SAN/0499-26
MDC G8224

10-MWE Solar-Thermal
Central-Receiver Pilot Plant

SOLAR-FACILITIES DESIGN INTEGRATION

METEOROLOGICAL STATION REQUIREMENTS SPECIFICATION (RADL ITEM 7-19)

November 1979

WORK PERFORMED UNDER CONTRACT
DE-AC03-79SF10499

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
5301 BOLSA AVENUE
HUNTINGTON BEACH, CA 92647

U.S. Department of Energy

MCDONNELL DOUGLAS CORPORATION

Solar Energy

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ABBREVIATIONS

The following abbreviations shall apply to this specification:

ACR	Active Cavity Radiometer
BCS	Beam Characterization Subsystem
CT	Circumsolar Telescope
DAS	Data Acquisition System
EES	Electronics Environmental Shelter
GFE	Government Furnished Equipment
IRIG	Inter-range Instrumentation Group
LBL	Lawrence Berkeley Laboratory
MCS	Master Control System
MWe	Megawatt Electrical
NIP	Normal Incidence Pyrheliometer
PSP	Precision Spectral Pyranometer
SFDI	Solar Facilities Design Integrator
SLL	Sandia Livermore Labs
STMPO	Solar Ten Megawatt Project Office
WNW	West-North-West

PREFACE

This document is provided by the McDonnell Douglas Astronautics Company (MDAC) in accordance with Department of Energy Contract No. DE-AC-03-79SF10499, Reports and Deliverables List, Item 7-19. The document contains meteorological hardware specifications pertaining to the McDonnell Douglas and Martin Marietta collector fields as defined on 30 July 1979.

Questions concerning this document should be directed to R. G. Riedesel at (714) 896-3357.

Section 1
SCOPE

This document identifies the meteorological parameters which affect plant operation and performance evaluation and support special collector field studies such as wind/heliostat structural and cloud/collector field interactions. It includes the identification of the instruments required to measure those parameters, the instrument locations, and suggests designs for integrating the hardware into the collector field. All meteorological related equipment up to the signal input to the Data Acquisition System (DAS) of the Master Control System (MCS) computer is included. Operational and survival environmental conditions, maintenance, and spares requirements are discussed.

Manufacturer-supplied information on the major hardware of interest is compiled in Appendix A. The equipment shown on the list should not be construed as an endorsement of the manufacturer's product. Hardware of equivalent performance characteristics and quality available from any other supplier is acceptable.

This specification does not include weather forecasting systems nor monitoring subsystems that require development except for the modified Beam Characterization System (BCS) for atmospheric attenuation measurement. All other hardware mentioned are readily available off-the-shelf items.

This specification does not include Master Control System (MCS) Data Acquisition System (DAS) hardware/software required for data reduction, storage and display of the collected meteorological data nor specifications or standards governing basic civil, structural or electrical design.

Section 2
DATA REQUIREMENTS

2.1 TYPE OF MEASUREMENTS

The following is a list of the meteorological parameters of interest.

- Insolation - direct normal, circumsolar, global, cloud detection
- Wind - speed, direction
- Temperature - dry bulb
- Air moisture - dew point
- Precipitation - rain and snow
- Atmospheric pressure
- Hail (size, direction, energy)
- Aerosols (atmospheric attenuation of visibility)
- Atmospheric gradient - lightning

2.2 MEASUREMENTS AND INSTRUMENTS (GENERIC NAMES)

Table 1 lists the measurements which shall be performed and the generic names of the applicable instruments.

Table 1. Instruments and Measurements

Measurement	Instrument (Generic names)
• Direct normal insolation (normal plant operation)	Normal incidence pyrheliometer (NIP) - Tracker required
• Direct normal insolation (calibration)	Active cavity radiometer (ACR) - Tracker required
• Direct normal insolation (circumsolar irradiance)	Circumsolar telescope
• Total global insolation and cloud detection	Pyranometer
• Total global insolation (calibration)	Precision spectral pyranometer (PSP)
• Wind speed	Cup anemometer
• Wind direction	Wind vane
• Temperature (dry bulb)	Resistance thermometer
• Air moisture	Dewpoint
• Precipitation	Rainfall gage (tipping bucket)
• Atmospheric pressure	Barometer
• Hail (size, direction, energy)	Hail cubes
• Aerosols	Nephelometer
• Atmospheric attenuation of visibility	Modified beam characterization subsystem (BCS)
• Atmospheric gradient	Lightning warning system

Section 3

OPERATIONAL AND SURVIVAL ENVIRONMENTAL CONDITIONS

All instrumentation hardware shall be capable of normal operation under the following environmental conditions:

- Dry bulb temperature: 16-113°F
- Wet bulb temperature: 14-77°F
- Snow load: 5 lb/ft^2
- Ice buildup: 2 inches
- Precipitation: 6 in/hr for 2 min, 2.4 in/hr for 30 min
- Seismic: Horizontal response 0.25g
  Vertical response 2/3 horizontal value

All instrumentation hardware shall be capable of surviving the following environmental conditions:

- Isolation level: 1150 $watts/meter^2$ (W/m^2)
- Dry bulb temperature: 9-117°F
- Wet bulb temperature: 5-82°F
- Wind at 10-m elevation (sustained + gusts): 90 mph
- Hail: 1 inch dia at 75 ft/sec
- Dust Devils: 38 mph max wind speed

Section 4
EQUIPMENT SPECIFICATIONS

4.1 SENSORS

4.1.1 Insolation

4.1.1.1 Direct Normal Insolation

The following list of instrumentation to measure direct normal insolation is to be considered adequate for plant operation and evaluation only if the Circumsolar Telescope is made available to Pilot Plant.

Normal Incidence Pyrheliometer (NIP)

Direct normal insolation shall be continuously monitored by a pyrheliometer whose characteristics shall be equivalent to or better than the following:

- Sensitivity of 8 microvolts per watt meter $^{-2}$
- Aperture to length ratio of 1 to 10, subtending an angle of 5 degrees 43 minutes 30 seconds
- Temperature sensitivity of ±1 percent over the ambient temperature range of +16°F to +113°F
- Linearity of ±0.5 percent from 0 to 2800 watts meter^{-2}
- Response time of 1 second (1/e signal)

A manufacturer's specification for an acceptable normal incidence pyrheliometer with the appropriate modifications is shown in Appendix A.

Active Cavity Radiometer (ACR) - Dual Cavity Sensor

An ACR shall be used to calibrate the NIP.

Readings from the ACR may be intermittent but no less than once every 2 minutes. Other ACR characteristics shall be equivalent to or better than the following:

- Measurement uncertainty of less than ±0.5% relative to the absolute radiation scale defined in S.I. units (1000 watts per meter^2 irradiance level)
- Irradiance range: 0 to 1500 watts per meter^2
- Field of View: 5 degree full angle, circular
- Sensitivity: 10 watt per meter^2 per volt^2
- Timer Constant: 1.5 seconds maximum

A manufacturer's specification for a single cavity ACR is shown on pages A-2 and A-3 of Appendix A. This instrument is being replaced by the more accurate dual cavity ACR which will be available in the early part of 1980. SFDI recommends the dual cavity ACR.

Circumsolar Telescope (CT)

Circumsolar irradiance shall be measured by a Circumsolar Telescope (CT) provided by DOE. The telescope is fabricated by the Lawrence Berkeley Laboratory (LBL).

Appropriate space, location, power, and data acquisition facilities for the instrument shall be provided. The instrument includes two Precision Spectral Pyranometers (PSP) and an Active Cavity Radiometer (ACR). The ACR is built into the telescope but the PSPs will need space near the telescope for normal to the sun and horizontal mounting. The telescope location is discussed in Section 5.0. The 110-115 VAC (1 kilowatt) power is required for the instrument's built-in power supply and signal conditioner which powers and conditions all components.

Four measurement signals between -10 to +10 volts will be produced by the instrument for its own DAS system. A real-time interface for the signal output from the instrument shall be built for the MCS DAS via the Micromux multiplexer.

4.1.1.2 Global Insolation - Cloud Detection

Total global insolation measurements, and indirectly, cloud detection shall be performed by pyranometers. Several pyranometers shall be located around the heliostat field (Section 5) to detect the level of obscuration caused by passing clouds. An inexpensive pyranometer such as the Lambda LI-200S or equivalent shall be used for this purpose.

For obtaining a more precise value of total global insolation as well as to calibrate the less accurate Lambda LI-200S, the Eppley Precision Spectral Pyranometer (PSP) or equivalent shall be used. The manufacturer's description of the PSP may be found on Page A-4 of Appendix A.

4.1.2 Wind

4.1.2.1 Speed

Wind speed shall be measured by cup anemometers. A manufacturer's specifications for an acceptable cup anemometer is shown on pages A-5 and A-6 of Appendix A.

4.1.2.2 Direction

Wind direction shall be indicated by wind vanes. A manufacturer's specifications for an acceptable wind vane is shown on pages A-7 and A-8 of Appendix A.

4.1.3 Temperature

4.1.3.1 Dry Bulb

The dry bulb temperature shall be measured by a platinum resistance sensor. Its characteristics shall be equivalent to or better than the following: 100 ± 0.1 ohm at 0°C; R_{100}/R_0 : 1.3916; usable temperature range: -30 to 130°C.

4.1.4 Air Moisture

4.1.4.1 Dewpoint

The air dewpoint temperature shall be measured by a lithium chloride dewpoint sensor with a platinum resistance thermometer bulb. A manufacturer's specifications for an acceptable dewpoint sensor is shown on page A-9 of Appendix A.

4.1.5 Precipitation

4.1.5.1 Rain and Snow

Rainfall and snowfall shall be measured by a tipping bucket rain gage. The gage shall have a heater for snow and ice conditions. A manufacturer's specifications for an acceptable low inertia tipping bucket rain gage is shown on page A-10 of Appendix A.

4.1.6 Atmospheric Pressure

4.1.6.1 Pressure Transducer

A pressure transducer for the pressure range of 24.6 to 31.5 inches Hg (625 mm to 801 mm Hg) and for an elevation range of sea level to 3,200 feet shall be used to measure atmospheric pressure. A manufacturer's specifications for an acceptable pressure transducer is shown on page A-11 of Appendix A.

4.1.7 Hail

4.1.7.1 Hail Cubes

Hail cubes shall be used to record hail stone size, direction, and energy. There are no manufacturers of hail cubes so the cubes shall be fabricated. The general specifications for the cubes (refer to Figure 1) are as follows:

The cube shall consist of five 1-foot-square sides made of 1-inch thick polystyrofoam (floral board) and covered with aluminum foil (1.5 mil). The hailstone dents in the aluminum foil indicates the hail stone size, direction, and energy. The 1-foot-square polystyrofoam squares shall be mounted on 1-foot-square plywood slabs which in turn are attached to a pole that shall be imbedded securely into the ground with a concrete base. The cube shall be

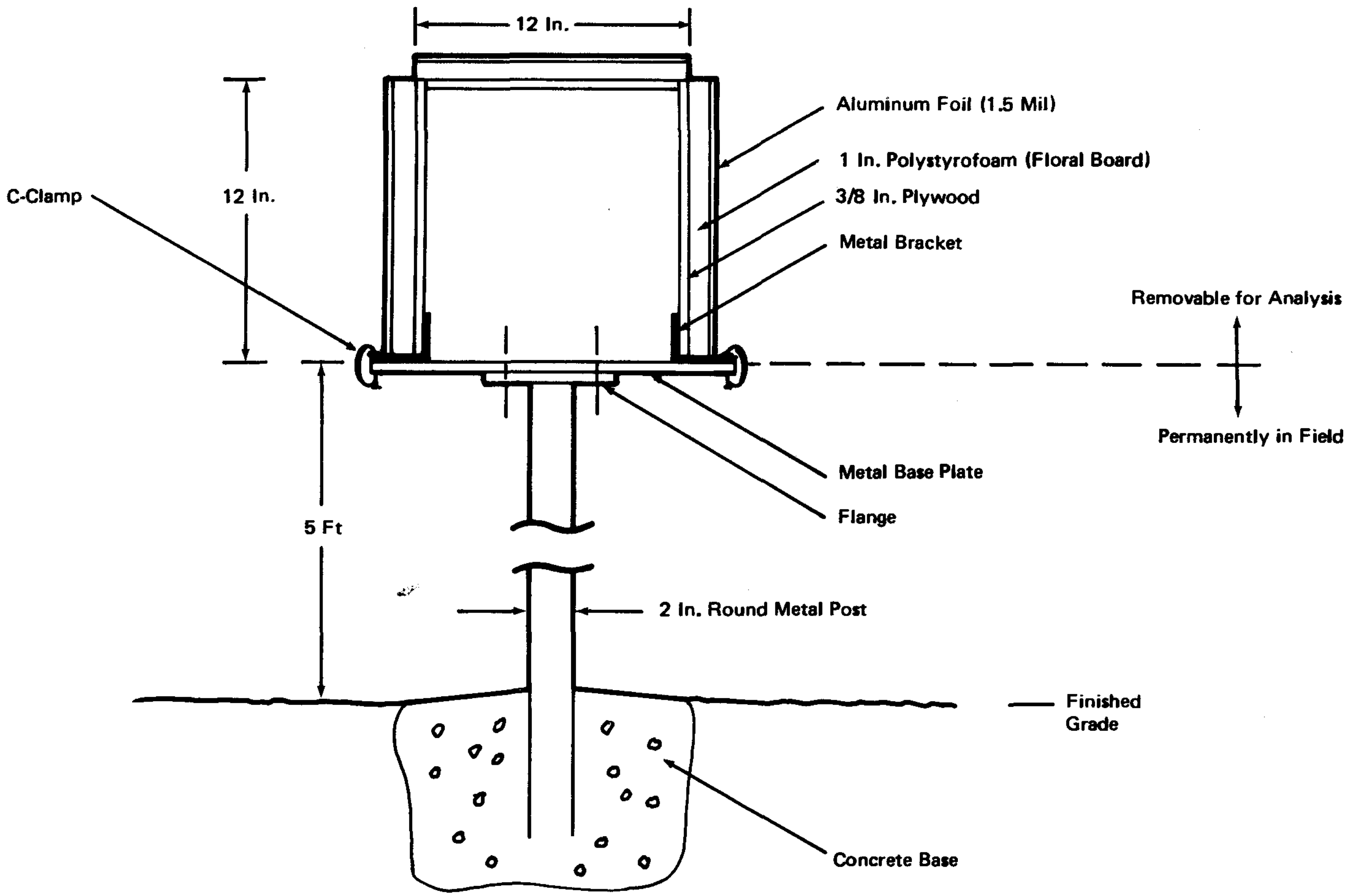

Figure 1 Hail Cube (Suggested Design)

oriented with one face in each of the compass point direction, i.e., North, South, East, and West, and shall be clearly marked to show which face is facing which direction with large letters N, S, E, W on each face for the respective direction.

The minimal height of the bottom of the cube from the ground shall be 5 feet. The pole shall be secured below the ground surface by concrete. The cube shall be easily changeable so that an undamaged cube could easily replace the hail damaged cube which shall be removed for analysis after a hail storm. An organization with extensive experience in hail cube analysis shall be chosen to analyze the hail damaged cubes for the parameters of interest. The following named group or its equivalent shall be selected to do the hail cube analysis:

Dr. Stanley A. Changnon, Jr.
Head Atmospheric Sciences Section
Illinois State Water Survey
605 East Springfield
Champaign, Illinois 61802

4.1.8 Atmospheric Attenuation of Solar Flux

4.1.8.1 Modified Beam Characterization Subsystem (BCS)
Serious consideration shall be given to modifying the BCS to measure solar flux attenuation between the heliostats and the receiver due to atmospheric aerosols and particulates. McDonnell Douglas Astronautics Company (MDAC) has developed the proprietary BCS and is scheduled to complete the BCS atmospheric attenuation modification development by the end of 1979.

Said modifications include the implementation of two constant light sources (one close to the camera and one on the BCS target) and the incorporation of appropriate software algorithms to interpret BCS camera data. For more detailed information on the BCS, refer to the following reports and deliverable lists (RADL):

RADL No.	RADL Item Description	Delivery Date
2-6	Beam Characterization Subsystem Specification	05 Dec 1979
3-1	BCS Technical Object and Des Requirements	05 Sept 1979
3-2	BCS Hardware and Software Specification	02 May 1980

If the cost is within STMPO's acceptable limits and the performance is on par with expectations, i.e., the system can accurately measure reduction of solar flux, then SFDI urges the implementation of the system.

4.1.8.2 Aerosols

Measurement of atmospheric aerosols shall be performed by a nephelometer. A manufacturer's specification for an acceptable nephelometer is shown on pages A-12 through A-15 in Appendix A.

4.1.9 Lightning

4.1.9.1 Lightning Detection

Warning of impending lightning conditions shall be provided for the entire heliostat field out to a radius of 1 mile about the center of the heliostat field. Approaching storm clouds shall be detected as far off as 10 miles. The alarm devices shall consist of at least a red panel light, a panel audio alarm with an on/off switch, and a terminal block with normally open contacts for operation of external alarms. A manufacturer's specification may be found on page A-16 of Appendix A. Any equivalent system meeting the above criteria is also acceptable.

4.2 AUXILIARY EQUIPMENT

4.2.1 Tracker

The NIPs and ACR shall be mounted on trackers which can accommodate both instruments on a single mount. A manufacturer's specification for an acceptable tracker is shown on page A-17 of Appendix A.

4.2.2 Wind Tower

The 10-meter towers shall not have guy wires. The towers shall be mounted on concrete foundations and withstand wind loads of 90 mph.

It shall be able to support at least a 300-pound load and shall be configured to minimize wind drag. An acceptable 10-meter tower from a manufacturer can be found on page A-18 of Appendix A. Any other tower design meeting the above criteria will also be acceptable.

Junction boxes mounted at the base of the wind towers shall be oriented vertically, 3 feet or more above the ground, have one to two small (1/8 to 1/4 inch diameter) drain holes, and weather seal.

4.3 POWER SUPPLIES AND SIGNAL CONDITIONERS

The power supply and signal conditioners shall be contained in a single unit. It shall be a research grade, multipurpose, multiparameter signal conditioning module which shall interface with a wide variety of analog sensors and convert the inputs from these sensors into a standardized voltage and current output. Each input channel shall be allotted space for one printed circuit board (PCB) which is designed for a particular sensor or function such as wind speed, wind direction, temperature, solar radiation, etc. The PCBs shall contain the necessary conversion, amplification and scaling to provide a pair of analog outputs.

The unit shall have a built-in power supply which converts the power source, 110 VAC, into regulated 12 VDC and 5 VDC needed by most sensors.

A manufacturer's specification for such a unit can be found on Page A-19 of Appendix A.

The three instruments which will not interface with the aforementioned unit are the following:

- ACR - This instrument has a special power requirement of 30 VDC in addition to being a portable unit. A separate portable control unit which includes a power supply, a signal conditioner and a liquid crystal readout for in-field instrument checkout shall be purchased from the manufacturer. The 110 VAC power and signal output cables are required.
- Nephelometer - This unit requires special electronics to accommodate the flash lamp and signal conditioning. The control unit shall be purchased from the manufacturer.
- Circumsolar Telescope - The circumsolar telescope is a portable unit and shall come with its own power supply, signal conditioning, and DAS. The only provisions required shall be 100-115 VAC power (1 kilowatt) and a real-time signal output interface with the MCS DAS via the Micromux multiplexer.

4.4 DATA ACQUISITION (SEE FIGURE 2)

The data acquisition system shall consist of remote units near the sensors, each unit being capable of multiplexing up to 16 analog or digital inputs and convert them to frequency coded time multiplexed digital signals. The receiver units located near the MCS DAS convert the frequency signal to a three-digit BCD format and store all channels in its internal memory. Upon command, the receivers shall transmit the continuously updated channel information to the MCS DAS over a standard ACS II serial interface. A receiver shall be capable of handling up to four remote units. A manufacturer's specification on an acceptable system is shown on Pages A-20 through A-23 in Appendix A.

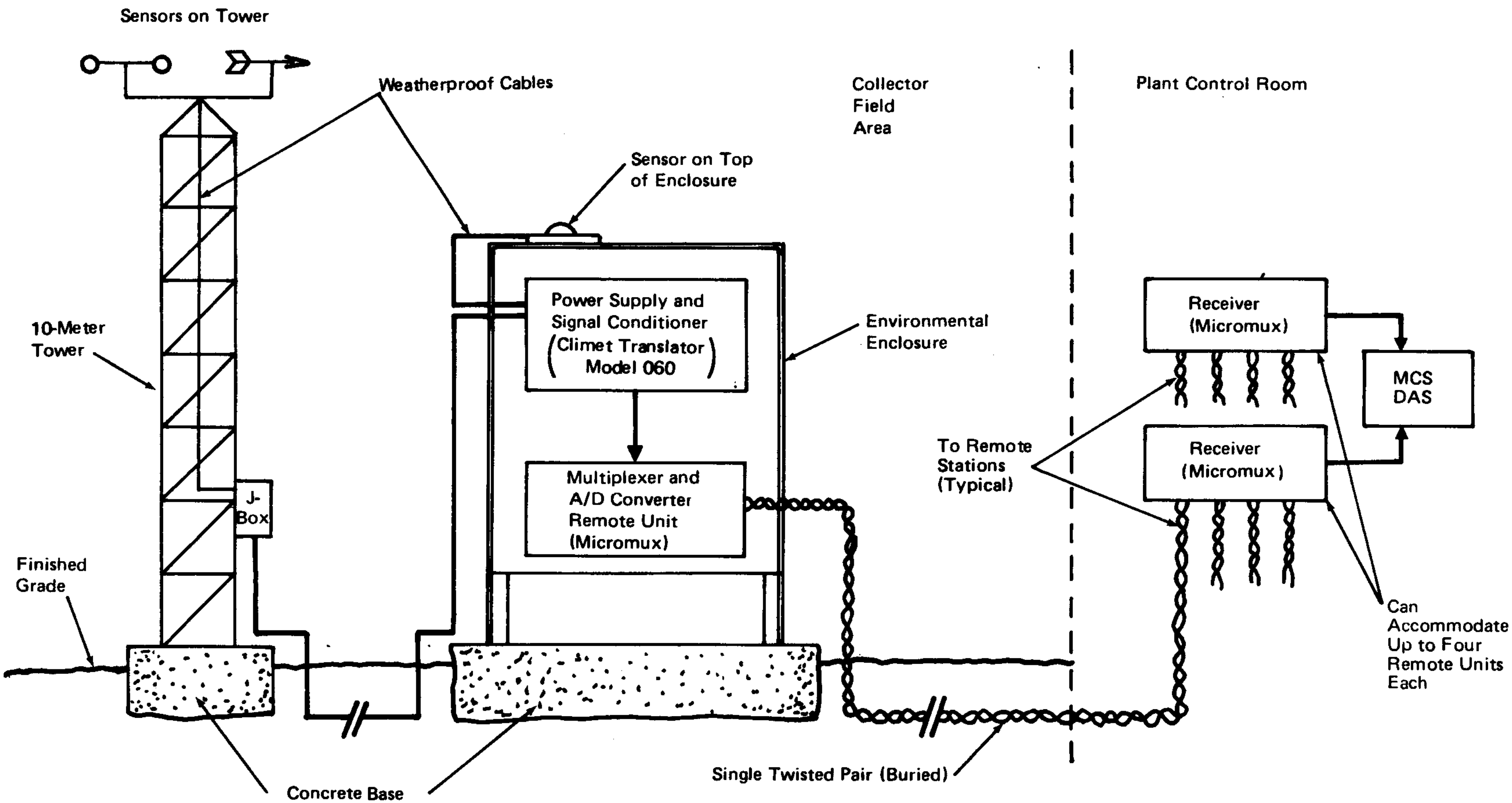

Figure 2. Data Acquisition System

Section 5
INSTRUMENT LOCATION

Figures 3 and 4 show the locations of the weather station instrumentation hardware for the McDonnell Douglas and Martin Marietta heliostat fields, respectively. There shall be one weather instrumentation station (shown as a hexagon) at each compass point of the field and at the central receiver tower. There shall be wind towers within the field in the West-North-West (WNW) direction adjacent to heliostats instrumented for wind loading studies. One hail cube is placed in the middle of the northwest field and one in the middle of the northeast field. These are shown as ◇HC in Figures 3 and 4.

