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FINAL REPORT
Research and Development of an Airborne Multispectral Scanner to Measure Fire, Terrestrial and Atmospheric Characteristics (50 Channel)

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(NASA-CR-193121) RESEARCH AND DEVELOPMENT OF AN AIRBORNE MULTISPECTRAL SCANNER TO MEASURE FIRE, TERRESTRIAL AND ATMOSPHERIC CHARACTERISTICS (50 CHANNEL) Final Report, 10 May 1989 - 28 Feb. 1991 (Daedalus Enterprises) 24 p

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Table of Contents

1. Project Summary

The goal of this research and development effort was to design and develop a spectrometer (AB184) and high temperature blackbody reference source (AC12206) which, when used in conjunction with NASA-owned scanner equipment (AADS1278 Scanner System), would permit the airborne measurement of fire, terrestrial, and atmospheric characteristics occurring within a scene.

The AB184 spectrometer is a 50-channel spectrometer which operates over the 1-13 μm wavelength range. The exact location of the 50 spectral bands measured by this spectrometer are defined below:

	SPECTROMETER CHANNEL NUMBER	BAND EDGES (in μm)
NEAR IR1 PORT	1	1.15 - 1.20
	2	1.20 - 1.25
	3	1.25 - 1.30
	4	1.30 - 1.35
	5	1.35 - 1.40
	6	1.40 - 1.45
	7	1.45 - 1.50
	8	1.50 - 1.55
NEAR IR2 PORT	9	1.55 - 1.60
	10	1.60 - 1.65
	11	1.65 - 1.70
	12	1.70 - 1.75
	13	1.75 - 1.80
	14	1.80 - 1.85
	15	1.85 - 1.90
	16	1.90 - 1.95
	17	1.95 - 2.00
	18	2.00 - 2.05
	19	2.05 - 2.10
	20	2.10 - 2.15
	21	2.15 - 2.20
	22	2.20 - 2.25
	23	2.25 - 2.30
	24	2.30 - 2.35

	SPECTROMETER CHANNEL NUMBER	BAND EDGES (in μm)
MIDBAND PORT	25	3.00 - 3.15
	26	3.15 - 3.30
	27	3.30 - 3.45
	28	3.45 - 3.60
	29	3.60 - 3.75
	30	3.75 - 3.90
	31	3.90 - 4.05
	32	4.05 - 4.20
	33	4.20 - 4.35
	34	4.35 - 4.50
	35	4.50 - 4.65
	36	4.65 - 4.80
	37	4.80 - 4.95
	38	4.95 - 5.10
	39	5.10 - 5.25
	40	5.25 - 5.40
THERMAL PORT	41	8.20 - 8.60
	42	8.60 - 9.00
	43	9.00 - 9.40
	44	9.40 - 9.80
	45	9.80 - 10.2
	46	10.2 - 10.7
	47	10.7 - 11.2
	48	11.2 - 11.7
	49	11.7 - 12.2
	50	12.2 - 12.7

The primary mission of the AB184 Spectrometer is to characterize high temperature fire scenes. To facilitate this process, the High Temperature Blackbody Reference Source Assembly AC12206 has been developed. Its use within the scanner system should enable the quantification of high temperature scenes.

The results of this particular research and development effort have been highly successful. Both the AB184 Spectrometer and the AC12206 High Temperature Blackbody Reference Source have been developed and tested during this contract effort. The performance of this newly developed hardware exceeds the original design goals established for its operation. In particular, assembly AC12206 has been shown to operate up to a maximum temperature of 350°C given 20°C ambient laboratory conditions. The design goal for this assembly was ≥200°C. In addition, testing of the AB184 Spectrometer has established that it provides 50 operational detector channels as expected (although, as delivered, two of the indium antimonide preamps are non-functional). For high temperature scenes up to 1200°C, excellent scanner performance is expected. Useful scanner operation is also anticipated to be achieved when one extends the operation of the instrument to include the characterization of the solar-reflective and/or self-radiative properties of normal terrestrial scenes.

1.1. Introduction

This research and development effort consisted of designing, manufacturing, integrating, and testing what has become denoted as the AB184 Spectrometer and the AC12206 High Temperature Blackbody Reference Source Assembly. The modular integration of these two pieces of equipment with existing NASA-owned scanner hardware (AADS1278 Scanner System) permits the airborne characterization of fire, terrestrial, and atmospheric conditions occurring within the scanner scene.

The AB184 Spectrometer is primarily designed to detect the spectral characteristics of high temperature scenes such as lava flows or wildfires. However, it can also be configured to acquire hyperspectral reflection and radiation data emanating from normal terrestrial scenes. The AB184 Spectrometer is optically and mechanically compatible with the AB122 Scan Head. It mounts directly on top of the AB122 via a series of mounting holes and precision positioning pins. The AB184 Spectrometer optically accepts a one-inch diameter, broadband collimated beam as its input. As its output, the AB184 Spectrometer produces 12 channels of analog electrical data. Each of the 12-output channels can, individually, represent the sum of as many as seven spectrometer channels. The exact spectral characteristics of the system output data can be customized by the user for various applications.

The AC12206 High Temperature Blackbody Reference Source Assembly functions as a high temperature calibration source which facilitates quantification of fire scenes. It is modular with and mounts directly to the AB122 Scan Head.

The results of this particular research and development effort have been highly successful. Both the AB184 Spectrometer and the AC12206 High Temperature Blackbody Reference Source have been developed and tested during this contract effort. In all but one area of stand-alone operation, the newly developed hardware functions at a level which exceeds originally established design goals. At delivery, the one deficiency in stand-alone spectrometer operation is the presence of two non-functional indium antimonide detector preamps.

The preamps which are used to amplify the detector signals in spectrometer channels 9-24 and 25-40 are purchased directly from the vendor, Cincinnati Electronics, Inc. These preamps are of a low-power, hybrid type design. All 32 of these hybrid type preamps were functional upon delivery from Cincinnati Electronics. However, at some point during integration and testing, the preamp circuits used to amplify spectrometer channels 27 and 35 were damaged. It is not known how this may have occurred. A major effort is not anticipated in order to correct this problem. However, the preamps will probably have to be sent back to Cincinnati Electronics in order to accomplish this task. A lack of funding and the need to keep all hardware at the Daedalus facility during integration created a situation wherein this repair could not be performed prior to delivery.

In addition to this stand-alone spectrometer deficiency, there was one other system level deficiency recognized during integration of the AB184 Spectrometer with the NASA-owned AADS1278 Scanner equipment. When fully integrated, the electronics contained in the AB184 Spectrometer run off of power (±15V) supplied by the AB325 Power Distributor. During the final stages of system integration, 2 independent problems associated with the ±15V power supply contained in the AB325 Power Distributor surfaced. First of all, it became apparent that the ±15V supply contained in the AB325 lacked sufficient power to drive all of the electronics contained in the AB184 Spectrometer. There is sufficient power to drive the AB184 Spectrometer provided that it is configured with a single AD18402 Summing Amplifier Circuit Board. As designed, the AB184 is capable of operating with two AD18402 circuit boards installed and operating. The AD18402 circuit boards allow the user to customize a 12-channel system output from the 50 spectrometer output channels. With two distinct AD18402 circuit boards simultaneously installed in the AB184 Spectrometer, the user is able to switch back and forth between two customized 12-channel system outputs at any time during scanner operation. Due to the power limitations described above, this switching capability is not possible at the time of system delivery. Only a single AD18402 circuit board can be installed at any one time.

The second problem associated with the ±15V power supply contained in the AB325 Power Distributor is the fact that noise from this power source is the dominant noise term for some of the spectrometer channels. This is particularly true for the channels processed by the Cincinnati Electronics hybrid preamps (channels 9-40). A significant reduction in the single-channel noise measurement was achieved when the AB184 Spectrometer was powered with a stand-alone laboratory supply. An attempt to quantify these results can be found in Section 4 of this report.

Daedalus has initiated an effort to correct at least a portion of the problems caused by the ±15V power supply contained in the AB325 Power Distributor.

A search for a larger capacity and, hopefully, quieter power supply has already begun. It is anticipated that the supply will be purchased by Daedalus and sent to NASA where a field modification will then take place. Delivery of the replacement power supply to NASA is expected to lag delivery of AB184 Spectrometer by several months. Until the field modification is made, the spectrometer can only be operated when configured with a single AD18402 Summing Amplifier Circuit Board.

