UPLOOKING INTERFEROMETER DEVELOPMENT SYSTEM

BOMEM M-120

University of Wisconsin
Space Science and Engineering Center

Jan. 8, 1990

DESCRIPTION OF EXPERIMENTAL PROGRAM

A period of intensive instrument development was initiated starting Aug. 30, 1989 at the University of Wisconsin - Space Science and Engineering Center (SSEC) utilizing a Michelson 120E (with DTGS detector) on loan from Bomem, Inc. of Quebec, Canada. The purpose of this development was to prove the concept that the Michelson 120 series could form the basis of a calibrated atmospheric radiation sensor whose low unit cost would allow wide distribution to university and government research centers around the world. By Nov. 30, 1989 (with an upgrade to a MCT detector) all known problems had been solved and the system was generating spectral data equal in quality to the High-resolution Interferometer Sounder previously developed by SSEC. The complete success of the development system program places SSEC ready to proceed with design and development of an actual prototype atmospheric radiometer as soon as adequate funding becomes available. The prototype system is envisioned as a highly automated calibrated radiometer and atmospheric sounding system built around a Bomem MB-120 using one (or more) liquid nitrogen cooled detectors.

The experimental measurement program that coincided with the instrument development covered a five week period in Madison beginning November 1, 1989, during which five instruments were run under various atmospheric conditions. The instruments were the

NCAR Cross-chain Loran Atmospheric Sounding System (CLASS),
E. Elorante's volume scanning lidar,
C. Grund's high resolution lidar,
W.L. Smith's High-resolution Interferometer Sounder (HIS)
and ground-based interferometer development system (M120).

In addition, the McIDAS system of the Space Science and Engineering Center (SSEC) was used to capture satellite visible and IR images of Madison during satellite overpasses.

The goals of the experiment included:

(1) Testing and validation of a low cost interferometer system (the M120).

(2) Collection of a data set containing coincident lidar and downwelling high resolution infrared data for various cloud conditions, including cirrus clouds.

(3) Comparison of upwelling infrared satellite measurements and coincident downwelling radiation to assess quantitatively the impact of cloud radiance on earth radiation budget.

The preliminary conclusions can be summarized as follows:

(1) The testing of the low cost ground-based radiometer was a complete success. The instrument provided high quality data with high reliability and low maintanence. With this success, the way is cleared for development of a prototype stand-alone instrument.

(2) A wide variety of weather conditions were sampled with a range of instruments. Some of the best cases included time sequences proceeding from clear air, to thin cirrus, to low water clouds, and during which all five instruments were running and satellite overpasses were captured. Evaluation of individual cases is underway.

The instruments were set up at four sites in and around Madison, Wisconsin. The infrared radiometers and the satellite communications were placed on the roof of the 16 story Space Science and Engineering Center on the Uni. of Wisconsin campus. The CLASS system trailer was located in a parking lot two blocks south of the SSEC. The high resolution lidar was located on the roof of a building (Van Hise) three blocks north of the SSEC. The volume scanning lidar was situated on a ridge near Pine Bluff observatory about 20 miles west of Madison. At least one person was required at each site during operation of the instrument at that site. Each instrument could operate independently of all of the others. Telephones were used to communicate between sites to coordinate activities.

Data storage was different for the different instruments. The radiometer instruments created PC-compatible data files which were accessible on a PC LAN, eventually being archived on 9 track reel tape. The CLASS data was obtained in PC compatible format as well. The lidar data is archived on optical disk using a VAX-based computer system. The satellite data is stored in the McIDAS database and is accessible only through a McIDAS terminal. All three systems can interface using ETHERNET connections.

A M120 data segment consists of a 5 minute sky view bounded by four 2 1/2 minute hot and cold blackbody views. The coincident HIS measurements were made by capturing a real-time data segment during the five minute sky view. Since this HIS segment contains equal numbers of sky, hot, and cold blackbody views, the actual period of sky integration for the HIS is only 1/3 that of the M120. Of course a continuous record of HIS data is available on cassette tape.

The remainder of this document give examples of the operation of the development system obtained during the experimental observing program.

TIMELINE FOR GROUNDBASED INTERFEROMETER DEVELOPMENT SYSTEM

12-1-88(?) Michelson 120E arrives from Bomem.

12-29-88 Set-up in lab. Rm 1051.
Software installation. Version 1.42n.
Window installation.

12-30-88 First hot source spectra. Cigarette lighter.

1-2-89 System checkout completed.

7-1-89(?) M120E packed and shipped to Bomem trade show.

8-30-89 Development system kickoff meeting.
M120 unpacked and checked.

9-19-89 Measurements made for preliminary fore optics design.

10-25-89 Fore-optics alignment using alignment scope.
Tested mirror rotation software.

10-26-89 Field of view mapped with hot source.
Aft optics adjusted.
Temporary ambient HBB and LN_2 CBB alignment.
First sky data. High resolution with DTGS.
Temperature data recorded manually.

10-27-89 Calibration software checks out.
Low resolution sky data.
Ice bath calibration done.
Instrument responsivity determined.

11-1-89 First HIS/M120 uplooking intercomparison.
Good agreement at low resolution.

11-2-89 Second HIS/M120 uplooking intercomparison.
Qualitative agreement. Confused by cloud content.
Initially unable to calibrate due to "coadding".

11-3-89 Successfully integrated automatic thermistor measurement into data stream.

11-4-89 Computer systems set to universal time for data tagging.

11-7-89 Noticed inside of KBr window badly degraded.
Found and plugged holes in M120 case. Instituted "bagging and purging" procedure.
Inspected Beamsplitter. OK.
Replaced original desicant with "Drierite".

11-9-89 Replaced window with spare.
Replaced DTGS detector with MCT. Aligned HBB.
Transferred M120 to new optics bench and cart.

11-10-89 Optimized MCT detector position.

11-11-89 Preliminary noise analysis.

11-12-89 First failure when M120 drops below 5 Celsius.
Assembled wooden shelter.
Successful sky data taken. Cirrus.
Calibration problem uncovered. Raw IFGs are scaled by the number of coadded scans.

11-13-89 Clear sky data taken. Low signal to noise.
Coincident CLASS launch.
Adjusted pre-amp gain (R7). Noticed asymmetry

11-14-89 Properly adjusted pre-amp gain.

11-17-89 Thermistor calibration tests.

11-18-89 Set field stop to 30mr full FOV.
Clear sky HIS/M120 intercomparison.
Includes 60 Hz noise from power supply.

11-20-89 Sky data taken. 60HZ noise present.

11-21-89 Sky data taken. 60HZ noise present.
60 Hz Testing begins.

11-22-89 Open mouth dewar (CBB) explodes.

11-24-89 60 Hz testing continues.

11-27-89 Loosely placed mu-metal shielding.

11-29-89 Sky data taken. Partially reduced 60 Hz noise.

11-30-89 Completed mu-metal shielding of power supply.
Eliminated 60Hz problem.
Clear sky data taken. No known problems.

12-1-89 Sky data taken. Good data.