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

On top of each compass point station base shall be an environmental enclosure for sensitive equipment such as power supplies, signal conditioners, multiplexers, and A/D converters. The enclosure shall be 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 shall be capable of easy access and removal of the electronic equipment.

A power/signal cable distribution panel shall be mounted within the enclosure. A two-panel door shall be located at one end for easy access to the front of the electronic packages. A lock shall be 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 shall be environmentally protected.

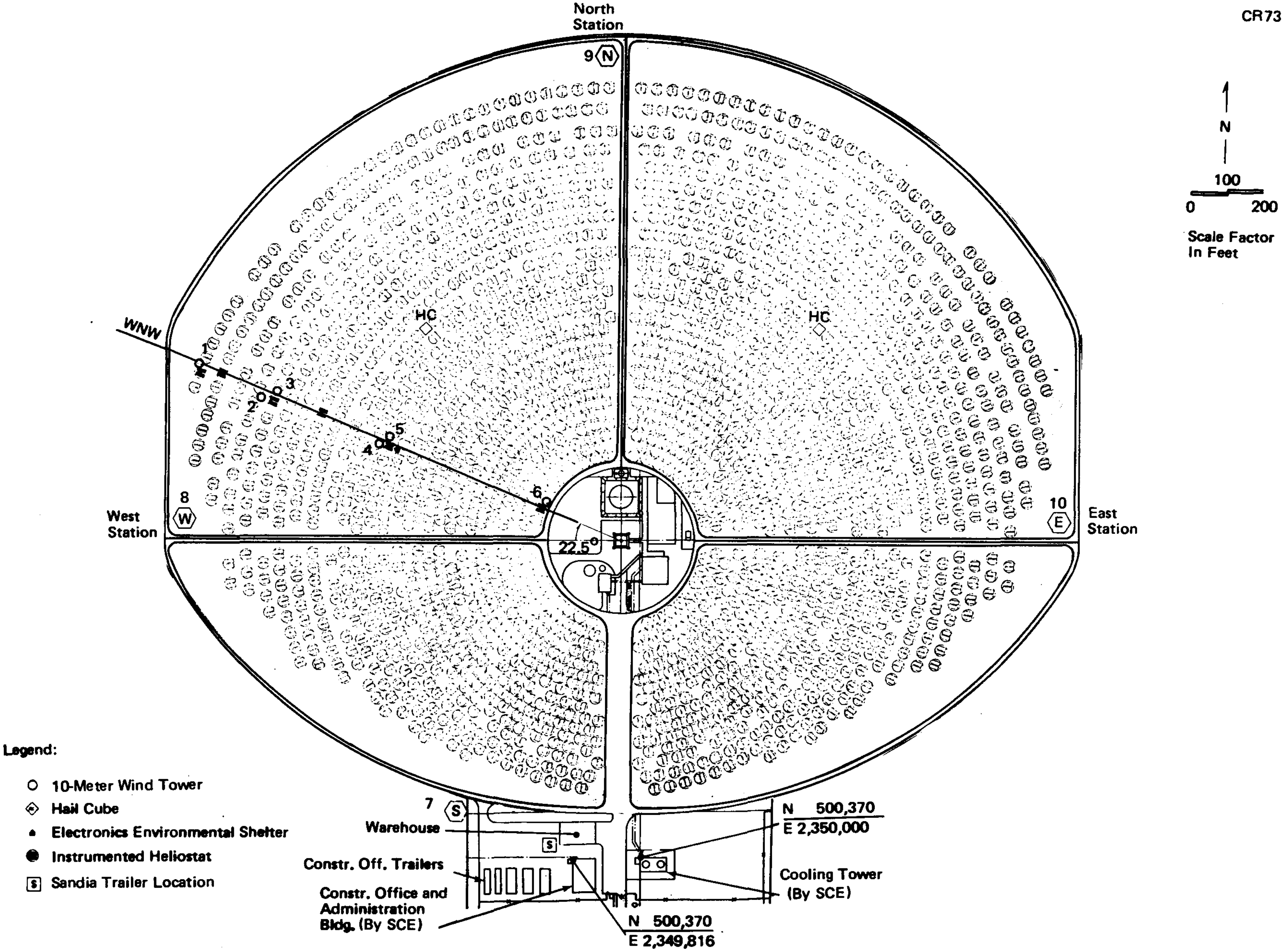

Figure 3. Weather Station Instrument Locations - MDAC Field

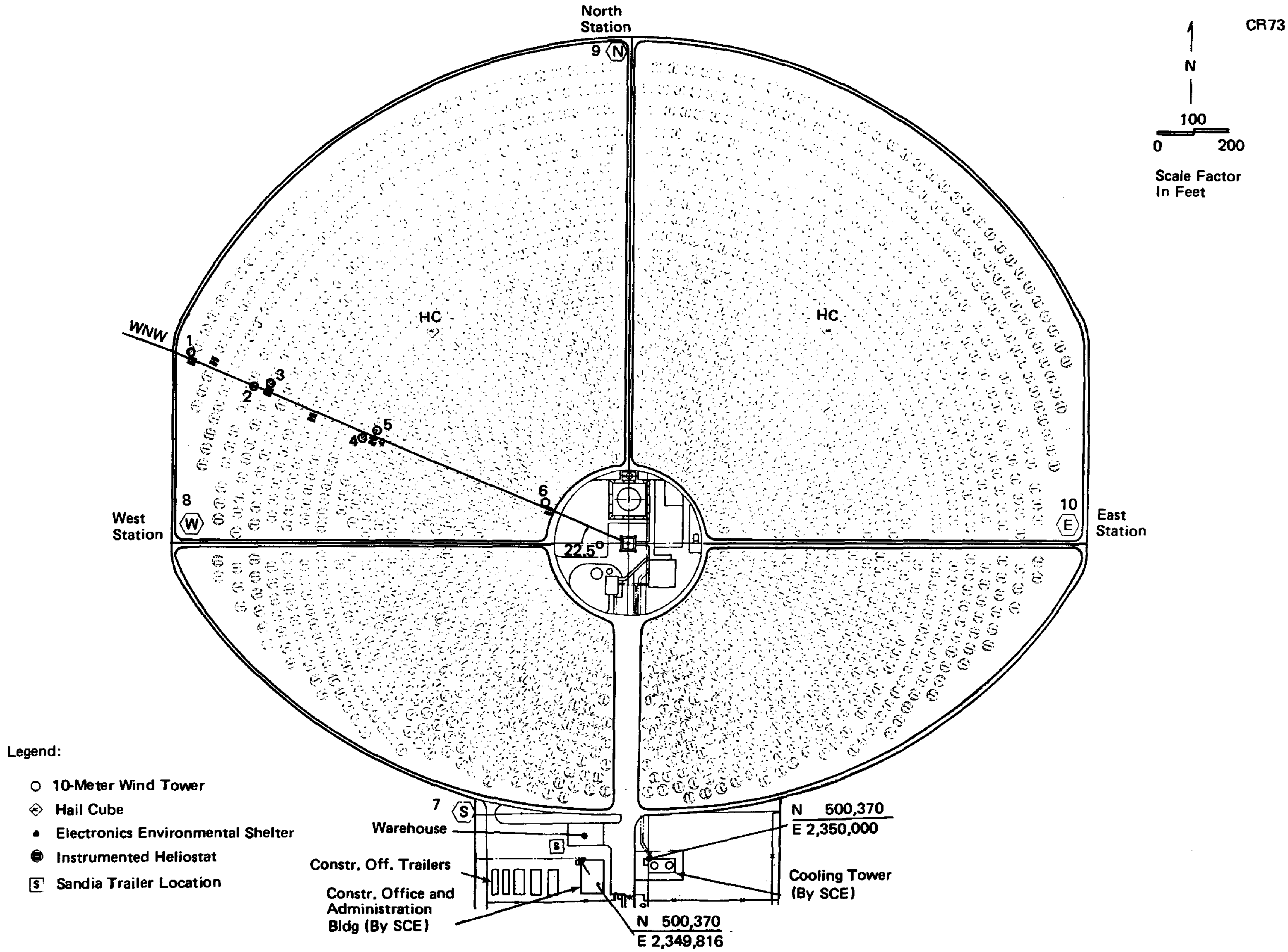

Figure 4. Weather Station Intrument Locations - Martin Field

5.1 SOUTH STATION

The South Station (see Figures 5 and 6) which is the main station, shall be located per collector field reference XY coordinates (coordinate convention shown in Appendix B) as indicated in Figure 5. It shall have a concrete slab base of approximately 16 by 10 feet.

A rigid environmental enclosure shall be dixed to accommodate all instrumentation electronics (power supplies, signal conditioners, multiplexers, A/D converters, ACR electronics, and CT electronics and CT DAS).
The approximate size of this enclosure is 60 inches wide by 60 inches high by 36 inches deep and it shall be located on the southwest end of the concrete base, 2 feet away from the base's edge with the long end in the east-west direction.

The CT electronics and CT DAS dissipates 1 kW heat and requires an operational environmental temperature of 70 ± 10°F. This will probably dictate the required cooling capacity of the enclosure's cooling system. The final total cooling requirement will depend on all the equipment selected.

On top of the enclosure shall be permanently mounted a pyranometer (Lambda) and a NIP. Power, signal cabling, and appropriate space shall be provided on top of the enclosure for a portable PSP and a portable ACR which may be moved to other station locations.

On the southeast corner of the base shall be a 5-foot-diameter vacant area where the circumsolar telescope shall be located. The 5-foot-diameter vacant area shall be 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 shall be a 3 by 4 foot area reserved for the circumsolar telescope support equipment. All circumsolar telescope hardware shall be GFE.

On the west end of the base and at least 1.0 foot in from the base's edge shall be located a tipping bucket rain gage.

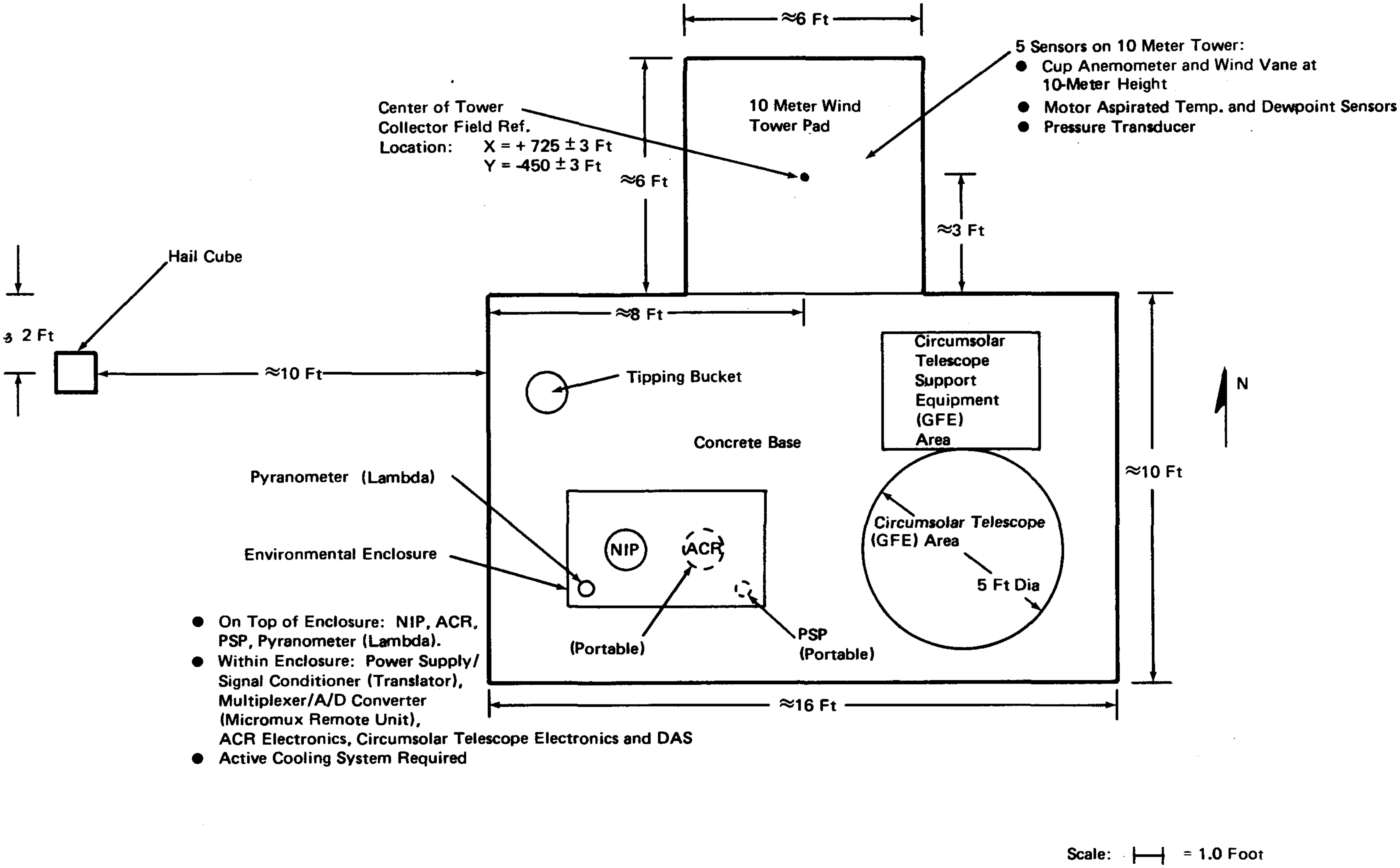

Figure 5. South Station (Main Station) - Suggested Design

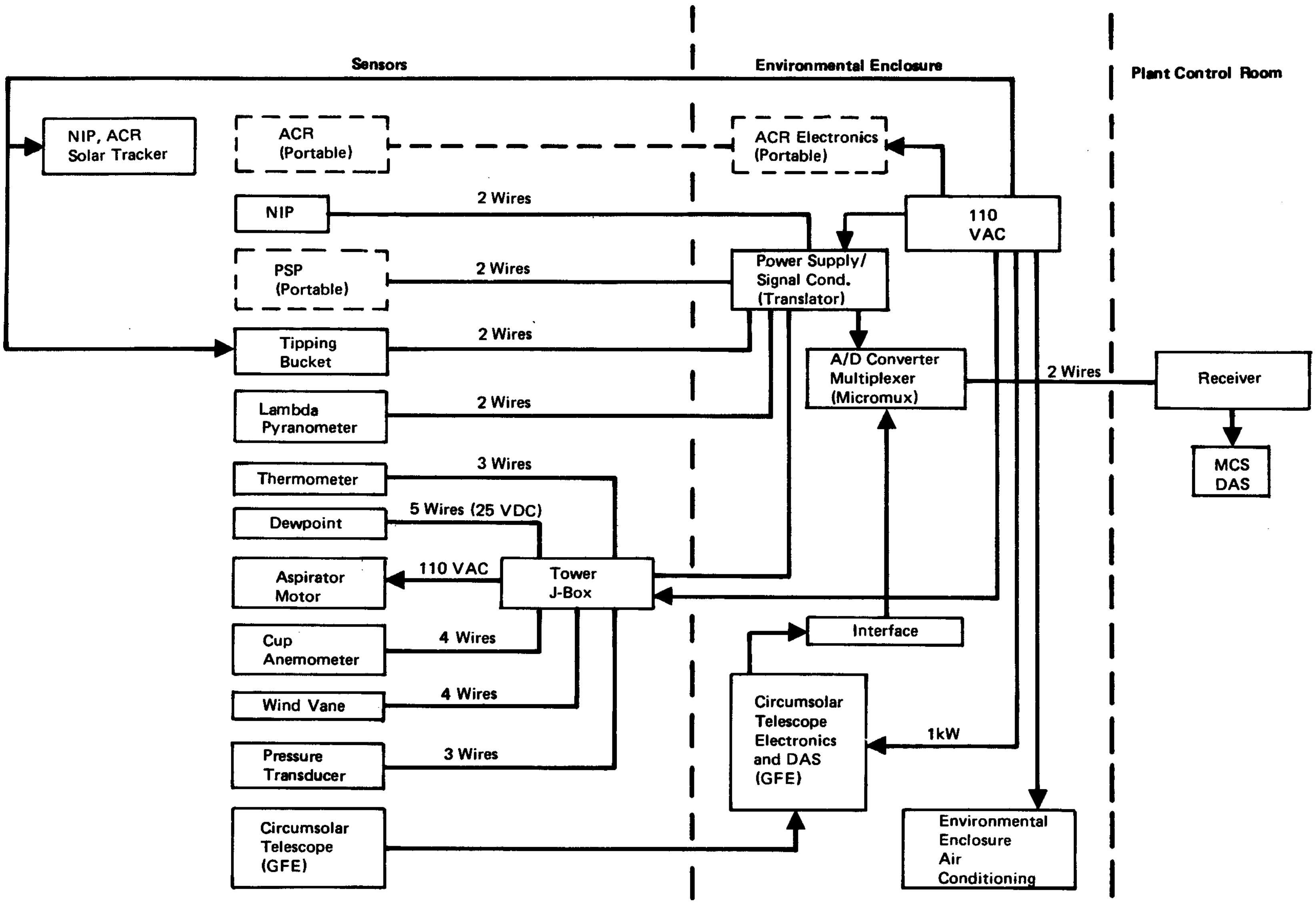

Figure 6. South Station (Main Station) Cabling Requirements

Adjacent to the base (north of base) shall be a 6 by 6 foot square concrete area where a 10-meter tower shall be located. On the tower at the 10-meter level shall be a cup anemometer and wind vane mounted on a cross arm. A motor aspirated temperature and dewpoint sensor shall be mounted just below the wind sensors (see page A-18 of Appendix A). A pressure transducer shall be mounted at the 6-foot level of the tower. On a pole 10 feet from the concrete base in the westerly direction shall be a hail cube.

5.2 WEST STATION

The West station (Figures 7 and 8) shall be located per collector field reference XY coordinates as indicated in Figure 7. It shall be a 9 by 6.5 feet concrete slab base with the long end in the east-west direction. The surface of the base shall be at least 2 inches above the surrounding finished grade.

An environmental enclosure approximately 60 inches wide by 48 inches high by 30 inches deep to accommodate all station electronics shall be located at the south side of the base. On top of the enclosure shall be permanently mounted a pyranometer and cabling provisions for a portable PSP. Requirements for electronics environmental protection, access, drainage, cable connections, and safe guarding shall be the same as that for the South Station environmental enclosure. An active cooling system may be required depending on the equipment chosen.

North of the environmental enclosure base shall be a 6 by 6 foot tower base. On the tower at the 10-meter height shall be a cup anemometer and a wind vane mounted on a crossarm.

A hail cube shall be located 10 feet west of the concrete base.

5.3 NORTH STATION

The North station (Figures 9 and 10) shall be located per collector field reference XY coordinates as indicated in Figure 9. The specifications of the base, environmental enclosure, and 10-meter tower shall be identical to that of the West station. There shall be a NIP and cabling provisions for a portable ACR and a portable PSP on top of the environmental enclosure.

Hail cube is located 10 feet north of the base.

