CSC/TM-79/6301

INTERNATIONAL ULTRAVIOLET EXPLORER IMAGE PROCESSING INFORMATION MANUAL
VERSION 1.0

Prepared for

GODDARD SPACE FLIGHT CENTER

By

COMPUTER SCIENCES CORPORATION

Under

Contract NAS 5-24350
Task Assignment 674

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January 23, 1980

TO: IUE Principal Investigators
FROM: B. Turnrose, C. Harvel IUEIPCC
SUBJECT: New User Documentation

Enclosed you will find one copy of CSC/TM-79/6301, "International Ultraviolet Explorer Image Processing Information Manual, Version 1.0". This document is a greatly expanded version of previous documentation on IUE image processing and as such replaces the old "International Ultraviolet Explorer Image Processing Information Packet." Version 1.0 of the current document describes IUESIPS as of 1 November 1979, but a brief chronology of changes to the system is included so that the document in fact may be used to define IUESIPS as it has existed since April 1978. Updates to version 1.0 will be issued as necessary in order to incorporate documentation of future modifications to the system.

Two significant changes to the processing system have been made since Version 1.0 went to press, and copies of two memos describing these changes are being included at this time so that you may file them with your copy of Version 1.0. These memos are IUE Data Reduction memos XII and XIII, "Absolute Calibration of Low Dispersion Spectra" and "Modification of Photometric Correction to Extrapolate the Intensity Transfer Function," respectively. These memos appear in NASA IUE Newsletter No.8 but are repeated here because of their significance; in general, the Newsletter will serve as the distribution medium for future notices of modifications.

IUE DATA REDUCTION

XII. Absolute Calibration of Low Dispersion Spectra

As of 9 January 1980 low dispersion net spectra are provided on the IUE Guest Observer magnetic tapes in both an instrumental and an absolutely-calibrated form. Prior to this time, the data contained in the area of the tape file designated as "absolutely calibrated" were an exact repeat of the instrumental intensities. The instrumental net intensities in flux numbers (FN) are given just as they have always been, and the absolutely-calibrated net intensities are calculated by multiplying the instrumental net intensities by the adopted inverse sensitivity function S_λ^{-1}. The functions S_λ^{-1} adopted herein for the LWR and SWP cameras are those presented by Bohlin and Snijders in IUE Newsletter 2 (Photometric Calibration of the IUE - Memo VI Joint US/UK/ESA Calibration for Low Dispersion Large Aperture, 18 September 1978) and in Bohlin, et al. 1980, Astron. & Astrophys. (in press), with the three following modifications:

1) The Bohlin-Snijders function for LWR has been modified slightly at 1900 Å and 1850 Å. See Bohlin, Holm, & Snijders, 1979, IUE Newsletter 8, Photometric Calibration of the IUE-Memo VII.

2) The modified Bohlin-Snijders functions have been interpolated using a 3-point parabolic fit to the logarithm to yield values every 10 Å in LWR and every 5 Å in SWP.

3) These interpolated functions have been truncated (i.e., set to zero) outside of rather conservative wavelength limits in order to suppress the correction of noisy flux points at the extreme wavelengths where the spectral response is low.

The adopted S_λ^{-1} functions are listed in Tables 1 and 2 as functions of the wavelength in angstroms; the units of S_λ^{-1} are erg cm^{-2} $Å^{-1}$ FN^{-1} where FN is the extracted IUE response.

Several points must be made in regard to the "absolutely-calibrated spectra," and the S_λ^{-1} functions used to obtain them.

1) All intensities are time-integrated, it being currently impossible to divide out by the actual exposure time in seconds in an automatic way because the actual exposure times are not suitably stored in the image header records. The values presented are FNxS_λ^{-1} (erg $cm^{-2}Å^{-1}$), and can be converted to absolute flux by dividing by the actual exposure time in seconds.

2) The adopted S_λ^{-1} functions are those pertinent to the intensity transfer functions (ITF) in use since 22 May 1978 and to the EXTLOW extraction program also in use since 22 May 1978. The correction of the SWP ITF error on 7 July 1979

Table 1

SWP Low Resolution Interpolated Inverse Sensitivity Function (Erg $cm^{-2}Å^{-1}FN^{-1}$)

λ (Å)	S_λ^{-1}	λ (Å)	S_λ^{-1}	λ (Å)	S_λ^{-1}
900.00,	0.00	1450.00,	2.750-14	1720.00,	2.421-14
1189.80,	0.00	1455.00,	2.794-14	1725.00,	2.390-14
1190.00,	4.481-14	1460.00,	2.838-14	1730.00,	2.356-14
1195.00,	4.021-14	1465.00,	2.882-14	1735.00,	2.322-14
1200.00,	3.650-14	1470.00,	2.926-14	1740.00,	2.288-14
1205.00,	3.397-14	1475.00,	2.970-14	1745.00,	2.254-14
1210.00,	3.178-14	1480.00,	3.020-14	1750.00,	2.220-14
1215.00,	2.987-14	1485.00,	3.067-14	1755.00,	2.178-14
1220.00,	2.822-14	1490.00,	3.111-14	1760.00,	2.140-14
1225.00,	2.680-14	1495.00,	3.152-14	1765.00,	2.106-14
1230.00,	2.562-14	1500.00,	3.190-14	1770.00,	2.076-14
1235.00,	2.459-14	1505.00,	3.221-14	1775.00,	2.050-14
1240.00,	2.370-14	1510.00,	3.250-14	1780.00,	2.032-14
1245.00,	2.294-14	1515.00,	3.279-14	1785.00,	2.015-14
1250.00,	2.230-14	1520.00,	3.305-14	1790.00,	1.999-14
1255.00,	2.184-14	1525.00,	3.330-14	1795.00,	1.984-14
1260.00,	2.145-14	1530.00,	3.367-14	1800.00,	1.970-14
1265.00,	2.111-14	1535.00,	3.396-14	1805.00,	1.956-14
1270.00,	2.083-14	1540.00,	3.416-14	1810.00,	1.943-14
1275.00,	2.060-14	1545.00,	3.428-14	1815.00,	1.932-14
1280.00,	2.048-14	1550.00,	3.430-14	1820.00,	1.920-14
1285.00,	2.038-14	1555.00,	3.409-14	1825.00,	1.910-14
1290.00,	2.030-14	1560.00,	3.386-14	1830.00,	1.900-14
1295.00,	2.024-14	1565.00,	3.362-14	1835.00,	1.892-14
1300.00,	2.020-14	1570.00,	3.337-14	1840.00,	1.884-14
1305.00,	2.020-14	1575.00,	3.310-14	1845.00,	1.876-14
1310.00,	2.020-14	1580.00,	3.281-14	1850.00,	1.870-14
1315.00,	2.022-14	1585.00,	3.251-14	1855.00,	1.865-14
1320.00,	2.026-14	1590.00,	3.221-14	1860.00,	1.861-14
1325.00,	2.030-14	1595.00,	3.191-14	1865.00,	1.857-14
1330.00,	2.032-14	1600.00,	3.160-14	1870.00,	1.853-14
1335.00,	2.037-14	1605.00,	3.126-14	1875.00,	1.850-14
1340.00,	2.045-14	1610.00,	3.093-14	1880.00,	1.847-14
1345.00,	2.056-14	1615.00,	3.061-14	1885.00,	1.845-14
1350.00,	2.070-14	1620.00,	3.030-14	1890.00,	1.843-14
1355.00,	2.090-14	1625.00,	3.000-14	1895.00,	1.841-14
1360.00,	2.113-14	1630.00,	2.974-14	1900.00,	1.840-14
1365.00,	2.136-14	1635.00,	2.947-14	1905.00,	1.840-14
1370.00,	2.162-14	1640.00,	2.919-14	1910.00,	1.840-14
1375.00,	2.190-14	1645.00,	2.890-14	1915.00,	1.840-14
1380.00,	2.222-14	1650.00,	2.860-14	1920.00,	1.840-14
1385.00,	2.255-14	1655.00,	2.829-14	1925.00,	1.840-14
1390.00,	2.289-14	1660.00,	2.797-14	1930.00,	1.840-14
1395.00,	2.324-14	1665.00,	2.765-14	1935.00,	1.840-14
1400.00,	2.360-14	1670.00,	2.733-14	1940.00,	1.840-14
1405.00,	2.401-14	1675.00,	2.700-14	1945.00,	1.840-14
1410.00,	2.441-14	1680.00,	2.663-14	1950.00,	1.840-14
1415.00,	2.481-14	1685.00,	2.628-14	1950.20,	0.00
1420.00,	2.521-14	1690.00,	2.594-14	2400.00,	0.00
1425.00,	2.560-14	1695.00,	2.561-14		
1430.00,	2.596-14	1700.00,	2.530-14		
1435.00,	2.633-14	1705.00,	2.505-14		
1440.00,	2.671-14	1710.00,	2.478-14		
1445.00,	2.710-14	1715.00,	2.450-14		

LWR Low Resolution Interpolated Inverse Sensitivity Function (Erg cm^{-2}Å^{-1}FN^{-1})

λ(Å)	S_λ^{-1}	λ(Å)	S_λ^{-1}	λ(Å)	S_λ^{-1}
1500.00,	0.00	2400.00,	0.760-14	2920.00,	0.397-14
1899.80,	0.00	2410.00,	0.730-14	2930.00,	0.407-14
1900.00,	5.200-14	2420.00,	0.702-14	2940.00,	0.418-14
1910.00,	4.597-14	2430.00,	0.676-14	2950.00,	0.430-14
1920.00,	4.092-14	2440.00,	0.652-14	2960.00,	0.443-14
1930.00,	3.665-14	2450.00,	0.630-14	2970.00,	0.457-14
1940.00,	3.305-14	2460.00,	0.610-14	2980.00,	0.473-14
1950.00,	3.000-14	2470.00,	0.591-14	2990.00,	0.491-14
1960.00,	2.724-14	2480.00,	0.573-14	3000.00,	0.510-14
1970.00,	2.497-14	2490.00,	0.556-14	3010.00,	0.528-14
1980.00,	2.312-14	2500.00,	0.540-14	3020.00,	0.550-14
1990.00,	2.161-14	2510.00,	0.524-14	3030.00,	0.576-14
2000.00,	2.040-14	2520.00,	0.509-14	3040.00,	0.606-14
2010.00,	1.972-14	2530.00,	0.495-14	3050.00,	0.640-14
2020.00,	1.911-14	2540.00,	0.482-14	3060.00,	0.682-14
2030.00,	1.857-14	2550.00,	0.470-14	3070.00,	0.730-14
2040.00,	1.811-14	2560.00,	0.459-14	3080.00,	0.783-14
2050.00,	1.770-14	2570.00,	0.449-14	3090.00,	0.843-14
2060.00,	1.739-14	2580.00,	0.439-14	3100.00,	0.910-14
2070.00,	1.712-14	2590.00,	0.429-14	3110.00,	0.987-14
2080.00,	1.688-14	2600.00,	0.420-14	3120.00,	1.073-14
2090.00,	1.667-14	2610.00,	0.411-14	3130.00,	1.169-14
2100.00,	1.650-14	2620.00,	0.403-14	3140.00,	1.278-14
2110.00,	1.645-14	2630.00,	0.395-14	3150.00,	1.400-14
2120.00,	1.638-14	2640.00,	0.387-14	3160.00,	1.533-14
2130.00,	1.630-14	2650.00,	0.380-14	3170.00,	1.686-14
2140.00,	1.620-14	2660.00,	0.372-14	3180.00,	1.862-14
2150.00,	1.610-14	2670.00,	0.365-14	3190.00,	2.065-14
2160.00,	1.610-14	2680.00,	0.359-14	3200.00,	2.300-14
2170.00,	1.603-14	2690.00,	0.354-14	3200.20,	0.00
2180.00,	1.588-14	2700.00,	0.350-14	3600.00,	0.00
2190.00,	1.567-14	2710.00,	0.347-14		
2200.00,	1.540-14	2720.00,	0.345-14		
2210.00,	1.497-14	2730.00,	0.343-14		
2220.00,	1.453-14	2740.00,	0.341-14		
2230.00,	1.409-14	2750.00,	0.340-14		
2240.00,	1.364-14	2760.00,	0.339-14		
2250.00,	1.320-14	2770.00,	0.339-14		
2260.00,	1.275-14	2780.00,	0.339-14		
2270.00,	1.230-14	2790.00,	0.339-14		
2280.00,	1.186-14	2800.00,	0.340-14		
2290.00,	1.143-14	2810.00,	0.341-14		
2300.00,	1.100-14	2820.00,	0.342-14		
2310.00,	1.054-14	2830.00,	0.344-14		
2320.00,	1.011-14	2840.00,	0.346-14		
2330.00,	0.972-14	2850.00,	0.350-14		
2340.00,	0.934-14	2860.00,	0.355-14		
2350.00,	0.900-14	2870.00,	0.360-14		
2360.00,	0.871-14	2880.00,	0.366-14		
2370.00,	0.843-14	2890.00,	0.373-14		
2380.00,	0.815-14	2900.00,	0.380-14		
2390.00,	0.787-14	2910.00,	0.388-14		

did not change the SWP S_λ^{-1} by more than 5 percent, and so the Bohlin-Snijders-function is still appropriate for the new ITF. See the Memo VII referred to above and included in this Newsletter 8.

3) The adopted S_λ^{-1} functions were derived from large-aperture exposures so that only relative fluxes are provided for small-aperture exposures (which do not contain the total flux from point sources).

4) Even though the adopted S_λ^{-1} functions are conservatively truncated, the instrumental net intensities are still written to tape over the full wavelength range of the original extraction. The S_λ^{-1} values given by Bohlin and Snijders beyond the range of calibration adopted here may thus be applied to the instrumental net intensities by the Guest Observer, should he or she so desire.

5) Only the net intensities appearing in the "merged spectrum", or "eslo" tape file (i.e., the slit-integrated signal) are absolutely calibrated. The 55 pseudo orders comprising the gross spatially-resolved data set ("essr") are <u>not</u> absolutely calibrated; they remain instrumental <u>gross</u> intensities as before.

<u>CalComp Plots</u>

As of the effective date of this memo, the CalComp plots of the net and log of net spectra are given in absolutely-calibrated form. The plots of the gross and background spectra remain in instrumental (FN) units.

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C. Harvel

IUE DATA REDUCTION

XIII. Modification of Photometric Correction to Extrapolate the Intensity Transfer Function

1. Introduction

A memorandum distributed to Guest Observers by A. V. Holm and recently reprinted in NASA IUE Newsletter 7 called attention to the errors in photometry which can arise because of the way in which the IUESIPS photometric correction program FICOR5 truncates the output flux number (FN) values for pixels with input DN values which exceed the corresponding maximum DN values in the intensity transfer function (ITF). The purpose of the present memo is to announce and describe a recently-implemented software modification (program FICOR6) which reduces these and other photometric errors by an extrapolation of the ITF.

2. Properties of the Upper ITF Levels

The ITF for each camera is comprised of a concatenation of averaged, geometrically corrected flat field exposures. The memo by Holm presented approximate DN values of the highest exposures in the ITF, in tabular form as a function of wavelength, in the vicinity of the low dispersion orders for each camera. These values were measured on printouts of 12 X 12 pixel averages of the DN values in the highest level for each ITF. Holm's measurements demonstrated that truncation error was potentially greatest for $\lambda \lesssim$ 1350 Å in SWP low dispersion and for $\lambda \gtrsim$ 2900 Å in LWR low dispersion, since for these wavelength regions the maximum DN levels in the ITF's were less than 220 DN. More precise measurements, obtained with computer extraction techniques much like those used to extract ordinary IUE spectra, have recently been made and will be presented in the next NASA IUE Newsletter.

3. Previous Photometric Correction Method: FICOR5

The photometric correction program FICOR5 in use until 10 January 1980 performed a simple linear interpolation for DN within the ITF tables to assign the corresponding FN value for each pixel. Pixels which are below-range (DN < lowest level of ITF) were assigned negative FN values by linear extrapolation back from the first two points of the ITF, but pixels which are above-range (DN > highest level of ITF $\equiv DN_{max}$) were truncated to FN_{max}, the FN value of the highest level. See Figure 1. Although this truncation is described in previous documentation (CSC TM-77/6250 "IUE Image Processing Overview and Mathematical Description"), the magnitude of the potential truncation errors at certain wavelengths has only been recently appreciated (Holm memo). Plans are underway to increase DN_{max} in the areas of both camera tubes where it is currently least by adding higher exposure levels to the ITF's for SWP and LWR.

For SWP, FN_{max} (as defined in Figure 1) is 17632; for LWR, FN_{max} is 25220. Saturated pixels (DN=255) are assigned FN values of 32767.

An additional problem with the simple point-to-point linear interpolation done by FICOR5 occurred when the DN values in the ITF reach the saturation value (DN=255). When this occurs, DN within the range just below saturation were in most instances improperly transformed to FN since the DN in the ITF have been artificially limited to 255. Refer to Figure 2.

4. New Photometric Correction Method: FICOR6

Since 5:00 GMT on 10 January 1980 the program FICOR6 has been used to perform the photometric correction of all IUE images. FICOR6 changes the way FN values are assigned in the two special cases where FICOR5 was in error, through linear extrapolation of the ITF. In all other cases, including "below range" pixels, FICOR6 operates identically to FICOR5. Improvement in photometric accuracy results from the use of FICOR6; further improvement will be realized when higher ITF levels are added.

Case A - Extrapolation Beyond End of Unsaturated ITF

If $DN > DN_{max}$, an improved FN value is returned in FICOR6 by extrapolating past the end of the ITF; see Figure 1.

The extrapolation is linear, with a slope defined by the last two points in the ITF. The extrapolated FN value, FN_{extrap}, is greater than the FN_{max} value used in FICOR5 but is limited to a maximum value of 32767 (maximum halfword integer value), which is also the FN value assigned to saturated pixels (DN=255). In the future reduction era planned to begin in several months' time (see IUE Data Reduction memo VI in NASA IUE Newsletter 6), even saturated pixels will be allowed to assume extrapolated FN values up to some maximum value, but under the present reduction system they are still set to 32767 in order to allow flagging. Hence, an FN value of 32767 can result from either a saturated input or an unsaturated extrapolation limited by the halfword integer format; both are flagged in the same way by the ϵ field, and both appear with the "+" symbol on CalComp plots. The keys on the plots have been modified to identify the "+" symbol as either "saturated, or limited extrapolation".

Case B - Extrapolation Within a Saturated ITF

The new program FICOR6 improves the photometry in cases when the ITF is saturated by assigning FN values by linear extrapolation from the two highest unsaturated points in the ITF; see Figure 2. This method calculates a better slope for the ITF in the affected region and returns FN values which are normally less than the corresponding FN values returned by FICOR5.

The detailed ITF measurements which will be presented in next NASA IUE Newsletter document those regions of the SWP and LWR low dispersion spectra subject to the inaccurate intensity transformation of this type previously made by FICOR5. These regions, where $DN_{max}=255$ in the ITF, are the long wavelengths of SWP and the short wavelengths of LWR (low dispersion in each case).

5. A Sample Comparison of the Old and New Methods

In Figure 3 a comparison is made of spectra reduced using FICOR5 and FICOR6. The spectra shown are extracted from LWR 1349, an 8 second exposure of θ^1 C Ori, which was selected because it exceeded the LWR ITF exposures at some wavelengths. Note that in the region of heaviest exposure the FN returned by FICOR6 are greater than the FN returned by FICOR5: at these wavelengths, extrapolation beyond the end of the unsaturated LWR ITF is performed. For this particular exposure, the FICOR6 FN values which have been extrapolated are up to ~ 15 percent larger than the truncated FICOR5 FN values. Note that at lower exposure levels, FICOR5 and FICOR6 give identifical results.

6. Identification of Old and New Methods

Apart from using the effective date of 10 January 1980 to identify use of the new program FICOR6, Guest Observers may verify which photometric correction version was used to reduce any given spectrum by means of the image processing history portion of the image label. Spectra reduced with FICOR5 bear that inscription, whereas spectra reduced using FICOR6 are so marked.