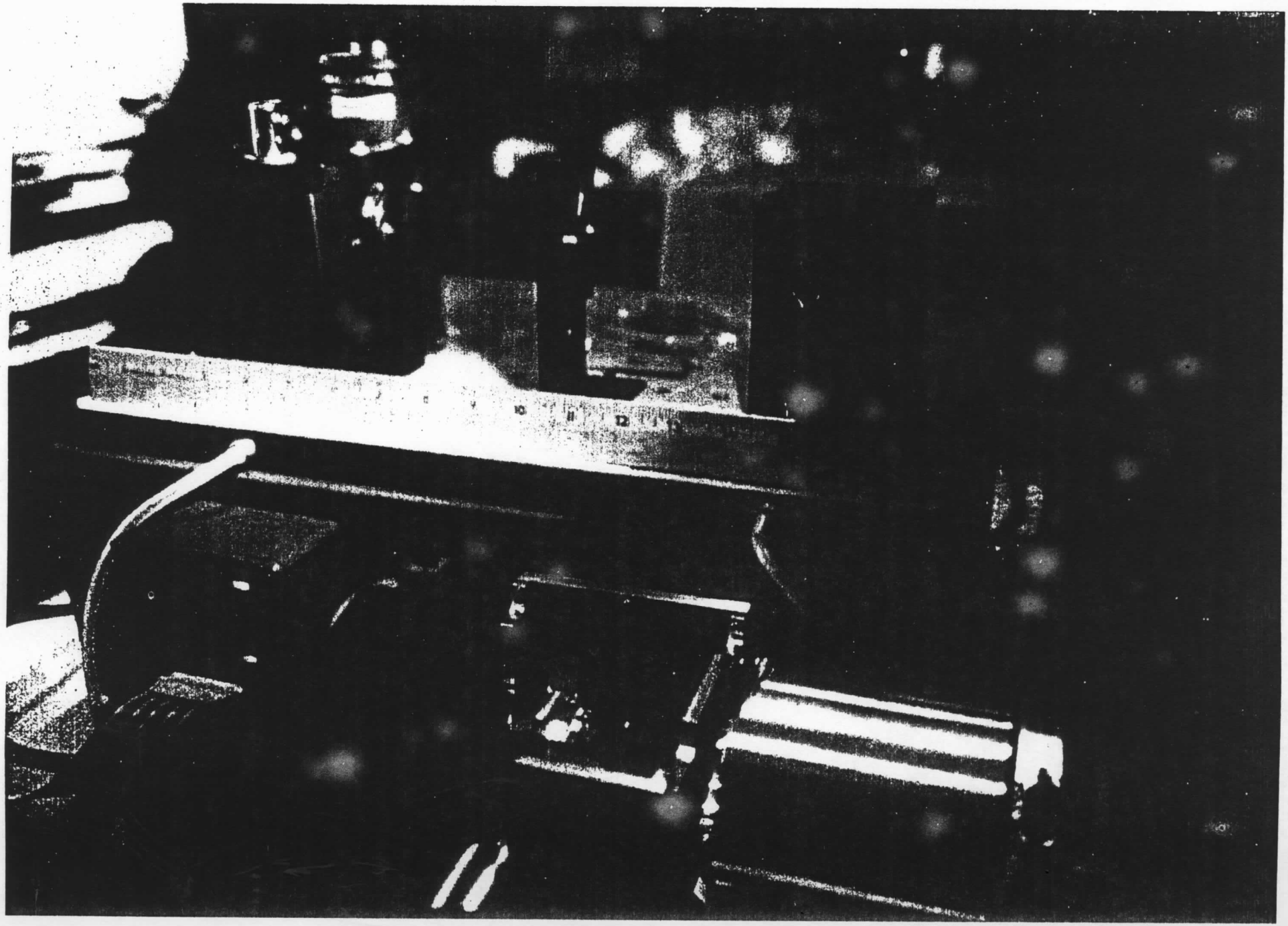
12-4-89 Installed Bomem software v1.45a

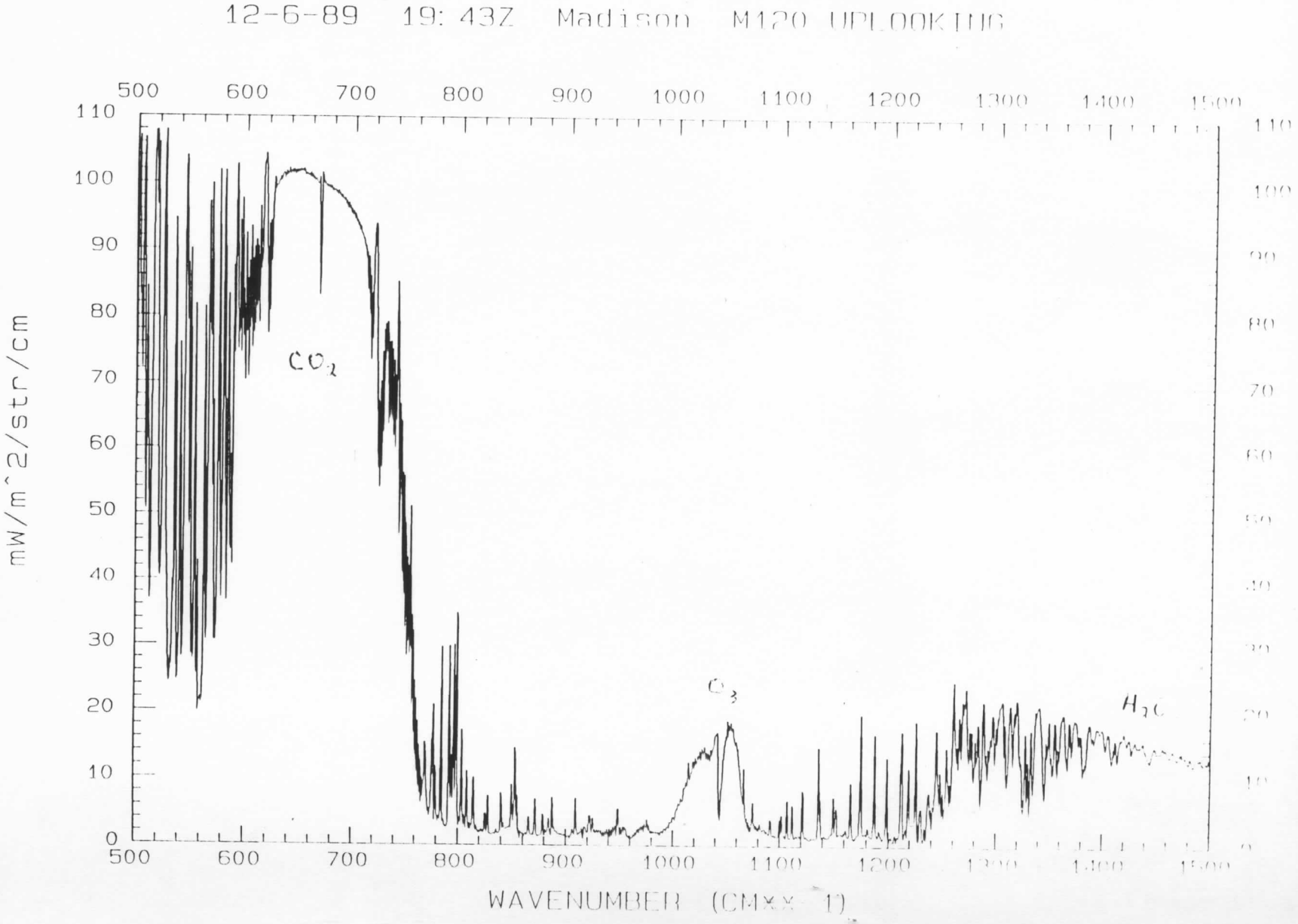
12-5-89 HIS/M120 intercomparison. Mixed clouds.

12-6-89 HIS/M120 intercomparison. Ultra-clear.

12-8-89 M120 slant path clear sky data.