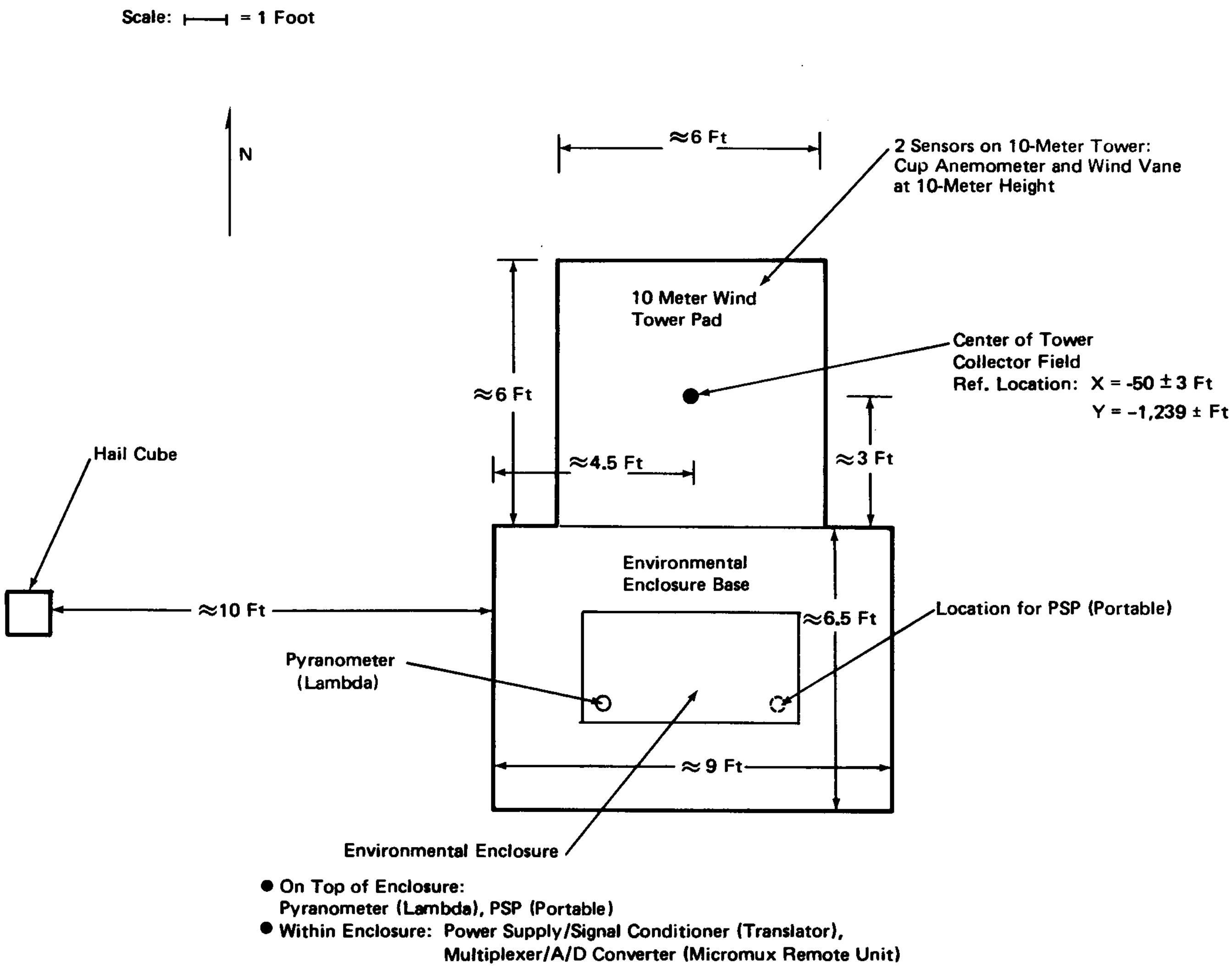

Figure 7. West Station (Suggested Design)

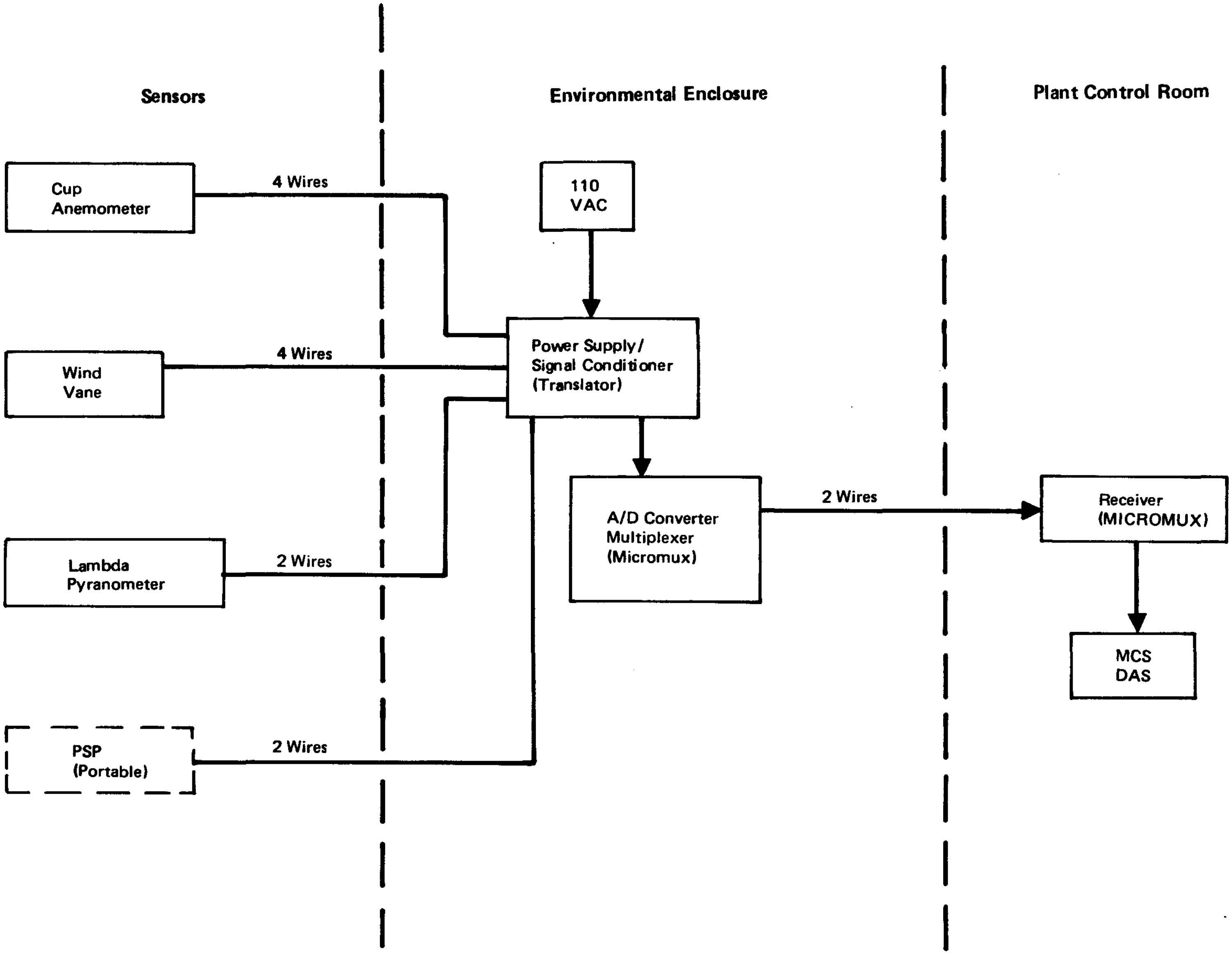

Figure 8. West Station Cabling Requirements

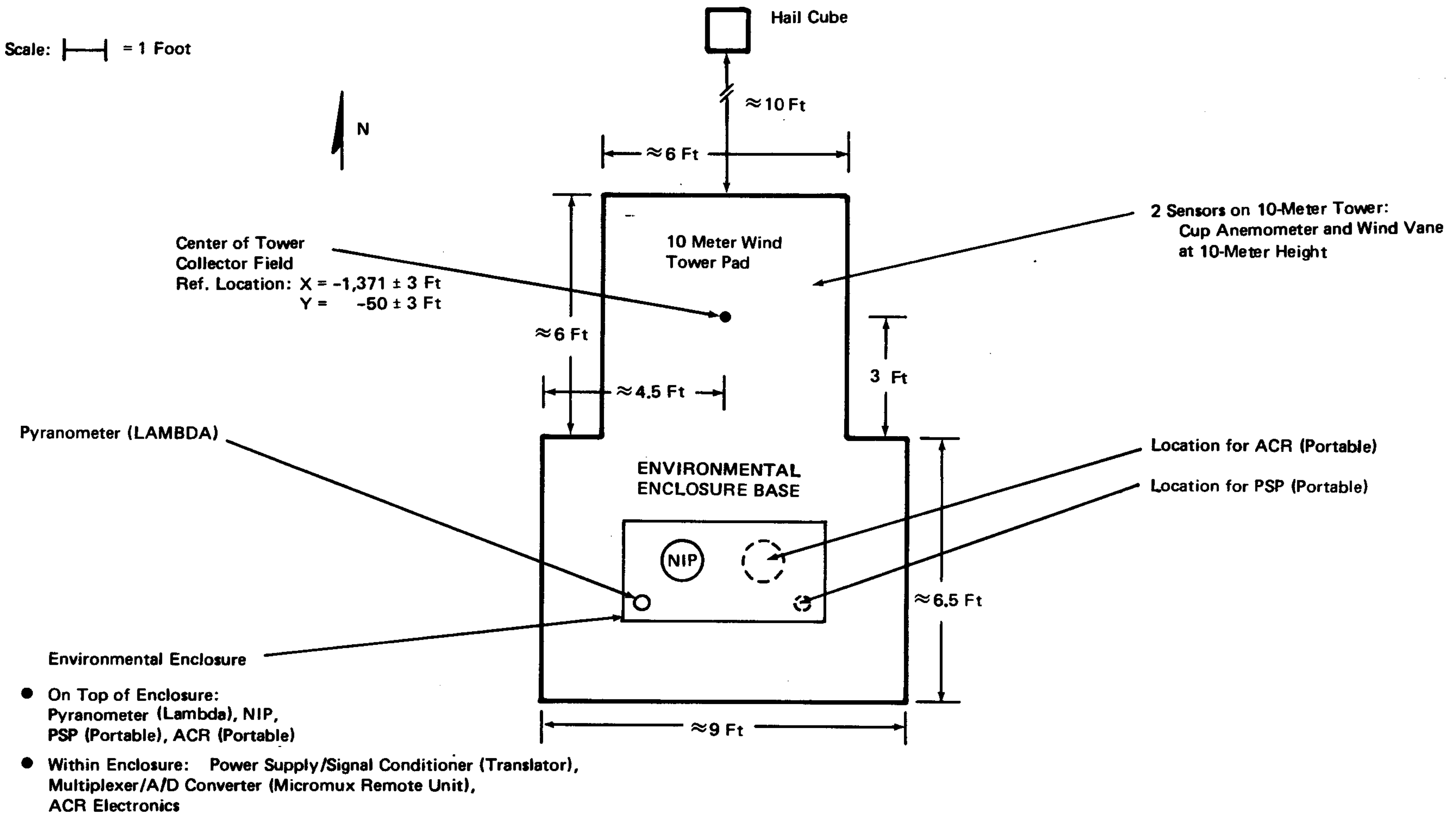

Figure 9. North Station (Suggested Design)

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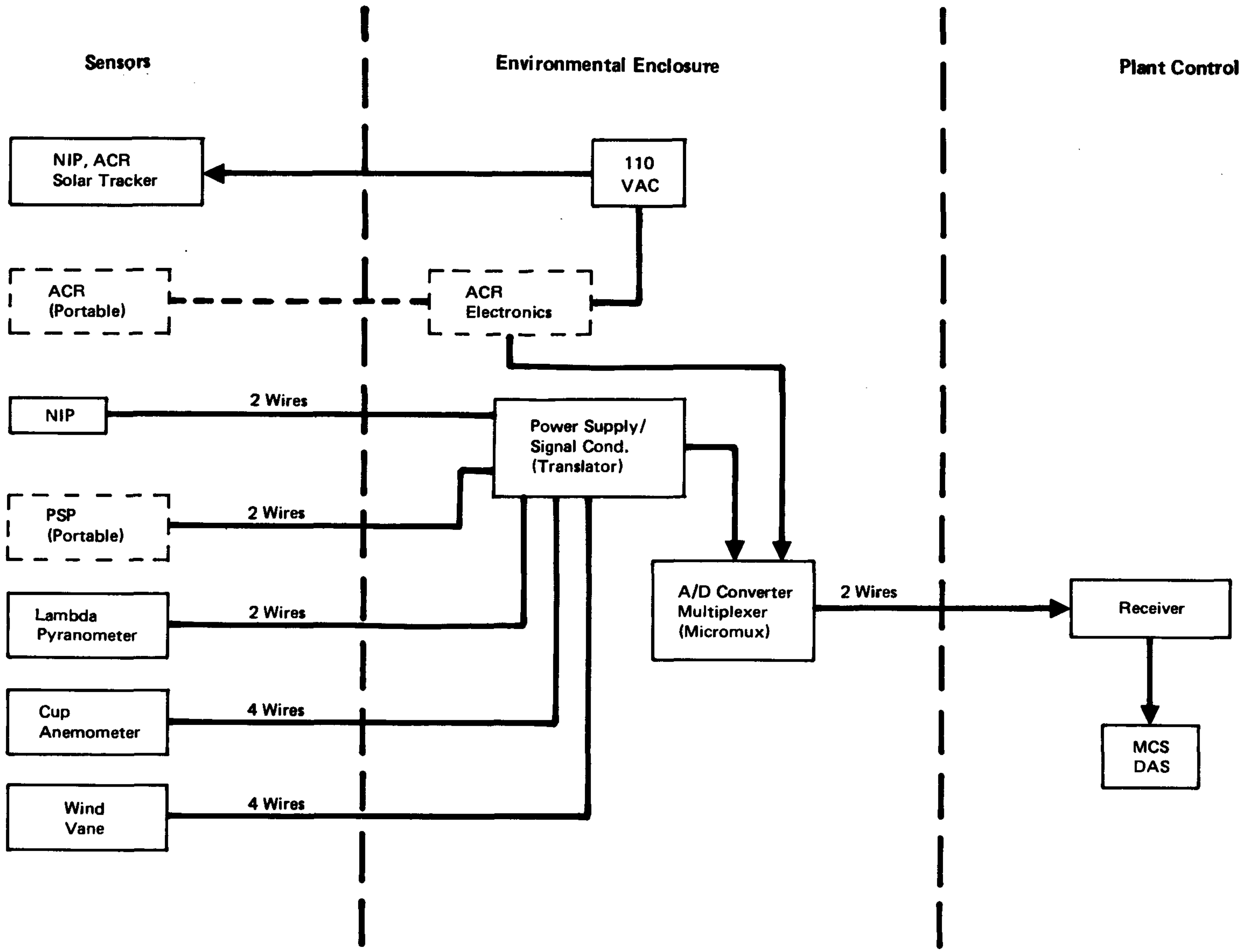


Figure 10. North Station Cabling Requirements

5.4 EAST STATION

The East station (Figures 8 and 11) shall be located per collector field reference XY coordinates as indicated in Figure 11. The station characteristic dimensions and requirements are identical to that of the West Station except for the hail cube which is located 10 feet east of the base.

The wind towers at the aforementioned weather stations should be oriented North-South, East-West. The crossarms shall be furnished by the equipment supplier and the booms by the steel tower contractor. The crossarms at the towers adjacent to the North-South stations shall be oriented East-West and the arms at the East-West stations shall be oriented North-South.

5.5 IN-FIELD HAIL CUBES

Two hail cubes (in addition to the four at the weather stations) shall be located within the field: one in the northwest direction and one in the northeast, as indicated by ◇HC◇ in Figures 3 and 4. The collector field layout reference XY coordinates are:

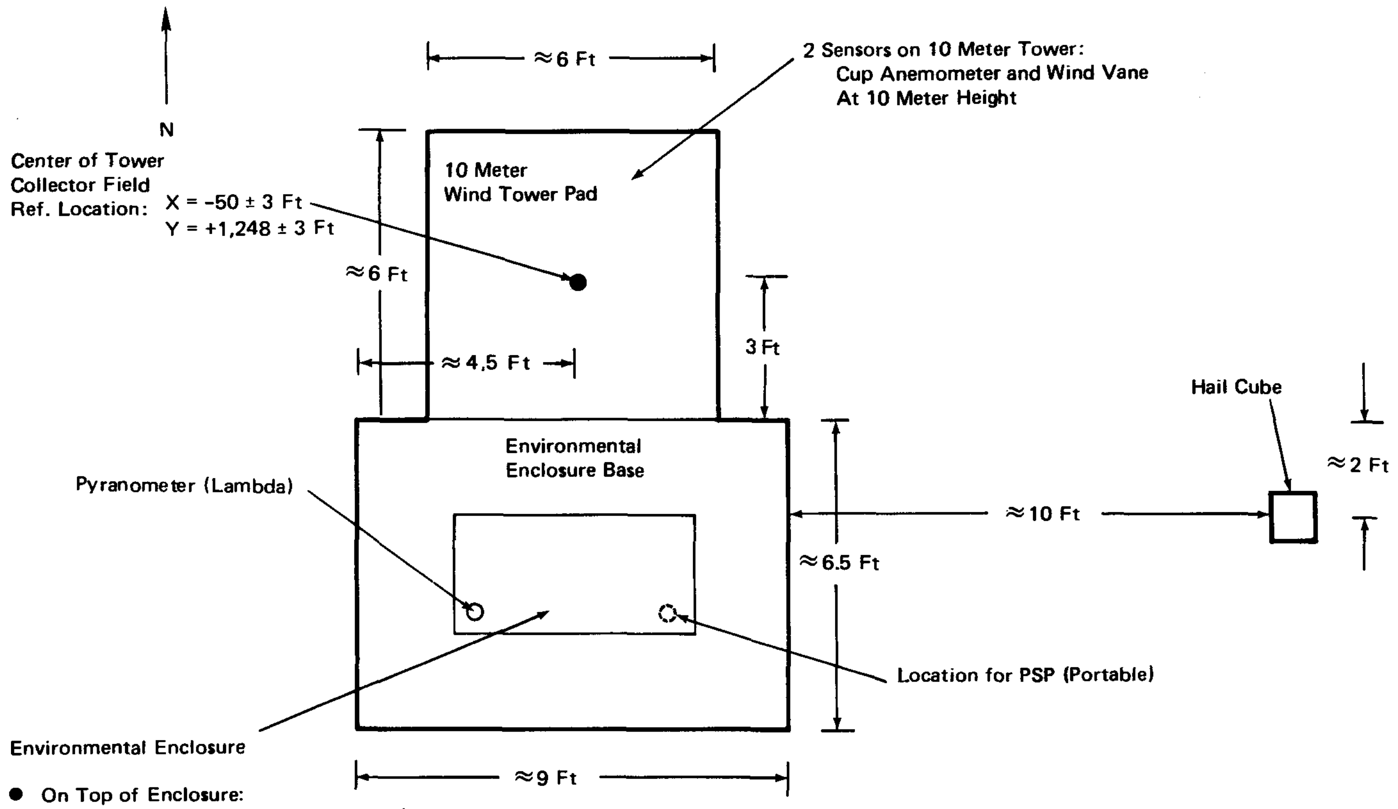
	X	Y
Hail Cube No. 1	-476.473	-650.038
Hail Cube No.	-476.473	+650.038
(tolerance of ±2 feet)		

5.6 CENTRAL RECEIVER TOWER

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, shall be located in the easterly direction on the east side and also in the westerly directly on the west side of the receiver tower at level 7 as shown in Figures 12 and 13.

A nephelometer, motor-aspirated temperature, and dewpoint sensor shall be located within the tower structure on the same level as the wind sensors. The nephelometer shall be mounted near the temperature and dewpoint sensors in a vertical position with the sample inlet port down. The nephelometer electronics shall be located not more than 6 feet from the sensor.

Scale: |—| =1 Foot



- On Top of Enclosure:
  Pyranometer (Lambda), PSP (Portable)
- Within Enclosure: Power Supply/Signal Conditioner (Translator),
  Multiplexer/A/D Converter (Micromux Remote Unit)

Figure 11. East Station (Suggested Design)

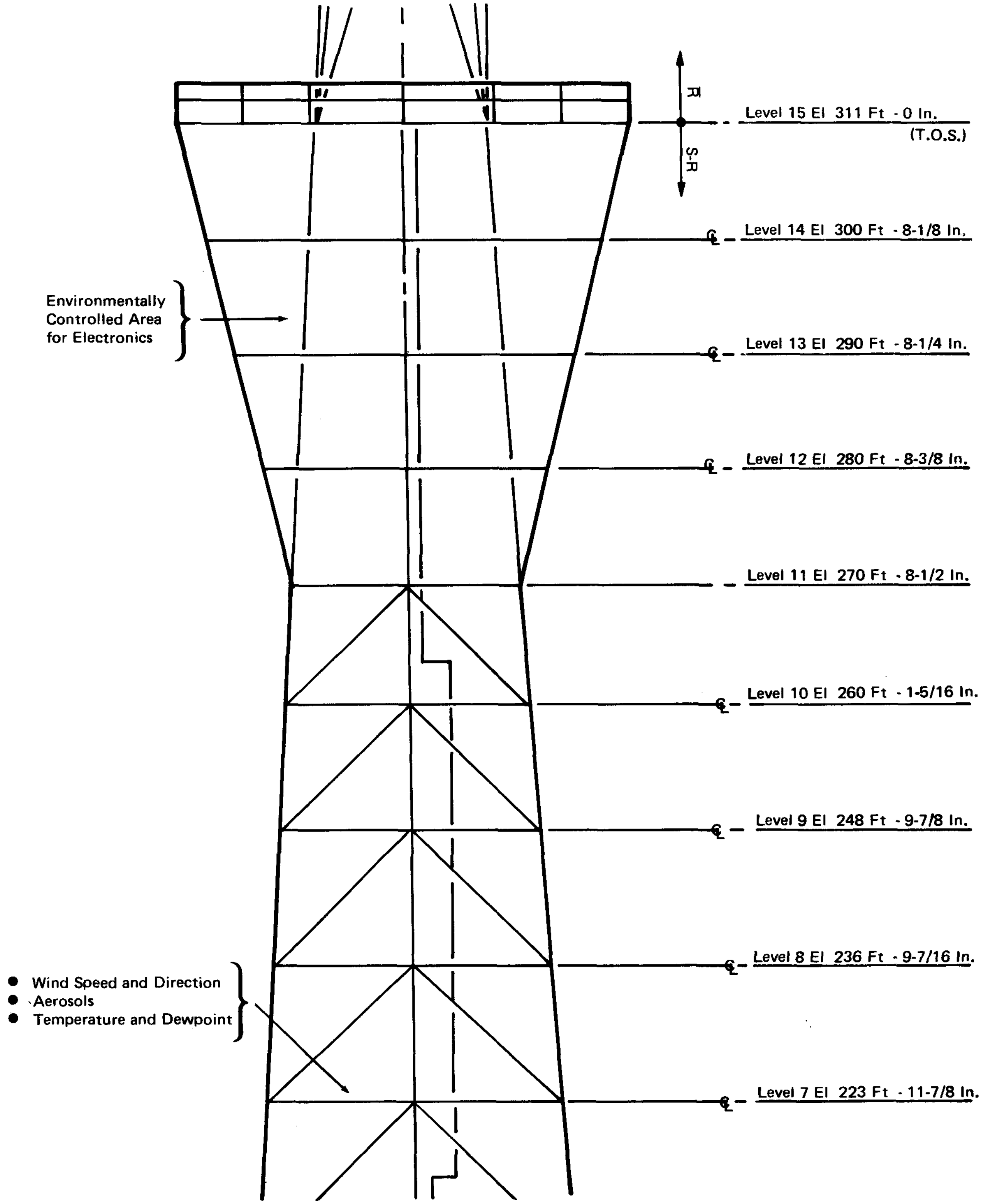


Figure 12. Central Receiver Tower

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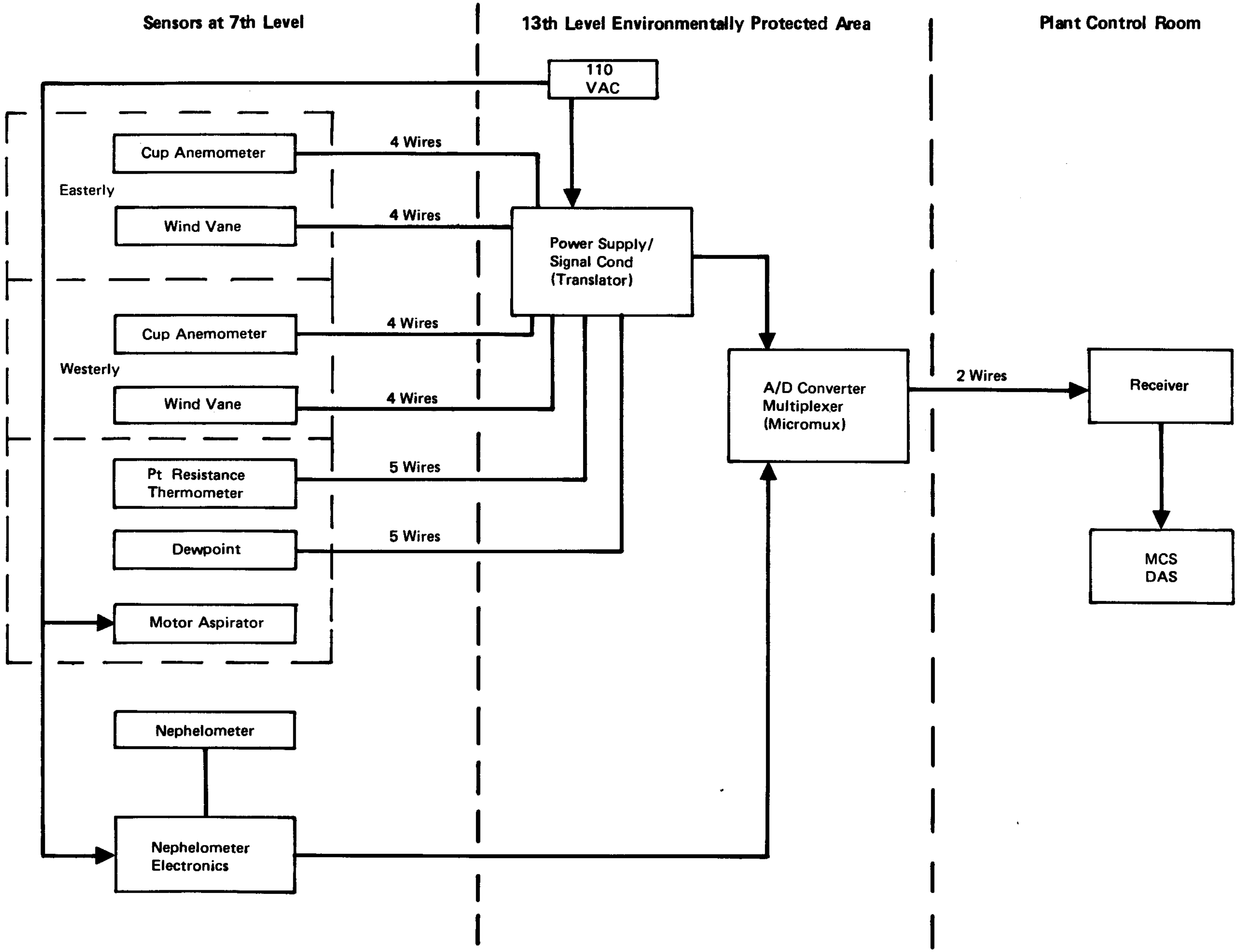


Figure 13. Central Receiver Tower (Level 7) Cabling Requirements

Power supplies, signal conditioners, multiplexers, and A/D converters shall be located in the environmentally protected area on the 13th level.