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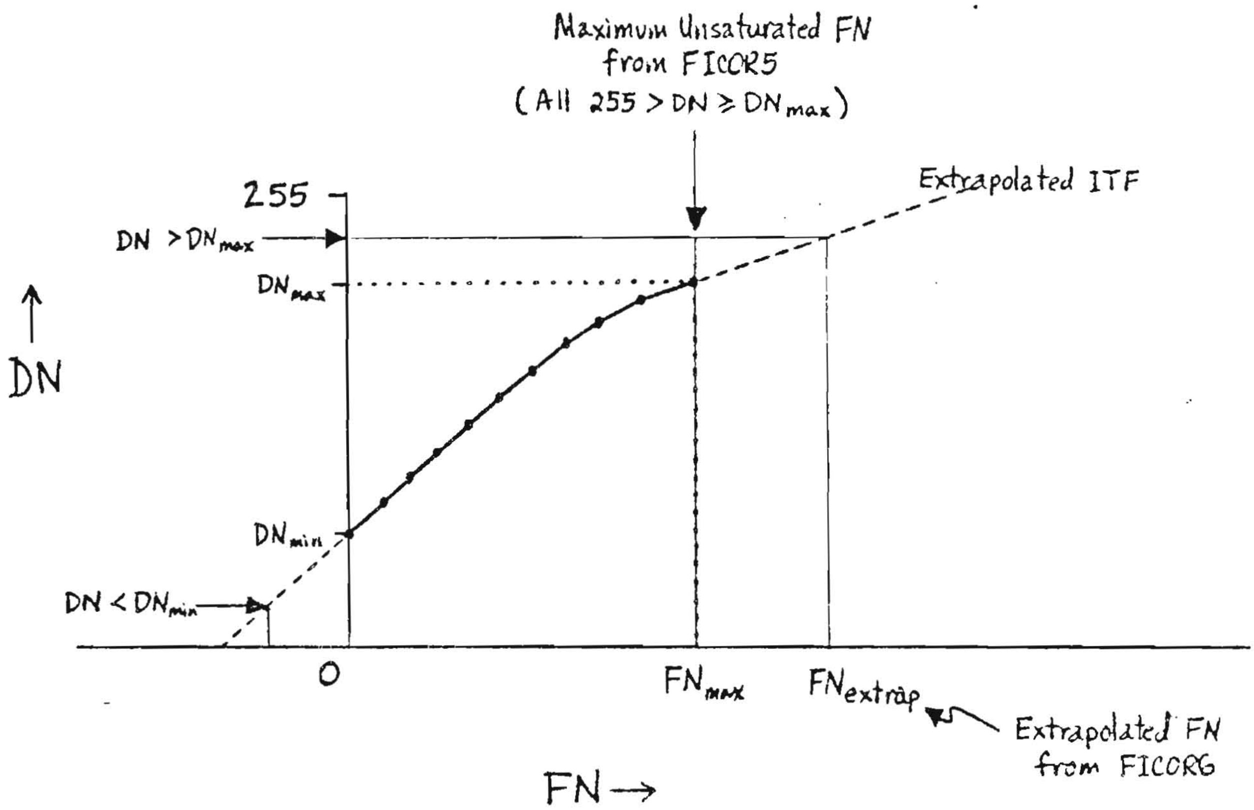

Figure 1. Difference in calculation of FN for 255>DN ≥ DNmax in FICOR5 and FICOR6.

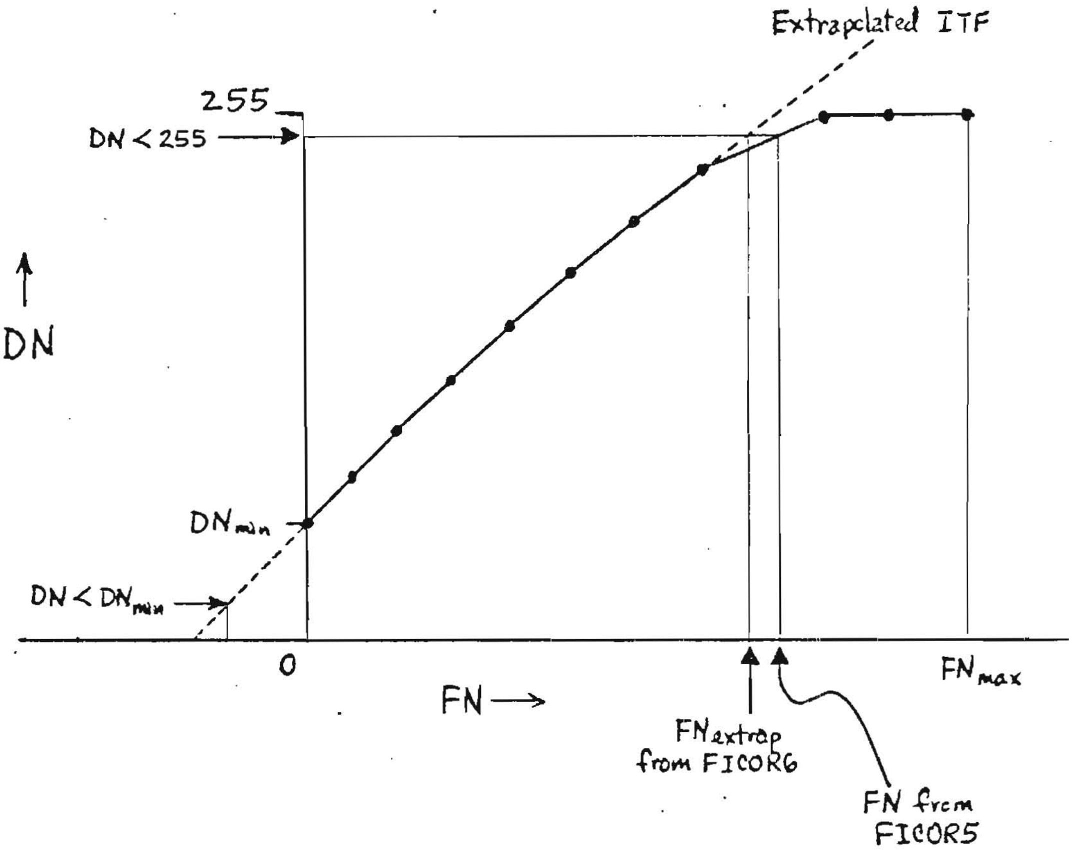

Figure 2. Difference in FICOR5 & FICOR6 calculation of FN for large DN when ITF is saturated.

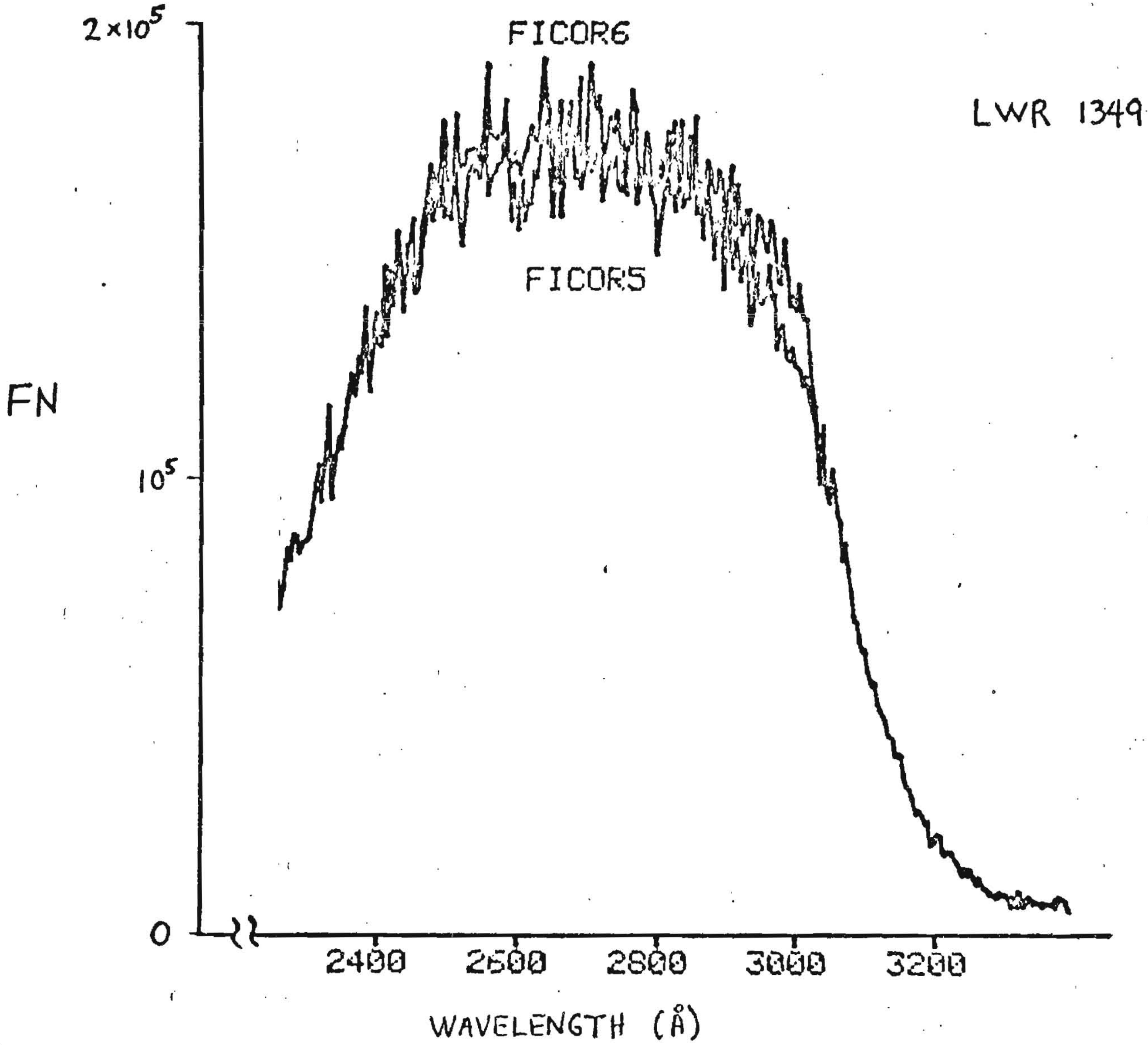

Figure 3. Portions of extracted gross spectra of LWR 1349, comparing effects of FICOR5 vs. FICOR6.

ABSTRACT

Information needed by International Ultraviolet Explorer (IUE) Guest Observers to understand the IUE Spectral Image Processing System (IUESIPS) and its products is presented within this document. The document is intended to be a working manual which will be periodically updated to reflect significant changes in the IUE image processing system as it is used at the IUE Observatory at the Goddard Space Flight Center (GSFC). The information contained within this version 1.0 reflects the state of IUESIPS as of November 1979.

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SECTION 1 - INTRODUCTION

This document is intended to provide the International Ultraviolet Explorer (IUE) Guest Observers with the information necessary to understand the image processing operations which are performed on IUE data and to interpret properly the various output products resulting from these reduction procedures. Its scope includes descriptions both of the significant steps in the overall reduction procedure and of the detailed nature of the end products (e.g., magnetic tape file formats, etc.). As such, it is complementary to the document IUE Image Processing Overview and Mathematical Description (CSC/TM-77/6250) which stresses the mathematical details of individual IUE image processing programs.

The information contained within this document has been gathered from the experience of the first year and one-half of operation of IUE and includes data frequently requested by Guest Observers. It is expected that the contents will be updated periodically to reflect modifications in the image processing software and/or output products. It is therefore advisable that the Guest Observer receive the current version of this document upon each visit to the IUE Observatory; prior editions may be obsolete.

SECTION 2 - IMAGE PROCESSING OVERVIEW

2.1 PHILOSOPHY AND SCOPE OF IUE IMAGE PROCESSING

The primary scientific goal of the IUE Spectral Image Processing System (IUESIPS) is to provide the IUE Guest Observer (GO) with data reduced from his observations in a standard manner so as to be as free of instrumental effects as possible. Toward this end, image processing operations requiring either detailed knowledge of the performance of the IUE scientific instrument or large-scale computing facilities are performed by the resident image processing staff. These processing operations include the correction of all images for the geometric distortion of the camera system by means of fiducial reseau marks which are superimposed on the images; the photometric calibration of geometrically-corrected images by means of pixel-by-pixel intensity transfer functions which correct for the vidicon shading and non-linear response; the wavelength calibration of geometrically-corrected images by means of analytical dispersion relations determined by platinum-lamp comparison-line spectral images; the extraction of spectral intensity as a function of wavelength from the geometrically and photometrically corrected target images; and, finally, the reduction of the spectral intensity to an absolute flux system by means of observations of photometric standard stars (low dispersion). Figure 2-1 summarizes these image processing functions performed on IUE images. A general description of the procedures used for each of these operations is given in Sections 3 through 7 below; a detailed explanation of the processing algorithms is given in the document IUE Image Processing Overview and Mathematical Description, CSC/TM-77/6250.

2.2 DATA PRODUCTS SUMMARY

The various end products of the image processing operations performed on each image are assembled into a Guest Observer Data Package which is delivered to the appropriate GO. This Data Package is designed to be amenable

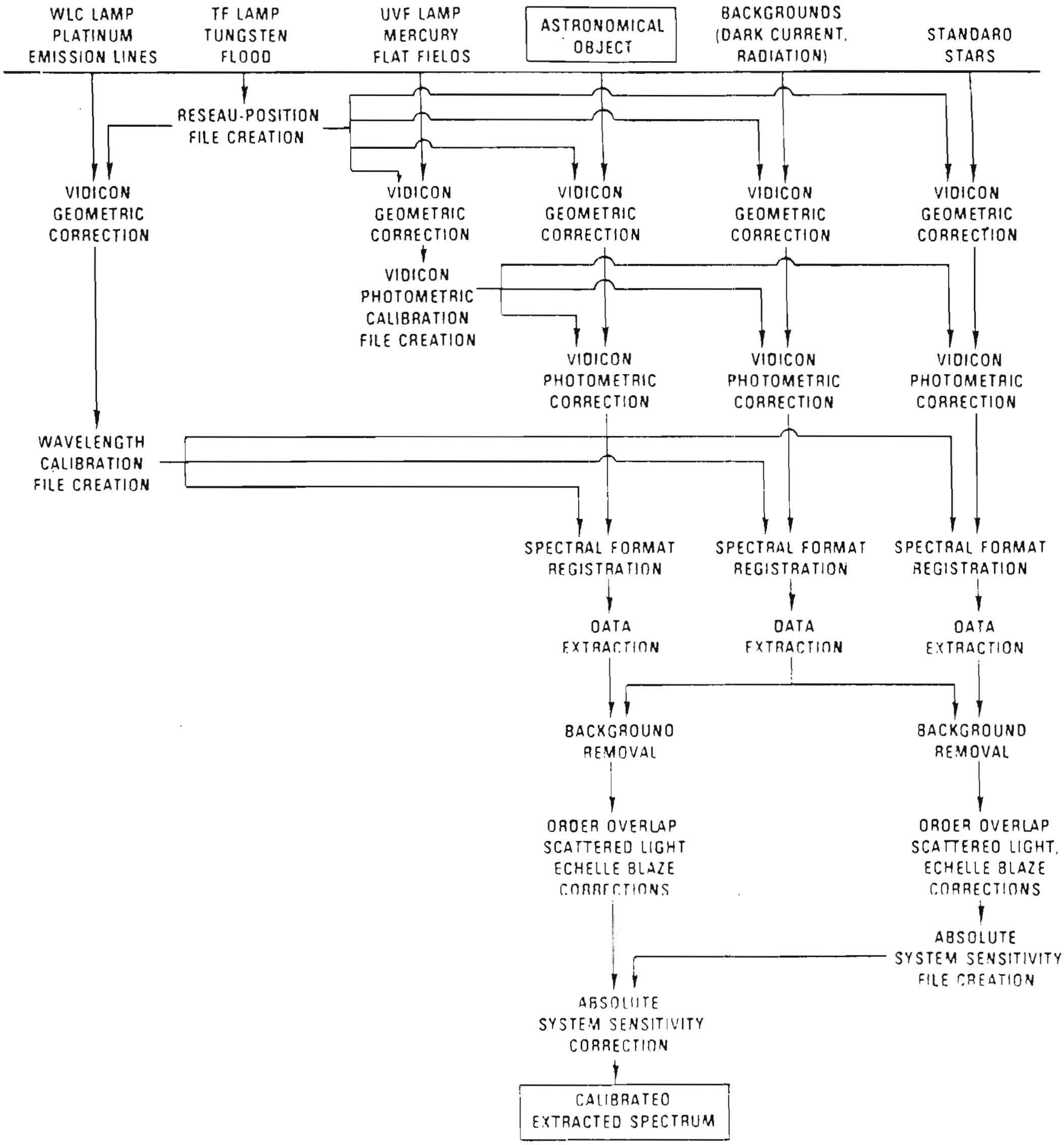


Figure 2-1. IUESIPS Functional Overview

to immediate astronomical analysis and includes photographic hardcopy images (Photowrite images), CalComp plots of extracted spectra, magnetic tape files containing both raw and processed data and computer listings. Each of these items is discussed in detail in Section 8.

2.3 GUEST OBSERVER'S IMAGE PROCESSING SPECIFICATIONS

In order to satisfy the needs of the basic IUE data reduction operation, viz., provide a homogeneous Data Package for all images in a timely fashion, the range of image processing functions which are performed on IUE data is purposefully limited and standardized. Within this framework, several basic processing options are available to the GO. For this reason, it is imperative that the section on each Observatory Record Sheet labeled "PROCESSING SPECIFICATIONS" be filled out by the GO. These specifications are the means by which the basic processing options are selected, and no defaults are permitted. Images for which specifications are lacking will not be processed. An example of the PROCESSING SPECIFICATIONS box is provided in Figure 2-2. The various choices which are listed are explained in the relevant sections of this document (see Table of Contents); the "manual shift" line refers to the image registration procedures described in Section 5.2.

PROCESSING SPECIFICATIONS

*** NO DEFAULTS ***
DO NOT PROCESS ______
EXTENDED SOURCE REDUCTION ____
POINT SOURCE REDUCTION ________
PROCESS BOTH APERTURES ________
MANUAL SHIFT ________
USE SPECIAL CALIBRATION ________
(IMAGE NO. ___________________)

Figure 2-2. Processing Specifications Section of IUE Observatory Record Sheet

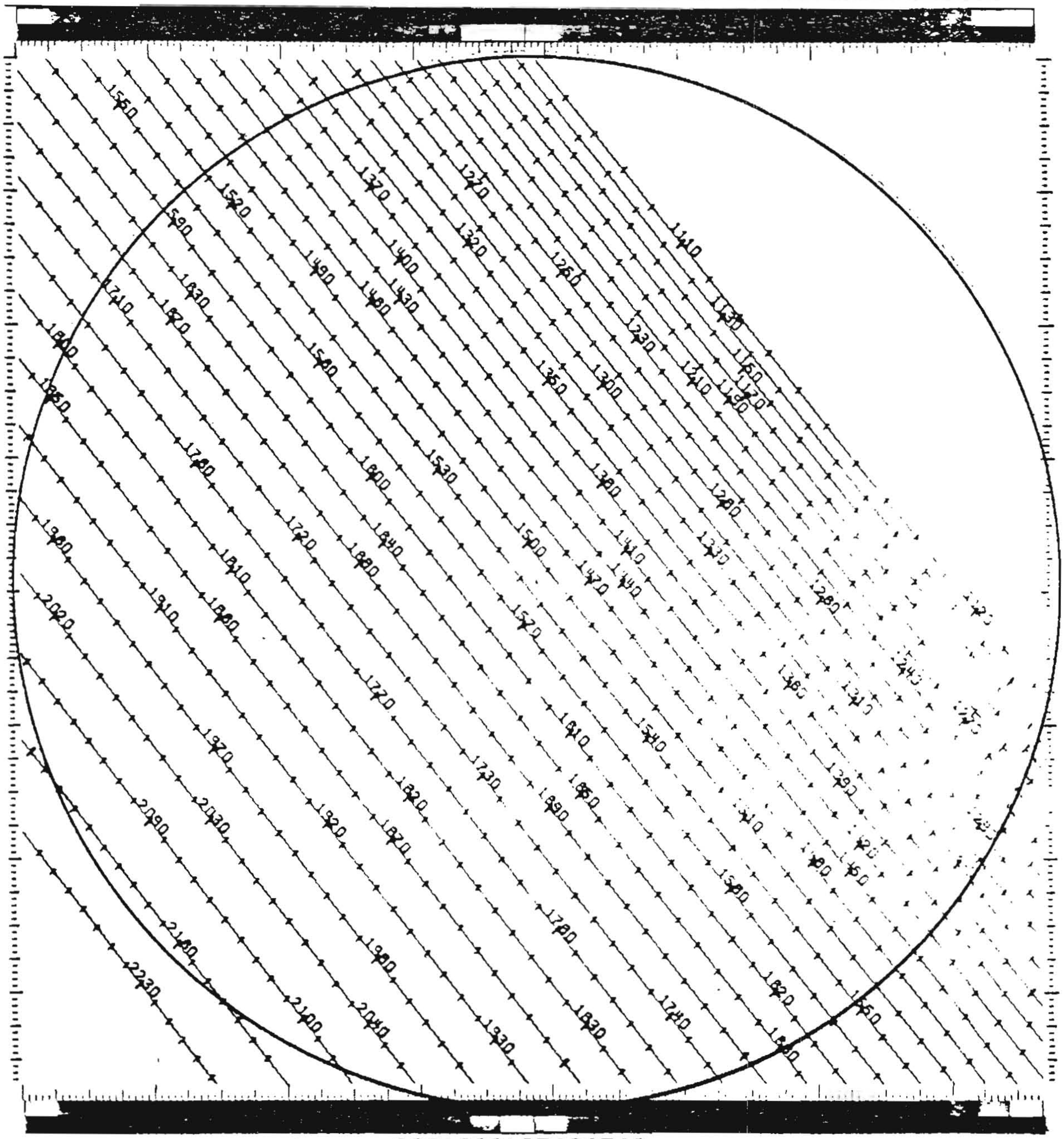
SECTION 3 - NATURE OF IUE DATA

3.1 IMAGE AND LABEL PARAMETERS

Each raw IUE image consists of a 768 by 768 array of 8-bit picture elements or "pixels". Each vidicon scan line consists of 768 pixels or "samples"; 768 such scan lines comprise the entire image. Line 1, sample 1 is at the upper left corner of the image; line 768, sample 768 is at the lower right corner of the image. Each raw pixel value lies in the range 0 to 255 (integers only). The units of raw pixel values are DN (or data numbers), which are proportional to the integrated charge read out from the SEC vidicon target in the camera scanning process.