2. Spectrometer Spectral Performance

Preliminary spectral band edges were defined for each of the 50 spectrometer channels prior to the start of this Phase II SBIR research and development effort. The placement of these preliminary band edges was based on the concept of continuous multispectral coverage of broad wavelength regions. The exact placement of the individual band edges in this system was not based on any unique scientific concerns. Rather, broad atmospheric windows were selected as ranges of instrument operation and, within each atmospheric window, the energy was to be dispersed into several spectrometer channels. This design concept was determined to be the most economical way of producing a scanner capable of characterizing high temperature fire scenes.

The results of spectral alignment testing of the AB184 Spectrometer have shown that the actual 50% power band edges of the operational instrument closely match the preliminary design goals.

Figures 1-3 represent the normalized response of AB184 Spectrometer channels 2, 5, and 7 respectively. These three spectrometer channels are all located in the Near IR1 Port and their spectral locations and bandwidths are indicative of the behavior of the Near IR1 Port channels in general. Below is a table which summarizes both the operational and the design-goal 50% power points for these three spectrometer channels.

	Channel	50% Power Points Design Goal		50% Power Points Operational	
		Lower	Upper	Lower	Upper
Near IR1 Port	2	1.20 μm	1.25 μm	1.191 μm	1.247 μm
	5	1.35 μm	1.40 μm	1.350 μm	1.400 μm
	7	1.45 μm	1.50 μm	1.459 μm	1.510 μm

Analysis of this table and Figures 1-3 shows that the operational band edges of channel 5 are identical to the preliminary design goals. As one moves to lower wavelengths (channel 2) the operational band edges are shifted to wavelengths slightly lower than the design goals. The opposite occurs as one moves to higher wavelengths (channel 7). Here the operational band edges shift to wavelengths higher than the design goal. In addition to the shift in band edges, the operational bandwidths of channels 2 and 7 begin to exhibit a slight wavelength broadening. This same general behavior occurs in the other three spectrometer ports. As one moves away from the channels located near the center of a given port, the operational band edges either shift to a lower or higher wavelength and, for the most part, the bandwidth increases.

It is theorized that the bandwidth broadening at the edges of a port is caused by a slight degradation in the image quality of the spectrometer's imaging lenses at the edge of their field-of-views. Sometimes this broadening is not apparent in the normalized channel response curves because of the presence of a second phenomenon: the rapid fall-off of the detector response at the extreme edges of its operational wavelength range. The second measurable phenomenon, the general shifting of operational band edges to either higher or lower wavelengths as one moves towards the edges of a given port, is probably the result of uncontrolled element-to-element isolation gaps present in the various detector arrays.

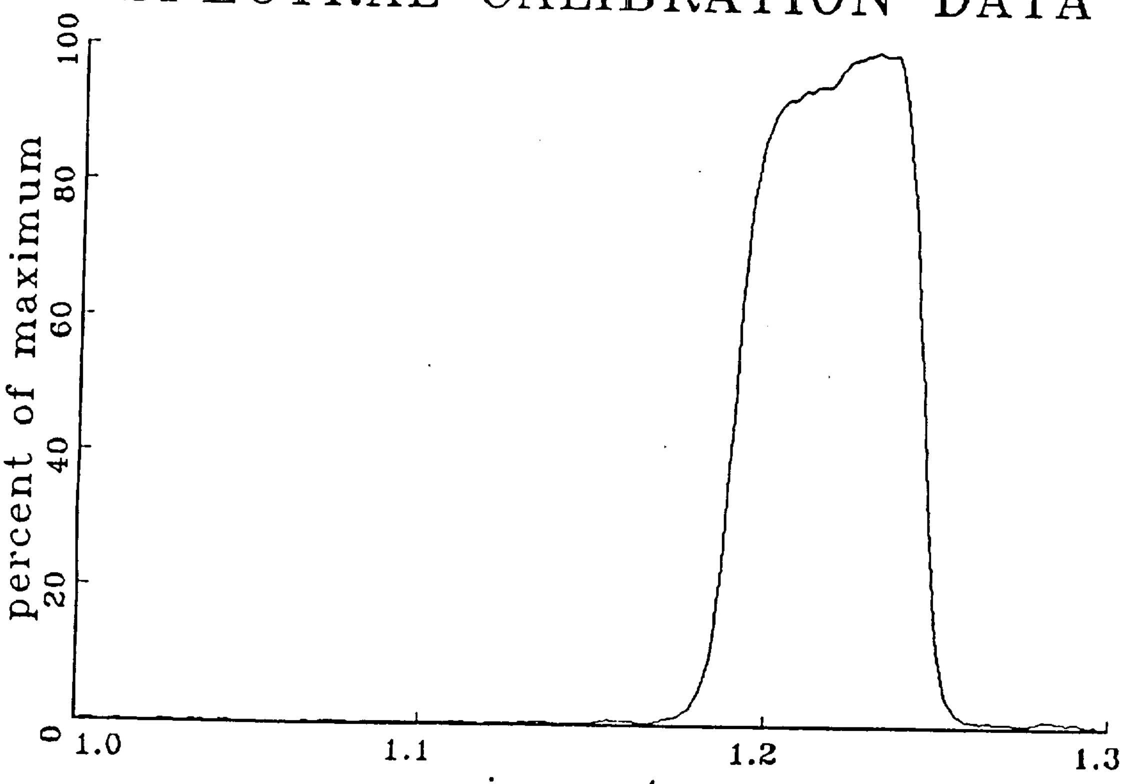
Figure 1.

SPECTRAL CALIBRATION DATA

File: N29102.CH Wed Feb 13 10:23:39 1991 Page 1

Operator Name:	JMG
Operator Comment(s):	SLITS=260
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	.72-1.35uM FILTER IN
Spectrometer Identification:	WILDFIRE(AB184)
Detector(s) Identification:	NEAR IR1
Monochromator Speed:	1000
Monochromator Start Reading:	10000
Monochromator End Reading:	13000
Grating Identification:	300G 30000A
Source Identification:	TUNG 91 120V
Number of Readings:	299
File Code:	4 [4AUG06]
Raw Data File	29102.CH
Normalization Data File	12feb91.rf1

SPECTRAL CALIBRATION DATA



LOWER HALF POWER POINT AT 1.191 micrometers
UPPER HALF POWER POINT AT 1.247 micrometers
PEAK POWER AT 1.233 micrometers

99% of the energy is between 1.150 and 1.261 nm

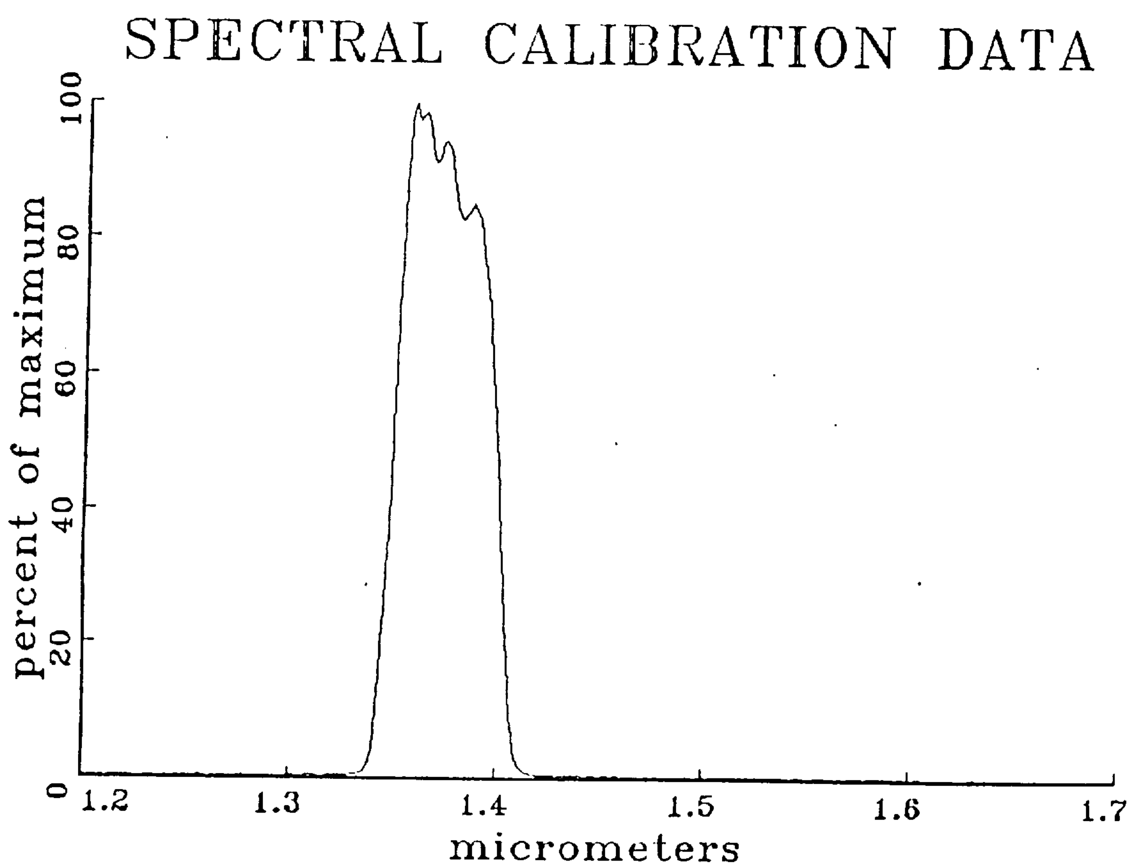
Figure 2.