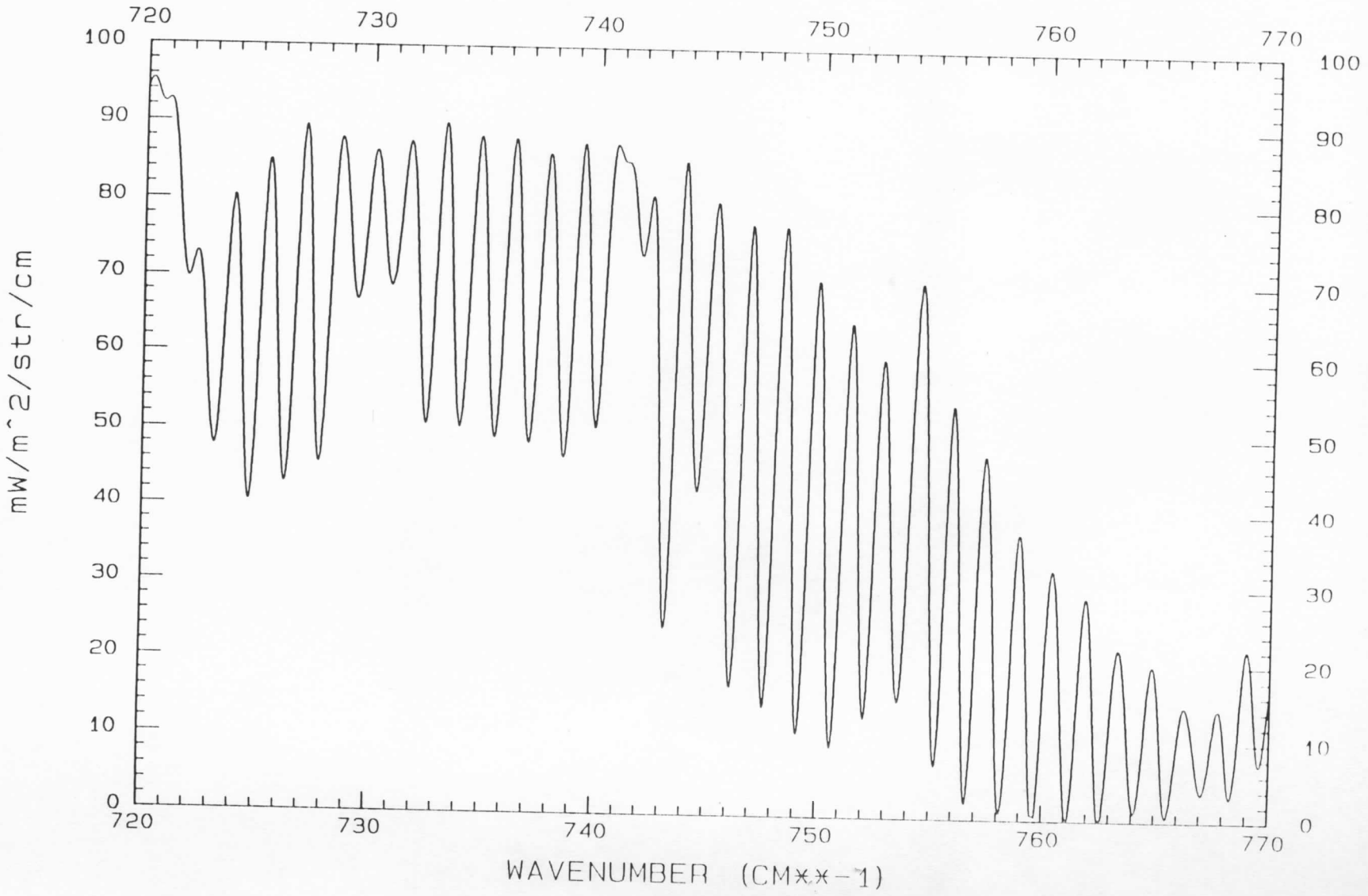
12-22-89 M120 Arctic high pressure clear sky data.



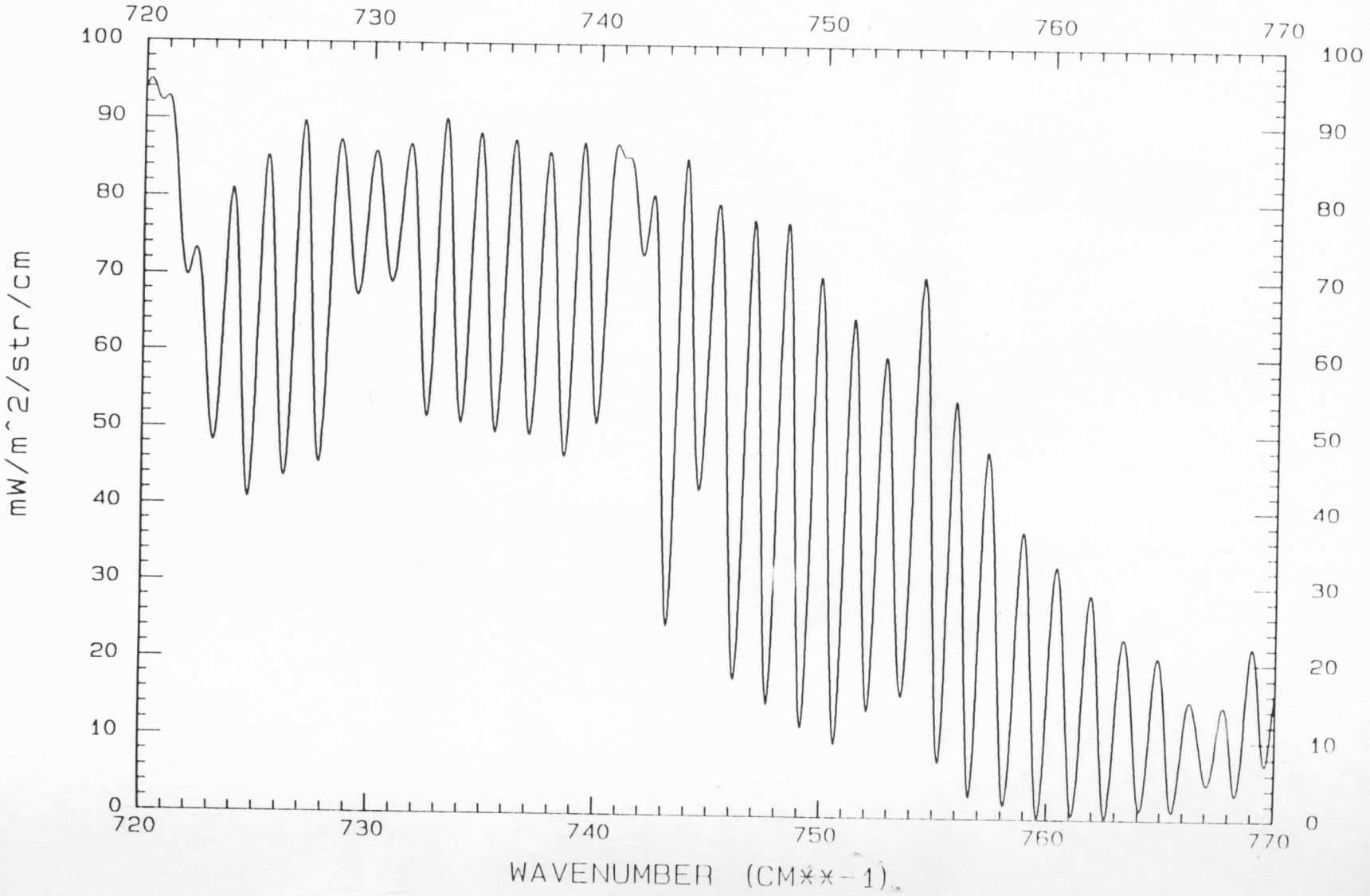

12-6-89 19:43Z Madison M120 UPLOOKING
500 600 700 800 900 1000 1100 1200 1300 1400 1500
110 100 90 80 70 60 50 40 30 20 10 0
mW/m^2/str/cm
CO2
O3
H2O
WAVENUMBER (CM** -1)
12-08-1989 01:52:31