5.7 PLANT CONTROL BUILDING ROOF

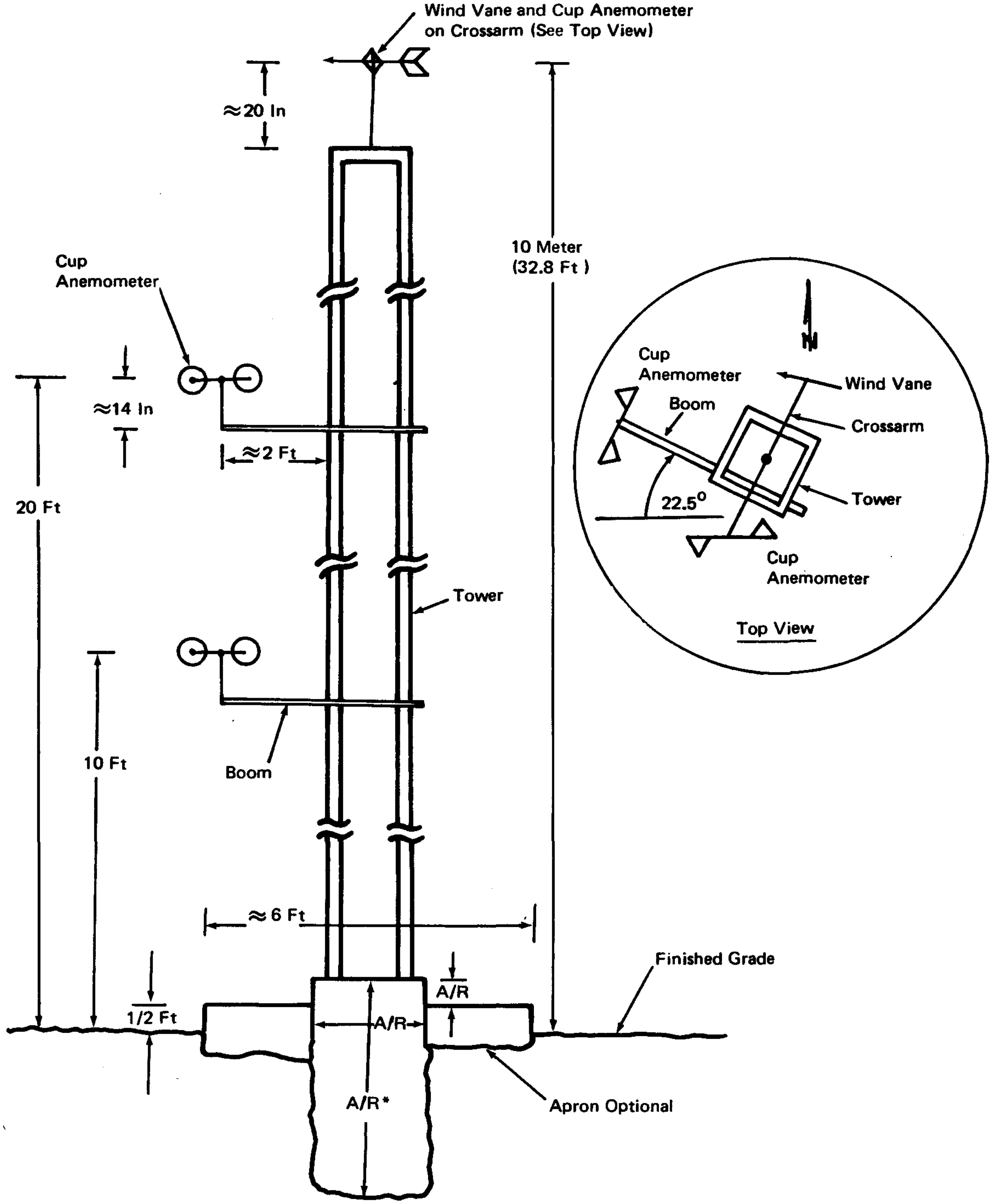
The lightning sensor of the lightning warning system shall be located on the southeast corner of the plant control building roof and the electronics module shall be located in the plant control room.

5.8 WEST-NORTH-WEST (WNW) DIRECTION

Six 10-meter towers shall be located at the designated spots in the West-North-West (WNW) direction in the field. These towers (numbered 1 through 6 in Figures 3 and 4) shall be adjacent to the heliostat (indicated by shading in Figures 3 and 4) that will be instrumented by Sandia for wind structural loading studies. Each tower (Figure 14) shall have 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 shall be in the WNW direction, i.e., 292.5° (0° is North, angle measured clockwise). The cross arm shall be mounted perpendicular to the boom.

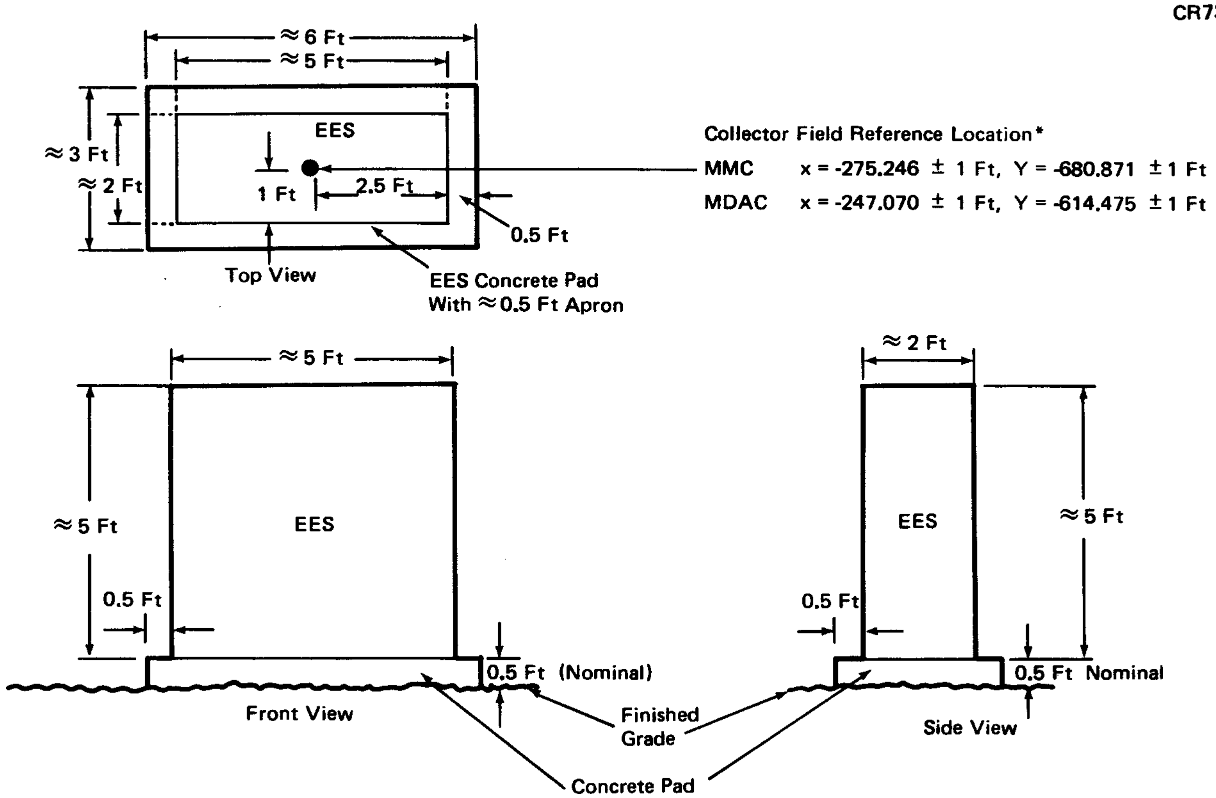
An electronics environmental shelter (Figure 15) used to house power supplies, signal conditioners, multiplexers, A/D converters, and transmitter shall be located adjacent to wind tower 5 as shown in Figures 3 and 4. The shelter shall be temperature controlled (active cooling may be required) to maintain the temperature limits required by the electronics housed. The shelter shall sit on a concrete base designed to accommodate a light load. A 6-inch apron whose surface is at least 6.0 inches above the finished grade shall surround the shelter. The shelter shall be oriented with the long axis parallel to the circle radius and have double doors and a lock which will permit access only to authorized personnel.

Figures 16 and 17 show the cabling requirements for the wind sensors and the structures sensors. All sensors in the WNW direction shall not be more than 1,000-foot cable length from the EES. Figure 18 shows the delineation of responsibility between SFDI and Sandia Livermore Labs (SLL) for the WNW wind/structures evaluation.



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

Figure 14. In Field Wind Tower (WNW Direction)



* These Coordinates Supersede Those in the Collector Field Layout Specification (RADL Item 2-12), SAN/0499, MDC G8201, September 1979.

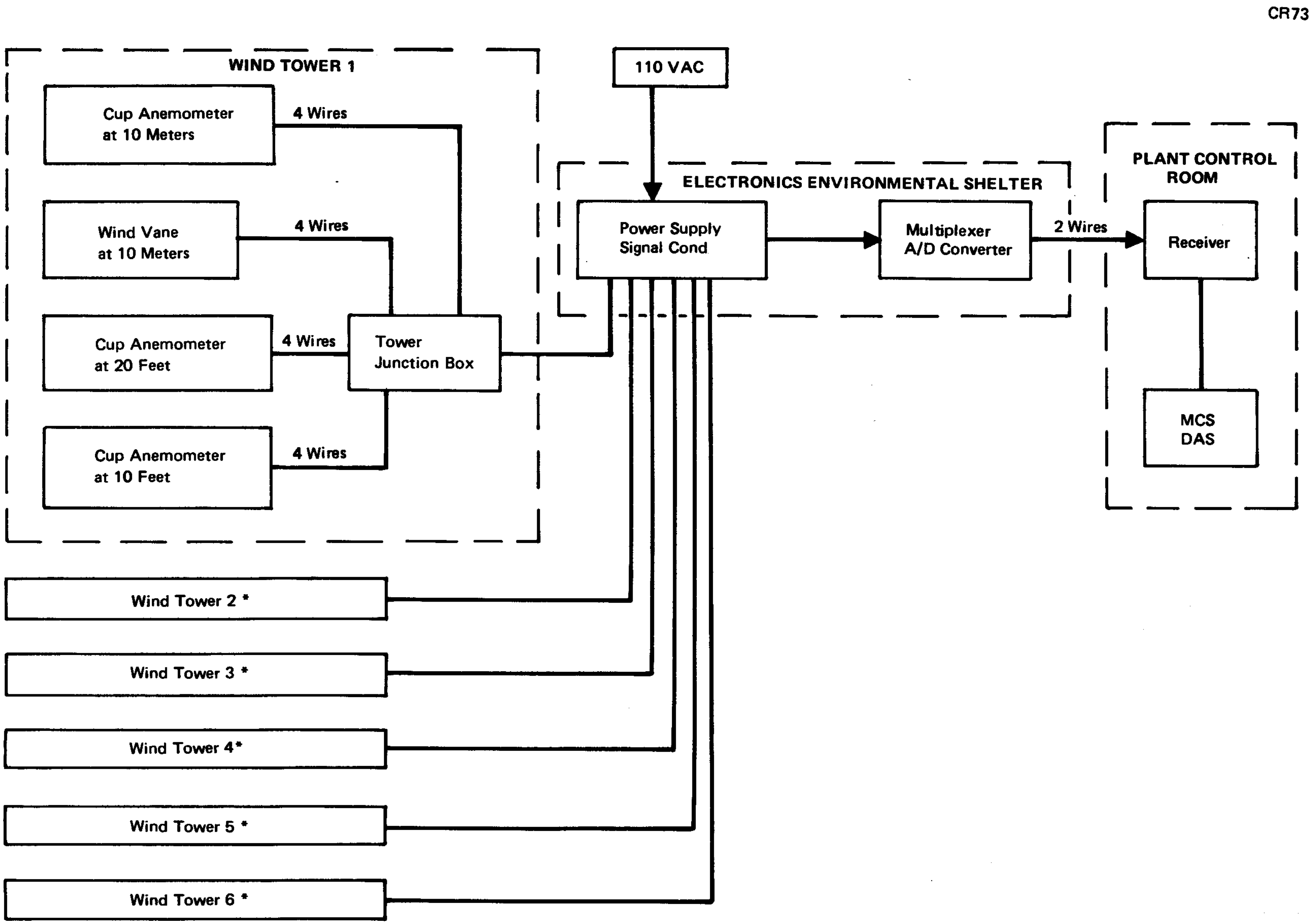
Figure 15. Electronics Environmental Shelter (EES)

Power required by the SLL EES electronics is approximately 110 ± 8 VAC at 10 to 15 amperes. An on/off switch to control the power and an Inter-Range Instrumentation Group (IRIG) time signal from the control room shall be provided for the SLL ESS electronics.

SLL will be collecting their structural data via telemetry in a trailer located near the warehouse. SFDI shall provide power in the form of 110 VAC, not to exceed 1,000 watts, for the SLL DAS and 230 VAC 1 phase, not to exceed 400 watts, for the SLL air conditioner.

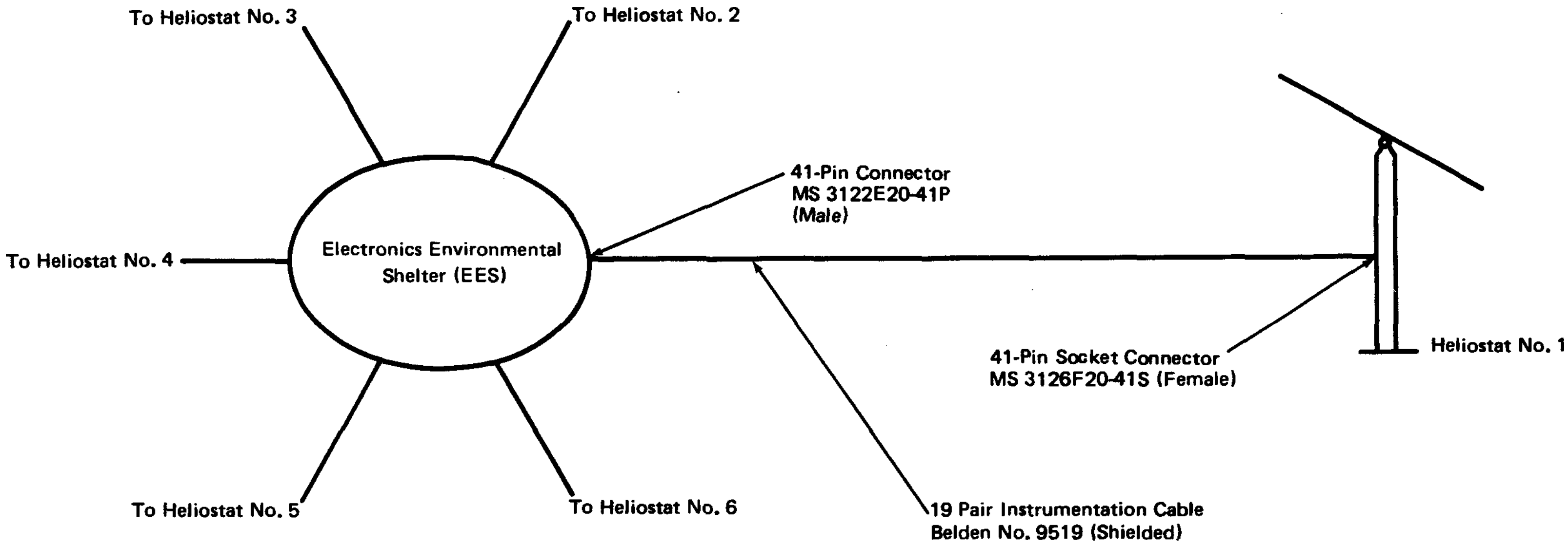
Table 2 shows the collector field layout reference XY coordinates for the WNW wind towers and EES.

Table 3 summarizes SFDI meteorological sensors and electronics locations.



* Same Instrumentation as Wind Tower 1.

Figure 16. West-North-West (WNW) Direction Cabling Requirements



1. All Six Cables Should Have an Extra 5-foot Length Inside the Electronics Shelter and an Extra 2-foot Length at the Heliostat.
2. The Connectors and Belden No. 9519 Cables are SFDI Responsibility.

Figure 17. Sandia Livermore Labs (SLL) WNW Structurally Instrumented Heliostat Cable Routing

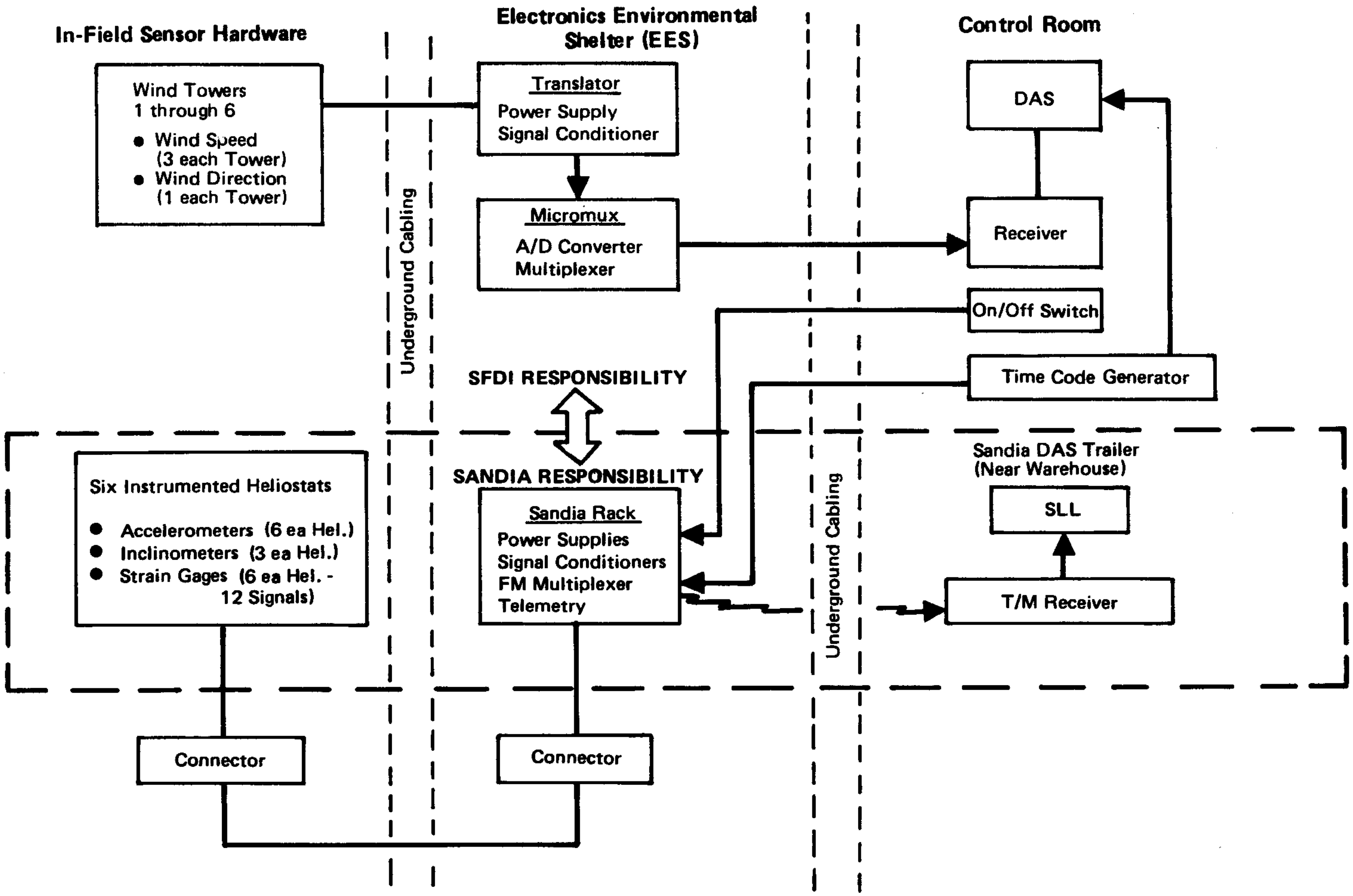


Figure 18. West-North-West (WNW) Direction Heliostat and Wind Instrumentation

Table 2. Wind Tower and EES Locations*

Tower No. or EES	MMC Collector field coordinates		MDAC Collector field coordinates	
	X	Y	X	Y
1	-532.592	-1,217.970	-488.476	-1,175.916
2	-440.043	-1,051.583	-400.832	-1,013.023
3	-445.838	- 993.992	-405.543	- 958.822
4	-298.302	- 748.853	-275.246	- 680.871
5	-308.881	- 705.195	-281.844	- 639.148
6	- 99.436	- 201.059	- 99.436	- 201.059
EES	-275.246	- 680.871	-247.070	- 614.475

*These coordinates supersede those in the Collector Field Layout Specification (RADL ITEM 2-12), SAN/0499, MDC G8201, September 1979.

Table 3. Instruments According to Location

I SOUTH STATION - MAIN STATION

- On 10-Meter Tower
  1. Cup anemometer and wind vane on crossarm at 10 meters.
  2. Motor-aspirated temperature and dewpoint sensors directly below wind sensors.
  3. Barometer directly below temperature/dewpoint sensors.
- On Top of Environmental Enclosure
  1. Normal incident pyrheliometer (NIP).
  2. Active Cavity Radiometer (ACR) - portable.
  3. Pyranometer.
  4. Precision Spectral Pyranometer (PSP) - Portable.
- Other Areas
  1. Circumsolar Telescope (CT).
  2. Hail Cube on post.
  3. Tipping bucket rain gage.

Table 3. Instruments According to Location (Continued)

- Within Environmental Enclosure

  Power supplies, signal conditioners, multiplexer, A/D converter, ACR electronics, and CT electronics and CT DAS.

- Total

  Nine permanent electronic sensors, cabling provisions for one ACR and one PSP.

