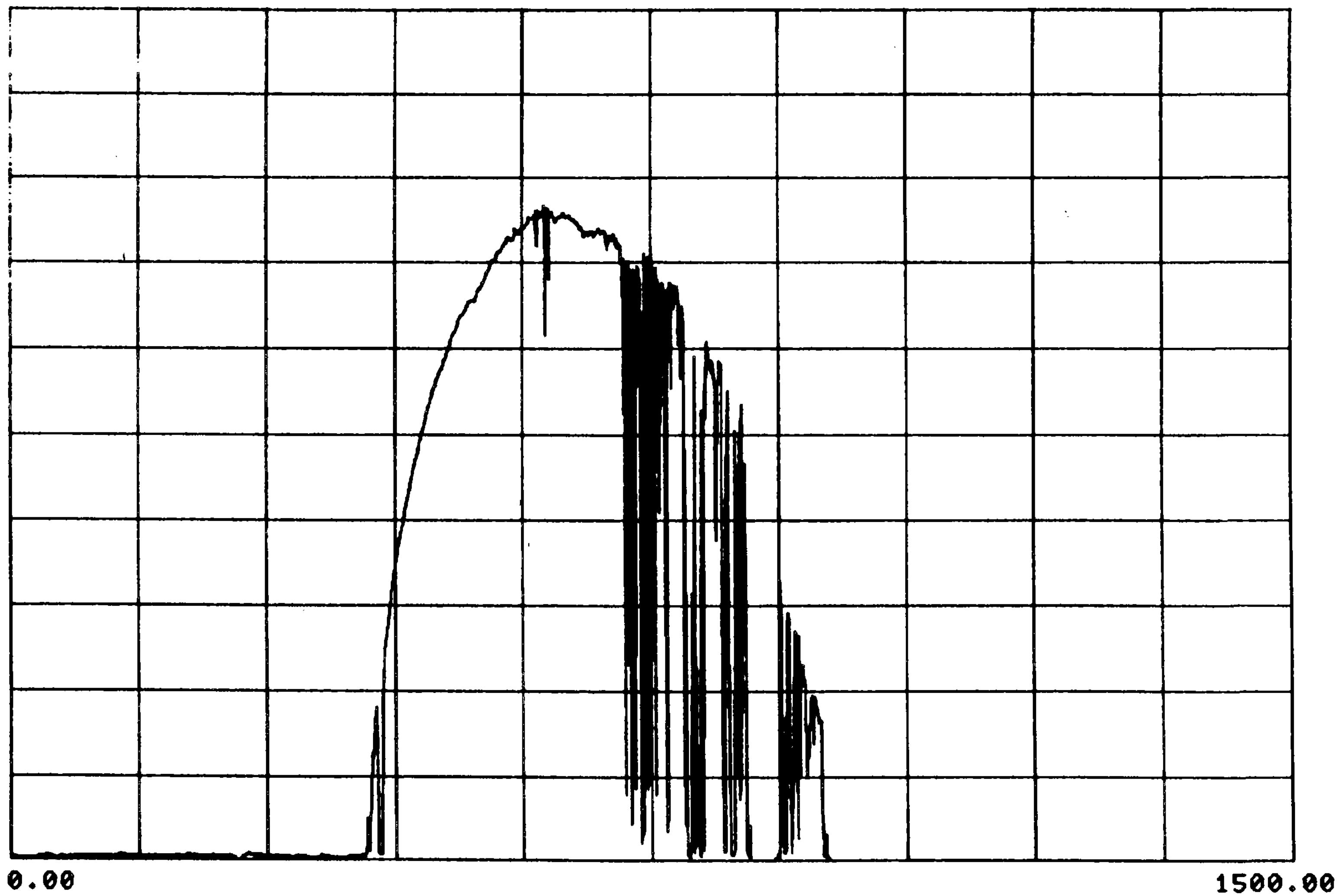
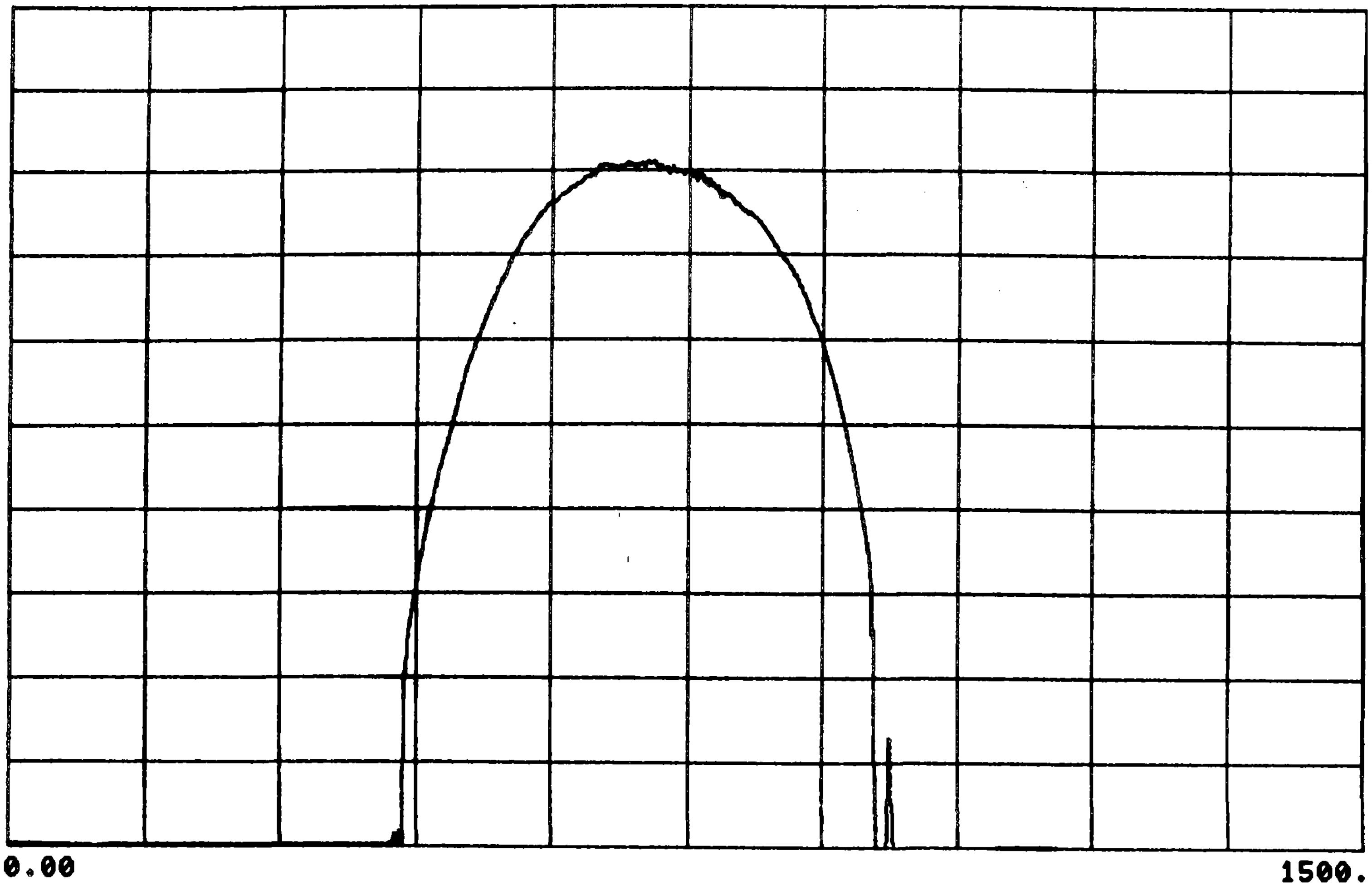


ATX1817   NIP (NORTH STATION)   0.0 -   1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL1   NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 345 00 00 00.000   FOR   1500.0000 MINUTE(S)



