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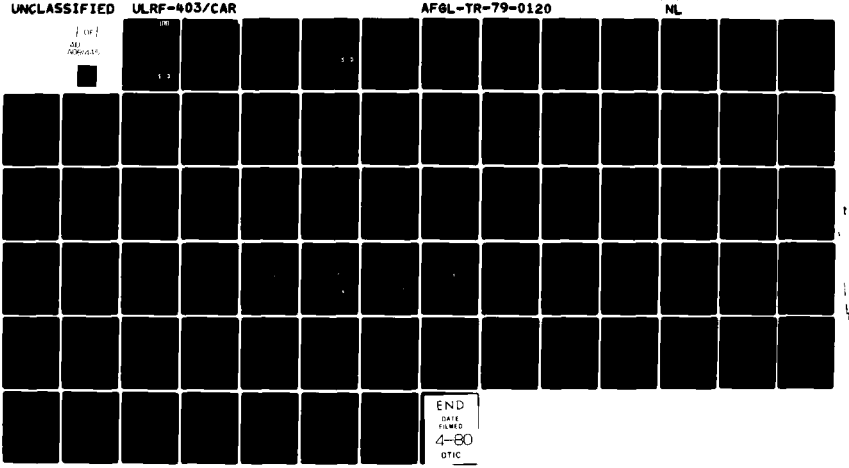

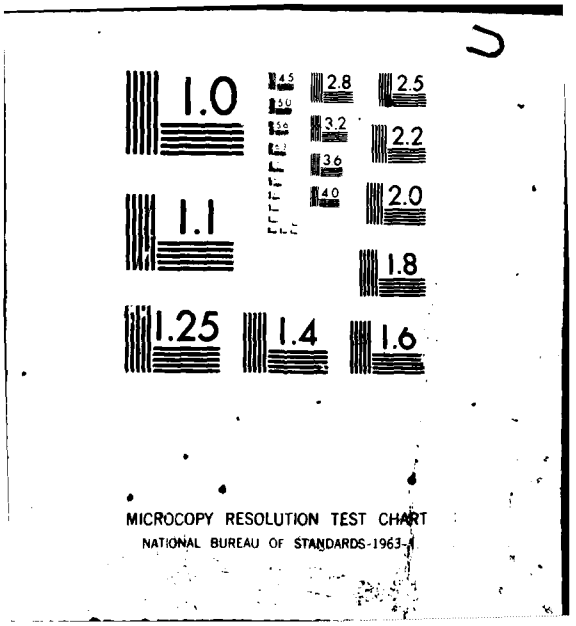
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AFGL-TR-79-0120

(12) LEVEL II

MEASUREMENT OF NEUTRAL TEMPERATURE IN THE 120-180 KM REGION OF THE ATMOSPHERE FOLLOWING TMA RELEASES FROM A ROCKET

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May 1979

Final Report for Period 17 January 1977 to 17 August 1978

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Resonance-Fluorescence
Molecular Vibrational-Rotational

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Atmospheric temperature measurements at approximately 160 km altitude over White Sands Missile Range on 24 September 1977 were made by the AlO sunlit resonance fluorescence technique. A rocket borne payload released trimethyl aluminum (TMA) in one large cloud at morning twilight. Twelve minutes of data were used to calculate temperatures at the top of the cloud averaging 628°K and at bottom averaging 578°K. The standard deviation of any one mea- →

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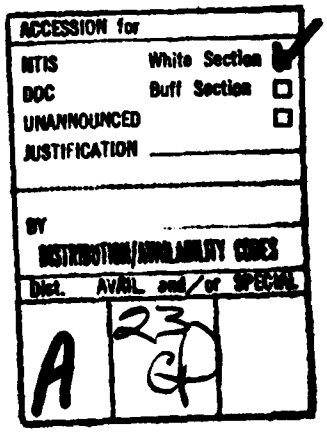
20. ABSTRACT

surement involving typically 40 seconds of data was generally between 5 and 11°K. Included in this report is the most detailed description to date of the procedures and statistical background underlying the 'AIQ Temperature' technique developed by the author over the last eleven years.

ACKNOWLEDGEMENT

We take pleasure in acknowledging the encouragement and assistance of Dr. Dan Golomb from 1967 onward in the development of the overall technique of measuring upper atmosphere temperatures using A10.



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1.0 INTRODUCTION

Over the last 17 years many uses of TMA (trimethyl aluminum) trails in the upper atmosphere have been made by various experimenters (Blamont et al, 1961; Armstrong, 1963; Rosenberg et al, 1964). In addition to measuring winds and diffusion rates, (Authier et al, 1962, 1963, 1964; Authier, 1964; Harang, 1964; Golomb et al, 1967, 1972; Rees et al, 1974) have also measured temperature by studying the temperature dependent vibrational-rotational intensity distribution of the blue-green system of AlO ($B^2\Sigma^+ - X^2\Sigma^+$) generated when TMA is exposed to sunlight in the presence of atomic oxygen (see Figure 1).

Recent experiments under the direction of AFGL (Aladdin, Aeolus, etc.) have centered around rocket released puffs of TMA on the downleg of a rocket trajectory from 180 km down to 120 km with approximately 10 km spacing (see Figure 2).

A program involving one rocket payload for winds and temperature studies was conducted at White Sands Missile Range on 24 September, 1977. In this case the rocket made only one release at approximately 160 km altitude at 5:00 A.M. local time during morning twilight (8° solar depression). The experimental procedure consisted of observing the top and bottom of the cloud for 30 to 40 second periods. In general, adequate signal to noise ratio is maintained until 1 or 2° solar depression although, after this length of time (approximately 20 minutes) from an initial release at say 8° solar depression, only at the lowest altitudes 120-130 km are there "sharp" enough features to permit altitude discrimination in the spectrometer's line of sight and accurate photographic triangulation of altitude. In this program, only 12 minutes of data was taken with the above limitation being reached more quickly at the higher altitudes available in this particular experiment.

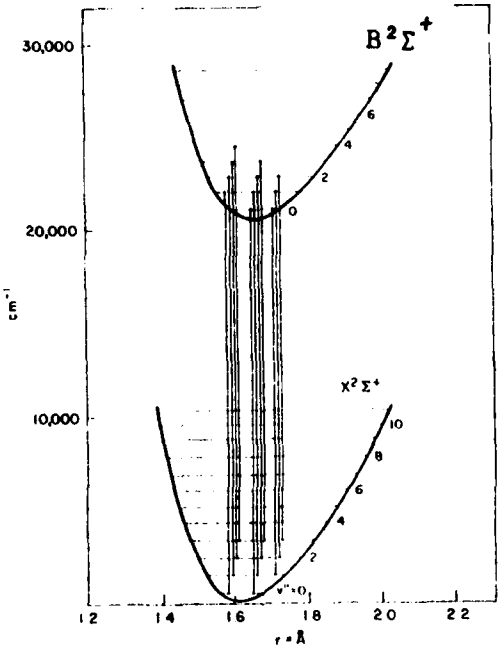


Figure 1. The $B^2\Sigma^+$ and $X^2\Sigma^+$ Levels of the AlO Molecule.

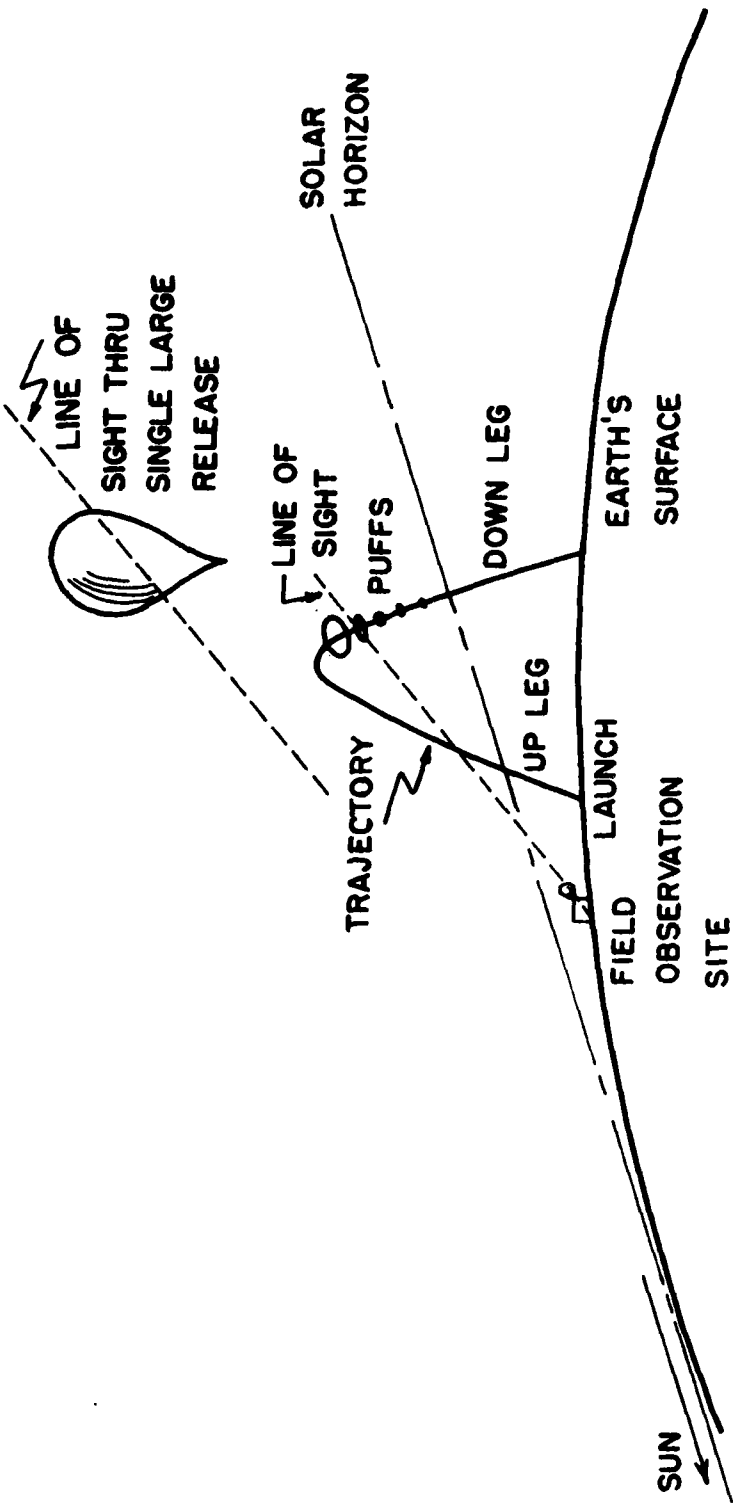


Figure 2. Observational Geometry

2.0 INSTRUMENTATION AND PROCEDURE

The heart of field instrumentation is a 1/2 meter Fastie-Ebert scanning spectrometer. The input optics is a 50 cm focal length F/5.0 lens which "images" the input slit upon the sky as a horizontal slit 7° wide by .06° high. The spectrometer is co-mounted on a tripod adjustable in elevation and azimuth along with a secondary electron conduction (SEC) vidicon low light level television camera (and a 35 mm photographic camera as backup) for both boresight recording and real-time aiming of the spectrometer. The grating of the spectrometer is tilted to scan in wavelength by a synchronous motor through an adjustable cam mechanism at a rate of one scan every five seconds. Photoelectron pulses from the photomultiplier are processed with standard "nuclear" counting electronics and recorded on a high speed (60 ips) magnetic tape recorder. Also recorded are a sample of the 60 Hz waveform driving the synchronous motor scanning the spectrometer and audio comments of the person aiming the spectrometer. A block diagram of the Field Instrumentation is shown in Figure 3.

The boresight TV camera is recorded on a video tape recorder along with time from a digital clock superimposed on one corner of the video frame. Also recorded on the video tape recorder's audio channel is the commentary of the "aimer" describing what he is pointing the instrument at as well as when he is moving it or holding steady on some feature (see Figure 4).

The aimer makes use of a TV monitor for aiming in addition to various direct sights mounted on the tripod. He also has view of a chart recorder displaying the spectrum being recorded in order to ascertain the quality (amplitude) of the spectra from a particular feature.

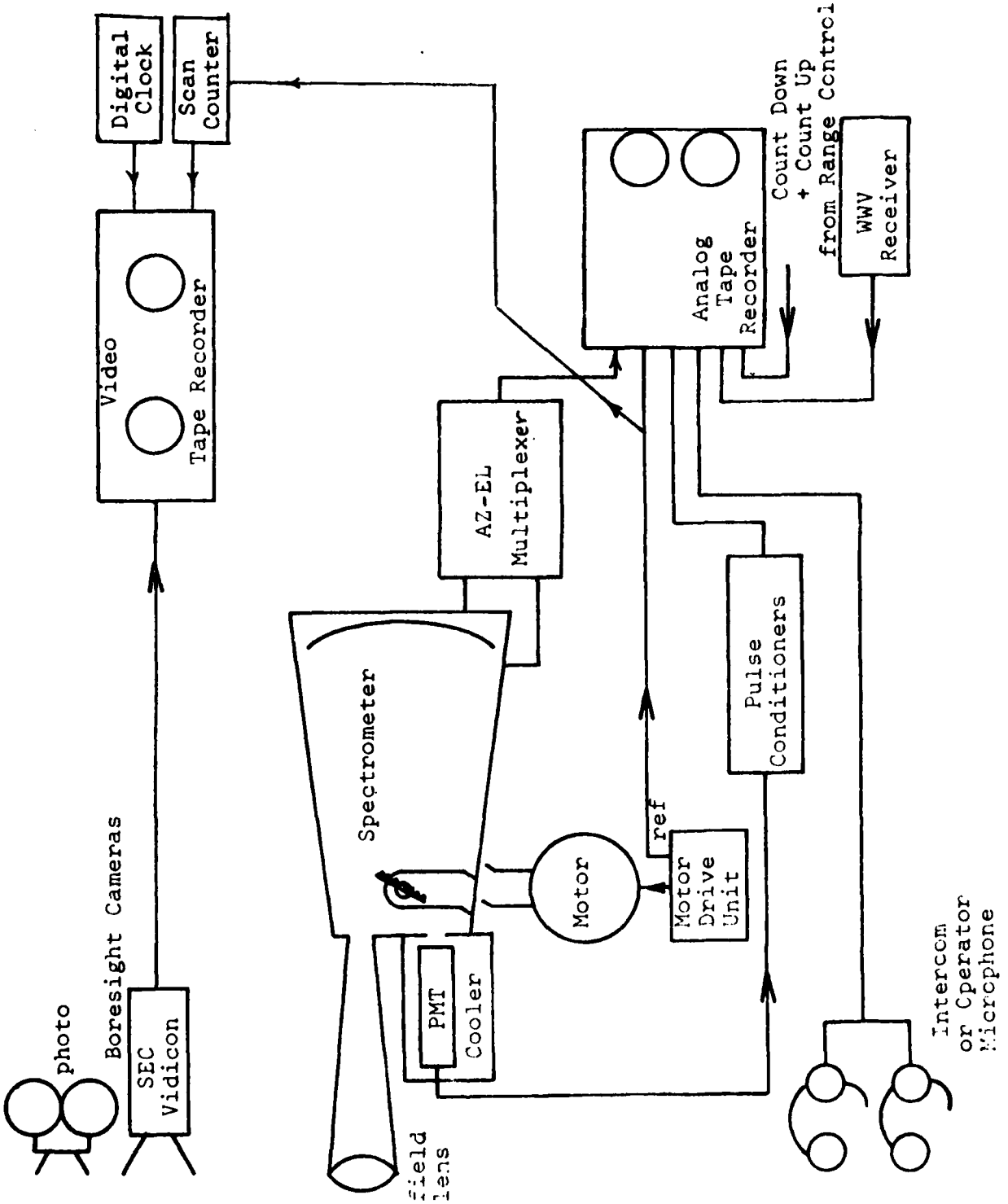


Figure 3. Block Diagram of Field Instrumentation

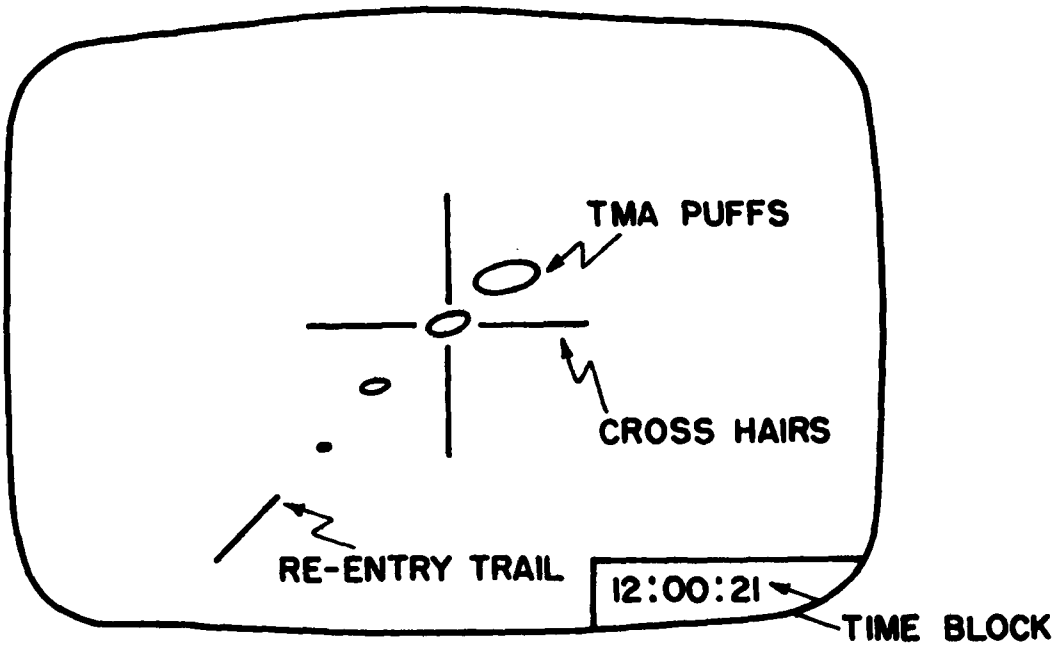


Figure 4. Boresight TV Monitor (Typical)

After the experiment certain calibrations are recorded. An iron-neon hollow cathode lamp is scanned to establish the wavelength calibration of the spectrometer and the shape of the spectrometer's slit function. A light box (LDF #6) with a radiance calibration traceable to an NBS quartz-iodine irradiance standard is scanned to establish the variation of the spectrophotometer's sensitivity with wavelength. Records of the photomultiplier output, with the spectrometer scan stopped, versus the step number of the calibrated apertures in the lightbox are used to establish the amplitude linearity of the counting-recording system. In a photon counting scheme such as this, counts are lost at higher counting rates due to "dead-time". Prior to the experiment boresight calibrations using a several kilometer distant light source are made to align all the sights as well as markers on the boresight TV monitor and fiduciaries on the photographic camera with the very narrow (vertically) field of view of the spectrometer. Later, during data reduction, playback of the TV recording of this boresight calibration will again allow us to place markers on the TV monitor used for playback.

3.0 DATA REDUCTION

Data reduction was carried out in the following steps. A block diagram of data reduction is shown in Figure 5.

1. Digitize Data - The tapes brought back from the field are "replayed" and the photon counts are totaled every 1/60th of a second using as a clock the recorded 60 Hz waveform originally driving the synchronous motor on the grating drive. The totalized counts are recorded on a digital tape recorder whose operation as well as the counting and interface to the analog "playback" tape recorder is handled by a microprocessor based system.

The following programs are used on the AFGL CDC 6600 computer:

2. Program CONVERS - The "stranger" type digital tape created above is converted to a SCOPE format file by CONVERS.

3. Program ALO TAPE DUMP - Prints all of the data on the high speed printer in an easy to examine format together with a running index to keep track of position along the tape (see Table 1).

4. Program LB AVG takes sections of data, that have been identified by examining the dump above as observations of the lightbox at various aperture steps, and computes the average count corresponding to the lightbox steps 0, 1, 2, 4, 8, 16, ..., 1024 (see Table 2).

5. Program LBTAU takes the averages computed above (k') plus the measured "hole factors" for each attenautor step on the light box (k) and adjusts the parameters α, β, τ in the expression below for best fit to properly weighted values of k and k'.