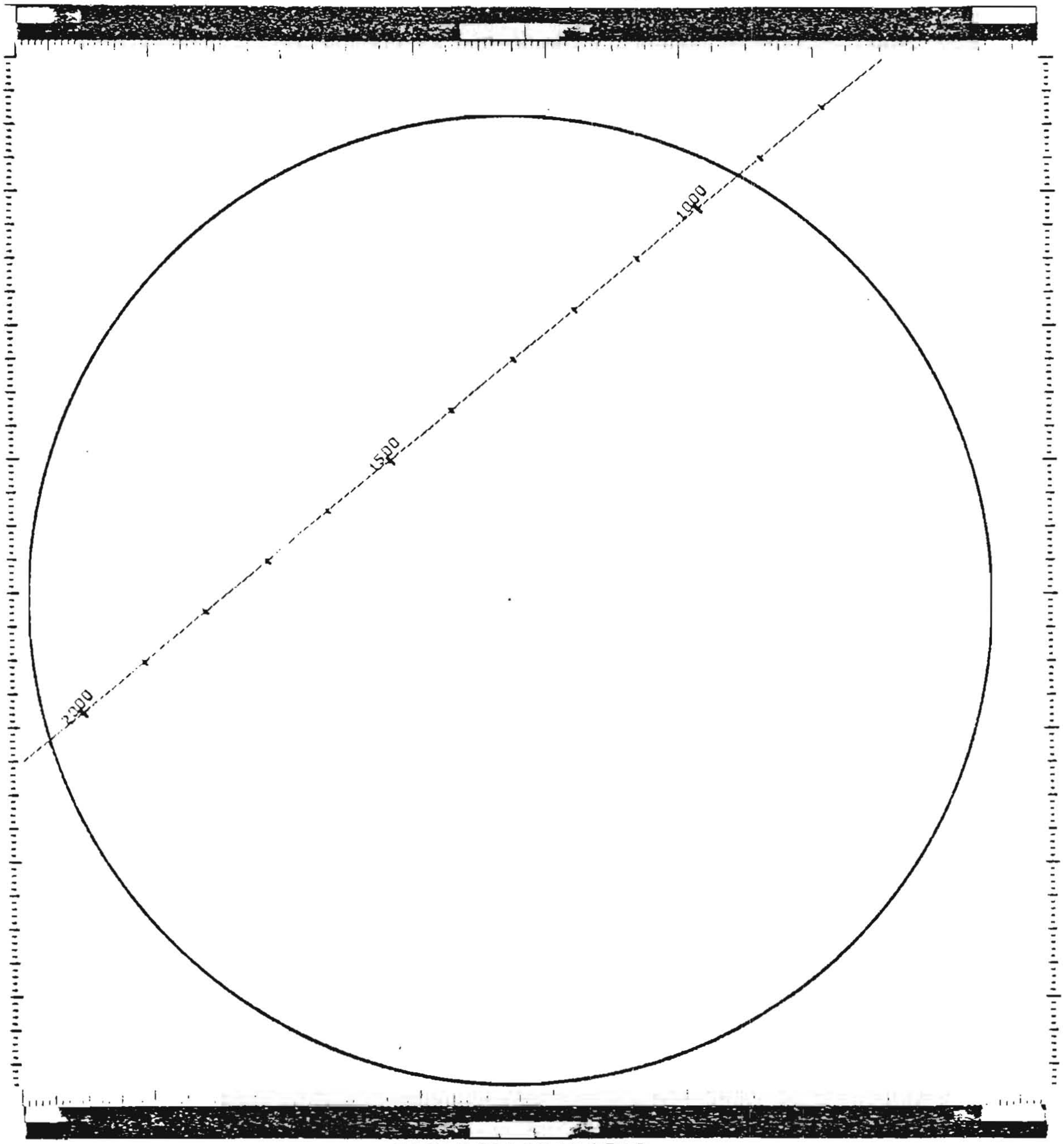
Associated with each raw image is a set of 20 header, or label, records. Each record is 360 8-bit bytes long (a concatenation of 5 72-byte logical records). This set of 20 label records is generated by the IUE Operations Control Center (OCC) software during image acquisition and contains various identifying parameters and scientific/engineering data pertinent to the image. The label associated with a given image can be expanded (up to a maximum of 30 records) to contain a log or history of the image processing operations in a manner which is illustrated in Section 8, where a detailed description of the standard label-record formats will be found.

Raw IUE images must be corrected for the instrumental effects of the SEC vidicon camera system before meaningful data can be extracted from them. The geometric distortion and radiometric (photometric) nonlinearities and nonuniformities introduced by the vidicon system are compensated for by the methods described in Section 4. Once an image has been transformed to a geometrically correct frame of reference, the layout of the spectral format in either dispersion mode is (apart from the small thermal shifts discussed in Section 5) mathematically predictable. Figures 3-1 through 3-4 illustrate schematically the spectral formats in both dispersion modes, for both the long and short



0001000107680768
*OSCRIBE2
**** SWP HIGH-DISPERSION WAVELENGTH SCALE ****
*MASK

Figure 3-1. Schematic Representation of the Echelle (High Dispersion) Spectral Format in the Short Wavelength Prime (SWP) Camera, Small Aperture



000100010768O768
*DSCRIBE2 -
**** SWP LOW-DISPERSION WAVELENGTH SCALE *****
*MASK

Figure 3-2. Schematic Representation of the Low Dispersion Spectral Format in the SWP Camera, Small Aperture

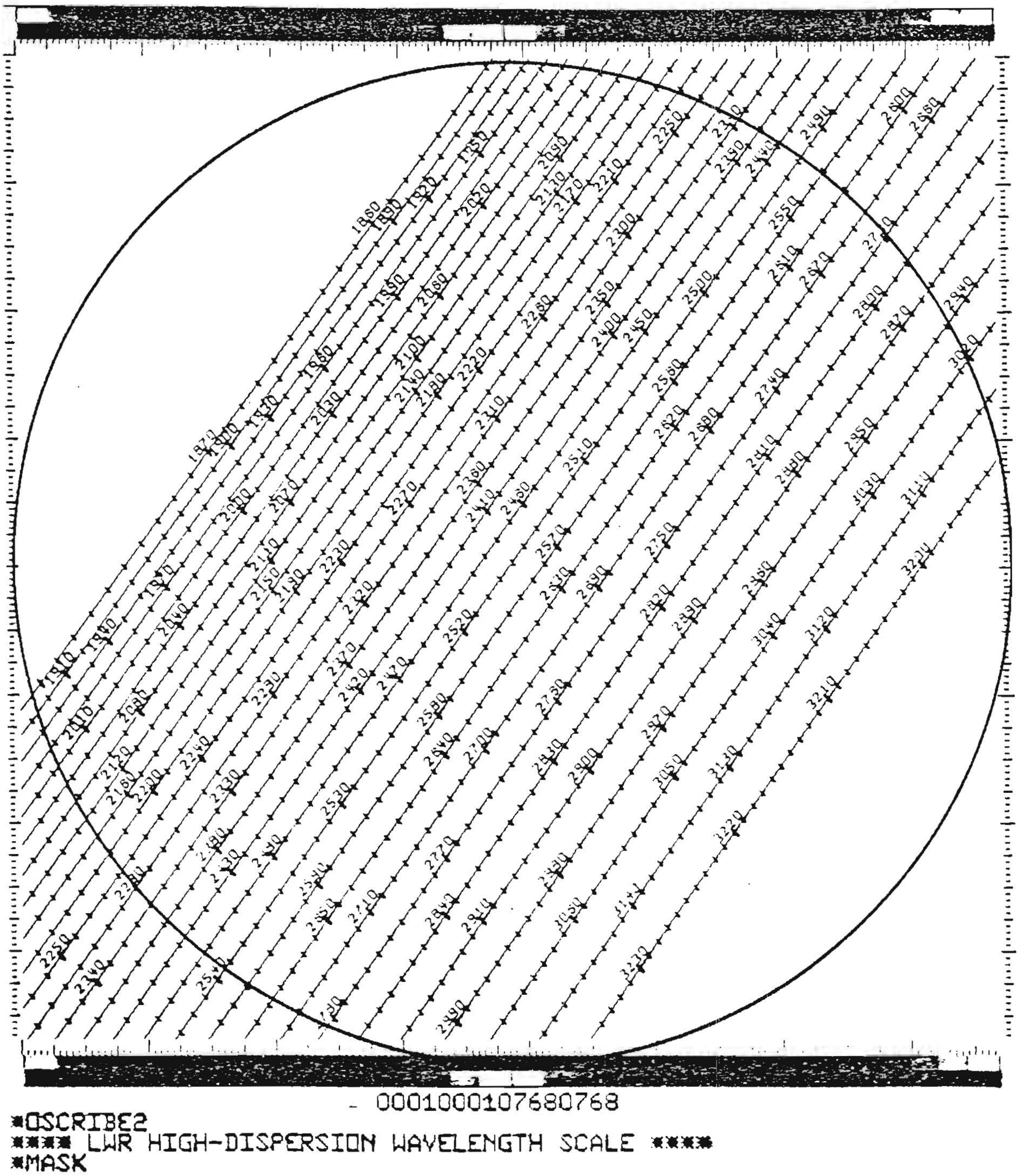


Figure 3-3. Schematic Representation of the Echelle (High Dispersion) Spectral Format in the Long Wavelength Redundant (LWR) Camera, Small Aperture

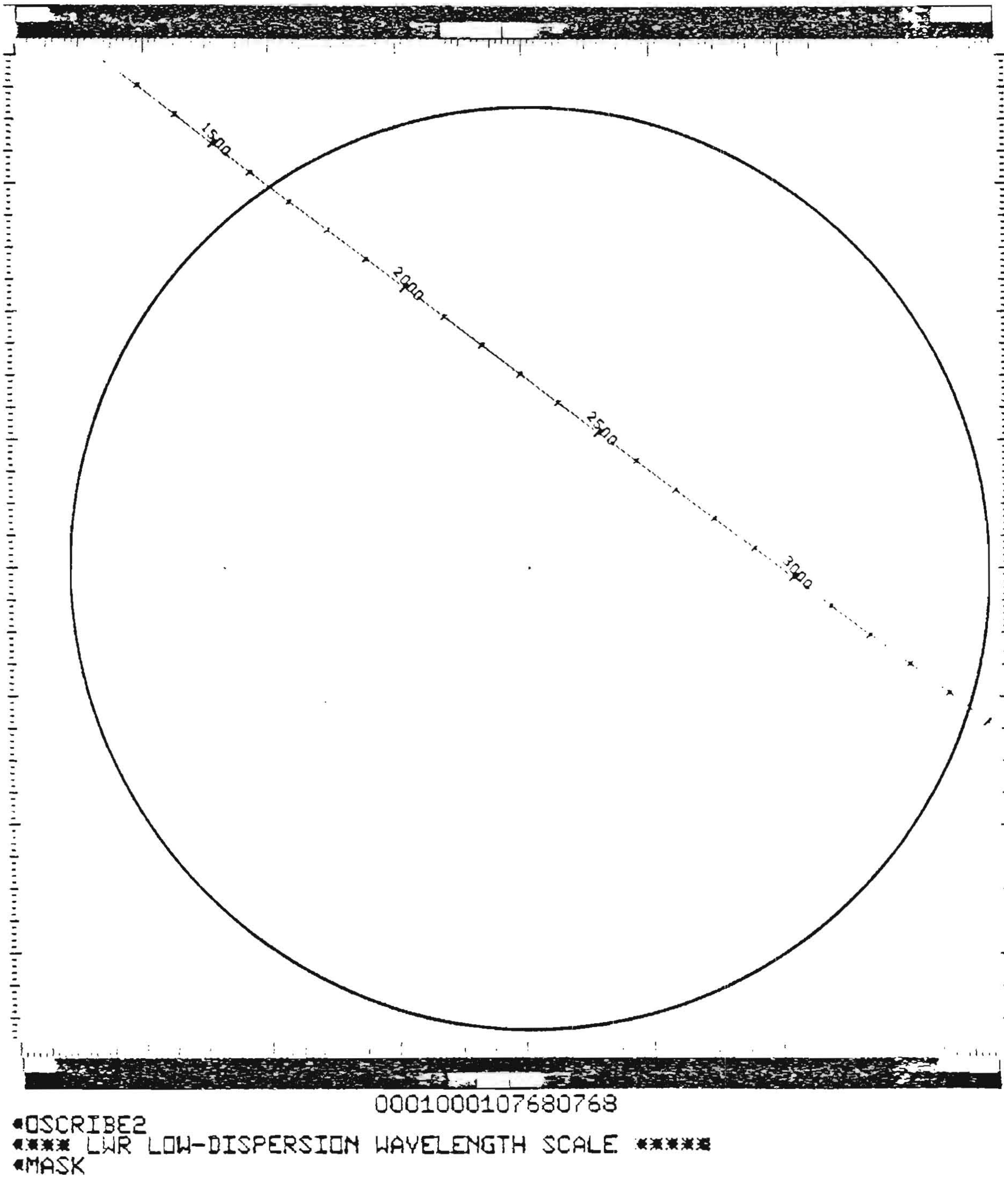


Figure 3-4. Schematic Representation of the Low Dispersion Spectral Format in the LWR Camera, Small Aperture

wavelength spectrographs, as seen in the geometrically-corrected frame of reference, and as defined by the mathematical dispersion relations described in Section 5. The square border defines the 768 by 768 array comprising the whole image, whereas the inscribed circle defines the area from which spectral information is extracted. For high dispersion, only every other echelle order is indicated. For both high and low dispersion, the order location shown is that for the small entrance aperture (see Section 3.2). Numbers and tick marks along the orders mark the wavelengths in Å.

3.2 SPECTROGRAPH GEOMETRY

Both the long and short wavelength IUE spectrographs have two entrance apertures: a small aperture (nominal 3-arcsec diameter circle; actually 3.2 arcsec for SWP and 4.0 arsec for LWR) and a large aperture (nominal 10 arcsec by 20 arcsec elongated figure; actually 10.3 by 23.0 arcsec for SWP and 10.2 by 23.8 arcsec for LWR)(Reference 1). In the long wavelength spectrograph, the center of the large aperture (LWLA) is located some 41 arcsec from the center of the small aperture (LWSA). In the short wavelength spectrograph, the center of the large aperture (SWLA) is located some 40 arcsec from the center of the small aperture (SWSA). In the geometrically-corrected frame of reference, the "plate scale" for both the LWR and SWP cameras is 1.525 ± 0.01 arcsec/pixel.

In the SWP camera, the geometry of the two entrance apertures in relation to the image scan lines and the high and low resolution dispersion directions is shown in Figure 3-5. This figure is drawn in the geometrically-corrected frame of reference. Note particularly the fact that the separation of the SWLA and SWSA is very nearly along the echelle dispersion direction. Therefore, short wavelength high dispersion images in which both apertures are exposed will result in nearly complete superposition of the large and small aperture spectra (with a wavelength offset given in Table 3-1).

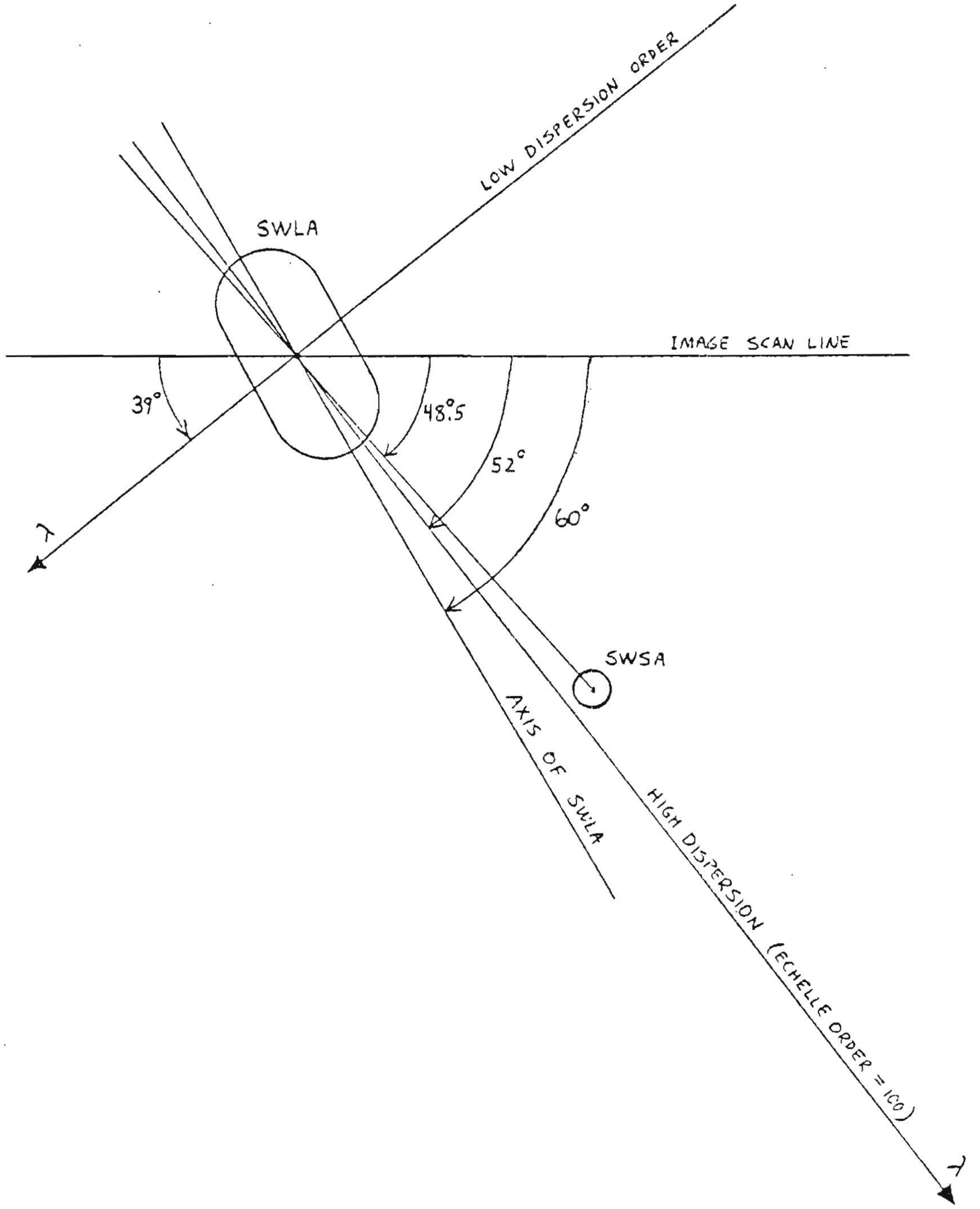


Figure 3-5. SWP Geometry

Figure 3-6 illustrates the LWR geometry. The large aperture-small aperture separation is less coincident with the echelle dispersion direction than in the short wavelength spectrograph.