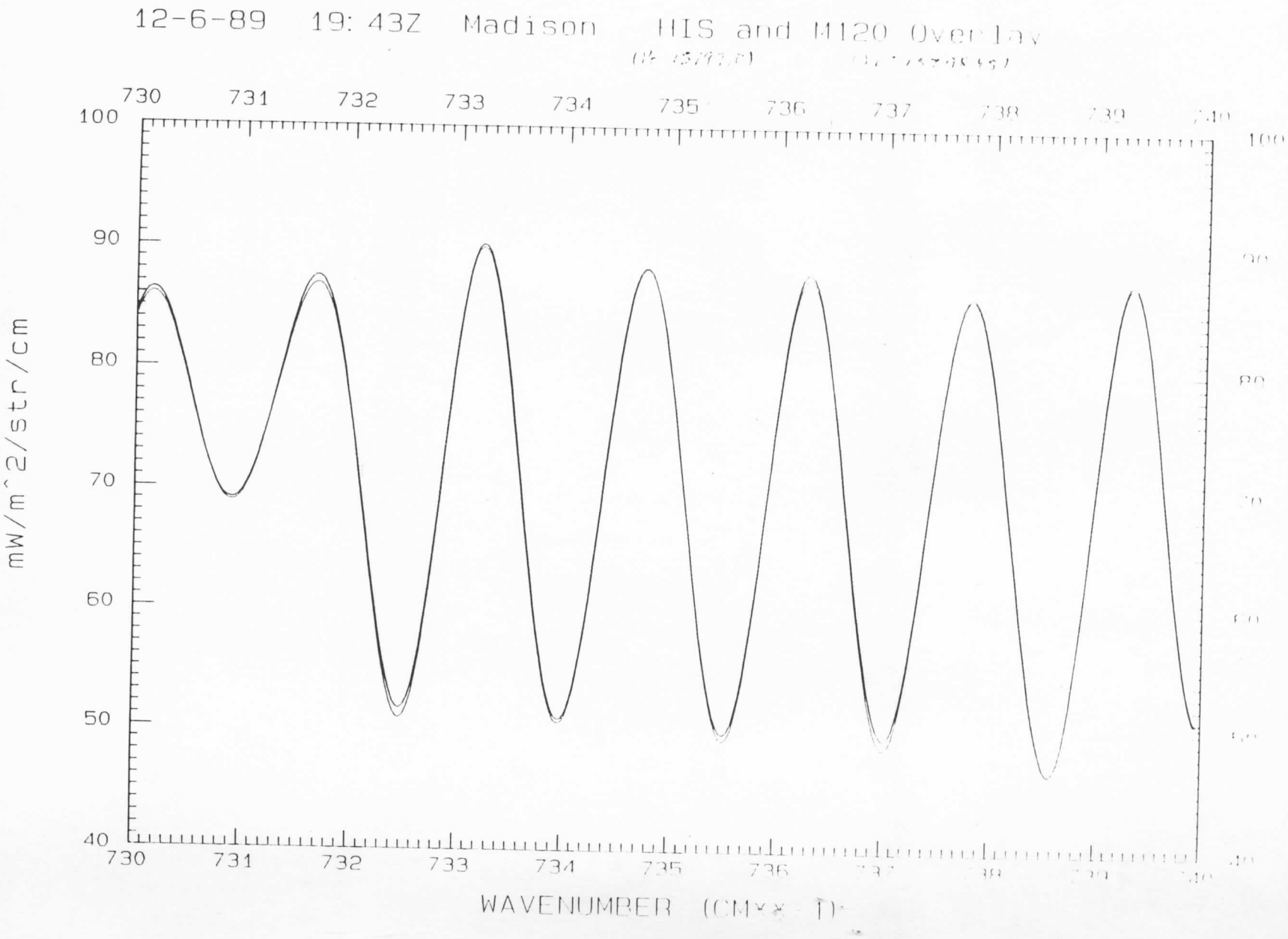
Temperature Sounding Group

12-6-89 Madison M120 UPLOOKING (19: 43Z)



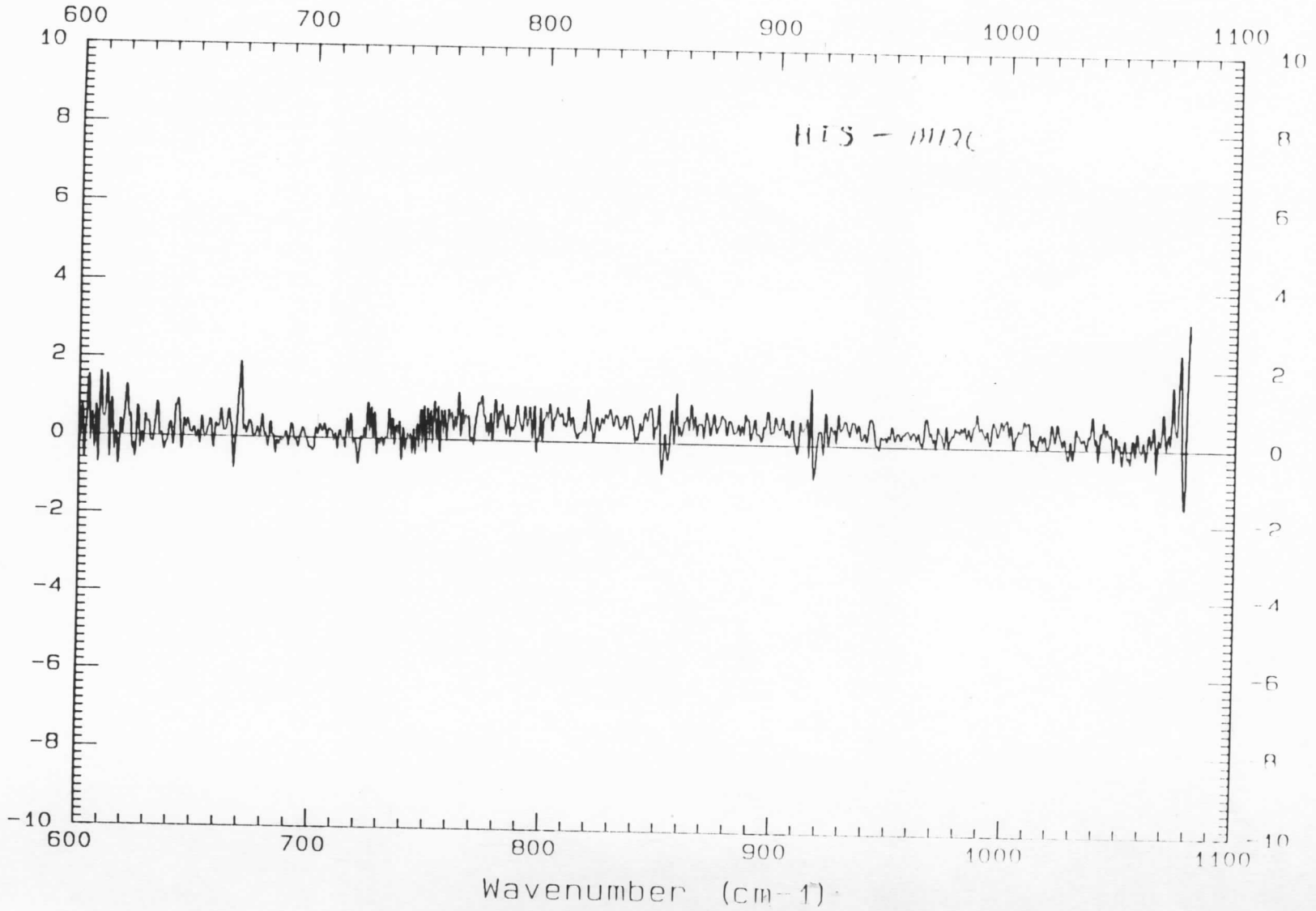
12-08-1989 01: 09: 58


12-6-89 Madison HIS UPLOOKING (19: 43Z)
720
730
740
750
760
770
100
90
80
70
60
50
40
30
20
10
0
mW/m^2/str/cm
WAVENUMBER (CM**-1)
12-08-1989
01: 20: 43