ATX1817   NIP (NORTH STATION)   0.0 -   1000.0 W/M2

SOLAR DATA PLOT PLOT $ MISL3 NTH SAMPLE AVERAGE = 1
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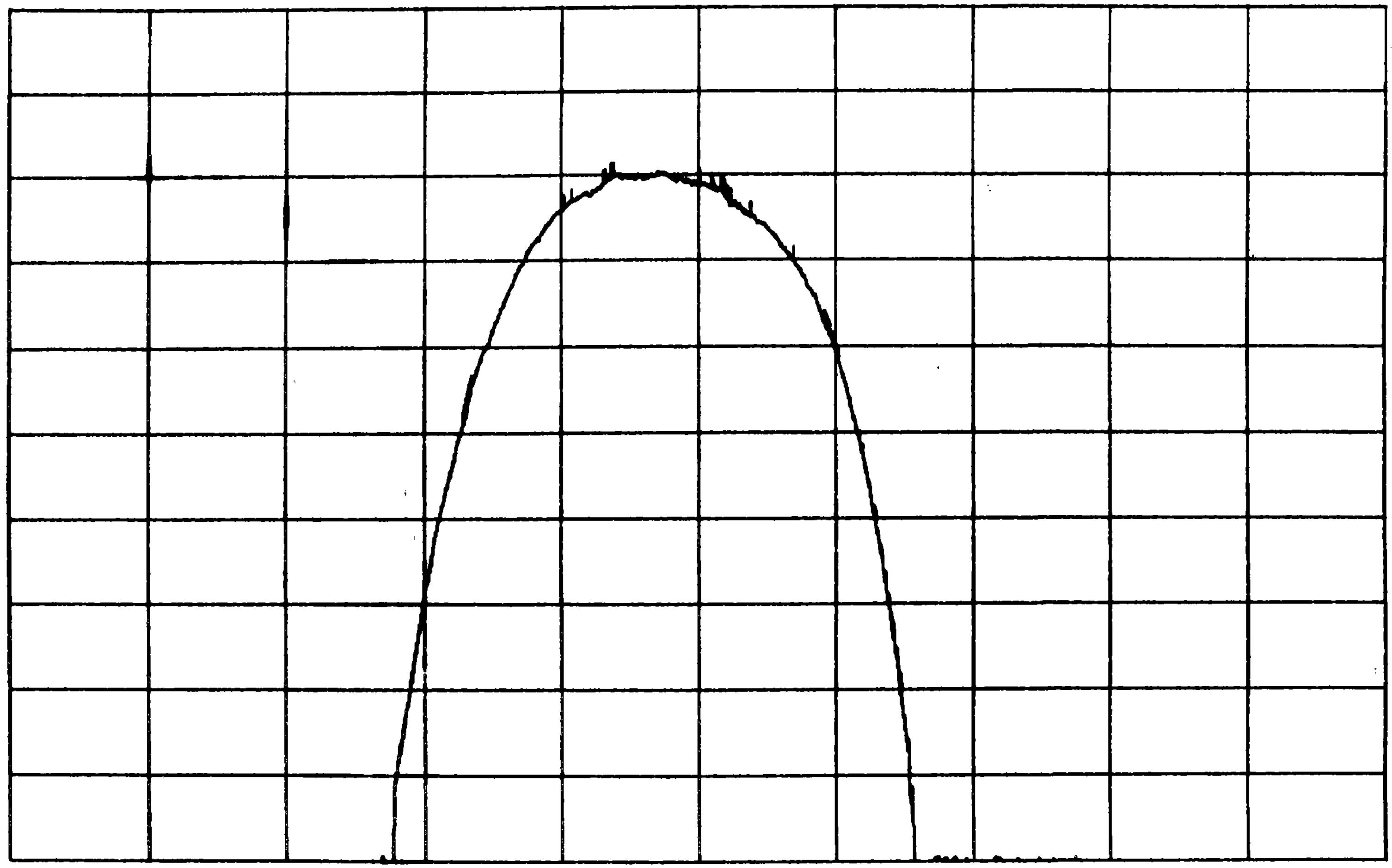
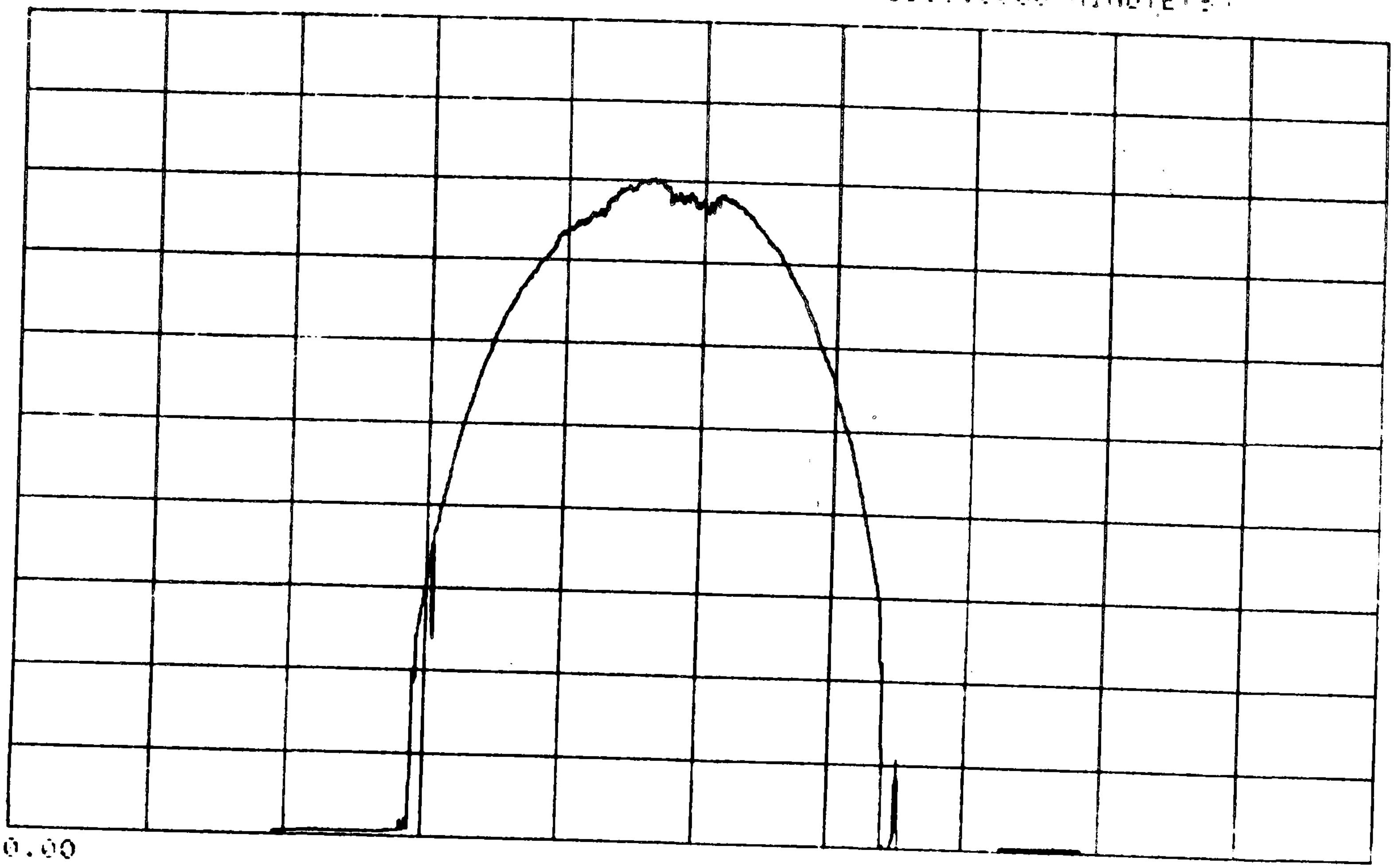
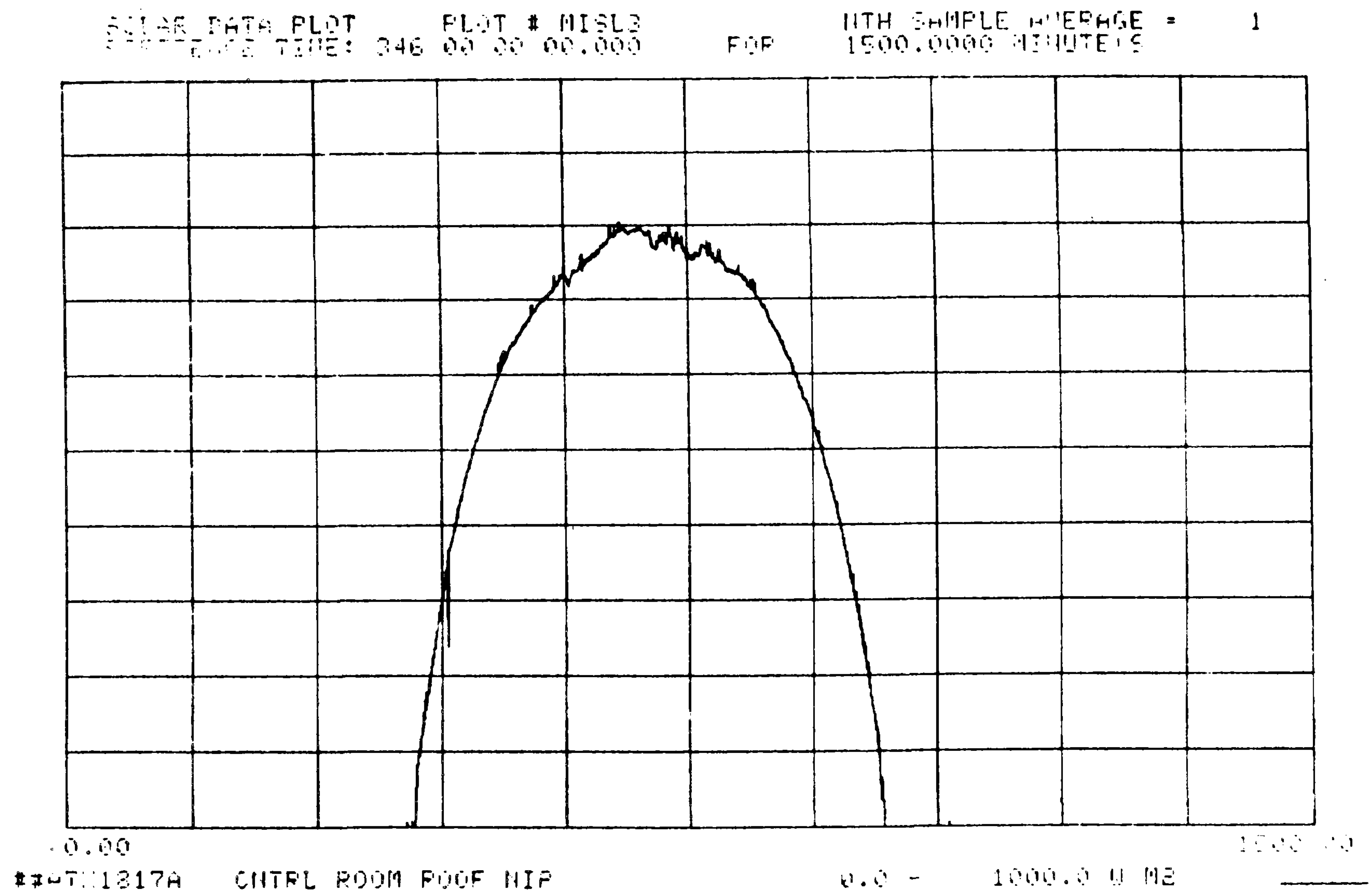


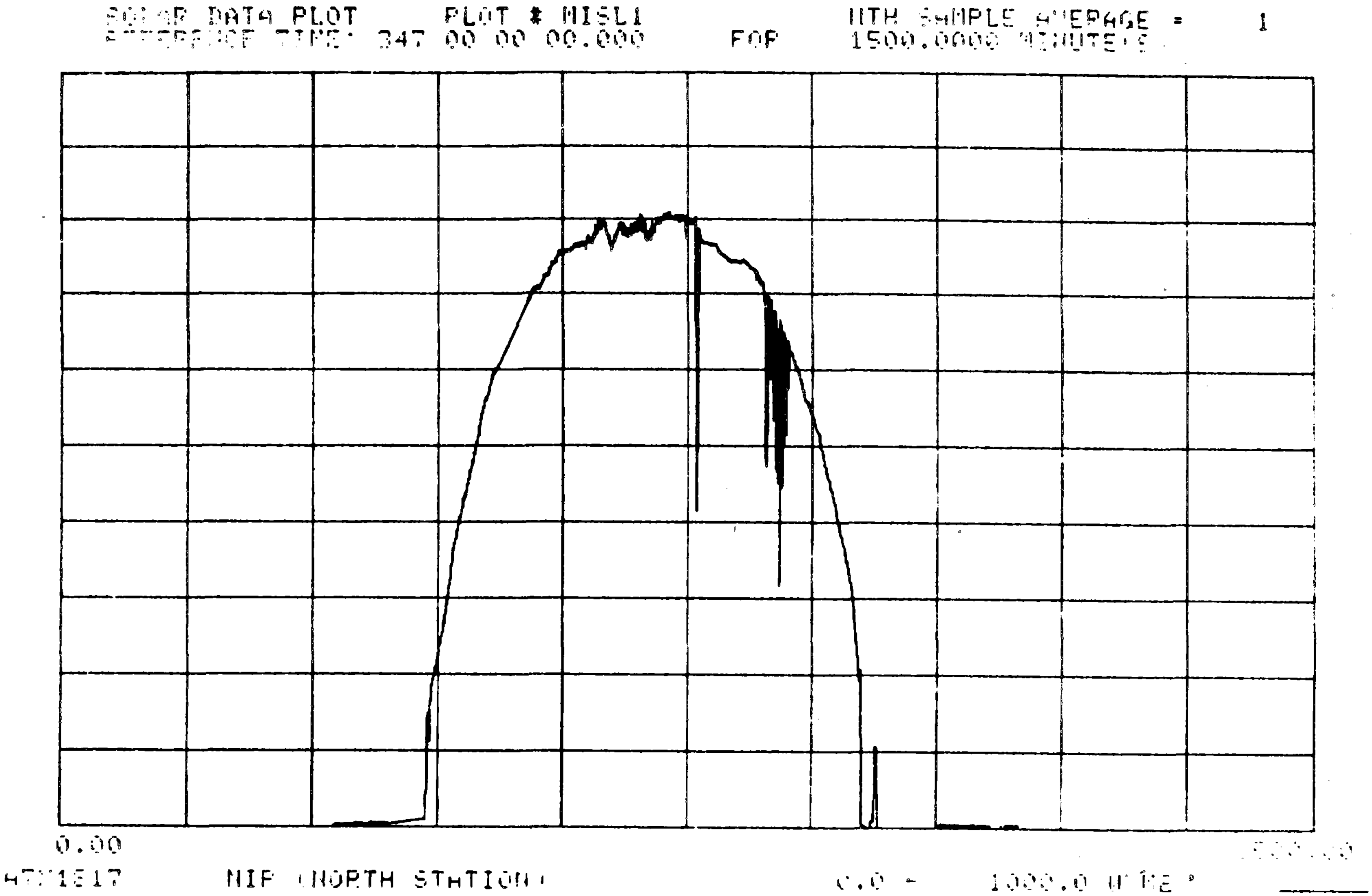
$$ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2

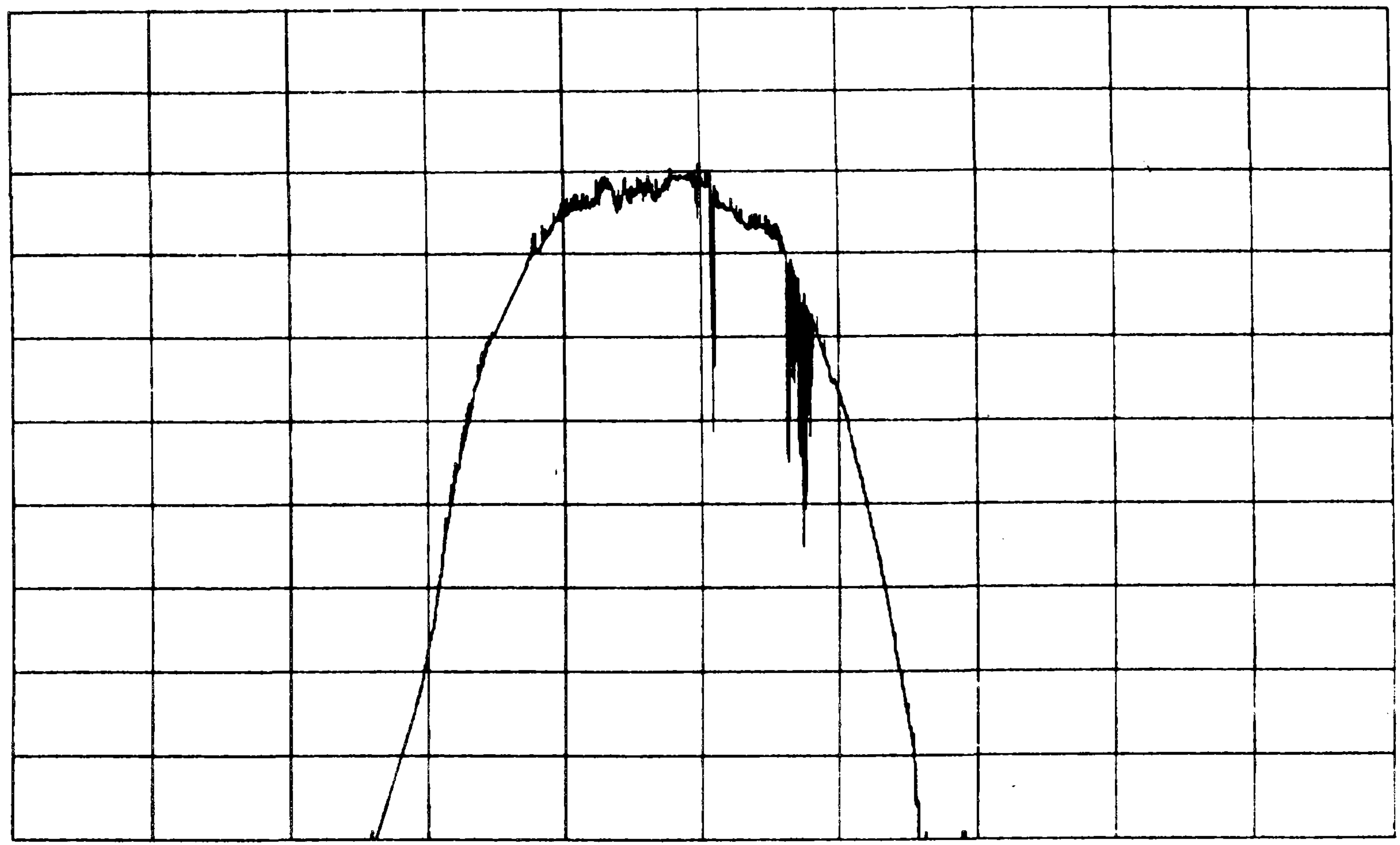
DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
TIME: 346 00 00 00.000 FOR 1500.0000 MINUTE(S)



