Effective Date: 18 July 1980

IUE DATA REDUCTION

XVII. Mean Reseaux and Dispersion Constants

In memorandum XI of this series (IUE Newsletter No. 7), the rationale for adopting mean calibration files for IUE image processing production use was explained. The chief advantage of mean files over the usual biweekly calibrations is that thermal fluctuations are averaged out, yielding calibrations more appropriate to the "typical" IUE image. Extensive studies of the temporal and thermal behavior of reseau positions and dispersion constants have been made since the publication of memorandum XI (see reference 1 for preliminary results), allowing a complete set of mean calibration files, for both dispersions, to be determined and quantitatively evaluated. Herein we report the calculation, evaluation, and implementation of mean calibration files, effective in all standard IUESIPS production at GSFC as of 10:00 GMT 18 July 1980. Note that the new mean low-resolution dispersion constants used as of that date differ slightly from the earlier means presented in IUE Newsletter No. 7.

MEAN RESEAUX

Calculation and Display

To determine reseau positions as accurately as possible for use in constructing means, 16 LWR 60% or 77% UVITF images exposed between day 73 of 1978 and day 204 of 1979, and 20 SWP 60% or 77% UVITF images exposed between day 85 of 1978 and day 334 of 1979 were collected. UVITF images were chosen so as to avoid contamination by the platinum spectrum and/or the possible effects of uneven illumination of the TFLOOD lamps in the biweekly WAVECAL + TFLOOD calibration images on which reseaux have normally been measured in the past.

In addition, several improvements were made in the details of the procedure followed by the FNDRES program which locates the reseaux. These include the use of a better template for the large reseau in row 11, column 11, and the use of 3 more reseaux in SWP and 2 more reseaux in LWR near the tube edges so as to reduce the amount of extrapolation required to achieve the full 13-by-13 grid of reseaux used in the geometric correction process. Furthermore, the average positions found on the UVITF images with the improved FNDRES were calculated <u>without</u> the row-and-column smoothing procedure usually applied to reseaux measured on a single image. This smoothing, consisting of polynomial fitting of the found reseau positions along each row and column of the reseau grid (done with the program RESOFIXL), introduced undesirable effects discussed further below. Statistical peculiarities in individual images tend to be removed in the averaging process used to construct the current means.

The mean found reseau positions for the SWP camera are given in Table 1. The values are given in line and sample pairs (line value on top), arranged on the page according to row and column number (1 to 13) within the reseau grid. The means for the LWR camera are given in Table 2. For both cameras, the 1σ scatter about the mean positions is $\sim 0.10 - 0.20$ pixels over most of the tube, except near the edges where extrapolation of the found positions is required and where the scatter increases to values $\sim 0.30 - 0.40$ pixels. In general, the scatter in the SWP values is slightly higher than the LWR scatter.

The geometrically correct reseau grid (i.e., the reseau locations to which the geometric correction step maps the found reseau positions) for each camera is centered on line number 390, sample number 410 (these are the pixel coordinates for the reseau in row 7, column 7 of the grid). In SWP, all reseaux are spaced 56 pixels apart in the line and sample directions in the correct reseau grid. In LWR, the spacing is 55 pixels. Using these correct reseau grids and the mean found reseau positions reported here, it is possible to generate a display which illustrates the geometric distortion corresponding to the mean found reseau positions. In Figure 1 we show the positions of the 169 reseaux in the correct SWP grid as diamonds; the vectors indicate the displacements from the correct positions to the corresponding mean found positions, magnified by a factor of 2. The amount of distortions is therefore exaggerated for display, although the directions and relative proportions of the displacement vectors are correct. In Figure 2 we show the similar result for LWR.

Effects of Smoothing

As mentioned above, no smoothing of the found positions was employed in the construction of the mean reseau files. Several specific experiments were conducted to determine the effects of applying the usual smoothing algorithm to reseau sets. The mean reseau positions were smoothed and compared to the unsmoothed values. Figures 3 and 4 illustrate these comparisons, made with the same display technique used to generate Figure 1 and 2, except that here we plot the unsmoothed mean positions as diamonds and the displacements to the corresponding smoothed mean positions as vectors, but now with a magnification factor of 80.

TABLE 1 - MEAN FOUND RESEAU POSITIONS: SWP

		1	2	3	4	5	6	7	8	9	10	11	12	13
LINE	1	70.879	67.854	65.412	61.797	58.715	55.771	53.080	50.954	49.245	48.981	48.700	49.820	49.941
SAMPLE	1	77.284	132.376	188.159	243.267	299.253	353.939	407.539	460.669	513.112	564.331	616.912	668.301	720.629
LINE	2	124.743	121.718	119.276	115.661	112.579	109.765	107.249	105.197	103.635	103.371	103.090	104.210	104.331
SAMPLE	2	77.257	132.349	188.132	243.240	298.820	353.814	407.959	461.632	514.567	565.786	618.367	669.756	722.084
LINE	3	179.705	176.680	174.238	170.627	167.511	164.868	162.366	160.246	158.963	158.422	158.141	159.261	159.382
SAMPLE	3	77.047	132.139	187.923	242.947	298.515	353.875	408.380	462.565	516.009	568.202	620.783	672.173	724.500
LINE	4	233.952	230.927	228.782	225.556	222.925	220.281	218.085	216.063	214.902	214.299	214.094	215.214	215.335
SAMPLE	4	76.608	131.701	187.665	242.926	298.694	354.160	409.153	463.853	517.595	570.537	623.443	674.833	727.160
LINE	5	287.382	285.305	283.657	280.907	278.300	275.807	273.741	271.880	270.652	270.091	269.842	270.866	272.807
SAMPLE	5	77.777	131.726	187.772	242.877	298.844	354.740	410.129	465.422	519.861	573.270	627.175	678.913	731.241
LINE	6	341.675	340.504	339.256	337.116	334.896	332.556	330.412	328.652	327.186	326.304	326.139	326.820	328.762
SAMPLE	6	79.689	133.278	189.112	244.052	299.906	355.745	411.275	466.797	521.458	575.237	629.156	681.459	733.787
LINE	7	396.743	395.858	394.851	393.191	391.153	388.948	386.913	385.106	383.672	382.663	382.298	382.639	384.075
SAMPLE	7	81.153	134.821	190.279	245.040	300.828	356.844	412.581	468.206	523.514	577.728	632.224	684.801	737.587
LINE	8	451.705	451.549	450.872	449.397	447.475	445.258	443.107	441.276	439.594	438.205	437.814	437.493	438.805
SAMPLE	8	84.559	137.350	192.422	246.958	302.334	358.183	414.080	469.767	524.935	579.514	634.118	687.338	740.730
LINE	9	507.604	507.825	507.014	505.985	504.042	501.854	499.707	497.815	495.873	494.120	493.640	492.605	493.917
SAMPLE	9	86.900	139.537	194.277	248.394	303.757	359.583	415.409	471.157	526.871	581.796	636.587	690.097	743.489
LINE	10	563.363	563.479	562.560	561.665	559.617	557.326	554.899	552.854	550.696	548.605	547.635	546.122	547.435
SAMPLE	10	90.600	143.417	197.541	251.007	305.954	361.194	416.753	472.336	527.835	582.762	637.577	691.202	744.594
LINE	11	619.166	619.281	618.207	617.402	615.238	612.893	610.056	607.849	605.400	603.087	602.122	600.609	601.921
SAMPLE	11	93.364	146.181	199.711	252.890	307.563	362.184	417.614	473.047	528.556	583.509	638.789	692.414	745.805
LINE	12	673.979	674.094	673.021	672.184	669.782	667.261	664.602	662.304	659.692	657.479	656.514	655.001	656.313
SAMPLE	12	96.398	149.215	202.745	254.973	308.865	363.042	417.895	473.186	528.674	583.739	639.019	692.644	746.036
LINE	13	728.193	728.308	727.234	726.398	723.995	721.233	718.302	715.710	713.099	710.885	709.920	708.407	709.719
SAMPLE	13	96.456	149.274	202.803	255.031	309.798	363.472	418.052	473.097	528.585	583.650	638.930	692.555	745.947