Table 3-1 lists a set of dimensions of significance in the geometrically corrected frame of reference for both the long and short wavelength spectrographs, as measured in the LWR and SWP cameras. Included are the dimensions subtended by the various entrance apertures in pixels, arcsec, and (where relevant) angstrom units. The conversion to angstrom units depends upon the wavelength calibrations which are discussed in Section 5 and indicates the degree of wavelength smearing which can be expected for uniformly illuminated apertures.

3.3 SPECTROGRAPH RESOLUTION

The optical resolution obtained at the center of the LWR and SWP cameras, as measured on raw high dispersion platinum-lamp exposures in which the small apertures were uniformly illuminated is full width at half maximum (FWHM) = 2.5 = 0.4 pixels. The wavelength equivalents of this resolution figure are listed in Table 3-2. The tabular values are guidelines only; the fact that the optical resolution degrades as one departs from the tube center has been ignored in compiling the entries. Furthermore, the FWHM = 2.5 pixels is assumed relevant to both dispersion modes although different spectrograph optics are involved in each mode and only the high dispersion case has been directly measured (with uniformly illuminated apertures).

Similar measurements on geometrically corrected images indicate that the FWHM is increased by approximately 0.1 pixel over the raw-image value of 2.5 pixels.

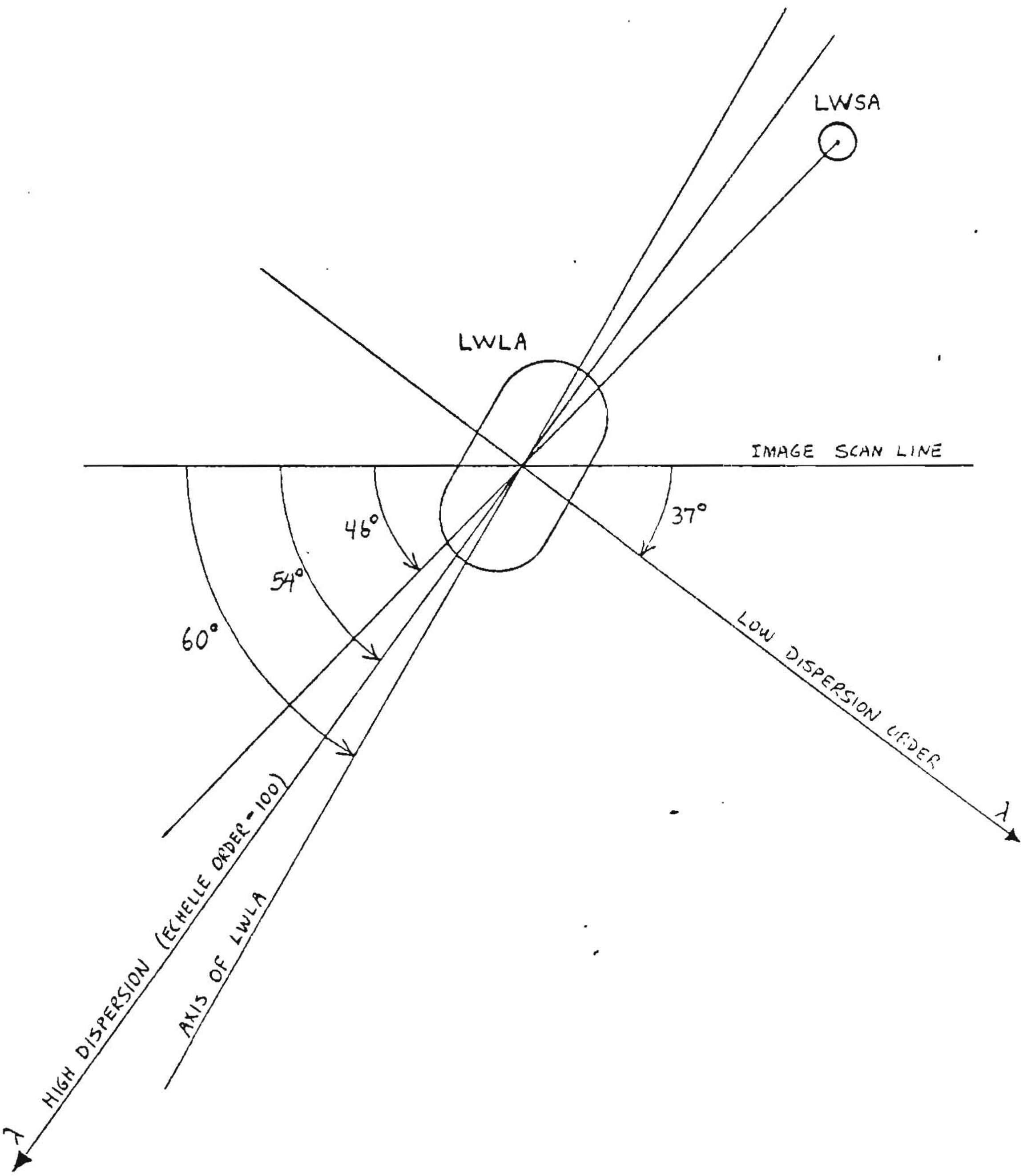


Figure 3-6. LWR Geometry

Table 3-1. Relevant Dimensions and Separations in the Long and Short Wavelength Spectrographs, LWR and SWP Cameras (Adopted scale of 1.525 ± 0.01 arcsec/pixel)

CAMERA	QUANTITY	DISP. MODE	PIXELS	ARCSECONDS	ANGSTROMS
SWP	SEPARATION OF SWLA AND SWSA (CENTER TO CENTER)	H	26.3 ± 0.2	40.0 ± 0.3	0.92 ± 0.01*
		L	26.3 ± 0.2	40.0 ± 0.3	N/A
SWP	EXTENT OF SWLA PARALLEL TO ORDER	H	15.2 ± 0.7	23.2 ± 1.0	0.53 ± 0.02*
		L	6.8 ± 0.7	10.4 ± 1.0	11.3 ± 1.0
SWP	EXTENT OF SWLA PERPENDICULAR TO ORDER	H	6.8 ± 0.7	10.4 ± 1.0	N/A
		L	15.2 ± 0.7	23.2 ± 1.0	N/A
SWP	EXTENT OF SWSA	H	2.1 ± 0.2	3.2 ± 0.3	0.07 ± 0.01*
		L	2.1 ± 0.2	3.2 ± 0.3	3.5 ± 0.3
LWR	SEPARATION OF LWLA AND LWSA (CENTER-TO-CENTER)	H	26.9 ± 0.2	41.0 ± 0.3	1.49 ± 0.01*
		L	26.9 ± 0.2	41.0 ± 0.3	N/A
LWR	EXTENT OF LWLA PARALLEL TO ORDER	H	15.7 ± 0.7	23.9 ± 1.0	0.88 ± 0.04*
		L	6.8 ± 0.7	10.3 ± 1.0	18.0 ± 1.8
LWR	EXTENT OF LWLA PERPENDICULAR TO ORDER	H	6.8 ± 0.7	10.3 ± 1.0	N/A
		L	15.7 ± 0.7	23.9 ± 1.0	N/A
LWR	EXTENT OF LWSA	H	2.6 ± 0.2	4.0 ± 0.3	0.15 ± 0.01*
		L	2.6 ± 0.2	4.0 ± 0.3	6.9 ± 0.5

*FOR ECHELLE ORDER m = 100. FOR OTHER ORDERS, MULTIPLY TABULAR ANGSTROM VALUES BY 100/m.

Table 3-2. Wavelength Equivalents (A) to Spectrograph Resolution of FWHM = 2.5 ± 0.4 pixels in the SWP and LWR Cameras (Raw Images)

	High Dispersion			
Camera	Order 125	Order 100	Order 75	Low Dispersion
SWP	0.07	0.09	0.12	4.2
LWR	0.11	0.14	0.19	6.6

SECTION 4 - GEOMETRIC AND PHOTOMETRIC CORRECTION

4.1 GEOMETRIC CORRECTION PROCEDURE

Raw IUE images suffer from geometric distortion introduced by the SEC vidicon cameras. The electrostatically-focused image section of the camera produces a pincushion distortion, while the magnetically-focused readout section produces an S-distortion. The first image processing step for each image is therefore a geometric correction of the raw image, performed by means of bilinear interpolation within a square grid of 169 fiducial marks (reseaux) which are deposited on the faceplate of each camera. The correction is really a resampling of the pixel values in the original image to produce a transformed image in which each pixel is referred to its own standard location with respect to the camera faceplate. In the transformed image the spectral orders are nominally straight. Note that since the resampling operation is done in the (non linear) DN space of the raw image, some photometric error is introduced. The choice of performing the geometric correction before the pixel values are linearized (by means of the photometric correction discussed in the next section) is clearly a tradeoff between the photometric error resulting from the nonlinear resampling and the photometric error which would result if the pixels were not accurately registered with the intensity transfer functions (see next section).

The observed (distorted) positions of the reseau marks are measured on floodlamp exposures which are typically obtained approximately every two weeks. The departure of the measured positions from the known (undistorted) positions determine the local distortion near each reseau mark; distortion at intermediate points is obtained by bilinear interpolation between the reseaux. This distortion mapping thus determines the geometry of the correction which "removes" the distortion. Since the vidicon distortion is known to be sensitive to camera temperature, the use of a given distortion model for a 2-week period is slightly inaccurate (relative distortion changes at the sub-pixel level have been observed from day to day). Guest Observers to whom exact distortion corrections are critical may obtain their own calibration images, as explained in Section 5.

4.2 PHOTOMETRIC CORRECTION PROCEDURE

Following their transformation to a geometrically-corrected frame of reference, images are corrected for "radiometric distortion", i.e., nonuniform and non-linear vidicon response. This photometric correction procedure transforms the input DN value for each pixel to a normalized output level (flux number, or FN) which is linearly related to the incident flux on the vidicon faceplate at the location corresponding to the particular pixel in question.

4.2.1 Intensity Transfer Functions (ITF)

The photometric correction of an image is effected by means of a pixel-by-pixel intensity transfer function, or ITF. This function provides the DN to FN mapping of each pixel in the image, and because there is reproducible spatial structure to the detector response ("fixed pattern noise") down to the single-pixel level, an accurate registration of each image with the ITF is essential to an accurate photometric correction. The need to register each pixel with its correct response curve as accurately as possible causes the geometric correction step to precede the photometric correction step in standard processing.

The ITF for each camera is generated from a series of geometrically corrected mercury flood-lamp flat-field images at graded exposure levels (11 levels for SWP; 12 levels for LWR). The lowest level is the zero-exposure level or "null pedestal" representing the background left by the vidicon flood/erase camera prep procedure which precedes every normal exposure. The highest level is a several-hundred-second flood lamp exposure which lies at or close to the vidicon saturation limit of 255 DN. Because of the response nonuniformities, for the highest exposure level saturation is reached over part of the image, but less sensitive areas of the tube will remain unsaturated.

The conversion of DN to FN for any given pixel is performed by linearly interpolating within the lookup table of 11 or 12 DN values (the ITF) for that pixel to assign the corresponding graded exposure time, normalized as follows. (The treatment in the case of out-of-range or saturated pixels, where interpolation is not possible, is discussed in Section 4.2.2.)

$$FN = \frac{T \cdot MULT}{FACTOR} \tag{4-1}$$

where T · MULT is the linearly interpolated product of the graded exposure time T in seconds with a corresponding multiplicative factor MULT, and where FACTOR is an overall normalization factor. There is a T value and a MULT value for each of the 11 or 12 exposure levels comprising the ITF, whereas FACTOR is a constant for each camera (FACTOR = 0.1778 for SWP, 0.28333 for LWR). MULT may in principle be different for each exposure level, to account for flood-lamp variability, although in practice constant MULT values have been used and the T values have been adjusted to "effective" values to account for lamp drifts during the ITF creation; these approaches are equivalent since it is the product T · MULT which is the interpolated quantity. The set of T and MULT values for the ITF are added to the IUESIPS label of each image as it is photometrically corrected; Figure 4-1 illustrates this section of the label information for an LWR image. Note that T values are given here in units of 0.01 seconds.

In July 1979 an error was discovered in the 20 percent flood exposure level (the third level of 11) in the SWP ITF in use since 22 May 1978. This error was such as to result in overestimated FN values for all pixels involving the third ITF level in the interpolation process: viz., pixels with output FN (before offset added in--see discussion below) such that 1084 < FN < 4291. In the worst of such cases (FN = 2141), the overestimate reached ~60 percent. The error was rectified as of 7 July 1979 by assembling a new SWP ITF with a correct

```
**********    CEOM. & PHOTOM. CORRECTED IMAGE **********                  C
-PCF C/** DATA REC. 12 1    1    1 768 9210 5 2  6.1  5.0 2536     .00000 1PC
     0          2303        4069        8008       10073       11878    1PC
 15883         20149       24471       29391       34333       42032    1PC   T VALUES
17.000        17.000      17.000      17.000      17.000      17.000    1PC
17.000        17.000      17.000      17.000      17.000      17.000    1PC   MULT VALUES
TUBE   2 SEC EHT  6.1 ITT EHT  5.0 WAVELENGTH 2536 DIFFUSER 0           1PC
      C     MODE I FACTOR   .283E 00                                    1PC
*FICORS   12:11Z MAY 28,'79                                             HC
```

Figure 4-1. Image Label Information Relating to the ITF Used to Perform the Photometric Correction of an LWR Image third level. At the same time, the opportunity was taken to refine the effective exposure time (T values) for all 11 levels in the SWP ITF, to better account for lamp drift and on-board computer timing quantization. The T values used in the old SWP ITF may be found in Figure 4-2(a); those used in the new SWP ITF appear in Figure 4-2(b). The array of T values entered into the image label in the format shown in these Figures allows a positive identification of the ITF version used to process any given SWP image.

In the geometrically and photometrically corrected images produced by IUESIPS, the FN value for each pixel is represented in a 16-bit or "halfword" integer format in which the 16th bit is a sign designator. Whereas this format can accommodate negative FN values (which can result from extrapolation beyond the null level of the ITF; see Section 4.2.2), a positive offset of 2000 FN units is added to all unsaturated FN values deriving from Equation (4-1) in order to suppress negative pixel values which cannot be represented in the photowrite hard copy images. All current IUE extraction programs (see Section 6) subsequently remove this 2000 FN offset from the geometrically and photometrically corrected image during the extraction process; Guest Observers who extract their own spectra directly from the geometrically and photometrically corrected images on their GO tapes should be aware that these images contain this offset.

4.2.2 Saturated and Out-of-Range Pixels

Pixels which are either saturated ($DN_{image} = 255$) or out-of-range ($DN_{image} <$ DN of the lowest, or null, level in the ITF or $DN_{image} >$ DN of the highest level in the ITF) cannot be treated by Equation (4-1). The following special procedures are used in the photometric correction of such pixels.

Saturated pixels ($DN_{image} = 255$) are assigned the artifically large and limiting value of FN = 32767. This enables a simple flagging mechanism to be used to identify such pixels in the spectral extraction step through the "quality measure" or ϵ field (see Section 6).

```
********** GEOM. & PHOTOM. CORRECTED IMAGE **********                  C
PCF C/** DATA REC. 11 1   1   1 768 8448 5 3  6.1  5.0 2536   .00000 1PC
          0        1753       3461       6936       9000     10575   1PC
      14299       17709      21546      25156      28074             1PC
     11.000      11.000     11.000     11.000     11.000    11.000   1PC
     11.000      11.000     11.000     11.000     11.000             1PC
TUBE   3 SEC EHT   6.1 ITT EHT   5.0 WAVELENGTH 2536 DIFFUSER 0      1PC
     C      MODE : FACTOR    .178E 00                                1PC
*FICORS   15:067 MAY 28,'79                                          PC
```

(a) Old ITF

```
********** GEOM. & PHOTOM. CORRECTED IMAGE **********                  C
PCF C/** DATA REC. 11 1   1   1 768 8448 5 3  6.1  5.0 2536   .00000 1PC
          0        1684       3374       6873       9091     10536   1PC
      14371       17745      21524      25105      28500             1PC
     11.000      11.000     11.000     11.000     11.000    11.000   1PC
     11.000      11.000     11.000     11.000     11.000             1PC
TUBE   3 SEC EHT   6.1 ITT EHT   5.0 WAVELENGTH 2536 DIFFUSER 0      1PC
     C      MODE : FACTOR    .178E 00                                1PC
*FICORS   13:532 AUG 09,'79                                          PC
```

(b) New ITF

Figure 4-2. Image Label Information Relating to the ITF Used to Perform the Photometric Correction of an SWP Image: (a) Old ITF Used Prior to 7 July 1979; (b) New ITF used as of 7 July 1979.

Below-range pixels (DN_{image} < null level of ITF) can result from statistical fluctuations or null pedestal drift. These pixels are assigned FN values based on a linear extrapolation of the first two points of the ITF to DN below the null level. Such FN are negative (since FN = 0 for the null DN value), and they are the reason for use of the 2000 FN positive offset applied to all unsaturated FN values (Section 4.2.1). The extrapolations are generally small enough that with the 2000 FN offset, a net positive value is obtained.

Above-range pixels (DN_{image} > highest level of ITF) result from exposure levels exceeding the highest level used in constructing the ITF. To such pixels the current software assigns an FN value equal to that for the highest level in the ITF, unless the pixel is saturated, in which case FN = 32767 is assigned as described above. That is, the software truncates the assigned FN for above-range pixels to the maximum value (plus offset). For the current ITFs, these maximum (unsaturated) values are 25220 for LWR, and 17632 for SWP, to which the 2000 FN offsets are then added. Depending on pixel location, the upper DN limits for the current ITFs can be as small as ~ 180 - 190 DN, although over most of the tube in both cameras the limit exceeds 220 DN. Unsaturated DN values larger than these appropriate limits result in truncated FN values. Table 4-1 lists the approximate upper DN limits for the current ITFs in the vicinty of the low dispersion spectra for each camera, measured from printed averages of 12 × 12 pixel areas. With these values, Guest Observers may determine roughly whether their data at a particular low dispersion wavelength will have photmetric error due to the truncation. More accurate data, including data for the high dispersion mode, will eventually be available.

Table 4-1. Approximate Highest DN Values in the ITF

SWP		LWR	
λ	DN	λ	DN
1200	197	2100	250
1300	216	2300	245
1400	235	2500	240
1500	245	2700	225
1600	243*	2900	220
1700	239*	3100	190
1800	228*	3300	180
1900	242*		

*Higher Levels exist which may include saturated pixels.

SECTION 5 - WAVELENGTH CALIBRATION

5.1 PLATINUM - LAMP CALIBRATION IMAGES

Approximately every two weeks a high and low dispersion small aperture spectrum is made of the on-board hollow cathode platinum-neon calibration lamp with each of the two active cameras (SWP and LWR). The low dispersion exposures are usually a combination of the calibration spectrum and a flood-lamp exposure.

These platinum lamp calibration images are used to establish the wavelength calibration, that is, to determine wavelength as a function of position.

5.2 COMPUTATIONAL DETAILS AND LIMITATIONS

5.2.1 Calculation of Dispersion Relations

Whenever a set of these calibration images is taken, it is processed to provide an analytic relation between wavelength and the line and sample position of a pixel. The pixel locations of the platinum emission lines are measured on geometrically-corrected calibration images by a cross-correlation search algorithm like that used to find reseau positions. (A few lines are measured manually to provide a set of starting values.) These platinum line positions are then combined with laboratory values for the wavelength and order number of each line and used in a regression analysis to determine a set of dispersion constants (A and B) relating wavelength and order number to pixel location according to the following separable relations:

$$\text{sample number} = A_1 Z_1 + A_2 Z_2 + A_3 Z_3 + \ldots\ldots\ldots\ldots + A_7 Z_7 \qquad (5\text{-}1)$$

$$\text{line number} = B_1 Z_1 + B_2 Z_2 + B_3 Z_3 + \ldots\ldots\ldots\ldots + B_7 Z_7 \qquad (5\text{-}2)$$

where

$$Z_1 = 1$$

$$Z_2 = m\lambda$$

$$Z_3 = (m\lambda)^2$$

$$Z_4 = m \qquad (5-3)$$

$$Z_5 = \lambda$$

$$Z_6 = m^2\lambda$$

$$Z_7 = m\lambda^2$$

for

m = order number

λ = wavelength (Å)

For low dispersion, the spectral format is represented by a linear relation (only terms 1 and 2 are used, where $m = 1$). For both dispersion modes, the analytical dispersion relations are apparently accurate representations of the actual spectral format to within one half of a pixel (formal standard deviations of the regression analysis are typically ≈ 0.3 pixels in both the line and sample directions). In high dispersion, approximately 170 platinum-neon lines are used in the regression analysis; in low dispersion, approximately 20 lines are used.