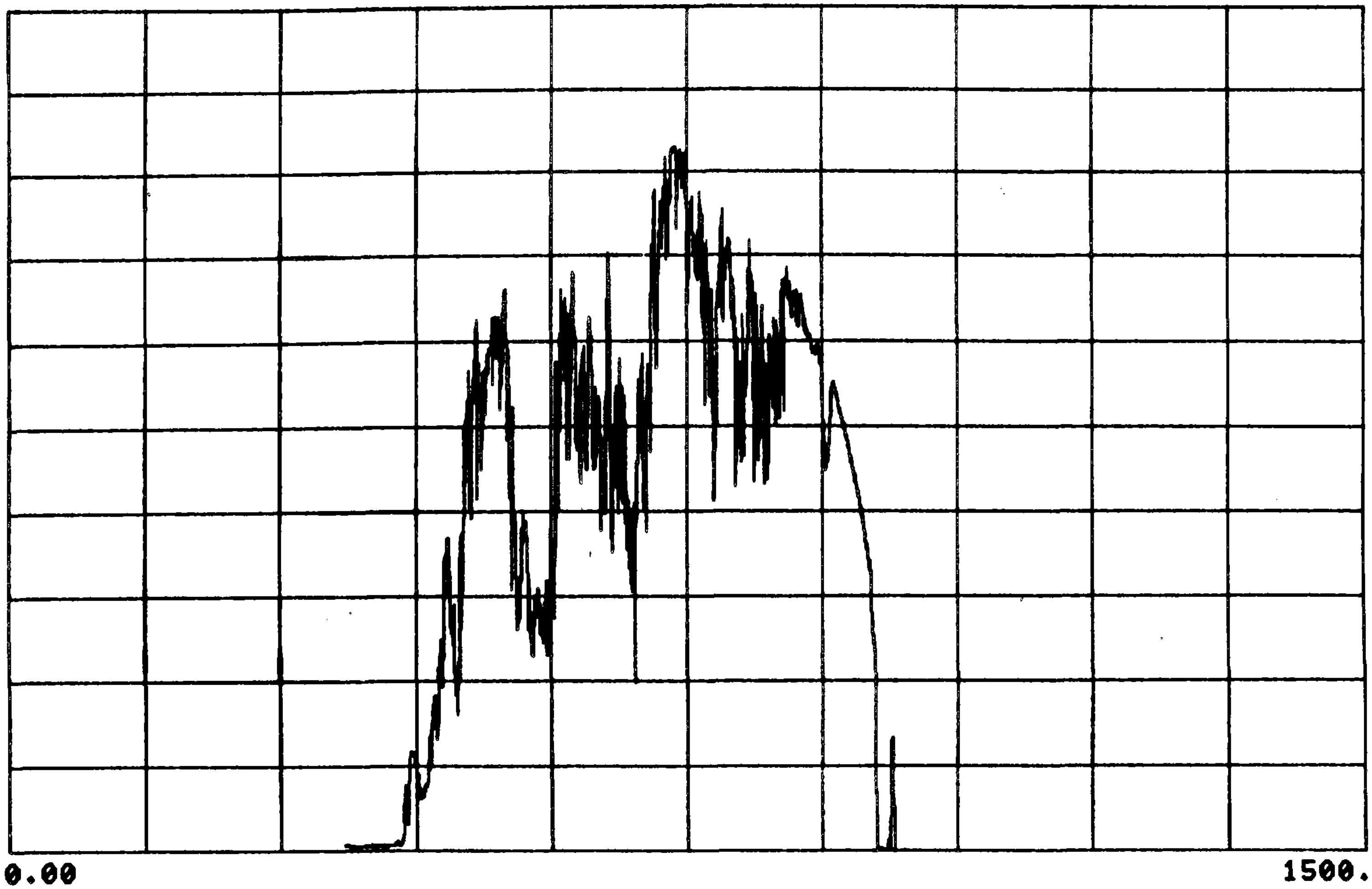
0.00 1500.00
HT: 1317 NIP (NORTH STATION) 0.0 - 1000.0 U NG


DATA PLOT
PLOT # MISL3
NTH SAMPLE AVERAGE = 1
TIME: 346 00 00 00.000
FOR
1500.0000 MINUTE(S
0.00
CNTRL ROOM ROOF NIP
0.0 - 1000.0 W M2


SOLAR DATA PLOT
PLOT # MISL1
NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 347 00 00 00.000
FOR 1500.0000 MINUTE(S)
0.00
NIP (NORTH STATION)
0.0 - 1000.0 W/M2

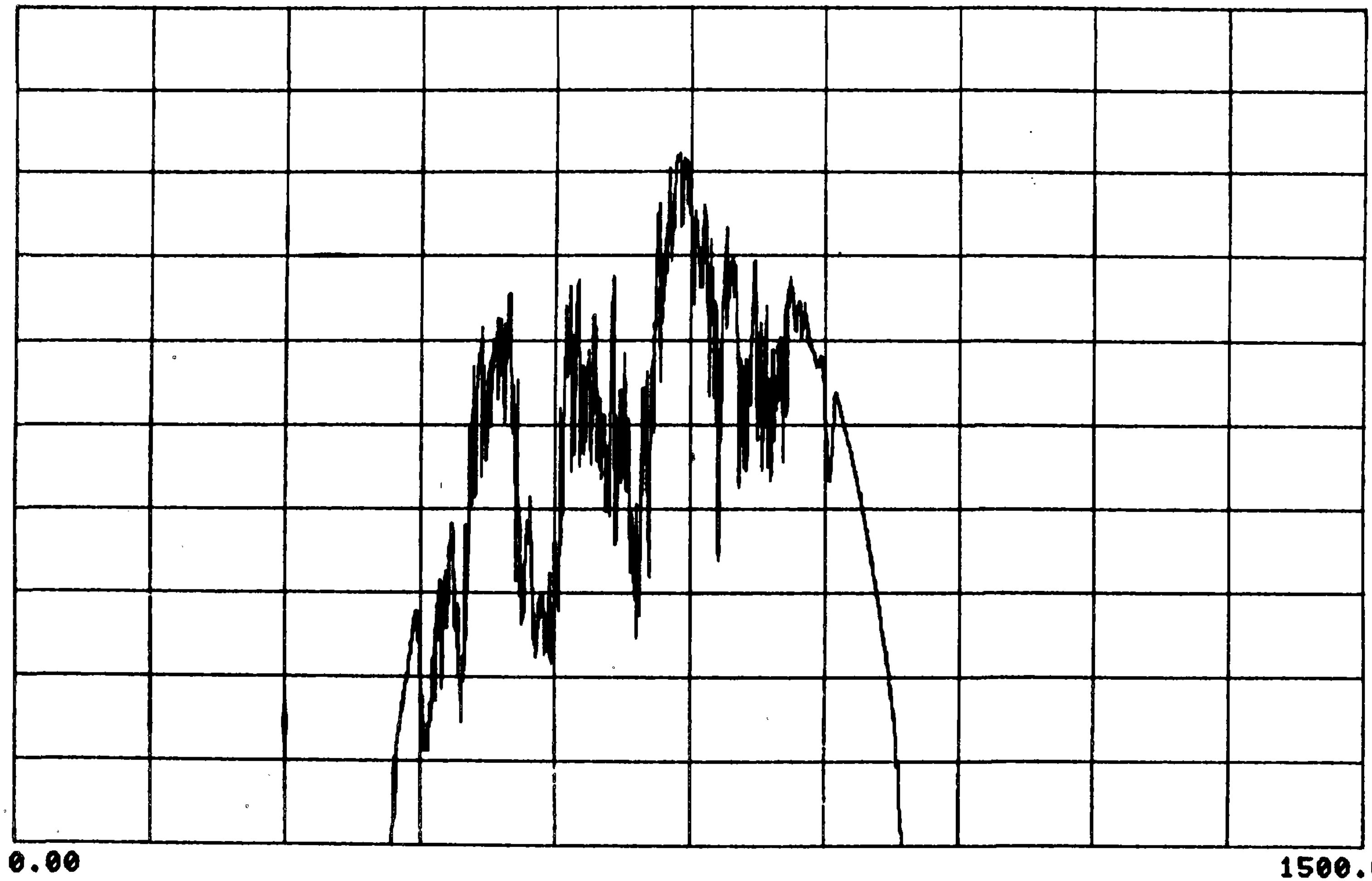

DATA PLOT
PLOT # MISL3
NTH SAMPLE AVERAGE = 1
TIME: 347 00 00 00.000
FOR
1500.0000
0.00
CNTRL ROOM ROOF NIP
0.0 - 1000.0 W M2

SOLAR DATA PLOT PLOT $ MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 350 00 00 00.000 FOR 1500.0000 MINUTE(S)