II WEST STATION

- On 10-Meter Tower

  1. Cup anemometer and wind vane on crossarm at 10 meters.

- On Top of Environmental Enclosure

  1. Pyranometer
  2. Cabling for portable PSP

- On Post

  1. Hail Cube

- Within Environmental Enclosure

  Power supplies, signal conditioners, multiplexer, A/D converter

- Total

  Three permanent electronic sensors, cabling provision for one PSP sensor.

III NORTH STATION

- On 10-Meter Tower

  1. Cup anemometer and wind vane on crossarm at 10-meter level.

- On Top of Environmental Enclosure

  1. Pyranometer
  2. NIP
  3. Cabling for portable PSP
  4. Cabling for portable ACR

- Within Environmental Enclosure

  Same as West Station

- On Post

  1. Hail Cube

Table 3. Instruments According to Location (Continued)

- Total

  Four permanent electronic sensors, cabling provision for one PSP and one ACR.

IV EAST STATION

- On 10-Meter Tower
  1. Cup anemometer and wind vane on crossarm at 10-meter level.
- On Top of Environmental Enclosure
  1. Pyranometer
  2. Cabling for portable PSP
- Within Environmental Enclosure

  Same as West Station
- On Post
  1. Hail Cube
- Total

  Three permament electronic sensors, cabling provision for one PSP.

V CENTRAL RECEIVER TOWER

- Level 7
  1. Cup anemometer and wind vane on 8-foot boom in easterly direction
  2. Cup anemometer and wind vane on 8-foot boom in westerly direction
  3. Motor aspirated temperature and dewpoint sensors
  4. Nephelometer and nephelometer electronics (power supply and signal conditioner)
- Total

  Seven permament electronic sensors
- Level 13

  Power supplies, signal conditioners, multiplexer, A/D converter

Table 3. Instruments According to Location (Continued)

VI PLANT CONTROL ROOM

- Roof
  1. Atmospheric gradient sensor (lightning warning)
- Control Room
  1. Lightning warning system electronics

VII MIDDLE OF NORTH-WEST FIELD

1. Hail Cube

VIII MIDDLE OF NORTH-EAST FIELD

1. Hail Cube

IX IN-FIELD IN WEST-NORTH-WEST (WNW) DIRECTION (292.5°)

- 10-Meter Wind Tower 1
  1. Cup anemometer on 2-foot boom at 10-foot height in WNW direction
  2. Cup anemometer on 2-foot boom at 20-foot height in WNW direction
  3. Cup anemometer and wind vane at 32.8-foot (10 meters) height
- Total

  Four electronic sensors

  10-Meter Wind Towers 2, 3, 4, 5, and 6 are the same as 10-Meter Wind Tower 1

X ADJACENT TO WIND TOWER 5

1. Electronics shelter with power supplies, signal conditioners, A/D converter, multiplexers, transmitters

Section 6
MAINTENANCE

Maintenance tasks shall be performed per manufacturer's suggested maintenance requirements and special maintenance requirements to assure the continuous gathering of data for plant operations and evaluation.

A manufacturer's suggested maintenance requirements schedule shall be compiled as instruments are selected from the manufacturers. The nature of the environment under which the instrument will operate shall be made known to the manufacturer for his assessment.

Special maintenance refers mainly to optical sensors (NIP, ACR, PSP, Lambda, Circumsolar Telescope) which tend to be very sensitive to any form of obscuration. Normal maintenance tasks and frequencies are shown in Table 4.

After unfavorable environmental conditions such as rain, snow, ice, frost, dew, hail, dust storms, etc., all sensors shall be checked visually and appropriate maintenance performed to assure the acquisition of accurate data.

After a hail storm, all hail cubes shall be removed and clearly marked as to their locations and sent to the selected agency for analyses. New hail cubes shall replace those removed.

Table 4. Maintenance Requirements of Optical Sensors

Sensor	Task	Frequency
NIP ACR PSP Lambda LI-200S	Glass lenses of the sensors shall be cleaned with a glass cleaning solution and rinsed with distilled water to prevent accumulation of residues. Finally, a soft paper towel shall be used to wipe the lens dry.	• Daily inspection. Perform tasks as necessary. • Inspect after rain, snow, ice, hail, dust storms and other adverse conditions and clean lenses as required.
Circumsolar Telescope	The main telescope lens shall be cleaned with distilled water applied with a squeeze bottle only. It shall be blown dry with a dry N_2 gas. The lens shall not be touched by hand at any time. All other lenses (two PSPs, ACR, filters) associated with the telescope shall be cleaned with a window cleaning fluid and flushed with distilled water squirted from a squeeze bottle. The lens shall then be wiped clean with a soft paper towel. Change desiccant and air filter.	• Daily inspection of lenses • Weekly performance of all maintenance tasks • Inspect lenses after rain, snow, ice, hail, dust storms and other adverse conditions and clean lenses as required.

Section 7
SPARES

Spare parts shall be available per manufacturer's suggestion based on 2 years. As experience is accumulated with the hardware, the spares inventory shall be modified to reflect the reliability and criticality of the instruments. Table 5 shows a preliminary list of the required spares.

Table 5. Spares Summary

	Instrument	No. of spares
1.	NIP	None
2.	ACR	None
3.	PSP	None
4.	Circumsolar Telescope	None
5.	Lambda LI-200S	One
6.	Cup Anemometer	One
7.	Wind Vane	One
8.	Platinum resistance thermometer	None
9.	Dewpoint sensor	None
10.	Tipping bucket rain gage	None
11.	Pressure transducer	None
12.	Nephelometer	None
13.	Lightning Sensor	None
14.	Hail Cubes	Six
15.	Solar Tracker	None
16.	Power Supplies	None
17.	Signal Conditioners	None
18.	Multiplexer, A/D Converter	None
19.	Receiver	None
20.	Aspirator Motor	None

Appendix A

MANUFACTURER-SUPPLIED INFORMATION

THE EPPLEY LABORATORY, INC.
12 Sheffield Ave., Newport, R. I. 02840, U.S.A. Telephone 401 847-1020

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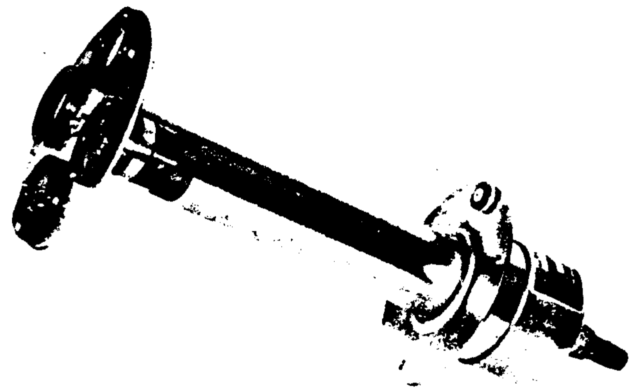


Eppley Normal Incidence Pyrheliometer

FOR EITHER TOTAL OR SPECTRAL MEASUREMENTS OF THE DIRECT SOLAR INTENSITY

Model NIP

The Eppley Normal Incidence Pyrheliometer, as its name implies, was designed for the measurement of solar radiation at normal incidence. In effect, it may be considered a thermoelectric version or variation of the Smithsonian Silver Disk Pyrheliometer, as it incorporates in its design some of the basic features of that instrument.

The sensitive element of the pyrheliometer is a E 6 type wire wound thermopile with a thermistor temperature compensating circuit if required, embedded in heat sink of thermopile. The receiver is coated with 3M Velvet Black.

The thermopile is mounted at the base of a brass tube, the aperture of which bears a ratio to its length of 1 to 10, subtending an angle of 5° 43′ 30″. The inside of this tube is blackened and suitably diaphragmed. The tube is filled with dry air at atmospheric pressure and sealed at the viewing end by a removable insert carrying a crystal quartz window 1 mm. thick. Two flanges, one at each end of the pyrheliometer tube, are provided with a sighting arrangement for aiming the instrument directly at the sun. A manually rotatable disk which can accommodate three filters (such as Schott OG1, RG2 and RG8) and leave one aperture free for total spectrum measurements is provided.

For periodic readings, the Pyrheliometer should be attached to a mount with provision for varying the elevation and the azimuth settings. If a continuous record is required, the pyrheliometer must be mounted on a power driven equatorial mount such as the Eppley Solar Tracker.

Instrument Characteristics

Sensitivity	8 microvolts per watt meter^{-2} approx.
Impedance	200 ohms approx.
Temperature dependence	±1 percent over ambient temperature range −20 to +40°C (temperature compensation of sensitivity can be supplied over other ranges within the limits −70 to +50°C at additional charge).
Linearity	±0.5 percent from 0-2800 watts meter^{-2}
Response time	1 second (1/e signal)
Mechanical vibration	capable of withstanding up to 20 g's
Calibration	reference Eppley primary standard group of pyrheliometers
Size	11″ long
Weight	5 pounds

Standard Model with wheel to accommodate three filters — Model NIP

California Measurements
50 East Montecito Avenue • Sierra Madre, California

THE RADIOMETRICS* MODEL 10 ACTIVE CAVITY RADIOMETER IS AN ACCURATE, AUTOMATIC INSTRUMENT FOR SOLAR RADIATION MEASUREMENTS.

- The Active Cavity Radiometer (ACR) was the first absolute pyrheliometer used in a high altitude experiment to determine the solar constant (Ref. 1, 2).
- The ACR was the reference instrument used by the Jet Propulsion Laboratory of the California Institute of Technology in a series of radiometer comparison tests at its Table Mountain Observatory. A result of these tests was the first discovery of the error in the International Pyrheliometric Scale (IPS) of 1956 (Refs. 3-5).
- The World Meteorological Organization sponsored an experiment at the World Radiation Center (Davos, Switzerland) in 1975 to define a new scale of reference for solar irradiance measurements. Three Radiometrics ACR's were among twelve pyrheliometers used in that experiment, and all three were within 0.1% of the new reference scale based on the average result of all the instruments (Ref. 6).
- The NOAA-NSF Research Applied to National Needs (RANN) Workshop on Accurate Radiometry for Solar Conversion has recommended the use of electrically calibrated active cavity radiometers for solar irradiance measurements (Ref. 7).

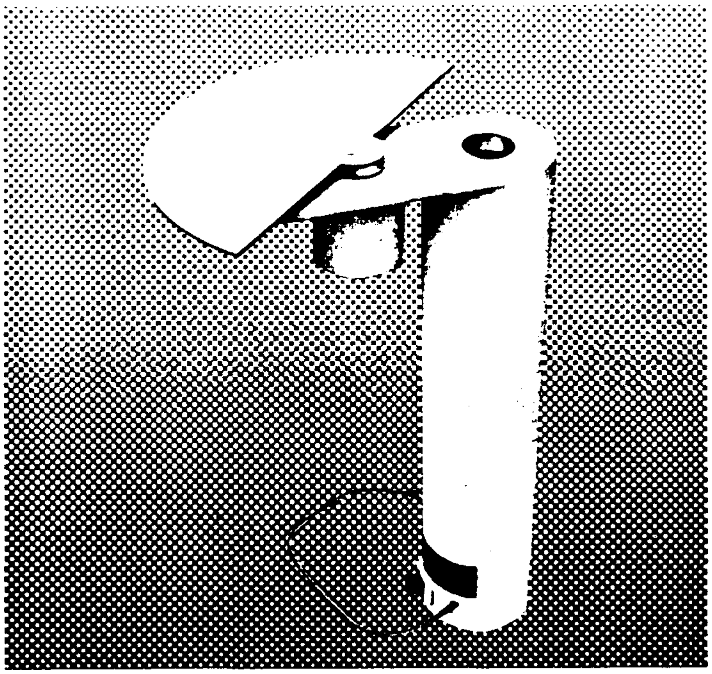
INTRODUCTION

The research and implementation of solar energy utilization requires the accurate measurement of solar irradiance at the earth's surface. The Active Cavity Radiometer is a state-of-the-art instrument specifically designed for this purpose. The ACR is a pyrheliometer capable of defining the absolute radiation scale with less than 0.25% uncertainty. The theory, design, and analysis of the ACR have been extensively discussed in the open literature (Refs. 8-12).

The ACR is the only commercially available self-operating absolute pyrheliometer. While most pyrheliometers are designed for manual operation, the ACR is compact, automatic, and easy to operate in any environment. It is especially suitable for unattended field installations. ACR'S are used in a wide variety of both research and applied measurements of solar irradiance. Radiometrics Model 10 ACR's are used by the Lawrence Livermore Laboratory (Ref. 13) in an experiment to correlate pyrheliometric irradiance measurements. They are also used by the National Oceanic and Atmospheric Administration (NOAA) in the Geophysical Monitoring for Climatic Change program. The Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia uses a Model 10 ACR as a reference standard for meteorological solar irradiance observations.

THEORY OF OPERATION

The essential elements of the ACR are shown in Figure 1. A low-mass silver cavity is the detecting element. The interior surface of the cavity is coated with a material having a high absorptance (α=0.95±0.01) for the solar spectral distribution; the effective cavity absorptance has been analytically shown to be 0.996±0.002, effecting a ten-fold decrease in the uncertainty of the cavity surface absorptance (Ref. 8). The cavity is surrounded by a guard which forms a thermal impedance between the cavity and the heat sink. Platinum wire temperature sensors are placed on both the cavity and the thermal impedance. The sensors are part of a bridge circuit as shown in Figure 2. A fixed-resistance heater is wound around the external apex of the cavity. The amount of current supplied to the heater is controlled by the platinum sensors and the closed-loop servo electronics. The dissipation of a fixed amount of power in the cavity produces a constant temperature drop across the thermal impedance. This drop, transduced by the platinum sensors, is precisely maintained by the electronic servosystem in the base of the radiometer.



The ACR operates in a differential mode. Each measurement is comprised of a reference (shutter closed) and an observation (shutter closed) phase. The radiant source is automatically chopped at low frequency, and the cavity heating power is monitored for each phase. In the reference phase, the power required to maintain the constant temperature drop across the thermal impedance is dc power supplied by the electronics. In the observation phase, the power required to maintain the same temperature drop is a combination of incident solar irradiance absorbed by the cavity and dc electrical power supplied by the electronics. The amount of electrical power automatically supplied to the cavity during the measurement phase is less than that supplied during the reference phase by an amount directly proportional to the radiant flux being measured. A constant of proportionality relates the absorption of radiant flux by the cavity to the dissipation of electrical power. The equation describing the ACR operation is

$$H=K(P_r-P_o)$$

where H=measured irradiance in Watts
K=detector constant=$(\alpha A)^{-1}$
α=effective cavity absorptance
A=effective cavity area
P_r, P_o=reference and observation phase electrical powers.

The output signal of the ACR is the voltage across the cavity heater winding. The measurements of P_r and P_o are simply the measurements of the voltages E_r and E_o during the reference and observation phases.

ADVANTAGES OF THE ACR

- AUTOMATIC ACTIVE MODE OF OPERATION IMPROVES ACCURACY
- SELF-OPERATING FEATURE ELIMINATES OPERATOR BIAS
- HIGH SIGNAL LEVELS FACILITATE REMOTE OPERATION
- SHORT TIME CONSTANT PROVIDES FAST INSTRUMENT RESPONSE
- SELF-OPERATING FEATURE REDUCES ANCILLARY INSTRUMENT COST
- SIMPLICITY OF ACR DESIGN REDUCES MANFACTURING COST

Radiometrics Corporation, Altadena, California

CALIBRATION

Each ACR is calibrated relative to the absolute radiation scale, as defined in the First International Comparison of Absolute Radiometers held in Davos, Switzerland, under the auspices of the World Meteorological Organization's Commission for International Measurements and Observations (1975). This scale is defined by the performance of 12 absolute cavity radiometers intercompared at Davos during 1975, three of which were Radiometrics ACR's. Two of these ACR's are maintained by Radiometrics as in-house standards. The Model 10 ACR's are guaranteed to reproduce the new reference scale to within less than ±0.5% at the 1,000 W/M^2 irradiance level.

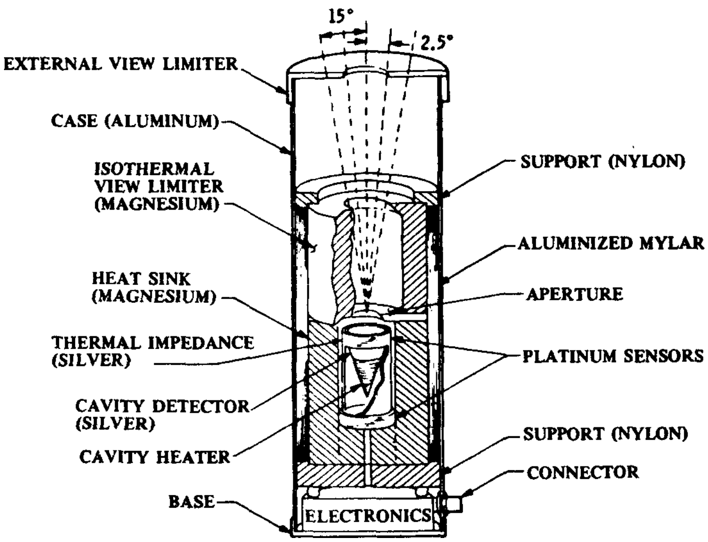


Fig. 1: Physical Features of ACR

SPECIFICATIONS

Detector element:	Conical silver cavity coated with high absorptance (α_s=0.95±0.01) material
Detector area:	1 cm^2
Measurement uncertainty:	Less than ±0.5% relative to the absolute radiation scale defined in S.I. units. (1000 W/M^2 irradiance level)
Irradiance ranges:	0-1500 W/M^2 (Standard) 0-100 W/M^2 (Optional)
Field-of-view:	5° full angle, circular. 1° shading angle. (Other FOV can be supplied)
Sensitivity:	10 W-M^{-2}-VOLT^{-2}
Timer constant:	1.5 seconds maximum
Output signal:	1-15 Vdc, 10 Vdc nominal
Output impedance:	1000 ohms
Chopper (shutter) frequency:	Shutter automatically opened and closed for one minute each; 1/2 RPM dc motor drive; manual override available as option
Power requirements:	30 Vdc @ 75 ma, 0.25% reg.
Readout instrumentation:	Digital voltmeter, 3½ digit, 0-19.99 Vdc full scale. Input impedance 1 megohm or larger.
Size and shape:	35 cm X 5 cm, tubular
Weight:	Approximately 1 kg
Mounting:	By 1/4-20 threaded hole at bottom end of tubular housing
Pressure and temperature range:	Hard vacuum to one atmosphere; 0 to +50 °C

Control Unit: dvm and power supply = $1,000

OPTIONAL EQUIPMENT AVAILABLE

- All-weather enclosure with removable quartz window
- Motorized equatorial solar tracker and optical drive corrector
- Control unit with 30 Vdc power supply, 3½ digit (0-19.99 Vdc) panel meter and remote-control range switch
- Field portable power supplies for ACR and solar tracker

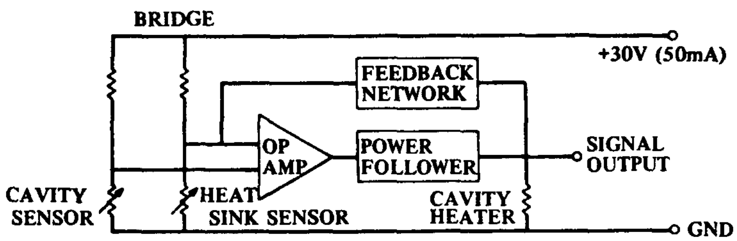


Fig. 2: ACR Schematic

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CALIFORNIA MEASUREMENTS

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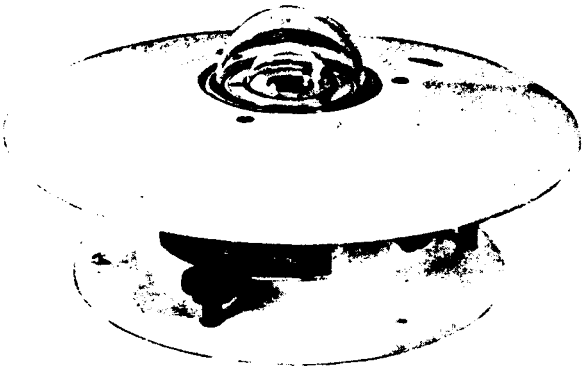


Eppley Precision Spectral Pyranometer

FOR THE MEASUREMENT OF SUN AND SKY RADIATION TOTALLY OR IN DEFINED WAVELENGTH BANDS

Model PSP

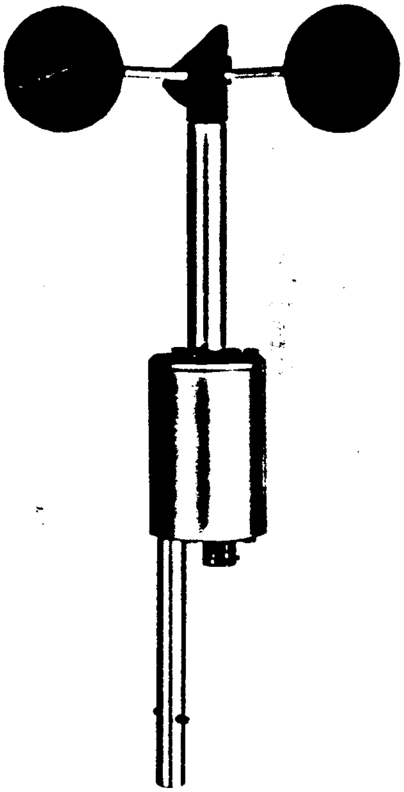
This pyranometer is an improved smaller model of the earlier instrument introduced in 1957. It comprises a circular multi-junction Eppley thermopile of the wire-wound type. The thermopile has the added advantage of withstanding severe mechanical vibration and shock. Its receiver is coated with Parsons' black lacquer (nonwave-length—selective absorption). This instrument is supplied with a pair of removable precision ground and polished hemispheres of Schott optical glass (the inner of clear WG7 glass, the outer of of WG7 glass). Yellow GG14, orange OG1, red RG2, dark red RG8 or other Schott optical glasses may be substituted. Also supplied is a spirit level and a desiccator which can readily be inspected. The instrument has a cast bronze body with a white enameled guard disc and comes with a transit or storage case.

The WG7 clear glass is transparent from a wave-length of about 285 to 2800 mu. The centers of lower sharp cut-off of the hemispherical filters are as follows: GG14, approximately, 500 mu: OG1, 530 mu: RG2, 630 mu: and RG8, 700 mu. For solar ultraviolet measurements, hemispheres of quartz are available.

Instrument Characteristics

Sensitivity	9 microvolts per watt meter^{-2} approx.
Impedance	650 ohms approx.
Receiver	circular 1 cm^{-2}, coated with Parsons' black optical lacquer
Temperature dependence	$\pm$1 per cent over ambient temperature range -20 to $+40$°C (temperature compensation of sensitivity can be supplied over other ranges at additional charge)
Linearity	$\pm$0.5 per cent from 0 to 2800 watts m^{-2}
Response time	1 second (i/e signal)
Cosine	$\pm$1 per cent from normalization 0 - 70° zenith angle $\pm$3 per cent 70 - 80° zenith angle
Orientation	no effect on instrument performance
Mechanical vibration	tested up to 20g's without damage
Calibration	integrating hemisphere (approx 1 cal cm^{-2} min^{-1}, ambient temperature $+25$°C):
Size	5¾" diameter, 3¾" high
Weight	7 pounds

Standard Model (as described above) Model PSP



MODEL 011-3

DESCRIPTION:

Climet Model 011-3 is a highly sensitive wind speed transmitter for use in projects which require precise measurement of wind velocities. It uses an LED light source, photo-transistor and chopper circuit to produce a pulse rate proportional to wind speed. The pulses are sent to the translator whose output is suitable for both digital and analog recording. Lightweight, but of extremely rugged design, the 011-3 can operate in the temperature range of -50°F to 155°F (-45°C to 68°C), making it ideal for arctic through tropical zone applications.