12-6-89 19:43Z Madison HIS and M120 Overlay
730
731
732
733
734
735
736
737
738
739
740
100
90
80
70
60
50
40
mW/m^2/str/cm
WAVENUMBER (CM
12-08-1989
03:41:49

Excellent Agreement

Madison 12-06-89 HIS (19:43Z) minus M120 (19:43Z)



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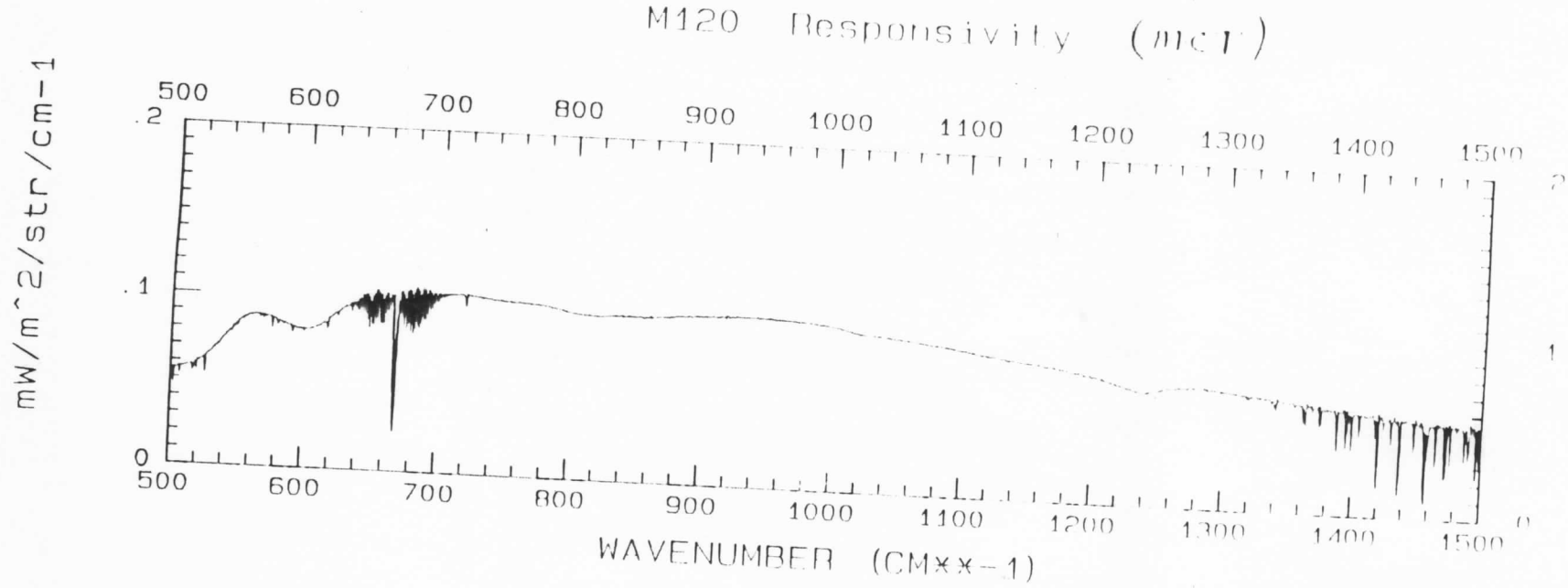

