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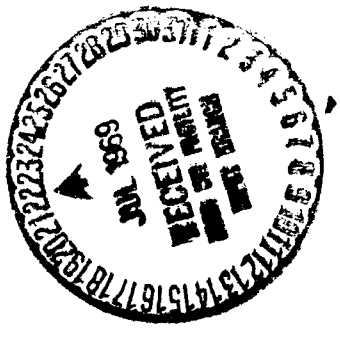
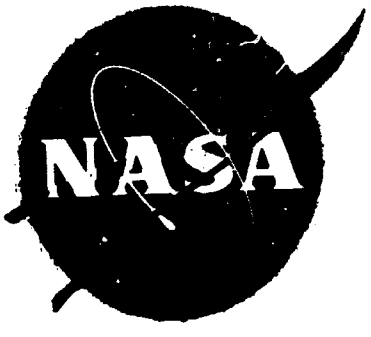
NASA REMOTE SENSING PROJECT

Technical Letter # 14





Mackay School of Mines
University of Nevada
Reno, Nevada

MACKAY SCHOOL OF MINES

UNIVERSITY OF NEVADA

RENO, NEVADA

Ground Data Investigations
Sonora Pass, Site 19-Mission 78

by
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Prepared for the
National Aeronautical and Space Administration

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TABLE OF CONTENT

INTRODUCTION..... 1

RADIOMETRIC AND TEMPERATURE DATA..... 2

SOIL MOISTURE..... 6

SPECTRAL INTENSITY MEASUREMENTS.....11

SPECTRAL HYGROMETRIC STUDIES.....14

CLOUD PHOTOGRAPHY.....19

RADIOSONDE BALLOON DATA.....21

INTRODUCTION

The data embodied in this technical letter was gathered during August of 1968, prior to and during flights 1 and 2 of mission 78, flown with the P3A, NASA 927 aircraft.

This data was gathered in support of the infrared spectrometer experiment under the direction of Dr. R. J. P. Lyon of Stanford University. The RS-7 infrared imager and the RC-8 metric camera were also operated in support of the infrared spectrometer.

Flight 1 on August 27, 1968, flew three high altitude and seven low altitude runs over Blackhawk Mountain. Three high altitude runs were made over Brown Bear Pass and two runs on the line between the two targets, a distance of 2-1/2 miles. Flight 2 of August 28th, included a low altitude run over Blackhawk Mountain, seven low altitude runs over Brown Bear Pass and a number of runs over the metamorphic rocks five miles south of Brown Bear Pass.

Ground truth information was provided by two crews, stationed at Blackhawk Mountain and Brown Bear Pass.

RADIOMETRIC TEMPERATURE,

THERMISTER TEMPERATURE AND WEATHER DATA

The following rock temperature and weather data was collected at ground stations and is presented in the original form; except for the conversion of all temperatures to the Celsius scale.

The radiometric data was taken with Barnes PRT-4, 8-14 micron bandpass infrared radiometers. The Blackhawk Mountain measurements were taken with a 3° field of view radiometer, the Brown Bear Pass measurements with an 18° field of view radiometer. Each radiometer target was chosen as a fairly representative example of the material. The radiometric temperatures have not been corrected for emissivity variations.

Thermister probe measurements were made using a Digatec digital thermometer and standard thermister probes. The digital probe air temperatures are taken using a wind shielded probe placed in the shade.

Weather observations were made at regular intervals. Wind velocities were measured with hand anemometers. Relative humidity was calculated from sling psychrometer readings.

Sonora Pass -- Site #19
Blackhawk Mtn.
August 27, 1968

Time	Run No.	Radiometer (8-14μ) Readings: Andesite Outcrop	Scree	Vegetation	Granite ½ mile	Digatic Readings: Air	Andesite Soil 0"	Andesite Soil 1"	Andesi e Soil 3"	Weather Data: Rel. Hum.	Wind	Cloud Cover
11:30		21.1	27.8	15.5	18.3	17.4 C	27.5	12.5	9.8	24%	10-15 SW	
11:45		21.1	28.8	16.1	18.3	18.0	29.8	12.6	9.2		15 SW	
11:55		22.2	29.4	16.1	19.4	18.8	31.2	13.3	9.5		15 SW	
12:05		22.8	30.5	15.5	20.0	19.0	29.0	13.5	9.5	25%	15 SW	Stratus
12:15		23.8	30.5	16.6	20.0	19.7	29.0	13.7	9.7		15 SW	
12:25		24.4	31.1	16.6	20.6	19.9	29.8	13.8	9.8		17 SW	
12:30		25.0	32.2	17.8	20.6	19.9	30.3	14.3	10.6	26%	20 SW	
12:40		25.0	32.2	18.9	20.6	19.9	30.4	14.9	10.8		20 SW	and
12:45		--	--	--	--	--	--	--	--	-	--	
12:50		26.1	32.2	20.0	20.6	20.3	30.1	15.5	11.0		17-20 SW	
13:00		--	--	--	--	--	--	--	--	14%	--	
13:15		26.1	32.8	20.6	20.6	22.2	32.2	15.9	11.8			Cirrus

TABLE 1

*All temperatures in degrees Celsius.

Sonora Pass -- Site #19
Brown Bear
August 27, 1968

Time	Run No.	Basalt† Soil	Basalt	Basalt Scree	Granite at Distance	Soil w/vegetation	Andesite at Distance	Rel. Hum.	Wind	Cloud Cover
12:05		26.1	28.3	35.6	17.8	16.1	18.3	28%	5-15W	2% on horiz
12:25	E2	26.1	31.1	39.3	18.3	16.6	19.4	29%	5-20W	--
12:28	E3	26.1	31.7	37.7	18.3	15.0	18.8	-	--	--
12:34	B2	26.1	--	--	--	--	--	-	--	--
13:04		26.6	31.1	38.3	19.4	16.6	20.6	34%	10-20W	15% cirrus
13:20		27.4	31.7	37.7	20.6	18.3	21.1			--

TABLE 2

*All temperatures in degrees Celsius.
†Soils with approximately 20% vegetation cover.