The platinum-neon lines used in the regression analysis were chosen from a larger set of platinum-neon lines based on the tested ability of the automatic cross-correlation routine to find them unambiguously. Some sample dispersion constants are given in Table 5-1.

5.2.2 Registration (Shift) Procedure

The IUE spectral format of geometrically corrected images is known to shift by as much as three pixels on a time scale of days or hours (the actual lower time limit has not been determined). This motion has been observed in both dispersion modes, and there is no evidence that it is not a uniform shift across the entire image. The causes of this motion are believed to be thermal effects in the spectrograph optical train, although this has not yet been conclusively proven.

Because of these shifts the set of dispersion constants which fit the calibration image very accurately may not necessarily fit a data image taken the next day in the sense that the locus of points defined by the dispersion relation will be a nearly straight line to one side of the data order instead of along it.

The data extraction routine to be described in Section 6 uses the dispersion relation to locate the pixels which comprise the spectrum and if the spectral format has shifted, the wrong pixels (mostly background) will be extracted. To correct this problem automatic and manual registration routines are provided to modify the dispersion constants. The automatic routine is used on spectra which have a strong but unsaturated continuum over most (more than 1/3) of their spectral range, whereas the manual routine is used on spectra of emission line objects, very weak spectra, and spectra saturated over most of their length.

To perform the automatic registration, a cross-correlation spectral-order-finding algorithm is invoked to sample the image at 12 discrete locations and

Table 5-1. Sample Dispersion Constants

CAMERA/ DISPERSION	DISPERSION CONSTANTS							
	A_1	A_2	A_3	A_4	A_5	A_6	A_7	SOURCE
SWP/LOW	981.37	-0.46657	—	—	—	—	—	MEAN OF 21 IMAGES
LWR/LOW	-298.22	0.30242	—	—	—	—	—	MEAN OF 22 IMAGES
SWP/HIGH	.16225E-4	-.18720E-0	.13274E-5	0.0	-.46738E-0	0.0	0.0	SWP 6170 DAY 225, 1979
LWR/HIGH	-.61012E-4	.15762E-0	-.57438E-6	0.0	.30235E-0	0.0	0.0	LWR 5335 DAY 225, 1979
	B_1	B_2	B_3	B_4	B_5	B_6	B_7	
SWP/LOW	-263.68	0.37618	-	—	—	—	—	MEAN OF 21 IMAGES
LWR/LOW	-266.66	0.22577	—	—	—	—	—	MEAN OF 22 IMAGES
SWP/HIGH	-.52454E-4	-.14617E-0	.13232E-5	0.0	.37507E-0	0.0	0.0	SWP 6170 DAY 225, 1979
LWR/HIGH	.17097E-5	-.29201E-0	.93942E-6	.71993E-1	.22788E-0	0.0	0.0	LWR 5335 DAY 225, 1979

6851/79

determine the line and sample offsets of the spectral format prependicular to the orders themselves. With these offset values, IUESIPS adjusts the A_1 and B_1 terms in the dispersion relations, in effect tailoring the dispersion equations for the particular target image in question. The values for the line and sample offsets are added to the IUESIPS label of the extracted spectrum (see Section 8.1.4).

It should be noted that since no wavelength identifications are used in this registration procedure, the operation is totally insensitive to shifts along the dispersion direction. Hence there is an inherent inaccuracy in the wavelength scale of extracted spectra due to any component of the shift in the direction of the dispersion. This error can in practice be corrected by the Guest Observer by recourse to specific line identifications in the extracted spectra; see Section 5.2.3.

When the manual routine is used, the image is displayed with a wavelength overlay generated using the given dispersion constants. If the dispersion lines of the overlay are observed to fall to one side or the other of the data, the image processing specialist will manually enter a shift in the line direction and a shift in the sample direction which will cause the overlay to be superimposed on the data to $\approx \pm$ 1/2 pixel. Just as in the automatic registration routine, the values for the line and sample offsets used are given in the IUESIPS label of the extracted spectrum.

Note that the GO can greatly facilitate the processing operation by specifying that the manual shift routine should be used (see Figure 2-2) for those images which would not be suitable for the automatic algorithm.

5.2.3 Zero-Point and Scale Errors

Movement of the spectral format can introduce wavelength errors equivalent to several pixels. If every pixel in the image were shifted in a direction parallel to the dispersion line by the same amount, all wavelengths would have the same zero point offset in the case of low dispersion (the dispersion relation is linear), and a zero point offset which was a function of order number in the case of high dispersion. If the pixels are shifted by varying amounts in the dispersion direction, the spectrum will be streched and/or compressed resulting in scale errors (i.e., errors which cannot be removed by identifying a line and applying the offset necessary to bring its wavelength to the known value).

The IUE spectra exhibit both offset and scale errors; however, the observed offset errors are far larger than the scale errors.

5.2.4 Large Aperture Wavelength Calibrations

The wavelength calibration images are usually made using the small aperture since it is unresolved and thus provides the sharpest possible images of the calibration lamp emission lines. The dispersion constants derived from these images will define a dispersion relation for the small aperture. When the large aperture is used to take data, it is necessary to modify the A_1 and B_1 terms of the dispersion relation to shift the dispersion line by the separation of the two apertures. The offsets in line and sample between these apertures have been measured to an accuracy of several tenths of a pixel unit (Reference 2). Note that as of 1 August 1979 telescope operations and image processing have both used the "physical center" offset values referred to in Reference 2. A complete discussion of these offsets and the offsets used earlier can be found in this reference.

Use of the large aperture can cause absolute wavelength errors as large as six pixels (the half width of the large aperture) times the reciprocal dispersion in angstroms per pixel (see Section 3 and Table 3-1). This is due to variations in placement of objects in the aperture or brightness variations across spatially extended objects. Errors of the magnitude given above occur: (1) when a star (point source) is placed near an edge of the aperture in the direction of dispersion away from the aperture center instead of at the center, or (2) when a structured (spatially resolved) object has a bright spot which lies offcenter in the dispersion direction. These are offset errors which can be corrected if the wavelength of one or more of the observed lines is known.

5.2.5 Nominal Accuracies

As with the biweekly updating of reseau positions, the determination of new dispersion relations with the same frequency is only an approximate solution to the problem of wavelength calibration. The significant operations overhead time of about 20 minutes required to obtain a calibration image (either wavelength calibration or reseau-position calibration) prohibits the sort of calibration frequency to which most ground-based observers are accustomed. The spectral format registration step which is performed on each target compensates for format drift perpendicular to the spectral orders but is insensitive to shifts along the orders. The set of wavelength calibrations so far accumulated has shown that calibration-to-calibration shifts of the spectral format (often uniform motion across the image, sometimes along the orders) have occurred in amounts up to several pixels, with no clear-cut relationship between time and amount of shift seen. As with reseau positions, there is no evidence for secular changes. The changes seen are generally believed to be thermally induced, although conclusive proof of this requires more study.

With the present calibration procedure, wavelength errors due to shifts along the dispersion direction are always possible; errors as large as 0.5Å (i.e., several times the spectral resolution) have been seen in extracted high dispersion spectra, although errors of only 0.1Å are more typical. A study of these errors has been made for SWP & LWR low dispersion and published in IUE Newsletter 5 (Reference 3). Nominal accuracies based on that study are given in Table 5-2.

Table 5-2. Nominal Wavelength Accuracies

Camera/Order	Dispersion	Error (Pixels)	Error (A)
SWP	Low	1.5	2.5
SWP/75	High	1.5*	0.07
SWP/100	High	1.5*	0.05
SWP/125	High	1.5*	0.04
LWR	Low	1.3	3.5
LWR/75	High	1.3*	0.1
LWR/100	High	1.3*	0.07
LWR/125	High	1.3*	0.06

*Error in pixel units for high dispersion is assumed to equal error for low dispersion. A high dispersion error analysis has not been performed as yet.

5.3 SPECIAL CALIBRATIONS

Guest Observers may obtain their own wavelength calibration images more frequently than the biweekly standards if they desire to devote a portion of their assigned observing time to such endeavors. At the present time, data are not available to assess the degree of improvement which this approach yields.

IUE Guest Observers who desire to obtain their own high dispersion wavelength calibration images in order to improve the accuracy of the wavelength scale on their extracted spectra are advised to also obtain either a separate TFLOOD exposure or a low dispersion platinum lamp-plus-TFLOOD exposure. This is necessitated by the fact that the high dispersion platinum spectrum used for wavelength calibration contains numerous lines, some of which lie extremely close to, or even superimposed upon, a number of reseau marks. When this occurs, the reseau-finding algorithm does not accurately calculate the positions of the affected reseaux, which in turn results in a bad geometric correction. The extent of this effect depends on the exact placement of the spectral format at the time the image is taken (it is known to shift by up to several pixels), and is far worse in the SWP camera than in the LWR camera.

Since reseaux are known to move (i.e., the geometric distortion is not immutable at the sub-pixel level), a wavelength calibration may be extremely inaccurate if reliable reseau positions cannot be computed for the same time frame as the wavelength calibration image. In order to do this, the separate TFLOOD or low dispersion standard calibration image (on which reseaux are not contaminated) is strongly recommended.

Guest Observers who wish to use a special calibration should fill in the last two lines of the "Processing specifications" (see Figure 2-2) indicating the image number of the special calibration to be used.

5.4 WAVELENGTH CORRECTIONS

5.4.1 Vacuum-To-Air Conversion

The wavelengths obtained using the platinum-neon calibration lamp are vacuum wavelengths. Since it is customary to list air wavelengths for lines longward of 2000 Angstroms, a vacuum-to-air wavelength correction is made for some of the LWR wavelengths. Corrections are made as follows:

1. All extracted wavelengths from the SW spectrograph are left uncorrected (vacuum wavelengths, even for $\lambda > 2000$ angstroms).

2. All extracted wavelengths from the LW spectrograph are corrected to air values if equal to or greater than 2000 angstroms; extracted wavelengths shorter than 2000 angstroms are left uncorrected (vacuum wavelengths). The formula used to do the correction for wavelengths equal to or greater than 2000 angstroms is:

$$\lambda_{air} = \lambda_{vac} / f(\lambda_{vac})$$

where

$$f(\lambda) = 1.0 + 2.735182 \times 10^{-4} + \frac{131.4182}{\lambda^2} + \frac{2.76249 \times 10^8}{\lambda^4}$$

5.4.2 Velocity Corrections

At the present time, no velocity corrections are applied to the extracted wavelengths. In the near future, however, the wavelengths will be corrected to compensate for the Earth's orbital velocity about the Sun and the satellite's orbital velocity about the Earth. The orbital elements used for the satellite will be updated as often as necessary to maintain an accuracy of ±1 km/sec in the computed line-of-sight velocity. (This is about 25 percent of the maximum satellite velocity).

SECTION 6 - EXTRACTION OF SPECTRAL INTENSITY

6.1 HIGH DISPERSION

6.1.1 Slit Integrated Spectra

Following the spectral format registration step, an analyzing slit is passed numerically by the computer along each order of the geometrically and photometrically corrected image (i.e., along trajectories specified by the dispersion relations), and entries in a table of slit-integrated instrumental spectral intensities as a function of wavelength are accumulated.

6.1.1.1 Point Source and Extended Source Reduction

In the point source reduction mode the gross spectrum of each order is extracted from the registered spectral image using an analyzing slit which is $\sqrt{2}$ pixels wide, and $5\sqrt{2}$ pixels high.

The point source reduction mode would be used for the extraction of data from spectra of very localized (significantly smaller in spatial extent than the 10 by 20 arcsec large aperture) or spatially unresolved objects when the large aperture is used, and for the extraction of all data taken through the small aperture. In addition to the point source reduction mode, IUESIPS provides a high resolution extended source reduction mode since in some cases the large aperture might be used in the high dispersion mode even though the object observed is an extended object. This would have the advantage of improved throughput and the disadvantage of substantial wavelength resolution loss caused by the orientation of the large aperture. In the high resolution mode the large aperture is oriented with its long axis almost parallel to the dispersion line. (See Table 3-1 and Figures 3-5 and 3-6.) In this extended source mode the extraction slit used is $7\sqrt{2}$ pixels long and thus it extends across most of the large aperture. The total area covered by the slit is 9 square pixels for the point source extraction and 13 square pixels for the extended-source extraction.

In addition to the gross spectrum, an interorder or background spectrum is also computed using data extracted approximately (to the nearest pixel center) half way between each pair of spectral orders with an analyzing slit which is a square, one pixel on a side. For any order the background spectrum is defined as the average of the values measured on either side of the order normalized to the total slit area used to extract the gross spectrum. It should be noted that the measured interorder (background) spectrum is the same in both the point and extended source modes.

In either the point or extended source modes, the extraction slit is oriented such that its long axis is approximately (to the nearest pixel center) bisected by the dispersion line, and runs nearly perpendicular to the dispersion line (it is actually along the diagonal of the image array which is within about 9 degrees of the perpendicular to the dispersion line--see Figures 3-5, 3-6, and 6-1.

Note that the analyzing slits used are all composed of full and half pixels (the half pixels are full pixels divided along their diagonals), and when the extraction is performed these slits are registered with the 768 by 768 pixel geometrically/photometrically corrected data image such that all the pixels in the slit correspond to pixels in the image. As a consequence of this necessity to register the pixel grids the analyzing slit for the gross spectrum is only approximately centered on the dispersion line and the one for the background spectrum is only approximately halfway between orders. In addition, the slit is stepped in the dispersion direction by an amount equal to the $\sqrt{2}$ pixels plus or minus what ever is necessary to bring about registration with the grid, i.e., there is one and only one slit center per scan line of the image. This means that the step size in wavelength varies with every step and that the wavelength for each extracted flux must be recorded as well as the flux (see Section 8).

In actually performing the extraction, the image is brought into the computer a few lines at a time. Within the boundaries of a circle defining the useful

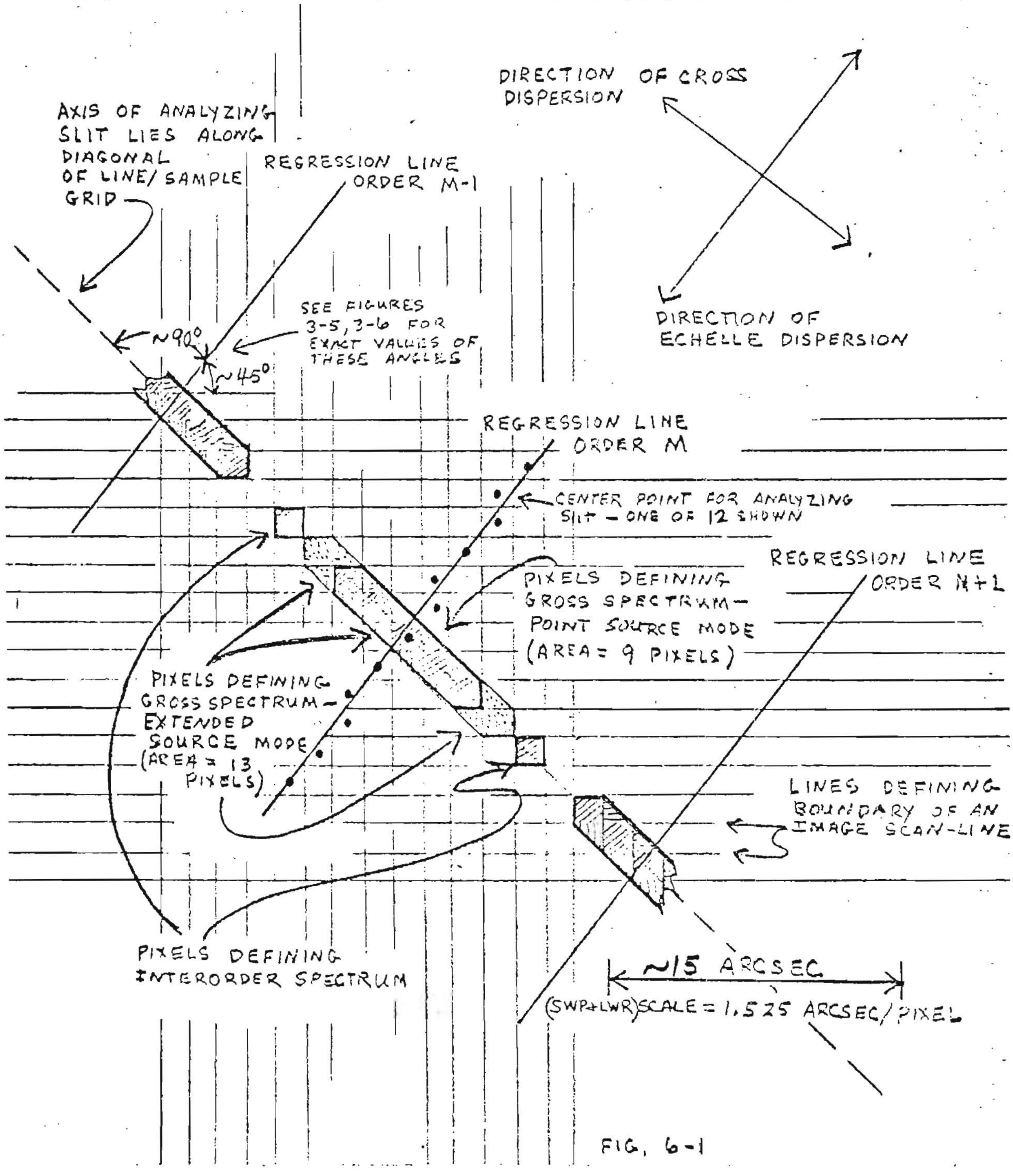


Figure 6-1. High Dispersion Extraction Slit Geometry

detector area on the image, for each order one entry (slit-integrated spectral intensity value) is generated per image line, and up to 600 entries per echelle order may be accommodated. As each on-order intensity measurement is made, the corresponding "background" or "interorder" intensity is also accumulated. A net spectrum defined to be the on-order or gross spectrum minus a smoothed version of the interorder background is later calculated. (A 15 point running average is performed twice on the interorder spectrum to smooth it before subtraction from the gross spectrum.)

6.1.2 Echelle Order Overlap

The background spectrum and to a certain extent the on-order spectrum tend to be contaminated by light from the adjacent echelle orders. The intensity profile perpendicular to an order is approximately gaussian with a full width at half maximum (FWHM) of 2.5 pixels, while the spacing between orders varies from about 12 to 5 pixels from the long to the short wave end of the echelle format. This problem is therefore most severe at the short wavelength end of the echelle format (high orders), and for cases where the large aperture is used for an extended source.

Computation of the background as it is currently done has two shortcomings. Firstly, the inter-order data consists of background and a contamination from on-order data. Secondly, the on-order data is contaminated by orders other than itself (primarily those to either side). The first effect is the more serious, and it results in background values that are too high - thus the NET flux tends to be too low.

This problem has been studied (Reference 4) by IUE observatory staff and the results of this study will appear in the IUE Newsletter.

6.2 LOW DISPERSION

6.2.1 Slit Integrated Spectra

In low dispersion, an algorithm similar to that described for high dispersion is used to generate the spectral intensity table, but with longer analyzing slits for both the on-order (gross) and background spectra. These longer slits are possible since there is no order-overlap problem (see Section 6.1.2) for low dispersion.

The long axis of the analyzing slit is along a diagonal of the 768 by 768 pixel data array as it is for high dispersion. It should be noted that for low dispersion the slit is rotated 90 degrees from the high dispersion case (see Figures 3-5 and 3-6), and is therefore nearly aligned with the axis of the large aperture.

6.2.1.1 Point and Extended Source Reduction

The point source reduction mode is used in low dispersion under the same circumstances that it is employed for the high dispersion case (see Section 6.1.1.1). The on-order analyzing slit used is $9\sqrt{2}$ pixels long (see Figure 6-2) while the background is extracted using two $5\sqrt{2}$ pixel long slits placed a distance $8\sqrt{2}$ or $11\sqrt{2}$ pixels to either side of the order. The distance $11\sqrt{2}$ pixels is used when the data are taken through the large aperture; the distance of $8\sqrt{2}$ pixels is used for small-aperture data.