TABLE 2 - MEAN FOUND RESEAU POSITIONS: LWR

		1	2	3	4	5	6	7	8	9	10	11	12	13
LINE	1	79.052	78.890	75.542	71.610	66.960	63.507	59.011	55.971	52.405	51.028	49.816	49.533	49.569
SAMPLE	1	61.336	113.863	167.428	221.218	274.358	327.813	380.627	432.325	484.112	534.632	586.192	638.000	689.615
LINE	2	132.984	132.823	129.475	125.542	120.893	117.848	113.624	111.057	108.036	106.659	105.447	105.164	105.200
SAMPLE	2	61.404	113.931	167.495	221.286	275.442	329.126	382.420	434.722	486.792	537.311	588.872	640.679	692.295
LINE	3	188.673	188.511	185.163	181.357	176.797	173.650	169.745	166.997	163.830	162.466	161.254	160.971	161.007
SAMPLE	3	63.390	115.917	169.482	223.052	277.070	330.824	384.078	436.620	489.177	540.313	591.874	643.681	695.297
LINE	4	242.534	242.372	239.797	236.230	232.180	229.085	225.368	222.860	219.881	218.784	217.470	217.187	217.223
SAMPLE	4	64.990	117.517	171.169	225.130	278.855	332.905	386.310	439.160	492.158	543.566	595.001	646.808	698.424
LINE	5	299.651	297.068	294.668	291.488	287.808	284.665	281.194	278.601	276.019	274.437	273.297	273.063	273.643
SAMPLE	5	67.573	120.100	173.843	227.271	281.025	334.827	388.539	441.869	495.249	546.946	599.068	650.934	702.549
LINE	6	354.190	352.074	349.905	347.098	343.891	340.970	337.775	334.894	332.290	330.620	329.470	329.005	329.584
SAMPLE	6	70.987	123.227	176.917	230.094	283.394	337.191	390.802	444.198	497.262	549.539	601.478	653.550	705.165
LINE	7	409.001	407.184	405.281	402.655	399.867	396.845	393.865	391.002	388.411	386.483	385.039	384.590	385.005
SAMPLE	7	74.966	126.776	180.041	232.804	285.889	339.693	393.124	446.547	499.893	552.273	604.678	656.705	708.231
LINE	8	463.972	462.679	460.769	458.229	455.507	452.416	449.389	446.450	443.981	441.637	439.936	439.122	439.162
SAMPLE	8	79.190	130.584	183.448	235.822	288.545	341.834	395.165	448.274	501.850	554.147	606.652	658.969	711.013
LINE	9	519.497	518.305	516.310	513.939	511.209	508.113	505.137	502.072	499.573	496.926	495.260	493.872	493.912
SAMPLE	9	83.940	134.618	186.885	238.603	290.894	344.022	397.010	450.304	503.946	556.533	609.366	661.333	713.377
LINE	10	575.003	573.811	571.401	568.887	565.881	562.584	559.457	556.300	553.801	550.665	548.757	547.299	547.340
SAMPLE	10	88.713	139.392	190.749	241.860	293.569	345.964	398.691	451.642	504.863	557.297	609.968	662.563	714.607
LINE	11	630.471	629.279	626.708	624.045	620.821	617.250	614.041	610.635	607.955	604.558	602.840	601.382	601.422
SAMPLE	11	92.199	142.877	193.997	244.499	295.875	347.828	400.140	452.854	505.914	558.417	610.981	663.577	715.621
LINE	12	684.540	683.348	680.777	678.072	674.544	670.930	667.500	664.069	661.323	658.262	656.543	655.085	655.126
SAMPLE	12	96.108	146.786	197.906	247.648	298.170	349.565	401.164	453.708	506.360	558.792	611.355	663.951	715.995
LINE	13	738.151	736.959	734.389	731.683	728.156	724.099	720.742	716.753	714.117	711.057	709.338	707.880	707.920
SAMPLE	13	96.248	146.926	198.046	247.788	300.409	351.250	402.249	454.332	506.543	558.974	611.538	664.134	716.177