$$k' = \frac{\alpha k + \beta}{1 + (\alpha k + \beta)\tau}$$

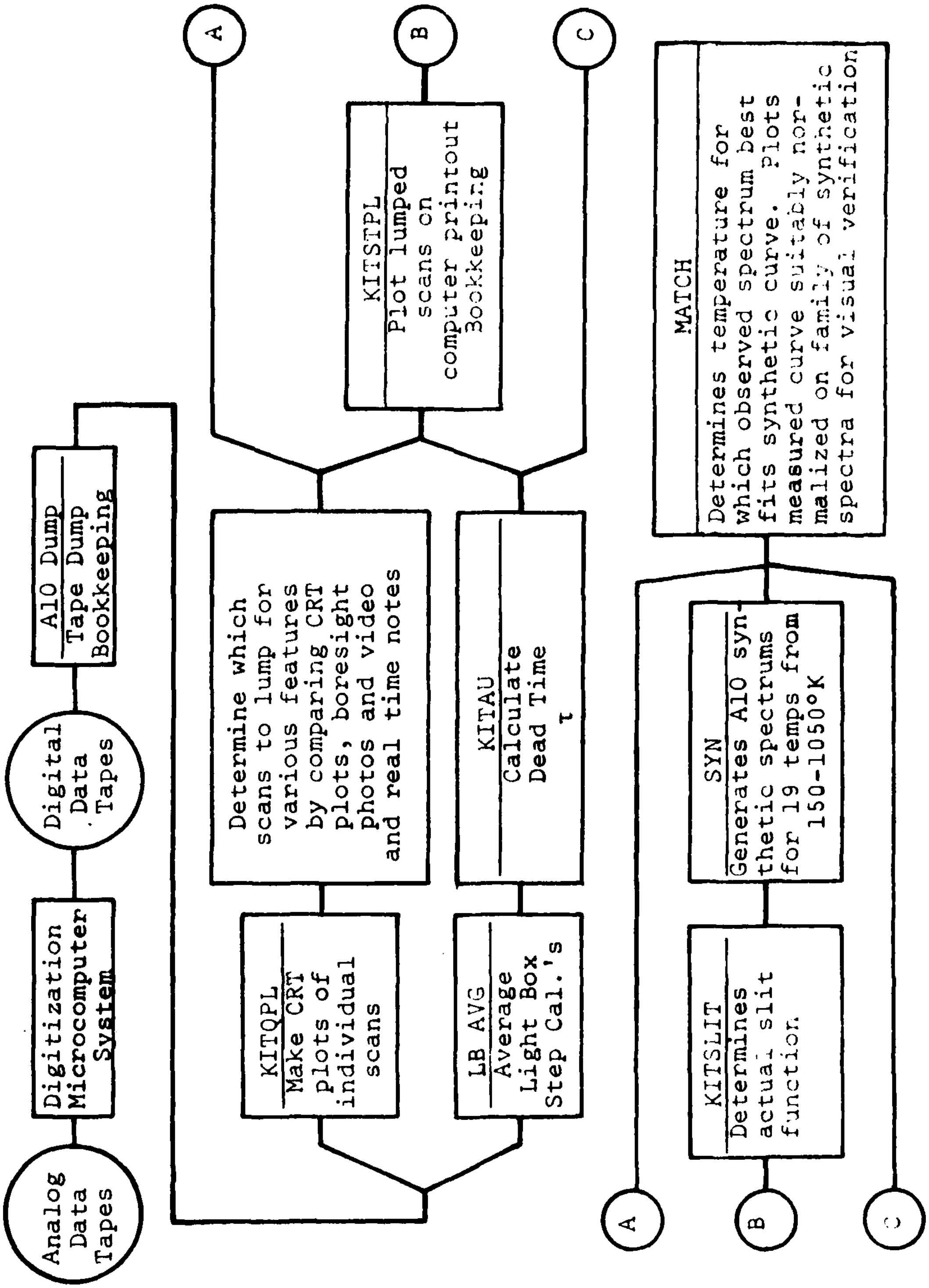


Figure 5. Block Diagram of Data Reduction

TABLE 1. SAMPLE OUTPUT OF A10 DUMP

FIRST WD	FILE 2																												LAST WD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
10501	32	26	19	24	21	20	21	15	18	11	17	14	15	16	16	15	11	16	16	12	14	16	19	14	17	20	19	22	21	22	10530
10531	19	23	25	28	26	24	26	29	29	30	32	36	35	32	30	34	31	38	34	35	38	38	43	34	35	44	36	34	39	34	10560
10561	39	40	38	35	36	39	39	45	41	51	58	56	70	72	83	92	98	102	102	93	97	92	81	78	67	49	35	35	24	19	10590
10591	9	7	2	1	2	1	2	1	2	1	1	1	1	2	4	0	1	1	1	1	1	0	1	1	1	1	1	2	0	2	10620
10621	1	2	2	1	1	1	1	1	0	2	0	1	1	1	1	0	1	0	0	1	1	0	1	1	0	1	0	1	0	2	10650
10651	39	92	33	36	43	20	16	24	19	13	9	6	6	6	1	4	1	2	1	2	1	0	1	1	3	2	1	3	2	2	10680
10681	1	3	2	2	2	1	2	2	2	1	2	3	2	2	2	3	3	2	2	2	2	2	3	3	2	3	3	2	3	3	10710
10711	5	2	4	3	3	4	4	4	4	2	4	3	4	5	4	6	4	5	5	5	6	5	3	5	6	3	7	5	5	5	10740
10741	6	4	6	7	7	5	6	6	6	5	9	6	6	6	8	8	8	9	10	8	9	8	7	9	10	10	7	10	6	12	10770
10771	6	12	10	8	14	10	14	11	11	11	11	14	12	11	12	16	14	14	17	17	16	18	24	26	26	30	30	30	29	29	10800
10801	30	27	23	23	23	20	17	15	16	11	17	15	14	15	14	13	15	16	11	13	13	17	17	18	18	19	22	18	20	24	10830
10831	27	32	26	28	23	25	27	31	38	30	35	28	34	33	34	37	29	36	35	34	35	41	35	34	33	34	37	38	39	43	10860
10861	38	41	34	40	42	41	39	51	43	47	62	71	76	80	84	95	99	100	101	100	95	96	88	76	62	52	42	32	27	15	10890
10891	13	4	2	2	1	0	0	0	2	1	1	0	1	1	2	1	0	1	1	1	2	2	1	0	1	0	1	1	0	1	10920
10921	2	0	1	1	2	1	1	0	1	2	0	0	1	1	2	2	0	1	1	0	2	1	1	0	1	0	2	1	0	1	10950
10951	52	89	35	39	41	16	14	30	20	13	11	5	5	6	5	3	1	1	2	0	3	2	0	2	2	1	1	2	1	1	10980
10981	2	1	1	2	1	1	2	3	2	2	2	1	3	2	1	4	2	1	3	2	2	2	1	4	2	2	3	5	2	3	11010
11011	3	3	3	3	4	2	4	5	4	2	4	4	6	6	6	5	7	7	4	7	7	4	6	4	6	5	4	6	4	6	11040
11041	8	4	5	7	4	6	5	6	6	8	6	10	8	8	9	6	10	9	8	9	8	9	7	8	10	11	8	14	9	11	11070
11071	9	14	16	10	9	17	14	11	14	11	13	12	10	14	15	14	17	15	19	17	18	22	25	23	28	29	28	30	29	30	11100
11101	31	30	28	21	26	26	18	17	19	15	13	14	14	15	16	12	16	16	12	18	18	16	19	23	22	17	26	17	19	23	11130
11131	20	25	27	26	27	24	33	25	28	26	36	31	32	33	35	34	35	35	39	35	38	42	39	37	39	38	40	40	34	31	11160
11161	42	37	38	35	41	39	43	43	50	61	58	67	76	82	83	88	91	107	103	108	112	101	85	76	62	59	42	40	31	18	11190
11191	10	5	2	1	1	1	0	2	1	2	1	1	1	2	0	1	0	2	0	1	3	1	1	1	1	1	1	1	1	1	11220
11221	1	1	0	2	1	1	1	1	0	0	1	0	2	0	1	0	1	1	1	0	1	0	1	2	1	0	1	0	2	1	11250
11251	133	38	41	36	21	17	30	16	13	10	8	4	5	3	3	3	1	1	2	2	1	2	2	3	1	2	1	2	2	2	11280
11281	3	2	2	1	3	2	2	2	2	3	2	1	2	3	2	3	3	3	2	4	2	3	4	3	2	2	5	2	3	3	11310
11311	2	3	4	3	5	5	5	3	5	5	5	5	5	7	5	4	4	5	6	6	6	6	6	6	5	5	7	5	7	6	11340
11341	6	6	5	7	5	7	5	6	5	6	8	5	7	8	8	8	9	8	8	9	10	8	6	11	13	11	10	12	10	10	11370
11371	11	9	13	14	13	11	15	9	11	14	13	14	12	15	15	12	12	17	20	23	29	21	26	24	29	28	29	30	28	28	11400
11401	30	26	26	24	24	19	21	14	10	15	17	14	15	16	13	14	16	16	17	17	23	22	24	17	22	22	21	22	21	27	11430
11431	25	26	29	26	27	24	27	31	35	28	37	37	35	29	40	33	41	33	35	36	40	38	46	41	34	42	44	40	40	39	11460
11461	36	46	42	42	42	47	45	42	54	59	70	75	90	85	95	104	111	118	100	102	86	89	73	71	55	43	34	28	23	12	11490
11491	6	2	0	2	1	0	2	0	1	1	1	2	1	2	2	0	2	1	1	0	2	0	2	1	1	0	2	1	1	0	11520
11521	1	1	1	1	1	1	1	1	0	2	1	1	1	0	1	0	1	0	1	1	0	2	1	1	0	0	1	1	1	50	11550
11551	93	37	35	34	18	13	32	18	11	9	9	-	4	6	4	3	1	2	3	1	3	2	4	1	2	1	1	2	2	2	11580
11581	4	0	0	3	2	2	1	3	2	2	1	3	3	3	2	1	3	1	4	3	2	3	2	4	4	3	3	3	4	3	11610
11611	3	4	3	4	4	5	3	4	6	9	6	3	6	7	8	5	7	8	6	4	3	4	4	6	5	5	4	5	6	5	11640
11641	4	7	5	6	5	6	6	6	9	6	6	8	4	8	7	8	8	10	7	9	9	12	8	7	10	11	11	11	11	15	11670
11671	12	10	17	13	9	11	12	13	12	8	11	14	13	12	15	12	14	12	20	22	19	23	29	28	29	31	33	32	29	25	11700
11701	29	29	26	25	20	17	19	18	15	16	11	13	17	12	17	17	16	14	18	18	18	15	21	19	18	22	26	25	25	23	11730
11731	28	27	26	32	28	31	31	31	31	36	32	39	37	35	35	38	40	30	44	37	43	44	42	46	38	38	42	46	41	40	11760
11761	38	39	38	43	41	46	42	48	52	64	74	71	87	88	93	103	101	109	108	96	92	79	75	66	50	44	41	30	20	10	11790
11791	4	2	4	1	1	0	1	0	1	1	0	1	2	2	1	2	1	0	2	0	3	0	2	0	0	1	0	1	2	0	11820
11821	0	1	2	1	1	1	1	1	1	0	1	0	1	2	1	1	1	1	3	1	2	1	2	0	2	1	1	2	1	72	11850
11851	125	55	47	48	20	14	29	17	10	8	5	3	3	2	1	1	0	1	1	0	1	1	0	1	0	1	0	1	0	0	11880
11881	0	1	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	11910
11911	2	0	1	0	1	0	1	1	0	0	1	0	0	0	1	3	1	1	1	0	1	0	0	1	1	1	0	1	2	0	11940
11941	0	0	1	1	2	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	4	0	1	11970
11971	1	2	0	1	3	0	1	0	2	1	0	0	1	0	2	1	0	1	0	1	0	1	0	1	0	0	1	1	0	0	12000

TABLE 2.

LIGHT BOX AVERAGE (LBAVG) OUTPUT

	WORD		WORD		COUNT		APERTURE STEP
FILE 1	START	12878	END	13715	AVERAGE	251.	1024
FILE 1	START	13743	END	14466	AVERAGE	118.	512
FILE 1	START	14475	END	15140	AVERAGE	63.	256
FILE 1	START	15139	END	15514	AVERAGE	23.	128
FILE 1	START	15935	END	16648	AVERAGE	12.	64
FILE 1	START	16655	END	17234	AVERAGE	5.	32
FILE 1	START	17409	END	18017	AVERAGE	3.	16
FILE 1	START	18035	END	18732	AVERAGE	1.	8
FILE 1	START	18859	END	19465	AVERAGE	.	4
FILE 1	START	19509	END	20110	AVERAGE	.	2
FILE 1	START	20275	END	20777	AVERAGE	.	1
FILE 1	START	21009	END	21541	AVERAGE	.	0
FILE 1	START	21740	END	22523	AVERAGE	29.	1024
FILE 1	START	22548	END	23186	AVERAGE	11.	512
FILE 1	START	23130	END	23710	AVERAGE	6.	256
FILE 1	START	23935	END	24527	AVERAGE	2.	128
FILE 1	START	24603	END	25214	AVERAGE	1.	64
FILE 1	START	25329	END	26022	AVERAGE	.	32
FILE 1	START	26310	END	27005	AVERAGE	171.	1024
FILE 1	START	27128	END	27812	AVERAGE	56.	512
FILE 1	START	27843	END	28457	AVERAGE	29.	256
FILE 1	START	28566	END	29221	AVERAGE	10.	128
FILE 1	START	29280	END	29941	AVERAGE	5.	64
FILE 1	START	29970	END	30668	AVERAGE	2.	32
FILE 1	START	31720	END	31	AVERAGE	1.	16
FILE 1	START	31440	END	32122	AVERAGE	.	8
FILE 1	START	32160	END	32791	AVERAGE	.	4
FILE 1	START	32850	END	33499	AVERAGE	.	2
FILE 1	START	33570	END	34177	AVERAGE	.	1
FILE 1	START	34320	END	34665	AVERAGE	.	0
FILE 1	START	34329	END	34677	AVERAGE	.	

where k' = measured counts

k = output of lightbox

τ = dead time

α = constant of proportionality since the hole factors for the aperture steps of the lightbox are in arbitrary units, not counts

β = an additive constant representing the dark current of the photomultiplier.

From this point forward in the data reduction the data can be corrected to remove the non-linearity introduced by the dead time inherent in the counting by the expression

$$k'' = \frac{k'}{1 - k'\tau} - \frac{\beta}{\alpha}$$

where k'' is the corrected counts (see Figure 6).

6. Program KITQPL makes plots on the CRT plotter of the raw data once the starting points of the scans are established from examining the dump of data in ALO TAPE DUMP. These "quick plots" can be visually correlated with the video tape boresight record by comparing the relative amplitude of the quick plot with the apparent brightness of the ALO image in the field of view. Once this timing has been established, a table is created of sequential scan numbers on the data tape versus the identification numbers on the video boresight record (see Figure 7).

7. Program KITSTPL makes strip plots on computer printout of the data tapes. Groups of sequential scans of the same feature in the TMA release are summed. Summed scans of the lightbox are plotted this way to establish the variation of sensitivity with wavelength of the instrument using the known calibration curves of the lightbox (traceable to NBS). This slight variation of sensitivity

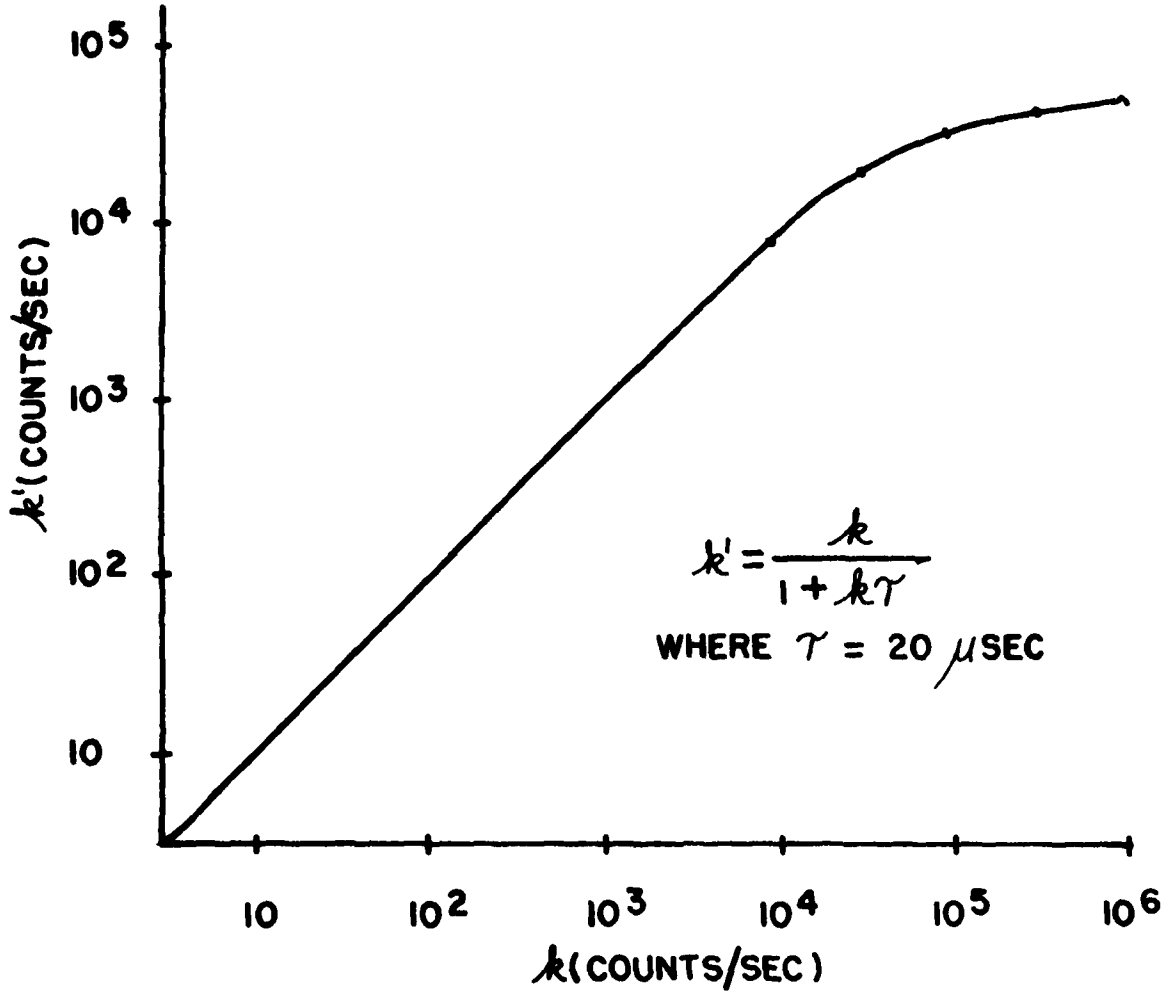


Figure 6. Dead Time Curves

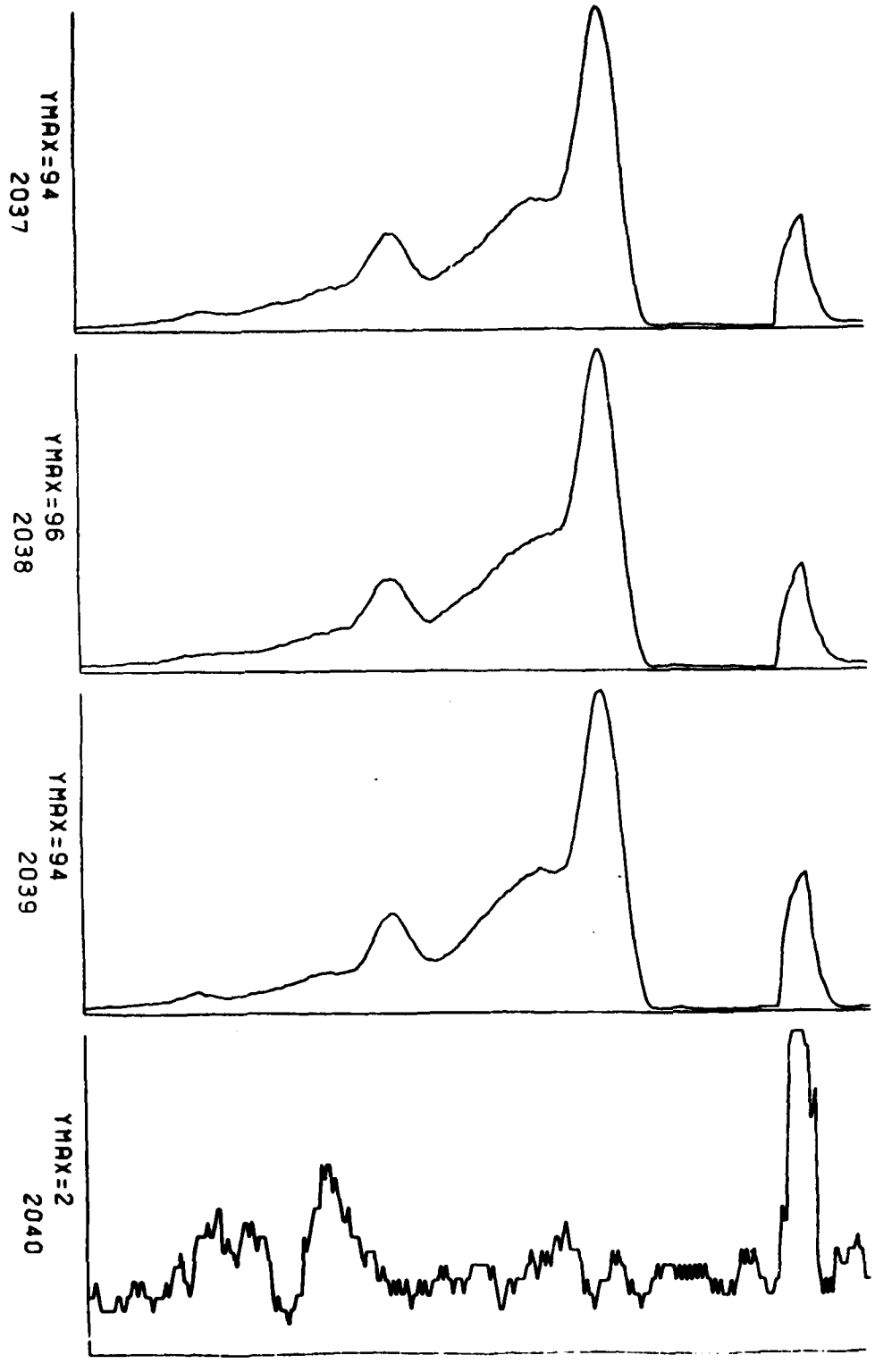


Figure 7. Quick Plot Sample (QPL)

(~5% over 100 Å) is used later to correct the data in MATCH (see Figure 8).

Scans of the iron hollow cathode lamp lines establish the wavelength calibration of the spectrometer system as well as the actual shape of the slit function.

8. Program KITSLIT takes the summed scans across selected lines and fits a triangular slit function to them, adjusting an arbitrary multiplicative constant, a background pedestal, the horizontal position and the width. Then scans of different lines can all be normalized and plotted on computer printout as shown in Figure 9. An accurate slit function can be deduced from this composite by hand drawing smoothed sections at the top and bottom of the straight line of the triangular function (physically, the sharp corners of the geometric optically correct triangular slit function are rounded off by diffraction).

9. Program SYN calculates a synthetic AlO spectra. The technique is similar to Harang (1966). The molecular parameters of Tyte and Nicholls (1964) are used to calculate the position of the rotational-vibrational lines. Populations of various rotational and vibrational levels are derived from the Boltzmann distribution law assuming thermal equilibrium with the ambient air which would appear to be a valid assumption up to approximately 170 km where the collision rate is 10/sec; the f-value of the AlO electronic transition is generally assumed to be 0.1 to 1.0 (Harang, 1966) implying that each molecule has 1 to 10 seconds or 10 to 100 collisions to attain thermal equilibrium between excitations. The solar excitation used is taken from the Utrecht Atlas (Minnaert et al, 1940). The band strength with Franck Condon factors is used to calculate absorption for various vibrational levels.

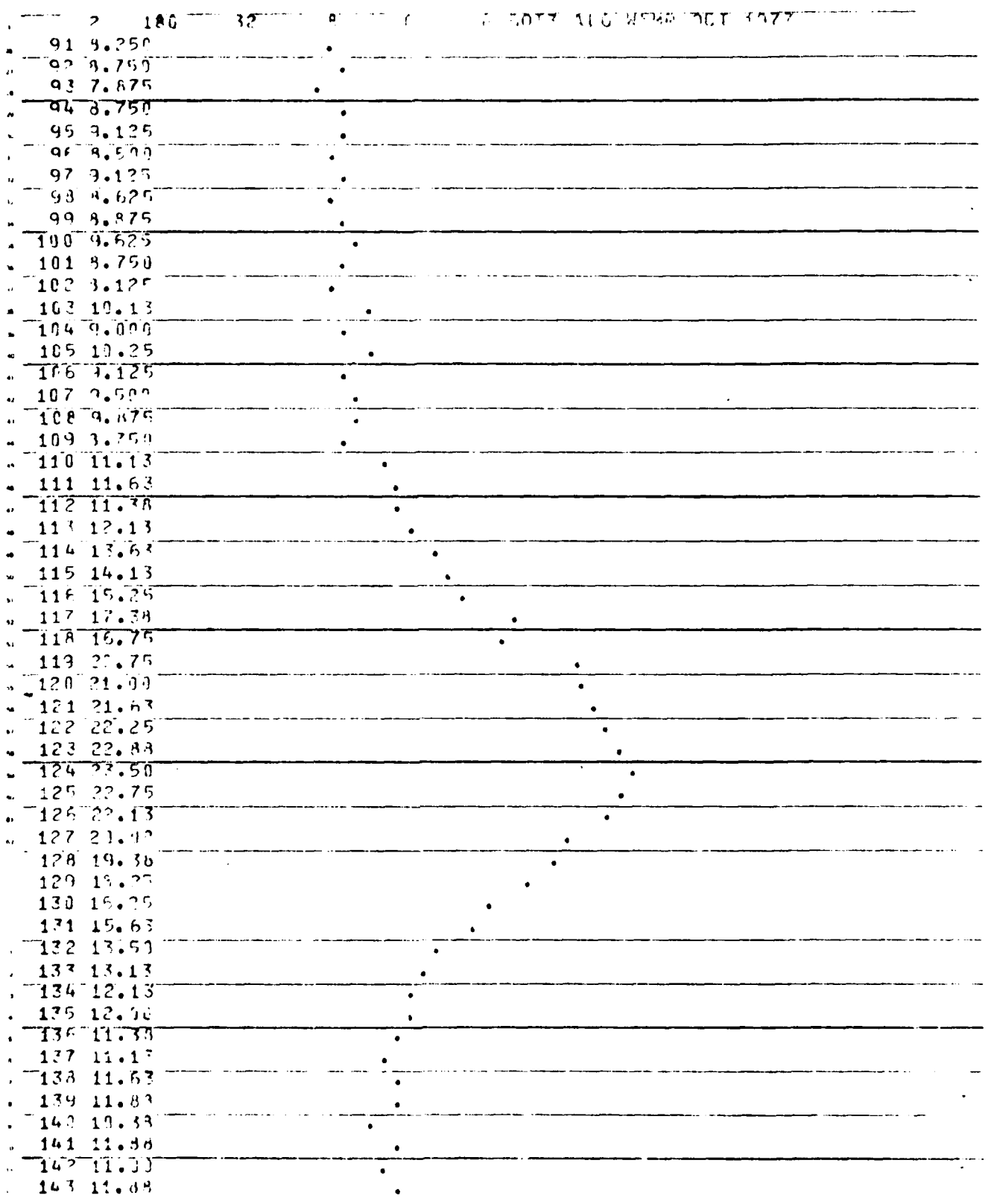


Figure 8. Sample of STPL Output

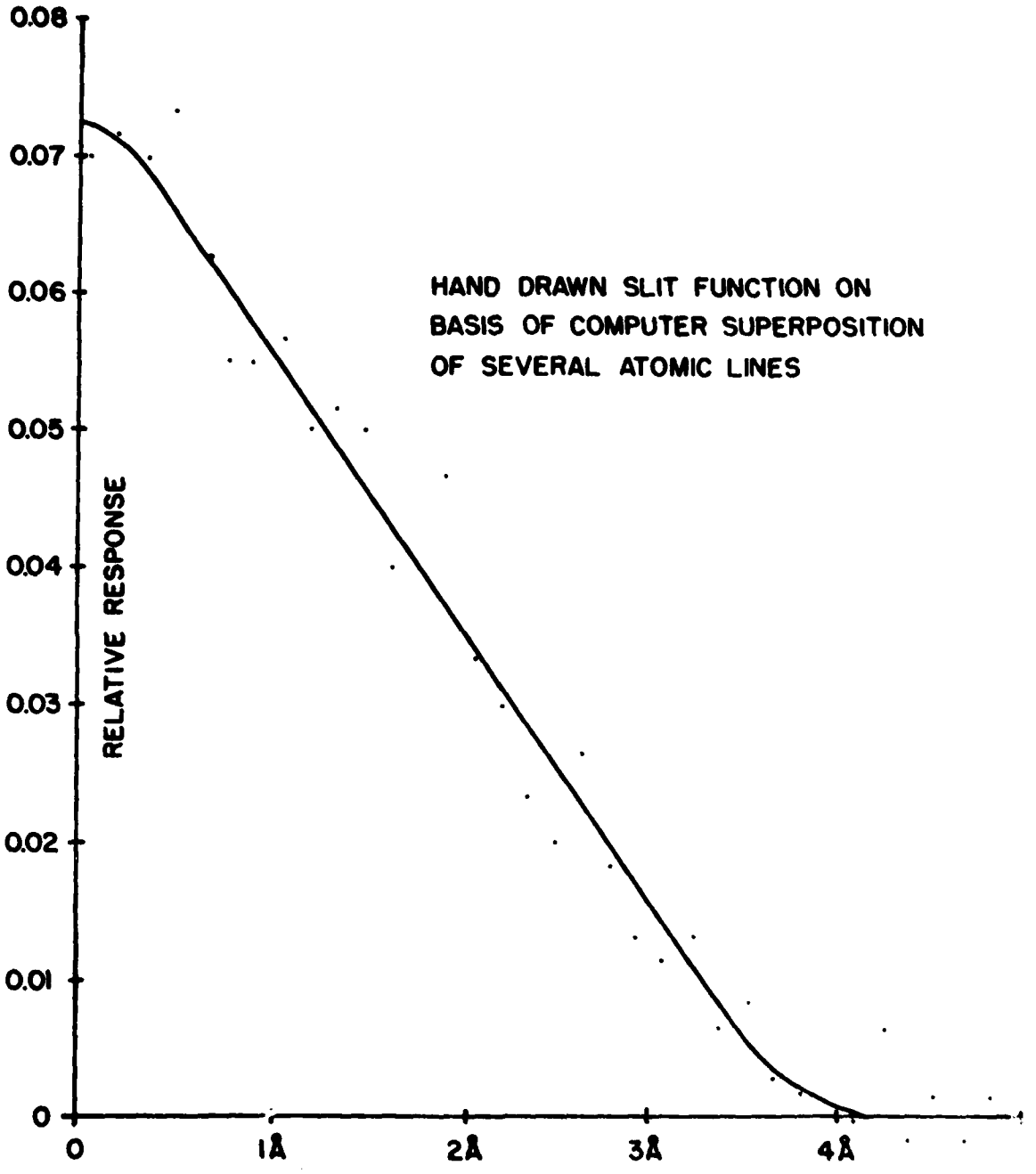


Figure 9. Slit Function Curve

Assuming dynamic equilibrium between vibrational levels and between rotational levels relative intensities can be assigned to each rotational line in the bands of a sequence.

The intensities of the first 75 rotational lines of each branch (P and R branches) in the first three bands of the $\Delta V = 0$ sequence are then convolved with the experimentally measured slit function derived in KITSLIT. This convolution is then tabulated every 1/4 Å and every 50 degrees from 150°K to 1050°K and stored as a permanent file. Plots of synthetic spectra are shown in Appendix B.

10. Program MATCH is the heart of the data reduction scheme. Inputs to MATCH are synthetic spectra from SYN already convolved with the slit function at 19 temperatures and the digitized spectrometer output. Groups of scans are summed or lumped as determined by the examination of quick plots from KITQPL and the study of the boresight records. The spectrometer output is then corrected for amplitude non-linearity or dead-time with subroutine FKAY using constants supplied by program KITAU. Correction is then made for variation of sensitivity with respect to wavelength using a linear approximation derived from the calibration scans of the lightbox.