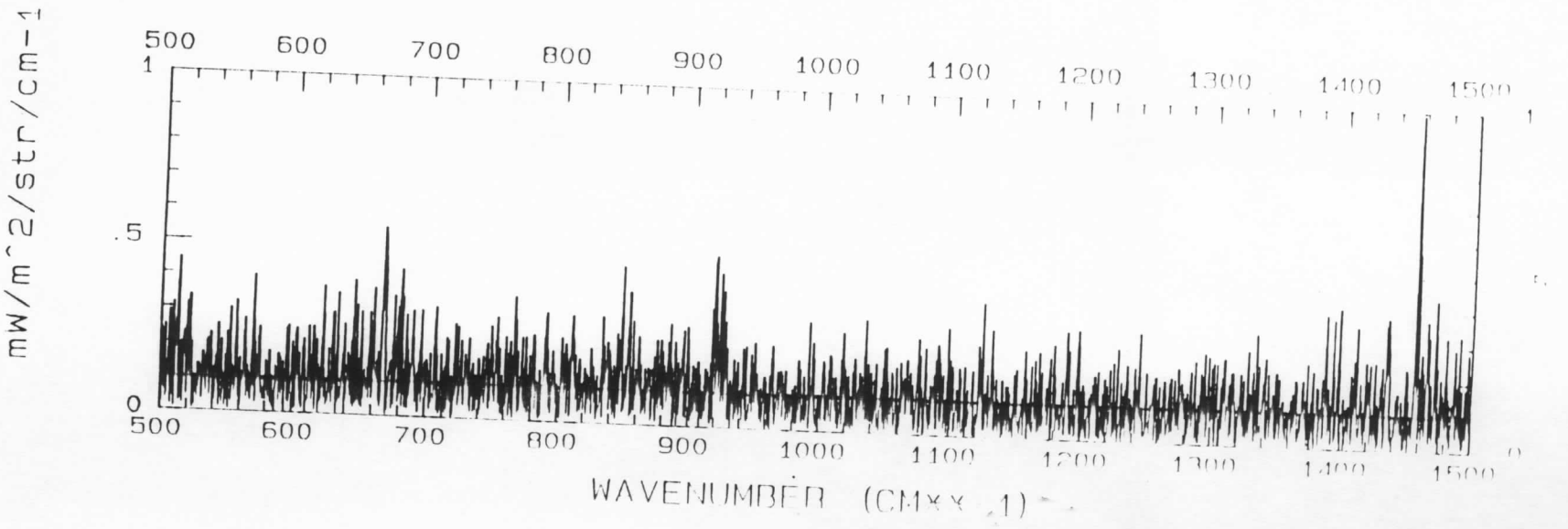

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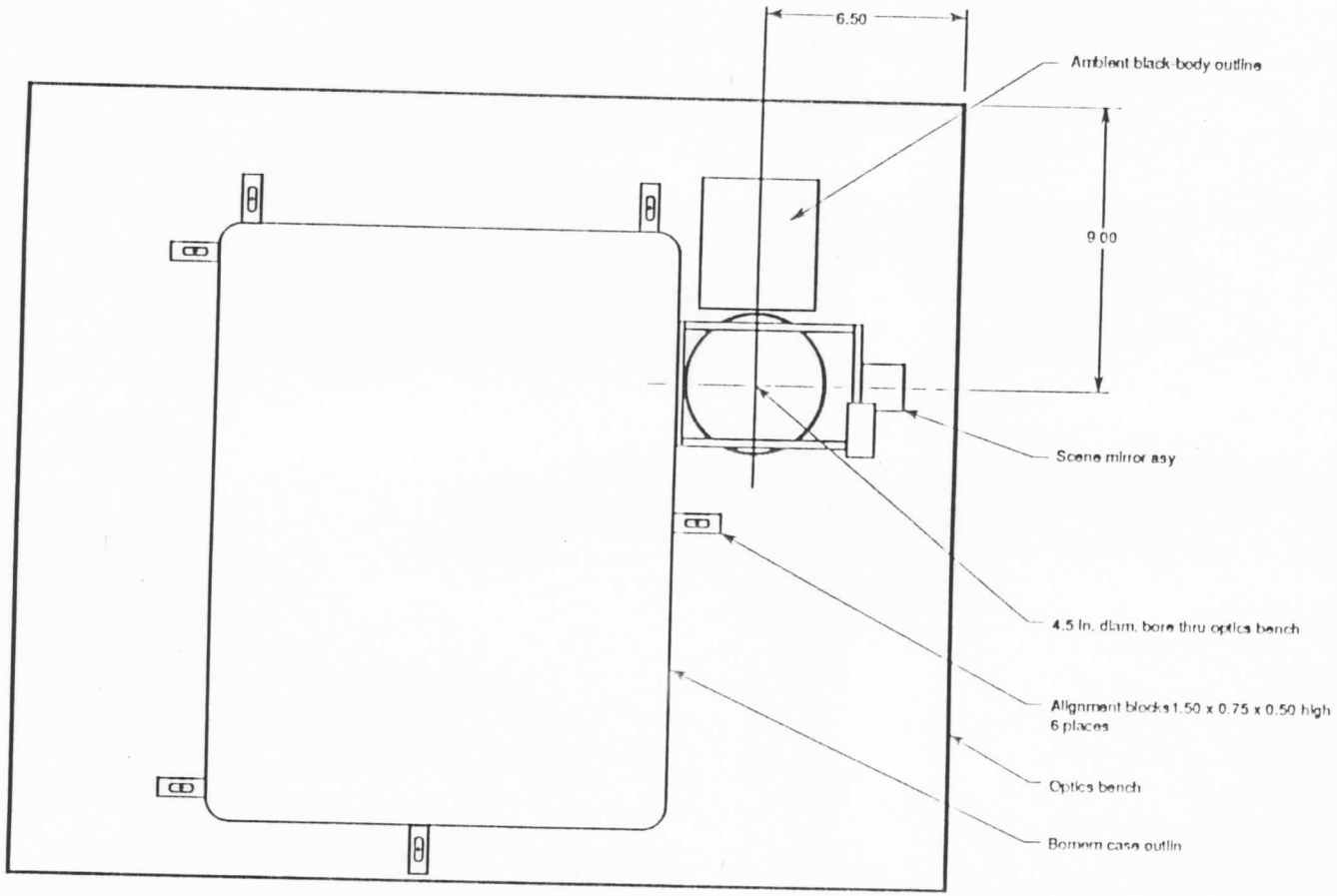
APPENDIX: TECHNICAL DIAGRAMS

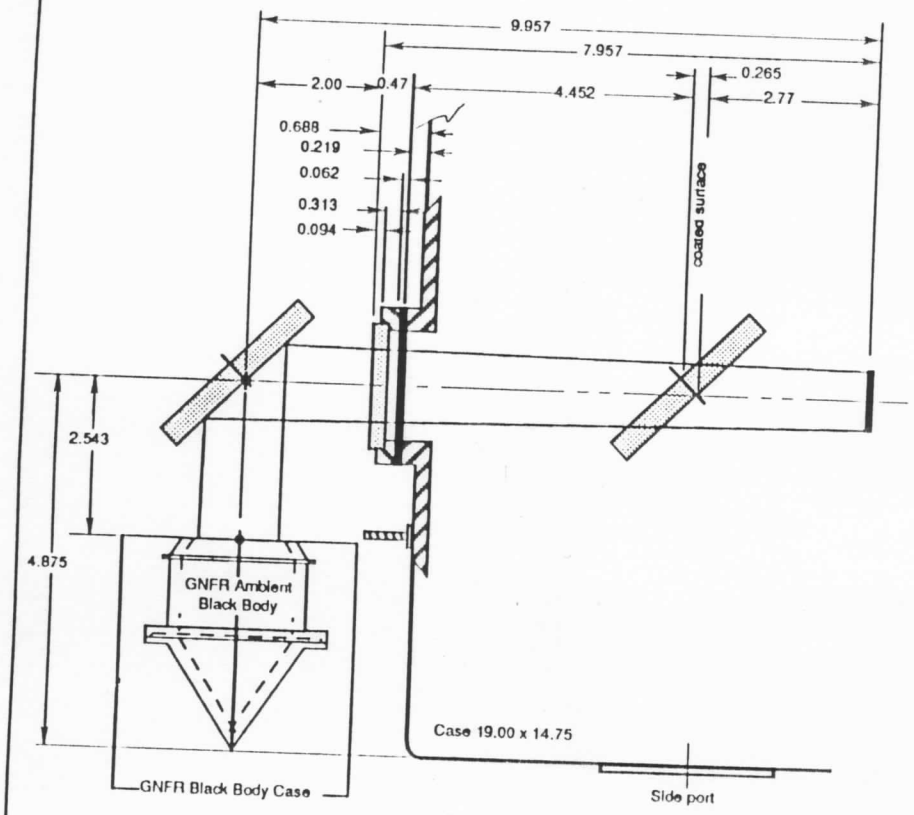


THE UNIVERSITY OF WISCONSIN

SPACE SCIENCE & ENGINEERING CENTER

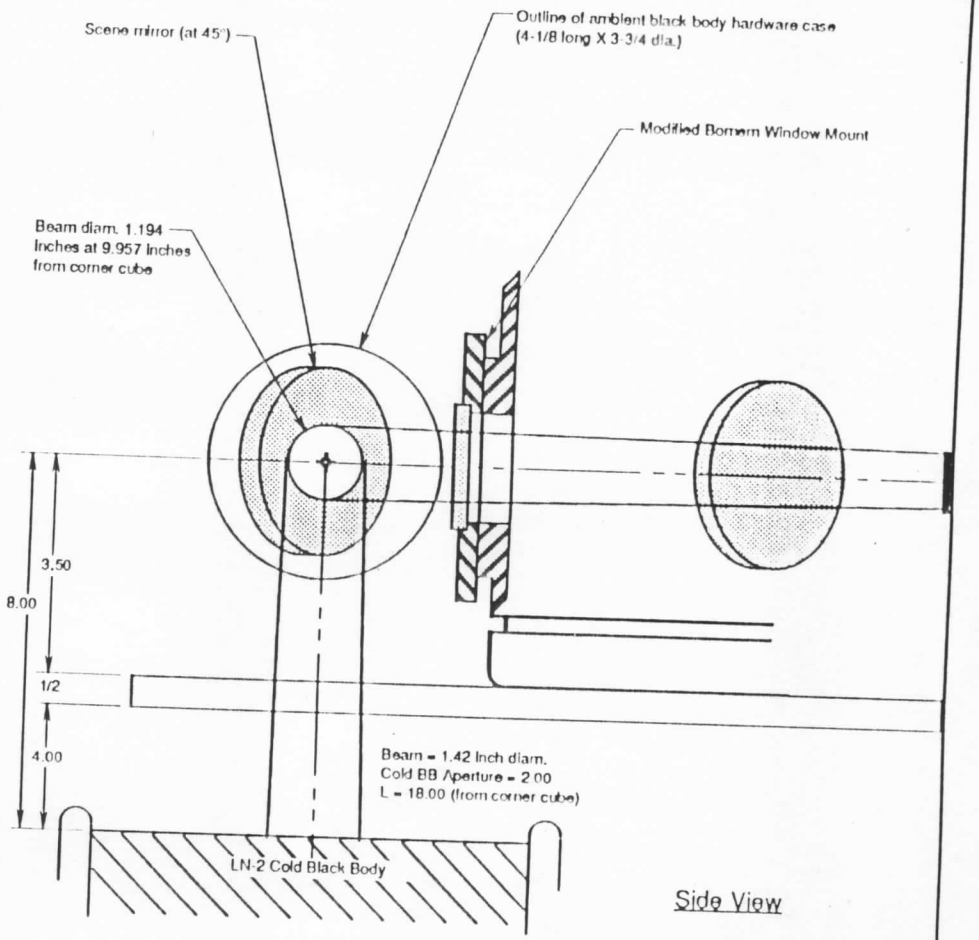
TITLE Michelson HIS
Optics Bench
Layout

Scale Full	Drafter JFS Date Oct 3, 1989	Checker	Engineer
Next Higher Assy		Product Assurance	Project Approval
Project No. 1090	Size B	Sheet 1 of 1	Drawing No. 1090 - 0015