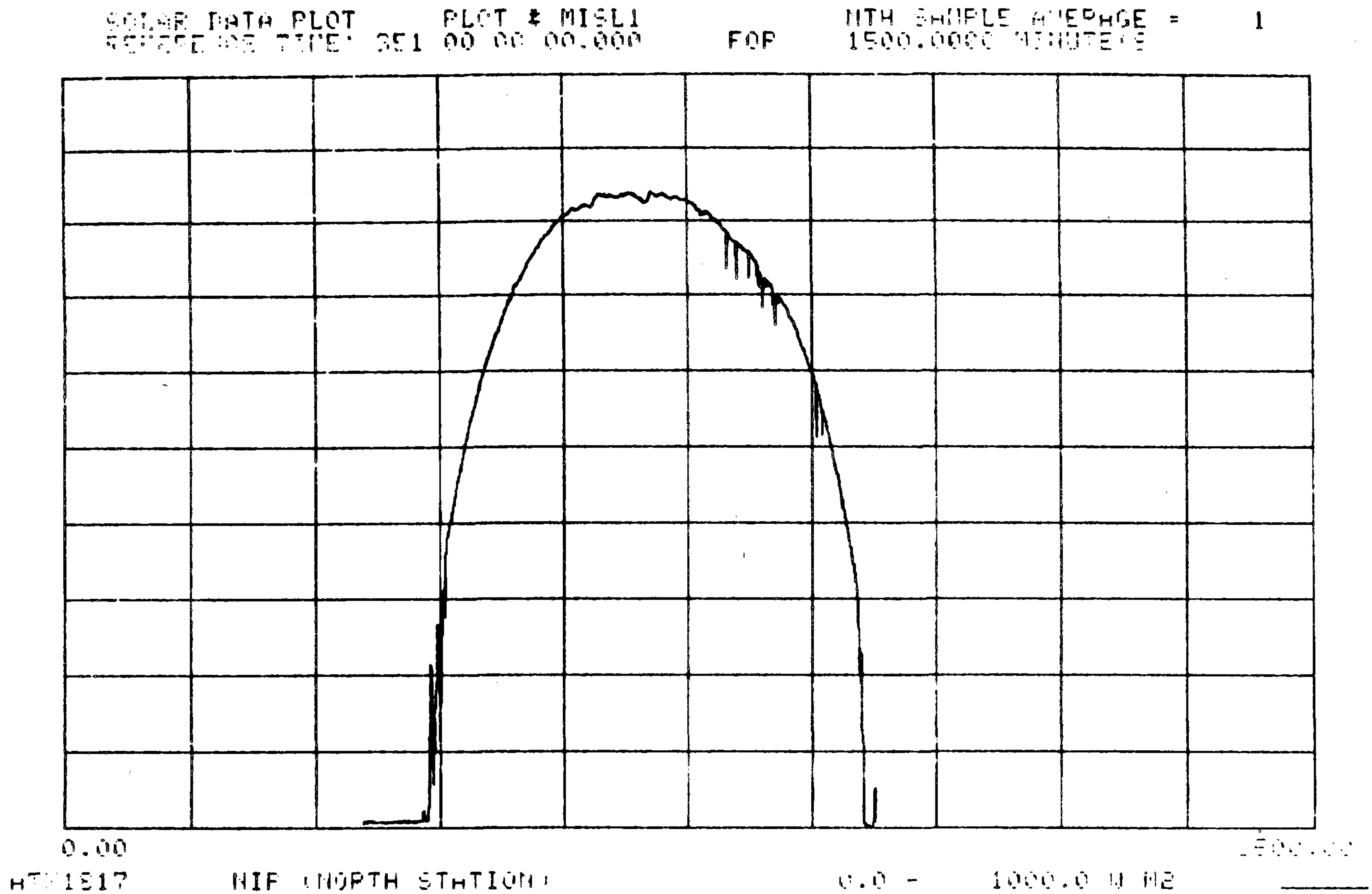


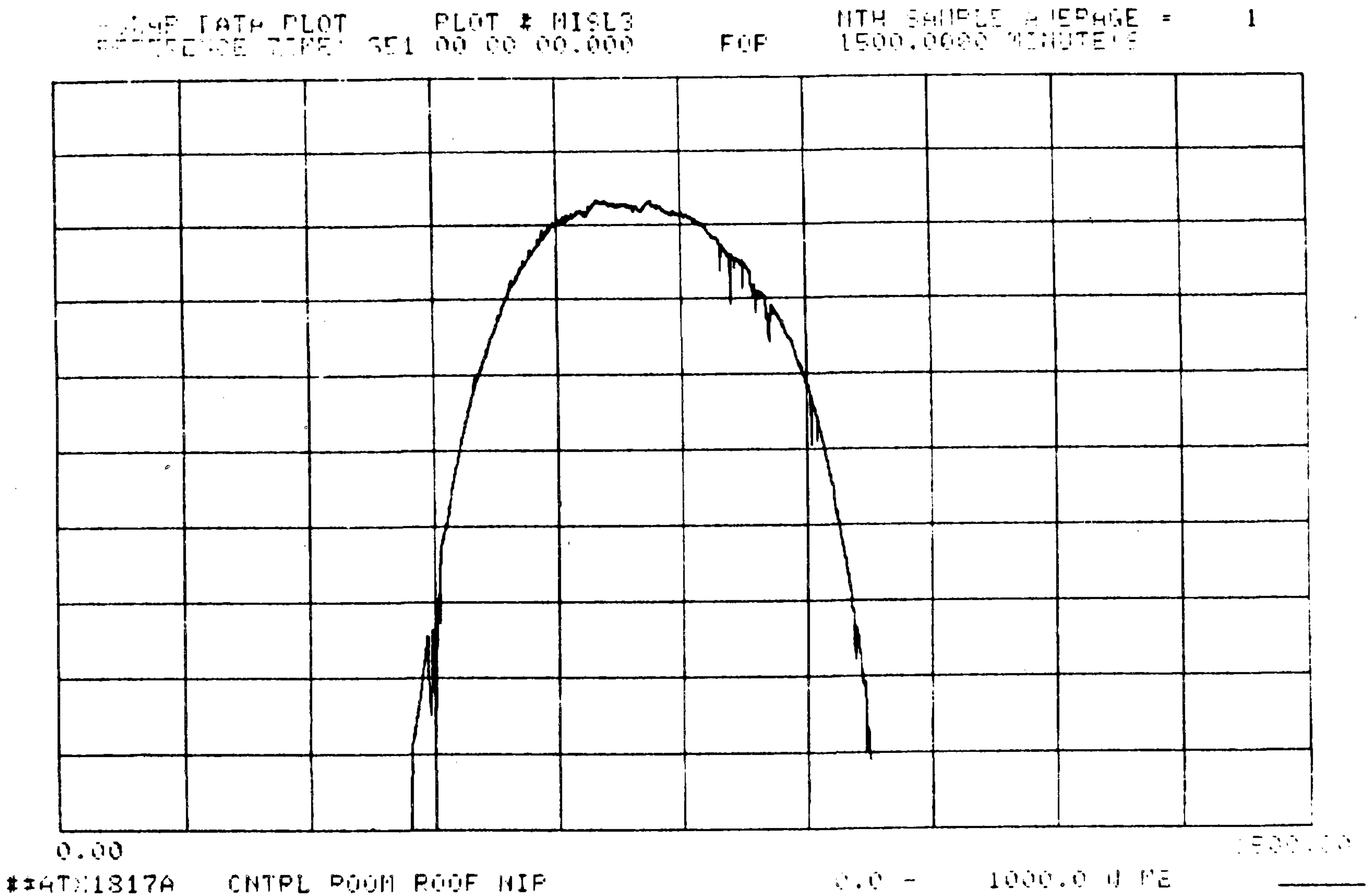
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
REFERENCE TIME: 350 00 00 00.000   FOR   1500.0000 MINUTE(S)

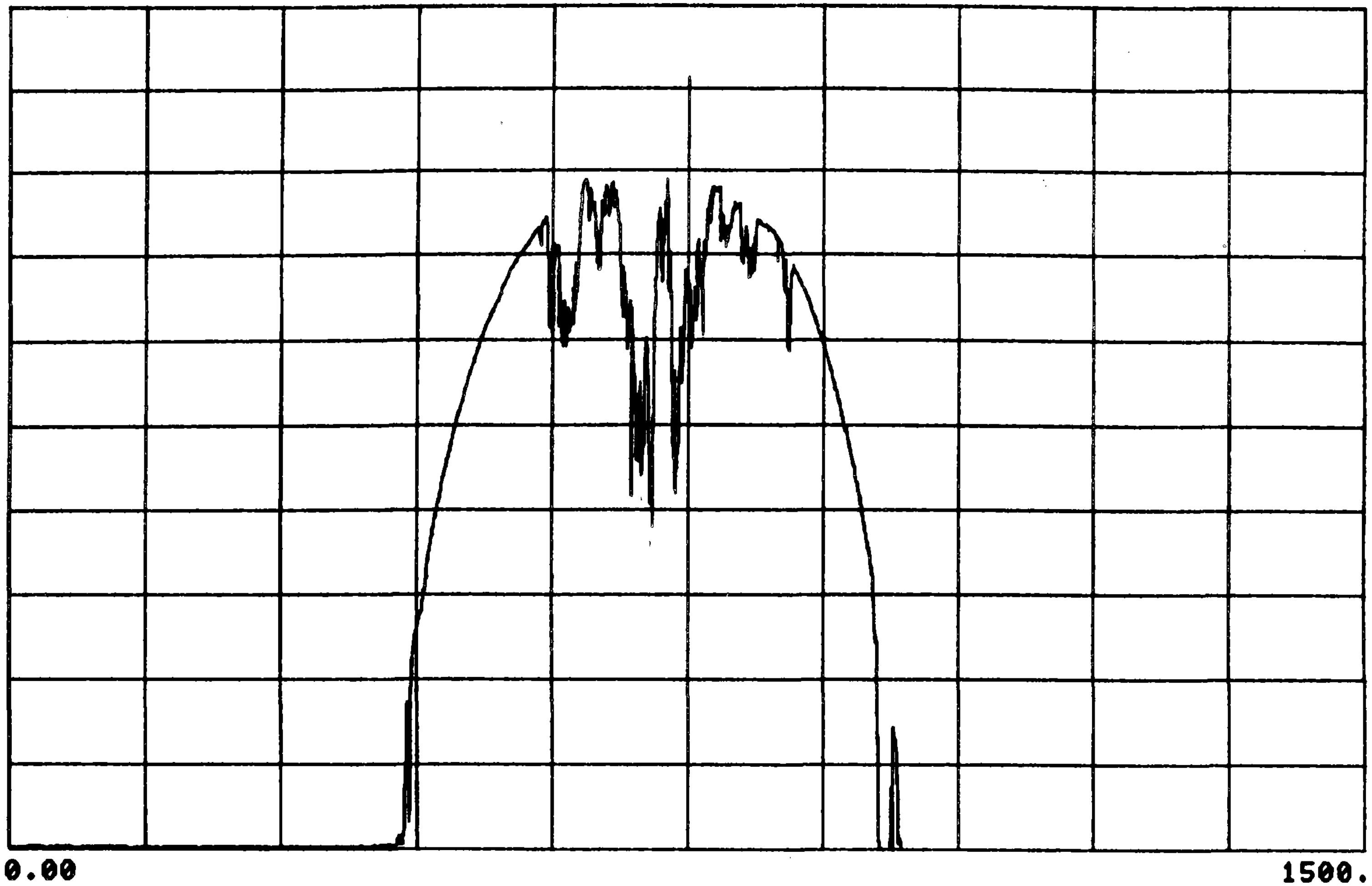


##ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2


SOLAR DATA PLOT
PLOT # MISL1
NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 351 00 00 00.000
FOR
1500.0000 MINUTE(S)
0.00
1500.00
HT 1517
NIF (NORTH STATION)
0.0 - 1000.0 W M2

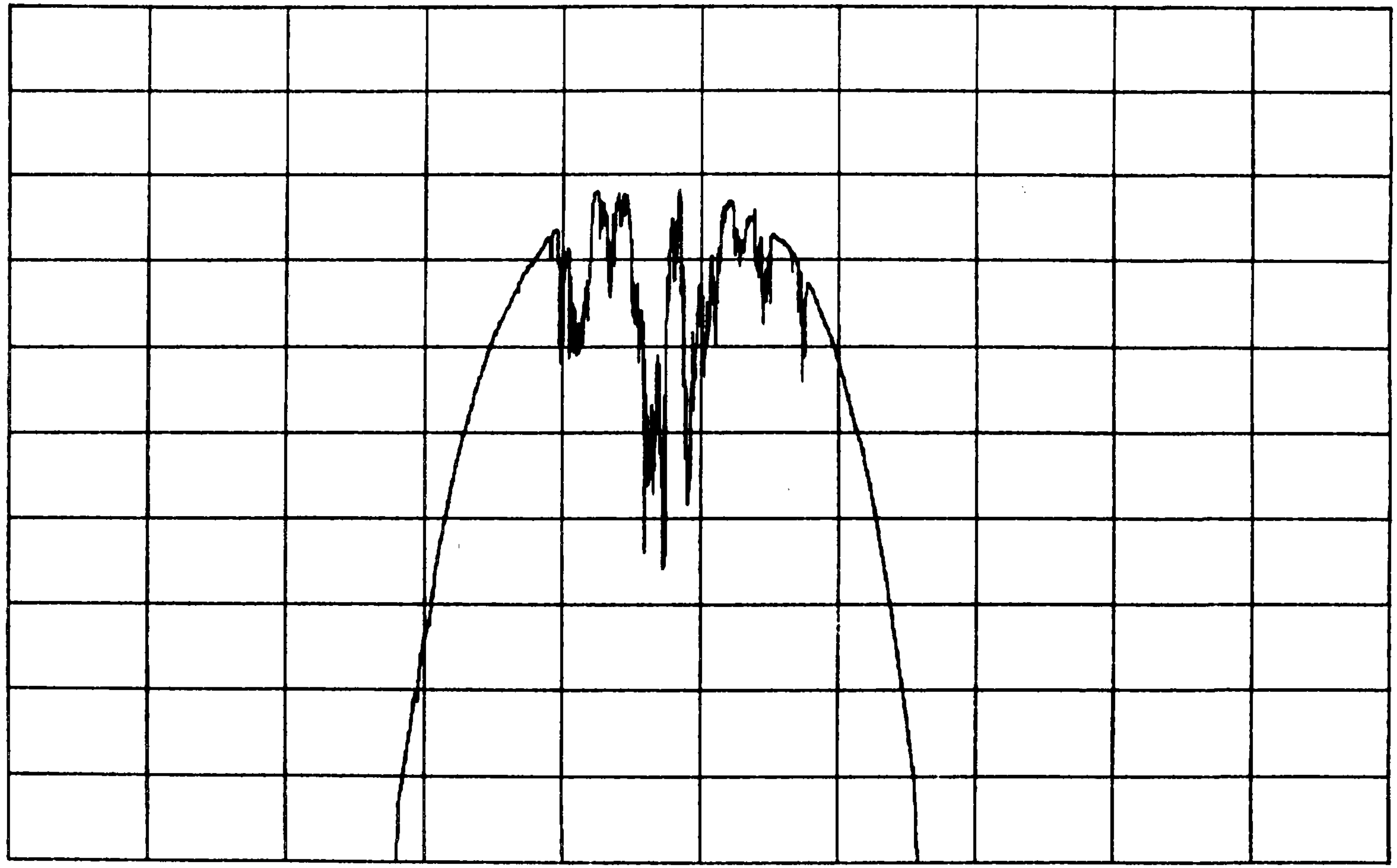

PLOT # MISL3
NTH SAMPLE AVERAGE = 1
351 00 00 00.000
FOP
0.00
**AT 1817A CNTRL ROOM ROOF HIP
1000.0

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 352 00 00 00.000 FOR 1500.0000 MINUTE(S)