    The data points in the lumped measured scans are then compared to each of the 19 synthetic spectra. Iterative adjustments are made to the exact horizontal (wavelength) position of the measured scan, a multiplicative factor which scales the synthetic spectra to the measured scan, and an additive constant which is added under the synthetic spectra as a pedestal. The iterative adjustments of the three variables described above and shown graphically in Figure 10 are made using as a criterion for best fit of the measured points to the synthetic curve the likelihood that the measured points result from a curve

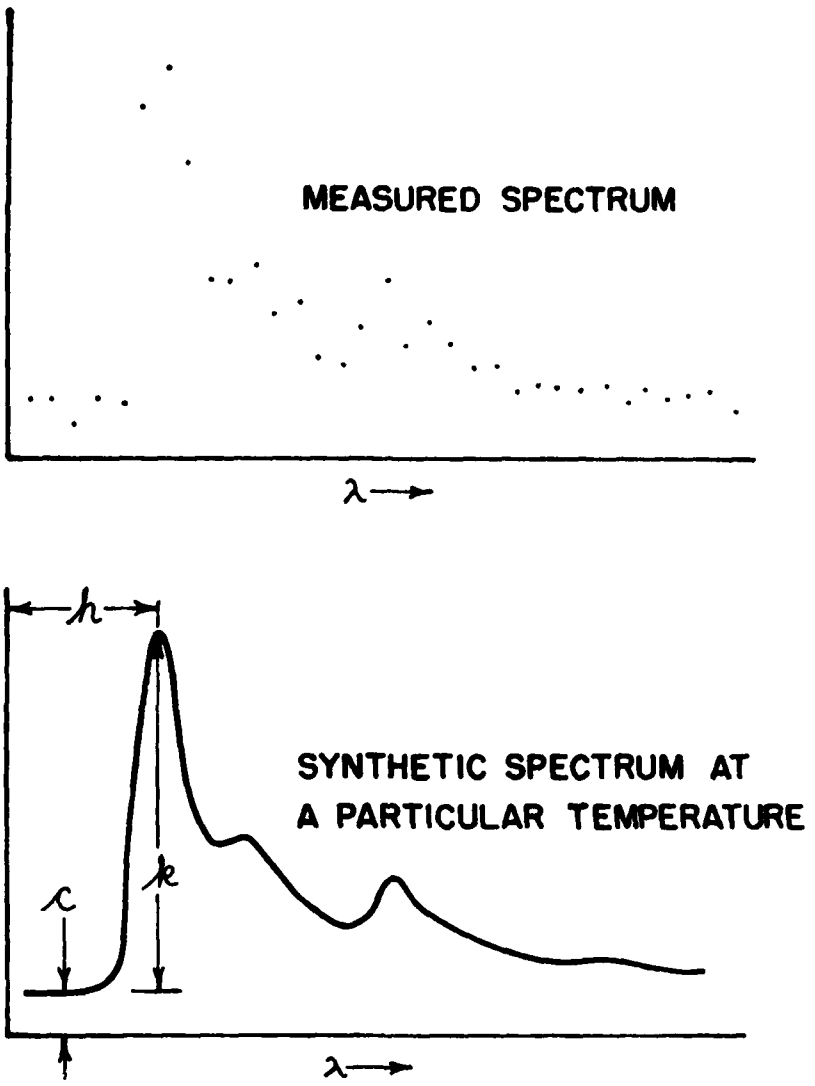
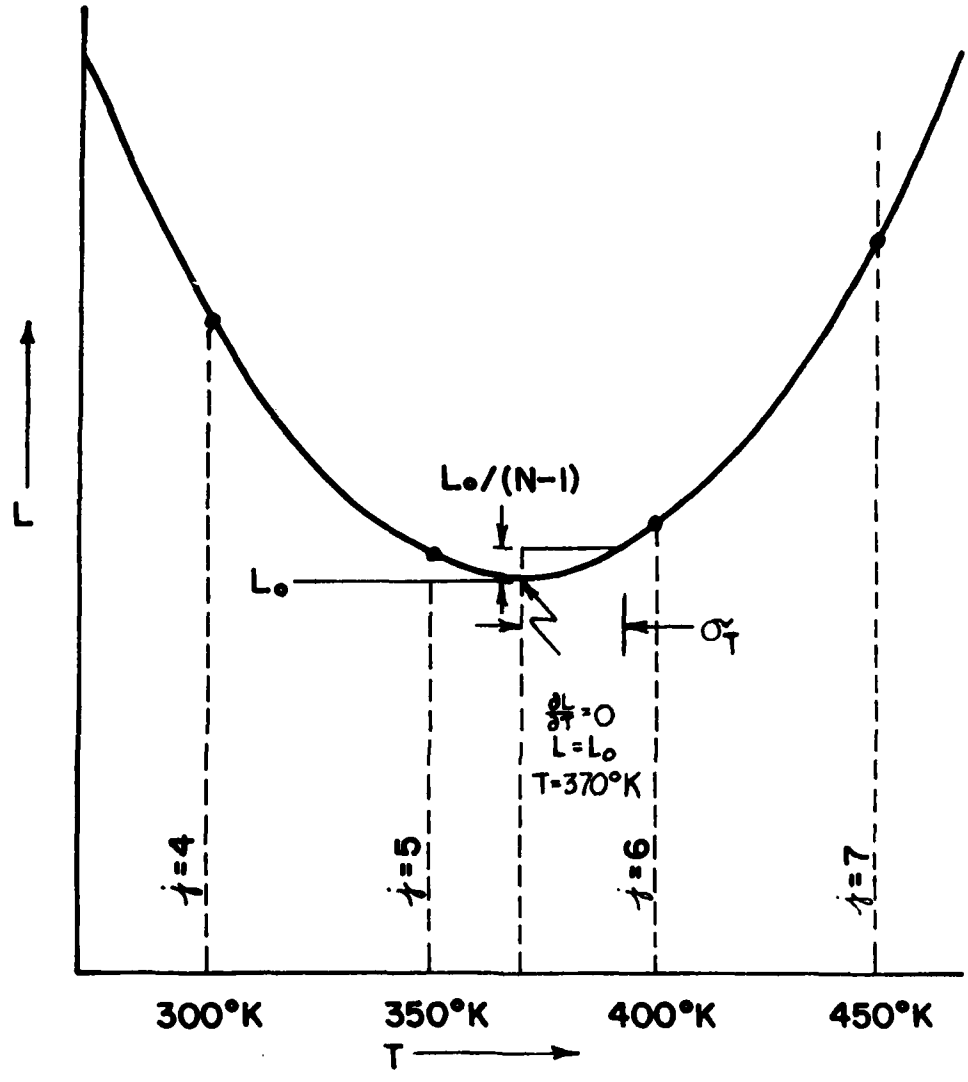


Figure 10. Adjustments Used in MATCH

same as the synthetic but made noisy according to Poisson statistics. The likelihood function is the product of the probabilities at each point in the measured scan that the point results from Poisson distributed errors about a point at the same wavelength in the synthetic spectrum. Incidentally, this type of maximum likelihood function procedure simplifies to become a least square fit when the errors in the measurement are Gaussian. It has been determined that in this application, involving counting randomly arriving photons which is properly described by Poisson statistics, with a fairly low number of counts at each point in the measured spectrum, considering that Gaussian statistics become a poorer approximation to Poisson statistics at smaller counts with a consistent bias from the skewed nature of the Poisson distribution and that the temperature deduced by this technique varies monotonically with the slope of the data points, use of least squares fitting rather than the maximum likelihood technique based on Poisson statistics results in a systematic error of as much as 15 degrees.

The temperature of the synthetic spectrum producing the maximum likelihood function as well as the next higher and next lower temperature and the three corresponding values of the likelihood function are used to generate a parabolic curve for a parabolic interpolation (see Figure 11). The peak of this parabola is used as the interpolated temperature of best fit. More details are supplied in Appendix A.

In Appendix B plots of the fourteen "lumped" or summed scans of measured spectra are shown along with five synthetic spectra closest in temperature to each of the measured spectra. The measured spectra are corrected for dead-time amplitude non-linearity and the variation of instrumental sensitivity with respect to wavelength.



WHERE:

N = NO. OF INDEPENDENT MEASUREMENTS

σ_T = STD. DEVIATION OF TEMPERATURE MEASUREMENT

L = SUM OF SQUARES (OR EQUIVALENT FOR POISSON STATISTICS)

T = TEMPERATURE

Figure 11. Interpolation of MATCH Results (Example)

The measured spectra as well as the five synthetic spectra are normalized to peak at 100 on the two decade 1 to 100 scale. The synthetic spectra are shown "sitting on top of" a pedestal C_j/k_j where C_j and k_j are the constants derived by the fitting procedure for best match of the particular synthetic spectrum to the measured spectrum. Even though only the region from 4824 Å to 4886 Å is used in the fitting procedure, more of the measured spectrum including part of the spectrometer return sweep is shown on the plot.

4.0 RESULTS

The results of the September 1977 White Sands temperature measurements are summarized in Table 3. Since there was only one puff or cloud, the data was taken from points near the top and near the bottom of the cloud rather than from the center of each in a series of small puffs as would usually be done in this sort of experiment. An average temperature for the observations of the top of the cloud weighted by $1/\sigma^2$ is 622°K with an overall σ of 22°K. Disregarding the three weak measurements where there may have been instrumental problems, the average is 628°K with a σ of 16°K. An average temperature for the observations of the bottom of the cloud with or without the two weak measurements was 578°K with an overall σ of 14°K.

Some of the scatter of individual measurements, particularly at the bottom of the cloud, is a result of having in the line of sight to the bottom, the more rapidly diffusing upper part of the cloud. In general, only the earliest measurements of A10 at altitudes as high as these are accurate for reasons of altitude spread along the line of sight through the cloud.

Better altitude resolution could have been had if the elevation angle of the line of sight were to have been lower; however, in the case of the White Sands site the logistic requirements precluded moving the observation site back 100-200 km as would have been preferred. Also the accident of having a very large release over perhaps 7-10 km rather than the smaller "point" releases did not aid the altitude precision either.

WSMR A10 TEMPERATURE

24 September 1977

File No. 2 AMUL = 0.3010 Calculations 19 June 78

Description	Scan No.	Sum	Peak	Max. Amp.		Time	Temp. [°K]	σ
TOP 1	8	7	210.5	117		11:59:38	650	6
BOT 1	16	8	207.4	63		12:00:21	571	8
BOT 2	24	8	204.2	80		12:01:01	574	7
BOT 3	32	8	201.5	101		12:01:41	601	7
TOP 2	49	5	194.9	210		12:02:58	621	6
BOT 4	54	3	193.8	130		12:03:18	606	11
BOT 5	58	9	191.5	13	Weak	12:03:53	600	20
TOP 3	68	8	186.1	23	Weak	12:04:41	574	16
TOP 4	76	9	183.5	23	Weak	12:05:23	594	13
TOP 5	86	5	179.7	23	Weak	12:06:03	575	18
BOT 6	93	6	177.9	11	Weak	12:06:41	572	29
BOT 7	100	8	175.0	91		12:07:21	569	6
BOT 8	122	11	166.2	78		12:09:18	570	5
TOP 6	136	7	160.0	118		12:10:18	614	6

TABLE 3

5.0 REFERENCES

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A P P E N D I X A

STATISTICAL DEVELOPMENT OF FITTING PROCEDURE

APPENDIX A

The general likelihood function where the error distributions at each point are independent is

$$L_j = \prod_{i=1}^{n} P_{\lambda ij}(y_i) \qquad (1)$$

where y_i = table of values representing measurements at successive points in the measured spectrum.

$P_{\lambda ij}(y_i)$ = the probability that a point in the spectrum having a long term average λ_{ij} would be measured as y_i in a single measurement.

$$\lambda_{ij} = k_j z_{ij} + C_j \qquad (2)$$

where z_{ij} = table of values of synthetic spectra at wavelengths corresponding to y_i at the same i index and temperature j.

k_j = an arbitrary multiplicative factor used to scale the synthetic spectrum to the measured spectrum and will be optimized to obtain the maximum likelihood at a given j.

C_j = an arbitrary additive constant added to the synthetic spectrum to represent a constant background or pedestal under the measured spectrum. It will be optimized same as k_j.

In this case where the distribution of individual measurements about a long term average is a Poisson distribution

$$P_{\lambda ij}(y_i) = \frac{(\lambda_{ij})^{y_i} \ell^{-\lambda_{ij}}}{(y_i)!} \qquad (3)$$

Combining (1), (2) and (3) and taking the logarithm of both sides

$$\ell n\ L_j = \sum_{i=1}^{n} [y_i\ \ell n(k_j\ z_{ij} + C_j) - (k_j\ z_{ij} + C_j) - \ell n(y!)] \quad (4)$$

It is necessary now to find the maximum likelihood of $\ell n\ L_j$ as a function of k_j, C_j and j independently. The third term in (4) is not a function of the above so it can be ignored for the time being. At any given j then the optimum k_j and C_j are those which allow the partial derivatives below (5), (6) to be zero

$$\frac{\partial\ \ell n\ L_j}{\partial\ k_j} = 0 = \sum_{i=1}^{n} [\frac{y_i\ z_{ij}}{k_j\ z_{ij} + C_j} - z_{ij}] \quad (5)$$

$$\frac{\partial\ \ell n\ L_j}{\partial\ C_j} = 0 = \sum_{i=1}^{n} [\frac{y_i}{k_j\ z_{ij} + C_j} - 1] \quad (6)$$

Unfortunately there is no analytic solution for k_j and C_j as in the analogous procedure for a Gaussian distribution (least squares). The Newton Rapsohn method will be used to effect a solution.

$$f_j(k_j,C_j) = 0 = \sum_{i=1}^{n} \frac{y_i\ z_{ij}}{k_j\ z_{ij} + C_j} - \sum_{i=1}^{n} z_{ij} \quad (7)$$

$$g_j(k_j,C_j) = 0 = \sum_{i=1}^{n} \frac{y_i}{k_j\ z_{ij} + C_j} - n \quad (8)$$

in general

$$f(k_0 + \delta_k,\ C_0 + \delta_C) = 0 = f(k_0,C_0) + \delta_k \frac{\partial f(k_0,C_0)}{\partial k} + \delta_C \frac{\partial f(k_0,C_0)}{\partial C} \quad (9)$$

$$g(k_0 + \delta_k,\ C_0 + \delta_C) = 0 = g(k_0,\ C_0) + \delta_k \frac{\partial g(k_0,C_0)}{\partial k} + \delta_C \frac{\partial g(k_0,C_0)}{\partial C} \quad (10)$$

solving the right-hand side of both equations.

$$\delta_\kappa = \frac{g\frac{\partial b}{\partial c} - f\frac{\partial g}{\partial c}}{\frac{\partial b}{\partial k}\frac{\partial g}{\partial c} - \frac{\partial f}{\partial c}\frac{\partial g}{\partial k}} \tag{11}$$

$$\delta_C = \frac{f\frac{\partial g}{\partial k} - g\frac{\partial f}{\partial k}}{\frac{\partial f}{\partial k}\frac{\partial g}{\partial c} - \frac{\partial f}{\partial c}\frac{\partial g}{\partial k}} \tag{12}$$

initial values of k_0 and C_0 are

$$k_0 = y_{max} - y_{min} \tag{13}$$

$$C_0 = y_{min} \tag{14}$$

new values for k and C are

$$k = k_0 + \delta_\kappa \tag{15}$$

$$C = C_0 + \delta_C \tag{16}$$

which are iterated until $\delta\kappa/k$ and δ_C/C are both less than 10^{-6} or so. Convergence to the 10^{-6} criteria takes five or six iterations.

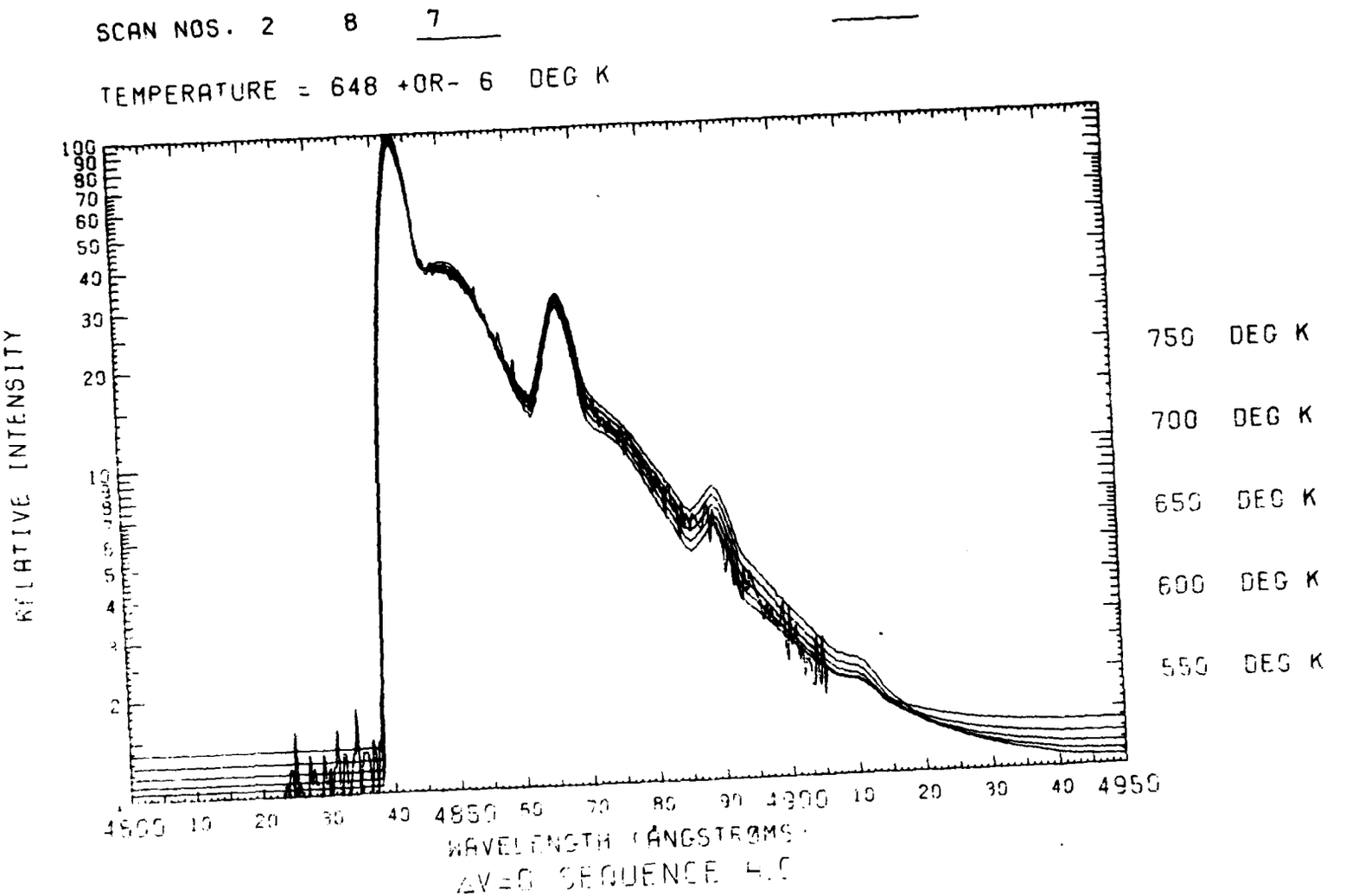
Once optimum k_j and C_j values are found corresponding to a particular T_j the actual likelihood function at each j can be computed. The T_j at which the likelihood function is maximum is the temperature of best fit. The preceding T_j along with T_{j+1} and T_{j+2} are used to generate a parabola

$$L = AT^2 + BT + C \tag{17}$$

The peak of the parabola, where $\partial L/\partial T = 0$ is used to indicate an interpolated value of T. The shape of the parabola near the peak is used to deduce a σ_T in a manner similar to Dyer (1970, unpublished) for least squares fitting (see Figure 11).

A P P E N D I X B

VISUAL VERIFICATION OF MATCH RESULTS


SCAN NOS. 2 8 7
TEMPERATURE = 648 +OR- 6 DEG K
RELATIVE INTENSITY
100
90
80
70
60
50
40
30
20
10
5
4
3
2
4900 10 20 30 40 4950 60 70 80 90 5000 10 20 30 40 4950
WAVELENGTH (ANGSTROMS)
750 DEG K
700 DEG K
650 DEG K
600 DEG K
550 DEG K
ΔV=0 SEQUENCE 5.0

SCAN NOS. 2 16 8

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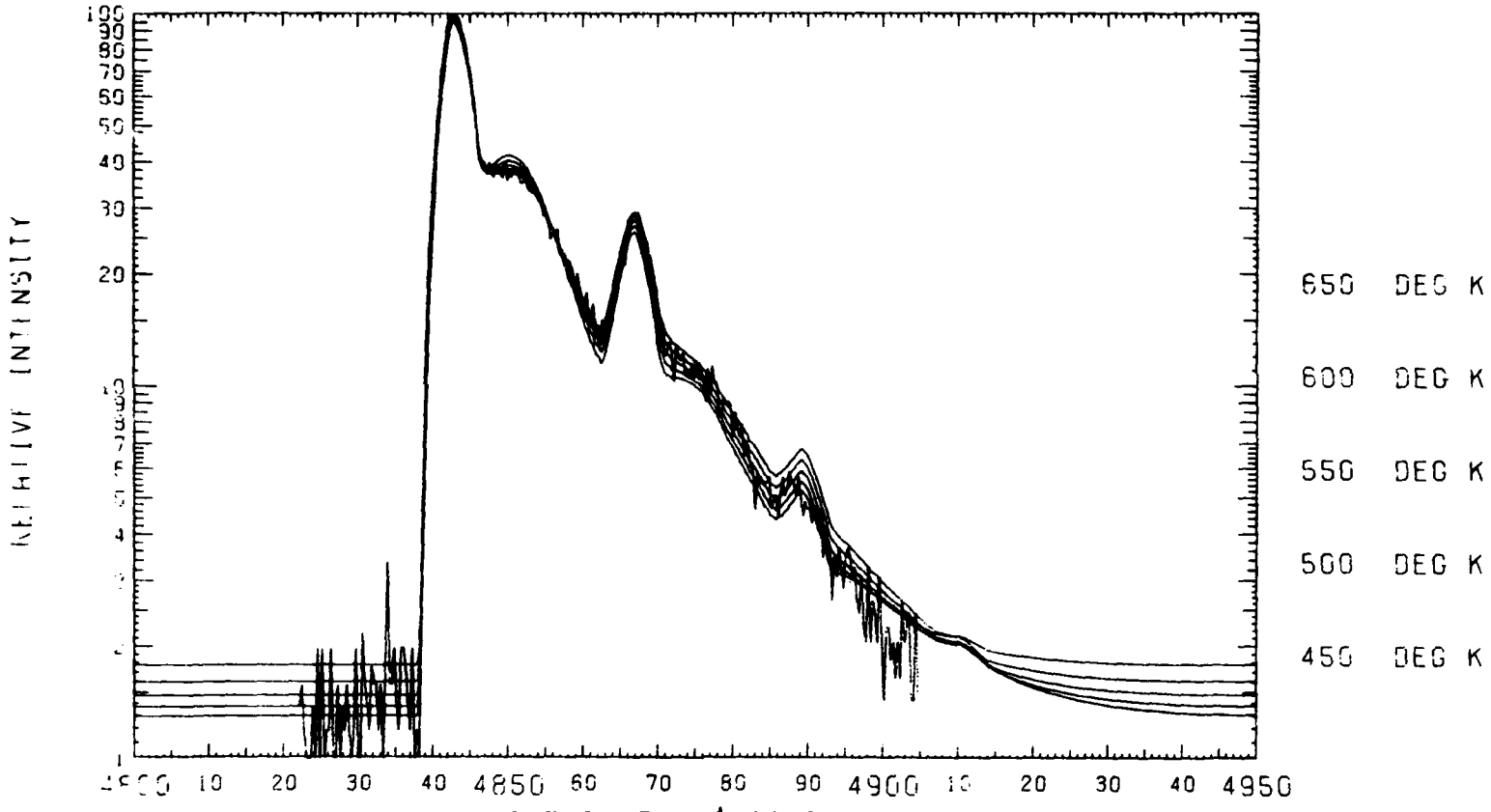
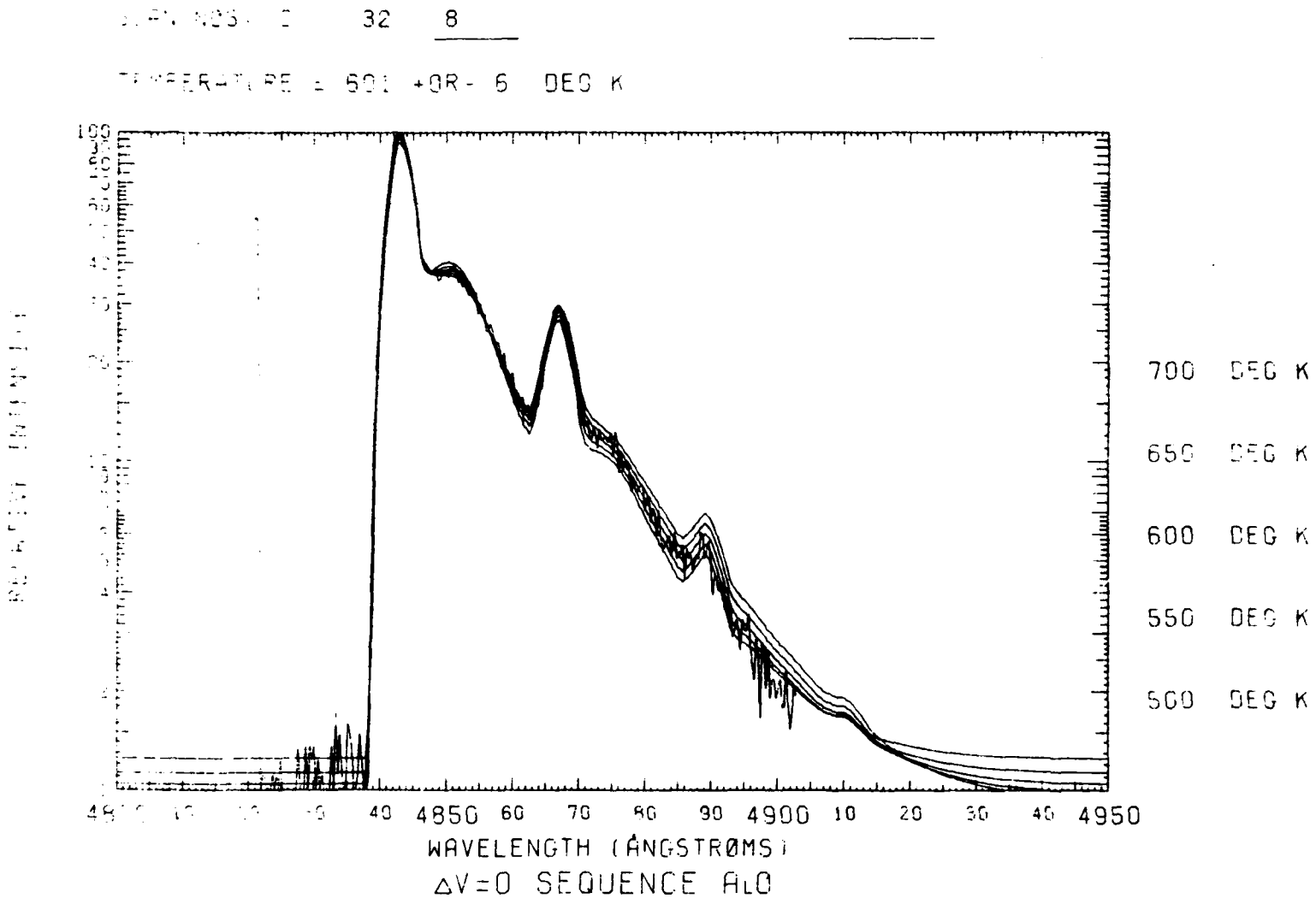
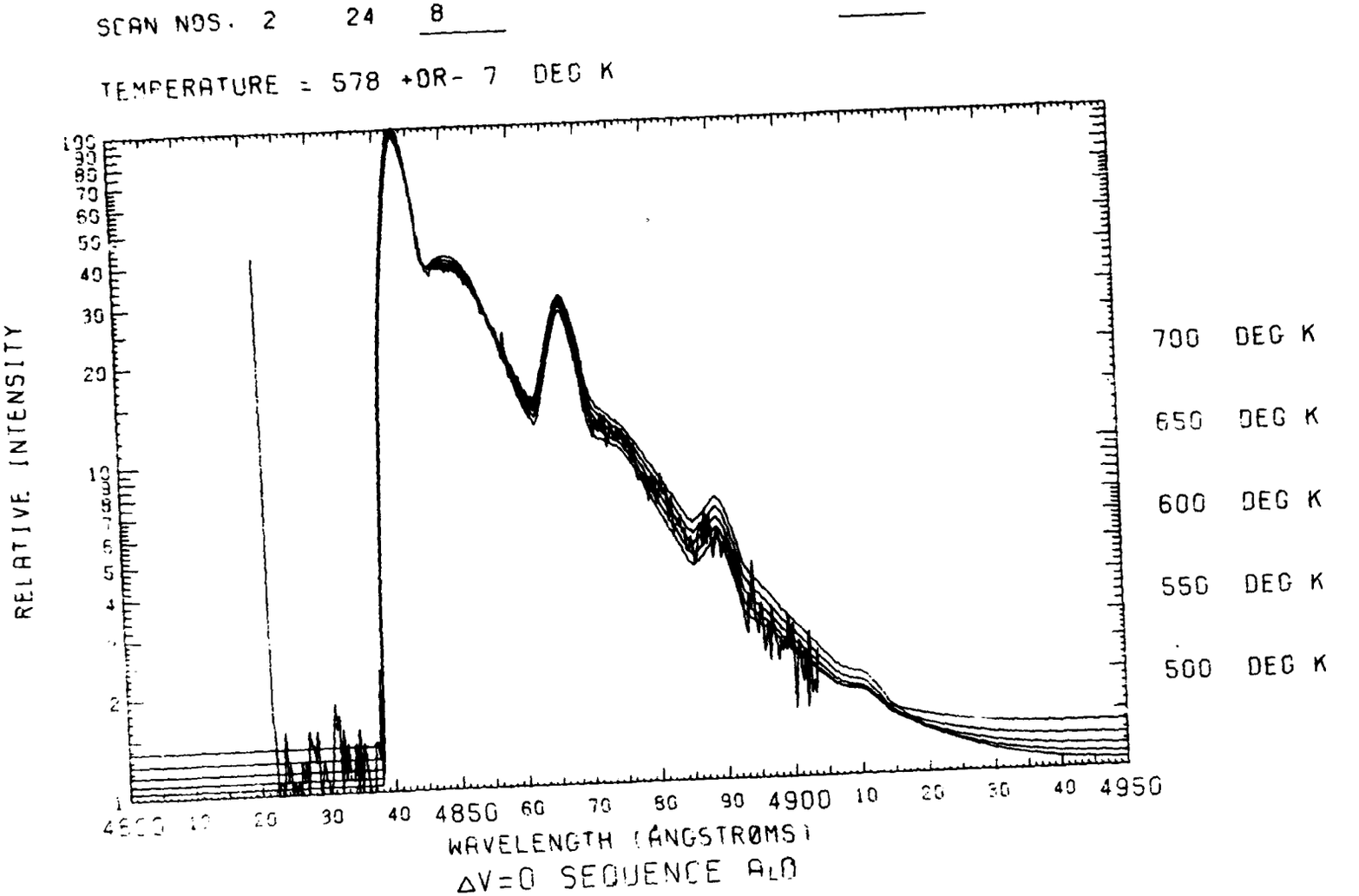
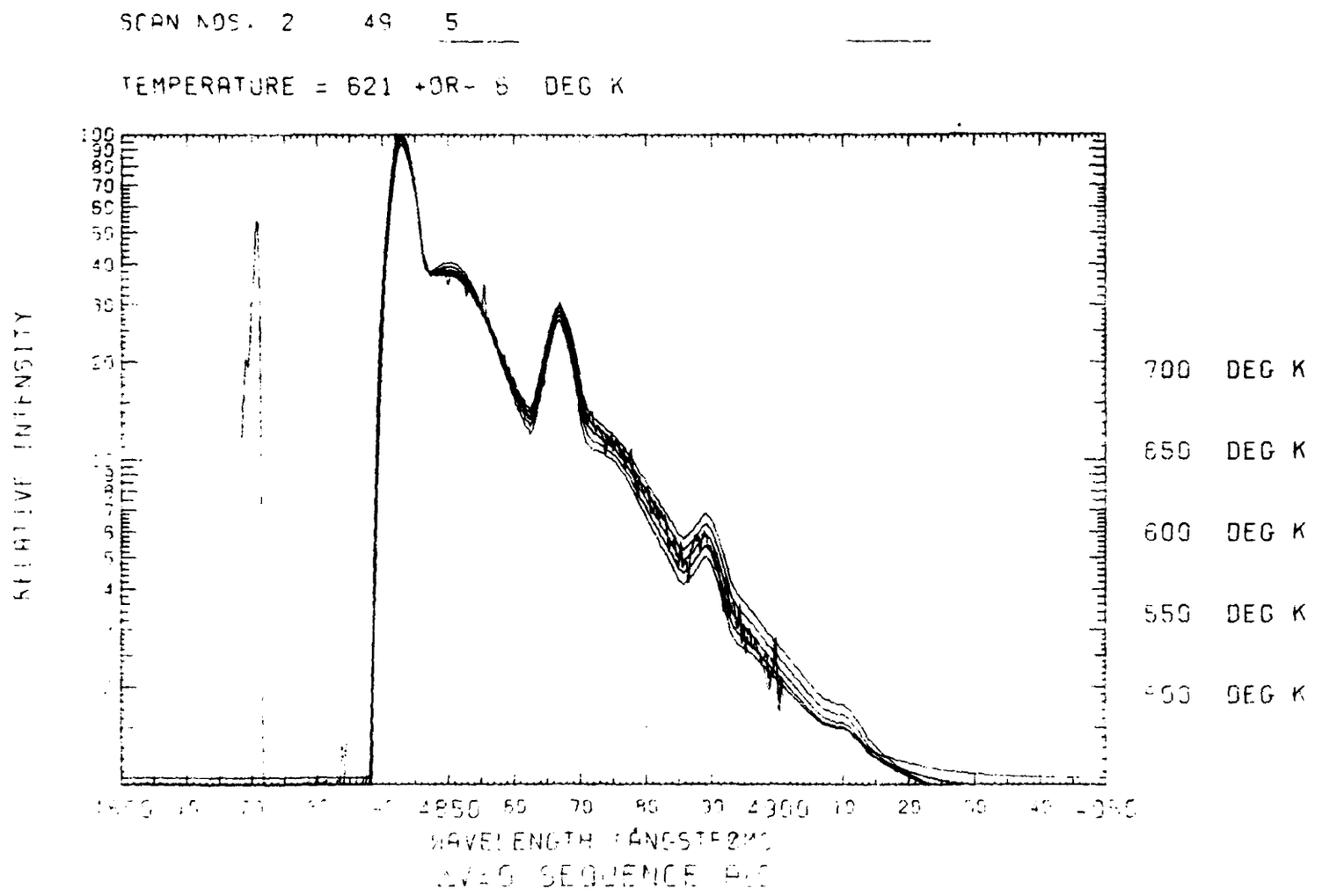