Top View

Length (Corner Cube to Ambient Black Body) = 12.50 Inches
Aperture stop = 0.875
Field stop = 0.167
Beam divergence = 0.86° (half angle)
Ray trace at Ambient Black Body = 1.255 (BB Apert. = 1.40)

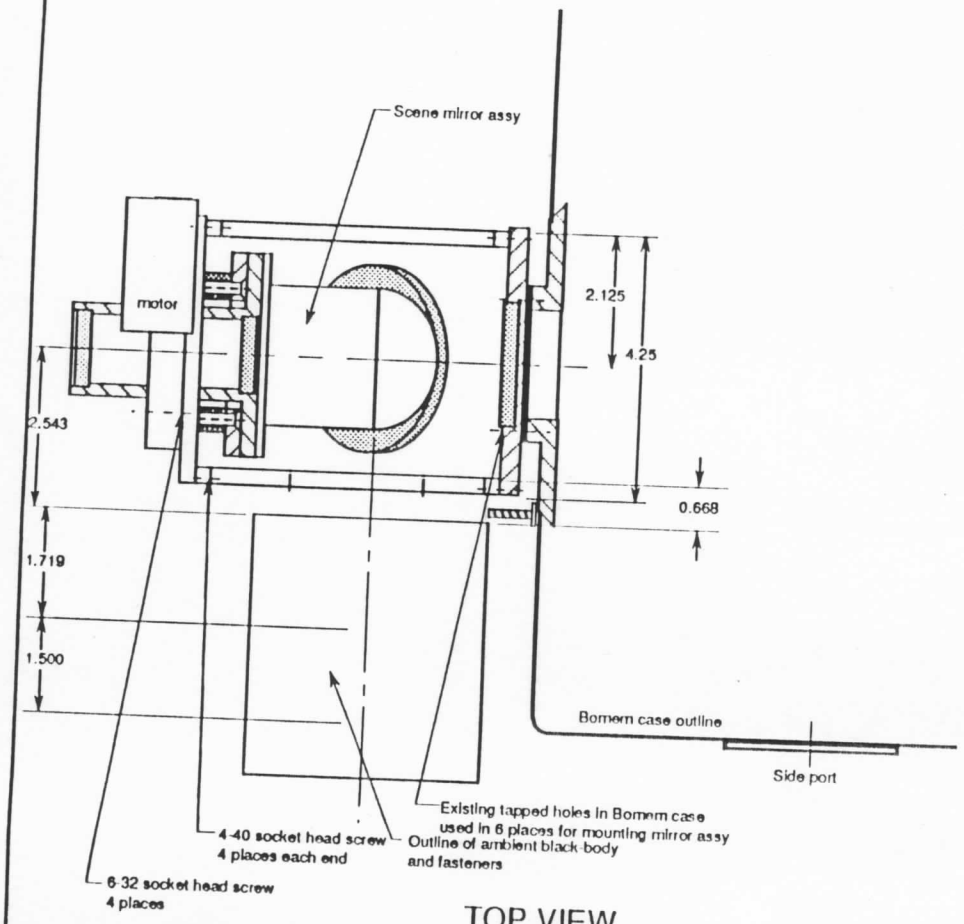


Side View

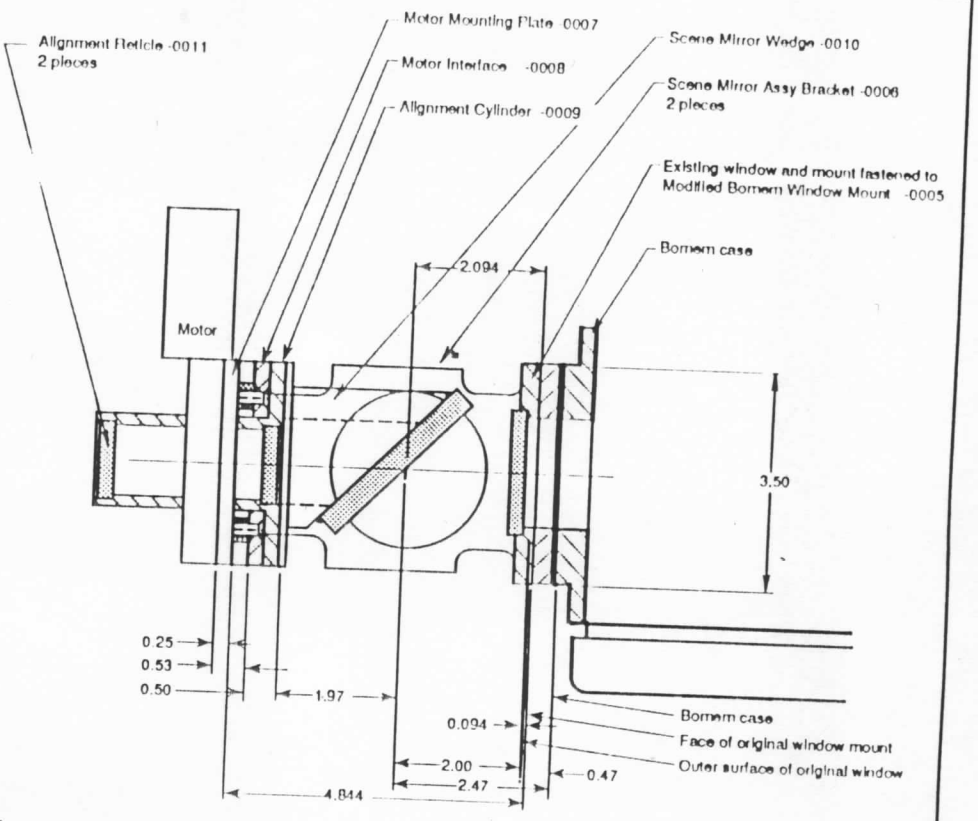
THE UNIVERSITY OF MICHIGAN

SPACE SCIENCE & ENGINEERING CENTER

TITLE	Michelson HIS Scene Mirror Ray Trace Layout		
Scale Half	Drafter JF S Date Sep 29, 1989	Checker	Engineer
Next Higher Assy		Product Assurance	Project Approval
Project No.	Size B	Sheet 1 of 1	Drawing No. 1090 - 0001



TOP VIEW



SIDE VIEW

THE UNIVERSITY OF WISCONSIN

SPACE SCIENCE & ENGINEERING CENTER

TITLE Michelson HIS
Hardware
Layout (Top and Side Views)

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Project No	Size B	Sheet 1 of 2	Drawing No - 1090 - 0002