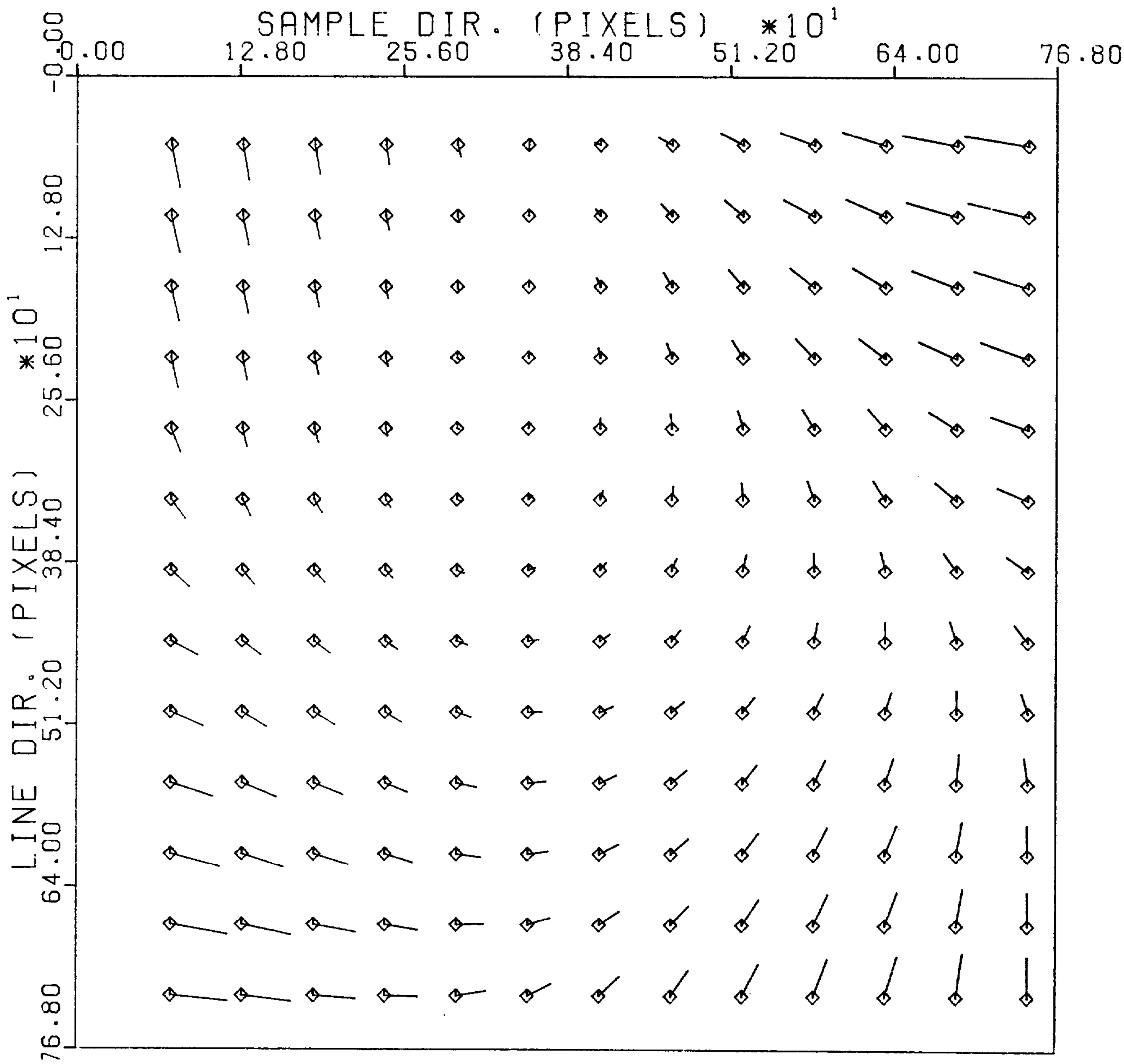


FIGURE 1 - Displacements of mean reseaux from correct grid, SWP
(Magnified by 2)

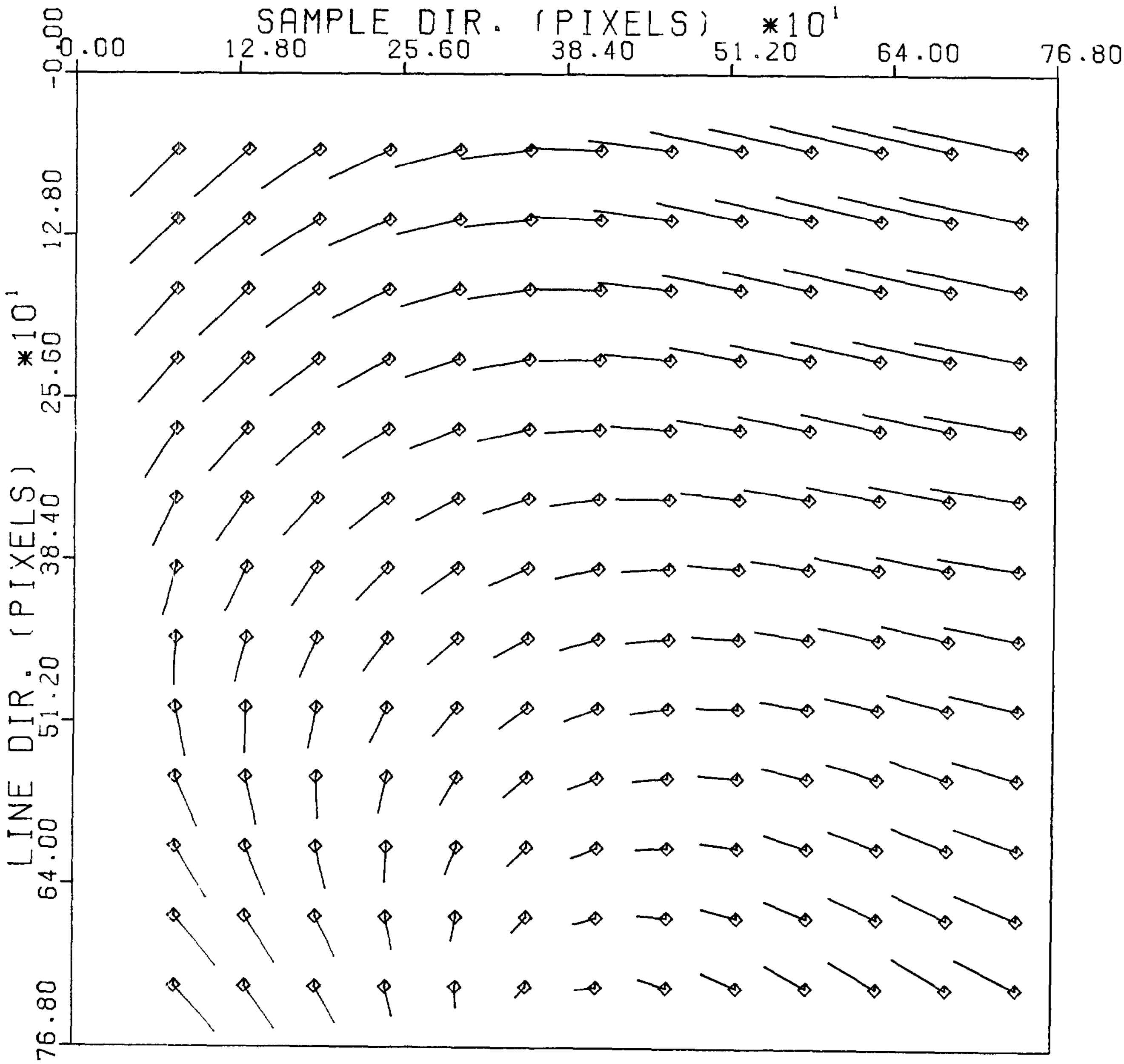


FIGURE 2 - Displacements of mean reseaux from correct grid, LWR
(Magnified by 2)