Sonora Pass -- Site #19
Brown Bear
August 28, 1968

Flight Data		Radiometer (8-14u) Readings					Digatic Readings					Weather Data			
Time	Run No.	Basalt† Soil	Basalt	Basalt Scree	Granite Dist.	Andesite Dist. with vegetation	Basalt† Soil	Bush	Loose Basalt ¼"	Loose Basalt 3"	Basalt Rock	Air	Rel. Hum.	Wind	Cloud Cover
09:40	-	20.5	26.1	27.8	18.9	15.6	17.2	--	24.9	12.8	14.1	12.1	32	0	2% cirru
10:05	-	20.7	28.9	33.9	19.4	18.9	18.4	22.2	30.1	13.4	16.3	13.2	-	-	4% cirru
10:25	BH	22.8	30.5	34.4	20.0	17.8	20.0	--	34.3	14.9	18.2	14.7	35	0	5% cirru
10:34	1	22.2	31.1	33.9	20.0	17.8	21.1	--	35.9	15.5	19.1	15.3	-	-	--
10:41	3	23.8	32.2	34.4	22.2	18.9	21.1	--	36.8	15.9	20.2	15.8	-	-	--
10:46	5	22.8	31.1	35.0	18.9	21.1	20.0	--	39.2	16.2	19.9	15.6	33	4W	7% cirru
10:51	7	23.3	32.2	35.0	21.1	21.6	21.1	--	36.1	16.4	19.7	15.6	32	-	--
11:05	MS	24.4	33.3	37.2	22.2	22.8	23.8	--	38.6	17.2	22.9	17.1	31	3SW	8% cirru
11:14	-	26.6	33.9	37.7	21.6	21.1	23.3	--	39.6	17.7	24.0	17.2	-	-	--

*All temperatures in degrees Celsius.
†Soils with approximately 20% vegetation cover.

TABLE 3

SOIL MOISTURE DETERMINATIONS

The following soil moisture determinations were made in the lab on sealed samples collected during the flights. Because of the limited effective penetration of the infrared spectrometer, (the prime instrument on mission 78), only the very surface layer of the soil was sampled. This was accomplished by scraping off the surface layer from an area approximately 15 centimeters square and sealing the 100 to 200 grams of material in a steel moisture can. These samples were returned to the lab and processed as soon as possible.

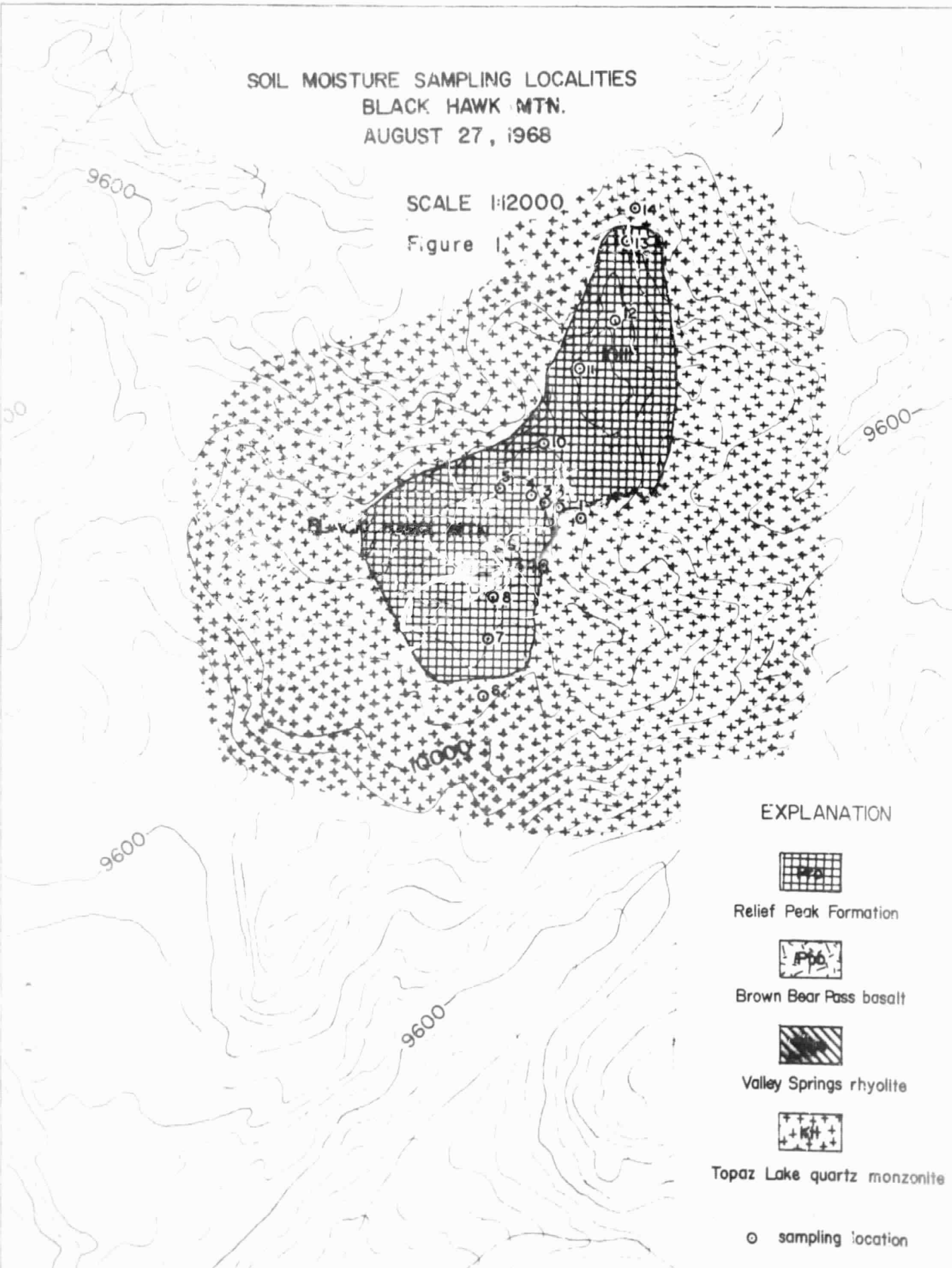
In the lab the samples were unsealed, weighed, dehydrated by roasting for two hours at 105°C and reweighed for moisture loss. The cans were cleaned, weighed, and their weights subtracted from both the wet and dry soil weights, before percent moisture was calculated.

Figures 1 and 2 show the location of the soil moisture sampling sites at Blackhawk Mountain and Brown Bear Pass respectively. Tables 4 and 5 show the moisture content of the samples.

SOIL MOISTURE SAMPLING LOCALITIES
BLACK HAWK MTN.
AUGUST 27, 1968

SCALE 1:12000

Figure 1.