DESIGN FEATURES:

An anodized aluminum housing protects the photo-transistor-LED light source and solid state amplifier assembly. Shielded precision bearings, two "O" ring seals, and humiseal treatment guard against moisture and particulate contamination. A weatherproof connector offers additional safeguard from harsh environments and insures the integrity of the output signal.

The Lexan cups are of a beaded design which significantly reduces the effects of wind turbulence. Special lubrication is used in the shielded bearings to insure a low threshold in extreme environments where conventional lubricants congeal and fail. Bearing replacement, when required, is easily accomplished in the field without special tools.

The high strength/weight ratio of Lexan allows an unusually low distance constant* of 5 feet (1.5m).

*The distance constant is a measure of the lag characteristics of an anemometer defined by Shubauer and Adams as ". . . the distance travelled by the air after a sharp-edged gust or partial lull has occurred for the anemometer rate to reach (1_1/e) or 63% of the new equilibrium." Ref. Shubauer and Adams, "Lag of Anemometers," N.B.S. Report 3245, 4/16/54.

OPERATION:

The 3-cup anemometer coupled to a stainless steel drive shaft responds to the wind and rotates the 50-slot light beam chopper. Rotation of the chopper alternately masks and exposes the photo-transistor to the miniature LED light source. As the photo-transistor responds to the light passing through the chopper wheel, electrical pulses are generated, amplified, then doubled in rate to provide a resultant 10 volt peak square-wave output proportional to wind velocity.

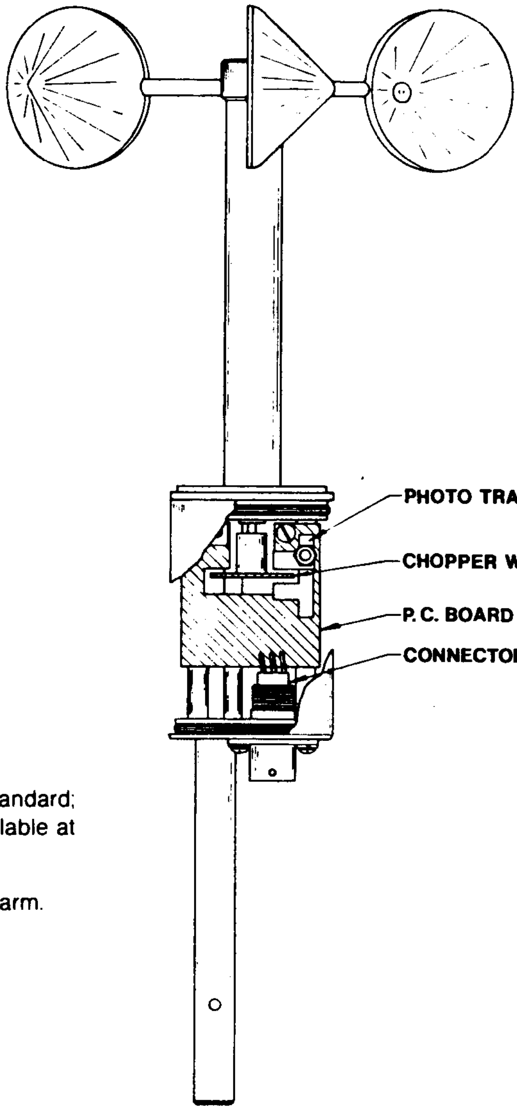
SPECIFICATIONS:

Performance

Range:	0-110 mph .... (49 meters/sec)
Threshold:	0.6 mph ....(0.27 meters/sec)
Calibrated Range:	Threshold-90 mph. (0.27-40 meters/sec)
Accuracy:	±1% or 0.15 mph. (0.07 meters/sec) whichever is greater
Temperature Range:	-50°F to 155°F .... (-45°C to 68°C)
Distance Constant:	5 feet........................... (1.5m)

Electrical

Power Requirements:	12 VDC @ 15mA
Output Signal:	1.5 PPS to 3100 PPS
Output Impedance:	Max of 50 Ohms
Output Load:	Min of 600 Ohms
Use with:	Climet 060 series translators and wind speed PCB (05-8003)



Physical

Weight:	12 ounces .... (340 grams)
Height (overall):	13-3/4 inches .... (35 cm)
Housing Dimension:	3-1/2 in. H x 2 in. D......... (9 cm x 5 cm)
Cup Diameter:	7-1/4 in....................... (18 cm)
Finish:	Clear anodize
Cable:	4-conductor #18 wire, 25 feet (7.6m) long standard; other lengths up to 1500 feet (456 m) available at additional costs.
Mounting Fixture:	Climet Model 091-1, instrument mounting arm.

Traceability

Anemometer cup assemblies supplied with the 011-3 are certified with a National Bureau of Standards secondary reference and are accurate to within 1 percent (0.15 mph or 0.07 mps) from threshold to 90 mph.

ORDERING INFORMATION:

The 011-3 transmitter INCLUDES the following:

1. 014-133 Cup Assembly
2. A-8195-2 Signal Cable, 25 feet (7.6 m) standard; other lengths up to 1500 feet (456 m) available at additional cost.

OPTIONS:

014-133-1 Teflon Cup Assembly
014-133-2 Stainless Steel Cup Assembly

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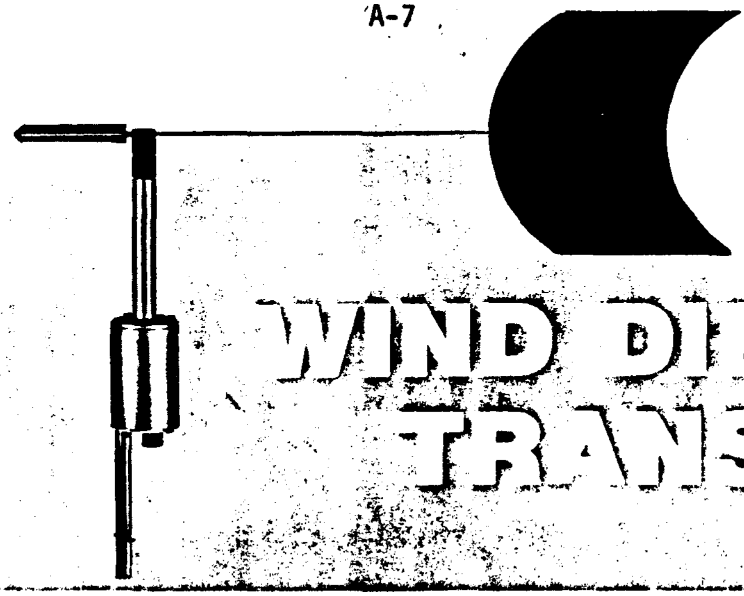


MODEL 012-15 WIND DIRECTION TRANSMITTER

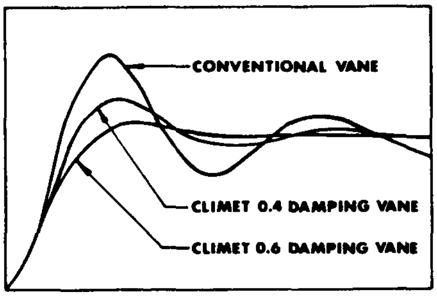
DESCRIPTION:

Climet Model 012-15 Wind Direction Transmitter is a low-threshold instrument which provides precise measurements of wind azimuth and the frequency and amplitude of azimuth variations. This research-grade transmitter uses an extremely sensitive wind vane which permits immediate response and negligible overshoot, thus reliable dynamic responses to low-order variations in wind direction are obtainable. The output from the transmitter is a very stable analog voltage which is proportional to the horizontal wind direction. Lightweight, but of extremely rugged design, the 012-15 can operate in temperature extremes of -50°F to 155°F (-45°C to 68°C), making it ideal for arctic through tropical zone applications.

DESIGN FEATURES:

An anodized aluminum housing protects the teflon sealed bearings and micro-torque potentiometer. Two "O" ring seals offer additional safeguard against moisture and particulate contamination. Use of a weatherproof connector further guarantees the integrity of the output signal.

The 0.4 damping ratio* vane airfoil is an integrally molded skin of polyurethane. The 0.6 damping ratio vane airfoil is constructed of expanded bead polystyrene. Special lubrication is used in the sealed bearings to insure a low threshold in extreme environments where conventional lubricants congeal and fail. Bearing replacement, when required, is easily accomplished in the field without special tools.



*The damping ratio is the percent of critical damping, which is defined as the logarithm to the base "e" of the successive amplitudes of the decay curve described by the vane in obtaining a final direction when an abrupt change in wind direction is applied to it. The damping ratio is defined by the following equation:

$$2\pi h/(1-h^2)^{1/2}=\log_e x_1/x_2$$

where h is the damping ratio and X_1 and X_2 are successive amplitudes

OPERATION:

The 012-15 transmitter is comprised of a symmetrical airfoil vane, integral stainless steel drive shaft, a precision micro-torque potentiometer, and the housing with related fittings. The wind vane is directly coupled to the potentiometer by the drive shaft and causes the potentiometer wiper to directly follow movements of the wind vane. A zenered DC power supply from the translator printed circuit board (PCB) is applied across the potentiometer. The subsequent sensor output voltage (wiper voltage) is a fixed ratio of volts per degree. This fixed ratio allows transmitters to be interchanged without recalibration requirements.

AMBIGUOUS POINT LOGIC (APL) FEATURE:

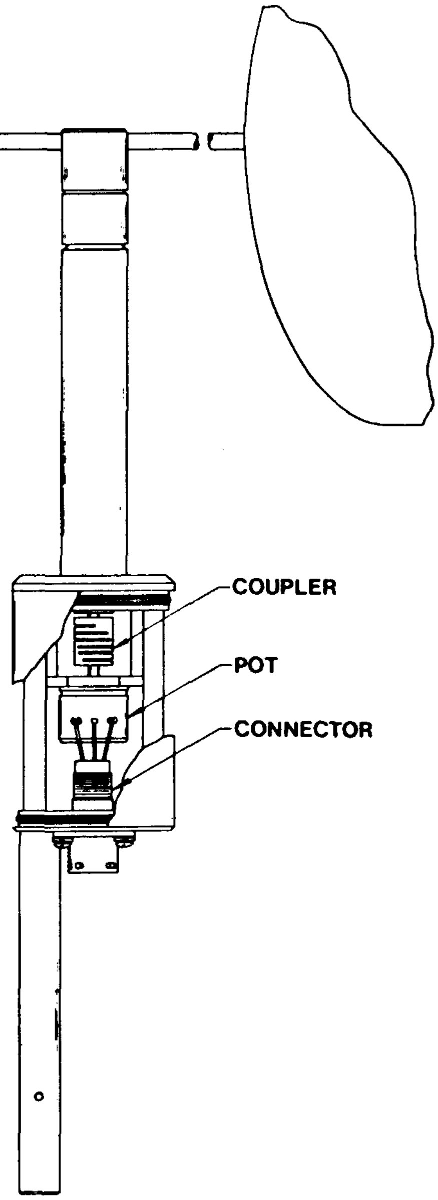
This feature modifies the sensor output voltage to provide a continuous variable output voltage proportional to wind direction over a full 540° range. APL eliminates discontinuities over the full azimuth range to minimize abrupt excursions on strip chart recording equipment. APL is also extremely desirable when there is a requirement for mathematical operations such as signal averaging and standard deviation computations.

The electronics for the APL are mounted on the PCB located in the translator. Accordingly, the option for measuring over a 0-360° or 0-540° range is determined by selecting the desired range and the applicable PCB.

SPECIFICATIONS:

Performance Characteristics

Range:	Mechanical, 360° continuous; electrical 0-355°
Threshold:	0.75 mph .... (.34 meters/sec)
Accuracy:	±3°
Linearity:	±½% of full scale
Response:	Delay distance less than 1 meter
Temperature Range:	-50°F to 155°F .... (45°C to 68°C)
Damping Ratio:	.4 standard (.6 optional)



Electrical Characteristics

Sensor Signal Output

Power Requirements:	Provided by translator PCB
Output Signal:	0-6.8V corresponding to 0-360°
Output Impedance:	10,000 ohms
Use with:	Climet 060 Series Translators and Wind Direction PCB (05-8002 for 360°) (05-8167 for 540°)

Physical Characteristics

Weight:	12 ounces .... (340 grams)
Height (overall):	16-1/2 inches .... (42 cm)
Housing Dimension:	3-1/2 in. (H) x 2 in. (D) ...... (9 cm x 5 cm)
Finish:	Clear Anodize
Mounting Fixture:	Climet Model 091-1, Instrument Mounting Arm
Cable:	4-conductor #18 wire, 25 feet long, terminated in pigtail connections. Extra cable up to 1,500 feet (456m) long can be provided at additional cost.

ORDERING INFORMATION:

The 012-15 Transmitter INCLUDES the following:

1. 014-134 Vane Assembly (.4 damping ratio, standard)
2. A-8196-2 Signal Cable, 25 feet (7.6m) standard; other lengths up to 1500 feet (456m) available at additional cost.

Options

1. 014-136 Vane Assembly (.6 damping ratio)

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MODEL 015-12

DEWPOINT SENSOR

CLIMET INSTRUMENTS

Climet's dewpoint sensor consists of bifilar wire electrodes wound on a cloth sleeve which covers a hollow tube or bobbin. ("Bifilar" describes a winding which has two separate conductors wound side by side). The bifilar electrodes are not interconnected but depend on conductivity of the atmospherically moistened lithium chloride for current flow. As the moisture content in the air increases, the lithium chloride absorbs water vapor and becomes conductive. Current then begins to flow between the electrodes and heats the bobbin. Some of the moisture is thereby evaporated until an equilibrium temperature is reached on the bobbin. The equilibrium temperature is thus related to the dewpoint temperature of the air. A thermometer bulb (thermistor sensor or platinum resistance) is mounted inside the bobbin to measure the cavity temperature, which is converted to actual dewpoint temperature by a Climet electronic temperature translator.

Climet's Model 015-12 Lithium Chloride Dewpoint Sensor provides precision measurement of dewpoint temperature. The Model 015-12 is designed to be used in conjunction with Climet's Model 016-2 Aspirated Radiation Shield and standard temperature translators.

SPECIFICATIONS

Range: -40° C to $+50^{\circ}$ C
Mounting: Mounts in Climet 016-2 Shield
Power Requirements: 25 volts ac (115 volts ac when used with Climet power supply)
Sensing Element: Thermistor sensor standard (platinum resistance sensor optional) *

* When ordering, please specify either thermistor sensor or platinum resistance to be supplied for the dewpoint temperature measurement.

Climet Instruments Company
A DIVISION OF WEHR CORPORATION
1620 West Colton Avenue Redlands, CA 92373
Phone AC 714/793-2788

0501-3 and 0501-4 Tipping Bucket Rain Gauge

GENERAL

The 0501-3/4 tipping bucket rain gauge is designed to operate with a variety of recording systems. A measured 7.95 cc of water causes the bucket to over balance and swing to the opposite side. A magnet mounted under the bucket passes close to a magnetic switch during the tipping action causing a momentary closure of the switch. This pulse may be used to trigger a step marking stylus motor or actuate a digital counter, or other similar devices.

Each bucket tip of 7.95 cc of water, funneled from the 7.86 inch diameter collector tube, is equal to 1/100 of an inch of rainfall.

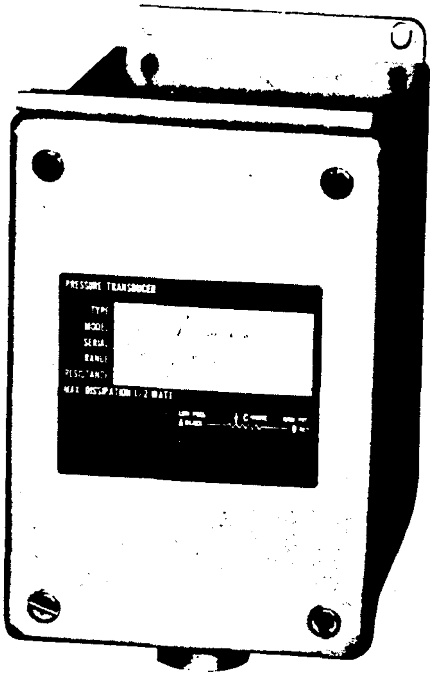
The 0501-3 is the basic rain gauge. The 0501-4 has a heater installed for use in climates expecting snow or ice.

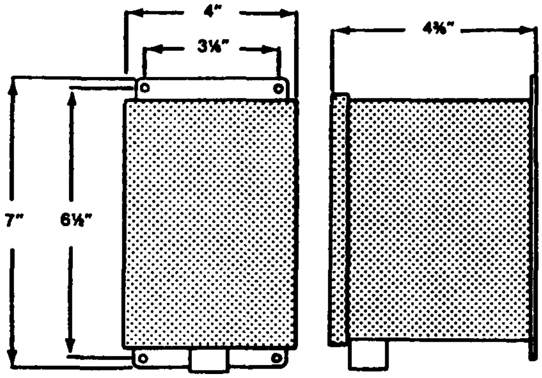
SPECIFICATIONS

Low Inertia Tipping Bucket Raingauge

7.86 inch I. D. Collector Tube
One tip = 7.95 cc of water
One tip = 1/100 of an inch of rain
Accuracy at 0.5" per hour rate is within ±0.125%
Accuracy at 2" per hour rate is within ±0.25%
Accuracy at 3" per hour rate is within ±0.7%
Accuracy at 10" per hour rate is within ±5%
Magnetic Switch rated 12 VA at 500 V. max. D.C. - resistive load
Collector Tube is 24" high and 8" in diameter

MODEL 0502





The sensing element of the 0502 Pressure Transducer is comprised of five stacked diaphragms of NiSpan-C® alloy and is housed in a weatherproof enclosure. Changes in pressure cause expansion and contraction of the diaphragms which are mechanically linked through Invar® fittings to a precision potentiometer. The potentiometer produces a variable resistance output which is converted to an electrical analog signal for direct reading of the atmospheric pressure. Climet printed circuit board (PCB) Model 05-8002-8 and any Climet 060 Series translator are required to obtain two standard analog signals of a 0-1 milliamp *and* 0-1 volt. Other signals up to a maximum of 0-20 milliamps and 0-10 volts are available upon request.

A careful choice of construction materials minimizes errors due to temperature changes and thus allows the rugged 0502 to operate in the range -30°F (-35°C) to 180°F (83°C).

0502-1	27.0" to 31.5"	686 mm to 801 mm	Sea Level
0502-2	28.0" to 32.0"	712 mm to 813 mm	Sea Level
0502-3	24.6" to 31.5"	625 mm to 801 mm	Sea Level - 3,200'
0502-4	21.8" to 28.5"	554 mm to 724 mm	2,800' - 6,200'
0502-5	19.2" to 25.7"	488 mm to 653 mm	5,800' - 9,200'
0502-6	16.9" to 23.0"	430 mm to 585 mm	8,800' - 12,200'

Resolution 0.15% Repeatability ±0.2% Linearity ±0.3% Temperature Coefficient .0025%/F°

The 0502 Transducer must be used with printed circuit board 05-8002 in conjunction with any of Climet's 060 Series translators.

All 0502 Transducers include 25 feet (7.6m) of 3-wire 18 AWG Signal Cable. Other lengths up to 150 feet (46m) maximum are available at extra cost.

FOR FURTHER INFORMATION REGARDING THIS AND OTHER FINE CLIMET PRODUCTS CONTACT:

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Integrating Nephelometer

meteorology research, inc.
Box 637
Altadena, California 91001
(213) 791-1901: TWX-910-588-3291
A Subsidiary of Cohu, Inc.

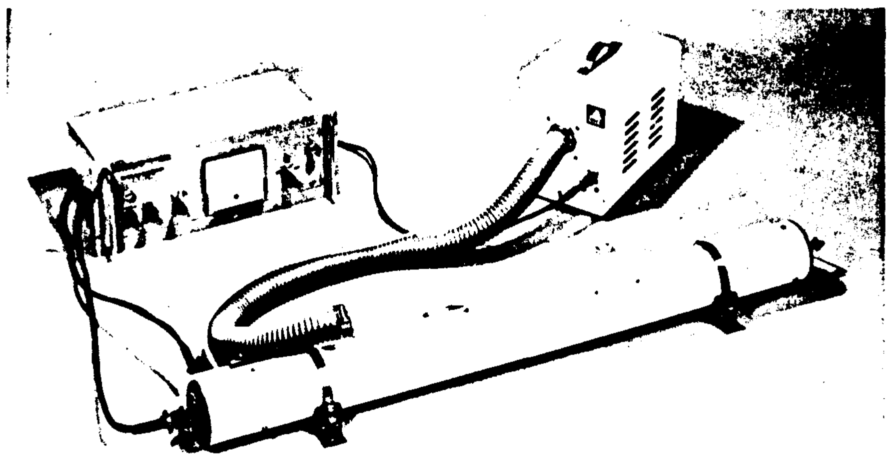
The Integrating Nephelometer is one of a series of specially designed instruments manufactured by MRI to accommodate the pressing and growing need for air pollution detection and measurement. It is a compact, reliable, and easy-to-operate electro-optical device which can, unattended, continuously monitor air and provide a readout of atmospheric particle contamination.

The pollution effects on visibility are not always discernable to the naked eye—especially at night or in the presence of fog, rain, or snow—but the Nephelometer is constructed to detect and measure air samples it draws from the immediate atmosphere and compare the effects of the suspended particles or other foreign substances with clean, unpolluted air.

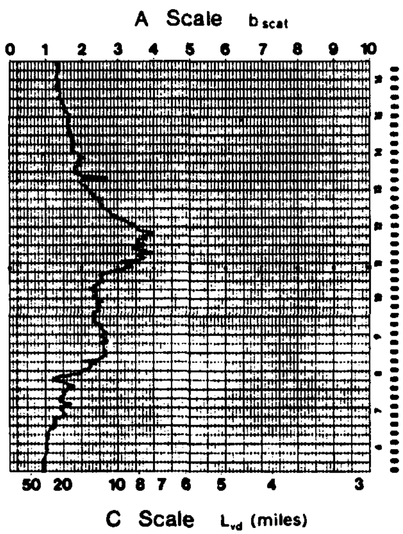
Principles of Operation

An air sample is continuously drawn through a chamber where it is illuminated by a pulsed flash lamp. The scattered light is detected by a photomultiplier tube looking at the illuminated air sample. The signal produced by the photomultiplier is averaged and compared with a reference voltage from another phototube looking at the flash lamp. Three linear sensitivity ranges are selectable and a built-in calibrator is provided. Scattering from clean, filtered air and from Freon-12 is used as a calibration reference.

The Integrating Nephelometer can become your electronic "eyes," providing a continuous source of data previously too difficult and expensive to obtain. Measuring in the same wavelength as the human eye, Local Visual Distance is indicated in miles, from as little as 0.3 miles to infinity.