$\Delta V=0$ SEQUENCE $A_1\Pi$

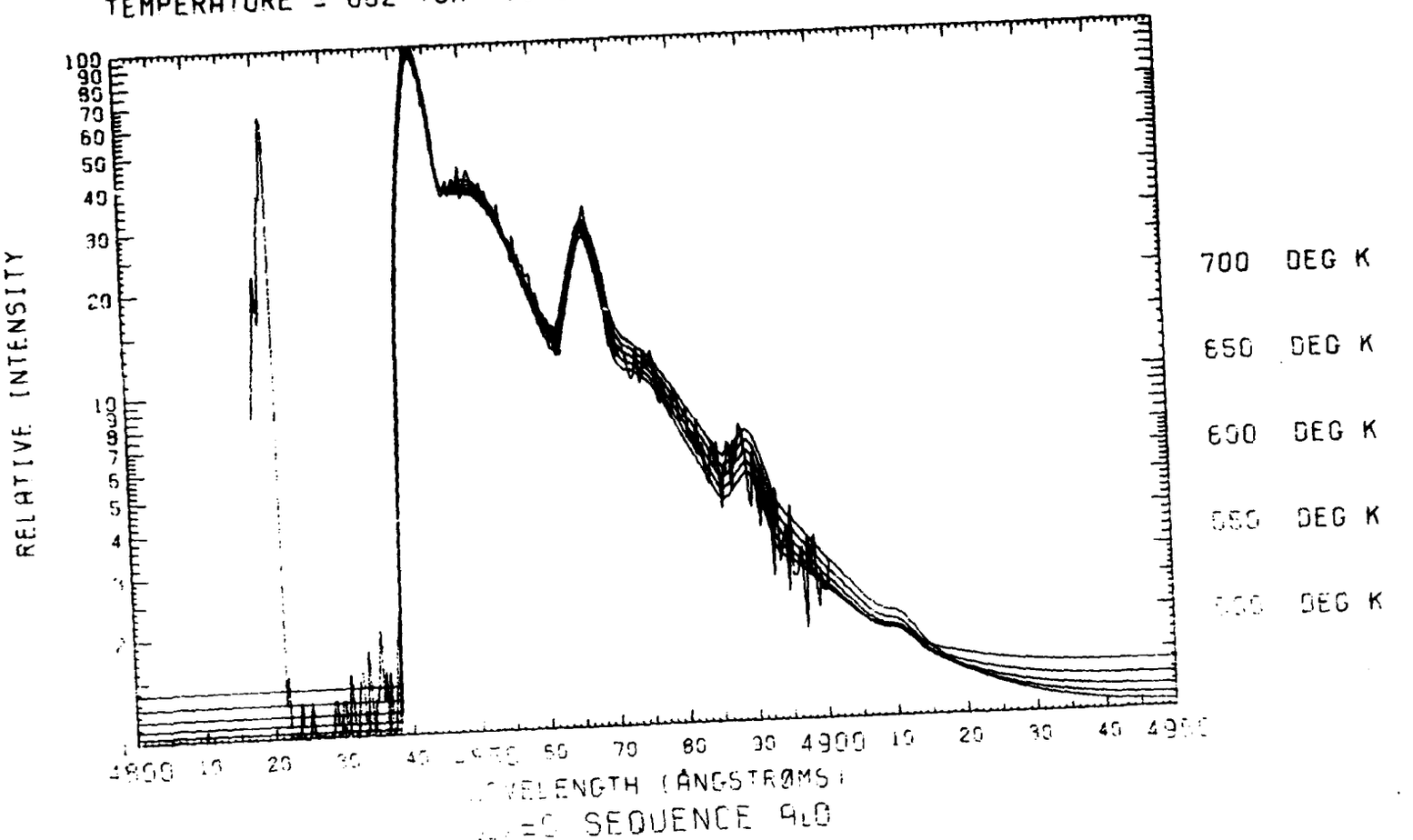

32 8
TEMPERATURE = 501 +OR- 6 DEG K
700 DEG K
650 DEG K
600 DEG K
550 DEG K
500 DEG K
4850
4900
4950
WAVELENGTH (ÅNGSTRØMS)
ΔV=0 SEQUENCE AlO


SCAN NOS. 2 24 8
TEMPERATURE = 578 +OR- 7 DEG K
RELATIVE INTENSITY
100
95
90
85
80
70
60
50
40
30
20
10
4
2
1
4800 10 20 30 40 4850 60 70 80 90 4900 10 20 30 40 4950
WAVELENGTH (ANGSTRØMS)
700 DEG K
650 DEG K
600 DEG K
550 DEG K
500 DEG K
ΔV=0 SEQUENCE A1Π


SCAN NOS. 2 49 5
TEMPERATURE = 621 +OR- 6 DEG K
RELATIVE INTENSITY
700 DEG K
650 DEG K
600 DEG K
550 DEG K
WAVELENGTH (ANGSTROMS)
AVCO SEQUENCE B-2

SCAN NOS. 2 54 3

TEMPERATURE = 602 +OR- 11 DEG K



STAR NOS: 2 58 9

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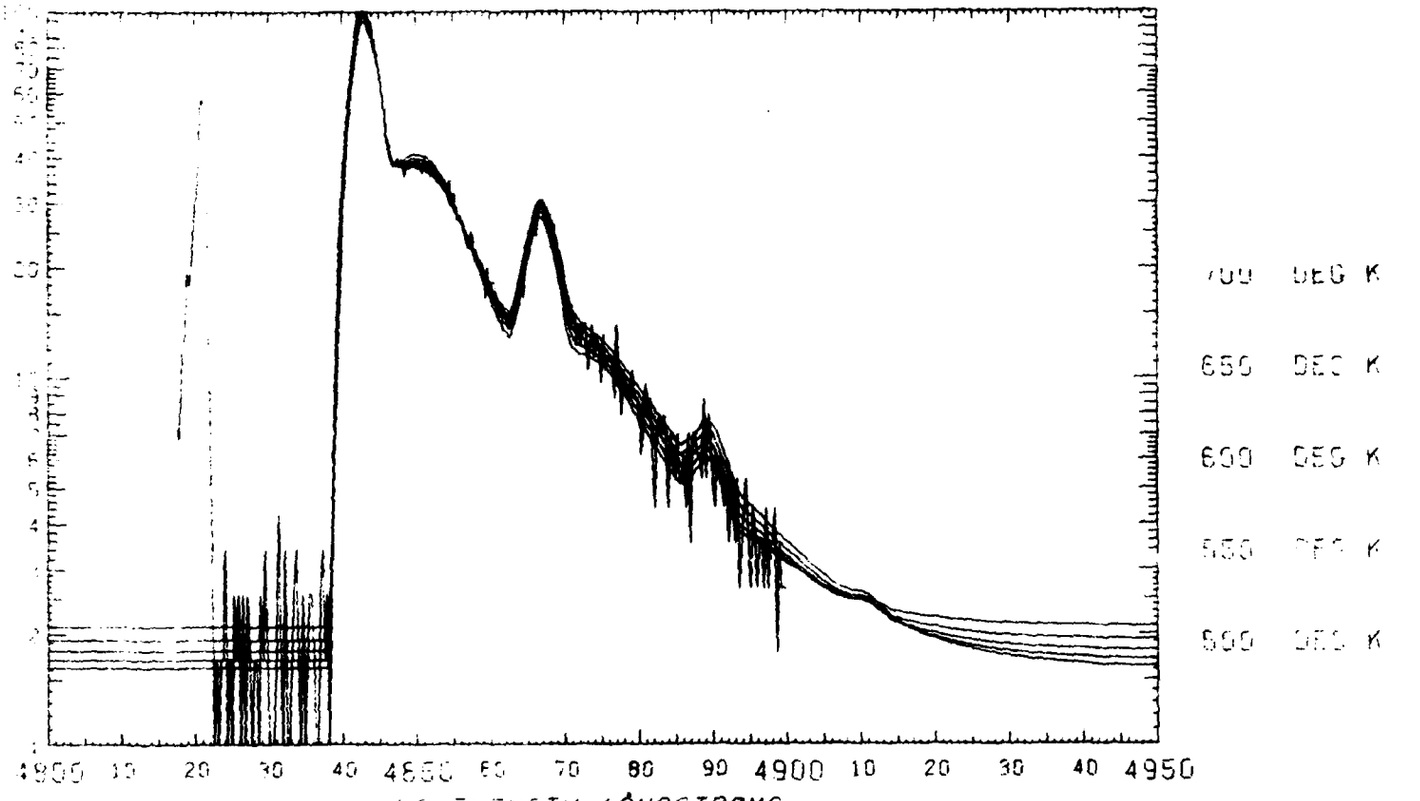

ZVEZ SEQUENCE ALO

SCAN NOS. 2 68 8

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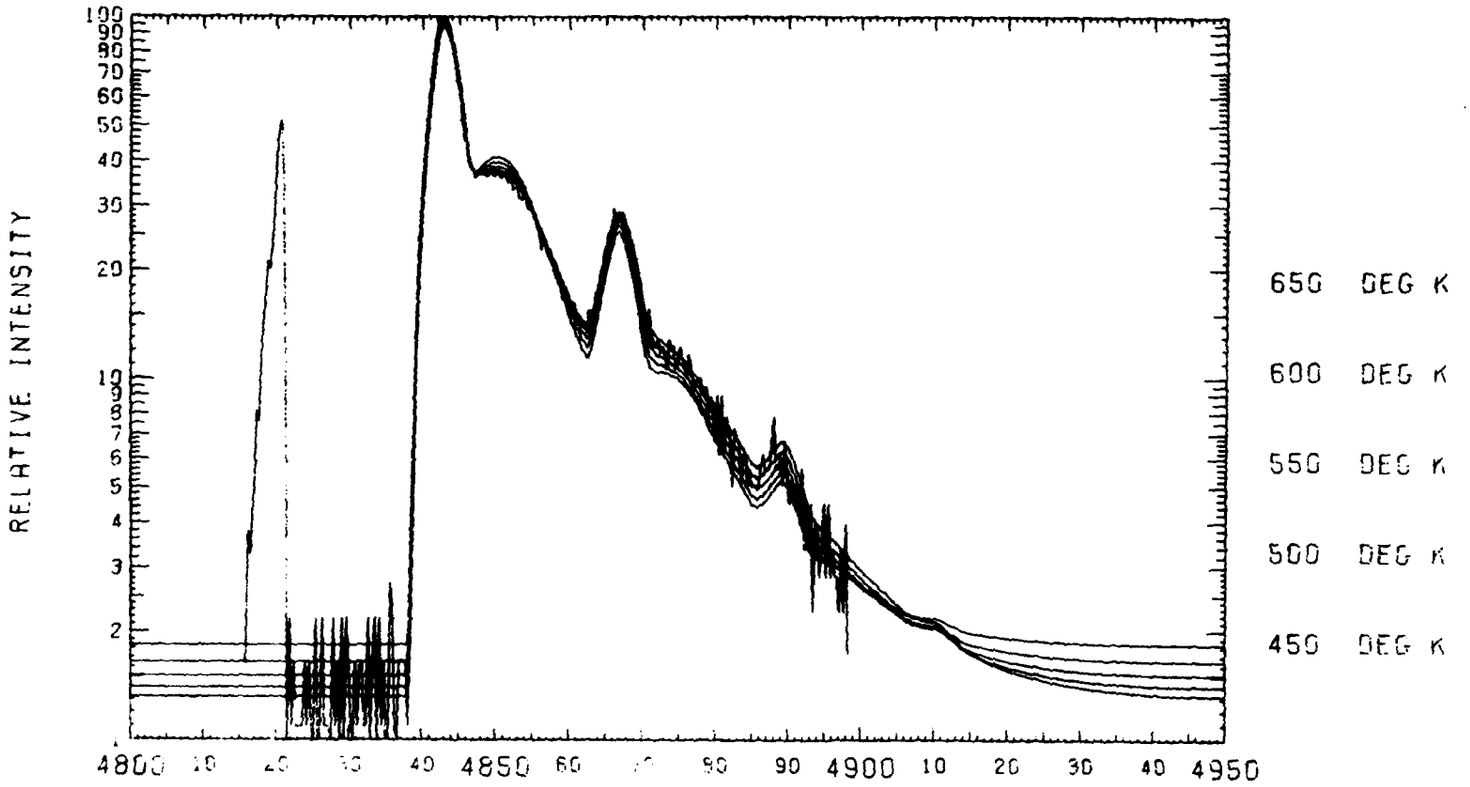
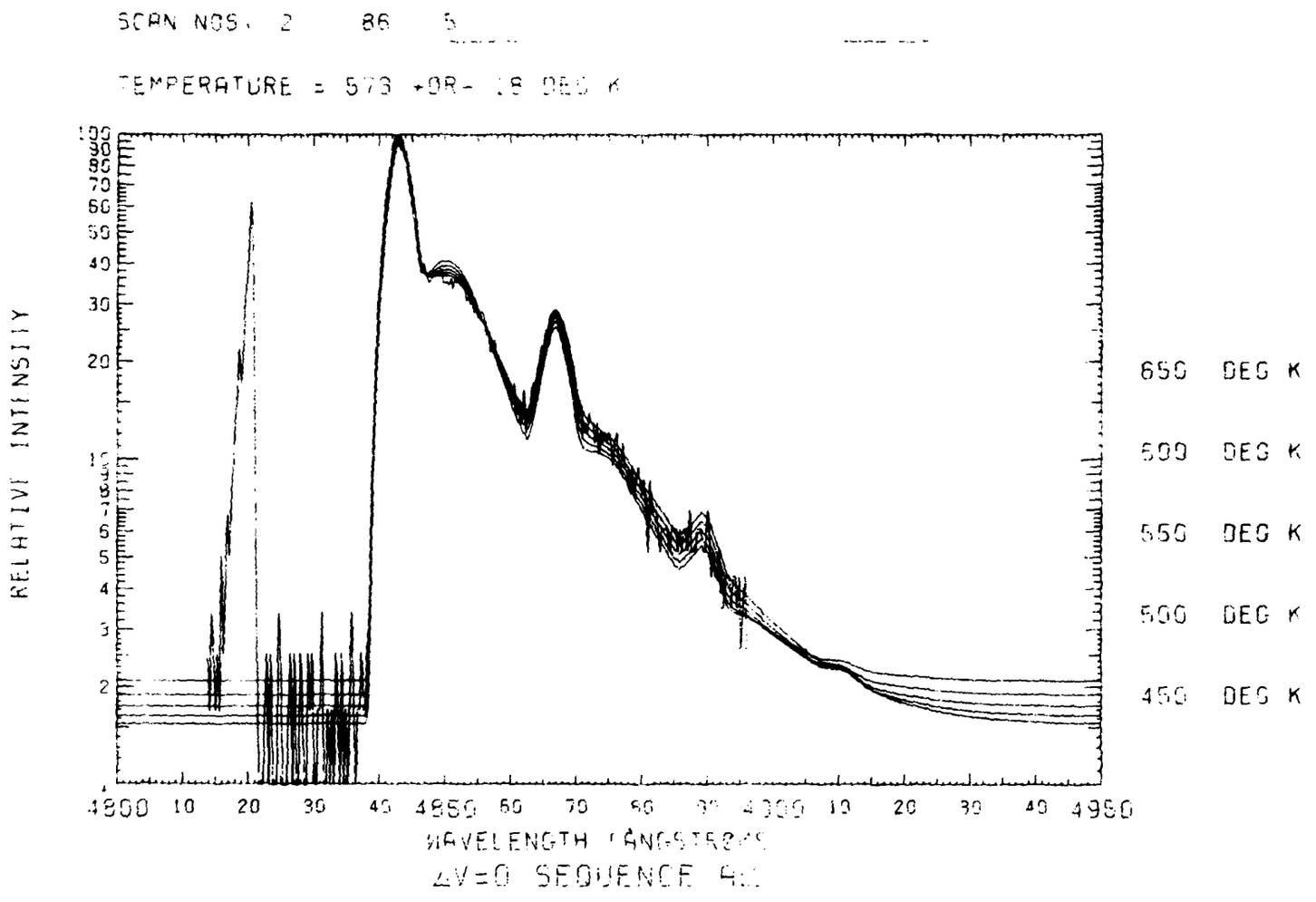


ΔV=0 SEQUENCE A₁Σ


SCAN NOS. 2 86 5
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RELATIVE INTENSITY
650 DEG K
600 DEG K
550 DEG K
500 DEG K
450 DEG K
WAVELENGTH (ANGSTROMS)
ΔV=0 SEQUENCE