SOIL MOISTURE

BLACK HAWK MOUNTAIN

SONORA PASS - SITE 19

Locality	Sample No.	Wt. % Water 8/27/1968	Soil Type
#1	N1132	.14%	Gruss
#2	N1133	.87%	Andesite Talus
#3	N1134	.35%	Andesite Talus
#4	N1135	.94%	Andesite Soil
#5	N1136	.69%	Andesite Soil
#6	N1137	.28%	Gruss
#7	N1138	.87%	Andesite Soil
#8	N1139	1.17%	Andesite Soil
#9	N1140	.80%	Andesite Soil
#10	N1141	.67%	Andesite Soil
#11	N1142	.40%	Andesite Soil
#12	N1143	.68%	Andesite Soil
#13	N1144	1.46%	Andesite Soil
#14	N1145	.18%	Gruss

Average of 11 Andesite derived soils .81%

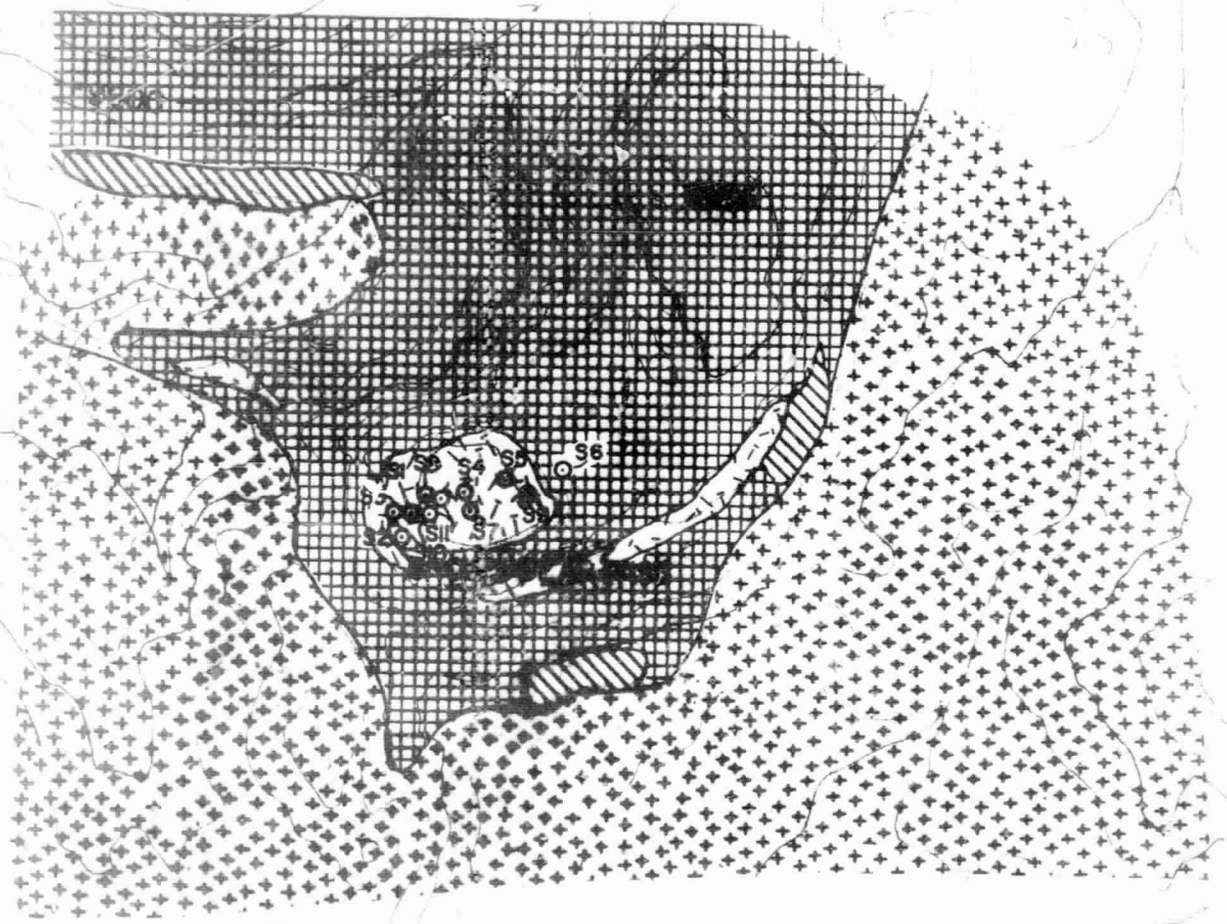
Average of 3 Granite derived soils .20%

TABLE 4

SOIL MOISTURE SAMPLING LOCALITIES
BROWN BEAR PASS
AUGUST 27-28, 1968

SCALE 1:12000

Figure 2



EXPLANATION

Relief Peak Formation

Topaz Lake quartz monzonite

⊙ sampling location

10430

10030

Mosquito Lake

Emigrant Meadow Lake

SOIL MOISTURE

BROWN BEAR PASS

SONORA PASS - SITE 19

Locality	Sample No.	Wt. % Water 8/27/1968	Sample No.	Wt. % Water 8/28/1968
#1	N1146	3.03%	N1159	3.03%
#2	N1147	2.94	N1160	1.31%
#3	N1148	2.43%	N1161	1.91%
#4	N1151	2.41%	N1158	2.99%
#5	N1152	5.39%	N115	3.14%
#6	--	--	N1157	8.39%*
#7	--	--	N1154	2.31%
#8	N1150	.73%+	--	--
#9	--	--	N1156	2.24%
#10	--	--	N1153	1.20%
#11	N1149	2.61%	--	--