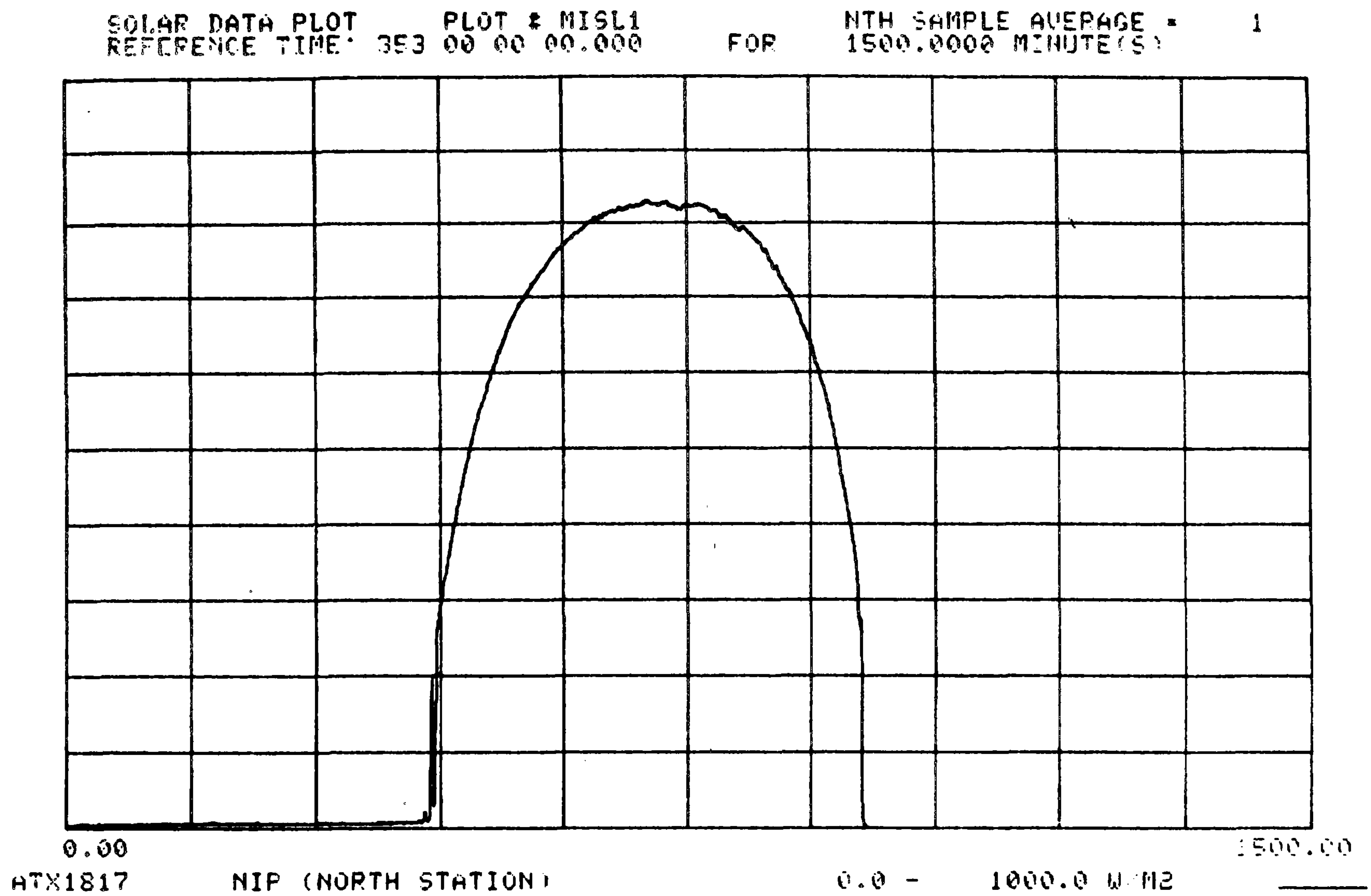


ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL3 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 352 00 00 00.000 FOR 1500.0000 MINUTE(S)



##ATX1817A CNTRL ROOM ROOF NIP 0.0 - 1000.0 W/M2


SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
REFERENCE TIME: 353 00 00 00.000 FOR 1500.0000 MINUTE(S)
0.00
1500.00
ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT PLOT ‡ MISL1 NTH SAMPLE AVERAGE = 1
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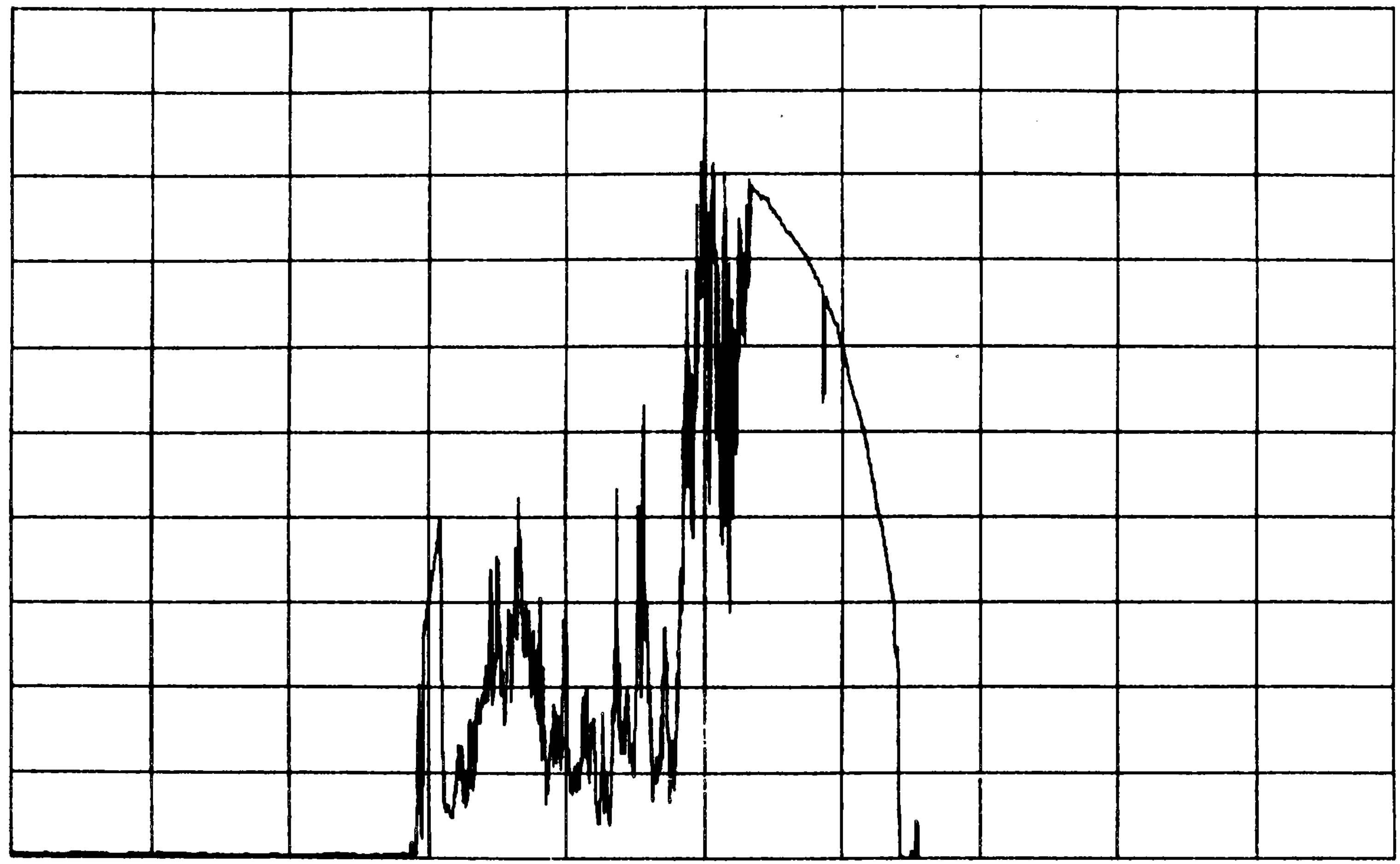

ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

SOLAR DATA PLOT   PLOT # MISL3   NTH SAMPLE AVERAGE =   1
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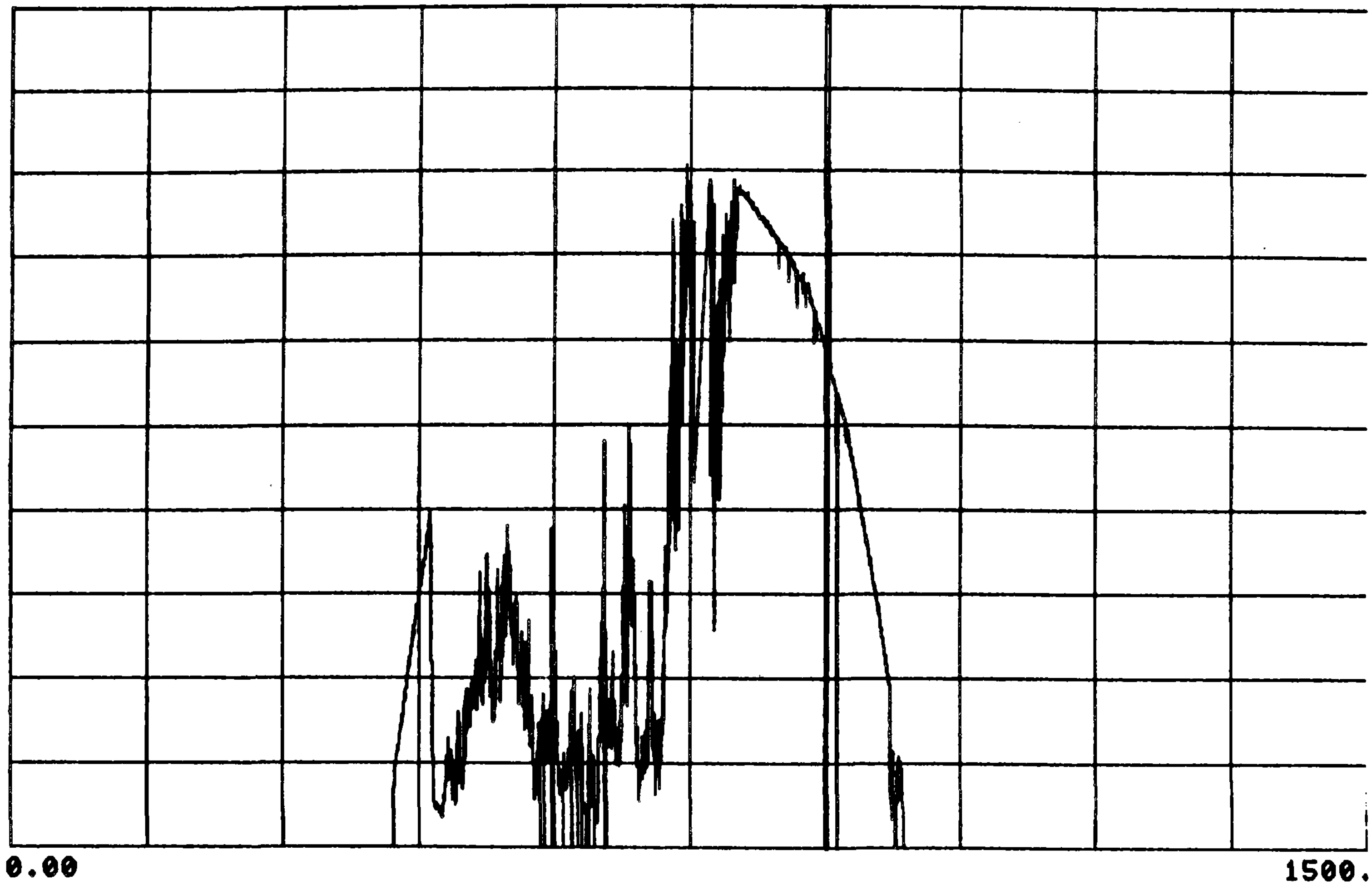

$$ATX1817A   CNTRL ROOM ROOF NIP   0.0 -   1000.0 W/M2

SOLAR DATA PLOT PLOT # MISL1 NTH SAMPLE AVERAGE = 1
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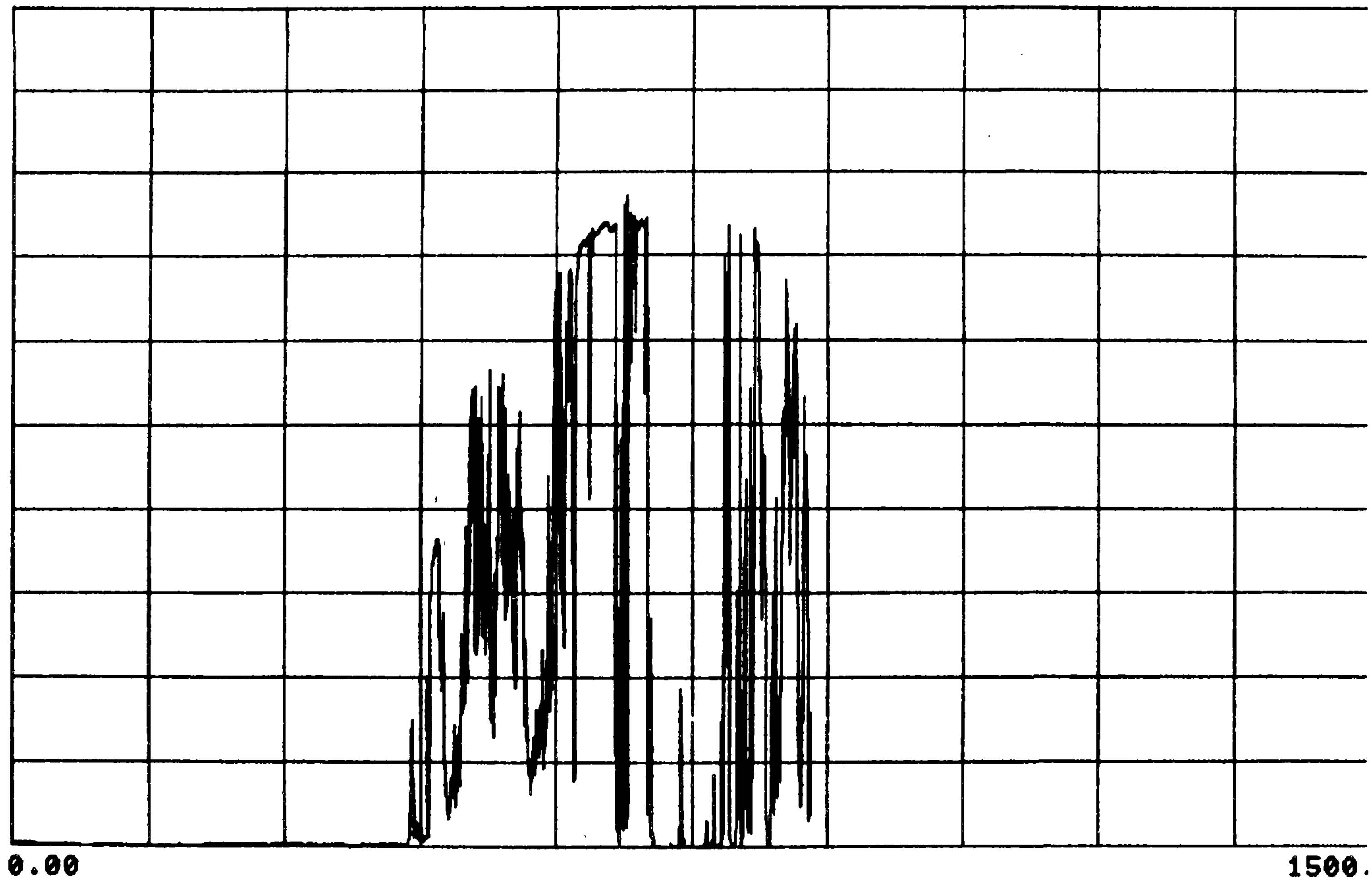

ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

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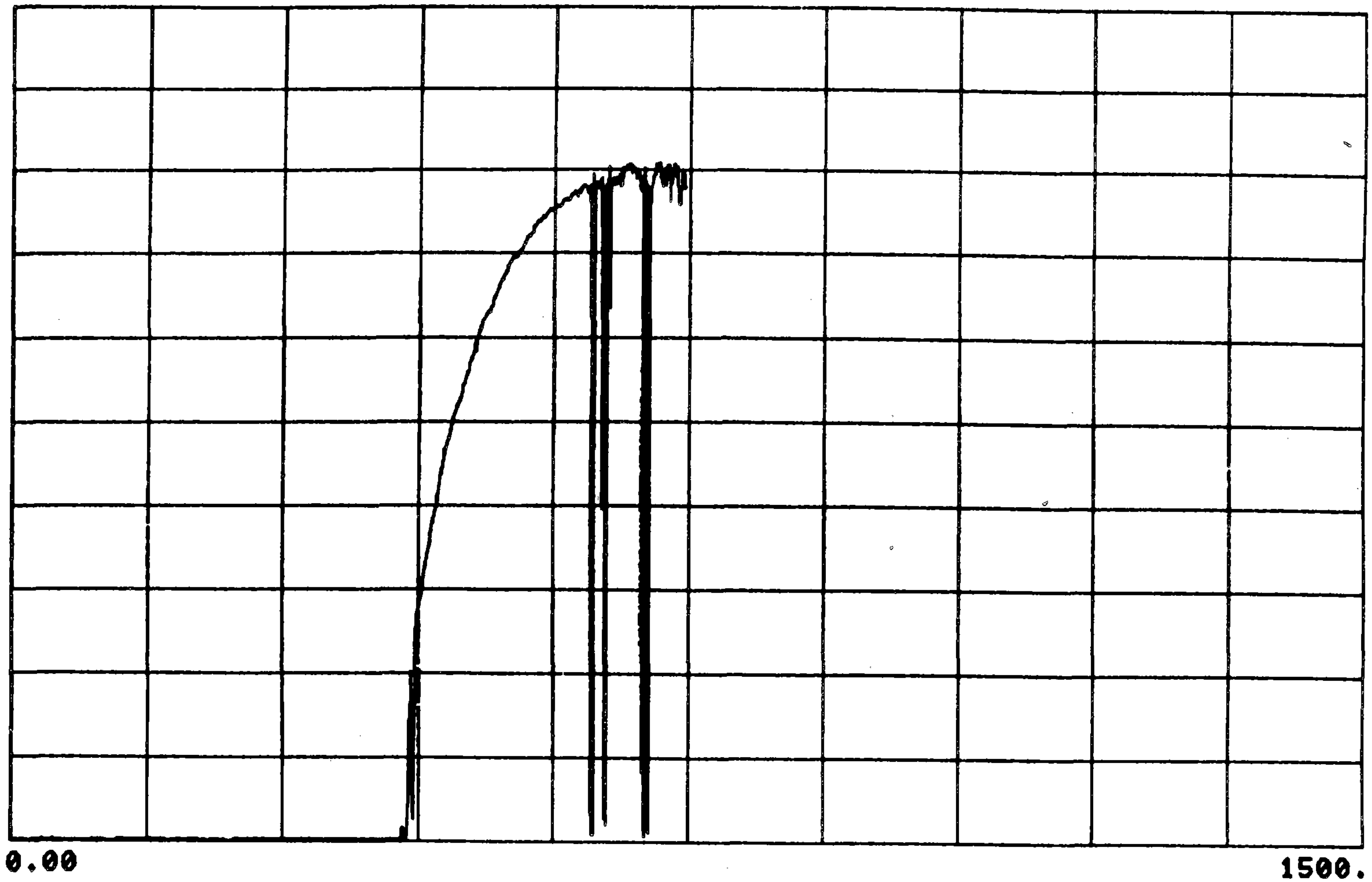

ATX1817 NIP (NORTH STATION) 0.0 - 1000.0 W/M2

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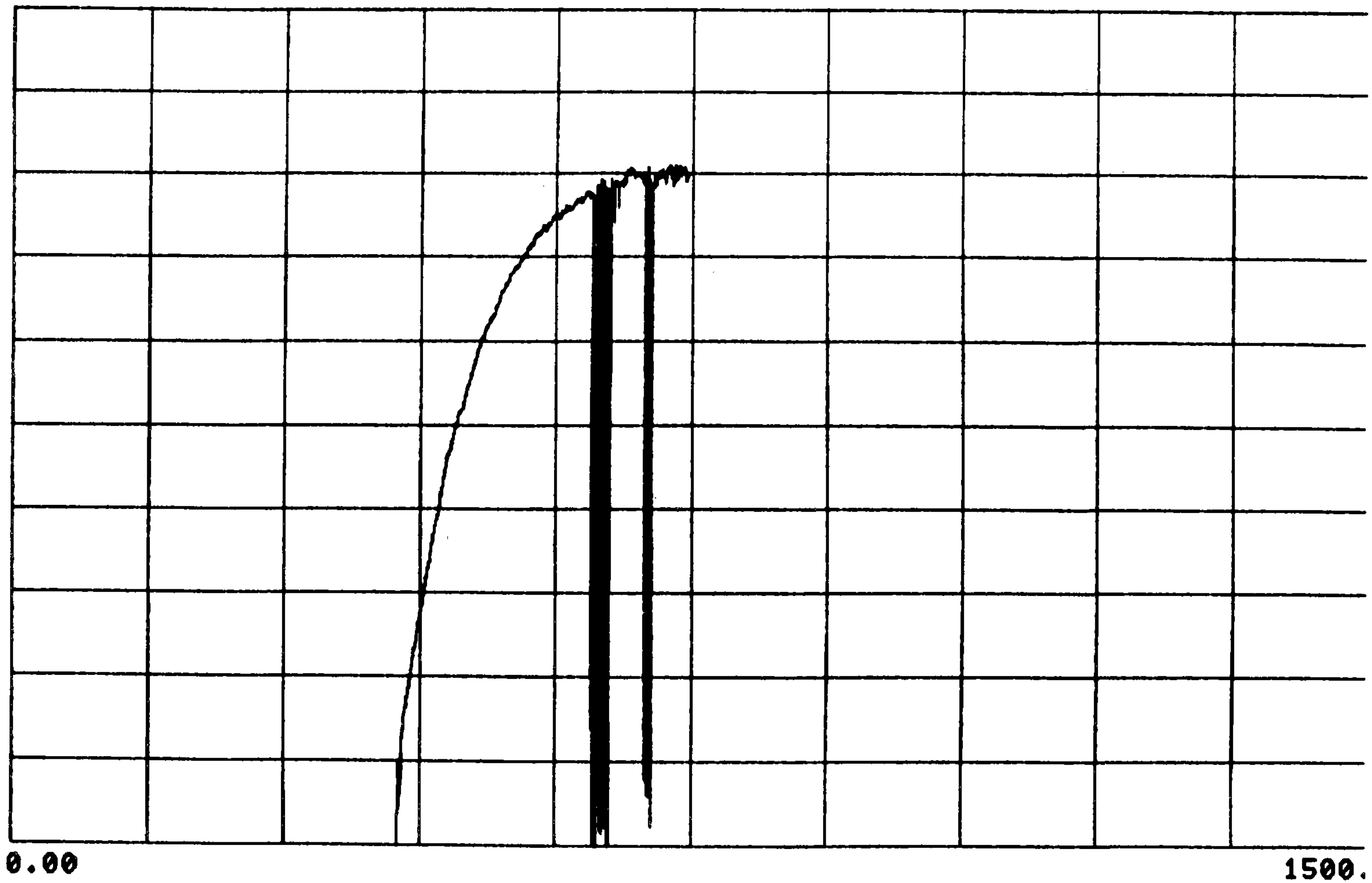

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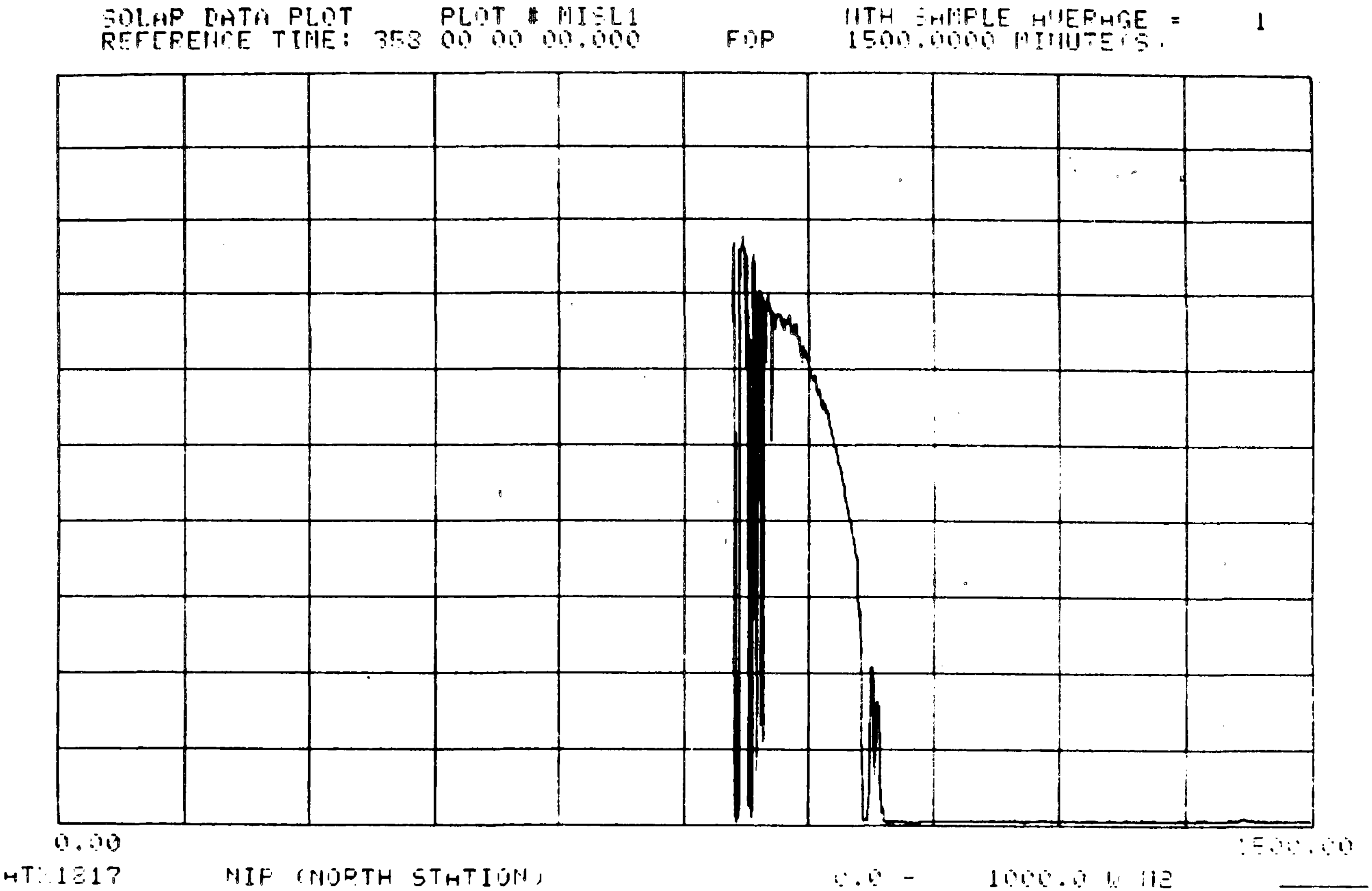
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HT 1817 NIP (NORTH STATION) 0.0 - 1000.0 W M2