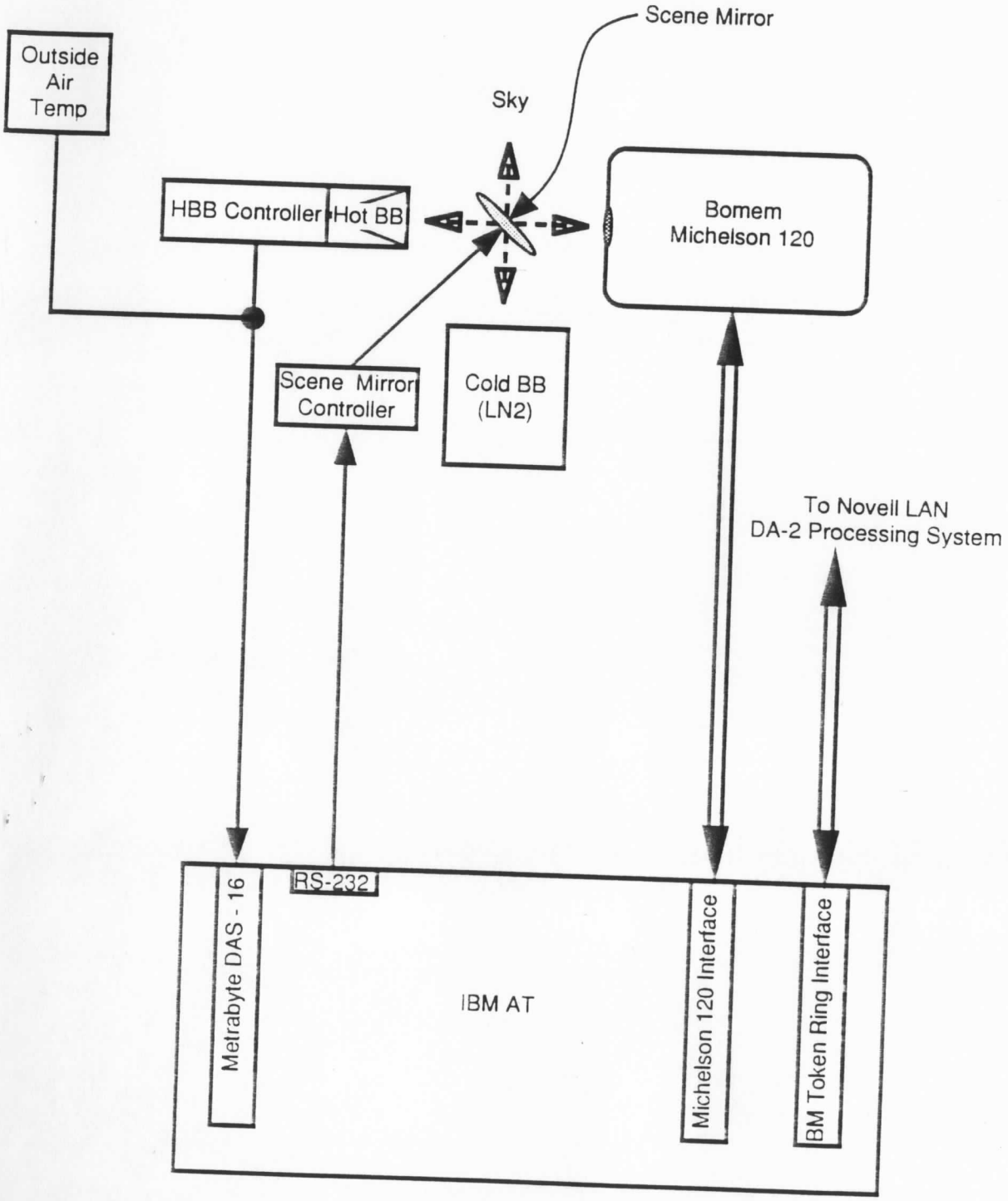

Figure 1

Hardware Interfaces

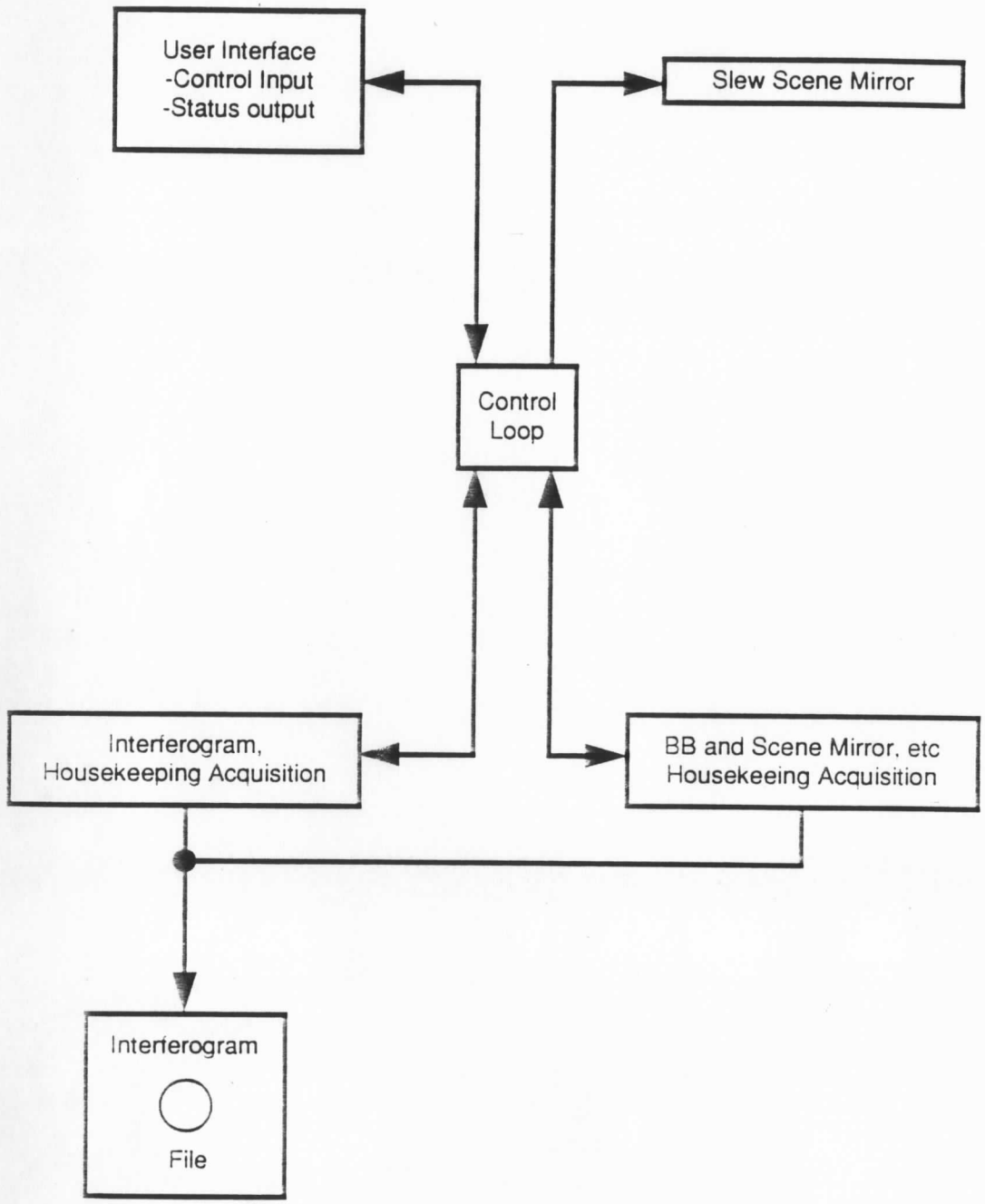

Figure 2

Control Program Interfaces