File: N291C5.CH

SPECTRAL CALIBRATION DATA
Wed Feb 13 09:40:26 1991

Page 1

Operator Name:	JMG
Operator Comment(s):	SLITS=350
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	1.2-2.0uM FILTER IN
Spectrometer Identification:	WILDFIRE(AB184)
Detector(s) Identification:	NEAR IR1
Monochromator Speed:	1000
Monochromator Start Reading:	12000
Monochromator End Reading:	16500
Grating Identification:	300G 30000A
Source Identification:	TUNG 91 120V
Number of Readings:	448
File Code:	4 [4AUG80]
Raw Data File	291C5.CH
Normalization Data File	12feb91.rf2

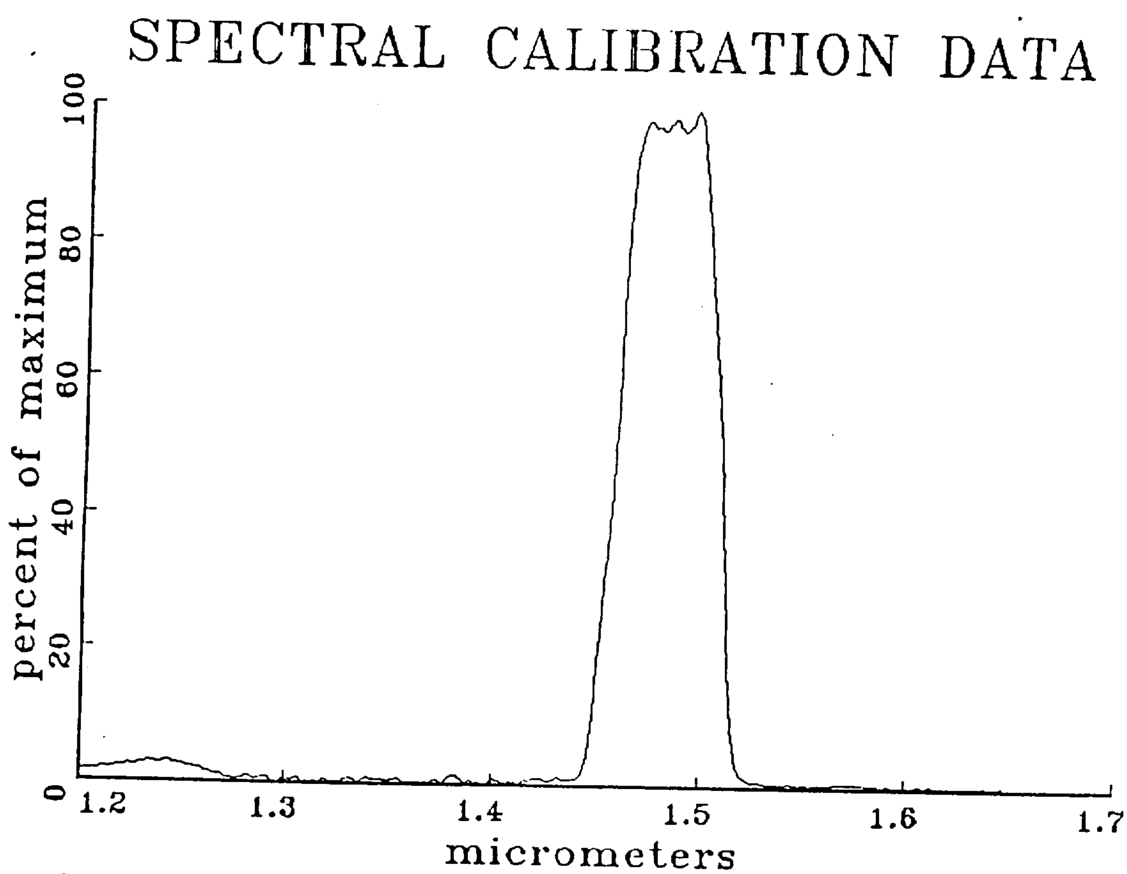


LOWER HALF POWER POINT AT	1.350 micrometers
UPPER HALF POWER POINT AT	1.400 micrometers
PEAK POWER AT	1.359 micrometers

99% of the energy is between 1.341 and 1.442 nm

Figure 3.

Operator Name:	JMG
Operator Comment(s):	SLITS=280
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	1.2-2.0uM FILTER IN
Spectrometer Identification:	WILDFIRE(AB184)
Detector(s) Identification:	NEAR IR1
Monochromator Speed:	1000
Monochromator Start Reading:	12000
Monochromator End Reading:	16500
Grating Identification:	300G 30000A
Source Identification:	TUNG 91 120V
Number of Readings:	418
File Code:	4 [4AUG86]
Raw Data File	291c7.ch
Normalization Data File	12feb91.rf2



LOWER HALF POWER POINT AT 1.459 micrometers
UPPER HALF POWER POINT AT 1.510 micrometers
PEAK POWER AT 1.496 micrometers

95% of the energy is between 1.422 and 1.524 nm

Figures 4-12 represent the normalized response of AB184 Spectrometer channels 12, 17, 24, 25, 32, 40, 41, 45, and 49 respectively. The table below summarizes both the operational and the design-goal 50% power points for these spectrometer channels.

Channel	50% Power Points Design Goal		50% Power Points Operational	
	Lower	Upper	Lower	Upper
12	1.70 μm	1.75 μm	1.689 μm	1.741 μm
17	1.95 μm	2.00 μm	1.954 μm	2.003 μm
24	2.30 μm	2.35 μm	2.308 μm	2.355 μm
25	3.00 μm	3.15 μm	2.989 μm	3.140 μm
32	4.05 μm	4.20 μm	4.059 μm	4.202 μm
40	5.25 μm	5.40 μm	5.294 μm	5.405 μm
41	8.20 μm	8.60 μm	8.153 μm	8.495 μm
45	9.80 μm	10.20 μm	9.836 μm	10.178 μm
49	11.70 μm	12.20 μm	11.732 μm	12.171 μm

3. Spectrometer Measurement Sensitivity

The primary mission of the AB184 Spectrometer is to characterize high temperature fire scenes. To do this properly, the detector signals must be prevented from saturating both the analog electronics and the digitizer A/D's. A scene temperature of 1200°C was established as the highest non-saturating temperature over which the system must operate. To achieve this goal, the detector preamplifier gain must be set at a level much lower than what is used in normal terrestrial scanners.