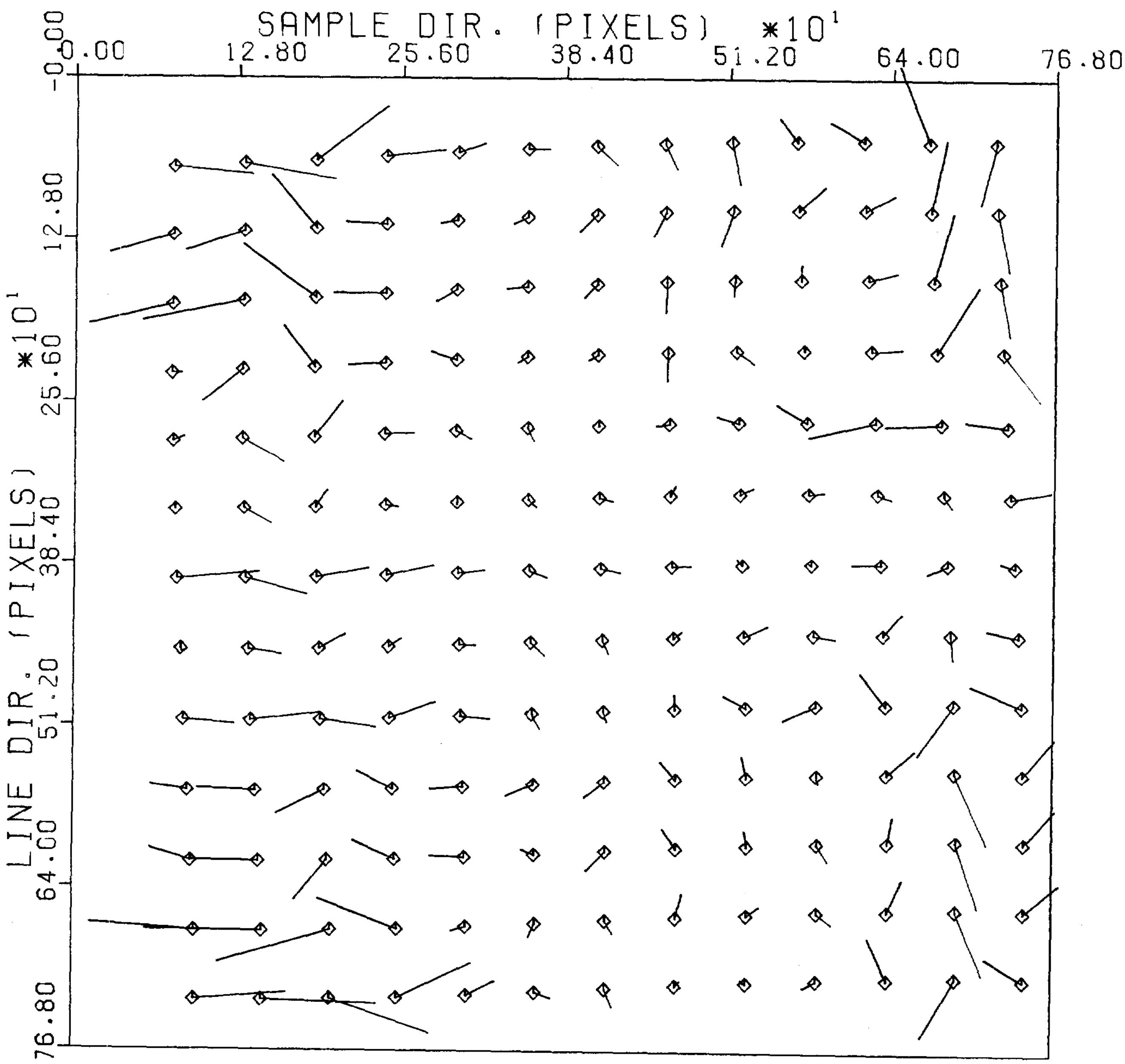


FIGURE 3 - Displacements of smoothed mean reseaux from mean reseaux, SWP
(Magnified by 80)