In those cases where the large aperture is used and either the source is extended (spatially resolved) or the spectrum is trailed the extended-source reduction mode is recommended. In this mode the on-order slit has a height of $15\sqrt{2}$ pixels and the background is taken with a $5\sqrt{2}$ pixel long slit a distance $11\sqrt{2}$ pixels from the order.

For the extended source mode the on-order analyzing slit has an area of 29 square pixels while for the point source mode its area is 17 square pixels.

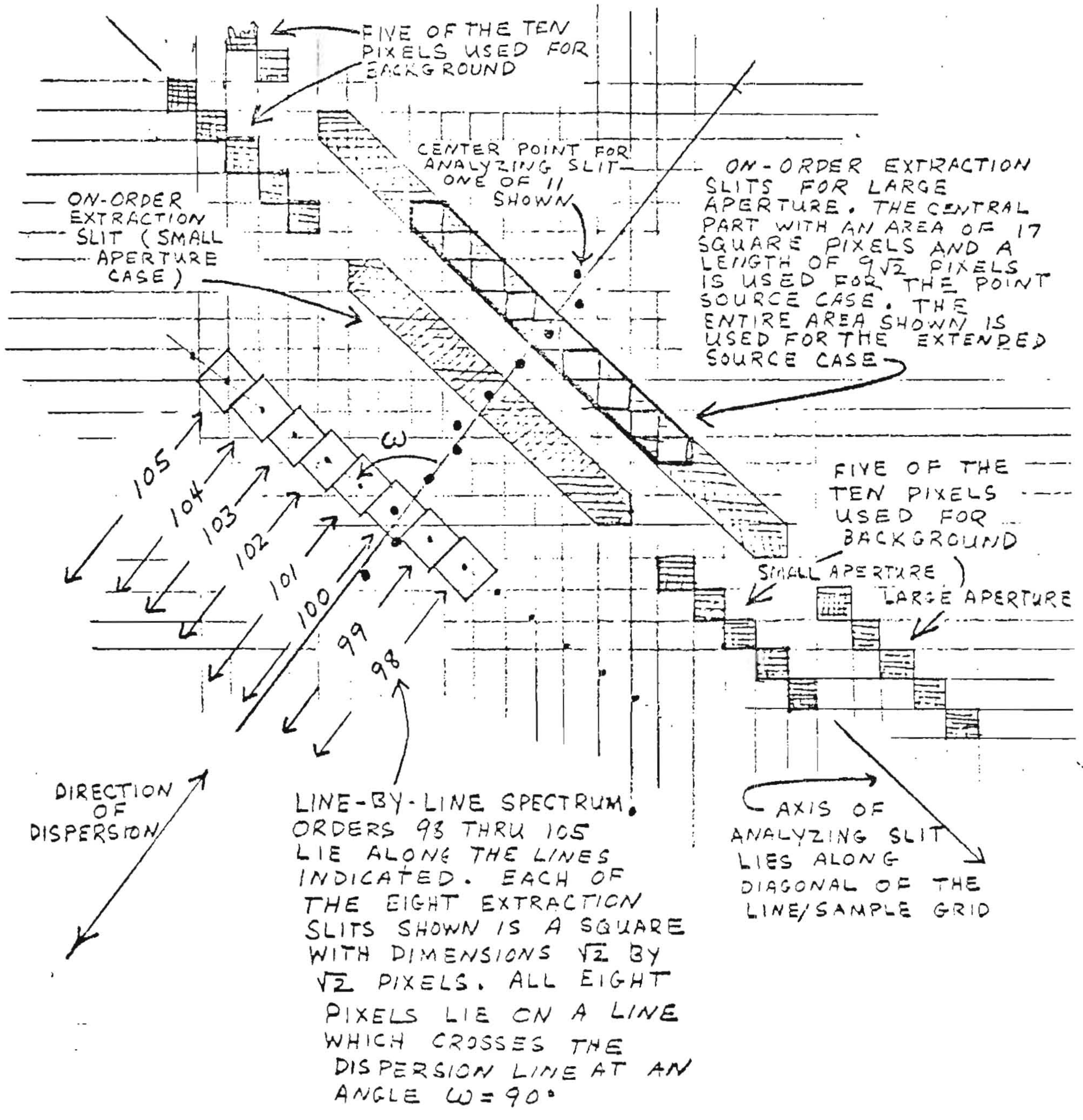


Figure 6-2. LOW DISPERSION Extraction Slit Geometry

In both cases the background slit has an area of 5 square pixels. As in the case of high dispersion the extracted background flux is smoothed, normalized to the area of the on-order slit, and subtracted from the on-order extracted flux to compute a NET flux.

6.2.2 Spatially-Resolved (Line-by-Line) Spectra

6.2.2.1 Analyzing Slit Placement

A set of 55 "spatially-resolved gross spectra" is extracted from the geometrically and photometrically corrected image. These spectra are extracted in a direction parallel to the direction of dispersion with a square slit which is $\sqrt{2}$ by $\sqrt{2}$ pixels in size and which is oriented at an angle of 45 degrees to the line and sample directions. The spatial separation of each spectrum is $\sqrt{2}$ pixel widths (~perpendicular to the dispersion direction), and each spectrum is treated as a separate "order" (see Figure 6-2). The 28th or central spectrum is centered on the dispersion line and assigned an order number of 100; each of the other 54 spectra are assigned an order number equal to $100 \pm n$, where $n\sqrt{2}$ pixels is the distance of the extracted spectrum from the dispersion line (hence, order numbers 73-127 are assigned).

The analyzing slit (as shown in Figure 6-2) has an area of 2 square pixels, and is positioned and oriented at each step such that its area overlays parts of several pixels (up to seven). The flux value extracted using this slit is thus a weighted average of the FN values of the several pixels which fall partially or wholly within the slit; the weights used are proportional to the areas overlaid. The centers of these analyzing slits are choosen in two ways depending on which of the 55 orders is involved. If the slit in question lies on the central order (order 100), its center is identical to that used for the low dispersion point source and extended source modes, but if it is on one of the 54 orders to either side of order 100, its center is defined to be a distance $n\sqrt{2}$ pixels from order 100, where this distance is measured along a line which crosses order 100 at an angle $\omega(\omega \sim 90^{0})$.

At present (September 1979) the angle ω is set equal to 90^{0} for all extractions, and while this is optimum for trailed spectra (the star is trailed perpendicular to the dispersion), it is not the best value that could be used for large aperture observations of extended sources, since the long axis of the large aperture is not perpendicular to the dispersion line (see Figures 3-5 and 3-6). Eventially changes will be made to the extraction schemes to use the optimum angle for the data being extracted.

Since in low dispersion the large aperture extends for several optical resolution elements perpendicular to the dispersion, this series of extractions parallel to the dispersion provides spatially-resolved spectra of extended objects.

6.2.2.2 Wavelength Assignments

Associated with a given extracted-data-sample in the central order of the line-by-line (order 100) there are 54 such samples (one for each of the other "orders") that are assigned the same wavelength as the given sample. These 54 samples are those that lie on the line which crosses order 100 at an angle ω, and which passes through the given sample in order 100. The wavelengths used are computed from the dispersion relation using as input the line and sample locations of the extracted-data-samples lying along order 100.

6.2.2.3 Rectified Image Segment

The flux information contained in the 55 gross spectra is also translated into an image format. A 55-line image, referred to as a "rectified image segment" is defined with halfword pixel values equal to the extracted fluxes in the corresponding 55 spectra.

6.3 UNITS OF EXTRACTED SPECTRA

Until corrected by the appropriate absolute instrumental response function (IRF), the extracted spectra are in IUE flux units--arbitrarily scaled time integrated values of exposure measured with the slits defined for each case above. In the case of a background spectrum the flux is normalized to the area of the slit defining the corresponding gross spectrum.

6.4 QUALITY MEASURE (ϵ) VALUES

For both high and low dispersion, in addition to a wavelength each extracted flux is assigned a data quality measure, ϵ, which is defined as follows:

ϵ = .264 x (pixel distance from tube center) $+ \epsilon_r + \epsilon_s$

ϵ_r = - 800 if the center of the slit defining the gross flux is within 2 pixels of a reseau; - 400 if the center of the slit defining the background flux is within 2 pixels of a reseau (low dispersion only); 0 otherwise.

ϵ_s = - 1600 if any pixel contributing to flux is saturated (i.e., DN = 255); 0 otherwise.

6.5 ECHELLE BLAZE ("RIPPLE") CORRECTION

The high dispersion echelle spectra must be corrected for the effects of the sharply blazed echelle gratings used. The echelle blaze function is theoretically a parameterized sinc function for each echelle order with the maximum at the central wavelength. The empirical data collected so far suggest that the actual blaze function, however, is less steep and varies with order number in a fashion more complicated than the theoretical result, although definitive pronouncements require the ability to establish a reliable net spectrum (i.e., solution of the order-overlap and halation problems (see Sections 6.1.2, and 6.6). Until these problems are resolved the parameterized sinc function, $F_{corr}(\lambda)$, defined below will be used:

$$F_{corr}(\lambda) = \frac{F(\lambda) \text{ extracted net}}{R(\lambda)}$$

where

$$R(\lambda) = \frac{\sin^2 X}{X^2} (1 + a X^2)$$

and

$$X = \text{Min} \begin{bmatrix} \dfrac{\pi m^2 (\lambda - \lambda c)}{K} \\ \\ 2.61 \end{bmatrix}$$

$$\lambda_c = K/m$$

m = echelle order number

K = echelle grating constant

a = adjustable parameter

Current values for K and a are given in Table 6-1.

Table 6-1. Echelle Blaze Parameters

	K	a
SWP	137,725	0.10
LWR	231,150	0.09

6.6 BACKGROUND REMOVAL (SCATTERED LIGHT, HALATION, AND RADIATION BACKGROUND)

For both high and low dispersion the background is composed of (1) a component which is caused by radiation and varies slowly across the vidicon target, (2) a component which is caused by halation and which varies as the inverse-square of distance from the source on the target, and (3) a component which is caused by scattered light and which varies in a complicated manner across the target depending on the distribution of on-order spectral features observed. The background contamination may also contain light from an adjacent echelle order (see Section 6.1.2).

Currently the only correction for the three background components applied to the GROSS spectrum to obtain the NET (both high and low dispersion) is to subtract the smoothed extracted background from the GROSS. In the case of the low dispersion NET this procedure gives good results since the background used is an accurate representation of the true background. For the high dispersion NET this is not always true due to the order overlap problem.

Work is in progress to increase the accuracy of the background removal procedure by finding a solution to the order overlap problem.

SECTION 7 - ABSOLUTE FLUX CALIBRATION

7.1 LOW DISPERSION SPECTRA

By means of IUE observations of ultraviolet photometric standard stars, absolute flux calibrations may be defined as described extensively by Bohlin et al. (Reference 1). Inverse sensitivity functions S_λ^{-1} can be determined such that the absolute flux F_λ (ergs cm^{-2} sec^{-1} Å^{-1}) may be computed from the extracted IUE flux number (FN) spectra as follows:

$$F_\lambda = \frac{S_\lambda^{-1}}{t} FN_\lambda \qquad (7\text{-}1)$$

where t is the exposure time in seconds. Reference 1 contains tables of S_λ^{-1} for the LWR and SWP cameras, although the SWP function relates to the "old" SWP ITF (see Section 4.2.1). Preliminary results indicate that a new S_λ^{-1} determined using the new SWP ITF will not differ greatly from the old.

As of the present time, the actual S_λ^{-1} functions are not applied to any of the data given to the Guest Observers; all spectra appear in FN units. Those spectra which are referred to as "absolutely calibrated" in Section 8 are currently generated using dummy S_λ^{-1} functions and exposure times set to unity. It is anticipated that in the near future, the proper S_λ^{-1} functions will be available for use in the generation of the standard low dispersion GO data package.

7.2 HIGH DISPERSION SPECTRA

There are no short-term goals for determining high dispersion S_λ^{-1} functions to provide an absolute flux calibration in the high dispersion mode. Improvements to the echelle order overlap and ripple correction algorithms are required before accurate high dispersion spectrophotometry is feasible. Thus, high dispersion spectra referred to as "absolutely calibrated" are in fact at the present time still in FN units: dummy S_λ^{-1} values set to unity are used to generate these spectra currently.

SECTION 8 - GUEST OBSERVER DATA PACKAGE

8.1 OUTPUT PRODUCTS DESCRIPTION

8.1.1 Photowrite Hardcopy Images

Every IUE image which is treated by the image processing system has a photographic hardcopy generated by an Optronics Photowrite device. This device produces photographic representations in 256 descrete grey levels (i.e., in an 8-bit format) of the IUE two-dimensional spectral images on 8" x 10" film sheets, using as input magnetic tape files containing the images in digital form. The input magnetic tapes are generated by the Sigma-9 image processing computer and contain, in addition to the images themselves, ancillary information which is also transmitted to the Photowrite film and which facilitates the identification and interpretation of the images. This information includes a 16-step linear grey scale, a tick-marked border and selected lines of the IUESIPS label associated with each image. The typical Photowrite film sheet is arranged to display three images side-by-side: the raw image, the geometrically-corrected image with a wavelength-scale overlay showing the location of the registered dispersion relations, and a scaled version of the geometrically and photometrically corrected image.

The image with the wavelength scale overlay is particularly significant, in that it provides a permanent record of the placement of the analyzing slit used to extract the spectral intensity. That is, the analyzing slit follows each order centered on the dispersion relation marked by the overlay. If for any reason the dispersion relations do not adequately track the orders (for example, because of a bad geometric correction or an improper registration), the extracted intensities will be inaccurate. The overlaid image will make such circumstances immediately apparent.

The geometrically and photometrically corrected image is presented in a scaled form because the 8-bit Photowrite format will not accept the 16-bit photometrically-corrected pixel values. The scaling is done by dividing the 16-bit values by 70, so that most unsaturated pixels will fall in the 0 to 255 range. Sixteen-bit values exceeding 17850 are scaled to the value 255, and 16-bit values less than 0 are scaled to the value 0, although the 2000 FN offset discussed in Section 4.2 should suppress negative values.

In addition to the Photowrite hardcopy images generated by the image processing system, a single large-scale copy of every raw image available on a telescope operations archive tape will be produced before any computer processing is performed. This Photowrite hardcopy image is produced for quick delivery to the GO. Because it is generated prior to computer processing, this image contains none of the ancillary data such as grey scales and label data, etc., described above. Because it is generated at twice the scale of the "processed image" Photowrites, it is particularly suitable for detecting image flaws such as radiation events, "hot pixels," cosmic ray tracks, reseau marks, etc., which can affect the extracted spectral intensities. The Guest Observer is advised to examine these images carefully in this respect to avoid misinterpretation of the data.

It cannot be too strongly emphasized that Photowrite hardcopy images are in fact merely convenient visual representations of the digital data. They are by no means intended to support photometric measurements.

8.1.2 CalComp Plots

Extracted IUE spectral intensities are plotted as a function of wavelength on 10-inch full scale, continuous-roll, gridded paper by an offline CalComp plotter. These plots provide a convenient representation of the extracted spectra, but they are not intended to be the definitive data display medium, because of the inherent limitations discussed below. The primary source of reduced data remains the magnetic tape files given to each Guest Observer (see Section 8.1.3).

Low dispersion spectra are plotted at a horizontal scale of 50 Å/inch, with the vertical scaling determined automatically by the data being plotted (the maximum unsaturated extracted flux point is at least one half of the 10-inch full scale). Points which are affected by saturated pixels or reseau marks are plotted with special symbols on the basis of the associated ϵ quality measure values described in Section 6. Three separate plots are provided for each low dispersion spectrum: (1) the gross spectrum, background spectrum, and smoothed background spectrum plotted on a common axis, (2) the net spectrum (gross minus smoothed background), and (3) the common logarithm of the net spectrum. Each plot is identified by an excerpt from the IUESIPS label for the spectrum. Whenever possible, such information has been kept to a minimum to reduce plotting time. In particular, for low dispersion spectra, only the second plot (net spectrum) displays all of the image processing history records added to the image label; the first and third plots have abbreviated headers containing only the first 5 lines from the IUESIPS label.

High dispersion spectra are plotted partly at a 10 Å/inch horizontal scale, and partly at 2 Å/inch horizontal scale. As in the low dispersion case, the vertical scaling is data dependent. For high dispersion, two plots are provided: (1) the gross spectrum and the smoothed interorder spectrum, at 10 Å/inch, and (2) the net spectrum (gross minus smoothed interorder) after the correction for the echelle "ripple" function has been applied. The second plot may be at 10 Å/inch or 2 Å/inch. As is the case for low dispersion, the first plot is preceded by an abbreviated header for identification purposes.

Guest Observers are reminded that the CalComp plots are of only finite accuracy. Although new plotter hardware in use since August 1979 has increased the precision of the plots, the old plotter hardware used previously was limited to a precision of approximately ± 0.5 percent, which meant that scale or registration errors of one small grid unit (0.05 inch) could be expected over distances of 10 inches. This tolerance remains the limit of precision guaranteed in all delivered plots, although most plots generated on the new hardware will exceed this precision. As an aid to the Guest Observer in assessing the internal registration precision of each plot, special registration symbols are plotted before and after the data are plotted, as follows. Before the axes are drawn, a "+" symbol is plotted just above and to the left of the origin; after the horizontal axis is drawn, and before the paper is rewound to begin the data plotting, a second "+" symbol is plotted just above and slightly beyond the end of the horizontal axis. When the paper is rewound to the origin to start the plotting of flux points, an "×" symbol is overplotted at the location of the first "+" mark plotted. As long as registration has not been lost since the start of the axis plotting (the first "+"), a "*" symbol will result from the overplot; lost registration will result in a symbol without a unique intersection point (e.g., "*"). Similarly, a second "×" overplot is made at the location of the second "+" mark after all the flux points have been plotted. As before, a "*" symbol signifies good registration between the axis and data plotting.

8.1.3 Magnetic Tapes

Each Guest Observer is given magnetic tapes (GO tapes) containing the raw and reduced data for each of his or her images. These tapes are in 800 bytes per inch (bpi), 9-track, odd parity NRZ (No Return to Zero) format. The various files associated with each image represent the most complete rendering of the data delivered to the Guest Observer and are intended to be the primary data source for further astronomical analysis.

A summary listing of the contents of each GO tape is provided for quick reference on a Guest Observer Tape Contents sheet,[1] on which the nature of each tape file is described in coded form (raw image = ri, geometrically corrected image = gi, geometrically and photometrically corrected image = gpi, geometrically and photometrically corrected image segment = gpis, reseau-position data set = res, spatially resolved ("line-by-line") extracted low dispersion spectrum = essr, merged low dispersion extracted spectrum = eslo, and merged high dispersion

[1] It is anticipated that in the near future, the handwritten Guest Observer Tape Contents sheet will be replaced by an expanded version of the Tape Contents Summary (see Figure 8-12).

extracted spectrum = eshi.) Figure 8-1 illustrates how a typical Tape Contents sheet would appear for both low and high dispersion images. Note that the name of the processing module ("scheme" name) used for each image is also listed; a key to the scheme names and the type of processing they perform is given in Table 8-1.

In addition to the Tape Contents listings prepared for each GO tape as described above, a computer-generated printout ("Labelprint") relevant to tape contents is also provided; see Section 8.1.4.

As of July 1979, each GO tape begins with a Tape Header file identifying the inventory number of the tape. This is used for internal accounting purposes and should generally be ignored by the Guest Observer, although its format is given in Section 8.2 along with the formats for all other tape files which appear on GO tapes. The standard sequence of tape files for high and low dispersion images are as follows:

High Dispersion--3 files

1. Raw image (ri)
2. Geometrically and photometrically corrected image (gpi)
3. Merged extracted spectra, containing wavelengths, data quality flags, and fluxes for a) gross, b) interorder, c) net, and d) absolutely-calibrated;[1] ripple-corrected net spectra (eshi)

Low Dispersion (Single Aperture)--5 files

1. Raw image (ri)
2. Geometrically and photometrically corrected image (gpi)

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[1] Until suitable absolute system sensitivity functions are defined, "absolutely-calibrated" IUE spectra on GO tapes are expressed in FN units (same as other spectra); i.e., a sensitivity function of unity is applied.