Average of 14 typical rock outcrop area samples, 2.64% excluding N1150 and N1157

*High organic meadow soil

+Shore of pond - gravel, no fine material

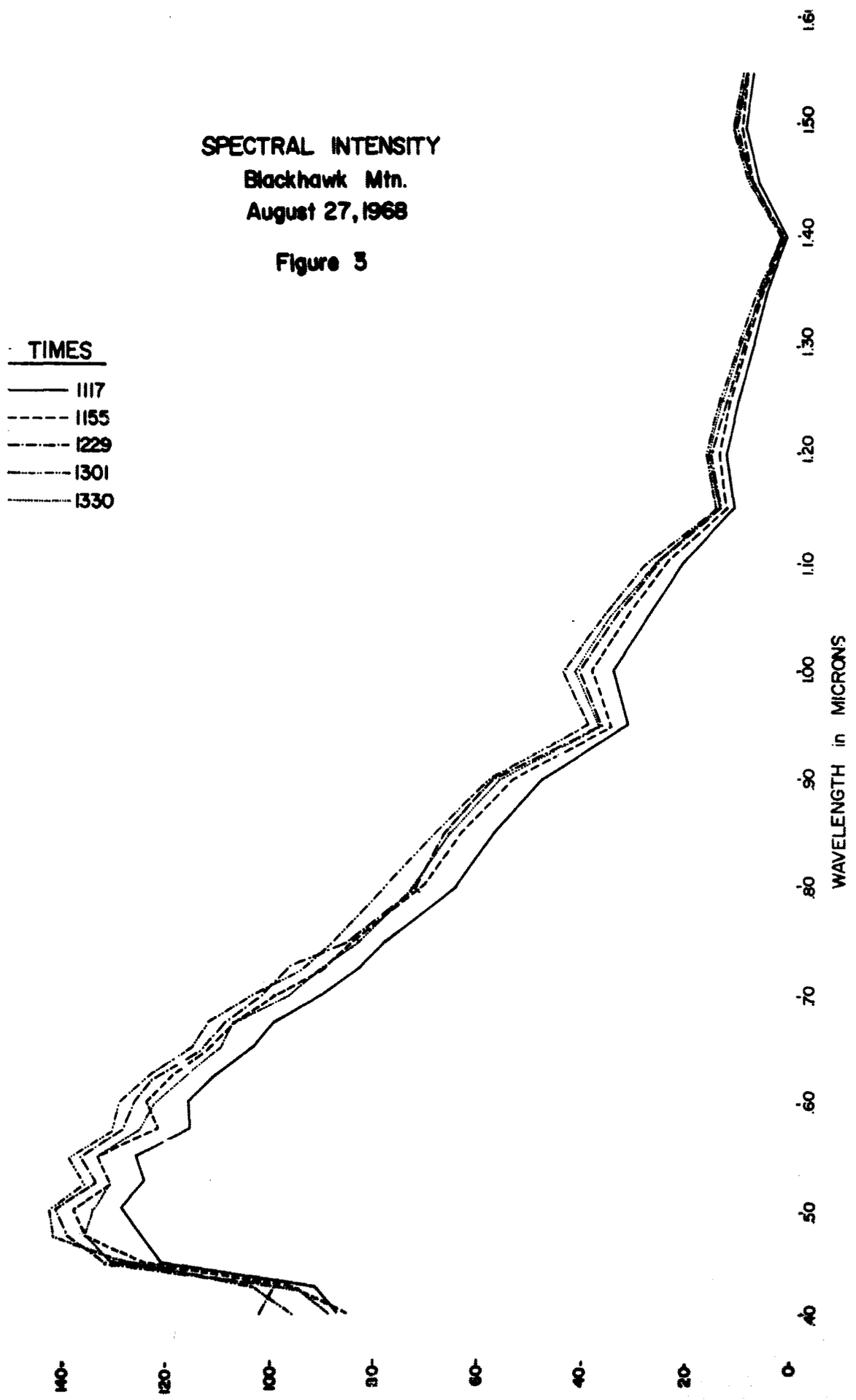
TABLE 5

.4 TO 1.55 MICRON SPECTRAL INTENSITY MEASUREMENTS

Spectral intensity measurements are a quantative measure of incoming solar radiation. The data presented here was obtained with an ISCO visible and near infrared spectrometer. The ISCO instrument was set up with the direct incidence head pointed at the sky directly overhead. The curves presented in figures 3 and 4 were generated from measurements taken at .025 micron intervals in the range .40 micron to .75 micron and .05 micron intervals in the range .75 micron to 1.55 microns. The readings taken for these spectral intensity curves show only the broad, general characteristics of the solar spectrum and no attempt was made to take readings at close spacing to delineate individual absorption lines. The spectral intensity plots have been corrected for instrument response to give true intensities in microwatts per square centimeter per millimicron. Figures 3 and 4 show the spectral intensity during flights 1 and 2 on August 27th and 28th respectively.

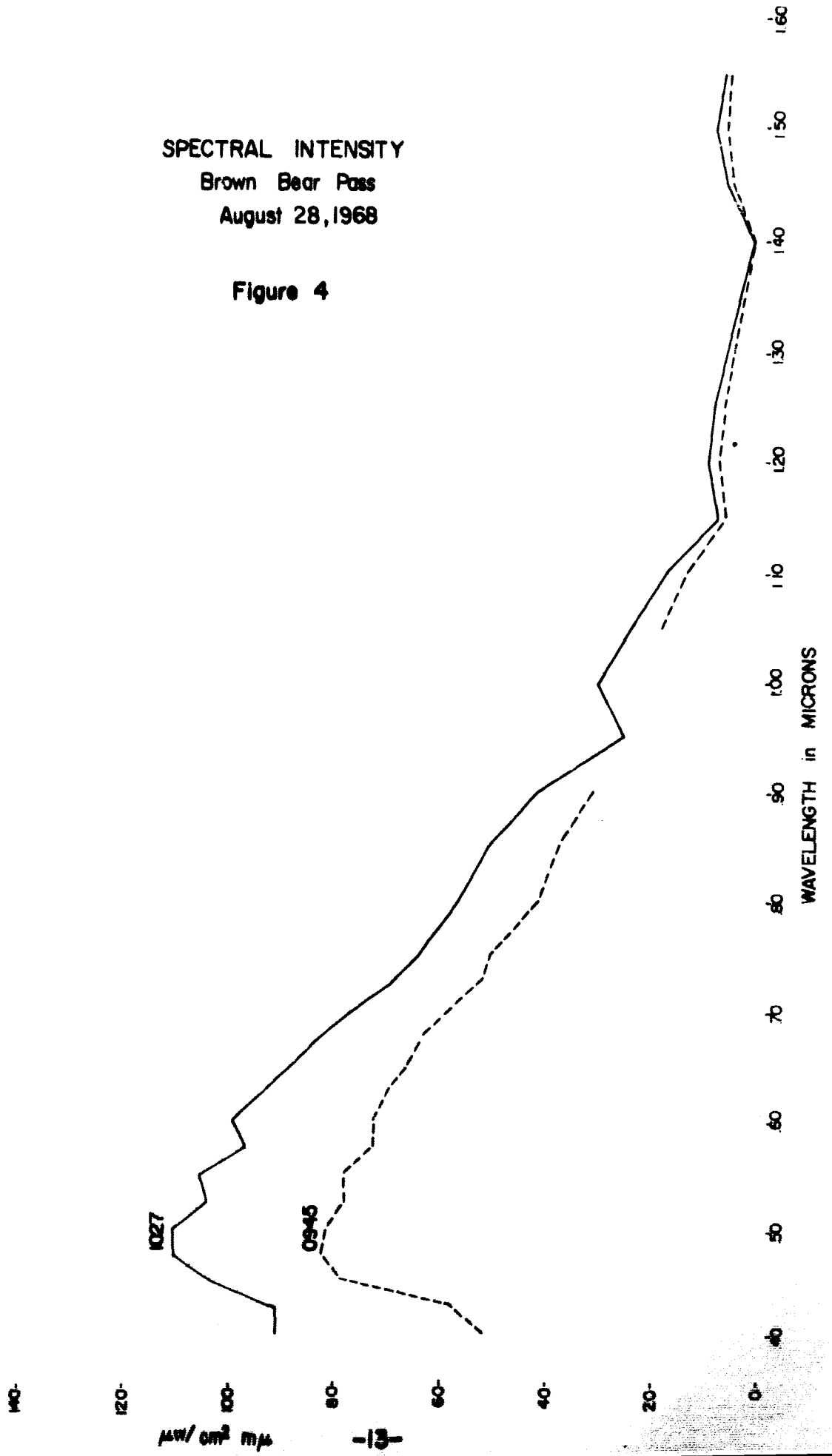
SPECTRAL INTENSITY
Blackhawk Mtn.
August 27, 1968