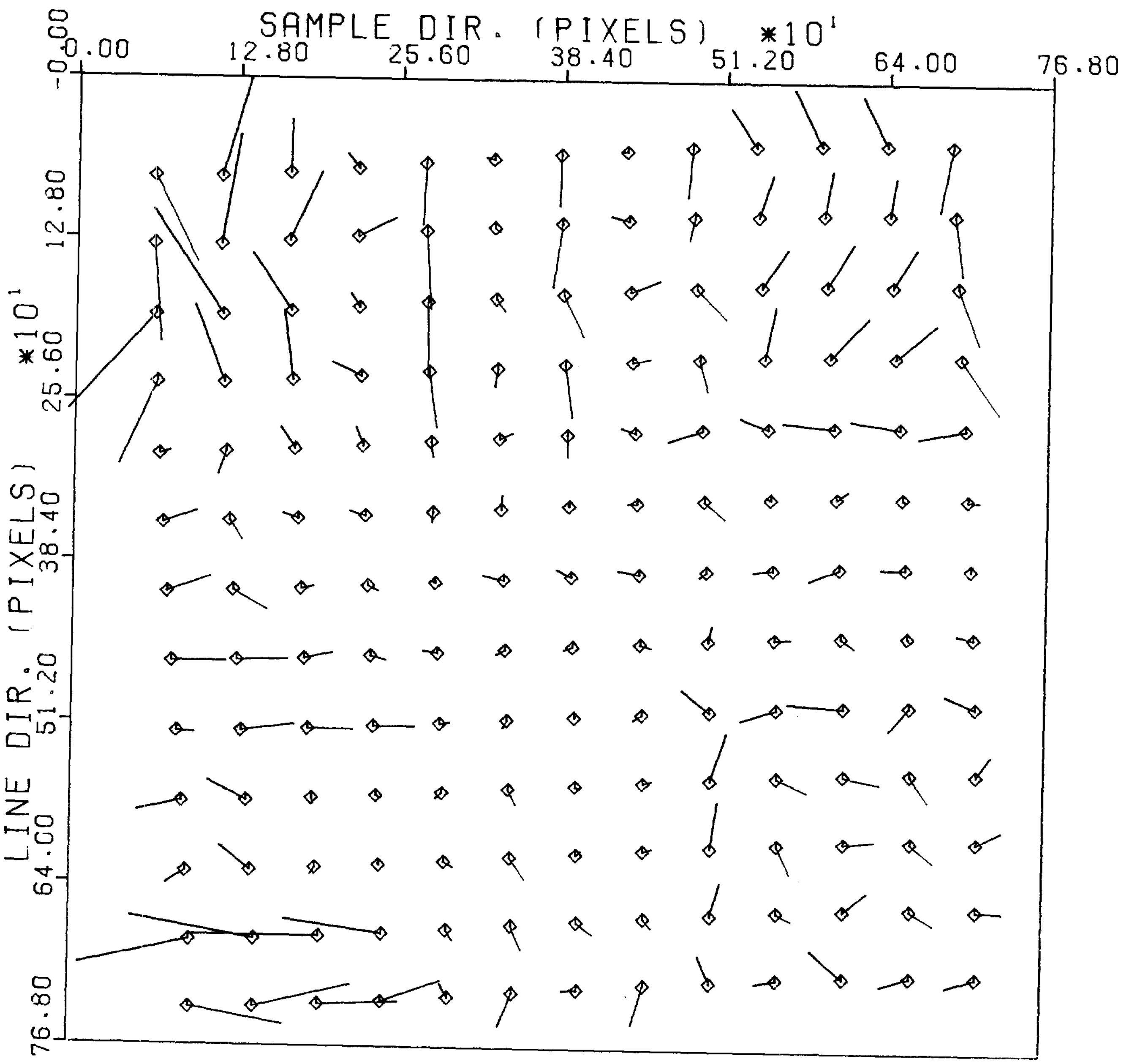


FIGURE 4 - Displacements of smoothed mean reseaux from mean reseaux, LWR
(Magnified by 80)

Note that for both cameras the effect of the smoothing is to generate correlated displacements along some of the rows and columns of the grid. Further checks of the mean reseau files against recently acquired individual images processed with and without smoothing indicate that the smoothing appears to impart a small-amplitude oscillation of neighboring reseau positions which is regarded as artificial.

A quantitative measure of the effects of reseau smoothing may be had by comparing the signal-to-noise ratios (SNR) for various areas in UVITF flat field exposures. SNR is determined by the program BOXSTAT2 which computes mean Flux Number (FN) values within 12-pixel-by-12-pixel boxes in the geometrically and photometrically corrected images as well as the standard deviations of the 144 FN values from the box mean, in each box. SNR in each box is thus the mean FN divided by the standard deviation. Because the quality of the photometric correction depends on the quality of the geometric correction, SNR measurements on flat-fields is one way to assess small variations in reseau locations. In Tables 3 and 4 we compare mean values of SNR measured on 60% UVITF flat fields for a number of areas within the tube face (the target ring is purposely excluded), for geometric corrections based on various sets of reseau positions. The region designated as "center" is the portion of the image starting at line 157, sample 157, and extending for 456 lines and 456 samples. Quadrants I-IV are the 4 quadrants of this center region, ordered such that quadrant I is at the upper right and quadrant numbers increase in counter-clockwise fashion. (See diagram below Tables 3 & 4).

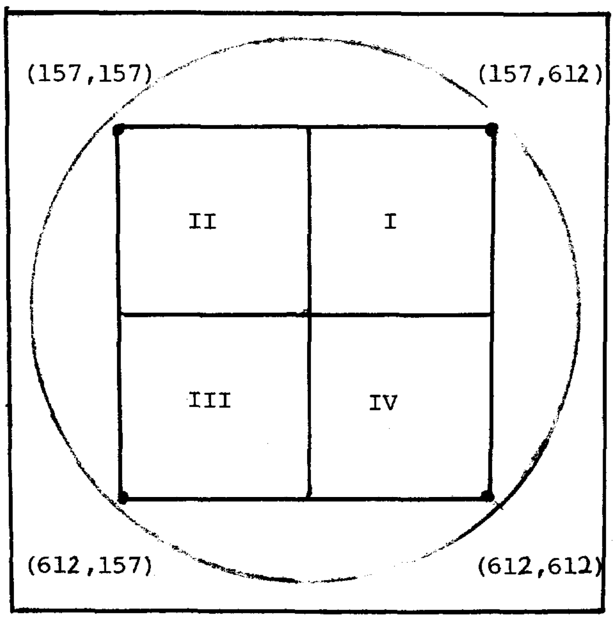
From Tables 3 and 4, several conclusions are drawn. First, the use of mean reseau positions does not significantly affect the photometric signal-to-noise characteristics for the two images tested, compared to the use of reseaux actually measured on the images themselves. This suggests that the use of mean reseau sets for production processing is a reasonable procedure. Second, whereas the reseau-smoothing algorithm yields very slightly but systematically improved mean SNR when applied to reseaux measured on a single image (first two rows of each table), there is on average no difference in the SNR of the central regions with and without smoothing of the <u>mean</u> reseaux (second two rows of each table). Because of this and the apparently artificial effects of smoothing cited earlier, the use of unsmoothed mean reseauxseems well justified. Third, there are in both cameras significant variations in SNR from quadrant to quadrant, independent of the exact set of reseaux used. The positional variation in SNR has long been known (e.g., reference 2) but perhaps not adequately stressed to Guest Observers.

Table 3 - Signal-to-Noise Ratios (SNR) of Portions of Geometrically and Photometrically Corrected Image, SWP 1244.

Reseaux \ Area	Center	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
Found	14.33	10.76	14.50	17.52	14.56
Found & Smoothed	14.80	10.86	15.19	18.17	14.97
Mean	13.90	10.27	13.63	17.21	14.50
Mean & Smoothed	13.89	10.11	13.74	16.92	14.79

Table 4 - Signal-to-Noise Ratios (SNR) of Portions of Geometrically and Photometrically Corrected Image, LWR 1150

Reseaux \ Area	Center	Quadrant I	Quadrant II	Quadrant III	Quadrant IV
Found	12.95	9.02	12.65	17.86	12.27
Found & Smoothed	13.23	9.23	12.99	18.13	12.56
Mean	12.97	9.10	12.71	17.72	12.37
Mean & Smoothed	12.96	9.12	12.60	17.46	12.65



Quadrants used in Table 3 are 4 statistics

In passing we note that the Intensity Transfer Functions (ITF) in current use were generated from images geometrically corrected using smoothed reseaux which were located without the FNDRES improvements mentioned earlier. The possible small effect this might have on the photometric accuracy of images geometrically corrected with the mean reseaux described here has not yet been investigated in detail.

MEAN DISPERSION CONSTANTS

The studies of the temporal and thermal variability of dispersion relations so far conducted (reference 1) have shown that with the longer baseline of data now available, there is evidence that dispersion relations obtained during the first year of IUE operation are not the most appropriate to use for current data. Details and discussions of these studies will be the subject of a future article in this series; however, on the strength of the findings, the mean dispersion relations calculated here have been derived only from images acquired since June 1979.

Low Dispersion

The dispersion relations determined from 24 SWP and 24 LWR standard TFLOOD + WAVECAL low dispersion images acquired between 1 June 1979 and 1 June 1980 were averaged together term by term to define mean dispersion constants for each camera. The individual dispersion relations used were those measured using the original technique of finding reseaux on a companion flat field image and smoothing those positions using RESOFIXL. The resulting mean dispersion constants are listed in Table 5 to 5 significant digits. Note that, contrary to the notation used in memorandum XI of this series which described the original mean low resolution dispersion relations, we denote the respective zero-point and scale terms as a_1, b_1 and a_2, b_2 instead of a_o, b_o, a_1, b_1. In so doing, we adopt a notation consistent with that used in the principal image processing documentation (reference 3) and in the IUE image header records themselves.