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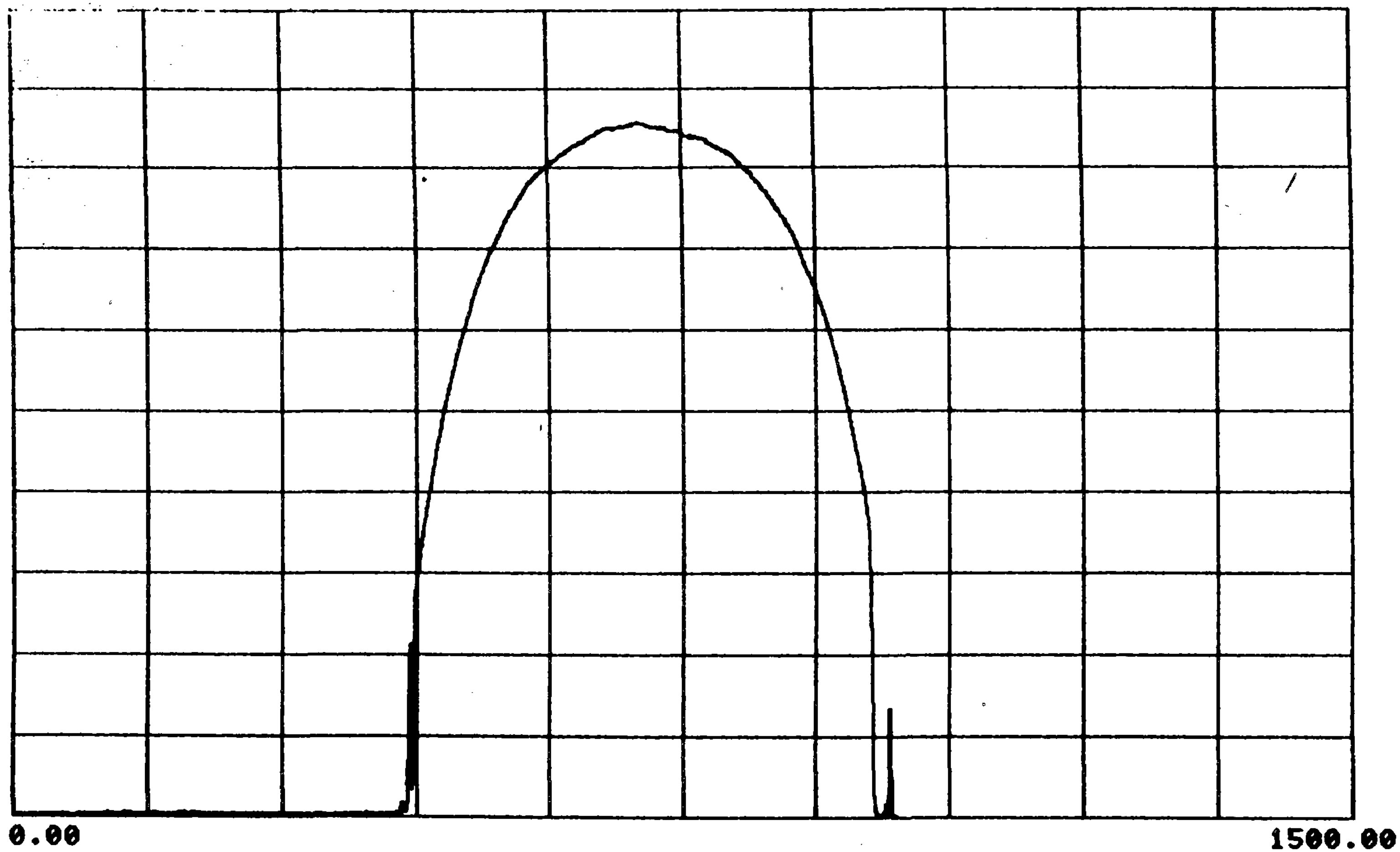

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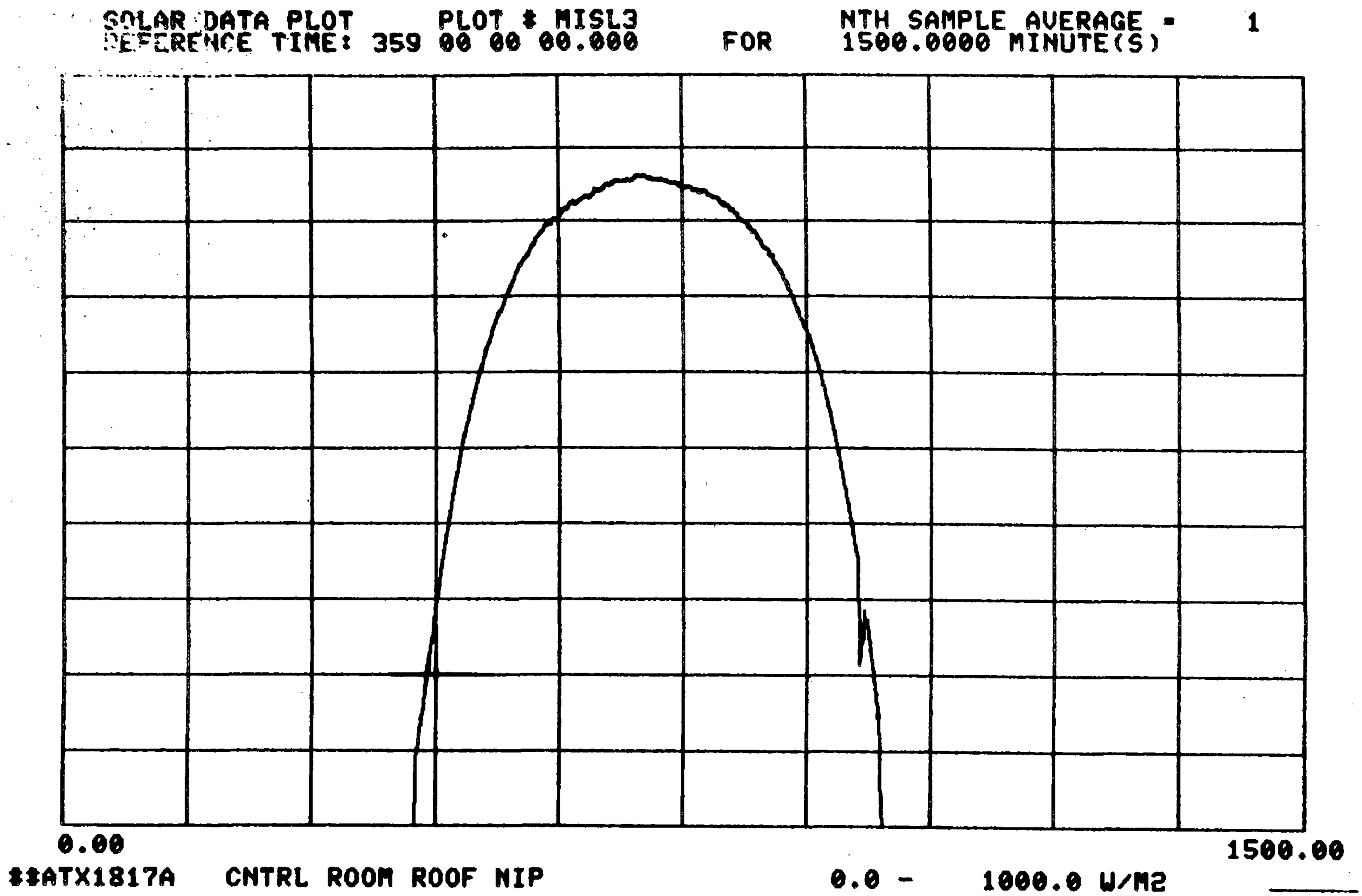
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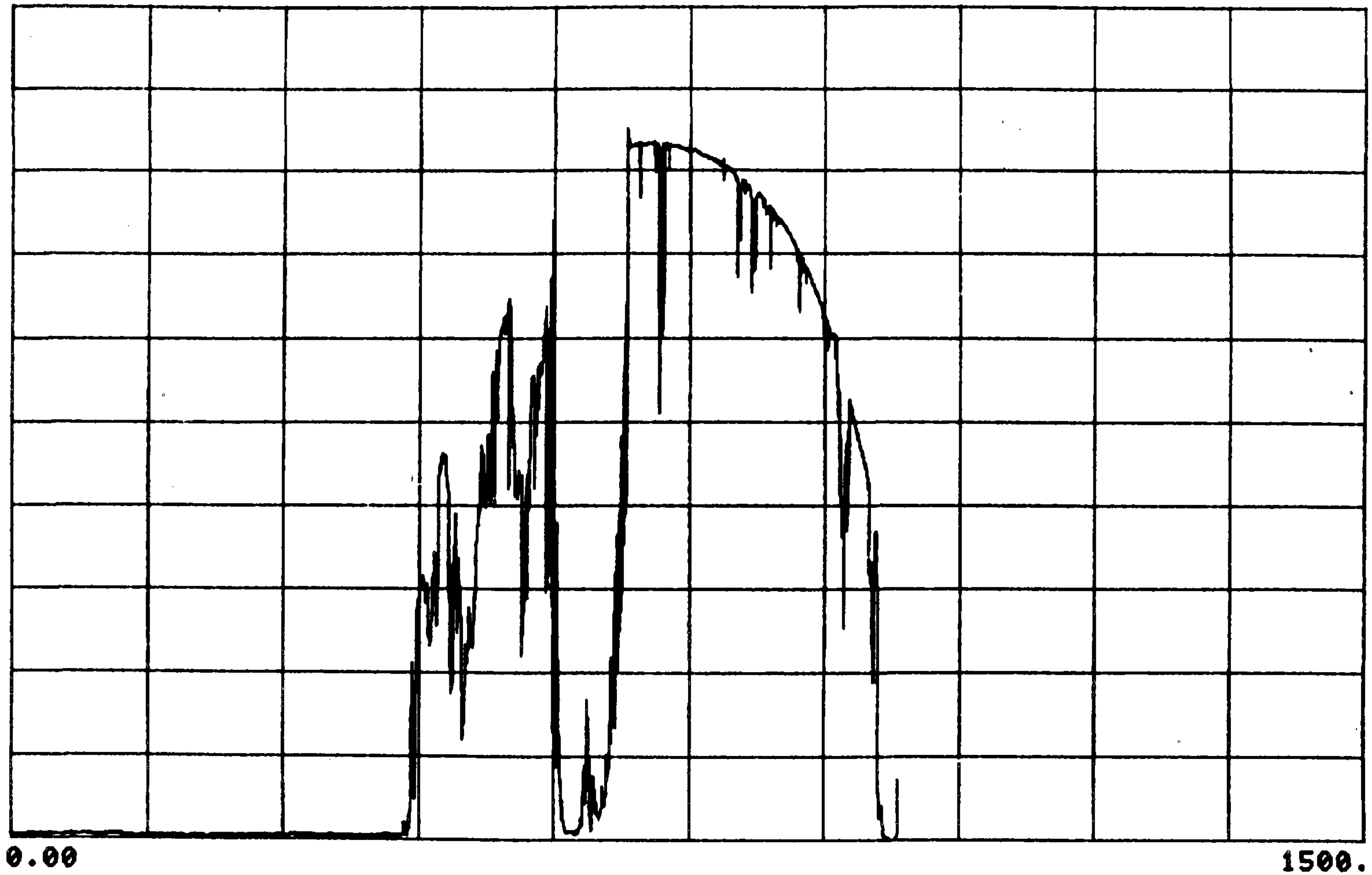

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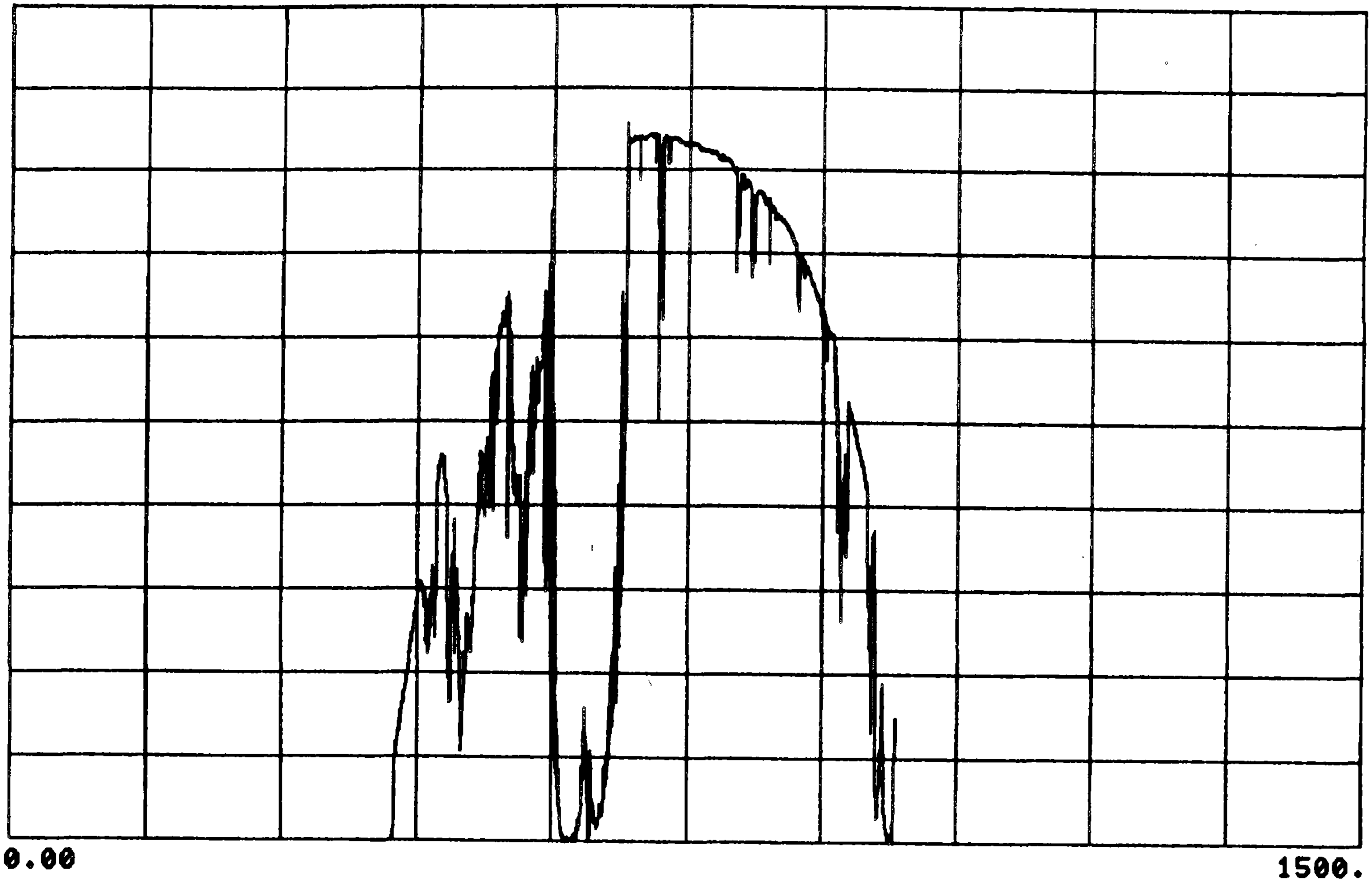