Figure 3



SPECTRAL INTENSITY
Brown Bear Pass
August 28, 1968

Figure 4



SPECTRAL HYGROMETRIC MEASUREMENTS

It is possible to measure total atmospheric moisture using the principle of differential light absorption by water molecules. Water vapor molecules are more likely to absorb light at certain wave lengths than at others; a relationship exists between the ratio of intensities of sunlight at an absorbing and a nonabsorbing wave length and the water vapor in the atmosphere between the observation point and the sun.

Several water vapor absorption bands are amenable to this type of measurement. The bands used for the following study were the water vapor band at .935 micron and the nonabsorbing comparison band (water vapor window) at .880 micron.

Two instruments were used to monitor atmospheric moisture during flights 1 and 2 of mission 78. The instruments measured the same points in the spectrum, but operate on slightly different principles and require different calibrations. One of the instruments is a specially designed spectral hygrometer developed by Jet Propulsion Laboratories in 1964. This instrument uses a photodiode as a detector and two interference filters centered on .880 micron and .935 micron to monochromatize the incoming light. The second instrument was a standard ISCO spectroradiometer. Its near infrared optical sensing system consists of a wedge interference filter and a germanium junction photocell. These two instruments may be seen in figures 5 and 6 respectively.

Calibration of the spectral hygrometer was made by Jet Propulsion Laboratories using radiosonde balloons. The ISCO was calibrated with data from the J.P.L. instrument. The J.P.L. calibration curve, relating the ratio of the light intensity in the water vapor band over the light intensity in the non-absorbing band to millimeters of precipitable water vapor, was modified to take into account the differing transmission of the two interference filters, in the J.P.L. instrument, and the varying detector response and wedge interference filter transmission in the ISCO. The resulting correlation curve relating the ratio of the direct ISCO readings to mm of precipitable water is shown in figure 7. This modified chart matches very closely emperical correlations made using the two instruments side by side.

Figures 8 and 9 show total moisture measurements made with both instruments during flights 1 and 2 of mission 78 at the Sonora Pass test site.

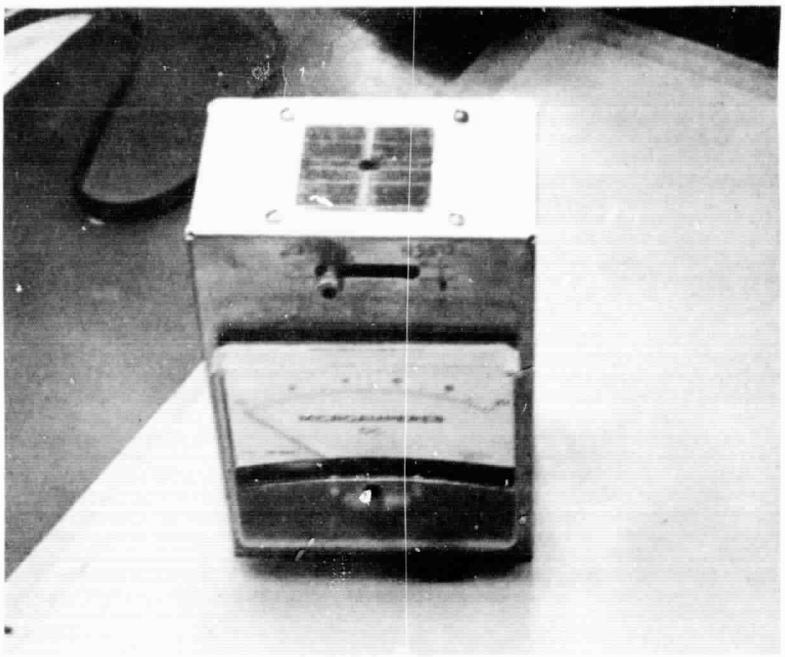
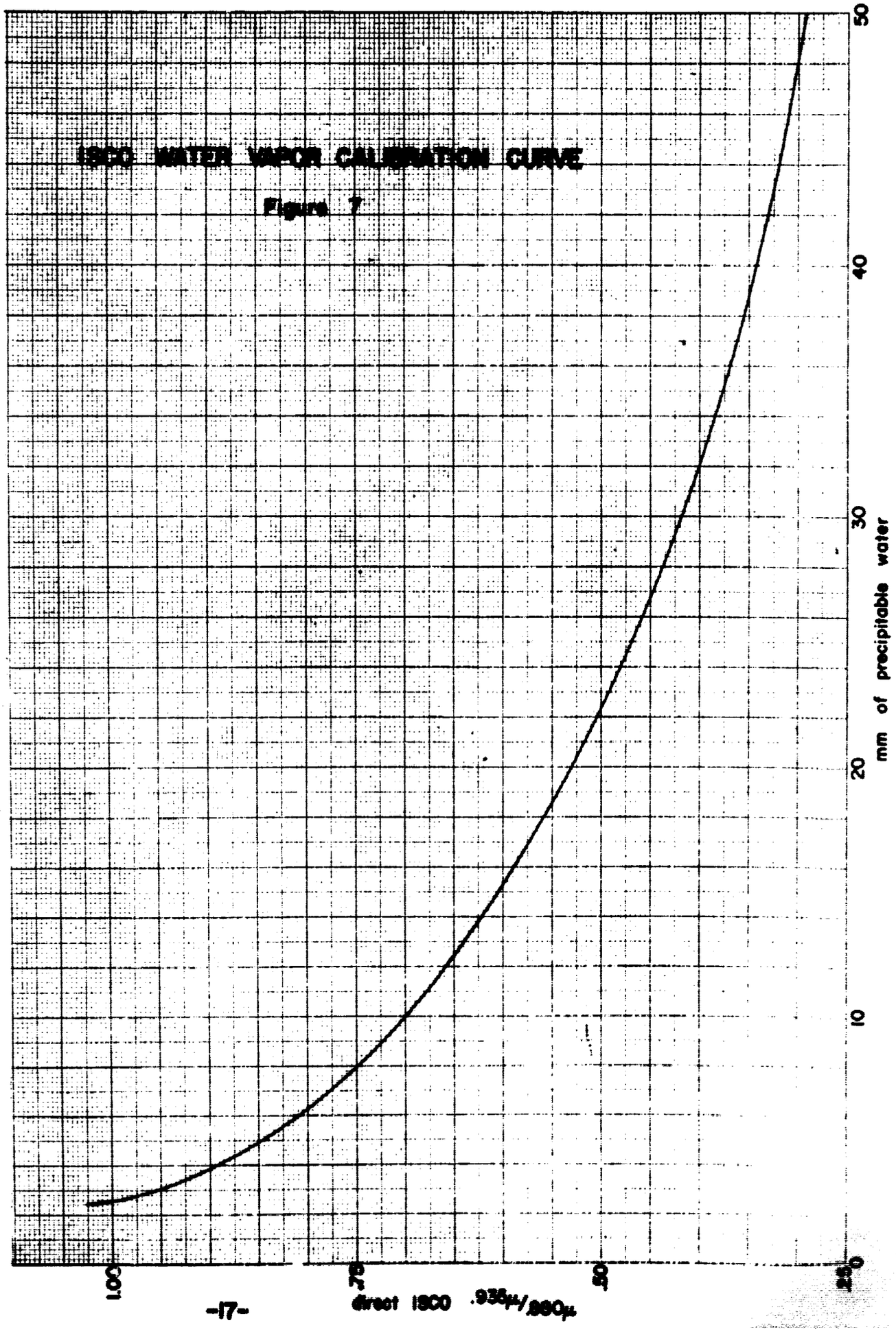