The new mean constants differ from the means reported in memorandum XI chiefly in the zero-point terms, where the largest difference is +0.86 pixels. The largest difference in the scale terms is .00002 pixels/Å.

High Dispersion

The dispersion relations determined from 24 SWP and 24 LWR standard TFLOOD + WAVECAL high dispersion images acquired between 1 June 1979 and 1 June 1980 were averaged together term by term to define the mean high resolution dispersion constants for each camera. As for low dispersion, the individual dispersion

Table 5 - Mean Dispersion Constants for Low Resolution, Adopted 18 July, 1980.

Camera	Aperture	a_1	a_2	b_1	b_2
SWP	Small	982.21	-.46657	-263.44	.37616
LWR	Small	-298.63	.30244	-265.80	.22579

Table 6 - Mean Dispersion Constants for High Resolution, Adopted 18 July 1980. (Small Aperture)

	SWP		LWR	
a_1	.787841752597664	D+3	-.512112131218370	D+4
a_2	-.174827009628957	D Ø	.149474938164753	D Ø
a_3	.128250164013606	D-5	-.557131203376991	D-6
a_4	Ø		.128677678460013	D-2
a_5	-.464346927595875	D Ø	.279988588392915	D Ø
a_6	Ø		Ø	
a_7	-.245917585466073	D-7	.964982411024015	D-7
b_1	-.624447811047980	D+4	.151718662770336	D+5
b_2	-.131942801615998	D Ø	-.275447072458253	D Ø
b_3	.127355792121042	D-5	.903443905778614	D-6
b_4	Ø		.661594536973941	D-1
b_5	.414873420270391	D Ø	.222497232868056	D Ø
b_6	.293871562110805	D-7	.225207671516958	D-7
b_7	-.286833642560946	D-6	.227041512913941	D-7

constants as originally measured on the WAVECAL images were used in calculating the means. Table 6 contains the values of the mean constants.

A SPECIFIC EXAMPLE

An example of the kind of improvements in data quality which can be realized through the use of mean reseaux and dispersion relations is illustrated by the tests conducted on the high dispersion image SWP 6602. Selected as an example of an image for which the original standard processing appeared to yield a poor background extraction (reference 4), SWP 6602 was reprocessed using the mean reseaux and dispersion constants. It was found that in certain orders the use of mean calibration files produced an improved (i.e., smoother and smaller valued) background compared to the original processing. In Figure 5 we illustrate the gross and background extractions for order 108 using both the original and the mean calibration files. Note how the artificial bumps in the original background extraction are diminished with the mean calibration files, whereas the gross extraction is little affected. Such improvement in the background spectrum leads to measurable changes in the net spectrum, as illustrated in Figure 6 for order 108, in which depressions due to background peaks were removed.

The image SWP 7020 was also reprocessed as a test of the mean calibration procedure. This image showed less dramatic improvement than SWP 6602; in no instance, however, did we find evidence indicating that using the mean calibration files adversely affected the spectral extraction.

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R. Bohlin GSFC
B. Turnrose CSC
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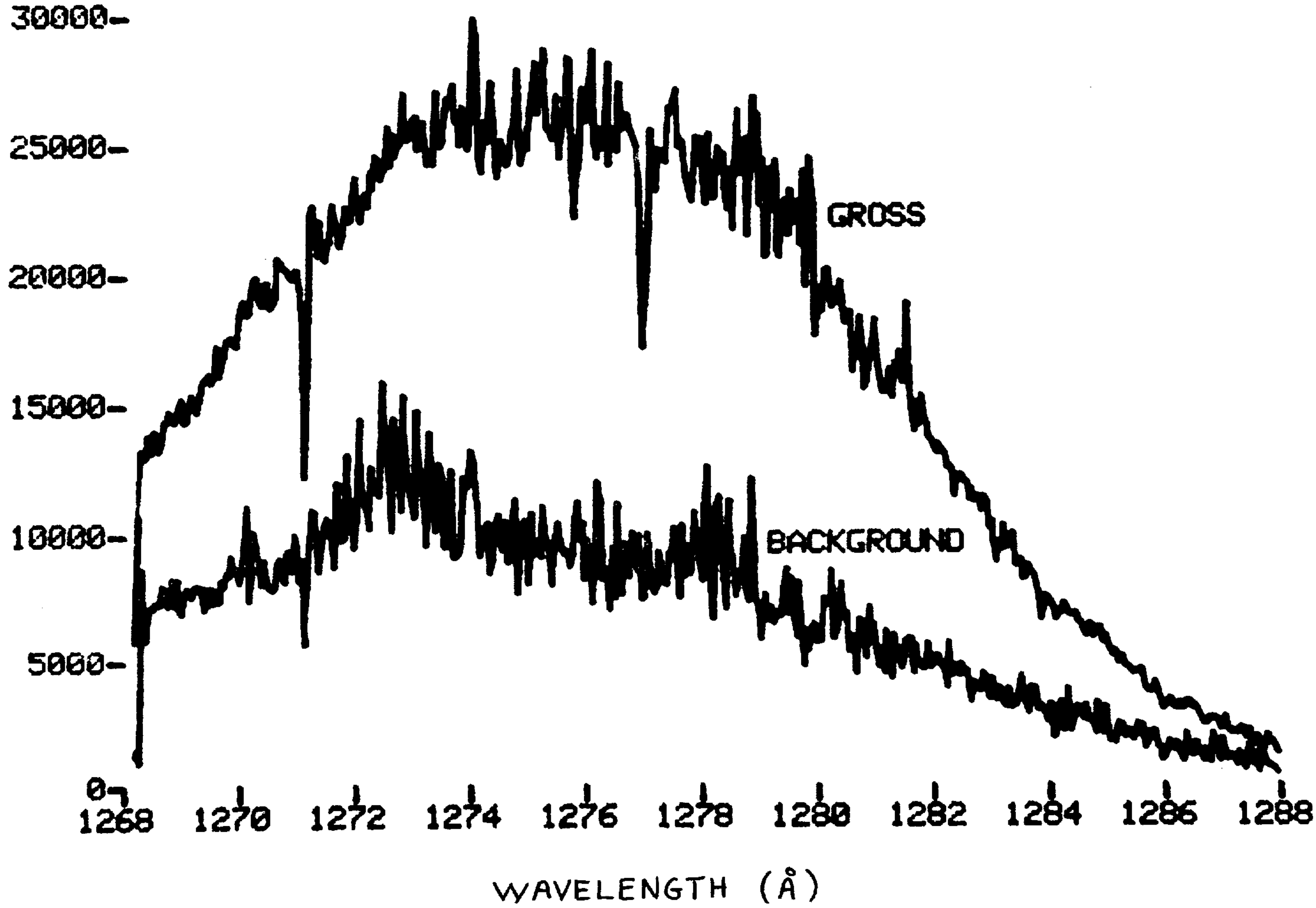

FIGURE 5a - Gross and background spectra, order 108, using original reseaux and dispersion constants (SWP 6602). Flux Scale is arbitrary.