SCAN NOS. 2 93 6

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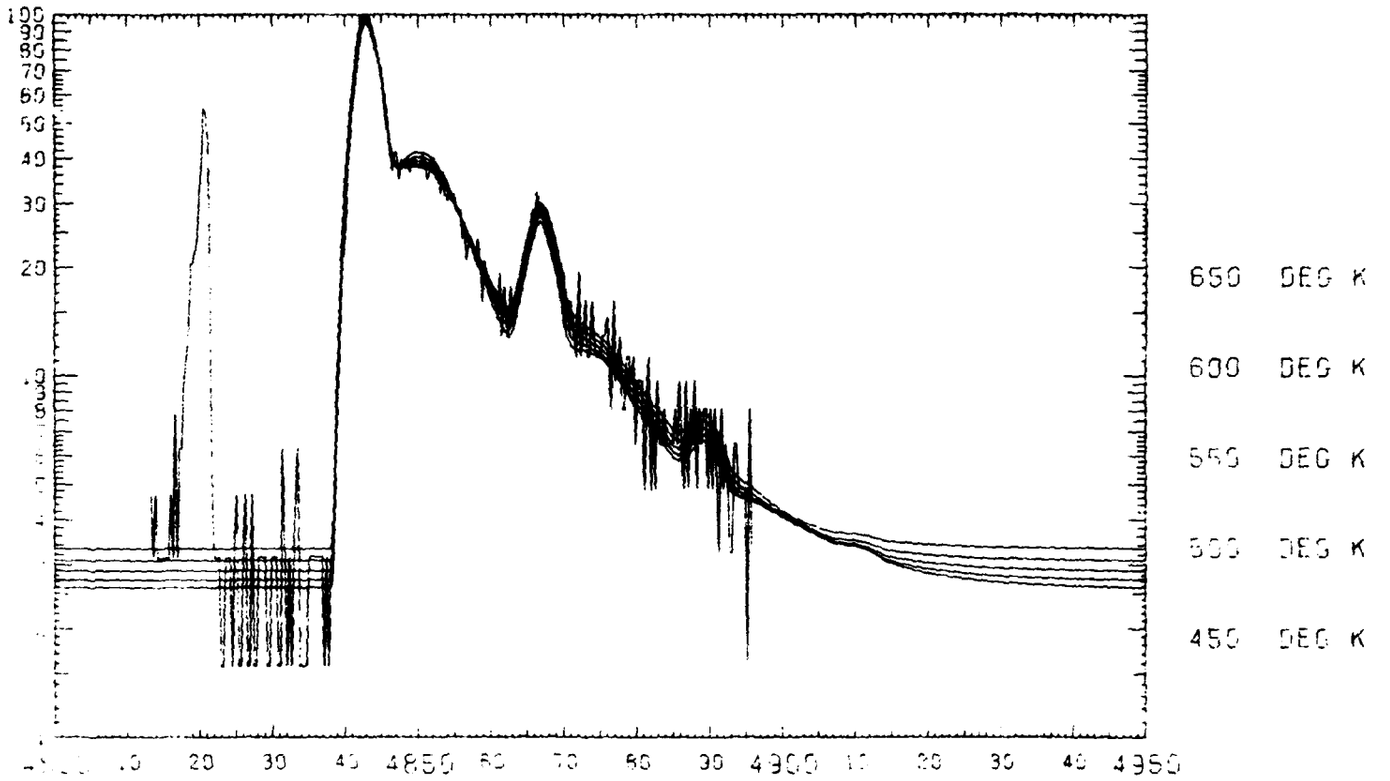
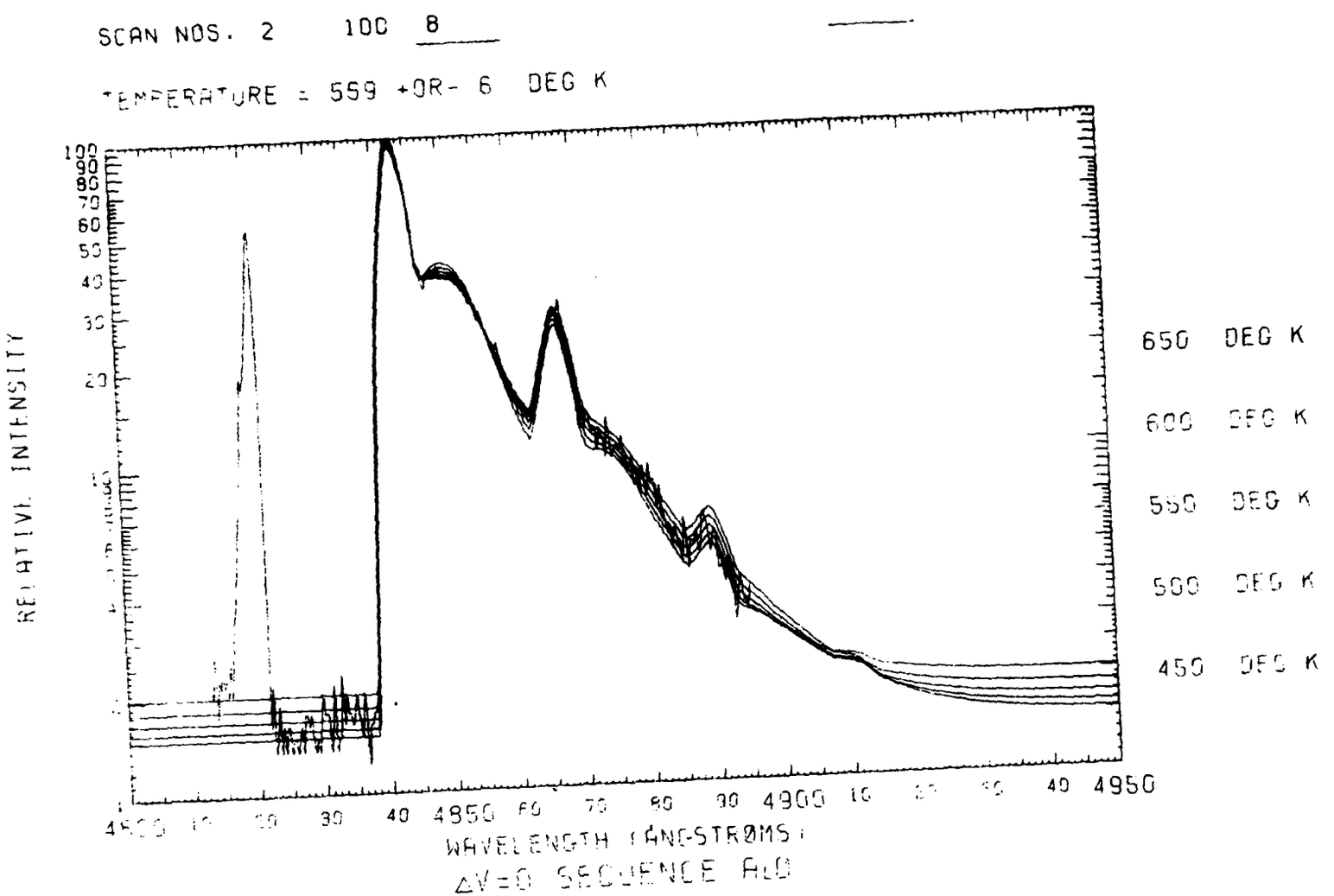
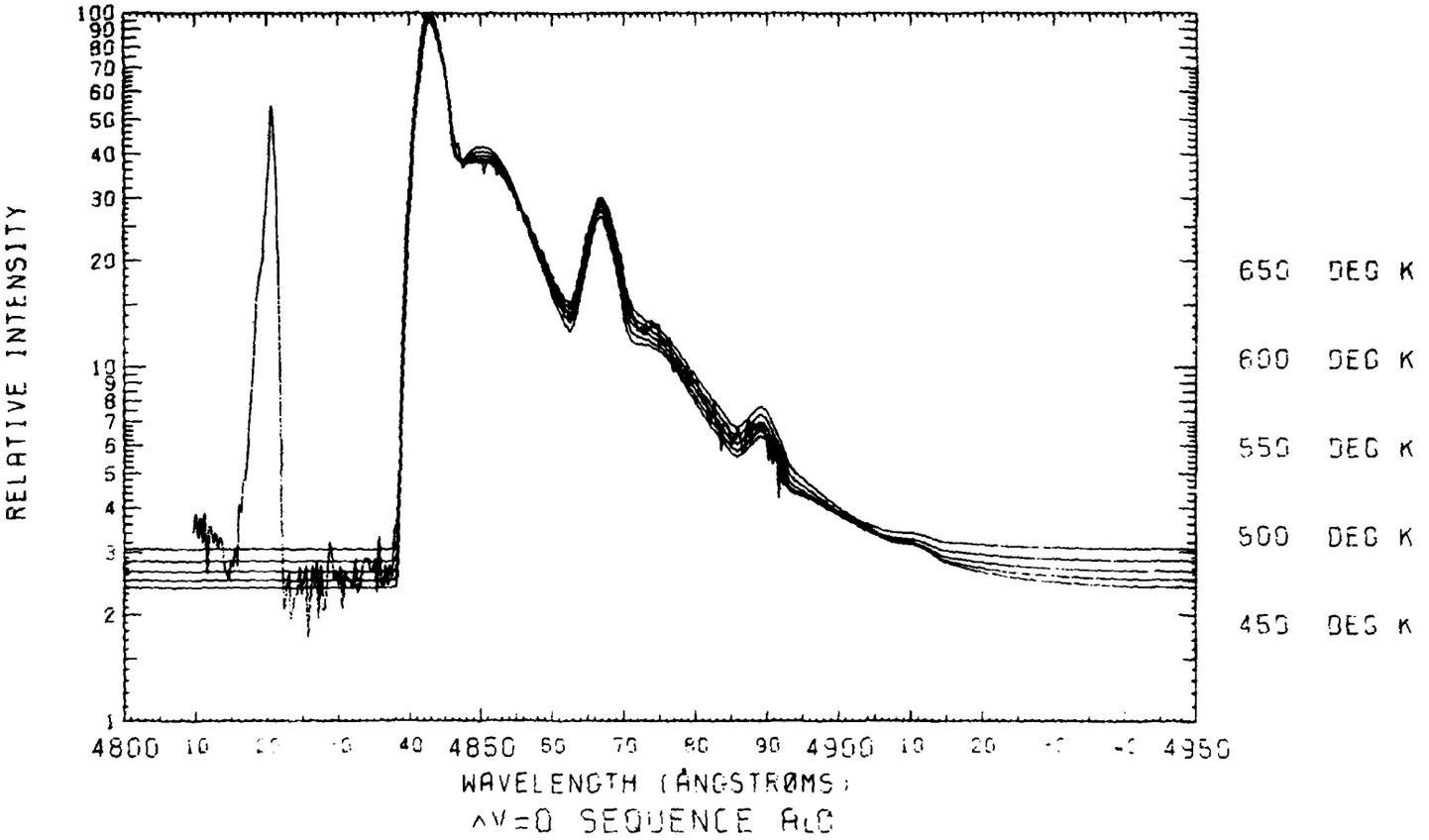


ΔV=0 SEQUENCE A1Σ


SCAN NOS. 2 100 8
TEMPERATURE = 559 +OR- 6 DEG K
RELATIVE INTENSITY
650 DEG K
600 DEG K
550 DEG K
500 DEG K
450 DEG K
4850
4900
4950
WAVELENGTH (ANG-STRØMS)
ΔV=0 SEQUENCE A-X

SCAN NOS. 2 122 11

TEMPERATURE = 570 +OR- 5 DEG K



WAVELENGTH (ÅNGSTRØMS)

ΔV=0 SEQUENCE $A_1\Sigma$

SCAN NOS. 2 136 7

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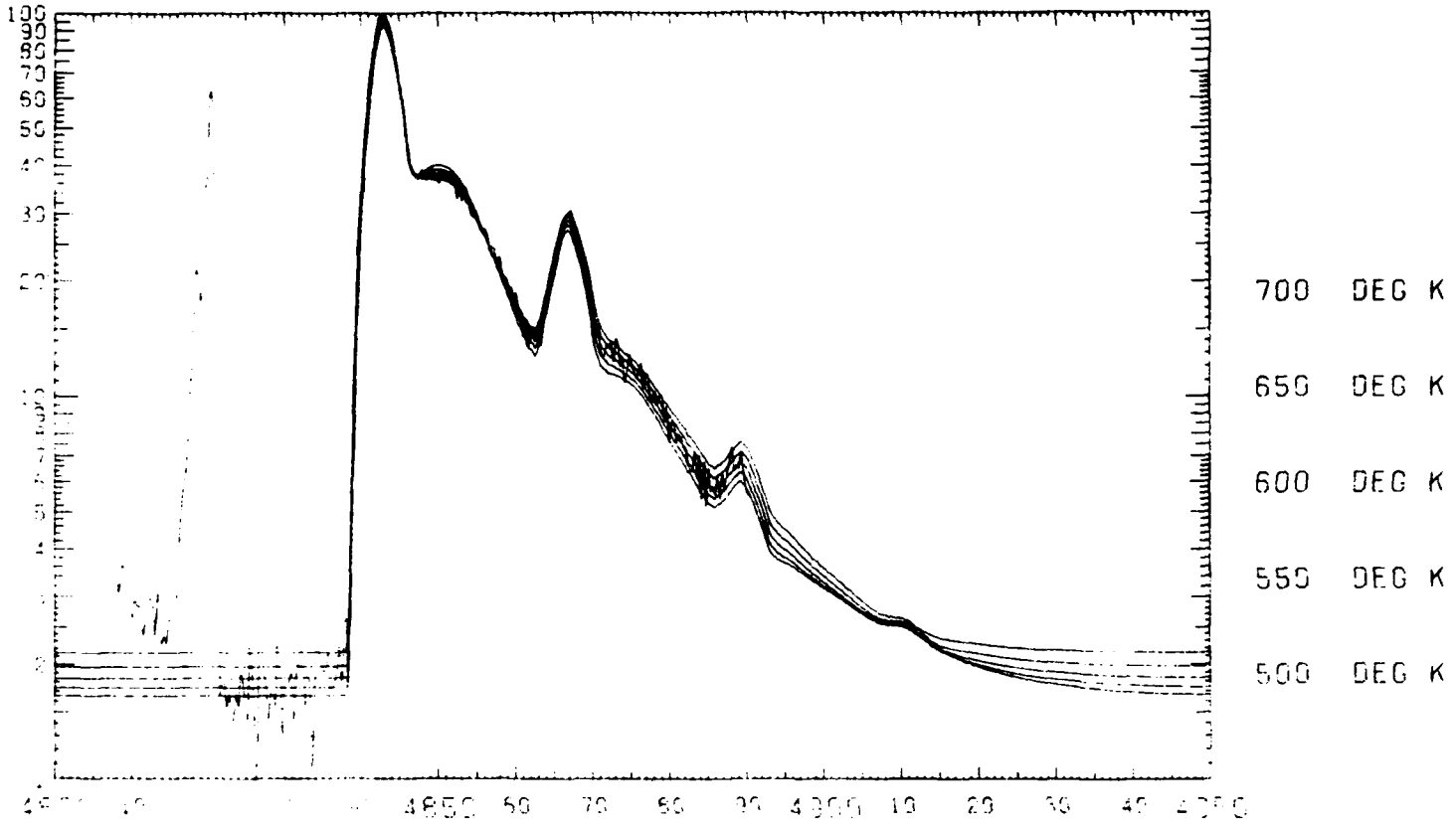