FIGURE 5
Jet Propulsion Laboratories Spectral Hygrometer

FIGURE 6
ISCO Spectroradiometer being used for hygrometric measurements at Blackhawk Mountain


ISCO WATER VAPOR CALIBRATION CURVE
Figure 7
50
40
30
20
10
0
mm of precipitable water
1.00
.75
.50
.25
direct ISCO .936μ/.880μ

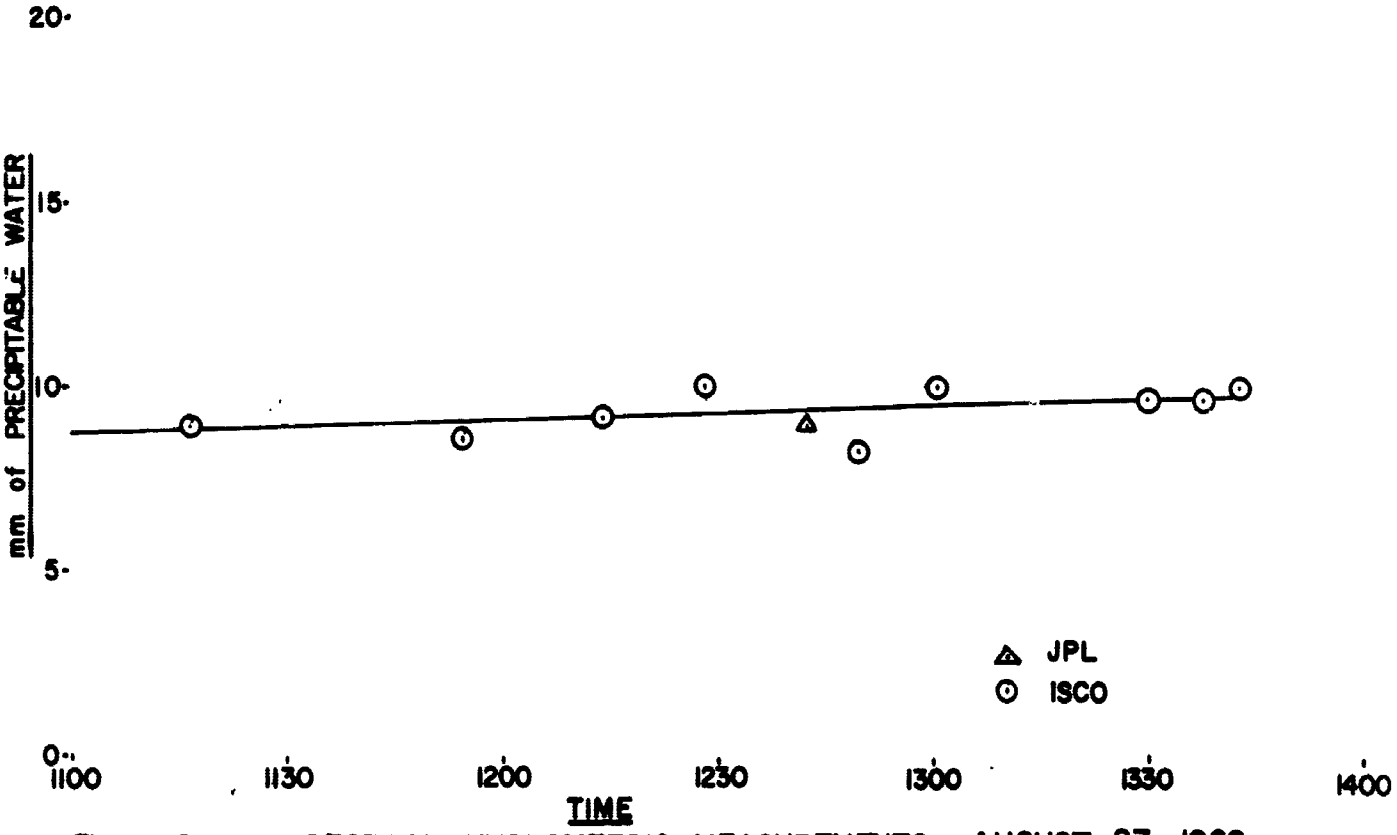


Figure 8 SPECTRAL HYGROMETRIC MEASUREMENTS - AUGUST 27, 1968

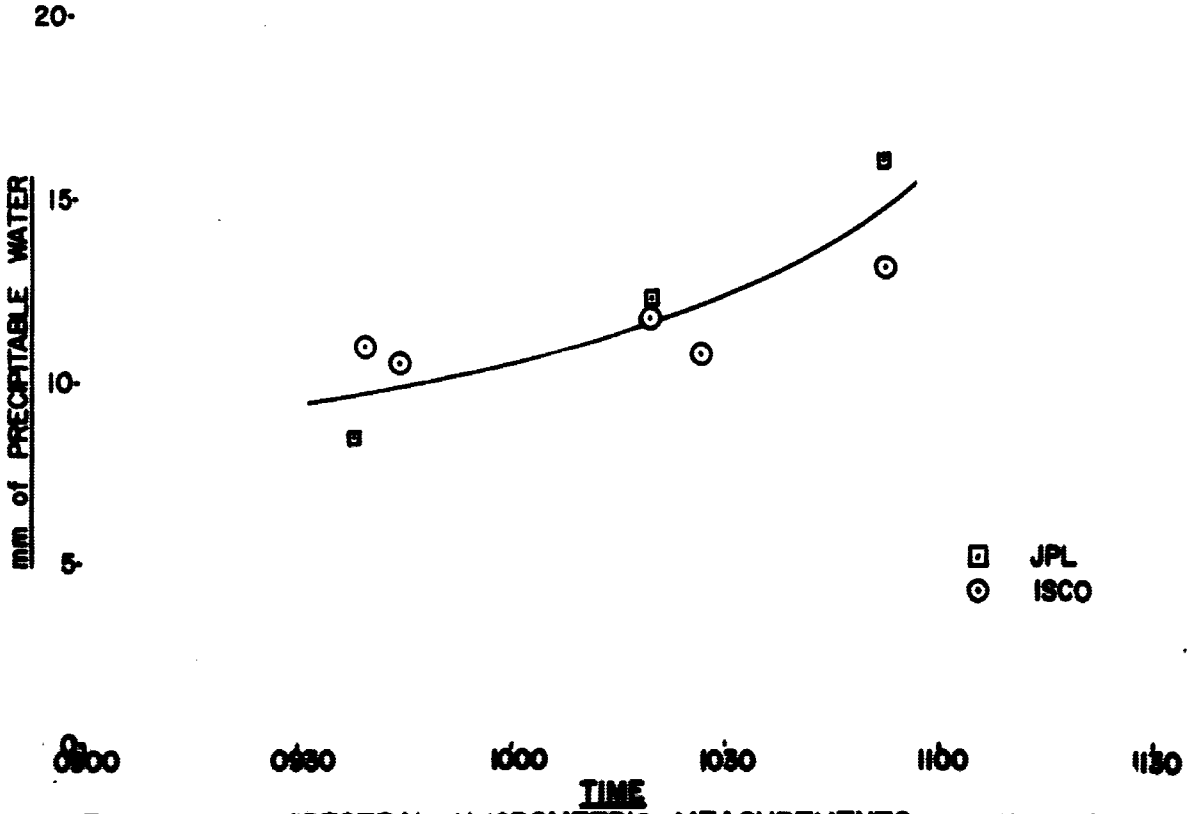


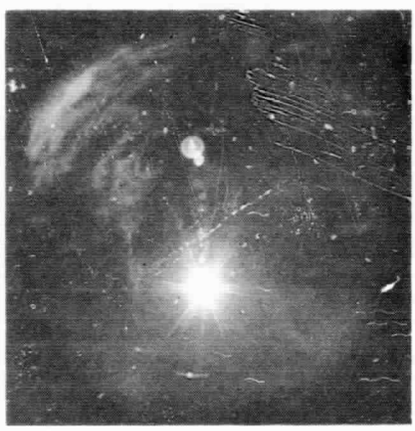
Figure 9 SPECTRAL HYGROMETRIC MEASUREMENTS - AUGUST 28, 1968

CLOUD PHOTOGRAPHY

A 35mm camera has been adapted with a 180° fisheye lens to provide non-subjective cloud cover documentation. Because of the nature of the lens system, the photographs are non-metric, i.e. radially distorted. The camera is held vertically to provide complete sky coverage. Each photograph shows, geometrically opposite the sun, several "ghosts" caused by internal reflections within the optical system.