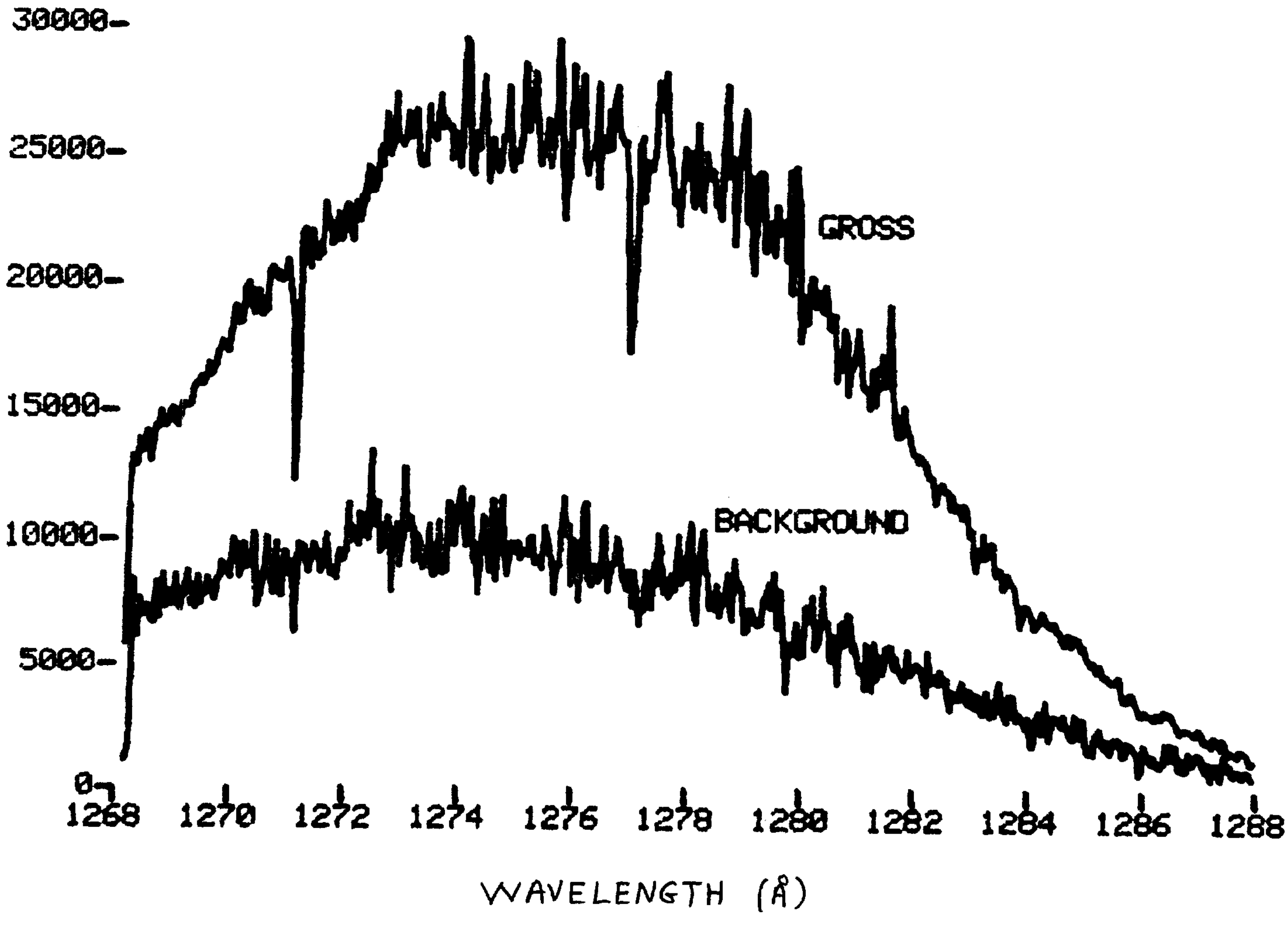

FIGURE 5b - Gross and background spectra, order 108, using mean reseaux and dispersion constants (SWP 6602). Flux Scale is arbitrary.