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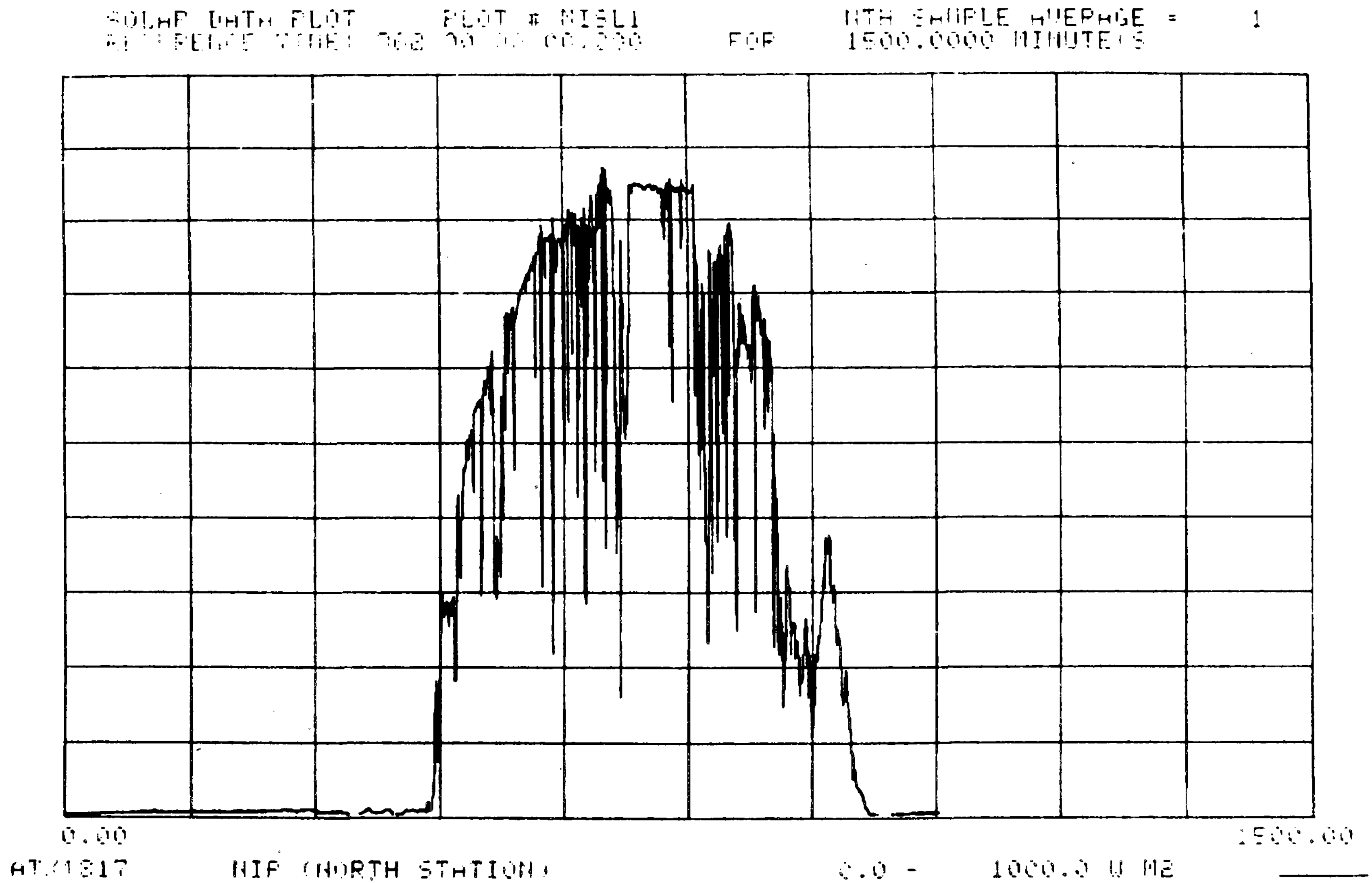
165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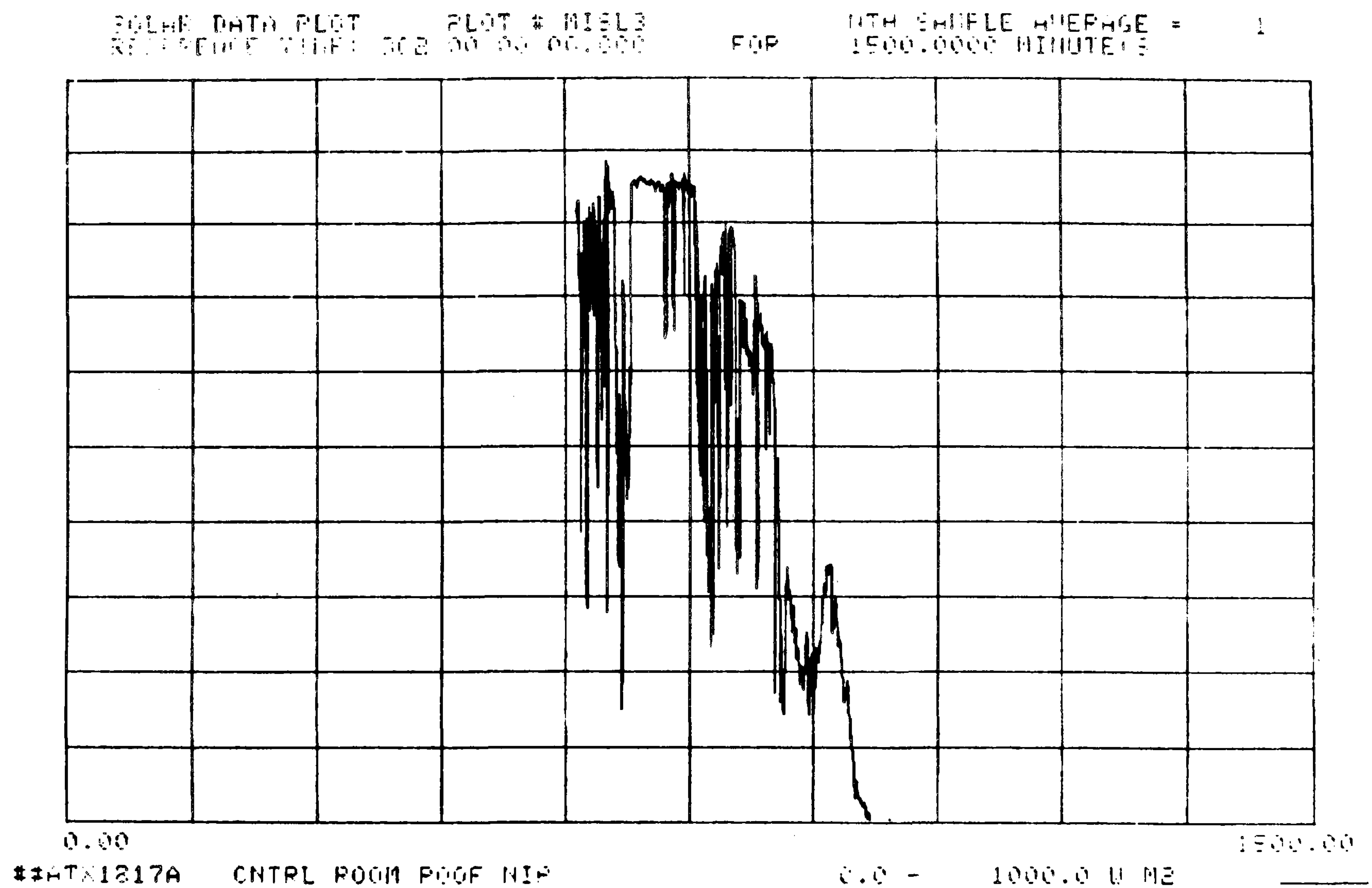
NIP (NORTH STATION)
0.0 - 1000.0 W M2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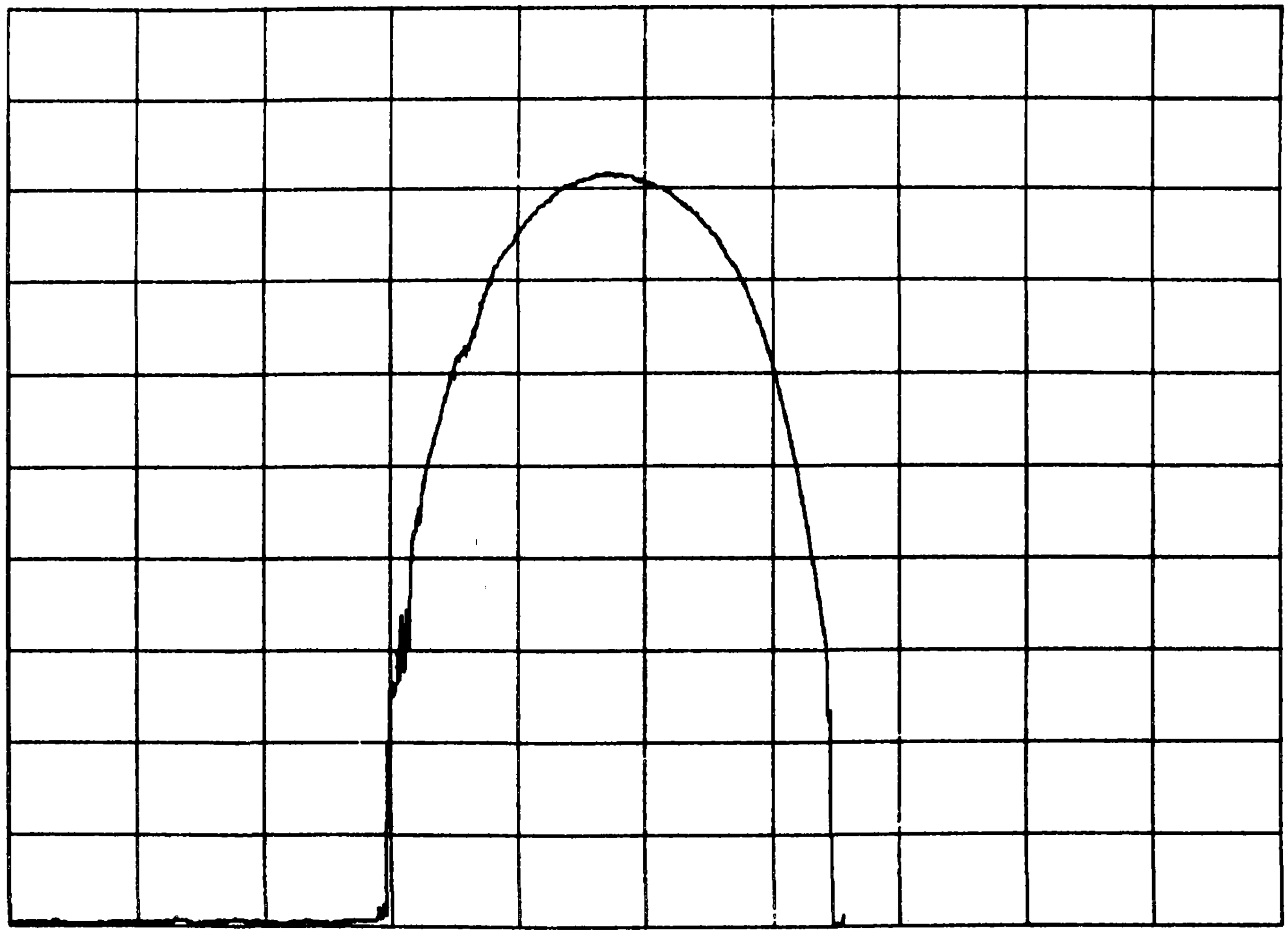

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