A P P E N D I X C

LISTING OF COMPUTER PROGRAMS

```
      PROGRAM ASP(OUTPUT,TAPE5,TAPE6,TAPE3,TAPE7,TAPE39)                  000720
CC    PROGRAM THEO                                                        000730
      DIMENSION TE(2),W(2),WX(2),WY(2),BE(2),ALFA(2),IZ(20),IIZ(20)       000740
      DIMENSION FC(8,8),R(8,8),SNV(8),SNJ(8,80),EMI(8,80),APS(8,80)       000750
      DIMENSION FR(3,3,80),FP(3,3,80),JEX(8)                              000760
      DIMENSION MJR(80),MJQ(80),MJP(80),BLAP(80),BIP(80),BLAR(80),        000770
     1BIR(80)                                                             000780
      COMMON TE,W,WX,WY,BE,ALFA                                           000790
      COMMON/SPECTP/BLAP,BLAR,BIP,BIR                                     000800
      WRITE(6,297)                                                        000810
  297 FORMAT (30H1ALO PROGRAM 1968 FOLLOWING DATA USED )                  000820
      REWIND   7                                                          000830
      READ(5,295)IDATE,MOG                                                000840
      WRITE(6,2951)IDATE,MOG                                              000850
  295 FORMAT(I6,I2)                                                       000860
 2951 FORMAT(1X,I6,I2)                                                    000870
      READ (5,296)(JEX(IJEX),IJEX=1,5)                                    000880
      WRITE(6,296)(JEX(IJEX),IJEX=1,5)                                    000890
  296 FORMAT(1H ,5A10)                                                    000900
      READ(5,109)TSOL,YSOL,SOLO                                           000910
      WRITE(6,1091)TSOL,YSOL,SOLO                                         000920
  109 FORMAT(2F10.0,E12.4)                                                000930
 1091 FORMAT(1X,2F10.0,E12.4)                                             000940
      READ(5,111)(TE(I),W(I),WX(I),WY(I),BE(I), ALFA(I),I=1,2)            000950
      WRITE(6,1111)(TE(I),W(I),WX(I),WY(I),BE(I), ALFA(I),I=1,2)          000960
  111 FORMAT(F12.4,F11.5,F12.7,F9.6,F9.7,F10.7)                           000970
 1111 FORMAT(1X,F12.4,F11.5,F12.7,F9.6,F9.7,F10.7)                        000980
      READ(5,112)G,IMAX,JMAX                                              000990
      WRITE(6,1121)G,IMAX,JMAX                                            001000
  112 FORMAT(F20.3,2I3)                                                   001010
 1121 FORMAT(1X,F20.3,2I3)                                                001020
      DO 113  I=1,IMAX                                                    001030
      DO 113 II=1,IMAX                                                    001040
      READ(5,114)L,LL,FC(I,II),R(I,II)                                    001050
      WRITE(6,1141)L,LL,FC(I,II),R(I,II)                                  001060
  114 FORMAT (2I2,E11.4,F7.3)                                             001070
 1141 FORMAT(1X,2I2,E11.4,F7.3)                                           001080
  113  CONTINUE                                                           001090
      READ(5,122)M,IAX,IIAX,JNAX                                          001100
      WRITE(6,1221)M,IAX,IIAX,JNAX                                        001110
  122 FORMAT(4I3)                                                         001120
 1221 FORMAT(1X,4I3)                                                      001130
      IF(M)127,127,1233                                                   001140
  127 DO 128 I=1,IAX                                                      001150
      DO 128 II=1,IIAX                                                    001160
      DO 128 J=1,JNAX                                                     001170
      READ(5,180)IA,IB,LQ,JP,TP,FP(I,II,J),JQ,JR,TR,FR(I,II,J)           001180
      WRITE(6,1801)IA,IB,LQ,JP,TP,FP(I,II,J),JQ,JR,TR,FR(I,II,J)         001190
  180 FORMAT(2I3,I4,I3,F10.2,F10.3,2I3,F10.2,F10.3)                       001200
 1801 FORMAT(1X,2I3,I4,I3,F10.2,F10.3,2I3,F10.2,F10.3)                    001210
  128  CONTINUE                                                           001220
 1233 READ(5,193)LL,JKAX                                                  001230
      WRITE(6,1931)LL,JKAX                                                001240
      READ (5,193 )(IZ(L),IIZ(L),L=1,LL)                                  001250
      WRITE(6,1931)(IZ(L),IIZ(L),L=1,LL)                                  001260
  193 FORMAT (14I4)                                                       001270
 1931 FORMAT(1X,14I4)                                                     001280
      READ(5,115)T,DELT,TMAX                                              001290
      WRITE(6,1151)T,DELT,TMAX                                            001300
      TBEGIN=T                                                            001310
  115 FORMAT (3F10.1)                                                     001320
 1151 FORMAT(1X,3F10.1)                                                   001330
  292 FORMAT (26H THESE DATA ON TAPE IF 1 =,I2)                           001340
      WRITE(6,292)MOG                                                     001350
      READ(5,193 )ISPECP,ILINE,ICON,IINV                                  001360
      WRITE(6,1931)ISPECP,ILINE,ICON,IINV                                 001370
  123 CONTINUE                                                            001380
      GT=1.0/(6.6952*T)                                                   001390
      JAX=JMAX+1                                                          001400
      V=0.0                                                               001410
      Q=1.0                                                               001420
  116 V=V+1.0                                                             001430
      GO=(W(2)-WX(2))*V-WX(2)*V*V                                         001440
      EX=EXP (-GO*GT)                                                     001450
      Q=Q+EX                                                              001460
      IF(EX*200.0-1.0)117,117,116                                         001470
  117 OV=Q                                                                001480
      DO 120 L=1,IMAX                                                     001490
      VL=L-1                                                              001500
      GOO=(W(2)-WX(2))*VL-WX(2)*VL*VL                                     001510
      VN=(1.0/OV)*EXP (-GOO*GT)                                           001520
      SNV(L)=VN                                                           001530
  120 CONTINUE                                                            001540
      R=BE(2)-ALFA(2)*1.5                                                 001550
```

```
      D=4.0*BF(2)*BE(2)*BE(2)/(W(2)*W(2))                              001560
      AJ=0.0                                                           001570
      Q=1.0                                                            001580
  146 AJ=AJ+1.0                                                        001590
      A=AJ*(AJ+1.0)                                                    001600
      FJ=B*A-D*A*A                                                     001610
      F=EXP (-FJ*GT)                                                   001620
      FA=(AJ+AJ+1.0)*F                                                 001630
      Q=Q+FA                                                           001640
      IF((FA*100.0/Q)-1.0)147,147,146                                  001650
  147 QJ=Q                                                             001660
      DO 148 I=1,IMAX                                                  001670
      V=I-1                                                            001680
      BB=BE(2)-ALFA(2)*(V+0.5)                                         001690
      DO 148 J=1,JAX                                                   001700
      SJ=J-1                                                           001710
      S=(SJ+1.0)*SJ                                                    001720
      FS=BB*S-D*S*S                                                    001730
      F=EXP (-FS*GT)                                                   001740
      SF=(SJ+SJ+1.0)*F/QJ                                              001750
  148 SNJ(I,J)=SF                                                      001760
      SO=0.6952*TSOL                                                   001770
      SOL=SLOF(YSOL,SO)                                                001780
      C=SOLO/SOL                                                       001790
      DO 355 I=1,IMAX                                                  001800
      DO 150 J=1,JMAX                                                  001810
      SUM=0.0                                                          001820
      DO 152 II=1,IMAX                                                 001830
      UR=1.0-G*R(I,II)                                                 001840
      FK=UR*UR*FC(I,II)                                                001850
      SV=SNV(II)                                                       001860
      SIV=SV*FK                                                        001870
      TYR=SNY(I,II,J,J-1)                                              001880
      TYP=SNY(I,II,J,J+1)                                              001890
      IF(M)179,179,154                                                 001900
  179 IF(I-IAX)174,174,154                                             001910
  174 IF(II-IIAX)178,178,154                                           001920
  178 IF(J-JMAX)176,176,154                                            001930
  176 FRR=FR(I,II,J)                                                   001940
      FRP=FP(I,II,J)                                                   001950
      GO TO 153                                                        001960
  154 FRR=1.0                                                          001970
      FRP=1.0                                                          001980
  153 IF(J-1)155,155,156                                               001990
  155 SIR=0.0                                                          002000
      GO TO 157                                                        002010
  156 SJ=SNJ(II,J-1)                                                   002020
      CJ=J-1                                                           002030
      CCJ=2*(J-1)+1                                                    002040
      SR=CJ/CCJ                                                        002050
      SL=C*SLOF(TYR,SO)                                                002060
      SIR=SJ*SR*TYR*SL*FRR                                             002070
  157 SSJ=SNJ(II,J+1)                                                  002080
      DJ=J                                                             002090
      DDJ=2*J+1                                                        002100
      SP=DJ/DDJ                                                        002110
      SSL=C*SLOF(TYP,SO)                                               002120
      SIP=SSJ*SP*SSL*TYP*FRP                                           002130
      SI=SIV*(SIP+SIR)                                                 002140
      SUM=SUM+SI                                                       002150
  152 CONTINUE                                                         002160
      AFS(I,J)=SUM                                                     002170
  150 CONTINUE                                                         002180
  355 CONTINUE                                                         002190
      DO 160 I=1,IMAX                                                  002200
      DO 161 J=1,JMAX                                                  002210
      SUM=0.0                                                          002220
      DO 162 II=1,IMAX                                                 002230
      UR=1.0-G*R(I,II)                                                 002240
      FK=UR*UR*FC(I,II)                                                002250
      IF(J-1)163,163,164                                               002260
  163 SIR=0.0                                                          002270
      GO TO 165                                                        002280
  164 SR=J-1                                                           002290
      SYR=SNY(I,II,J,J-1)                                              002300
      S3R= SYR*SYR*SYR                                                 002310
      SIR=SR*S3R                                                       002320
  165 SP=J                                                             002330
      SYP=SNY(I,II,J,J+1)                                              002340
      S3P=SYP*SYP*SYP                                                  002350
      SIP=SP*S3P                                                       002360
      SI=(SIP+SIR)*FK                                                  002370
  162 SUM=SUM+SI                                                       002380
  161 EMI(I,J)=SUM                                                     002390
```

```
  160 CONTINUE                                                          002400
      SDN=2.726E-04                                                     002410
      SDN=1.-SDN                                                        002420
      WLMAX=0.                                                          002430
      WLMIN=100000.                                                     002440
      AMPMAX=0.                                                         002450
      DO 194 LL=1,LL                                                    002460
      I=IZ(L)+1                                                         002470
      II=IIZ(L)+1                                                       002480
 1901 FORMAT(1X,I6,F10.1,4I4, F10.3,E15.4,2I4,F10.3,E15.4)              002490
      RR=1.0-G*R(I,II)                                                  002500
      FK=FC(I,II)*RR*RR                                                 002510
      DO 168J=1,JKAX                                                    002520
      AE=AFS(I,J)/EMI(I,J)                                              002530
  170 SR=J-1                                                            002540
  172 SP=J                                                              002550
      SNYP=SNY(I,II,J,J+1)                                              002560
      SNYR=SNY(I,II,J,J-1)                                              002570
      T3P=SNYP*SNYP*SNYP                                                002580
      T3R=SNYR*SNYR*SNYR                                                002590
      BLAP(J)=SDN*100000000/SNYP                                        002600
      BLAR(J)=SDN*100000000/SNYR                                        002610
      MJR(J)=J-2                                                        002620
      MJP(J)=J                                                          002630
      MJQ(J)=J-1                                                        002640
      BIP(J)=SP*AE*FK*T3P                                               002650
      BIR(J)=SR*AE*FK*T3R                                               002660
      IF(I.NE.II)GO TO 173                                              002670
      IF(BIP(J).GT.AMPMAX)AMPMAX=BIP(J)                                 002680
      IF(BIR(J).GT.AMPMAX)AMPMAX=BIR(J)                                 002690
      IF(BIP(J).LT..001*AMPMAX)GO TO 1725                               002700
      IF(BLAP(J).GT.WLMAX)WLMAX=BLAP(J)                                 002710
      IF(BLAP(J).LT.WLMIN)WLMIN=BLAP(J)                                 002720
 1725 CONTINUE                                                          002730
      IF(BIR(J).LT..001*AMPMAX)GO TO 173                                002740
      IF(BLAR(J).GT.WLMAX)WLMAX=BLAR(J)                                 002750
      IF(BLAR(J).LT.WLMIN)WLMIN=BLAR(J)                                 002760
  173 CONTINUE                                                          002770
      IF(J.EQ.20)WRITE(6,1901)IDATE,T,IZ(L),IIZ(L),MJQ(J),MJP(J),BLAP(J)002780
     1,BIP(J),MJQ(J),MJR(J),BLAR(J),BIR(J)                              002790
  168 CONTINUE                                                          002800
      IF(MOD.EQ.1)WRITE(7     )(IDATE,T,IZ(L),IIZ(L),MJQ(J),MJP(J),BLAP(002810
     1J),BIP(J),MJQ(J),MJR(J),BLAR(J),BIR(J),J=1,JKAX)                  002820
      IF(L.EQ.1.AND.T.EQ.500.)WRITE(6,1901)(IDATE,T,IZ(L),IIZ(L),MJQ(J),002830
     1MJP(J),BLAP(J),BIP(J),MJQ(J),MJR(J),BLAR(J),BIR(J),J=1,JKAX)      002840
  194 CONTINUE                                                          002850
      IF(IINV.EQ.1)CALL INVEN(LL,JKAX)                                  002860
      IF(ISPECP.EQ.1)CALL SPECVC(WLMAX,WLMIN,LL,JKAX,JEX,T)             002870
      T=T+DELT                                                          002880
      IF(T.LE.TMAX)GO TO 123                                            002890
      BACKSPACE   7                                                     002900
      PRINT 1931, JKAX                                                  002910
      READ (  7) (ID,T,I1,I2,MJQ(J),MJP(J),BLAP(J),BIP(J),MJQ(J),      002920
     1MJR(J),BLAR(J),BIR(J),J=1,JKAX)                                   002930
      WRITE(6,1901)(ID,T,I1,I2,MJQ(J),MJP(J),BLAP(J),BIP(J),MJQ(J),    002940
     1MJR(J),BLAR(J),BIR(J),J=1,JKAX)                                   002950
      REWIND   7                                                        002960
      IF(ICON.EQ.1)CALL HCON(TBEGIN,TMAX,DELT)                          002970
  555 CONTINUE                                                          002980
      IF(ISPECP.EQ.1)CALL PLOTV(4)                                      002990
      STOP                                                              003000
      END                                                               003010
C                                                                       003030
C                                                                       003040
C  4   SMALL SUBROUTINES                                                003050
C                                                                       003060
C                                                                       003070
      FUNCTION SLOF(A,SO)                                               003080
C     THEORETICAL SPECTRA                                               003090
      SLOF=A*A/(EXP(A/SO)-1.0)                                          003100
      RETURN                                                            003110
      END                                                               003120
      FUNCTION SNY(I,II,J,JJ)                                           003130
      DIMENSION TE(2),W(2),WY(2),WY(2),BE(2),ALFA(2)                    003140
      COMMON T,DELT,WX,WY,BE,ALFA                                       003150
      V=T                                                               003160
      VV=T-1                                                            003170
      AJ=J                                                              003180
      AJJ=JJ-1                                                          003190
      G1=W(1)*(V+0.5)-WY(1)*(V+0.5)*(V+0.5)                             003200
      G2=W(2)*(VV+0.5)-WY(2)*(VV+0.5)*(VV+0.5)                          003210
      H1=BE(1)*ALFA(1)*(V+0.5)                                          003220
      H2=BE(2)*ALFA(2)*(VV+0.5)                                         003230
      DE=4.0*SQ(1+BE(1)*BE(1)-(W(1)*W(1))                               003240
```

```
      D2=4.0*BE(2)*BE(2)*BE(2)/(W(2)*W(2))                              003250
      AA=AJJ*(AJJ+1.0)                                                  003260
      A=AJ*(AJ+1.0)                                                     003270
      F1=B1*A-D1*A*A                                                    003280
      F2=B2*AA-D2*AA*AA                                                 003290
      T1=TE(1)+G1+F1                                                    003300
      T2=TE(2)+G2+F2                                                    003310
      SNY=T1-T2                                                         003320
      RETURN                                                            003330
      END                                                               003340
C                                                                       003350
C                                                                       003360
C  5   HCON                                                            003370
C                                                                       003380
C                                                                       003390
      SUBROUTINE HCON(T1,T2,T3)                                         003400
      DIMENSION L(75),M(75),A(75),B(75),D(75),N(75),C(75)               003410
      DIMENSION Y(801)                                                  003420
      REWIND 3                                                          003430
C                                                                       003440
      DO 100 IPAS=1,1                                                   003450
C                                                                       003460
      REWIND 7                                                          003470
      IV=0                                                              003480
      ST=4800.                                                          003490
      IT1=T1+.001  $  IT2=T2+.001  $  IT3=T3+.001                       003500
      DO 70 IT=IT1,IT2,IT3                                              003510
    5 READ(7)(ID,T,IX,IY,L(J),M(J),A(J),B(J),L(J),N(J),C(J),D(J),J=1,75)003520
      IF((IX-IY).NE.IV)GO TO 5                                          003530
      DO 6 K=1,801                                                      003540
    6 Y(K)=0.                                                           003550
      DO 11 LL=1,4                                                      003560
      IF(LL.EQ.1)GO TO 7                                                003570
      READ(7)(ID,T,IX,IY,L(J),M(J),A(J),B(J),L(J),N(J),C(J),D(J),J=1,75)003580
    7 IF((IX-IY).NE.IV)GO TO 110                                        003590
      ITT=T+.01                                                         003600
      IF(ITT.NE.IT)GO TO 110                                            003610
      DO 11 I=1,2                                                       003620
      DO 11 J=1,75                                                      003630
      IF(I.EQ.2)A(J)=C(J)                                               003640
      IF(I.EQ.2)B(J)=D(J)                                               003650
      K1=4.*(A(J)-ST)-15.                                               003660
      K2=K1+30                                                          003670
      IF(K1.LT.1)K1=1                                                   003680
      IF(K1.GT.800)K1=800                                               003690
      IF(K2.LT.2)K2=2                                                   003700
      IF(K2.GT.801)K2=801                                               003710
      DO 11 K=K1,K2                                                     003720
      VK=K-1                                                            003730
      DLAM=A(J)-.25*VK-ST                                               003740
      Y(K)=Y(K)+B(J)*SLITFN(IPAS,DLAM)                                  003750
   11 CONTINUE                                                          003760
      YM=0.                                                             003770
      DO 12 K=1,801                                                     003780
      IF(Y(K).GT.YM)KM=K                                                003790
      IF(Y(K).GT.YM)YM=Y(K)                                             003800
   12 CONTINUE                                                          003810
      DO 13 K=1,801                                                     003820
   13 Y(K)=Y(K)/YM                                                      003830
      WRITE(3)IV,T,IPAS,KM,(Y(K),K=1,801)                               003840
      PRINT 14,IV,T,IPAS,KM                                             003850
   14 FORMAT(1X,16HSEQUENCE DELT V=,I2,7H, TEMP=,F6.0,13H DEG K, IPAS=, 003860
     1I4,30H          BANDHEAD AT STEP NUM,I4)                         003870
   70 CONTINUE                                                          003880
      ENDFILE 3                                                         003890
      PRINT 71                                                          003900
   71 FORMAT(2H1$)                                                      003910
  100 CONTINUE                                                          003920
      GO TO 120                                                         003930
  110 PRINT 111                                                         003940
  111 FORMAT(1X,26HWRONG ORDER ON DISK,RETURN)                          003950
  120 RETURN                                                            003960
      END                                                               003970
C                                                                       003980
C                                                                       003990
C  6   SLITFN                                                          004000
C                                                                       004010
C                                                                       004020
      FUNCTION SLITFN(N,DLAM)                                           004030
      DIMENSION FN(3,100),AMUL(3),LIM(3)                                004040
      DATA(FN(1,K),K=1,20)/5.54,5.50,5.40,5.22,4.90,4.56,4.12,3.64,3.22,004050
     12.76,2.30,1.86,1.42,1.00,.74,.48,.28,.16,.06,0./                  004060
      DATA(FN(2,K),K=1,14)/7.93,7.83,7.37,6.52,5.74,4.97,4.2,3.32,2.54, 004070
     11.74,1.,.32,.07,0./                                               004080
```

```
      DATA(FN(3,K),K=1,18)/8.8,8.6,8.1,7.4,6.6,5.8,5.0,4.2,3.4,2.65,     004110
     11.8,1.2,.75,.4,.2,.1,.05,0./                                       004120
      DATA LIM/20,14,18/                                                 004130
      DATA AMUL/.0794226,.6,.4062/                                       004140
C FOLLOWING CONSTANTS FOR ALADDIN II CLARA & HOPE APR 1972               004150
      DATA LIM/17/                                                       004160
      DATA AMUL/.10660/                                                  004170
      DATA(FN(1,K),K=1,17)/89.8,89.,84.,77.,68.4,59.4,50.8,              004180
     142.,33.8,25.2,16.4,9.6,5.4,2.8,1.4,.6,0./                         004190
      DATA LIM/13/                                                       004200
      DATA AMUL/.1019/                                                   004210
      DATA (FN(1,K),K=1,13)/227.,224.,209.,181.,153.,125.,98.,70.        004220
     1,42.,16.,2.,0.,0./                                                 004230
C ALADDIN 74 SLIT FN                                                     004240
      DATA LIM/30/                                                       004250
      DATA AMUL/.15/                                                     004260
      DATA (FN(1,K),K=1,30)/703.,701.,689.,671.,644.,616.,587.,558.      004270
     1,529.,500.,472.,443.,414.,385.,356.,327.,298.,270.,241.            004280
     2,212.,184.,155.,126.,97.,68.,41.,21.,9.,1.,0./                     004290
C POST-ALADDIN JAN 75 SLIT FN AL BURNER                                  004300
      DATA AMUL/.066175,.081125/,LIM/44,36/                              004310
      DATA (FN(1,K),K=1,44)/.0949,.0948,.0945,.093,.091,.0885,.0859,.083004320
     14,.0809,.0784,.0758,.0733,.0708,.0682,.0657,.0632,.0606,.0581,.055004330
     26,.0531,.0505,.048,.0455,.0429,.0404,.0379,.0354,.0328,.0303,.0278004340
     3,.0252,.0227,.0202,.0176,.0151,.0126,.0101,.0075,.0050,.0027,.0013004350
     4,.0007,0.,0./                                                      004360
C POST-ALADDIN JAN 75 SLIT FN TMA RELEASE                                004370
      DATA (FN(2,K),K=1,36)/.1176,.1173,.1156,.1120,.1083,.1045,.1008,.0004380
     197,.0933,.0895,.0858,.082,.0783,.0745,.0708,.0670,.0633,.0596,.055004390
     28,.0521,.0483,.0446,.0408,.0371,.0333,.0296,.0258,.0221,.0183,.014004400
     36,.0108,.0071,.0034,.0005,0.,0./                                   004410
C AEOLUS JAN 1975                                                        004420
      DATA AMUL/.15345085/,LIM/29/                                       004430
      DATA (FN(1,K),K=1,29)/142.5,140.,134.,127.8,121.7,115.6,109.4,103.004440
     12,97.2,91.,84.8,76.6,72.5,66.3,60.2,54.2,48.1,42.0,35.8,29.4,23.2,004450
     217.0,11.5,6.5,4.,2.,.7,0.,0./                                      004460
      DS=ABS(DLAM)/AMUL(N)+1.                                            004470
      IDS=DS                                                             004480
      IF(IDS.GE.LIM(N)-1)GO TO 20                                        004490
      DDS=IDS                                                            004500
      RDS=DS-DDS                                                         004510
      SLITFN=(1.-RDS)*FN(N,IDS)+RDS*FN(N,IDS+1)                          004520
      GO TO 30                                                           004530
   20 SLITFN=0.                                                          004540
   30 RETURN                                                             004550
      END                                                                004560
```

```
      PROGRAM MATCH(OUTPUT,TAPE5,TAPE6,TAPE2,TAPE3)                     008210
      DIMENSION NSF(8),NSTR(8),       MICRON(8),IDLIST(3),AMUL(8)       008220
      DIMENSION AMBDAP(3),                                              008230
      DIMENSION WAC(20),WAK(20)                                         008240
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)        008250
      INTEGER QW                                                        008260
      DATA ASKY/10HBLUE SKY  /                                          008270
C     DATA AMUL/.397113,.397113,.324082,.324082,.324082,.340185,        008280
C    1 1.62464,1.62464/                                                 008290
      DATA AMUL/.2712,.2712,.2712,.2712,.2712,.2712,.2712,.2712/        008300
      DATA NSF/1,1,1,1,1,1,1,1/                                         008310
C     DATA NSTR/60,60,183,278,67,231,291/                               008320
C     DATA NSTR/224,81,195,30,203,112,282,144/                          008330
C ALADDIN II CLARA AND HOPE                                             008340
C     DATA NSTR/170,149,144,230,0,0,0,0,/                               008350
C GOLIATH NOV 71                                                        008360
      DATA AMUL/.4076,.4076,0.,0.,0.,0.,0.,0./                          008370
      DATA NSTR/46,117,0,0,0,0,0,0/                                     008380
      DATA MICRON/135,135,135,176,176,176,176,176/                      008390
C ALADDIN 74                                                            008400
      DATA NSTR/79,79,79,79,79,79,79,79/                                008410
      DATA AMUL/.3055,.3055,.3055,.3055,0.,0.,0.,0./                    008420
C POST-ALADDIN JAN 75                                                   008430
      DATA NSF/1,1,2,2,2,2,2,2/                                         008440
      DATA NSTR/204,1,224,1,1,1,1,1/                                    008450
      DATA AMUL/.2647,1.,.3245,1.,1.,1.,1.,1./                          008460
      DATA AMBDAS/4824.3/,AMBDAF/4886.3/,AMBDAP/3*4842.5/               008470
      DATA AMUL/.3069,.3069,.3069,.3069,.3069,.3069,.3069,.3069/        008480
      DATA NSF/1,1,1,1,1,1,1,1/                                         008490
      DATA NSTR/290,143,244,143,182,143,1,1/                            008500
C WSMR OCT 77                                                           008510
      DATA NSTR/8*180/,AMUL/8*.3010/                                    008520
      REWIND 2                                                          008530
      REWIND 3                                                          008540
      REWIND 5                                                          008550
C  IF NUMBA.GE.6 A CRT PLOT IS MADE, OTHERWISE A PEN PLOT               008560
C IF NUMBA=0 NO PLOT IS MADE.                                           008570
CC  IAP IS PARAMETER FOR SCALE ON APLOT.                                008580
C  IF SM=0. NO SMOOTHING IS DONE.                                       008590
C  SM IS SMOOTHING PARABOLA HALF WIDTH IN ANGSTROMS.                    008600
C  IF STPL = 0. NO STRIP PLOT IS MADE.                                  008610
C  STPL=1. MAKES STRIP PLOT ON OUTPUT WITH APLOT.                       008620
C    IF STPL=2. THE STRIP PLOT IS MADE BUT NO OTHER PROCESSING IS DONE. 008630
C   IF STPL=3. ONLY STRIP PLOT IS MADE AND VALUE READ IN AS PEAK IS USED008640
C   FOR NSTR.                                                           008650
C  IF STPL=4. ONLY STRIP PLOT IS MADE, PEAK IS USED FOR NSTR            008660
C   AND SHOT IS USED FOR SMOOTHING.                                     008670
C  IF QW=QUICK PLOT, QUICK CRT PLOT OF FILES N1, N2, OF DATA TAPE IS    008680
C  MADE BUT NO OTHER PROCESSING IS DONE.                                008690
      READ(5,210)QW,N1,N2,STPL,IAP,SM,NUMBA1,NUMBA2                     008700
  210 FORMAT(4X,I1,6X,I2,3X,I2,7X,F2.0,5X,I2,5X,F2.0,6X,I1,5X,I1)       008710
      PRINT 211,QW,N1,N2,STPL,IAP,SM,NUMBA1,NUMBA2                      008720
  211 FORMAT(1X,3HQW=,I1,1X,5HFILES,I2,1X,2HTO,I2,7H, STPL=, 2.0,       008730
     1 1X,4HIAP=,I2,5H, SM=,F2.0,6H, PEN=,I1,1X,4HCRT=,I1)              008740
      NUMBA=NUMBA1+7*NUMBA2                                             008750
      IF(QW.NE.1)GO TO 1                                                008760
      CALL AL2(N1,N2,NSTR)                                              008770
      GO TO 100                                                         008780
    1 CONTINUE                                                          008790
      PRINT 201                                                         008800
  201 FORMAT(  82H1FILE NO.  SCAN NO.  SCANS SUMMED  TEMPERATURE(DEG. K)008810
     1  STD DEVIATION  DESCRIPTION,9X,9HPEAK SHOT)                      008820
      XPEAK=0.                                                          008830
      DO 3 K=1,801                                                      008840
    3 ZW(K)=4800.+.25*FLOAT(K-1)                                        008850
      DO 5 L=1,19                                                       008860
    5 T(L)=50*L+100                                                     008870
    7 READ (5,202)NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3                   008880
      IF(EOF(5))100,8                                                   008890
  202 FORMAT(9X,I2,10X,I4,5X,I3,9X,A10,A9,F6.2,A5)                      008900
    8 IF(STPL.LT.1.5)CALL ZSTORE(-NSF(NF))                              008910
      CALL ISNN(NF,+1,IDUMMY)                                           008920
                                                                        008930
      NSUM=MAXO(NSUM,1)                                                 008940
      DO 10 N=1,300                                                     008950
   10 Y(N)=1.                                                           008960
      NSTRNF=NSTR(NF                                                    008970
C AEOLUS MARCH 1975                                                     008980
      IF(NSC.GT.58)NSTRNF=NSTR(NF+2)                                    008990
      IF(NSC.GT.69)NSTRNF=NSTR(NF+4)                                    009000
      IF(STPL.GT.2.9)NSTRNF=PEAK                                        009010
      DO 22 N=1,NSUM                                                    009020
      N4=300*(N+NSC)+NSTRNF  -601                                       009030
      DO 20 K=1,300                                                     009040
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```
      CALL ISNN(K+N4,-1,IWN3)                                          009050
   20 Y(K)=Y(K)+FRAY(IWN3)                                             009060
   22 CONTINUE                                                         009070
      IF(STPL.LE..9)GO TO 25                                           009080
      ANSUM=NSUM                                                       009090
      DO 23 K=1,300                                                    009100