Integrating Nephelometer, Model 1550—The ***Nephelometer****, shown above, consists of an optical assembly, sampling and purge* ***air*** *pumps, the signal conditioning electronics, and interconnecting* ***cables and tubing****. Built for rugged continuous use, the optics do not contain any lenses or mirrors and the electronic circuitry is all solid-state.*



Applications

Research and Manufacturing

- Aerosol Research
- Automotive emissions
- Visibility measurement for flight operations, photography, outdoor testing, and transportation.
- Control of health and safety standards

Air Quality Monitoring

- Identification of day-by-day variations of air quality
- Correlation with meteorological, economical, and sociological factors
- Evaluation of effectiveness of regulatory measures
- Definition of severe problem areas with a network of stations or with mobile installations
- Modeling of pollution basins
- Prediction of pollution episodes, using past trends
- Aerial surveys of pollution

The Instrument

Theory

One of the most common and most apparent effects of air pollution is a reduction of visibility. The small polluting particles suspended in the air scatter light out of the line of vision, making distant objects appear less distinct to the eye. Sufficiently far away, there is a distance at which the difference in contrast between the background and the object being observed is too small to perceive. This distance defines the visibility.

The suspended particles scatter a ray of light in all directions—bouncing it back in the direction from which it came, glancing it at some angle sideways, or sending it on in the same direction. The amount of light scattered in any particular direction depends on the size and composition of the particle. Consequently, to measure the amount of light lost by scattering, it is necessary to measure the scattering at all angles.[1]

The MRI Integrating Nephelometer draws a sample of particle-laden air into it and measures the scattering from the particles in this sample. As a consequence of an ingenious geometrical configuration, the instrument directly measures the total of all the scattering over all scattering angles, hence the name *Integrating* Nephelometer. The measurement is displayed to the user as the scattering coefficient, b, defined as the reciprocal of the distance in which 63% of the light is lost from a light beam.

Experimental and theoretical studies by many observers have related b to the visibility which would occur if the atmosphere were everywhere uniform with the same properties as the sample being measured. The visibility is referred to by MRI as "local visual distance"; L_{vd}. Its relationship to the light scattering coefficient is given (for the particular light source used in the Integrating Nephelometer) by the relation $L_{vd} = 4.7/b$. The dial of the instrument also displays L_{vd} directly, in addition to b.

Recent research, in which the atmosphere was sampled in various locations throughout the United States, has shown that the distribution of particle sizes is fairly similar in all locations. Consequently, the amount of light scattering is proportional to the mass concentration, M, of suspended particulates when the air is sufficiently dry (relative humidity less than 70%). The relation is:

$$M\ (\mu g/m^3) = K \times b\ (m^{-1})$$

Where, for 90% of the observed cases, K has a "best value" of 3.8×10^5. This is of sufficient accuracy for many routine air pollution monitoring situations and a calibration can be made at the sampling location if greater accuracy is necessary.

Can Separate Smog from Fog!

There is a unique advantage of the Integrating Nephelometer approach over the human observer. Present air pollution visibility standards are not usable above a relative humidity greater than 70 percent because moisture has condensed on the airborne particles thus increasing the scattering. Under these conditions, a meaningful measurement of the contribution of atmospheric pollution to the degradation of visibility cannot be made. Any method for monitoring an aspect of air quality is not fully useful if it can't be applied at all times.

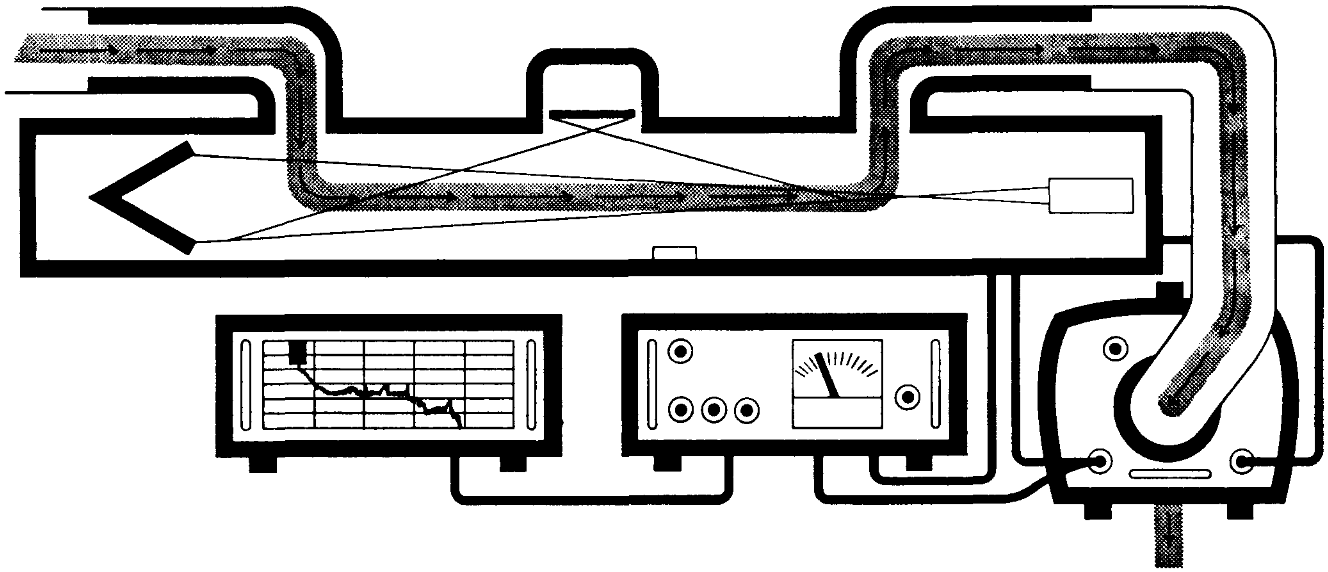
Thus, for cases of high humidity, the Integrating Nephelometer can be equipped with an intake heater (a standard accessory) which assures that the relative humidity of the observed atmospheric sample is always less than 70 percent. The heating eliminates the effect of moisture on the visibility and thereby gives the visibility degradation from the particles alone. Consequently, level of visibility reducing particles can be monitored 100% of the time.

Surpasses Other Instruments

Mass concentrations of particles are now measured by filter samplers and the reduction of data is an after-the-fact, time consuming, and expensive process. The Integrating Nephelometer provides the user with a real time, continuous measurement of particulates. Data from networks, or remote locations, may be telemetered conveniently.

Are Minimum Visibility Standards Here?

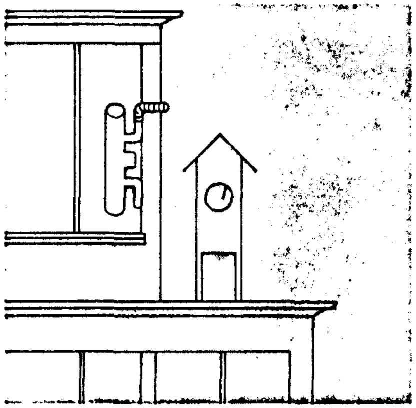
Close—perhaps closer than you think. It can be an effective way to target steps for cleaning up the atmosphere. Some states have already taken positive action. The result will be an additional requirement for local agencies and a greater responsibility for industry.



[1]*Charlson, R. J., N. C. Ahlquist, H. Selvidge, and P. B. MacCready, Jr., 1969: Monitoring of atmospheric aerosol parameters with the integrating nephelometer. J. Air Poll. Control Assoc., 19, 12, 937-942.*

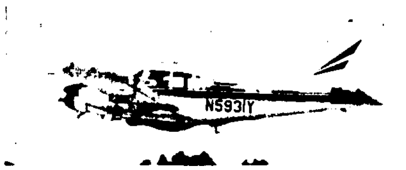
Applications

Air Pollution Control
Local, state, and federal agencies have used the Integrating Nephelometer with greater success to constantly monitor air pollution at both its source and at discretionary points in order to determine such factors as persistence, intensity, dissipation, and flow characteristics. This is possible because the instrument can be operated both as a stationary detection device or in a mobile capacity in an automobile or aircraft.

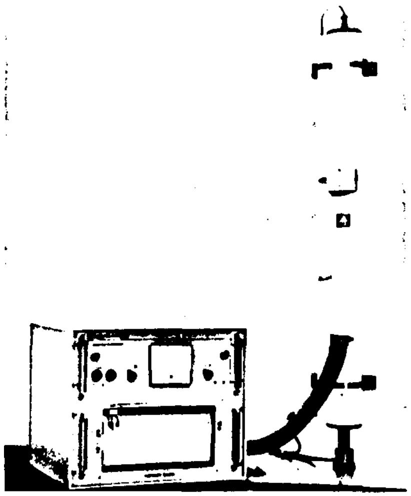


Integrating Nephelometer, Model 2050, shown at right, incorporates many of the components into a single case. This is most useful for stationary or mobile auto installations where the unit is independently operated.

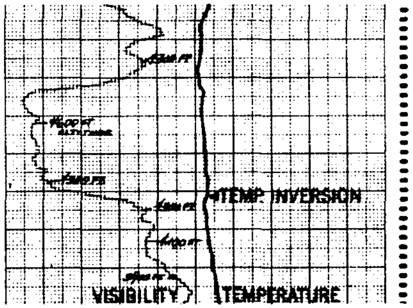
Expand your *Emission Inventory* to include both the source and downwind characteristics of the emission with the part-time availability of almost any aircraft. *Source identification* can be *achieved by flying simple aircraft* patterns. *Mapping and plume tracing* measurement of the particulate variations in the horizontal and vertical is easily accomplished.



For installation in any unpressurized aircraft with a 12 VDC or 24 VDC system, the MRI Inverter, Model 463, allows the operator to put his Integrating Nephelometer into airborne service in minutes.
Once the basic power supply is installed, the nephelometer can be placed in any convenient location. Sample air can be made available to the unit from air vents, windows, or doors.



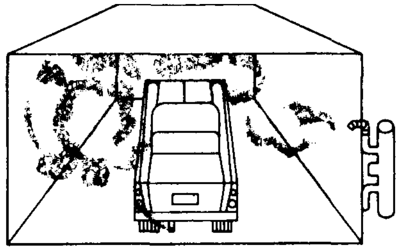
Vertical sounding of smog in the Los Angeles County basin showing particle concentration vs. temperature and height.



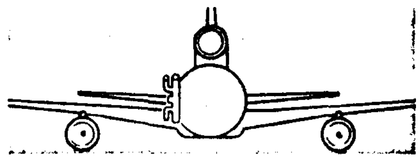
You can visually read the meter or record the data and annotate the chart. It is also possible to incorporate the Integrating Nephelometer into an airborne system and measure parameters such as temperature, turbulence, and altitude.
High sensitivity and instantaneous response over a selectable range of sampling rates and averaging times makes the nephelometer equally well suited for use in fixed locations and at aircraft operating speeds.

Ranges	b_{scat}	L_{vd} (miles)
A	0 - 10	∞ to 3 miles
B	0 - 40	∞ to 0.7 miles
A x 10	0 - 100	∞ to 0.3 miles

Automotive
Engine emission is an extremely important factor in today's quest for cleaner air. Therefore, manufacturers, as well as users of many fuels and engines, utilize the nephelometer to detect and measure pollution potential for existing as well as experimental engines and energy sources.
Many smog chambers are in use for conducting these types of tests. The continuous and instantaneous *monitoring of particulates* with the nephelometer has proven to be an invaluable aid.



Aerospace
Often, in support of various tests in the atmosphere, it is necessary to measure the scattering coefficient or visibility. In either a ground installation, or in an Air Force or Navy aircraft, the nephelometer performs equally well, providing data from the surface to altitudes in excess of 50,000 feet.
Other applications include the measurement of particulates as they are emitted from an aircraft jet engine. With no modifications, the nephelometer has been operated using the engine exhaust as a sample source.

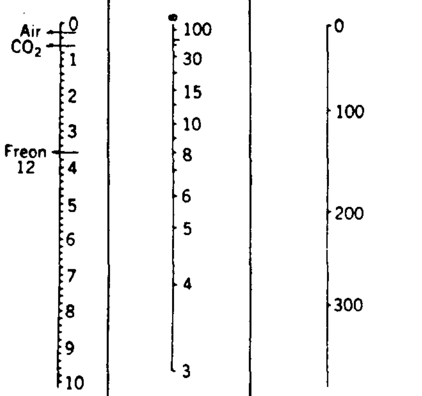


Specifications

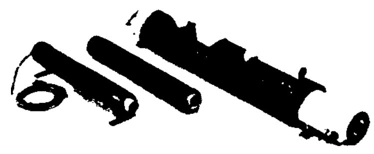
Model, Flexibility & Accessories

In order to satisfy the various applications of this instrument, selector switches are provided for both the flash rate and the time constant. Flash rates are ¼, 1, 4, and 8 per second and time constants of 0.1 second, 2, 5, 10, 20, 50, 100, and 200 seconds. For mobile use, a flash rate of 8 per second and a time constant of 0.1 second are commonly employed. At fixed locations, a rate of ¼ per second and a longer time constant, 100 or 200 seconds, lengthen the flash lamp life and conveniently smooth the data.

The scales below show the relationship of b, scattering coefficient; L_{vd}, local visual distance, and M, mass concentration in micrograms/meter³.

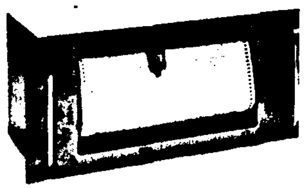


Air Sample Heater, Model 461



This intake heater may be used at relative humidities above 70% to separate pollution from natural atmospheric moisture. With the heater on, the nephelometer samples atmospheric pollution only —100% of the time.

Servo Recorder, Model 450



Power 115 VAC, 0-1 VDC input, 10-inch width of usable chart, 100-foot chart length, nonspill cartridge ink supply. Two speeds: 1-inch per minute for high resolution and 1-inch per hour for 50 days of continuous monitoring.

Sensitivity and Range
Scattering Coefficient — 0.1 to 100 x $10^{-4}m^{-1}$.
Local Visual Distance — to 0.3 miles (470 meters).
Mass Concentration — 0 to 3800 $\mu g/m^3$.
Three ranges, selectable to match the prevailing degree of pollution

Overall Accuracy — ±10% of Scale.

Power Input — 105 to 125 VAC, 60 Hz, 1 ampere, 70 watts maximum.

Signal Output — Meter: 0 to +5 VDC external terminals.

Temperature Compensated — —17.8° to 54.5°C (0° to 130°F.)

Maintenance — Calibrate once every 3 months. Flash lamp change after several million flashes (3 months routine operation).

Optical Assembly — Tubular, 10.2 cm dia. x 111.8 cm (4 in. dia. x 44 in.) Weight: 7.7 kg (17 lbs).

Electronics and Power Supply
Standard 48.3 cm (19 in.) rack, 17.8 cm (7 in.) high x 29 cm (11 in.) deep. Weight: 10.9 kg (24 lbs).

Air Sampling Pumps — Flow rate, 141.5 lpm (5 cfm). Weight: 4.5 kg (11 lbs).

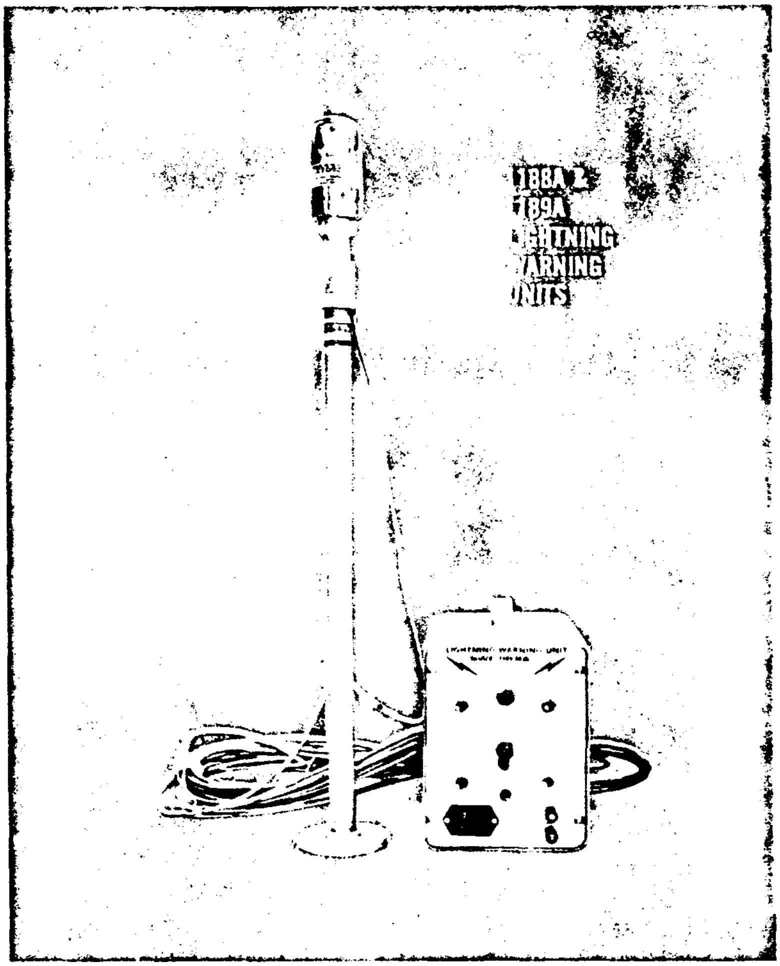
Servo Recorder
48.3 cm (19 in.) panel, 22 cm (8.75 in.) high x 29 cm (11 in.) deep. Max. 45 watts. Weight: 7.7 kg (17 lbs).

Intake Heater — A 6.4 cm (2.5 in.) dia. x 61 cm (24 in.) long heating chamber uses a 115 VAC, 105 watts self-protected element. Wrap-around insulation provided to cover the optical assembly. Weight: 2.7 kg (6 lbs).

Due to recent air freight regulations, it is no longer practical to ship freon. Therefore, the fittings which are provided with the nephelometer can be used with standard freon cans available at any local auto parts store.

1.5 W 6/78 LITHO IN U.S.A.

SWEENEY
B K SWEENEY MANUFACTURING CO



1188A & 1189A LIGHTNING WARNING UNITS

The Model 1188A is battery-powered for field usage, and the Model 1189A uses 110 volt AC line power, otherwise the units operate in the identical manner. The instruments measure atmospheric gradient and indicates, by an alarm signal, when the gradient reaches a preselected limit value. The monitored range, or protected area, is one mile radius about the probe location, although approaching storm clouds may be detected as far off as ten miles, at minimum limit value setting.

Specifications: 1188A and 1189A Lightning Warning Units.
Atmospheric Gradient Range: 0 to ±5 kilovolts/meter.
Gradient Read-Out: Internal alarm terminal block with normally closed contacts for external recorder (recorder not included).
Maximum Gradient Limit: Alarm settings of 1, 2, 3, 4, or 5 kilovolts/meter. Gradient above setting triggers alarm.
Alarm Devices: Red panel light, internal panel buzzer with on-off switch, terminal block with normally open contacts for operation of external alarm.
Operation Check: Panel "TEST" switch to verify alarm for positive and negative gradient signal.
Probe: 200 millicuries Tritium (H_3) radioactive foil, NRC approved harmless to personnel. Sweeney electrostatic amplifier.
Signal Cable: 50 Ft. supplied. Lengths to 1,000 Ft. available on special request.
Power Requirements:
Model 1189A – 115 VAC, 35 watts.
Model 1188A – One 90 V battery, Eveready #490 or equivalent. One 45 V battery, Eveready #762S or equivalent. Two 1½ V batteries, D cells. *(All batteries included).*
Dimensions: Instrument control panel 8" H x 6" W x 8" D. Probe 28" H x 3½" dia. base.
Shipping Weight:
Model 1189A – 10 pounds.
Model 1188A – 15 pounds.

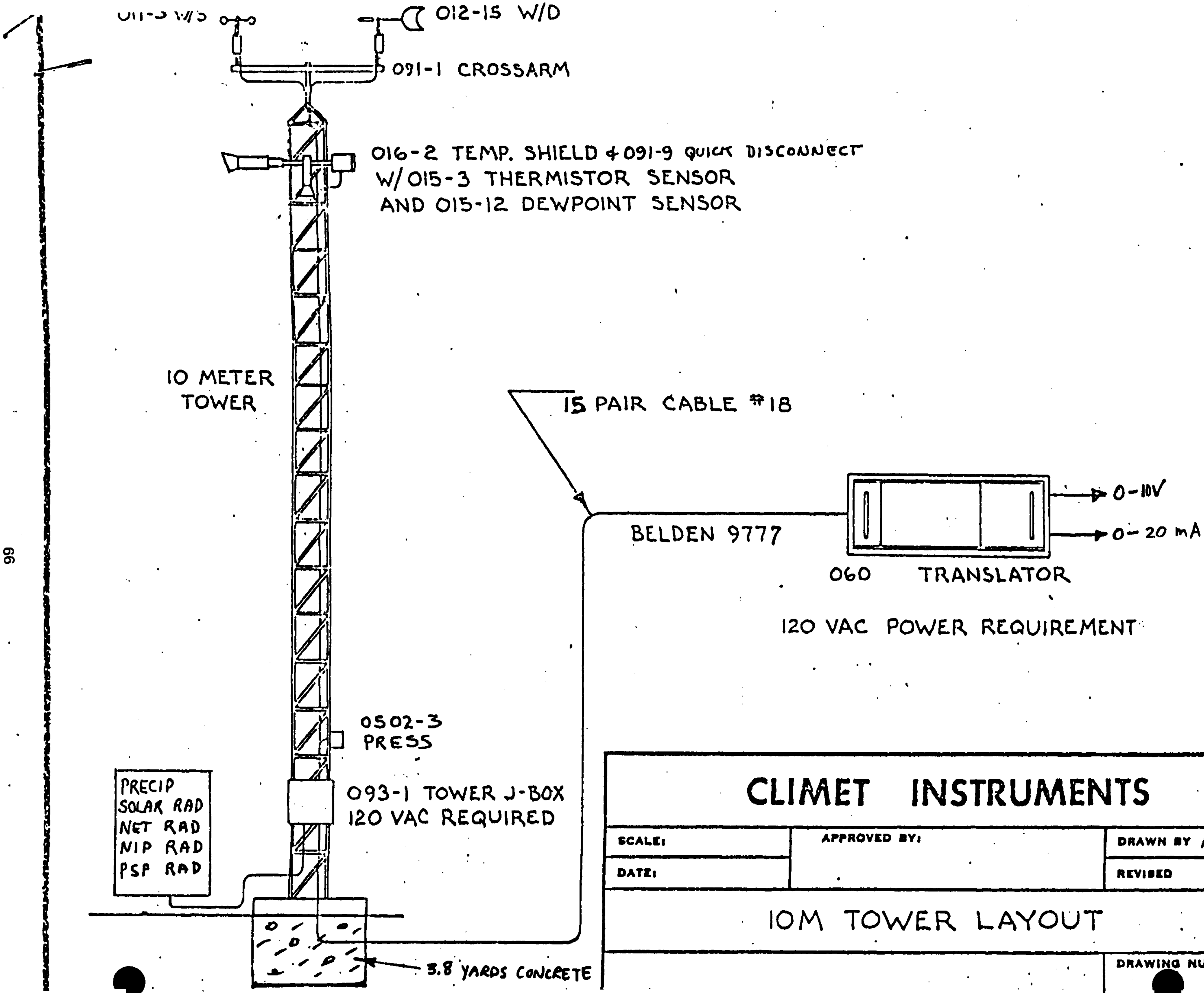
THE EPPLEY LABORATORY, INC.
12 Sheffield Ave., Newport, R. I. 02840, U.S.A. Telephone 401 847-1020

Model ST-3 The Eppley Model ST-3 Solar Tracker shown below accommodates up to three normal incidence pyrheliometer and incorporates worm and gear fine adjustments for declination and solar alignment. This unit can also be modified to handle other instruments used to measure direct solar radiation.