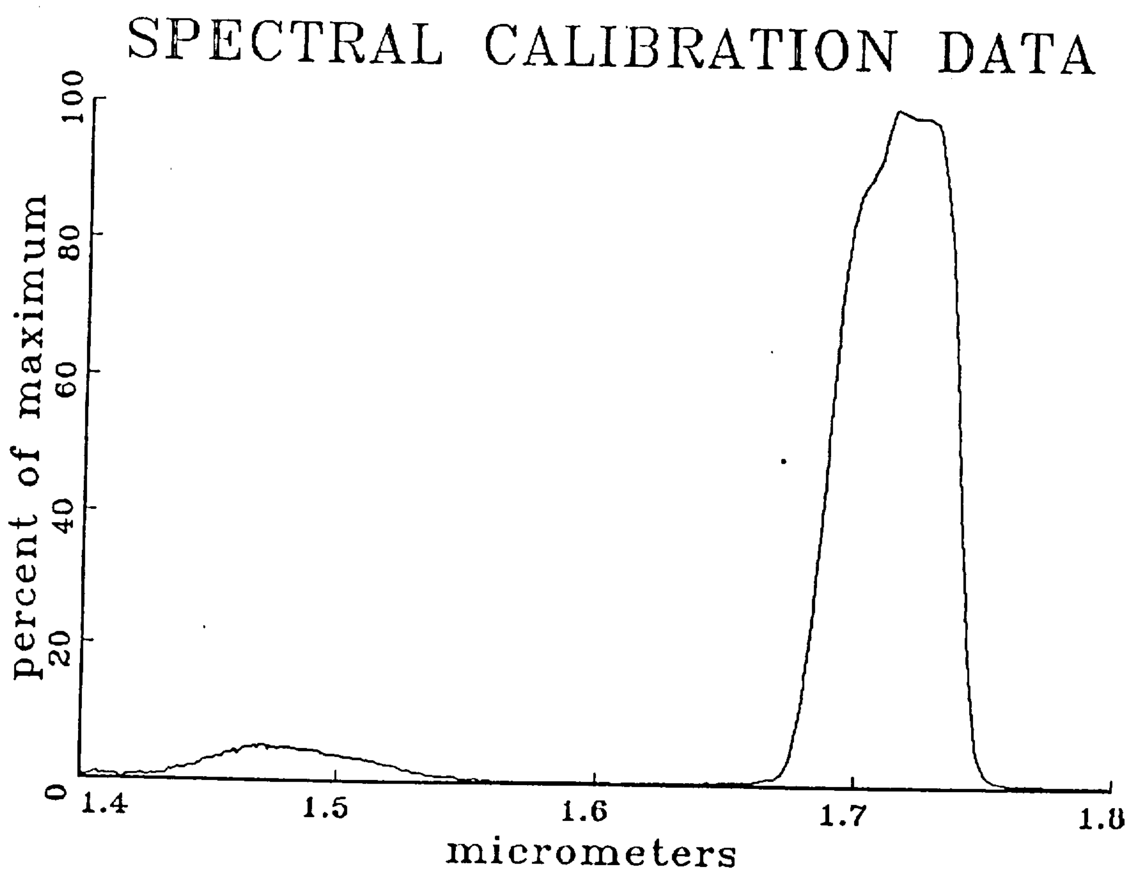
Figure 4.

File: N291C12.CH

SPECTRAL CALIBRATION DATA
Wed Feb 13 16:20:25 1991

Page 1

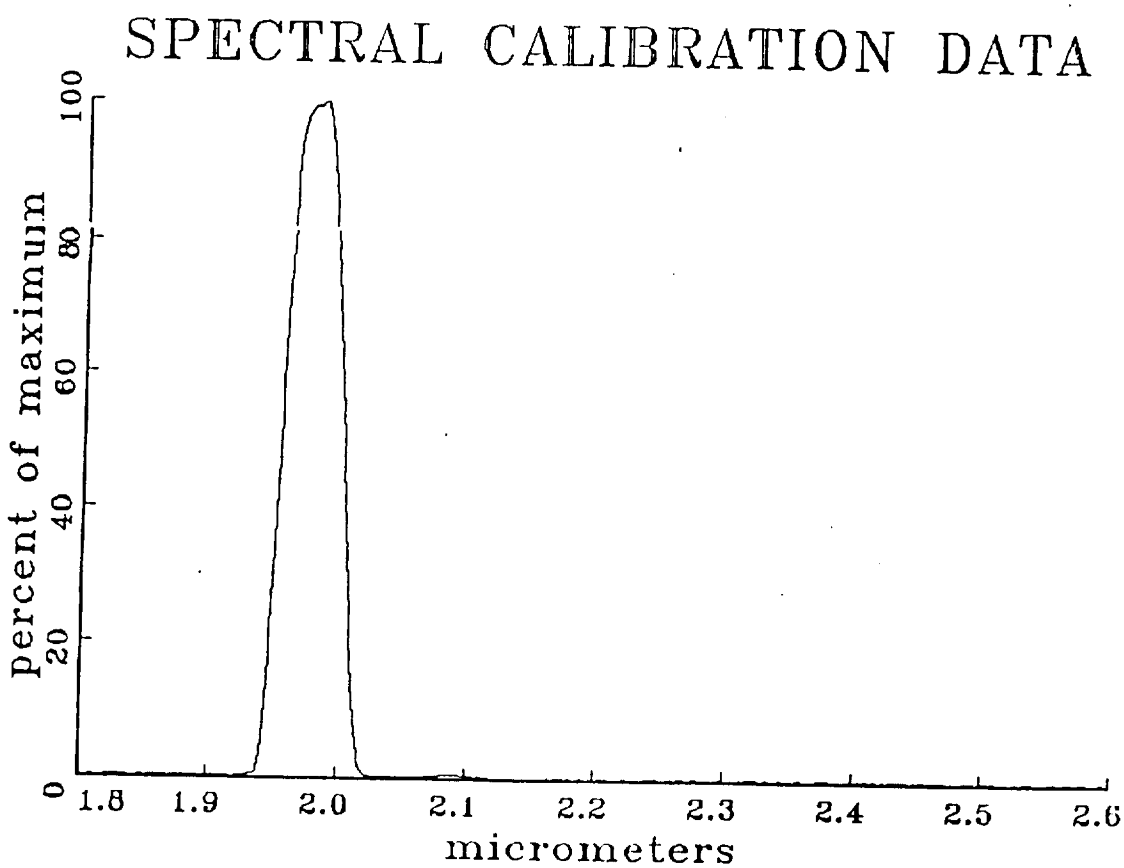
Operator Name:	JMG
Operator Comment(s):	SLITS=280
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	1.2-2.0uM FILTER IN
Spectrometer Identification:	WILDFIRE(AB184)
Detector(s) Identification:	1718-01A
Detector(s) Identification:	SDD-2296-16-H
Monochromator Speed:	1000
Monochromator Start Reading:	14000
Monochromator End Reading:	18000
Grating Identification:	300G 30000A
Source Identification:	TUNG 91 120V
Number of Readings:	399
File Code:	4 [4AUG86]
Raw Data File	291C12.CH
Normalization Data File	12feb91.rf3



LOWER HALF POWER POINT AT	1.689 micrometers
UPPER HALF POWER POINT AT	1.741 micrometers
PEAK POWER AT	1.715 micrometers

93% of the energy is between 1.664 and 1.767 nm

Operator Name:	JMG
Operator Comment(s):	SLITS=280
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	1.0-3.0uM FILTER IN
Spectrometer Identification:	WILDFIRE(AD184)
Detector(s) Identification:	1718-01A
Detector(s) Identification:	SDD-2296-16-H
Monochromator Speed:	1000
Monochromator Start Reading:	18000
Monochromator End Reading:	26000
Grating Identification:	300G 30000A
Source Identification:	TUNG 91 120V
Number of Readings:	796
File Code:	4 [4AUG86]
Raw Data File	291C17.CH
Normalization Data File	12feb91.rf4



LOWER HALF POWER POINT AT	1.954 micrometers
UPPER HALF POWER POINT AT	2.003 micrometers
PEAK POWER AT	1.985 micrometers

99% of the energy is between 1.923 and 2.021 nm

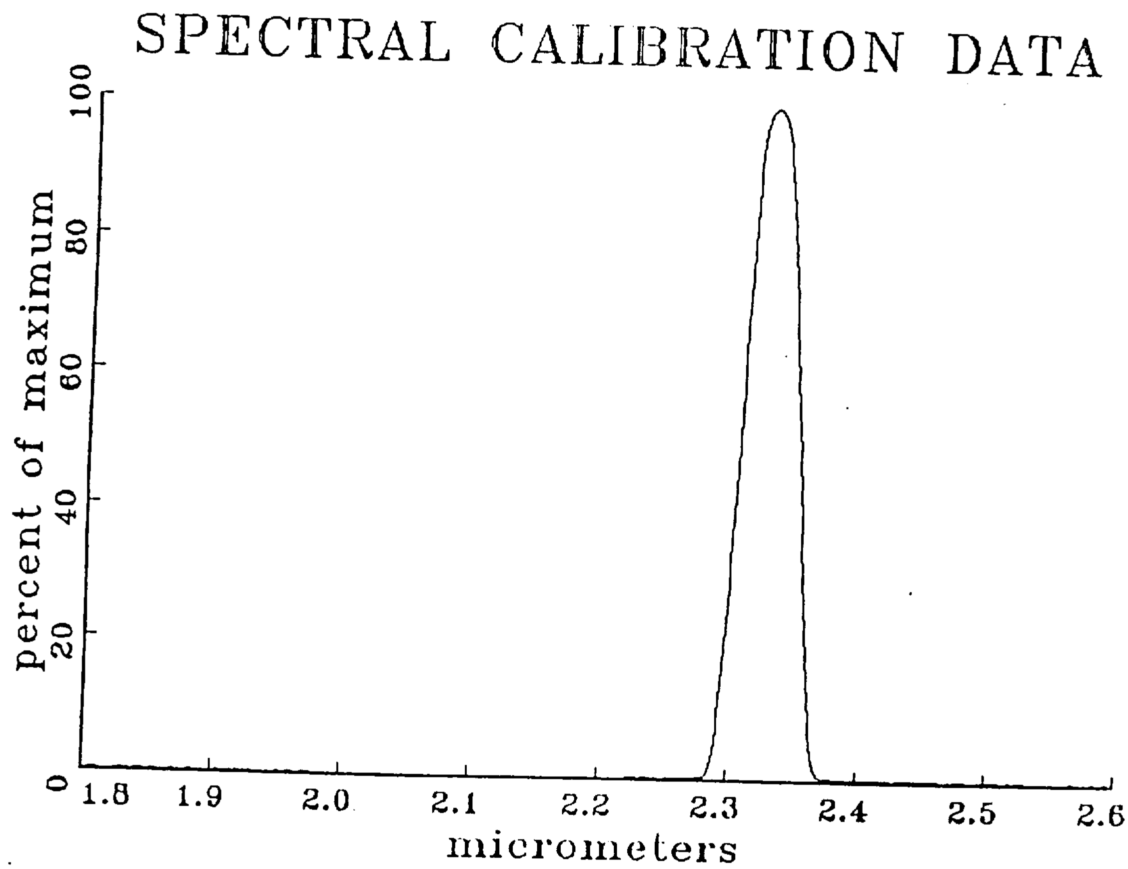
Figure 6.