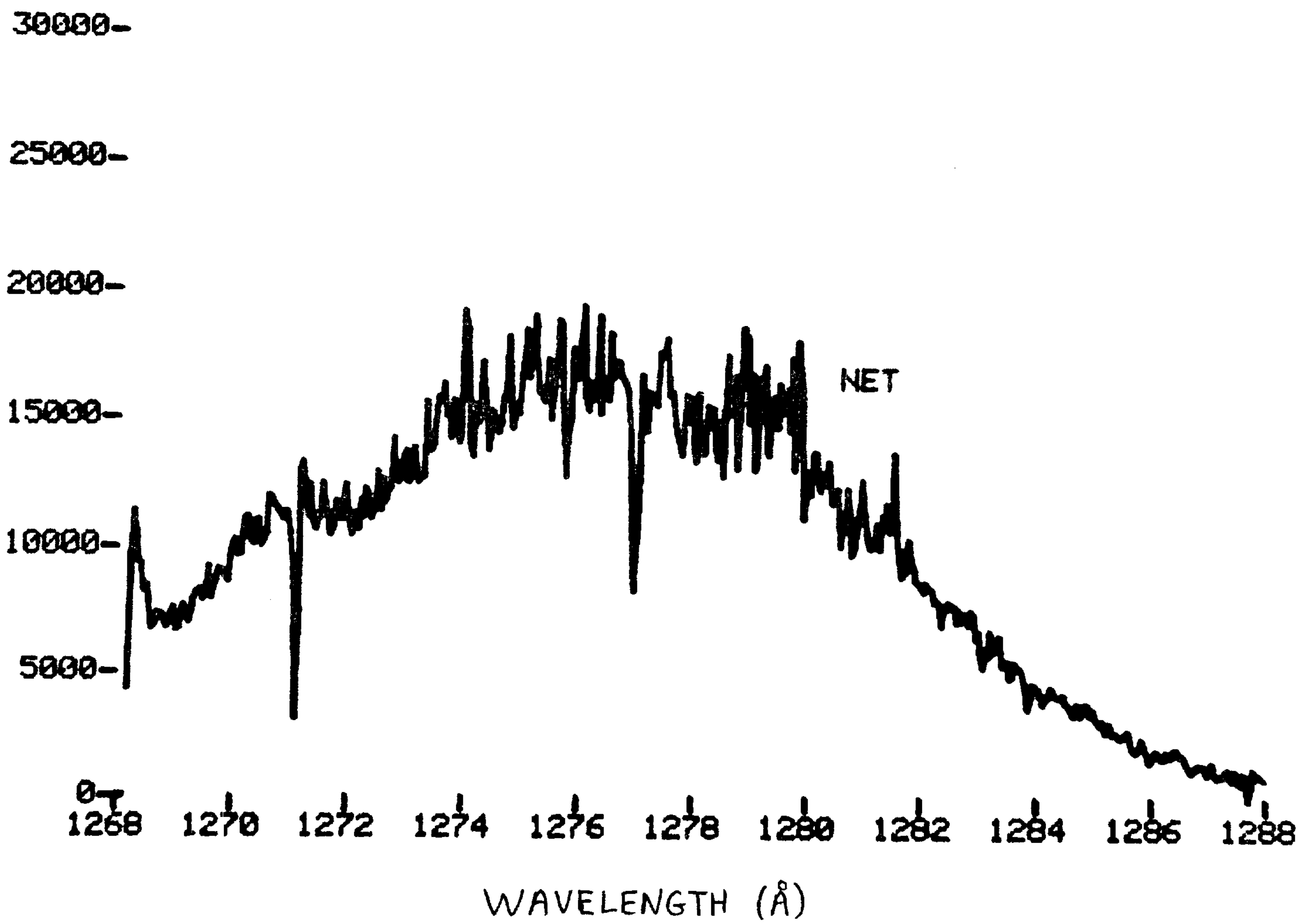

FIGURE 6a - Net spectrum, order 108, using original reseaux and dispersion constants (SWP 6602).
Flux scale is arbitrary.

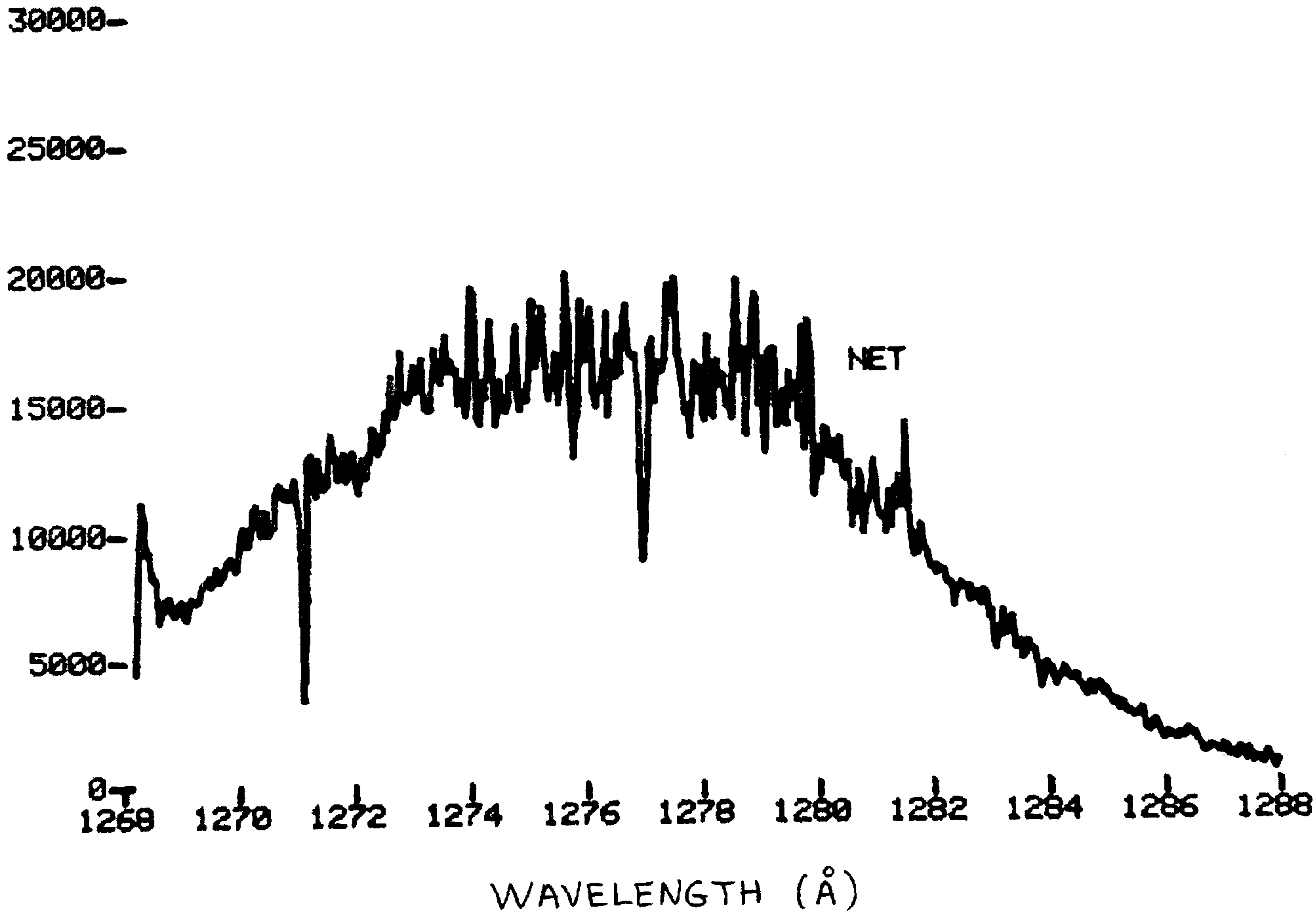

FIGURE 6b - Net spectrum, order 108, using mean reseaux and dispersion constants (SWP 6602). Flux scale is arbitrary.

1. Thompson, R.W., Turnrose, B.E., and Bohlin, R.C., "Effects of Temperature Fluctuations on IUE Data Quality," The Universe in Ultraviolet Wavelengths: The First Two Years of IUE. (IUE Symposium, GSFC, May 1980).

2. Lindler, D.J., and Bohlin, R.C., "Results of Basic Improvements to the Extraction of Spectra from IUE Images," ibid.

3. Turnrose, B.E., and Harvel, C.A., "International Ultraviolet Explorer Image Processing Information Manual, Version 1.0," CSC/TM-79/6301

4. Grady, C.A., "Problems and Programming for Analysis of IUE High Resolution Data for Variability," The Universe in Ultraviolet Wavelengths: The First Two Years of IUE. (IUE Symposium, GSFC, May 1980)