Table 8-1. Key to IUESIPS Scheme Names, Input Files, Type of Processing, and Magnetic Tape Output Files (1 of 2)

STANDARD SCHEME	INPUT IMAGE TYPE	NUMBER TAPE FILES	GO TAPE OUTPUT FILE DESCRIPTION	FILE REFERENCE NAME
CRI	RAW IMAGE ("DO NOT PROCESS")	1	1. RAW IMAGE	1. RI
FDRESn OR SFDRSn	RAW FLAT FIELD	2	1. RAW IMAGE 2. FOUND RESEAU POSITIONS	1. RI 2. RES
FES	RAW FINE ERROR SENSOR (FES) IMAGE	1	1. RAW FES IMAGE	1. FES
FnH $\binom{S}{L}$ $\binom{A}{M}$ C* OR FnHEMC*	RAW TARGET, HIGH DISPERSION (S = SMALL APERTURE, L = LARGE APERTURE, E = EXTENDED SOURCE REDUCTION FOR LARGE APERTURE, A = AUTO REGISTRATION, M = MANUAL REGISTRATION)	3	1. RAW IMAGE 2. GEOMETRICALLY AND PHOTOMETRICALLY CORRECTED HALFWORD IMAGE 3. EXTERNAL-FORMAT SPECTRAL FILE WHICH MERGES FOUR SEPARATELY EXTRACTED SPECTRA: a) GROSS b) INTERORDER c) NET (GROSS MINUS SMOOTHED INTERORDER) d) RIPPLE-CORRECTED, "ABSOLUTELY-CALIBRATED" NET SPECTRUM	1. RI 2. GPI 3. ESHI
FnL $\binom{S}{L}$ $\binom{A}{M}$ C* OR FnLEMC*	RAW TARGET, LOW DISPERSION, SINGLE APERTURE (S – SMALL APERTURE, L – LARGE APERTURE, E – EXTENDED SOURCE REDUCTION FOR LARGE APERTURE, A = AUTO REGISTRATION, M – MANUAL REGISTRATION)	5	1. RAW IMAGE 2. GEOMETRICALLY AND PHOTOMETRICALLY CORRECTED HALFWORD IMAGE 3. GEOMETRICALLY AND PHOTOMETRICALLY CORRECTED HALFWORD IMAGE SEGMENT DERIVED FROM THE FULL IMAGE IN THE VICINITY OF THE SPECTRAL ORDER ("RECTIFIED IMAGE SEGMENT") 4. EXTERNAL-FORMAT SPECTRAL FILE CONTAINING THE SET OF "SPATIALLY-RESOLVED" GROSS SPECTRA. EACH SPECTRUM IS TREATED AS A SEPARATE "PSEUDO-ORDER" 5. EXTERNAL-FORMAT SPECTRAL FILE WHICH MERGES FOUR SEPARATELY-EXTRACTED SPECTRA: a) GROSS b) BACKGROUND c) NET (GROSS MINUS SMOOTHED BACKGROUND) d) "ABSOLUTELY-CALIBRATED" NET SPECTRUM	1. RI 2. GPI 3. GPIS 4. ESSR 5. ESLO

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Table 8-1. Key to IUESIPS Scheme Names, Input Files, Type of Processing, and Magnetic Tape Output Files (2 of 2)

STANDARD SCHEME	INPUT IMAGE TYPE	NUMBER TAPE FILES	GO TAPE OUTPUT FILE DESCRIPTION	FILE REFERENCE NAME
FnLB $\binom{A}{M}$ C* OR FnLXMC*	RAW TARGET, LOW DISPERSION, DOUBLE APERTURE (B = POINT-SOURCE REDUCTION FOR LARGE APERTURE, X = EXTENDED-SOURCE REDUCTION FOR LARGE APERTURE, A = AUTO REGISTRATION, M = MANUAL REGISTRATION)	8	1.–2. AS FOR FILES 1-2 OF Fn $\binom{S}{L}$ $\binom{A}{M}$ C 3.–5. SMALL APERTURE DATA, AS FOR FILES 3-5 OF Fn $\binom{S}{L}$ $\binom{A}{M}$ C 6.–8. LARGE APERTURE DATA, AS FOR FILES 3-5 OF Fn $\binom{S}{L}$ $\binom{A}{M}$ C	1. RI 2. GPI 3. GPIS 4. ESSR 5. ESLO 6. GPIS 7. ESSR 8. ESLO
FNRMRn	RAW FLAT FIELD	2	1. RAW IMAGE 2. IMAGE WITH RESEAUX REMOVED, AND GEOMETRICALLY CORRECTED	1. RI 2. RRGI
HGEOMn	RAW WAVELENGTH CALIBRATION IMAGE, HIGH DISPERSION	1	1. GEOMETRICALLY CORRECTED IMAGE	1. GI
LGEOMn	RAW FLAT FIELD + WAVELENGTH CALIBRATION IMAGE, LOW DISPERSION	2	1. FOUND RESEAU POSITIONS 2. GEOMETRICALLY CORRECTED IMAGE	1. RES 2. GI

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*THE CHARACTER "C" IN THE MARKED SCHEMES INDICATES CURRENT (STANDARD) CALIBRATION FILES IN USE; IF SPECIAL CALIBRATIONS ARE USED, THE "C" WILL BE REPLACED BY THE CHARACTER "S".

NOTE: NOT ALL SCHEMES ARE RUN ON ALL IMAGES; CONSULT GUEST OBSERVER TAPE CONTENTS SHEET.
(n = CAMERA NUMBER; n = 2 FOR LWR, n = 3 FOR SWP).

GUEST OBSERVER TAPE CONTENTS

TAPE INV. # RI7631C　　　　DENSITY 800 bpi

OBSERVER Holm - PHCAL　　　　DATE July 30, 1979

FILE	IMAGE SEQUENCE #	SCHEME USED	FILE DESCRIPTION	OBJECT
1	Tape Header	—	—	—
2	SWP 5516	F3LBAC17*	ri	BD +75° 325
3	"	"	gpi	"
4	"	"	gpis	"
5	"	"	essr	"
6	"	"	eslo	"
7	"	"	gpis	"
8	"	"	essr	"
9	"	"	eslo	"
10	LWR 4487	F2HSAC18	ri	ETA UMA
11	"	"	gpi	
12	"	"	eshi	

*The number 17 added to the standard scheme name is an arbitrarily assigned computer job number and can be ignored.

Figure 8-1. Sample Guest Observer Tape Contents Sheet

3. Geometrically and photometrically corrected image segment (gpis)

4. Spatially resolved gross spectra, containing wavelengths, data quality flags, and gross fluxes for 55 separately extracted spectra, each treated as a distinct "pseudo-order" (essr)

5. Merged extracted spectra, containing wavelengths, data quality flags, and fluxes for (a) gross, (b) background, (c) net, and (d) absolutely-calibrated[1] net spectra (eslo)

Low Dispersion (Double Aperture)--8 files

1. ri
2. gpi
3. gpis (small aperture)
4. essr (small aperture)
5. eslo (small aperture)
6. gpis (large aperture)
7. essi (large aperture)
8. eslo (large aperture)

8.1.4 Computer Listings (Labelprints)

Each Guest Observer tape is accompanied by a computer-generated listing of the IUESIPS label for each file on the tape. Such listings are called "labelprints." The IUESIPS labels are written partly in EBCDIC characters and partly in binary-integer format. They contain much documentary information pertinent to the exposure and the status of the scientific instrument. Figures 8-2 through 8-12 illustrate the appearance of the labelprint listings for a GO tape with data from one image, a double-aperture low dispersion image of the standard star BD $+75^{\circ}$ 325. Note that in printing these listings, the labels are treated as if all data were in EBCDIC format, so that those portions of the label actually in binary format are interpreted as either nonsense or undefined characters.

---

[1] Until suitable absolute system sensitivity functions are defined, "absolutely-calibrated" IUE spectra on GO tapes are expressed in FN units (same as other spectra); i.e., a sensitivity function of unity is applied.

Figure 8-2 shows the label listing for the Tape Header file which begins each GO tape. It contains the GSFC inventory number of the tape.

Figures 8-3 and 8-4 show the label listing for the second tape file which contains the raw image. The relevant areas of the label are indicated in numerical sequence, with a description key in Table 8-2.

Figure 8-5 shows the label listing for the third file on the tape, the geometrically and photometrically corrected image. Note that since the only portions of the label which change for successive files associated with a given image are the file size field in label line 1 and the image processing history lines after label line 100, lines 6-100 are suppressed in this rendering for all files but the raw image. (All label lines are physically present in the magnetic tape version of the IUESIPS labels.[1]) Table 8-3 contains the descriptive key for Figure 8-5.

Figure 8-6 shows the label listing for the fourth file on the tape, the geometrically and photometrically corrected small aperture image segment. A key is given in Table 8-4.

Figure 8-7 shows the label listing for the fifth file on the tape, the spatially resolved (line-by-line) low dispersion small aperture extracted spectrum. Note particularly the different line and sample counts (fields 1 and 2) and data type descriptor (field 3).

Figure 8-8 shows the label listing for the sixth file on the tape, the merged extracted low dispersion spectrum for small aperture. Again note the image size attributes (fields 1 and 2) and the data type descriptor.

Figures 8-9 through 8-11 show the label listings for files 7 through 9 on the tape which are the large aperture equivalents to files 4 through 6.

---

[1] A certain subset of high dispersion images obtained during the first episode have truncated labels (i.e., lines have been removed) on the magnetic tape. This is because they were processed in part on the GSFC IBM S/360 computers to offload large processing backlogs, and that system will not accept as many label records as are present in the standard IUESIPS labels.

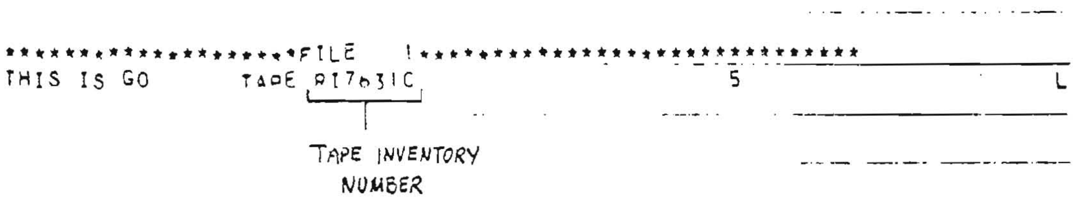

Figure 8-2. Labelprint for Tape Header File

Table 8-2. Key to Figures 8-3 and 8-4 (1 of 3)

Field No.	Contents
1	Starting line (record) no. of data file
2	Starting sample (byte) no. of data file
3	Number of lines (records) in data file
4	Number of samples (bytes per record) in data file Fields 1-4 collectively comprise the "size parameters" for the data file.
5	Camera scan step size (1-4)
6	EDS file no. (1 or 2)
7	Station flag (0 = ESA, 1 = NASA)
8	Camera no. (1 = LWP, 2 = LWR, 3 = SWP, 4 = SWR, 8 = FES1, 9 = FES2)
9	Dispersion flag (0 = high, 1 = low)
10	Image sequence no. (1-99999)
11	Running number of label line (1-150)
12	Continuation character in column 72 (C = more lines follow, L = this is last line of label)
13	SOC tape (raw image archive tape) no.
14	File no. of raw image on SOC tape
15	Total commanded exposure time (seconds). Sum of all exposures if more than one is taken
16	Guest Observer comments section
17	Event page section describing time-tagged sequence of procedures. Entries all begin with GMT time in hhmmss format. Oldest entries appear below the double blank lines. Note: SWLA = short wavelength large aperture, LWSA = long wavelength small aperture, etc.
18	Year of observation
19	GMT day of observation
20	Exposure start tag. GMT time given is near start of exposure. Format is: EXPOBC cam. no. t_{min} t_{sec} gain lamps

Table 8-2. Key to Figures 8-3 and 8-4 (2 of 3)

Field No.	Contents
21	Exposure end tag. GMT time given is near end of exposure but can be much later. Format is: FIN cam. no. T total exposure time S sec voltage V uvc voltage
22	Readprep tag. GMT time given is near start of image read. Format is: READPREP cam. no. IMAGE image sequence no.
23	Program ID
24	Category (1, 2, or 3)
25	Episode no. (1, 2, 3, . . . , etc.)
26	Observer signon name
27	Target list sequence no.
28	Catalog source (H, B, D, . . . , etc.)
29	Catalog code
30	Object name
31	Source type (0 = point, 1 = extended, 2 = invisible)
32	NASA/ESA flag (0 = NASA, 1 = ESA; cf. convention in field 7)
33	Guidance flag (1 = FES, 2 = GYRO, 3 = EPHEMERIS, 4 = MANUAL)
34	Right ascension of object: hhmmsst where t is tenths of seconds of time
35	Declination of object: ddmmss
36	Spectral type
37	Luminosity class (1-9)
38	V magnitude or flux
39	Color excess E(B-V) or color B-V
40	Estimated photon flux
41	Wavelength for flux estimate
42	Predicted exposure time
43	Predicted S/N ratio

Table 8-2. Key to Figures 8-3 and 8-4 (3 of 3)

Field No.	Contents
44	Binary section of label
45	Binary section of label
46	Image processing history section of label
47	File type descriptor
48	Name of image processing module last run on file
49	Time (Zulu, or GMT) of image processing scheme initiation
50	Continuation character "L" signifying end of label records

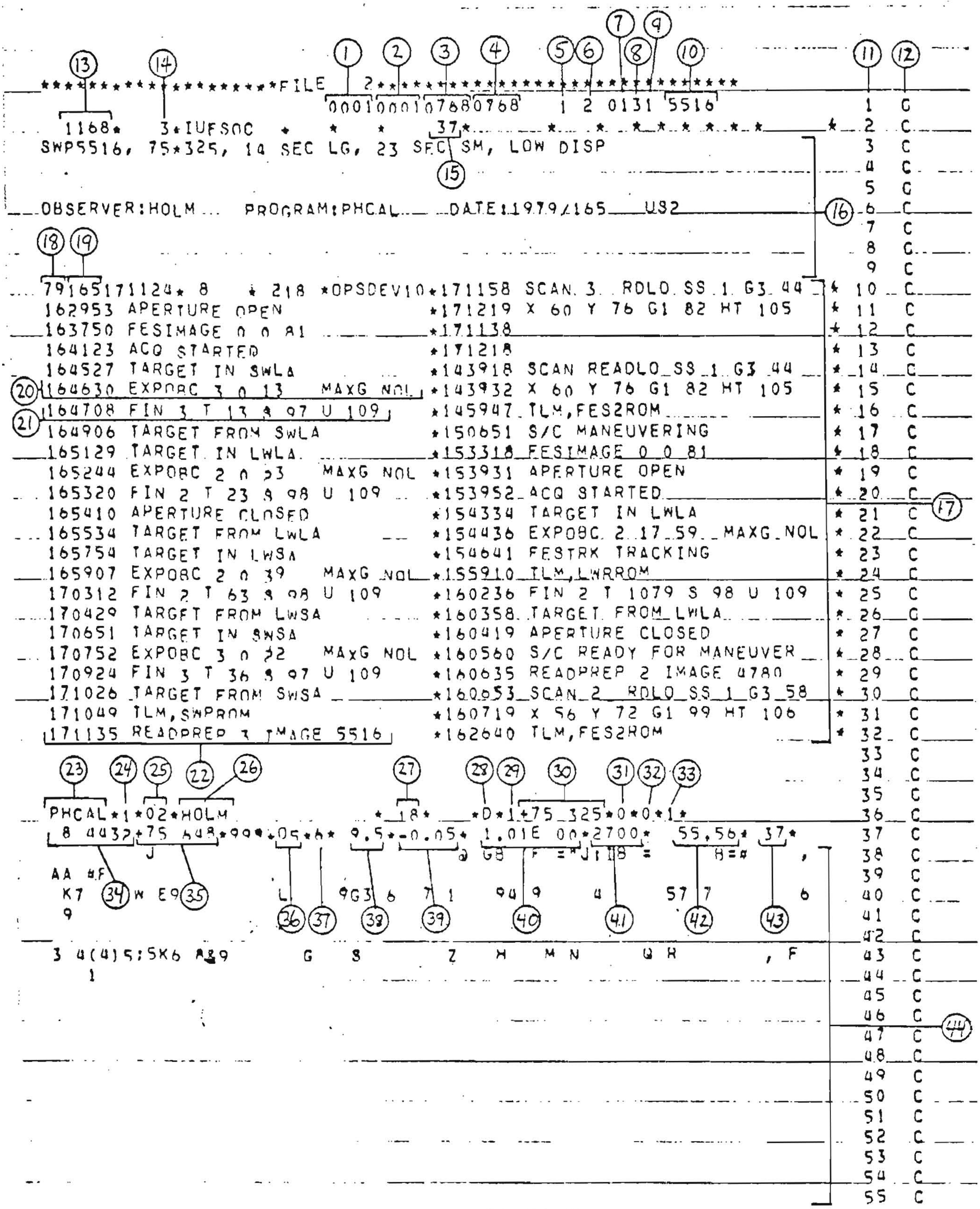

Figure 8-3. Labelprint for Raw Image File (part 1)

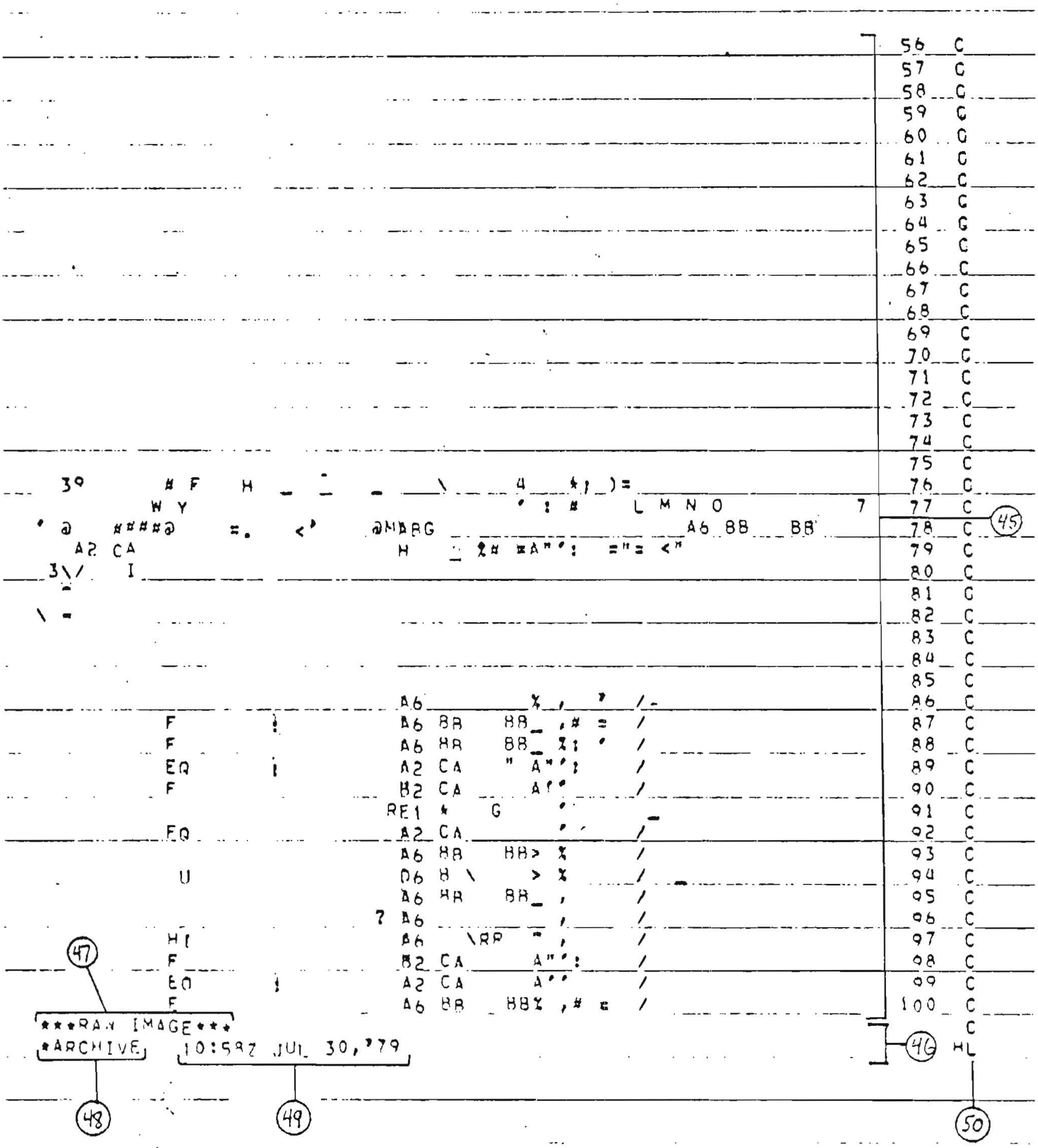

Figure 8-4. Labelprint for Raw Image File (part 2)