SPECTRAL CALIBRATION DATA
Wed Feb 13 17:21:36 1991

File: N291C24.CH

Page 1

Operator Name:	JMG
Operator Comment(s):	SLITS=200
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	1.8-3.0uM FILTER IN
Spectrometer Identification:	WILDFIRE(AB184)
Detector(s) Identification:	1710-01A
Detector(s) Identification:	SDD-2296-16-H
Monochromator Speed:	1000
Monochromator Start Reading:	18000
Monochromator End Reading:	26000
Grating Identification:	300G 30000A
Source Identification:	TUNG 91 120V
Number of Readings:	796
File Code:	4 [4AUG86]
Raw Data File	291C24.CH
Normalization Data File	12feb91.rf4



LOWER HALF POWER POINT AT	2.308 micrometers
UPPER HALF POWER POINT AT	2.355 micrometers
PEAK POWER AT	2.331 micrometers

99% of the energy is between 2.285 and 2.378 nm

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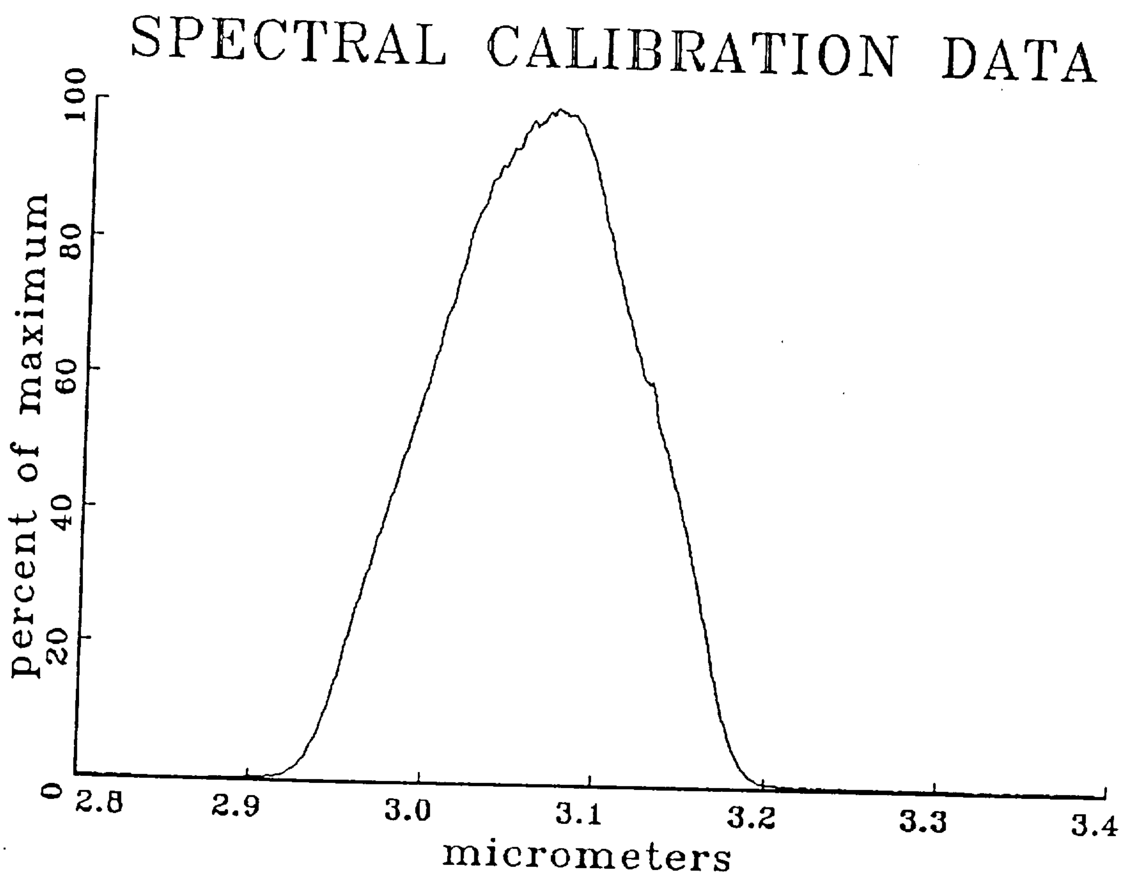
Figure 7.

SPECTRAL CALIBRATION DATA
File: N291C25.CH1 Tue Feb 12 14:54:12 1991 Page 1

Operator Name:	JMG
Operator Comment(s):	SLITS=1000
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	2.7-4.5uM FILTER IN
Spectrometer Identification:	WILDFIRE(AB184)
Detector(s) Identification:	1718-01B
Detector(s) Identification:	SDD-2296-16-H
Monochromator Speed:	1000
Monochromator Start Reading:	28000
Monochromator End Reading:	34000
Grating Identification:	3006 30000A
Source Identification:	TUNG 91 120V
Number of Readings:	597
File Code:	4 [4AUG86]
Raw Data File	FEB91c25.ch1
Normalization Data File	12feb91.rf5



LOWER HALF POWER POINT AT 2.900 micrometers
UPPER HALF POWER POINT AT 3.140 micrometers
PEAK POWER AT 3.073 micrometers

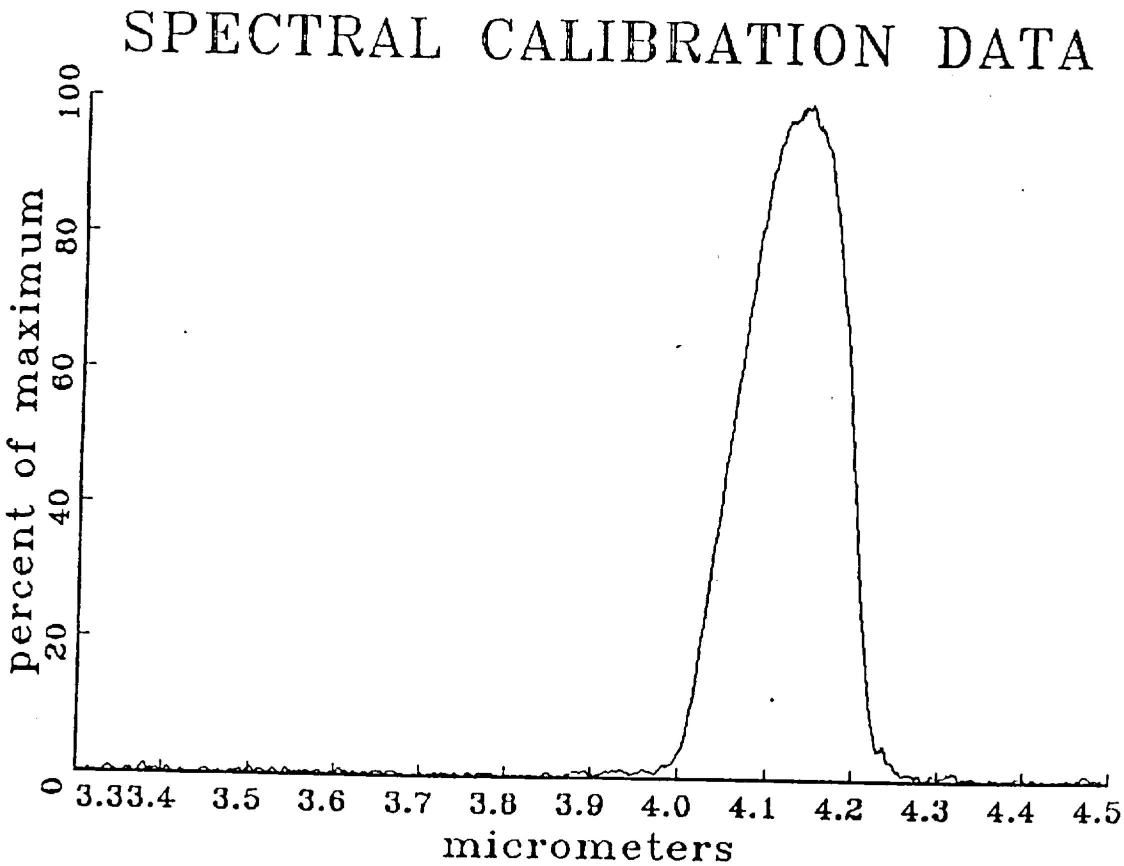
100% of the energy is between 2.906 and 3.208 nm