Incorporated are the following features:

1. **Pointing accuracy of ±.25° daily.**
2. **Latitude setting (any value from 0 to 90°).**
3. **Declination setting (+23.5 to -23.5°).**
4. **Leveling Screws**
5. **Weatherproof housing.**
6. **Easy unwinding of pyrheliometer leads.**
7. **Imput of 120 v 60 hz (or other specified supply).**

Inquiries are invited to accommodate other pyrheliometers or instrumentation where continuous pointing at the sun is a requirement.



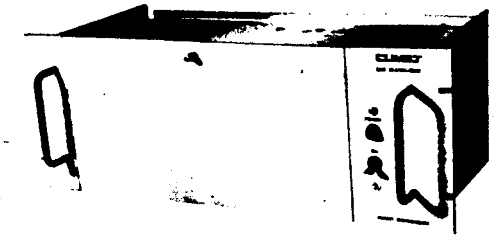
CLIMET INSTRUMENTS

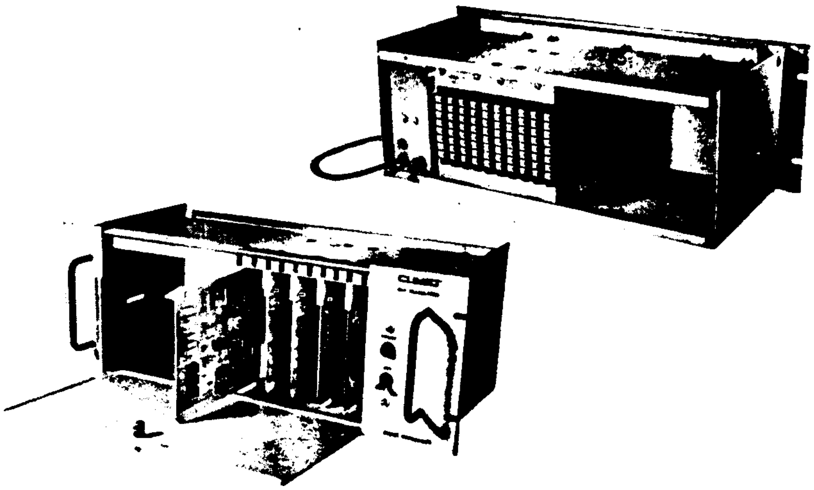
SCALE:	APPROVED BY:	DRAWN BY MSG
DATE:		REVISED

10M TOWER LAYOUT

DRAWING NUMBER

MODEL 060





DESCRIPTION AND OPERATION

The Climet Model 060 Translator is a research-grade, multipurpose, multiparameter signal conditioning module. It is designed to interface with a wide variety of analog sensors and convert the inputs from these sensors into a standardized voltage and current output. Each input channel is allotted space for one printed circuit board (PCB) which is designed for a particular sensor or function such as wind speed, wind direction, temperature, solar radiation, or a gas analyzer. PCB s contain the necessary conversion, amplification and scaling to provide a pair of analog outputs. Zero and full scale switches are immediately accessible on the front of each PCB by opening the translator's hinged front panel.

The 060 Translator's built-in power supply converts the required power source, 110 VAC, into a regulated ±15 VDC and +5 VDC needed for most sensor operation. Special models are available to operate from 220 VAC or +12 VDC power source.

A monitoring system using the 060 Translator can be expanded at a later date by merely inserting the appropriate PCB for the newly added sensors.

SPECIFICATIONS

Model Number

060-5	5 Channels	
060-10	10 Channels	
060-15	15 Channels	
060-20	20 Channels (maximum)	

INPUT CONNECTIONS: Barrier Strip

OUTPUT CONNECTIONS: Barrier Strip

PCB Outputs

VOLTAGE: 0-IV standard. Other ranges to a maximum of 0-10V on request. Offset ranges available.

CURRENT: 0-1mA standard. Other ranges to maximum of 0-20 mA on request. Offset ranges available.

Power Requirements

115VAC 50-400HZ, 220VAC or +12VDC special order

Physical

DIMENSIONS	19" wide x 7" high x 8¼" deep 48 cm x 18 cm x 21 cm
WEIGHT	12 lbs. (5.4 Kg)
SHIPPING WEIGHT	16 lbs. (7.2 Kg)
COLOR	Beige

ORDERING INFORMATION

Each 060 Translator includes:① AC power cord, 6 ft. (1.8m)② One extender Board

FOR FURTHER INFORMATION REGARDING THIS AND OTHER FINE CLIMET PRODUCTS CONTACT:

CLIMET®
INSTRUMENTS COMPANY
A DIVISION OF WEHR CORPORATION
POST OFFICE BOX 151 • 1320 W. COLTON AVE. • PHONE (714) 793-2788 • REDLANDS, CALIFORNIA 92373

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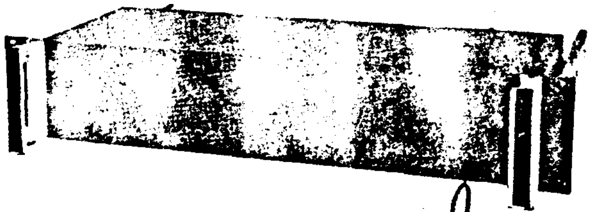
MICROMUX™



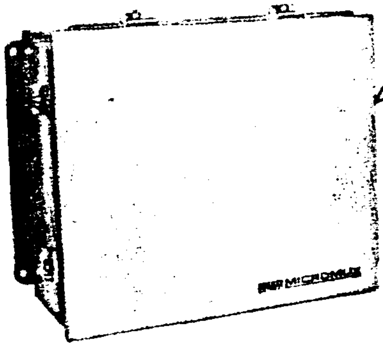
Micromux is a low cost industrial remote data acquisition system designed to reduce wiring costs and improve data integrity. Micromux is ideally suited to monitoring thermocouples, environmental variables, equipment maintenance functions, levels, pressures and other process signals. It is a rugged system that comes complete and ready to use in standard industrial packaging with a built-in computer interface. Micromux consists of from one to four electrically isolated remote units connected to a receiver. Each remote unit multiplexes 16 analog or digital inputs and converts them to frequency-coded time-multiplexed digital signals. These signals are then transmitted on a wire pair as far as 1500m (5000 ft.) to the receiver. The receiver converts the frequency signal to a three digit BCD format and stores the latest data from all channels in its internal memory. Upon command, the receiver transmits the continuously updated channel information to a computer over a standard ASCII serial interface.

The environmentally rugged remote units are intended to be used near the sensors and transmitters that generate the remote signal inputs. AC power is not required at the remote units because power is supplied by the receiver on the same twisted wire pair used for signal transmission. The receiver is intended for use near a computer.

Micromux is a money saving alternative to direct wiring of all signals to the computer room. Micromux reduces the process signal wiring required by a factor of 16 to 1. This savings, especially with the cost of wire and labor steadily rising, can easily amount to several times the cost of Micromux. In addition, significant advantages can accrue because of reduced documentation requirements and simplified cable routing.

Since Micromux is a computer interfaced data acquisition system, a local multiplexer at the computer is not needed. Micromux is price competitive on this basis alone.

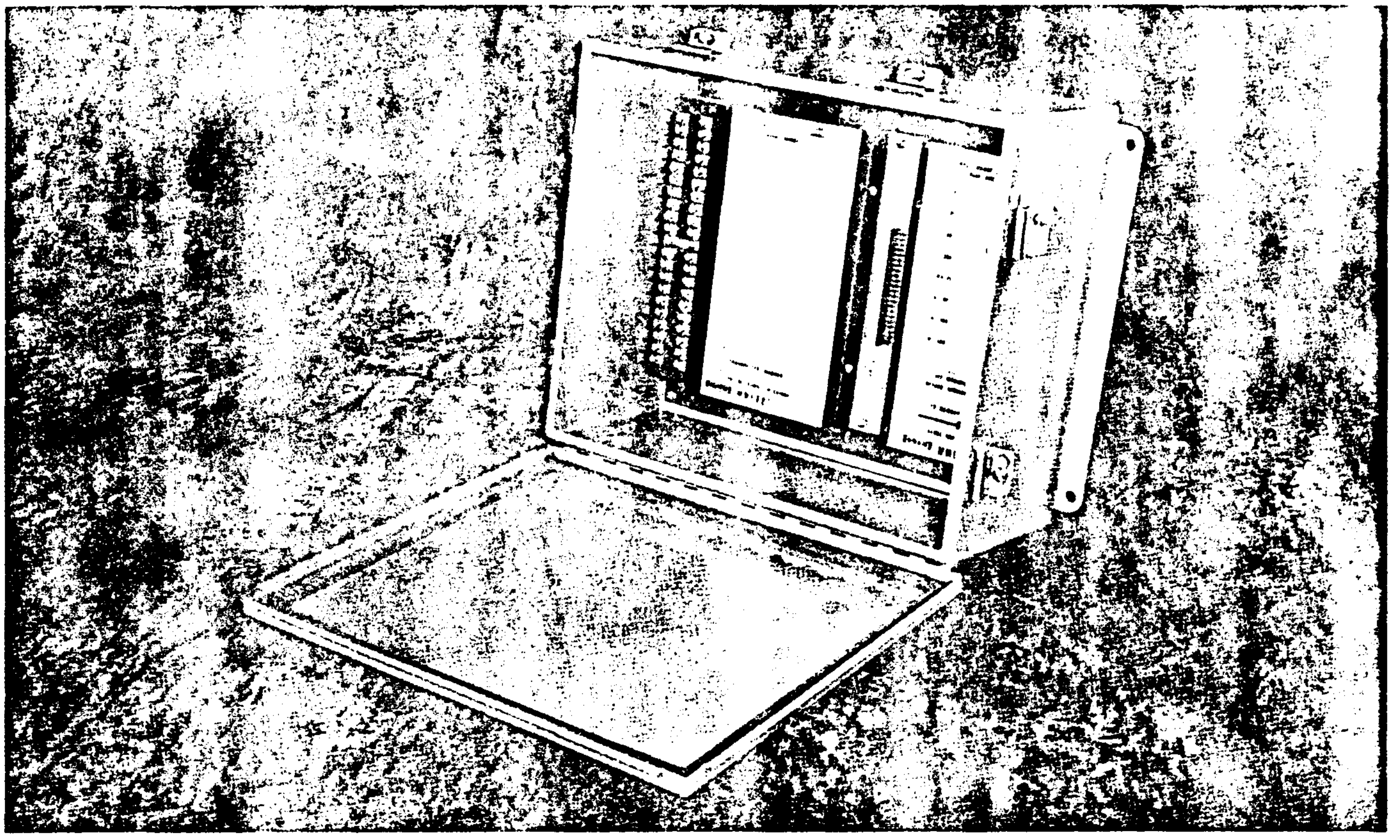
Micromux can be configured as a basic 16 channel system with one remote unit and one receiver. Up to four remote units can be connected to each receiver to achieve a capacity of 64 channels. And, as many as eight fully expanded receivers (512 data channels) can be connected to each communications interface of the computer.



Micromux reduces instrument signal wiring by a factor of 16:1 because the digitized signals from each 16 channel remote unit can be transmitted on a single wire pair to the Micromux receiver. Signals can be transmitted up to 1500 meters (5000 ft.). The environmentally rugged remote units will directly accept a variety of signals including thermocouples, low level voltages, current loops, high level voltages, and contact closures (on some ranges). The receiver stores the most recent value of each channel and transmitts this information upon demand to a computer over a standard ASCII serial interface.

REMOTE vs. LOCAL OPERATION

Micromux is an economical computer interfaced data acquisition system well suited for signals thousands of feet from a computer or for inputs only across the room.
The remote multiplexing, high noise immunity and rugged design of Micromux certainly make it the ideal tool to acquire distant data. But these same features and Micromux' low cost are also good reasons to use it to solve local data acquisition problems.



RUGGED AND RELIABLE CONSTRUCTION...

Micromux is designed for industrial environments. It is most effective where it will do the most good – at the sensor (where most conventional multiplexers cannot be used). Micromux can be used in most industrial environments: on the plant floor, mounted on a stack, on a river bank, or even in an air conditioned room.

The rugged construction of Micromux begins on the inside:

(1) Both printed circuit boards in the remote unit are covered with a polyurethane circuit coat.

(2) All components on these boards are protected with metal covers to prevent physical damage to the circuits.

(3) Each remote unit is mounted in a watertight NEMA 4 enclosure for additional protection.

(4) Pin and socket connectors are used in the remote unit to provide the best possible resistance to corrosive atmospheres.

(5) To guard against early failures, all units are burned in, under power, at high temperatures for one week.

Even though we have taken many steps to reduce field failures, we haven't forgotten to make Micromux easy to repair: Any malfunctioning printed circuit board can be replaced using only a screwdriver.

DATA INTEGRITY AND SECURITY...

Special attention was given to data integrity and security in the design of Micromux. Of course, the greatest improvement in data accuracy is due to Micromux' ability to digitize analog signals near their source. Digital signals are much less suceptible to noise interference than are analog signals. In addition, digital signals are not degraded by line losses when transmitted long distances as are analog voltage signals.

Several steps have been taken to further increase the data security of Micromux:

(1) A channel synchronization signal follows each channel of data.

(2) A line synchronization signal is included at the end of each 16 channels of data.

(3) Low pass input filters are included in each channel.

(4) An integrating voltage to frequency converter performs basic analog to digital conversion.

(5) Both channel and line synchronization signals are detected by integrators in the receiver.

(6) The digital output of the remote unit is sent as a current signal rather than a noise susceptible voltage signal.

(7) A noise cancelling differential transformer is used in the receiver to eliminate any noise that is impressed on the line.

(8) High noise immunity CMOS logic is used throughout.

(9) Input circuitry detects open sensors at the remote unit inputs.

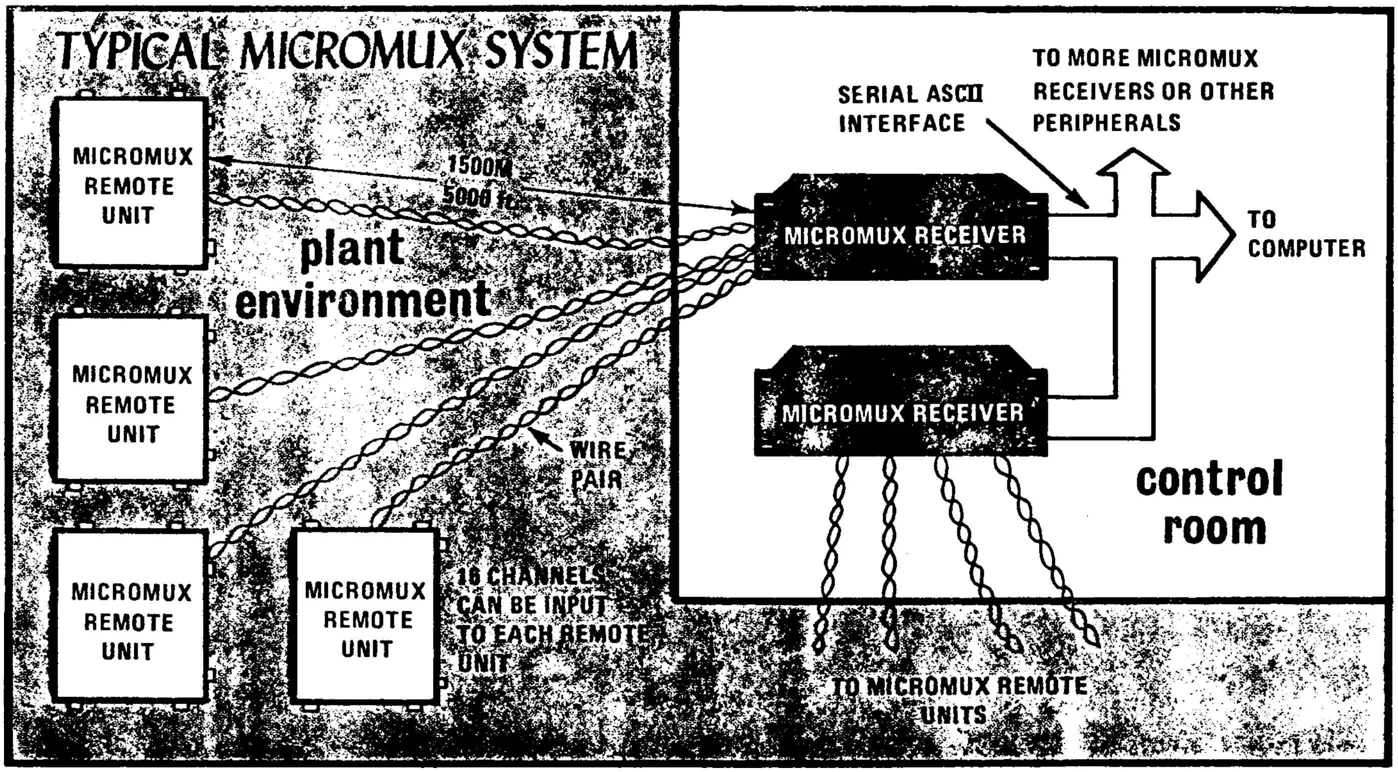
(10) Capability is also included to detect open receiver-remote lines.

SYSTEM SIZE

A Micromux installation can be expanded from the minimum of 16 channels to 512 channels on one computer communications interface. With additional communications interfaces, more channels may be added.

Micromux is especially suited to applications including a small number of signals (up to 64). Unitl now, many signals have been uneconomical to interface to a computer because they were too few to justify an expensive multiplexer and computer interface. Micromux' economical price and ease of use now put these signals within reach.

Micromux is made to be easily expanded as additional channels are needed. A minimum of overhead is included in the basic 16 channel system. Yet, if more channels are needed, the system can simply and easily be expanded in the field. Expansion requires only an additional remote unit and a plug-in board for the receiver.



COMPUTER INTERFACE

Micromux' computer interface is a standard high speed (2400 baud) teleprinter-like port: that is, a 20 mA current loop with ASCII coding (using one stop bit and optional parity). This output requires a low cost asynchronous 2400 baud communications interface. Since this interface is commonly available from most computer manufacturers, the use of Micromux does not need to be limited to one particular computer in your installation.

To permit efficient use of computer time, all channels connected to a receiver are stored in that receiver's buffer memory. The information in this data buffer memory is transmitted to the computer upon demand at 80 channels per second. All buffer memory locations are continuously updated by the remote units.

The rate at which the remote units update the buffer memory varies from 119 channels per second for a 512 channel system to 3.7 channels per second for a 16 channel system. The rate varies because the time required to update the buffer memory of an entire Micromux system is a constant 4.3 seconds independent of the number of channels in the system.

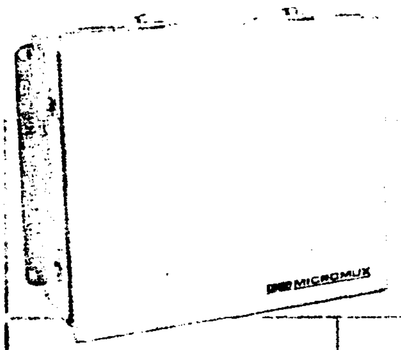
POWER SUPPLIES

The Micromux receiver contains the power supply for the entire Micromux system. Each remote unit receives power on the same twisted wire pair on which the signal is transmitted. This means that an AC supply is never needed to power the remote units. This can be a definite advantage, of course, for a source of AC power is not always near. Even if AC power is available, this feature eliminates one extra connection and some of the complexity of signal interface. Since AC power does not have to be wired into the remote enclosure, the amount of 50 or 60 Hz noise induced on the input signal lines is also reduced.

INPUT SIGNALS

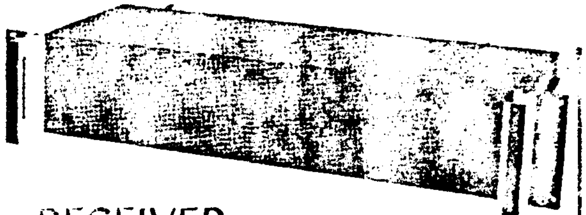
Micromux will accept a wide variety of voltage and current signals. These include thermocouples, other low level voltage signals, high level voltage signals, current signals and contact closures. An ambient temperature sensor is included in each remote unit to transmit cold junction temperature when reading thermocouples. Signals can be mixed, in four channel increments, in each remote unit. This feature makes Micromux even more economical in small systems when a variety of signals have to be interfaced.

TECHNICAL SPECIFICATIONS



REMOTE UNIT

Number of Inputs:	16 per remote unit
Input Type:	1) Thermocouples 2) 4-20mA, 10-50mA 3) Voltage - ±12.5mV to +10V 4) Contact Closures (on some ranges)
Input Filtering:	Single pole 1Hz filter
Common-mode Voltage:	600VDC/240VAC remote unit to earth ground, 7VDC/5VAC channel to channel
Input Protection:	310VDC/220VAC channel to channel
Common-mode Rejection:	>140dB at DC >100dB at 50 or 60Hz
Normal Mode Rejection:	>34dB at 50 or 60Hz
Remote to receiver distance:	1500M/5000 ft.
Data Rate to Receiver:	Varies from 119 channels per second for a 512 channel system to 3.7 channels per second for 16 channel system
Temperature Range:	-25°C to +85°C (-12°F to +185°F)
Enclosure:	NEMA 4 - 356mm x 305mm x 152mm (14" x 12" x 6") hinged cover
Weight:	10Kg (22 pounds)
Field Termination:	Barrier Strip (# 6 screw)



RECEIVER

Input:	From 1 to 4 remote units each connected with wire pair
Data Rate to Computer:	80 channels per second
Output:	2400 baud, ASCII, 20mA digital current loop. Even, odd or no parity with one stop bit
Output Interface:	Multidrop, up to 8 receivers per computer communications interface
Power Requirements:	105 - 125VAC/210 - 250 VAC/90 -110VAC, 47 - 440Hz, 50 watts
Temperature Range:	0 - 40°C (+32°F to +104°F)
Enclosure:	483mm (19") rack mount, 89mm (3.5") panel, 178mm (7.0") deep
Weight:	5.7Kg (12.5 pounds)

MICROMUX ACCURACY

Throughput Accuracy:	±0.2% of span
Accuracy Stability (vs. temperature of remote unit)	±0.01% of span/°C (±0.005%/°F) [±0.015% of span/°C (±0.008%/°F) for low level ranges]

PRICING

16 Channel Micromux System

(includes receiver and one remote unit)

Contact Burr-Brown for pricing of the exact system that you require.

Appendix B

XY COORDINATE SYSTEM DEFINITION

The location of weather stations and other equipment is specified in terms of a rectangular coordinate system with origin (0,0) located at the tower vertical centerline, the +X direction due south and the +Y direction due east. The center of each layout circle or arc from which the radius is specified is at coordinate location (+0.99,0). All dimensions are specified in feet.