   23 Y(K)=Y(K)/ANSUM                                                  009110
      PRINT 201                                                        009120
      WRITE(6,201)                                                     009130
      PRINT 204,NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3                     009140
      WRITE(6,204)NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3                   009150
      IF(STPL.GE.3.9)GO TO 235                                         009160
      CALL APLOT(300,IAP)                                              009170
      IF(STPL.GE.1.9)GO TO 7                                           009180
  235 DO 24 K=1,300                                                    009190
   24 Y(K)=Y(K)*ANSUM                                                  009200
   25 NSFNF=NSF(NF)                                                    009210
C                                                                      009220
C                                                                      009230
C                                                                      009240
C FOR INTERACTIVE ADJUSTMENT                                           009250
      INPASS=1 $ GO TO 27                                              009260
C                                                                      009270
      INPASS=0                                                         009280
26    NUMBA=0 $ INPASS=INPASS+1                                        009290
      PRINT 1002                                                       009300
262   READ 1001,APUT                                                   009310
      IF(APUT.NE.0.)GO TO 264 $ NUMBA=10 $ GO TO 262                   009320
264   PEAK=APUT                                                        009330
      PRINT 1003                                                       009340
      READ 1001,APUT                                                   009350
      IF(APUT.NE.0.)AMUL(NF)=APUT                                      009360
1001  FORMAT(F13.2)                                                    009370
1002  FORMAT(* PEAK=*)                                                 009380
1003  FORMAT(* AMUL=*)                                                 009390
27    CONTINUE                                                         009400
C                                                                      009410
C                                                                      009420
C                                                                      009430
C                                                                      009440
      DO 30 K=1,300                                                    009450
      YW(K)=AMBDAP(NSFNF) +AMUL(NF)*(PEAK-FLOAT(K))                    009460
      IF(INPASS.EQ.1)Y(K)=FRES(Y(K),YW(K))                             009470
30    CONTINUE                                                         009480
      IFITS=PEAK-(AMBDAF-AMBDAP(NSFNF))/AMUL(NF)                       009490
      IFITF=PEAK+(AMBDAP(NSFNF)-AMBDAS)/AMUL(NF)                       009500
      IFITS=MINO(IFITS,275)                                            009510
      IFITF=MAXO(IFITF,1)                                              009520
      IFITS=MAXO(IFITS,1)                                              009530
      IFITF=MINO(IFITF,275)                                            009540
      IF(STPL.GE.3.9)IFITS=1                                           009550
      IF(STPL.GE.3.9)IFITF=300                                         009560
      IF(STPL.LE.3.9)GO TO 37                                          009570
      CALL APLOT(300,IAP)                                              009580
      IF(STPL.GE.1.9)GO TO 7                                           009590
   37 IF(ASKY.NE.ALPH1)GO TO 50                                        009600
      DO 40 K=1,300                                                    009610
   40 X(K)=Y(K)                                                        009620
      XPEAK=PEAK                                                       009630
      PRINT 204,NF,NSC,NSUM,ALPH1,ALPH2,PEAK,ALPH3                     009640
  204 FORMAT(3X,I2,8X,I3,10X,I2,43X,A10,A9,F6.1,1X,A5)                 009650
      GO TO 7                                                          009660
   50 CONTINUE                                                         009670
      CALL FIT(801,19,IFITS,IFITF,TF,TE,FM,WAC,WAK,0.,XPEAK,AMUL(NF))  009680
      IDLIST(1)=NF$IDLIST(2)=NSC$IDLIST(3)=NSUM                        009690
      PRINT 203,NF,NSC,NSUM,TF,TE,ALPH1,ALPH2,PEAK,ALPH3               009700
  203 FORMAT(3X,I2,8X,I3,10X,I2,14X,F6.1,13X,F5.1,5X,A10,A9,F6.1,1X,A5) 009710
C                                                                      009720
C                                                                      009730
C                                                                      009740
C FOR INTERACTIVE ADJUSTMENT                                           009750
C     IF(NUMBA.NE.10)GO TO 26                                          009760
C                                                                      009770
C                                                                      009780
C                                                                      009790
      IF(NUMBA.EQ.0)GO TO 7                                            009800
      CALL SMOT(YW,Y,1,275,SM)                                         009810
      CALL NEWFLT(IDLIST,1,3,801, 1,275,TF,TE,MICRON(NF),19,WAC,WAK,   009820
     10,NUMBA,SM,XPEAK,AMUL(NF))                                       009830
      GO TO 7                                                          009840
  100 CONTINUE                                                         009850
      IF(NUMBA.EQ.1.OR.NUMBA.EQ.2)CALL ENDFLT                          009860
      STOP                                                             009870
      END                                                              009880
```

```
C                                                                       009900
C                                                                       009910
C 12   FRES                                                             009920
C                                                                       009930
C                                                                       009940
      FUNCTION FRES(F,FLAMD)                                            009950
      FL=FLAMD-4800.                                                    009960
C  USED WITH HAWAII DATA                                                009970
C     FRES=F*(.930753+.0011915*FL-.00000504*FL*FL)                      009980
C                                                                       009990
C                                                                       010000
C  USED WITH ALADDIN AND GENIE DATA                                     010010
      FRES=F*(1.+.00049038*FL)                                          010020
C                                                                       010030
      RETURN                                                            010040
      END                                                               010050
C                                                                       010070
C                                                                       010080
C 13   FKAY                                                            010090
C                                                                       010100
C                                                                       010110
      FUNCTION FKAY(KAYPRM)                                             010120
C ALADDIN 74                                                            010130
      DATA A/9818.9/,B/.0004572/,T/.0011618/                            010140
C POST-ALADDIN JAN 75                                                   010150
      DATA A/1./,B/1.00788/,T/.0011621/                                 010160
C                                                                       010170
C                                                                       010180
C WSMR OCT 77                                                           010190
      FKAY=KAYPRM                                                       010200
      RETURN                                                            010210
C                                                                       010220
C                                                                       010230
      FK=KAYPRM                                                         010240
C USED UP TO APR 73 ON ALADDIN II DATA                                  010250
C     FKAY=FK/(1.-FK/950.)                                              010260
C SLIGHTLY DIFFERENT NO. FOR GOLIATH NOV 71                             010270
C     FKAY=FK/(1.-FK/949.217)                                           010280
C AEOLUS MARCH L975                                                     010290
      DATA A/2699.8/,B/.0002055/,T/.0010693/                            010300
      FKAY=FK/(1.-FK*T)-B*A                                             010310
      RETURN                                                            010320
      END                                                               010330
```

```
C                                                                       010350
C                                                                       010360
C 14   FIT POISSON                                                      010370
C                                                                       010380
C                                                                       010390
      SUBROUTINE FIT(N,NT,N1,N2,TF,TE,FM,WACC,WAKK,SM,XPEAK,AMUL)       010400
C                                                                       010410
C-----------------------------------------------------------------------010420
C                                                                       010430
C ZW  WAVELENGTH ARRAY SYNTHETIC SPECTRA N ELEMENTS                     010440
C  Z  AMPLITUDE  ARRAY NT BY N                                          010450
C  N                                                                    010460
C  T  TEMPERATURE ARRAY NT ELEMENTS                                     010470
C  NT MUST BE LESS THAN 20                                              010480
C  YW MEASURED SPECTRA WAVELENGTH ARRAY NY ELEMENTS                     010490
C  Y  MEASURED SPECTRA AMPLITUDE ARRAY  NY ELEMENTS                     010500
C  NY                                                                   010510
C  TF BEST FIT TEMPERATURE                                              010520
C  TE ERROR BARS ON TEMPERATURE                                         010530
C   X = BACKGROUND ARRAY                                                010540
C                                                                       010550
C  NOTE  THE SYNTHETIC ARRAY MUST BE IN CONSTANT INCREMENTS IN WAVELENGT010560
C                                                                       010570
C                                                                       010580
C-----------------------------------------------------------------------010590
C                                                                       010600
      DIMENSION WACC(20),WAKK(20),AA(20),AM(20),F(19)                   010610
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)        010620
      AN=N-1                                                            010630
      I=N1                                                              010640
10     CONTINUE                                                         010650
      AK=AN*(YW(I)-ZW(1))/(ZW(N)-ZW(1))+1.                              010660
      IF(AK.GE.1..AND.AK.LT.AN+1.)GO TO 20                              010670
      IF(AK-1.)13,13,14                                                 010680
   13 N1=I+1                                                            010690
      GO TO 20                                                          010700
   14 N2=I-1                                                            010710
      GO TO 21                                                          010720
20     IF(I.GE.N2)GO TO 21                                              010730
      I=I+1                                                             010740
      GO TO 10                                                          010750
   21 D=N2-N1+1                                                         010760
      YMAX=0. $ YMIN=1.E+08 $ RYC=0.                                    010770
      DO 40 I=N1,N2                                                     010780
      YMAX=AMAX1(YMAX,Y(I))                                             010790
      YMIN=AMIN1(YMIN,Y(I))                                             010800
      IF(Y(I).LT.5.) GO TO 481                                          010810
      YI1=Y(I)+1.                                                       010820
      RYC=RYC+(YI1-.5)*ALOG(YI1)-YI1+1./(12.*YI1)-1./(360.*YI1**3)      010830
     1+1./(1260.*YI1**5)-1./(1680.*YI1**7)                              010840
      GO TO 485                                                         010850
481   KKY=1                                                             010860
      KY=Y(I)+.5                                                        010870
      IF(KY.EQ.2)KKY=2                                                  010880
      IF(KY.EQ.3)KKY=6                                                  010890
      IF(KY.EQ.4)KKY=24                                                 010900
      IF(KY.EQ.5)KKY=120                                                010910
      YKKY=FLOAT(KKY)                                                   010920
      RYC=RYC+ALOG(YKKY)                                                010930
485   YIP=AMAX1(.01,Y(I))                                               010940
      RYC=RYC-.5*ALOG(YIP)                                              010950
40    CONTINUE                                                          010960
      WAK=YMAX-YMIN $ WAC=YMIN                                          010970
      DO 55 J=1,NT                                                      010980
      CALL ZSTORE(J)                                                    010990
      LOOP=0                                                            011000
44    AZ=0. $ AYZD=0. $ AYD=0. $ AYZ2D2=0. $ AYZD2=0. $ AYD2=0.         011010
      LOOP=LOOP+1                                                       011020
      IF(LOOP.GT.50)F(J)=1.E+17                                         011030
      IF(LOOP.GT.50)GO TO 55                                            011040
      DO 46 I=N1,N2                                                     011050
      AK=AN*(YW(I)-ZW(1))/(ZW(N)-ZW(1))+1.                              011060
      K=AK                                                              011070
      CK=K                                                              011080
      AK=AK-CK                                                          011090
      ZZ=(1.-AK)*Z(K)+Z(K+1)*AK                                         011100
      AZ=AZ+ZZ/D                                                        011110
      BA=WAK*ZZ+WAC                                                     011120
      B=(I)/(D*BA)                                                      011130
      BB=B/BA                                                           011140
      AYD=AYD+B                                                         011150
      AYD2=AYD2+BB                                                      011160
      B=B*ZZ                                                            011170
      AYZD=AYZD+B                                                       011180
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      B=B/BA                                                            011190
      AYZD2=AYZD2+B                                                     011200
      B=B*ZZ                                                            011210
      AYZ2D2=AYZ2D2+B                                                   011220
46    CONTINUE                                                          011230
      DET=AYZ2D2*AYD2-AYZD2**2                                          011240
      FNOT=AZ-AYZD $ GNOT=1.-AYD                                        011250
      DELK=(GNOT*AYZD2-FNOT*AYD2)/DET                                   011260
      DELC=(FNOT*AYZD2-GNOT*AYZ2D2)/DET                                 011270
      WAK=WAK+DELK $ WAC=WAC+DELC                                       011280
      IF(DELK.GT.1.E-10*WAK.OR.DELC.GT.1.E-10*WAC)GO TO 44              011290
      WACC(J)=WAC                                                       011300
      WAKK(J)=WAK                                                       011310
      IF(WAC.LT.0..OR.WAK.LT.0.)F(J)=1.E+13                             011320
      IF(WAC.LT.0..OR.WAK.LT.0.)GO TO 55                                011330
      F(J)=0.                                                           011340
      DO 50 I=N1,N2                                                     011350
      AK=AN*(YW(I)-ZW(1))/(ZW(N)-ZW(1))+1.                              011360
      K=AK                                                              011370
      CK=K                                                              011380
      AK=AK-CK                                                          011390
      ZZ=(1.-AK)*Z(K)+AK*Z(K+1)                                         011400
      XI=1.                                                             011410
      IF(XPEAK.LT..001)GO TO 48                                         011420
      FK=XPEAK-(YW(I)-4861.34)/AMUL                                     011430
      M=FK                                                              011440
      ACG=M                                                             011450
      ACG=FK-ACG                                                        011460
      XI=ACG*X(M+1)+(1.-ACG)*X(M)                                       011470
48    B=WAK*ZZ+WAC                                                      011480
      B=B-Y(I)*ALOG(B)                                                  011490
50    F(J)=F(J)+B                                                       011500
55    F(J)=F(J)+BYC                                                     011510
201   FORMAT(1X,5E11.4)                                                 011520
      FM=10.E+10                                                        011530
      DO 60 J=1,NT                                                      011540
      IF(F(J).LT.FM) JT=J                                               011550
      IF(F(J).LT.FM)FM=F(J)                                             011560
   60 CONTINUE                                                          011570
      IF(JT.EQ.1.OR.JT.EQ.NT) GO TO 71                                  011580
      X1=T(JT-1)                                                        011590
      X2=T(JT)                                                          011600
      X3=T(JT+1)                                                        011610
      DO 70 NN=1,3                                                      011620
      GO TO (61,62,63),NN                                               011630
   61 Y1=F(JT-1)                                                        011640
      Y2=F(JT)                                                          011650
      Y3=F(JT+1)                                                        011660
      GO TO 64                                                          011670
   62 Y1=WACC(JT-1)                                                     011680
      Y2=WACC(JT  )                                                     011690
      Y3=WACC(JT+1)                                                     011700
      GO TO 64                                                          011710
   63 Y1=WAKK(JT-1)                                                     011720
      Y2=WAKK(JT  )                                                     011730
      Y3=WAKK(JT+1)                                                     011740
   64 Y4=(Y2-Y1)/(X2-X1)                                                011750
      Y5=(Y3-Y2)/(X3-X2)                                                011760
      X4=(X2*X2-X1*X1)/(X2-X1)                                          011770
      X5=(X3*X3-X2*X2)/(X3-X2)                                          011780
      AQ=(Y5-Y4)/(X5-X4)                                                011790
      BQ=Y4-AQ*X4                                                       011800
      CQ=Y1-AQ*X1*X1-BQ*X1                                              011810
      GO TO (65,66,67),NN                                               011820
   65 TF=-BQ/(2.*AQ)                                                    011830
      FM=AQ*TF*TF+BQ*TF+CQ                                              011840
      RM=FM*(1.+1./D)                                                   011850
      TE=BQ*BQ-4.*AQ*(CQ-RM)                                            011860
      TE=SQRT(TE)/(2.*AQ)                                               011870
      GO TO 70                                                          011880
   66 WAC=AQ*TF*TF+BQ*TF+CQ                                             011890
      GO TO 70                                                          011900
   67 WAK=AQ*TF*TF+BQ*TF+CQ                                             011910
   70 CONTINUE                                                          011920
      GO TO 72                                                          011930
   71 TF=T(JT)                                                          011940
      TE=999.0                                                          011950
   72 RETURN                                                            011960
      END                                                               011970
                                                                        011980
```

```
C                                                                       012000
C                                                                       012010
C 15   ZSTORE                                                           012020
C                                                                       012030
C                                                                       012040
      SUBROUTINE ZSTORE(L)                                              012050
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)        012060
      IF(L.LT.1) GO TO 16                                               012070
      IF(L-LL)91,100,6                                                  012080
6      LM=LL+1                                                          012090
      DO 8 M=LM,L                                                       012100
8      READ(3)IV,TT,MM,KK,( Z(JJ),JJ=1,801)                             012110
      LL=L                                                              012120
      GO TO 100                                                         012130
16     N5=13267898122369                                                012140
      IF(N4.NE.N5)N2=N5                                                 012150
      N4=N5                                                             012160
      NF=-L                                                             012170
      IF(NF.GT.N2)GO TO 22                                              012180
20     REWIND 3                                                         012190
      N2=1                                                              012200
22     N3=N2+1                                                          012210
      IF(NF.EQ.1) GO TO 28                                              012220
23     DO 25 N1=N3,NF                                                   012230
   24  READ(3)IV,TT,MM,KK,( Z(JJ),JJ=1,801)                             012240
      IF(EOF(3))25,24                                                   012250
25     CONTINUE                                                         012260
28     LL=0                                                             012270
90     N2=NF                                                            012280
      IF(L-1)100,6,6                                                    012290
   91 BACKSPACE 3                                                       012300
   92 LL=LL-1                                                           012310
      BACKSPACE 3                                                       012320
      IF(L.LT.LL)GO TO 92                                               012330
      READ(3)IV,TT,MM,KK,( Z(JJ),JJ=1,801)                             012340
  100 CONTINUE                                                          012350
      RETURN                                                            012360
      END                                                               012370
C                                                                       012390
C                                                                       012400
C 16   SHOT RECTANGULAR                                                 012410
C                                                                       012420
C                                                                       012430
      SUBROUTINE SHOT(X,Y,N1,N2,A)                                      012440
      COMMON YD(300),XD(300),YWD(300),ZD(801),ZWD(801),TD(19),Z(801)    012450
      DIMENSION X(1),Y(1)                                               012460
      IF(A.LE..001)GO TO 100                                            012470
      AS=(X(N1)-X(N2))/(N1-N2)                                          012480
      AS=ABS(AS)                                                        012490
      II=.5*A/AS+.5001                                                  012500
      NN=2*II-1                                                         012510
      II=II-1                                                           012520
      NN1=N1+II  $  NN2=N2-II                                           012530
      DO 30 I=NN1,NN2                                                   012540
      Z(I)=Y(I)                                                         012550
      DO 30 J=1,II                                                      012560
      II=I-J  $  JI=I+J                                                 012570
      Z(I)=Z(I)+(Y(IJ)+Y(JI))                                           012580
30     CONTINUE                                                         012590
      DO 40 I=NN1,NN2                                                   012600
40     Y(I)=Z(I)/FLOAT(NN)                                              012610
100    RETURN                                                           012620
      END                                                               012630
C                                                                       012650
C                                                                       012660
C 17   ISNN                                                            012670
C                                                                       012680
C                                                                       012690
      SUBROUTINE ISNN(N,K,ISN)                                          012700
      DIMENSION II(30)                                                  012710
      IF(K)20,20,10                                                     012720
10     N6=1328769881239                                                 012730
      IF(N4.NE.N6) N2=N6                                                012740
      N4=N6                                                             012750
      NF=N                                                              012760
      GO TO 100                                                         012770
20     IF(NF-N2)21,31,22                                                012780
21     REWIND 2                                                         012790
      N5=-29                                                            012800
      IF(NF.EQ.1)GO TO 32                                               012810
      N2=1                                                              012820
32     N5=-29                                                           012830
      N3=N2+1                                                           012840
      DO 30 N1=N3,NF                                                    012850
```

```
25     READ(2,209)(II(NN),NN=1,30)                                  012860
       IF(EOF(2))30,25                                              012870
30     CONTINUE                                                     012880
       GO TO 32                                                     012890
   31 IF(N.LT.N5)GO TO 50                                           012900
       IF(N.GE.N5+30)GO TO 32                                       012910
       GO TO 81                                                     012920
32     N2=NF                                                        012930
       N5=N5+30                                                     012940
       DO 40 N1=N5,N,30                                             012950
       N11=N1                                                       012960
40     READ(2,209)(II(NN),NN=1,30)                                  012970
209    FORMAT(30I3)                                                 012980
       N5=N11                                                       012990
       GO TO 81                                                     013000
   50 BACKSPACE 2                                                   013010
51     N5=N5-30                                                     013020
       BACKSPACE 2                                                  013030
       IF(N.LT.N5) GO TO 51                                         013040
       READ(2,209)(II(NN),NN=1,30)                                  013050
81     NN=N-N5+1                                                    013060
       ISN=II(NN)                                                   013070
100    RETURN                                                       013080
       END                                                          013090
```

```
C                                                                       013140
C                                                                       013150
      SUBROUTINE NEWPLT(IDLIST,K1,K2,NSYP,N1,N2,TF,TE,MICRON,NT,ACC,    013160
     1AKK,IV,NUMBA,SM,XPEAK,AMUL)                                       013170
C                                                                       013180
C  MAKES FANCY PLOT OF SYNTHETIC SPECTRA COMBINED WITH MEASURED SPECTRA 013190
C   IDLIST(K1) TO IDLIST(K2) IS A LIST OF SCAN NUMBERS TO BE PLOTTED    013200
C   Z(NT,NSYP) IS AN ARRAY OF SYNTHETIC SPECTRA                         013210
C   ZW    IS THE ARRAY OF WAVELENGTHS FOR THE ELEMENTS IN Z             013220
C   Y IS AN ARRAY OF MEASURED SPECTRA WITH NYEL ELEMENTS                013230
C   YW    IS THE ARRAY OF WAVELENGTHS FOR THE ELEMENTS IN Y             013240
C   TF IS THE BEST FIT TEMPERATURE FOR THAT SUM OF SCANS BY WFIT        013250
C   TE IS THE ERROR BAR ON TF                                           013260
C   MICRON IS THE SLIT WIDTHE CODE IN MICRONS                           013270
C   T   IS THE ARRAY OF TEMPERATURES USED IN THE SYNTHETIC CURVES       013280
C   NT IS THE NUMBER OF TEMPERATURES                                    013290
C   ACC AND AKK ARE THE BEST ADDITIVE AND MULTIPLICATIVE CONSTANTS      013300
C IV SEQUENCE OF ALO USED                                               013310
C                                                                       013320
      DIMENSION IDLIST(1)                                               013330
      DIMENSION ACC(20),AKK(20)                                         013340
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),YP(801)         013350
      INTEGER H                                                         013360
C   DRAW AXIS                                                           013370
      IF(NUMBA.EQ.10)GO TO 5                                            013380
      CALL SUPAPL(IV,2,1,NUMBA,0,0)                                     013390
      GO TO 6                                                           013400
    5 TID=IDLIST(3)                                                     013410
      CALL PPLOT(1,ZW,Z,IDLIST(1),IDLIST(2),TID)                        013420
C   FIND NUMBER OF BEST FIT TEMPERATURE                                 013430
    6 TT=T(NT)                                                          013440
      DO 1010 N=1,NT                                                    013450
      DT=ABS(T  (N)-TF)                                                 013460
      IF(DT.LT.TT)LL=N                                                  013470
 1010 IF(DT.LT.TT)TT=DT                                                 013480
      YMAX=0.                                                           013490
      DO 8 H=N1,N2                                                      013500
8     YMAX=AMAX1(YMAX,Y(H))                                             013510
C   IF NUMBA=7  A CRT PLOT WILL BE MADE.                                013520
C   IF NUMBA=10 A PRINT PLOT WILL BE MADE.                              013530
C   IF NUMBA=1  A PEN PLOT WILL BE MADE.                                013540
C   FOR PEN PLOT PF NAMED PENPLOTS MUST BE LOADED.                      013550
C   FOR CRT PLOT PF NAMED CRTPLOTS MUST BE LOADED.                      013560
C   FOR PRINT PLOT PF NAMED KITMAPAB MUST BE LOADED.                    013570
      NDI=NYEL-3                                                        013580
C   PLOT SYNTHETIC SPECTRA                                              013590
      DO 32 I=1,NSYP                                                    013600
      I2=I-1                                                            013610
      IF(ZW(I).GT.YW(N1))GO TO 33                                       013620
   32  CONTINUE                                                         013630
   33  DO 34 I=1,NSYP                                                  013640
      I1=I                                                              013650
      IF(ZW(I).GE.YW(N2))GO TO 35                                       013660
   34  CONTINUE                                                         013670
   35 DO 1100 MM=1,5                                                    013680
      L=LL+MM-3                                                         013690
      IF(L.LT.1.OR.L.GT.19)GO TO 1100                                   013700
      CALL ZSTORE(L)                                                    013710
C   SMOT CHANGES PRESENT Z ARRAY                                        013720
       CALL SMOT(ZW,Z,I1,I2,SM)                                         013730
      IF(MM.NE.1)GO TO 37                                               013740
   37 DO 38 I=1,NSYP                                                    013750
      Z(I)=(Z(I)*AKK(L)+ACC(L))/YMAX                                    013760
      Z(I)=AMAX1(Z(I),.01)                                              013770
   38 Z(I)=4.*ALOG10(Z(I))+8.                                           013780
      IF(NUMBA-10)40,39,40                                              013790
   39 CALL PPLOT(MM+1,ZW,Z,1,NSYP,T(L))                                 013800
      GO TO 1100                                                        013810
   40 IP=3                                                              013820
      DO 1090 M=1,NSYP                                                  013830
      ZZ=Z(M)                                                           013840
      X3=(ZW    (M)-4800.+200.*FLOAT(IV))*.08                           013850
      IF(ZZ.GT.8..OR.ZZ.LT.0..OR.X3.LT.0.)GO TO 1090                    013860
      IF(X3.GT.12.)GO TO 1096                                           013870
      CALL PLOT(X3,ZZ,IP)                                               013880
 1090 IP=2                                                              013890
 1096 AL=MM                                                             013900
C   LABLE SYNTHETIC SPECTRA FOR TEMPERATURE                             013910
      CALL NUMBER(12.5,AL+.2,T  (L),0.,-1)                              013920
      CALL SYMBOL(13.5,AL+.2,5HDEG K,0.,5)                              013930
 1100 CONTINUE                                                          013940
C   PLOT MEASURED SPECTRA                                               013950
      IP=3                                                              013960
      DO 1049 M=N1,N2                                                   013970
```