Figure 8.

File: N291C32.CH

SPECTRAL CALIBRATION DATA
Thu Feb 14 11:02:34 1991

Operator Name:	JMG
Operator Comment(s):	SLITS=1400
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	2.7-4.5uM FILTER IN
Spectrometer Identification:	WILDFIRE
Detector(s) Identification:	1718-01B
Detector(s) Identification:	SDD-2296-16-H
Monochromator Speed:	2000
Monochromator Start Reading:	33000
Monochromator End Reading:	45000
Grating Identification:	150g 6 uM
Source Identification:	GD 140V
Number of Readings:	597
File Code:	4 [4AUG86]
Raw Data File	291C32.CH
Normalization Data File	14feb91.rfC



LOWER HALF POWER POINT AT	4.059 micrometers
UPPER HALF POWER POINT AT	4.202 micrometers
PEAK POWER AT	4.148 micrometers

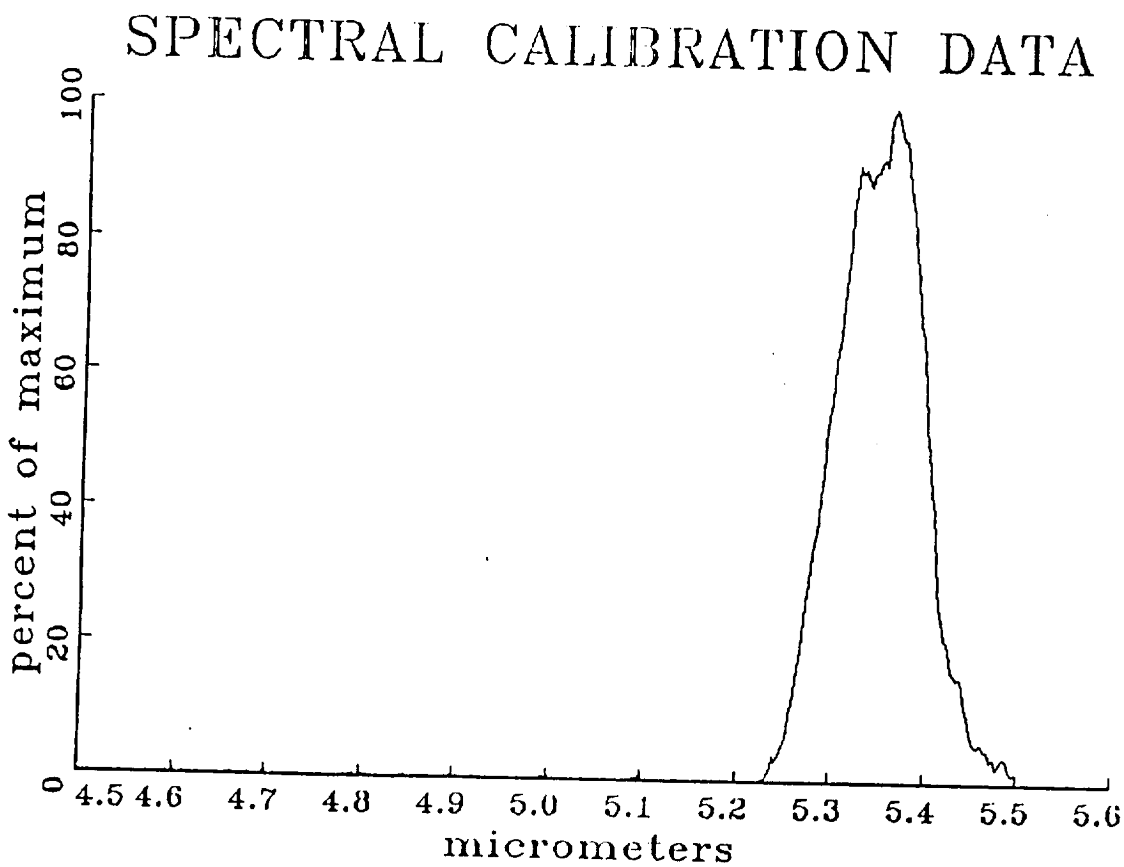
98% of the energy is between 3.971 and 4.256 nm

Figure 9.

File: N291C40.CH

SPECTRAL CALIBRATION DATA
Thu Feb 14 10:40:17 1991

Operator Name:	JMG
Operator Comment(s):	SLITS=1400
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	3.8-6.5uM FILTER IN
Spectrometer Identification:	WILDFIRE
Detector(s) Identification:	1718-01B
Detector(s) Identification:	SDD-2296-16-H
Monochromator Speed:	2000
Monochromator Start Reading:	45000
Monochromator End Reading:	56000
Grating Identification:	150g 6 uM
Source Identification:	GB 140V
Number of Readings:	540
File Code:	4 [4AUG86]
Raw Data File	291C40.CH
Normalization Data File	14geb91.rf7



LOWER HALF POWER POINT AT	5.294 micrometers
UPPER HALF POWER POINT AT	5.405 micrometers
PEAK POWER AT	5.365 micrometers

90% of the energy is between 5.224 and 5.445 nm

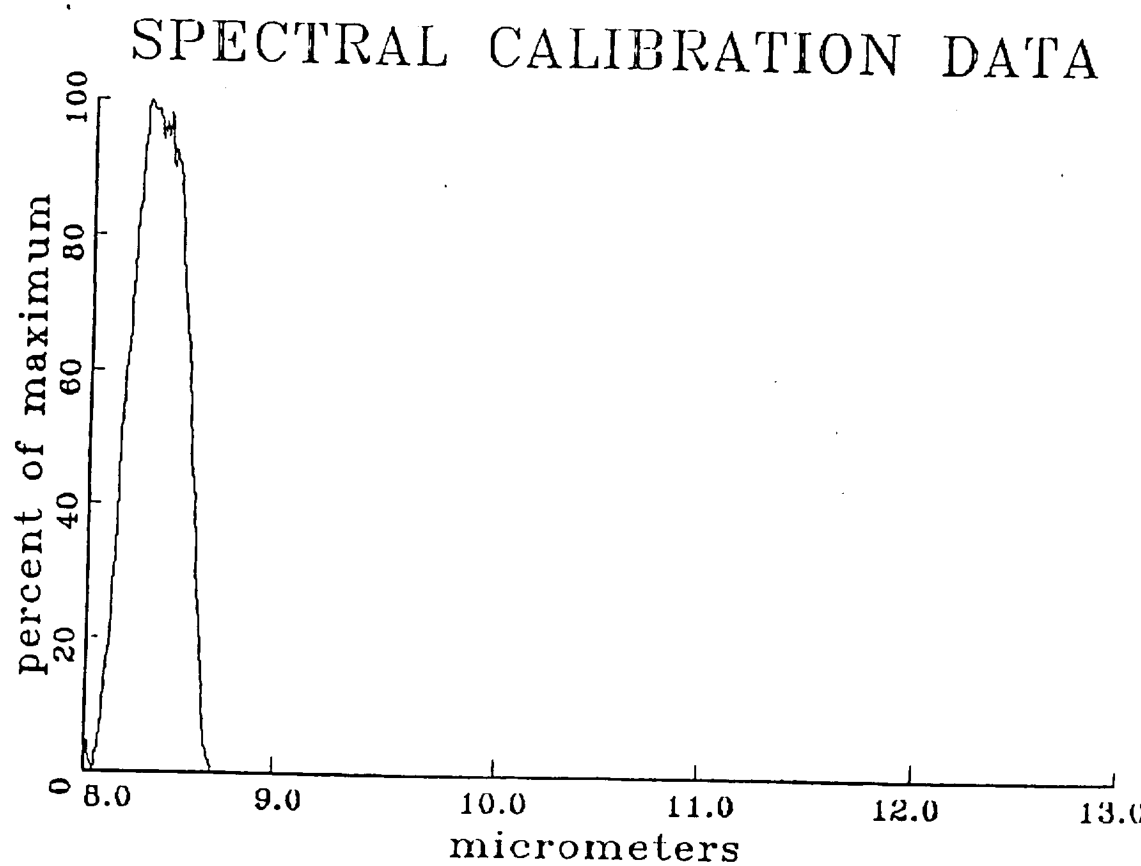
Figure 10.