During both flights at Sonora Pass, cloud cover was slight; however, the photographs show thin cirrus clouds moving in from the north. The three photographs on the following page, figure 10, were taken during flight 1 on August 27, 1968, from Blackhawk Mountain. Essentially, the same cloud conditions prevailed during flight 2 on August 28th, except that the cloud cover was slightly greater. In each photograph "up" is approximately north.

Time 1215 Sky clear
August 27, 1968, Blackhawk Mountain, Sonora Pass, Site 19



Time 1245 Cirrus clouds moving in from north
August 27, 1968, Blackhawk Mountain, Sonora Pass, Site 19

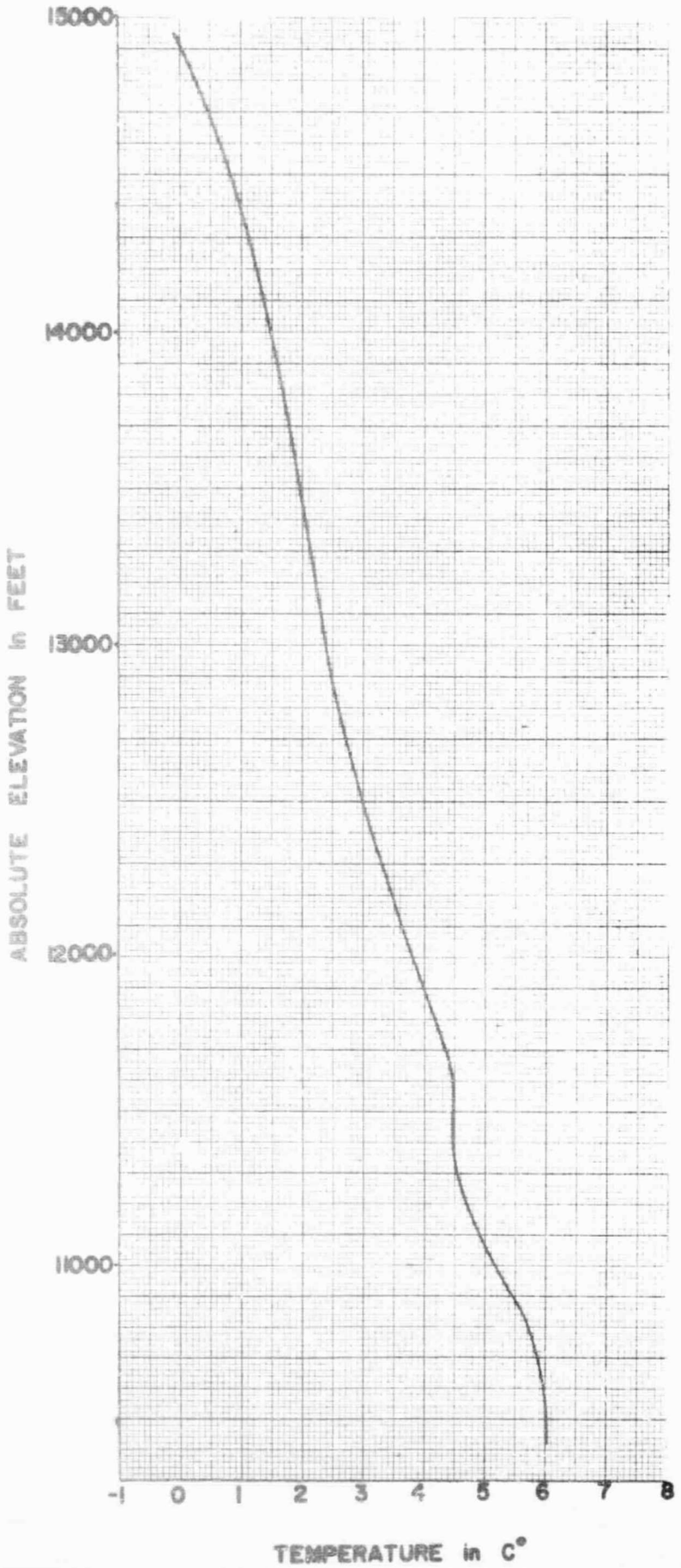
Time 1300 Cirrus clouds in north reaching zenith
August 27, 1968, Blackhawk Mountain, Sonora Pass, Site 19