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      X2=(YW    (M)-4800.+200.*FLOAT(IV))*.08                              013980
      XM=1.                                                                013990
      IF(XPEAK.LT..001)GO TO 1055                                          014000
      FK=XPEAK-(YW    (M)-4861.34)/AMUL                                    014010
      I=FK                                                                 014020
      ACG=I                                                                014030
      ACG=FK-ACG                                                           014040
      XM=ACG*X(I+1)+(1.-ACG)*X(I)                                          014050
1055  YY=100.*Y(M)/YMAX                                                    014060
      YY=AMAX1(YY,1.)                                                      014070
      Y3=4.*ALOG10(YY)                                                     014080
      YP(M)=Y3                                                             014090
      IF(X2.LT.0..OR.Y3.LT.0..OR.Y3.GT.9.)GO TO 1069                       014100
      IF(X2.GT.12.)GO TO 1070                                              014110
      IF(NUMBA.EQ.10)GO TO 1069                                            014120
      CALL PLOT(X2,Y3,IP)                                                  014130
 1069 IP=2                                                                 014140
 1070 IF(NUMBA.NE.10)GO TO 1071                                            014150
      CALL PPLOT(7,YW,YP,N1,N2,TF)                                         014160
      CALL PPLOT(8,ZW,Z,1,NSYP,TE)                                         014170
      GO TO 100                                                            014180
C   WRITE TEMPERATURE OF MEASURED SPECTRA                                  014190
 1071 CONTINUE                                                            014200
      CALL SYMBOL(0.,8.5,.2,31HTEMPERATURE =      +OR-    DEG K,0.,31)     014210
      CALL NUMBER(2.8,8.5,.2,TF,0.,-1)                                     014220
      CALL NUMBER(4.6,8.5,.2,TE,0.,-1)                                     014230
C   WRITE SCAN NUMBERS                                                     014240
      YT=9.29                                                              014250
      XT=2.                                                                014260
      CALL SYMBOL(0.,9.29,.19,9HSCAN NOS.,0.,9)                            014270
      DO 1080 K=K1,K2                                                      014280
      FPN=IDLIST(K)                                                        014290
      CALL NUMBER(XT,YT,.19,FPN,0.,-1)                                     014300
      XT=XT+1.                                                             014310
      IF(XT.LT.12.)GO TO 1080                                              014320
      XT=2.                                                                014330
      YT=YT-.35                                                            014340
 1080 CONTINUE                                                             014350
C   LABLE SLIT SIZE                                                        014360
      IF(MICRON.EQ.250)CALL SYMBOL(0.,8.5,.2,20HSLIT = 2.5 ANGSTROMS,0.,   014370
     120)                                                                  014380
      IF(MICRON.EQ.251)CALL SYMBOL(0.,8.5,.2,20HSLIT = 3.5 ANGSTROMS,0.,   014390
     120)                                                                  014400
      IF(MICRON.EQ.450)CALL SYMBOL(0.,8.5,.2,20HSLIT = 4.0 ANGSTROMS,0.,   014410
     120)                                                                  014420
  100 RETURN                                                               014430
      END                                                                  014440
C                                                                          014460
C                                                                          014470
C 19   PRINT PLOT                                                         014480
C                                                                          014490
C                                                                          014500
      SUBROUTINE PPLOT(KOD,X,Y,N1,N2,TITL)                                 014510
      DIMENSION TITLE(70),X(1),Y(1)                                        014520
      DATA HCTR/4860./,HGRD/12./,VCTR/4./,VGRD/1.7143/,FST/0./             014530
      DATA TITLE/6HWAVELN,6H (ANG),6HAMPLIT,3HUDE,-1.,0.,8H    FILE,       014540
     +8H    SCAN,8H  SUMMED,0.,0.,0.,8HTEMPERAT,3HURE,0.,0.,              014550
     +8H(K) +OR-,0.,0.,0.,1HE,0.,0.,1HD,0.,0.,1HC,0.,0.,1HR,              014560
     +0.,0.,1HA/                                                           014570
      IF(FST.NE.0.)GO TO 11                                                014580
      DO 10 J=35,70                                                        014590
   10 TITLE(J)=0.                                                          014600
      DO 101 J=50,62,3                                                     014610
  101 TITLE(J)=-1.                                                         014620
      DO 102 J=40,42                                                       014630
  102 TITLE(J)=-1.                                                         014640
      TITLE(48)=TITLE(46)=1.                                               014650
      TITLE(64)=999.                                                       014660
      TITLE(34)=3HXXX                                                      014670
   11 FST=1.                                                               014680
      KOM=3                                                                014690
      IF(KOD.EQ.1)KOM=0                                                    014700
      IF(KOD.EQ.8)KOM=4                                                    014710
      TITLE(65)=KOD-1                                                      014720
      IF(KOD.EQ.7)TITLE(65)=29.                                            014730
      IF(KOD.NE.1)GO TO 12                                                 014740
      TITLE(10)=N1 $ TITLE(11)=N2 $ TITLE(12)=TITL                         014750
   12 CONTINUE                                                             014760
      IF(KOD.EQ.7)TITLE(16)=TITL                                           014770
      IF(KOD.EQ.8)TITLE(18)=TITL                                           014780
      IF(KOD.GE.2.AND.KOD.LE.6)TITLE(-3+KOD+38)=TITL                       014790
      CALL MAPA(X,Y,N1,N2,KOM,HCTR,HGRD,VCTR,VGRD,TITLE)                   014800
      RETURN                                                               014810
      END                                                                  014820
```

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C                                                                       014880
      SUBROUTINE SUPAPL(IV,TYPE,IAXIS,NUMBA,IDIM,ID)                    014890
C                                                                       014900
C  MAKES VARIOUS FORMS OF PLOTS FOR ALO TEMPERATURE PROBLEMS            014910
C     IV=0,1 FOR DELTA V = 0 OR DELTA V = 1                             014920
C TYPE=0,2,5,FOR A LINEAR,2 CYCLE LOG,OR SQUARE ROOT PLOTS,RESPECTIVELY 014930
C     IAXIS=0,1 FOR NO NEW AXIS OR NEW AXIS                             014940
C     NUMBA=NO. OF PLOTS TO BE MADE(NOT NO OF AXIS)                     014950
C NUMBA 5 OR LESS IS PEN AND INK    PLOT, 6 OR GREATER IS         CRT PL 014960
C     IDIM=DIMENSION OF INPUT ARRAY,YARRAY, FROM LEFT TO RIGHT          014970
C IF IDIM=0 NO CURVE IS PLOTTED                                         014980
C     YARRAY=ARRAY TO BE PLOTED                                         014990
C ID= IDENTIFICATION NUMBER TO BE PRINTED WITH AXIS(4 DIGITS)           015000
C IF ID=0 NO NUMBER IS PRINTED AT ALL                                   015010
C                                                                       015020
      INTEGER TYPE                                                      015030
      DIMENSION YARRAY(1)                                               015040
      DIMENSION PRID(3)                                                 015050
      PRID(1)=10HAITROSSER                                              015060
      PRID(2)=DATE(DDUM)                                                015070
      PRID(3)=TIME(TDUM)                                                015080
      IF(MSTART.NE.3624321061.AND.NUMBA.LE.5)CALL PLTID3(PRID,340.,11., 015090
     11.)                                                               015100
      IF(MSTART.NE.3624321061.AND.NUMBA.LE.5)CALL NEWPEN(3)             015110
      IF(MSTART.NE.3624321061.AND.NUMBA.GE.6)CALL CRTPLT(PRID,1.,17.)   015120
      IF(MSTART.NE.3624321061)MEND=0                                    015130
      IF(MSTART.NE.3624321061)CALL PLOT(1.,1.,-3)                       015140
      MSTART=3624321061                                                 015150
      MEND=MEND+1                                                       015160
      IF(IAXIS.EQ.0)GO TO 400                                           015170
C     AXIS                                                              015180
      IF(MEND.NE.1.AND.NUMBA.GE.6)CALL FRAME(1.5,1.5)                   015190
      IF(MEND.NE.1.AND.NUMBA.LE.5)CALL PLOT(17.,0.,-3)                  015200
C     THE FOUR BORDER AXIS                                              015210
      CALL PLOT(0.,0.,3)                                                015220
      CALL PLOT(12.,0.,2)                                               015230
      CALL PLOT(12.,8.,2)                                               015240
      CALL PLOT(0.,8.,2)                                                015250
      CALL PLOT(0.,0.,2)                                                015260
C     X AXIS FEDUCIARIES                                                015270
      DO 120 K=1,2                                                      015280
      DO 120 I=1,149                                                    015290
      A=.05                                                             015300
      IF(I.EQ.5*(I/5))A=.1                                              015310
      IF(I.EQ.10*(I/10))A=.15                                           015320
      B=I                                                               015330
      B=.08*B                                                           015340
      C=0.                                                              015350
      IF(K.EQ.2)A=8.-A                                                  015360
      IF(K.EQ.2)C=8.                                                    015370
      CALL PLOT(B,A,3)                                                  015380
      CALL PLOT(B,C,2)                                                  015390
  120 CONTINUE                                                          015400
C     LABLE X AXIS                                                      015410
      IA=4800-200*IV                                                    015420
      IB=IA+150                                                         015430
      DO 303 M=IA,IB,10                                                 015440
      X=M-IA                                                            015450
      IF(M.EQ.50*(M/50))GO TO 301                                       015460
      FPN=M-100*(M/100)                                                 015470
      X=.08*X-.11                                                       015480
      CALL NUMBER(X,-.35,.15,FPN,0.,-1)                                 015490
      GO TO 302                                                         015500
  301 FPN=M                                                             015510
      X=.08*X-.35                                                       015520
      CALL NUMBER(X,-.4,.2,FPN,0.,-1)                                   015530
  302 CONTINUE                                                          015540
  303 CONTINUE                                                          015550
      CALL SYMBOL(3.8,-.8,.2,22HWAVELENGTH (ANGSTROMS),0.,22)           015560
      CALL SYMBOL(6.2,-.6,.2,1H.,0.,1)                                  015570
      CALL SYMBOL(7.4,-.8,.2,1H/,0.,1)                                  015580
      CALL PLOT(3.87,-1.25,3)                                           015590
      CALL PLOT(4.07,-1.25,2)                                           015600
      CALL PLOT(3.97,-1.07,2)                                           015610
      CALL PLOT(3.87,-1.25,2)                                           015620
      CALL SYMBOL(4.12,-1.25,.25,14HV=  SEQUENCE A,0.,14)               015630
      CALL SYMBOL(7.62,-1.25,.15,1HL,0.,1)                              015640
      CALL SYMBOL(7.77,-1.25,.25,1HO,0.,1)                              015650
      FPN=IV                                                            015660
      CALL NUMBER(4.62,-1.25,.25,FPN,0.,-1)                             015670
C     LABLE Y AXIS                                                      015680
      IF(ID)1004,1004,1005                                              015690
 1004 CONTINUE                                                          015700
      CALL SYMBOL(-1.1,2.3,.2,26HRELATIVE INTENSITY        ,90.,26)     015710
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      GO TO 1006
 1005 CONTINUE
      FIDNO=ID
      CALL SYMBOL(-1.1,1.1,.2,26HRELATIVE INTENSITY  NUMBER,90.,26)
      CALL NUMBER(-1.1,6.5,.2,FIDNO,90.,-1)
 1006 CONTINUE
C     LINEAR Y AXIS FEDUCIARIES
      IF(TYPE-2)1020,200,1021
 1020 DO 180 K=1,2
      DO 180 I=1,99
      A=.05
      IF(I.EQ.5*(I/5))A=.1
      IF(I.EQ.10*(I/10))A=.15
      B=I
      B=.08*B
      C=0.
      IF(K.EQ.2)A=12.-A
      IF(K.EQ.2)C=12.
      CALL PLOT(A,B,3)
      CALL PLOT(C,B,2)
  180 CONTINUE
C     LABLE Y AXIS LINEARLY
      CALL NUMBER(-.25,-.1,.2,0.,0.,-1)
      DO 340 M=10,90,10
      Y=M
      YY=.08*Y-.1
      CALL NUMBER(-.45,YY,.2,Y,0.,-1)
  340 CONTINUE
      CALL NUMBER(-.65,7.9,.2,100.,0.,-1)
      GO TO 270
C     LOGARITHMIC Y AXIS FEDUCIARIES
  200 DO 260 J=1,2
      DO 260 K=1,2
      DO 210  MA=1,4
      DO 210 M=1,4
      AMA=MA-1
      A=M
      A=4.*ALOG10(.1*A+1.+.5*AMA)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.95*FJ-11.95
      C=B+.05
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  210 CONTINUE
      DO 220 MA=3,6
      DO 220 M=2,8,2
      A=M
      AMA=MA
      A=4.*ALOG10(.1*A+AMA)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.90*FJ-11.90
      C=B+.1
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  220 CONTINUE
      DO 230 M=1,8
      A=M
      A=4.*ALOG10(A+1.)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.80*FJ-11.80
      C=B+.2
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  230 CONTINUE
      DO 240 M=1,2
      A=M
      A=4.*ALOG10(A+.5)
      FK=K
      A=A+4.*FK-4.
      FJ=J
      B=11.85*FJ-11.85
      C=B+.15
      CALL PLOT(B,A,3)
      CALL PLOT(C,A,2)
  240 CONTINUE
      DO 250 M=1,3
      A=M
      A=4.*ALOG10(A+6.5)
```

```
      FN=N                                                              016550
      A=A+4.*FN-4.                                                      016560
      FJ=J                                                              016570
      B=11.85*FJ-11.85                                                  016580
      C=B+4.15                                                          016590
      CALL PLOT(B,A,3)                                                  016600
      CALL PLOT(C,A,2)                                                  016610
  250 CONTINUE                                                          016620
      A=4.                                                              016630
      FJ=J                                                              016640
      B=11.75*FJ-11.75                                                  016650
      C=B+.25                                                           016660
      CALL PLOT(B,A,3)                                                  016670
      CALL PLOT(C,A,2)                                                  016680
  240 CONTINUE                                                          016690
C     LABLE Y AXIS LOGARYTHMICALLY                                      016700
      DO 310 M=1,9                                                      016710
      FFN=M                                                             016720
      Y=4.*ALOG10(FFN)-.08                                              016730
      CALL NUMBER(-.2,Y,.15,FFN,0.,-1)                                  016740
  310 CONTINUE                                                          016750
      DO 320 M=10,90,10                                                 016760
      FFN=M                                                             016770
      Y=4.*ALOG10(FFN)-.08                                              016780
      CALL NUMBER(-.35,Y,.15,FFN,0.,-1)                                 016790
  320 CONTINUE                                                          016800
      CALL NUMBER(-.5,7.93,.15,100.,0.,-1)                              016810
      GO TO 270                                                         016820
 1021 CONTINUE                                                          016830
C LABLE Y AXIS FOR SQUARE ROOT                                          016840
      CALL NUMBER(-.2,-.08,.15,0.,0.,-1)                                016850
      DO 1022 M=10,90,10                                                016860
      FFN=M                                                             016870
      Y=.8*SQRT(FFN)-.08                                                016880
      CALL NUMBER(-.35,Y,.15,FFN,0.,-1)                                 016890
 1022 CONTINUE                                                          016900
      CALL NUMBER(-.5,7.92,.15,100.,0.,-1)                              016910
C SQUARE ROOT FEDUCIARIES                                               016920
      DO 1028 K=1,2                                                     016930
      DO 1028 I=1,99                                                    016940
      A=.05                                                             016950
      IF(MOD(I,5).EQ.0)A=.1                                             016960
      IF(MOD(I,10).EQ.0)A=.15                                           016970
      B=I                                                               016980
      B=.8*SQRT(B)                                                      016990
      C=0.                                                              017000
      IF(K.EQ.2)A=12.-A                                                 017010
      IF(K.EQ.2)C=12.                                                   017020
      CALL PLOT(A,B,3)                                                  017030
      CALL PLOT(C,B,2)                                                  017040
 1028 CONTINUE                                                          017050
  270 CONTINUE                                                          017060
  400 CONTINUE                                                          017070
      IF(IDIM.EQ.0)GO TO 407                                            017080
C     PLOT                                                              017090
      IT=3                                                              017100
      YMAX=0.                                                           017110
      DO 401 I=1,IDIM                                                   017120
      IF(YARRAY(I).GT.YMAX)YMAX=YARRAY(I)                               017130
  401 CONTINUE                                                          017140
      DO 405 I=1,IDIM                                                   017150
      X=I                                                               017160
      DIM IDIM-1                                                        017170
      X=4.+(12./DIM)                                                    017180
      IF(IOPT-2)402,403,406                                             017190
  402 Y=YARRAY(I)*(8./YMAX)                                             017200
      GO TO 404                                                         017210
  403 IF(YARRAY(I).LT.YMAX/100.)YARRAY(I)=YMAX/100.                     017220
      Y=4.*ALOG10(100.*(YARRAY(I)/YMAX))                                017230
      GO TO 404                                                         017240
  406 IF(YARRAY(I).LT.0.)YARRAY(I)=0.                                   017250
      Y=8.*SQRT(YARRAY(I)/YMAX)                                         017260
  404 IF(Y.LT.0.)Y=0.                                                   017270
      CALL PLOT(X,Y,IT)                                                 017280
       IT=2                                                             017290
  405 CONTINUE                                                          017300
  407 RETURN                                                            017310
      END                                                               017320
```

```
C 21   APLOT                                                          017360
C                                                                     017370
C                                                                     017380
      SUBROUTINE APLOT(NE,ND)                                         017390
      DIMENSION IFO(3),B(121)                                         017400
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)      017410
      DATA IFO/10H(1X,I3,1X,,10HF5.2,1X,I2,10H1A1       )/            017420
C  NE=NUMBER OF ELEMENTS IN ARRAY TO BE PLOTTED.                      017430
C  Y=ARRAY TO BE PLOTTED.                                             017440
C  ND=NUMBER OF DECADES FOR LOG PLOT.                                 017450
C  ND=0 MAKES LINEAR PLOT.                                            017460
C  ND=NEGATIVE GIVES THAT FRACTION OF A DECADE.                       017470
C  CALL APLOT(-1,DUMMY,NSIZE) TO SET WIDTH OF PLOT.                   017480
C  DEFAULT VALUE IS 120 SPACES.                                       017490
C  MAXIMUM WIDTH IS 120 SPACES.                                       017500
      DATA A0/1H /,A1/1H./                                            017510
      NSIZE=120                                                       017520
      SIZE=NSIZE                                                      017530
      YM=0.                                                           017540
      DO 10 N=1,NE                                                    017550
10     YM=AMAX1(YM,Y(N))                                              017560
      IF(ND.NE.0)F=NSIZE/ND                                           017570
      IF(ND.LT.0)F=-NSIZE*ND                                          017580
      DO 40 N=1,NE                                                    017590
      YN=Y(N)/YM                                                      017600
      IF(ND.EQ.0)GO TO 21                                             017610
      YN=AMAX1(YN,.000000001)                                         017620
      NY=ALOG10(YN)*F+SIZE+1.000001                                   017630
      GO TO 22                                                        017640
21     NY=SIZE*YN+1.000001                                            017650
22     NY=MAXO(1,NY)                                                  017660
      NY=MINO(NSIZE+1,NY)                                             017670
      NSIZE1=NSIZE+1                                                  017680
      DO 30 J=1,NSIZE1                                                017690
30     B(J)=A0                                                        017700
      B(NY)=A1                                                        017710
      YN=ABS(Y(N))                                                    017720
      YN=AMAX1(YN,.000000000001)                                      017730
      IAL=ALOG10(YN)+1.000000001                                      017740
      IAL=31-IAL                                                      017750
      IAL=MINO(31,IAL)                                                017760
      IF(IAL.LE.26)GO TO 37                                           017770
      CALL MXPUTX(IAL,IFO(2),4)                                       017780
      WRITE(6,IFO)N,Y(N),(B(J),J=1,NY)                                017790
      GO TO 40                                                        017800
37     NYN=Y(N)                                                       017810
      WRITE(6,292)N,NYN,(B(J),J=1,NY)                                 017820
292    FORMAT(1X,I3,1X,I5,1X,121A1)                                   017830
40     CONTINUE                                                       017840
      CONTINUE                                                        017850
      CONTINUE                                                        017860
      CONTINUE                                                        017870
      CONTINUE                                                        017880
      CONTINUE                                                        017890
      RETURN                                                          017900
      END                                                             017910
C                                                                     017930
C                                                                     017940
C 22   AL2                                                           017950
C                                                                     017960
C                                                                     017970
      SUBROUTINE AL2(N1,N2,NSTR)                                      017980
      DIMENSION NSTR(8)                                               017990
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)      018000
      WRITE(6,201)                                                    018010
201    FORMAT(1X,13HENTER PROGRAM)                                    018020
      NUM=1                                                           018030
      DO 110 NN=N1,N2                                                 018040
      CALL ISNN(NN,+1,IDUMMY)                                         018050
      DO 100 N=1, 149                                                 018060
      I=300*N+NSTR(NN)-301                                            018070
      ISNMAX=0                                                        018080
      DO 20 K=1,300                                                   018090
      II=I+K                                                          018100
      CALL ISNN(II,-1 ISN)                                            018110
      IF(ISNMAX.LT.ISN)ISNMAX=ISN                                     018120
   20 Y(K)=ISN                                                        018130
      IF(ISNMAX.LE.0)GO TO 105                                        018140
      CALL SMOOTH(  300,11)                                           018150
      NID=1000*NN+N                                                   018160
      CALL QWPL(  NUM,NID,300)                                        018170
  100 CONTINUE                                                        018180
  105 CONTINUE                                                        018190
      PRINT 205,NN,N,NUM                                              018200
```

```
204    FORMAT(1X,316)                                                    018210
  110 CONTINUE                                                          018220
      CALL ENDPLT                                                       018230
      RETURN                                                            018240
      END                                                               018250
C                                                                       018270
C                                                                       018280
C 23   SMOOTH                                                          018290
C                                                                       018300
C                                                                       018310
      SUBROUTINE SMOOTH(  NDIM,NSM)                                     018320
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),S(801)          018330
      IF(NSM.LE.1) GO TO 100                                            018340
      N=NSM/2                                                           018350
      FNSM=N*2+1                                                        018360
      DO 10 K=1,N                                                       018370
      K2=N+K+1                                                          018380
      K3=NDIM+K-N                                                       018390
      S(K+1)=Y(K3)                                                      018400
   10 S(K2)=Y(K)                                                        018410
      DO 60 I=1,NDIM                                                    018420
      DO 20 K=1,N                                                       018430
   20 S(K)=S(K+1)                                                       018440
      S(N+1)=Y(I)                                                       018450
      Y(I)=0.                                                           018460
      DO 30 K=1,N                                                       018470
      IF(I+K.GE.NDIM+1) GO TO 40                                        018480
   30 Y(I)=Y(I)+Y(I+K)                                                  018490
   40 N1=N+I-NDIM+1                                                     018500
      N1=MAXO(N1,1)                                                     018510
      N1=N+N1                                                           018520
      DO 50 K=1,N1                                                      018530
   50 Y(I)=Y(I)+S(K)                                                    018540
   60 Y(I)=Y(I)/FNSM                                                    018550
  100 RETURN                                                            018560
      END                                                               018570
C                                                                       018590
C                                                                       018600
C 24   QWPL                                                            018610
C                                                                       018620
C                                                                       018630
      SUBROUTINE QWPL(       NO,ID, ZE)                                 018640
C   Y ARRAY IN                                                          018650
C  NO OF PLOTS OUTPUTTED EXCEPT MAY  NO=1 AT FIRST ENTRY                018660
C  ID OF PLOT IN                                                        018670
C  IZE OF Y  ARRAY                                                      018680
      DIMENSION PROGID(3)                                               018690
      COMMON Y(300),X(300),YW(300),Z(801),ZW(801),T(19),DUM(801)        018700
      PROGID(1)=10HKITROSSER                                            018710
      PROGID(2)=DATE(DDUM)                                              018720
      PROGID(3)=TIME(TDUM)                                              018730
      IF(NO.EQ.1)CALL CRTPLT(PROGID,1.,17.)                             018740
      IF(NO.EQ.1)CALL PLOT(3.65,0.,-3)                                  018750
      IF(NO.EQ.1)GO TO 61                                               018760
      IF(NO (NO/4)*4.EQ.1)CALL FRAME(4.15,.5)                           018770
      IF(NO-(NO/4)*4.EQ.1)GO TO 61                                      018780
      CALL PLOT(4.25,0.,-3)                                             018790
   61 FID=ID                                                            018800
      CALL PLOT(-4.,.4,3)                                               018810
      CALL PLOT(0,,.4,2)                                                018820
      CALL PLOT(0,,10.4,2)                                              018830
      YMAX=0.                                                           018840
      DO 1 I=1,IZE                                                      018850
      IF(Y      (I).GT.YMAX)YMAX=Y      (I)                             018860
1      CONTINUE                                                         018870
      IF(YMAX.LE.0.)GO TO 3                                             018880
      CALL NUMBER(-2.,-.4,.2,FID,0.,-1)                                 018890
      CALL SYMBOL(-3.,0.,.2,5HYMAX=,0.,5)                               018900
      CALL NUMBER(-2.,0.,.2,YMAX,0.,-1)                                 018910
      IT=3                                                              018920
      DO 2 I=1,IZE                                                      018930
      YY=-4.*Y      (I)/YMAX                                            018940
      IF(YY.GT.0.)YY=0.                                                 018950
      FI=I-1                                                            018960
      FIZ=IZE-1                                                         018970
      XX=.4+10.*FI/FIZ                                                  018980
      CALL PLOT(YY,XX,IT)                                               018990
      IT=2                                                              019000
2      CONTINUE                                                         019010
      NO NO+1                                                           019020
3      CONTINUE                                                         019030
      RETURN                                                            019040
      END                                                               019050
```

```
C                                                                       019360
C 26   SLIT PROGRAM                                                    019370
C                                                                       019380
C                                                                       019390
      PROGRAM SLIT(INPUT,OUTPUT,TAPE2,TAPE6=OUTPUT,TAPE7)               019400
      DIMENSION X(100),Z(100),V(10),D(10),G(10),DA(3)                   019410
      PRINT 909                                                         019420
909    FORMAT(/#  #####REMEMBER TO COPY TAPE7 AFTER EXECUTI#            019430
     + #ON.#####  #/)                                                   019440
      REWIND 2                                                          019450
      READ(2,902)AAN                                                    019460
      N=AAN+.000001                                                     019470
902    FORMAT(F9.3)                                                     019480
      DO 5 I=1,N                                                        019490
5      X(I)=I                                                           019500
      READ(2,902)(Z(I),I=1,N)                                           019510
      WRITE(6,904)                                                      019520
904    FORMAT(//3X#X#3X#Z#/)                                            019530
      WRITE(6,903)(X(I),Z(I),I=1,N)                                     019540
903    FORMAT(1X,F3.0,1X,F5.0)                                          019550
C   V(1)=T   V(2)=C   V(3)=W   V(4)=A                                   019560
      V(2)=.5#(Z(1)+Z(N))                                               019570
      V(4)=0.                                                           019580
      DO 10 I=1,N                                                       019590
      IF(Z(I).GT.V(4))JX=I                                              019600
      IF(Z(I).GT.V(4))V(4)=Z(I)                                         019610
10     CONTINUE                                                         019620
      V(4)=V(4)-V(2)                                                    019630
      V(1)=X(JX)                                                        019640
      ZW V(2)+.5#V(4)                                                   019650
      DO 15 I=1,N                                                       019660
      JX1=I                                                             019670
      IF(ZW.LT.Z(I))GO TO 16                                            019680
15     CONTINUE                                                         019690
16     DO 17 I=JX1,N                                                    019700
      JX2=I                                                             019710
      IF(ZW.GT.Z(I))GO TO 18                                            019720
17     CONTINUE                                                         019730
18     V(3)=X(JX2)-X(JX1)                                               019740
      D(3)=V(3) $ D(1)=V(1) $ D(2)=D(4)=V(4)                            019750
      KK=0                                                              019760
      WRITE(6,905)                                                      019770
905    FORMAT(/5X#N#5X#T#11X#C#11X#W#11X#A#/)                           019780
      DATA DA/10HVALUE      ,10HRANGE      ,10HFIT CRITER/              019790
      WRITE(6,906)KK,N,(V(K),K=1,4),DA(1)                               019800
      WRITE(6,906)KK,N,(V(K),K=1,4),DA(2)                               019810
      WRITE(6,907)                                                      019820
      DO 30 KK=1,40                                                     019830
      DO 20 K=1,4                                                       019840
      CALL FCRII(N,X,Z,K,V,D(K),G(K))                                   019850
20     CONTINUE                                                         019860
      REWIND 7                                                          019870
      WRITE(7,908)AAN,(V(K),K=1,4),(X(I),Z(I),I=1,N)                    019880
      WRITE(6,906)KK,N,(V(K),K=1,4),DA(1)                               019890
      WRITE(6,906)KK,N,(D(K),K=1,4),DA(2)                               019900
      WRITE(6,906)KK,N,(G(K),K=1,4),DA(3)                               019910
      WRITE(6,907)                                                      019920
906    FORMAT(2(1X,I2),4G12.6,1X,A10)                                   019930
907    FORMAT(1X)                                                       019940
30     CONTINUE                                                         019950
908    FORMAT(5F10.4)                                                   019960
      STOP                                                              019970
      END                                                               019980
      SUBROUTINE FCRII(N,X,Z,K,V,DG,GM)                                 019990
      DIMENSION X(1),Z(1),V(1)                                          020000
      GO=V(K)  $  DG=ABS(DG)  $  GM=0.                                  020010
      IF(K.EQ.2.OR.K.EQ.4)GM=1.E+08                                     020020
      DO 10 I=1,20                                                      020030
      FI=I                                                              020040
      G=GO-DG*(FI-1)*DG/10.                                             020050
      V(K)=G                                                            020060
      IF(K.EQ.2.OR.K.EQ.4)GO TO 5                                       020070
      GH=FCN(N,X,Z,V)                                                   020080
      IF(GH.GT.GM)G1=V(K)                                               020090
      IF(GH.GT.GM)GM=GH                                                 020100
      GO TO 10                                                          020110
5      GH=FCN(N,X,Z,V)                                                  020120
      IF(GH.LT.GM)G1=V(K)                                               020130
      IF(GH.LT.GM)GM=GH                                                 020140
10     CONTINUE                                                         020150
      V(K)=G1                                                           020160
      DG=.4*DG*ABS(G1-GO)                                               020170
      RETURN                                                            020180
      END                                                               020190
```

```
      FUNCTION FCN(N,X,Z,V)                                              020200
      DIMENSION X(1),Z(1),V(1)                                           020210
      T=V(1)  $  C=V(2)  $  W=V(3)  $  A=V(4)  $  RN=N  $  ZA=0.         020220
      DO 10 I=1,N                                                        020230
10     ZA=ZA+Z(I)-C                                                      020240
      ZA=ZA/RN                                                           020250
      YA=0.                                                              020260
      DO 12 I=1,N                                                        020270
      XT=X(I)-T                                                          020280
      YA=YA+YN(XT,A,W)                                                   020290
12     CONTINUE                                                          020300
      YA=YA/RN                                                           020310
      YS=0.                                                              020320
      DO 14 I=1,N                                                        020330
      XT=X(I)-T                                                          020340
      YI=YN(XT,A,W)-YA                                                   020350
      YS=YS+YI*YI                                                        020360
14     CONTINUE                                                          020370
      YS=YS/RN                                                           020380
      YNM=0.  $  ZS=0.                                                   020390
      DO 20 I=1,N                                                        020400
      XT=X(I)-T                                                          020410
      YNM=YNM+(Z(I)-C-ZA)*(YN(XT,A,W)-YA)                                020420
      ZS=ZS+(Z(I)-C-ZA)**2                                               020430
20     CONTINUE                                                          020440
      YNM=YNM/RN  $  ZS=ZS/RN                                            020450
      FD=ZS*YS                                                           020460
      FCN=YNM/SQRT(FD)                                                   020470
40     RETURN                                                            020480
      END                                                                020490
      FUNCTION FSQ(N,X,Z,V)                                              020500
      DIMENSION X(1),Z(1),V(1)                                           020510
      T=V(1)  $  C=V(2)  $  W=V(3)  $  A=V(4)  $  RN=N  $  FSQ=0.       020520
      DO 10 I=1,N                                                        020530
      XT=X(I)-T                                                          020540
      FI=Z(I)-C-YN(XT,A,W)                                               020550
10     FSQ=FSQ+FI*FI                                                     020560
      FSQ=FSQ/RN                                                         020570
      RETURN                                                             020580
      END                                                                020590
      FUNCTION YN(X,A,W)                                                 020600
      IF(X.LT.-W)GO TO 10                                                020610
      IF(X.GT.+W)GO TO 10                                                020620
      AX=X                                                               020630
      IF(X.GT.0.)AX=-X                                                   020640
      YN=A*(AX+W)/W                                                      020650
      GO TO 20                                                           020660
10     YN=0.                                                             020670
20     RETURN                                                            020680
      END                                                                020690
C                                                                        020710
C                                                                        020720
C     SLITC PROGRAM                                                      020730
C                                                                        020740
C                                                                        020750
      PROGRAM SLITC(INPUT,OUTPUT,TAPE2,TAPE6,TAPE7=OUTPUT)               020760
      DIMENSION X(200),Z(200),TITLE 70)                                  020770
      REWIND 6                                                           020780
      REWIND 2                                                           020790
      XMAX=0.                                                            020800
      ZMAX=0.                                                            020810
      ZMIN=1.E+10                                                        020820
      DO 15 J=1,10                                                       020830
      READ(2,901)AAN,T,C,W,A                                             020840
      IF(EOF(2))20,10                                                    020850
901    FORMAT(5F10.4)                                                    020860
10     N=AAN+.00001                                                      020870
      DATA L3/0./                                                        020880
      L1=L3+1                                                            020890
      L2=L1+N-1                                                          020900
      L3=L2                                                              020910
      READ(2,901)(X(I),Z(I),I=L1,L2)                                     020920
      DO 12 I=L1,L2                                                      020930
      X(I)=ABS(X(I)-T)                                                   020940
      Z(I)=(Z(I)-C)/(A*W)                                                020950
      IF(X(I).GT.XMAX)XMAX=X(I)                                          020960
      IF(Z(I).GT.ZMAX)ZMAX=Z(I)                                          020970
      IF(Z(I).LT.ZMIN)ZMIN=Z(I)                                          020980
      WRITE(7,902)X(I),Z(I)                                              020990
12     CONTINUE                                                          021000
902    FORMAT(2F10.5)                                                    021010
15     CONTINUE                                                          021020
20     CONTINUE                                                          021030
      AM=ALOG10(.2*XMAX)                                                 021040
```

```
      M=AM                                                              021050
      IF(AM.LT.0.)M=-INT(1.-AM)                                         021060
      IH=.20*XMAX/10.**M-.0000000001                                    021070
      HGRD=2.                                                           021080
      IF(IH.GT.2)HGRD=4.                                                021090
      IF(IH.GT.4)HGRD=10.                                               021100
      HGRD=HGRD*10.**M                                                  021110
      HCTR=HGRD*2.5                                                     021120
      AM=ALOG10(2.*ZMAX/9.)                                             021130
      M=AM                                                              021140
      IF(AM.LT.0.)M=-INT(1.-AM)                                         021150
      IH=(2.*ZMAX/9.)/10.**M-.0000000                                   021160
      VGRD=2.                                                           021170
      IF(IH.GT.2)VGRD=4.                                                021180
      IF(IH.GT.4)VGRD=10.                                               021190
      VGRD=VGRD*10.**M                                                  021200
      VCTR=VGRD*2.                                                      021210
      DO 30 J=1,70                                                      021220
30     TITLE(J)=0.                                                      021230
      TITLE(1)=6HWAVELN    $    TITLE(2)=6H STEPS                       021240
      TITLE(3)=6HAMPLIT    $    TITLE(4)=6HDEF                          021250
      TITLE(5)=-1.                                                      021260
      TITLE(64)=999.    $    TITLE(65)=29.                              021270
      TITLE(7)=3HXXX                                                    021280
      DO 40 J=1,3                                                       021290
      IF(J.EQ.1)KOM=0                                                   021300
      IF(J.EQ.2)KOM=3                                                   021310
      IF(J.EQ.3)KOM=4                                                   021320
      CALL MAPA(X,Z,L,L3,KOM,HCTR,HGRD,VCTR,VGRD,TITLE)                 021330
40     CONTINUE                                                         021340
      CONTINUE                                                          021350
      CONTINUE                                                          021360
      CONTINUE                                                          021370
      CONTINUE                                                          021380
      STOP                                                              021390
      END                                                               021400
```

```
C                                                                       030420
C                                                                       030430
C  '86 LIGHTBOX AVERAGE PROGRAM                                        030440
C                                                                       030450
C                                                                       030460
      PROGRAM AVG(TAPE2,OUTPUT,INPUT)                                   030470
      REWIND 2                                                          030480
      PRINT 104                                                         030490
      READ 102,II                                                       030500
      II=II                                                             030510
      CALL ISNN(II,II,IDUMMY)                                           030520
      DO 30 I=1,100                                                     030530
      PRINT 101                                                         030540
      READ 102,IS                                                       030550
      PRINT 103                                                         030560
      READ 102,II                                                       030570
      IF(IS.EQ.0.AND.II.EQ.II)                                          030580
      ISUM=0                                                            030590
      DO 20 N=IS,II                                                     030600
      CALL ISNN(N,-1,IW)                                                030610
      ISUM=ISUM+IW                                                      030620
20    CONTINUE                                                          030630
      ISUM=ISUM                                                         030640
      FSUM=ISUM/FLOAT(II-IS+1)                                          030650
      PRINT 105,FSUM                                                    030660
30    CONTINUE                                                          030670
101   FORMAT(1X,'NO. OF FIRST WD.=')                                    030680
102   FORMAT(2I5)                                                       030690
103   FORMAT(1X,'NO. OF LAST  WD.=')                                    030700
104   FORMAT(1X,'FILE NO. =')                                           030710
105   FORMAT(1X,'AVERAGE = ',F8.2)                                      030720
      STOP                                                              030730
      END                                                               030740
C                                                                       030750
C                                                                       030760
C 17   ISNN                                                            030770
C                                                                       030780
C                                                                       030790
      SUBROUTINE ISNN(N,K,ISN)                                          030800
      DIMENSION II(30)                                                  030810
      II(K)=20+20+10                                                    030820
10     NA=1302769811239                                                 030830
      IF(N4.NE.N6) N2=N6                                                030840
      N4=NA                                                             030850
      NE=N                                                              030860
      GO TO 100                                                         030870
20     IF(NE-N2)21,31,22                                                030880
21     REWIND 2                                                         030890
      N6=-99                                                            030900
      IF(NE.EQ.1)GO TO 32                                               030910
      N2=1                                                              030920
22     N6=-99                                                           030930
      N1=N2+1                                                           030940
      DO 30 NE=2,N3+NI                                                  030950
23     READ(2,209)(II(NN),NN=1,30)                                      030960
      IF(EOF(2))30,25                                                   030970
25     CONTINUE                                                         030980
30    GO TO 32                                                          030990
31    IF(N.LT.N6)GO TO 50                                               031000
      IF(N.GE.N6+30)GO TO 32                                            031010
      GO TO 33                                                          031020
32     N2=NE                                                            031030
      N6=N2+30                                                          031040
      DO 40 NE=N2,N+30                                                  031050
      I1=NE-N2                                                          031060
34     READ(2,209)(II(NN),NN=1,30)                                      031070
      IF(EOF(2))35,35                                                   031080
35     N6=-99                                                           031090
      GO TO 31                                                          031100
50    BACKSPACE 2                                                       031110
51     N6=N6-30                                                         031120
      BACKSPACE 2                                                       031130
      IF(N.LT.N6) GO TO 51                                              031140
      READ(2,209)(II(NN),NN=1,30)                                       031150
40     NE=N+N2+1                                                        031160
      ISN=II(NN)                                                        031170
100    RETURN                                                           031180
      END                                                               031190
```