File: N291C41.C12

SPECTRAL CALIBRATION DATA
Fri Feb 15 11:03:56 1991

Page 1

Operator Name:	JMG
Operator Comment(s):	SLITS=300
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	9-15uM FILTER IN
Spectrometer Identification:	WILDFIRE
Detector(s) Identification:	BELOV 90102-41
Monochromator Speed:	4000
Monochromator Start Reading:	80000
Monochromator End Reading:	130000
Grating Identification:	75g 8 uM
Source Identification:	GB 140V
Number of Readings:	1243
File Code:	4 [4AUG86]
Raw Data File	291C41.c12
Normalization Data File	21DEC87A.R12



LOWER HALF POWER POINT AT	8.153 micrometers
UPPER HALF POWER POINT AT	8.495 micrometers
PEAK POWER AT	8.266 micrometers

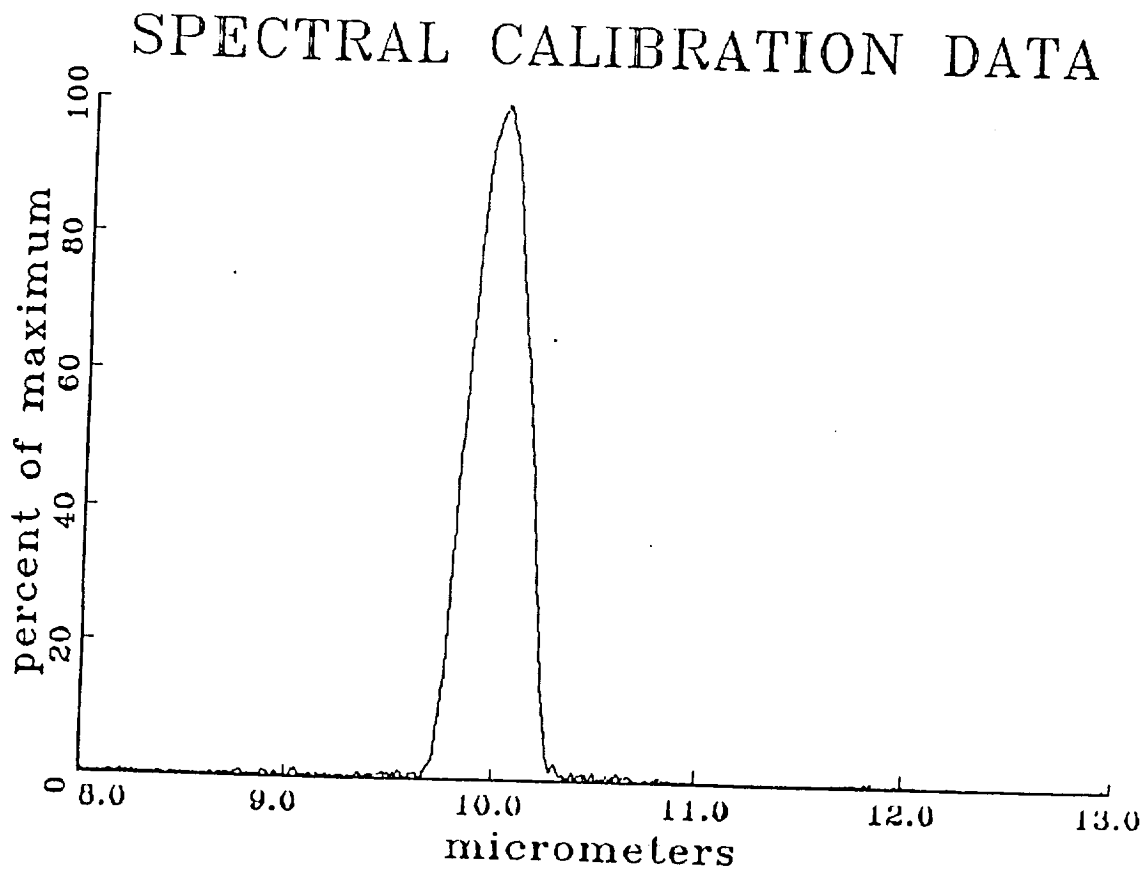
of the energy is between 8.040 and 8.725 nm

Figure 11.

File: N291C45.C12

SPECTRAL CALIBRATION DATA
Fri Feb 15 11:47:41 1991

Operator Name:	JMG
Operator Comment(s):	SLITS=370
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	9-15uM FILTER IN
Spectrometer Identification:	WILDFIRE
Detector(s) Identification:	BELOV 90102-41
Monochromator Speed:	4000
Monochromator Start Reading:	80000
Monochromator End Reading:	130000
Grating Identification:	75g 8 uM
Source Identification:	GB 140V
Number of Readings:	1243
File Code:	4 [4AUG86]
Raw Data File	291C45.C12
Normalization Data File	21DEC87A.R12



LOWER HALF POWER POINT AT 9.830 micrometers
UPPER HALF POWER POINT AT 10.178 micrometers
PEAK POWER AT 10.017 micrometers

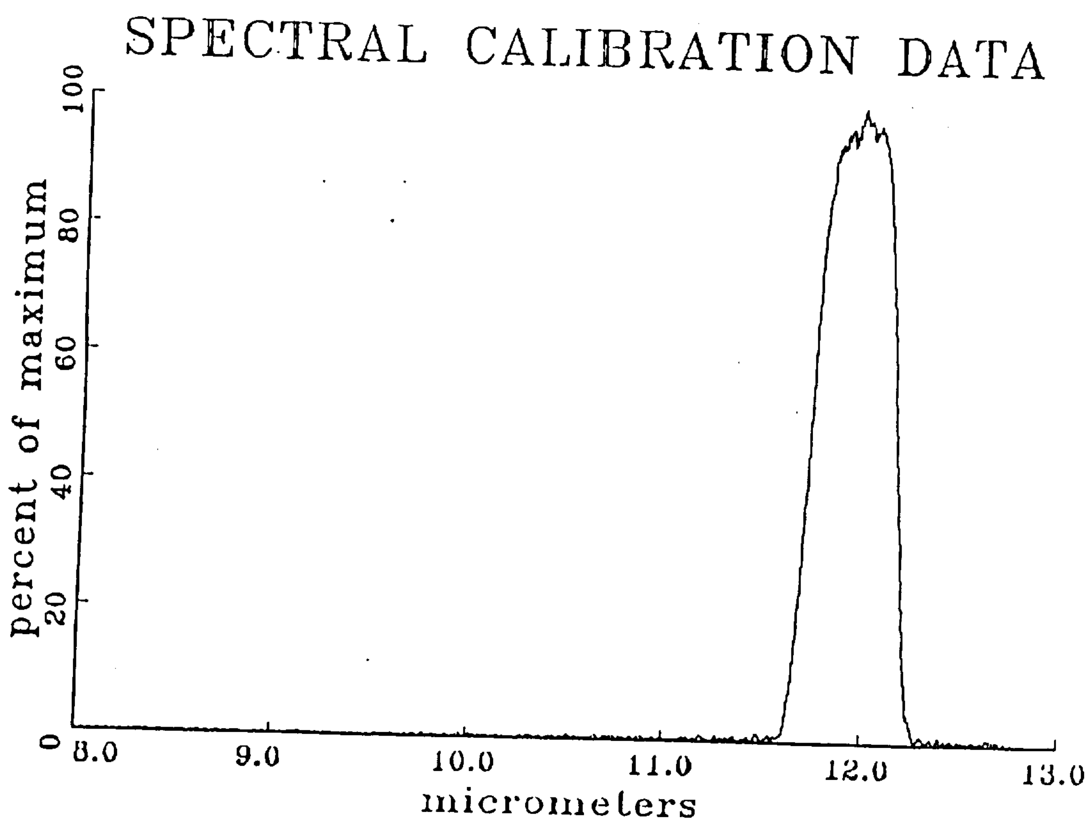
90% of the energy is between 9.655 and 10.339 nm

Figure 12.