FIGURE 10

RADIOSONDE MEASUREMENTS

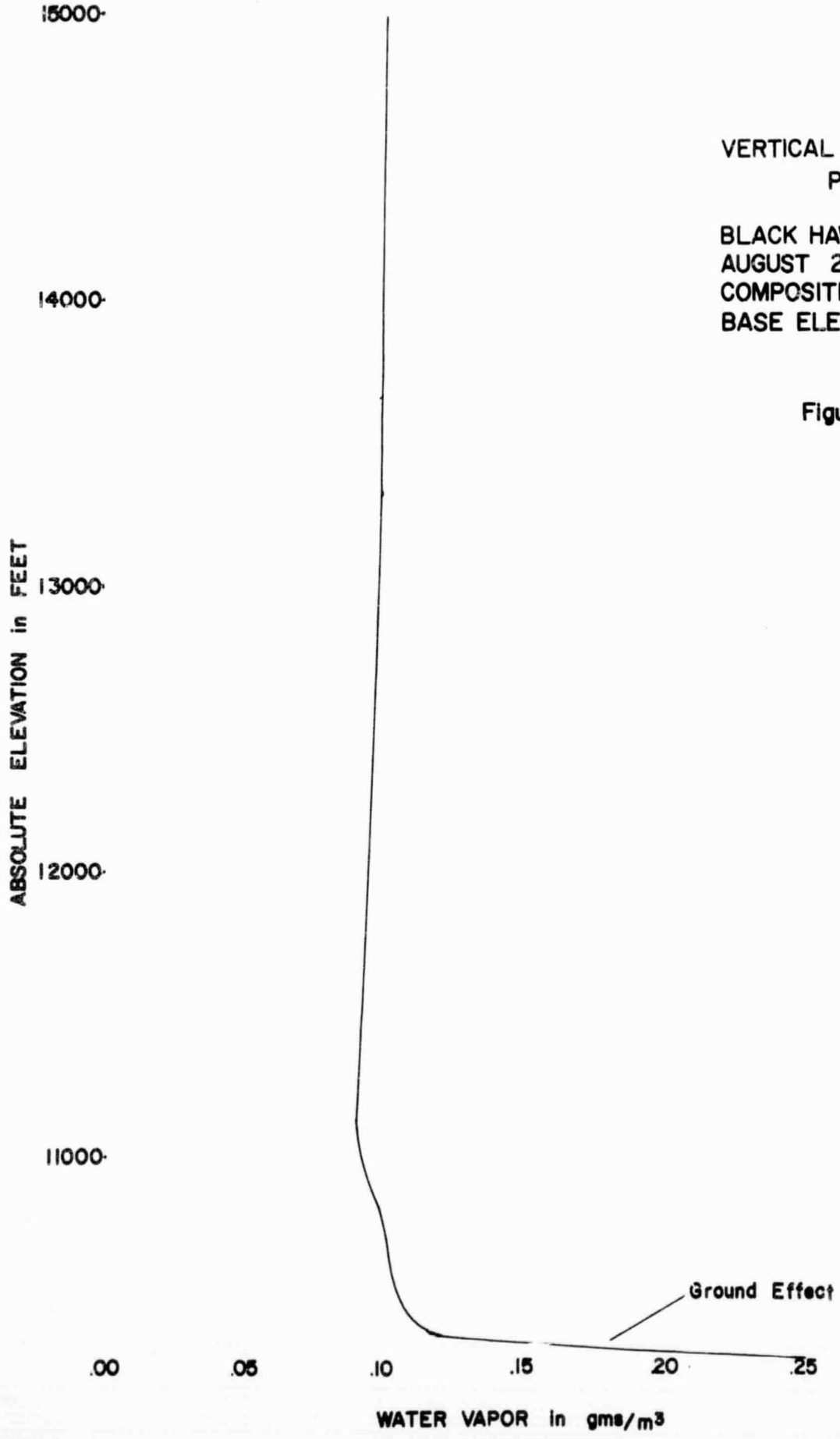
On August 27, 1968, during flight 1 of mission 78, radiosondes were flown on teathered balloons from Blackhawk mountain. A summary of the temperature and atmospheric water vapor data is given in figures 11 and 12. High wind velocities kept the air well mixed, so that the vertical profiles are rather consistant throughout the entire flight. Since changes with time were well within the instrumental error, both vertical temperature and moisture plots are the averages of all data taken.

Although no radiosonde data was taken on August 28th, surface conditions within the static air mass were approximately the same, and the August 27th data probably approximates very well upper air conditions on the following day.



VERTICAL TEMPERATURE PROFILE
BLACK HAWK MTN.
AUGUST 27, 1968
COMPOSITE 1100-1400
BASE ELEVATION 10348

Figure 11



VERTICAL WATER VAPOR PROFILE

BLACK HAWK MTN
AUGUST 27, 1968
COMPOSITE 1100-1400
BASE ELEVATION 10348

Figure 12