File: N291C49.C12

SPECTRAL CALIBRATION DATA
Fri Feb 15 11:27:03 1991

Operator Name:	JMG
Operator Comment(s):	SLITS=600
Operator Comment(s):	PRE TC=1S POST TC=1S
Operator Comment(s):	9-15uM FILTER IN
Spectrometer Identification:	WILDFIRE
Detector(s) Identification:	BELOV 90102-41
Monochromator Speed:	4000
Monochromator Start Reading:	80000
Monochromator End Reading:	130000
Grating Identification:	75g 8 uM
Source Identification:	GB 140V
Number of Readings:	1243
File Code:	4 [4AUG88]
Raw Data File	291C49.C12
Normalization Data File	21DEC87A.R12



LOWER HALF POWER POINT AT 11.733 micrometers
UPPER HALF POWER POINT AT 12.171 micrometers
PEAK POWER AT 11.973 micrometers

96% of the energy is between 11.490 and 12.366 nm

Most commonly accepted measures of scanner sensitivity performance are based on signal levels which are associated with either solar reflection or self-radiation of scenes at normal terrestrial temperatures (0-55°C). To optimally measure these phenomena requires preamplifier gain levels two or three orders of magnitude greater than those used in the AB184 Spectrometer. As designed, the AB184 Spectrometer can be used to record normal terrestrial scenes. This is accomplished by placing the added gain at the Summing Amplifier Circuit Board (AD18402) stage of the analog processing chain. Configured in this manner, the measurement sensitivity performance of the AB184 Spectrometer can be determined. When measured, these sensitivity performance values do not accurately represent the optimum performance of the system. The user must keep in mind that optimum sensitivity performance has been sacrificed in order to accommodate the specific requirements of the fire mission. Any electromagnetic pickup and/or electronic noise introduced after the preamplifier stage and before the Summing Amplifier stage of the analog processing chain will be amplified by whatever gain factor is applied by circuit board AD18402. The AB184 Spectrometer is especially susceptible to electronic noise in that the video signals travel a relatively long distance from the preamps to circuit board AD18402 in non-coaxial wires. If all the required gain is located in the preamplifier stage, the magnitude of the electronic noise term is reduced and, thus, measurement sensitivity is increased.

Another factor which needs to be addressed when discussing the measurement sensitivity performance of the AB184 Spectrometer is the presence of power supply noise in the spectrometer video data. As was previously mentioned in this report, power supply noise spikes appear as a dominant noise component of the spectrometer video signal. This is particularly true for channels 9-40. This problem might be coupled to the low preamplifier gain used in the AB184 Spectrometer. If a greater preamplifier gain was used, particularly in channels 9-40, one might see an increase in "white" detector noise without a comparable scaling of the power supply noise. If this were to occur and the "white" detector noise was increased to a point where it dominated the power supply induced noise, the benefit of operating the system with quieter power would be removed.

At several instances during instrument integration, the sensitivity performance of select channels was measured under conditions of increased preamplifier gain and/or quieter supply power. Independently, both techniques improved the measurement sensitivity performance of the spectrometer. A combination of both these techniques yielded the overall best system performance.

The table below summarizes the measurement sensitivity performance of the AB184 Spectrometer when optimized for both fires and normal scenes. The CONFIGURED FOR FIRE columns represent the performance of the spectrometer with the preamplifier gain set for fire operation, using system power (±15V), and with an external bandpass filter limiting the system bandwidth to 32 KHz. The OPTIMIZED FOR NORMAL SCENES columns represent the performance of the spectrometer with increased preamplifier gain, an external laboratory supply providing ±15V to the spectrometer, and with an external bandpass filter limiting the system bandwidth to 32

KHz. Note: This frequency is the 3 db point required for 25 s/s operation in the scanner system (maximum rate). Normal operation from a high altitude platform uses an upper frequency limit of either 16 KHz or 8 KHz, which will improve the system sensitivity from those values listed in the table.

AB184 SPECTROMETER MEASUREMENT SENSITIVITY PERFORMANCE					
CH #	NER Configured for FIRE	25 scans/sec NER Optimized for Normal Scenes	CH #	NETD Configured for FIRE	NETD Optimized for Normal Scenes
1	2.80 E-08	2.10	25	≈25	10
2	3.01	2.30	26	≈ 25	10
3	2.81	2.10	27	bad preamp	bad preamp
4	3.07	2.30	28	5.60	2.80
5	4.01	3.00	29	3.27	1.65
6	4.57	3.40	30	2.31	1.15
7	4.76	3.60	31	1.70	.85
8	4.09	3.00	32	1.63	.80
9	7.13	3.55	33	.98	.50
10	5.71	2.85	34	.63	.30
11	4.91	2.45	35	bad preamp	bad preamp
12	4.76	2.35	36	.56	.30
13	4.49	2.25	37	.58	.30
14	4.32	2.15	38	.63	.30
15	3.99	2.00	39	.78	.40
16	3.83	1.90	40	1.51	.75
17	3.91	1.95	41	.50	.30
18	3.88	1.95	42	.38	.23
19	3.80	1.90	43	.29	.17
20	4.14	2.10	44	.36	.22
21	4.50	2.25	45	.46	.28
22	4.93	2.50	46	.46	.28
23	5.12	2.55	47	.89	.53
24	5.54	2.75	48	1.14	.68
			49	1.50	.90
			50	2.65	1.60

A final comment regarding AB184 Spectrometer measurement sensitivity performance is required. As designed, the AB184 Spectrometer provides the user the capability of summing up to seven individual spectrometer channels to form a single system channel possessing an increased spectral bandwidth and, theoretically, increased measurement sensitivity performance. If the single channel video noise is white and random, summing two channels together should increase the combined noise of the channel to the square root of the sum of the individual noise terms. The signal would increase to the sum of the two individual channels. The combined effect would be to produce a channel possessing an increased signal-to-noise ratio (SNR) and, thus, improved measurement sensitivity performance. However, the results of the system ATP indicate that this improvement in SNR is not occurring. During the ATP, the single channel NETD of spectrometer channel 43 was measured. In addition to this, the NETD of the sum of spectrometer channels, 42-47, was also measured. The measured NETD of channel 43 was less than the 42-47 sum. The only explanation for this observed behavior is that the dominant video noise is coherent-type noise rather than random white noise. If the video noise is coherent, it will add linearly just as the signal does, thus, preventing any improvement in SNR. Power supply noise and 60-cycle pick-up are suspected of causing the observed results.

4. High Temperature Blackbody Reference Source Performance

The performance of the AC12206 High Temperature Blackbody Reference Source Assembly exceeds the design goals established for its operation. Its adjustable operational temperature range extends from 270°C to 350°C given 20°C ambient laboratory conditions. Because of concerns over possible side effects of operating this high temperature reference source in close proximity to the scan head and spectrometer optics, testing of assembly AC12206 within the system has been limited. Because of this, the long-term effects of operating assembly AC12206 are not known at this time. Even if long-term testing in the laboratory is carried out, it may not provide insight concerning how assembly AC12206 will effect the rest of the system hardware at operational altitudes. Further testing of assembly AC12206 is recommended prior to its use during an operational mission.

5. Conclusions and Recommendations

The AB184 Spectrometer is a functional instrument which can be used with the NASA-owned AADS1278 equipment to acquire scene data over high temperature scenes. For this application, the system is anticipated to perform in a superior fashion. Prior to the field modification of the AB325 Power Distributor (replacement of ±15V power supply), the AB184 Spectrometer can only be operated with a single AD18402 Summing Amplifier Circuit Board installed.

Extensive testing of the effects of operating the AADS1278 system with the AC12206 High Temperature Blackbody Reference Source Assembly installed is recommended prior to using this assembly in an actual scanner mission. Testing should take place using simulated operational environmental conditions.

If the spectrometer is to be used to acquire hyperspectral reflection and radiation data emanating from normal terrestrial scenes, consideration should be given to increasing the preamplifier gain to the required levels.

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15. Supplementary Notes

16. Abstract

The AB184 Spectrometer and the AC12206 High Temperature Blackbody Reference Source Assembly have both been successfully developed during this contract effort. The newly developed hardware provide a means of quantifying the spectral characteristics of high temperature fire scenes.

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