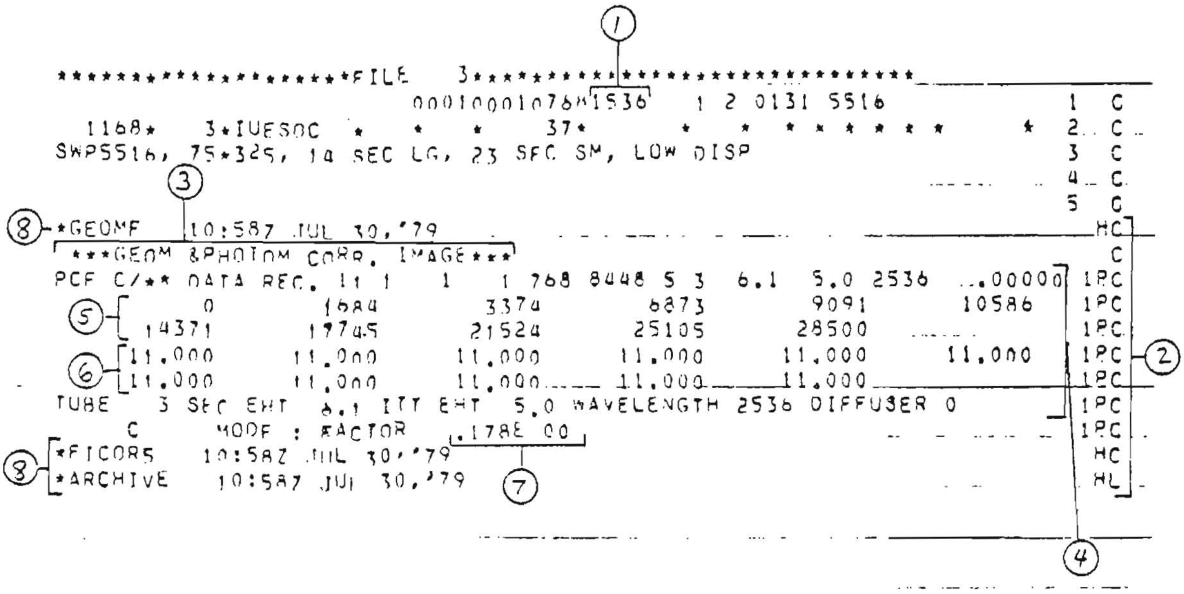

Figure 8-5. Labelprint for Geometrically and Photometrically Corrected Image

Table 8-3. Key to Figure 8-5

Field No.	Contents
1	Number of samples (bytes per record) in data file. Note change from raw image file (because of halfword data)
2	Image processing history section of label
3	File type descriptor
4	Data pertinent to ITF correction
5	Effective ITF exposure times (units = 0.01 sec)
6	ITF MULT values
7	ITF correction FACTOR value, rounded off
8	Image processing module name and time tags

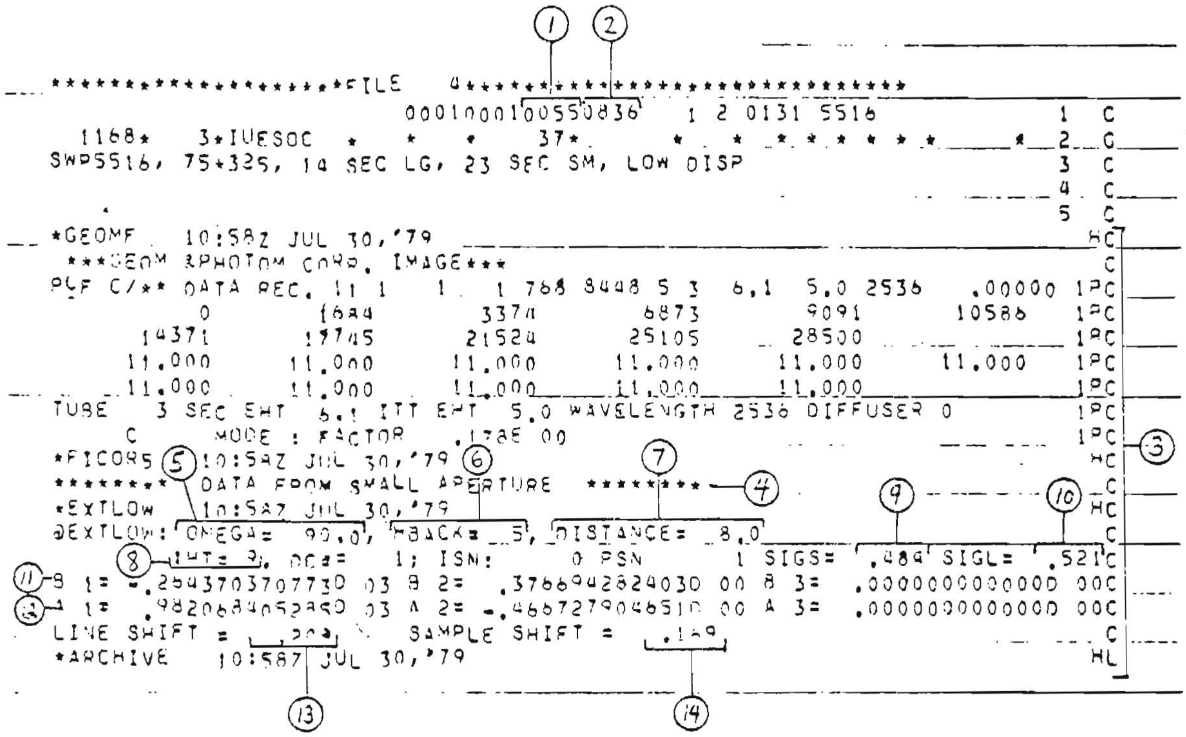

Figure 8-6. Labelprint for Geometrically and Photometrically Corrected Image Segment for Small Aperture

Table 8-4. Key to Figure 8-6

Field No.	Contents
1	Number of lines (records) in data file
2	Number of samples (bytes)
3	Image processing history section of label
4	Data source identifier
5	Value of "OMEGA" angle in low dispersion extraction (angle of line of constant wavelength assignment relative to dispersion direction)
6	Height of background extraction slit, in units of $\sqrt{2}$ pixel widths
7	Distance from dispersion line to center of background slit, in units of $\sqrt{2}$ pixel widths
8	Height of extraction slit in units of $\sqrt{2}$ pixel widths
9	Standard deviation of fitted dispersion relations in the sample direction, in pixel units
10	Standard deviation of fitted dispersion relations in the line direction, in pixel units
11	Array of B(1), B(2), . . . , etc., line-direction dispersion-constant values after registration shift. For low dispersion, LINE NO = $B(1) + B(2)\lambda$.
12	Array of A(1), A(2), . . . , etc., sample-direction dispersion-constant values after registration shift. For low dispersion, SAMPLE NO. = $A(1) + A(2)\lambda$.
13	Value of registration shift applied to fiducial B(1) value to obtain the actual value listed in field 11, in pixel units.
14	Value of registration shift applied to fiducial A(1) value to obtain the actual value listed in field 12, in pixel units.

```
                                          (1)  (2)
*********************FILE    5*****************************
                         0001000101661204   1 2 0131 5516        1 C
  1168*    3*IUFSOC  *    *    *     37*      *    * * * * * * *     *  2 C
SWP5516, 75*325, 14 SEC LG, 23 SEC SM, LOW DISP                      3 C
                                                                     4 C
                                                                     5 C
*GEOMF   10:58Z JUL 30,'79                                            HC
 ***GEOM &PHOTOM CORR. IMAGE***                                        C
PCF C/** DATA REC. 11 1    1    1 768 8448 5 3  6.1  5.0 2536   .00000 1PC
          0          1684         3374         6873         9091        10586   1PC
      14371         17745        21524        25105        28500                1PC
     11.000        11.000       11.000       11.000       11.000       11.000   1PC
     11.000        11.000       11.000       11.000       11.000                1PC
TUBE   3 SEC EHT  6.1 ITT EHT  5.0 WAVELENGTH 2536 DIFFUSER 0                   1PC
     C        MODE : FACTOR    .178E 00                                         1PC
*FICORS   10:58Z JUL 30,'79                                                      HC
*********  DATA FROM SMALL APERTURE  ********                                      C
*EXTLOW   10:58Z JUL 30,'79                                                      HC
@EXTLOW: OMEGA=  90.0, HBACK=  5, DISTANCE=  8.0                                   C
          :HT= 9, OC#=   1; ISN:      0 PSN       1 SIGS=  .484 SIGL=  .521C
B 1= -.264370370773D 03 B 2=  .376694282403D 00 B 3=  .000000000000D 00C
A 1=  .932068405285D 03 A 2= -.466727904651D 00 A 3=  .000000000000D 00C
LINE SHIFT =   .209     SAMPLE SHIFT =   .169                                     C
*ARCHIVE    10:58Z JUL 30,'79                                                    HC
*ITOE   10:58Z JUL 30,'79                                                        HC
***** LINE-BY-LINE SPECTRUM, SPATIALLY RESOLVED *****——(3)                        C
*ETOEM   10:58Z JUL 30,'79                                                       HC
*ARCHIVE   10:58Z JUL 30,'79                                                     HL
```

Figure 8-7. Labelprint for Spatially Resolved (Line-by-Line) Low Dispersion Spectral File for Small Aperture

```
                                              (1)  (2)
********************FILE     6*******************************
                                 000100010007 1204    1 2 0131 5516           1  C
  1168*    3*IUESOC  *    *    *     37*       *    *   * * * * * *      *    2  C
SWP5516, 75*325, 14 SEC LG, 23 SEC SM, LOW DISP                               3  C
                                                                              4  C
                                                                              5  C
*GEOMF    10:58Z JUL 30,'79                                                   HC
 ***GEOM &PHOTOM CORR, IMAGE***                                                C
PCF C/** DATA REC, 11 1    1    1 768 8448 5 3   6.1   5.0 2536  .00000 1PC
           0         1684         3374        6873        9091      10586   1PC
      14371         17745        21524       25105       28500              1PC
      11.000        11.000       11.000      11.000      11.000     11.000  1PC
      11.000        11.000       11.000      11.000      11.000             1PC
TUBE   3 SEC EHT   6.1 ITT EHT  5.0 WAVELENGTH 2536 DIFFUSER 0              1PC
      C      MODE : FACTOR    .1782 00                                      1PC
*FICORS    10:58Z JUL 30,'79                                                  HC
*********  DATA FROM SMALL APERTURE *********                                  C
*EXTLOW    10:58Z JUL 30,'79                                                  HC
@EXTLOW: OMEGA=  90.0, HBACK=  5, DISTANCE=  8.0                               C
          :HT= 9, DC#=    1; ISM:       0 PSN       1 SIGS=  .484 SIGL=  .521C
B 1= -.26437037077730 03 B 2=  .37669428240300 00 B 3=  .00000000000000 00C
A 1=  .98206840524850 03 A 2= -.46672790465100 00 A 3=  .00000000000000 00C
LINE SHIFT =   .209      SAMPLE SHIFT =   .159                                 C
*SMOOTH    10:58Z JUL 30,'79                                                  HC
*ARCHIVE    10:58Z JUL 30,'79                                                 HC
*ITOE     10:58Z JUL 30,'79                                                   HC
***** FILE OF MERGED EXTRACTED SPECTRA *****          ]                        C
***** GROSS, BACKGROUND, NET, & ABSOL. CALIB. NET *****]-(3)                  C
*ETOEM    10:58Z JUL 30,'79                                                   HC
*ARCHIVE    10:58Z JUL 30,'79                                                 HL
```

Figure 8-8. Labelprint for Merged Low Dispersion Extracted Spectral File for Small Aperture

```
**********************FILE    7*****************************
                              0001000100550806   1 2 0131 5516              1  C
  1168*    3*IUESOC  *   *   *    37*      *  * * * * * * * *          *  2  C
SWP5516, 75*325, 14 SEC LG, 23 SEC SM, LOW DISP                             3  C
                                                                            4  C
                                                                            5  C
*GEOMF    10:58Z JUL 30,'79                                                   HC
 ***GEOM &PHOTOM CORR. IMAGE***                                                C
PCF C/** DATA REC. 11 1   1   1 768 8448 5 3  6.1  5.0 2536   .00000 1PC
          0         1684       3374       6873       9091      10586   1PC
      14371        17745      21524      25105      28500              1PC
     11.000       11.000     11.000     11.000     11.000     11.000   1PC
     11.000       11.000     11.000     11.000     11.000              1PC
TUBE   3 SEC EHT  6.1 ITT EHT  5.0 WAVELENGTH 2536 DIFFUSER 0          1PC
    C       MODE : FACTOR    .178E 00                                  1PC
*FICORS   10:58Z JUL 30,'79                                               HC
********  DATA FROM LARGE APERTURE ********                                C
*EXTLOW   10:58Z JUL 30,'79                                               HC
@EXTLOW: OMEGA=  90.0, HBACK= 5, DISTANCE= 11.0                            C
        :HT= 9, DC#=   1; ISN:      0 PSN      1 SIGS=  .484 SIGL=  .521C
B 1= -.2840738244930 03 B 2=  .3766942824030 00 B 3=  .0000000000000 00C
A 1=  .9653085180010 03 A 2= -.4667279046510 00 A 3=  .0000000000000 00C
LINE SHIFT =   .506     SAMPLE SHIFT =   .409                              C
*ARCHIVE   10:58Z JUL 30,'79                                              HL
```

Figure 8-9. Labelprint for Geometrically and Photometrically Corrected Image Segment for Large Aperture

```
*************************FILE    8*******************************
                    0001000101661204   1 2 0131 5516                  1  C
  1104*    3*IUESOC   *     *     *     37*       *     * * * * * * * *    *   2  C
SWP5516, 75*325, 14 SEC LG, 23 SEC SM, LOW DISP                        3  C
                                                                       4  C
                                                                       5  C
*GEOMF     10:58Z JUL 30,'79                                            HC
 ***GEOM 3PHOTOM CORR, IMAGE***                                          C
PCF C/** DATA REC. 11 1    1    1 768 8448 5 3  6.1  5.0 2536   .00000 1PC
        0         1084        3374        6873        9091       10586  1PC
    14371        17745       21524       25105       28500              1PC
   11.000       11.000      11.000      11.000      11.000      11.000  1PC
   11.000       11.000      11.000      11.000      11.000              1PC
TUBE    3 SEC EHT  6.1 ITT EHT  5.0 WAVELENGTH 2536 DIFFUSER 0          1PC
     C       MODE : FACTOR    .178E 00                                  1PC
*FICOR5    10:58Z JUL 30,'79                                            HC
*********  DATA FROM LARGE APERTURE  ********                            C
*EXTLOW    10:58Z JUL 30,'79                                            HC
@EXTLOW: OMEGA=  90.0, HBACK=  5, DISTANCE= 11.0                         C
       IHT= 9, DC#=   1; ISN:      0 PSN        1 SIGS=  .484 SIGL=  .521C
B 1= -.28407382449930 03 B 2=  .37669428240030 00 B 3=  .0000000000000 00C
A 1=  .96530851890010 03 A 2= -.44672790465510 00 A 3=  .0000000000000 00C
LINE SHIFT =    .506      SAMPLE SHIFT =    .409                         C
*ARCHIVE    10:58Z JUL 30,'79                                           HC
*ITOF    10:58Z JUL 30,'79                                              HC
***** LINE-BY-LINE SPECTRUM, SPATIALLY RESOLVED ****                     C
*ETCEM    10:58Z JUL 30,'79                                             HC
*ARCHIVE    10:58Z JUL 30,'79                                           HL
```

Figure 8-10. Labelprint for Spatially Resolved (Line-by-Line) Low Dispersion Spectral File for Large Aperture

```
*************************FILE    9******************************
                         000100010007120 4   1 2 0131 5516            1  C
  1168*   3*IUESOC   *    *    *     37*      *    *  * * *  * * *   *  2  C
SWP5516, 75*325, 10 SEC LG, 23 SEC SM, LOW DISP                       3  C
                                                                      4  C
                                                                      5  C
*GEOMF     10:587 JUL 30,'79                                            HC
 ***GEOM &PHOTOM CORR. IMAGE***                                          C
PCF C/** DATA REC. 11 1    1    1 768 8448 S 3  6.1  5.0 2536  ..00000 1PC
        0         1684        3374        6873        9091      10586  1PC
    14371        17745       21524       25105       28500             1PC
   11.000       11.000      11.000      11.000      11.000     11.000  1PC
   11.000       11.000      11.000      11.000      11.000             1PC
TUBE   3 SEC EHT  6.1 ITT EHT  5.0 WAVELENGTH 2536 DIFFUSER 0          1PC
     C      MODE : FACTOR    .178E 00                                  1PC
*FICORS    10:587 JUL 30,'79                                            HC
*********  DATA FROM LARGE APERTURE  ********                            C
*EXTLOW    10:587 JUL 30,'79                                            HC
9EXTLOW: OMEGA=  90.0, HBACK=  5, DISTANCE= 11.0                         C
        IHT= 9, NCB=   1: ISN:      0 PSN       1 SIGS=  .484 SIGL=  .521C
B 1= -.2840738244930 03 B 2=  .3706942824030 00 B 3=  .0000000000000 00C
A 1=  .9653085189010 03 A 2= -.4667279046510 00 A 3=  .0000000000000 00C
LINE SHIFT =   .504     SAMPLE SHIFT =   .409                            C
*SMOOTH    10:587 JUL 30,'79                                            HC
*ARCHIVE   10:587 JUL 30,'79                                            HC
*ITOE     10:587 JUL 30,'79                                             HC
***** FILE OF MERGED EXTRACTED SPECTRA *****                             C
*** GROSS2, BACKGROUND, NET, & ABSOL. CALIB. NET ***                     C
*ETOEM     10:587 JUL 30,'79                                            HC
*ARCHIVE    10:587 JUL 30,'79                                           HL
```

Figure 8-11. Labelprint for Merged Low Dispersion Extracted Spectral File for Large Aperture

Figure 8-12 illustrates the tape contents summary listing which comprises the last page of each labelprint. The summary lists all files on the tape, with the files separated by image number. Table 8-5 provides the key to the fields enumerated in the figure.

Note that the data in field 1 of Figure 8-12 provides information otherwise unavailable to the Guest Observer except by actually reading the tape and searching for label records. Prior knowledge of this data is of particular convenience to Guest Observers using Control Data Corporation (CDC) computers to read their GO tapes.

8.2 MAGNETIC TAPE FILE FORMATS

As is apparent from the discussions Sections 3.1 and 8.1, each output file generated by IUESIPS consists of a set of label records followed by a set of data records. Schematically, a GO tape consists of series of files shown in Figure 8-13. For the ith file, the number of label records, N_i, the number of data records, M_i, and the length in bytes of each data record, B_i, all depend on the type of data in the file. The detailed label and data formats for each type of file which might appear on GO tapes are given in Sections 8.2.1 and 8.2.2.

8.2.1 Label Records

8.2.1.1 Normal Labels

Normal IUESIPS file labels consist of between 20 and 30 physical tape records. Each physical record is 360 bytes in length (one byte = 8 binary bits), being a concatenation of 5 logical records each 72 bytes long. A 72-byte logical record corresponds to one line in the labelprint listing described in Section 8.1.4. Thus, lines in the image label are blocked 5 at a time to form 360-byte physical records (blocks) on tape.

Raw image labels are 20 physical records (blocks) long. As the image proceeds through the processing system, additional label information is appended. one

SUMMARY OF TAPE CONTENTS.

FILE	IMAGE	RECORD NUMBERS		RECORD LENGTHS		NUMBER OF ERRORS
1	TAPE HDR	1	0	360	0	0
2	SWP 5516	21	768	360	768	0
3	SWP 5516	23	768	360	1536	0
4	SWP 5516	24	55	360	236	0
5	SWP 5516	25	166	360	1204	0
6	SWP 5516	25	7	360	1204	0
7	SWP 5516	24	55	360	806	0
8	SWP 5516	25	166	360	1204	0
9	SWP 5516	25	7	360	1204	0

STOP 0

IRADEDIT
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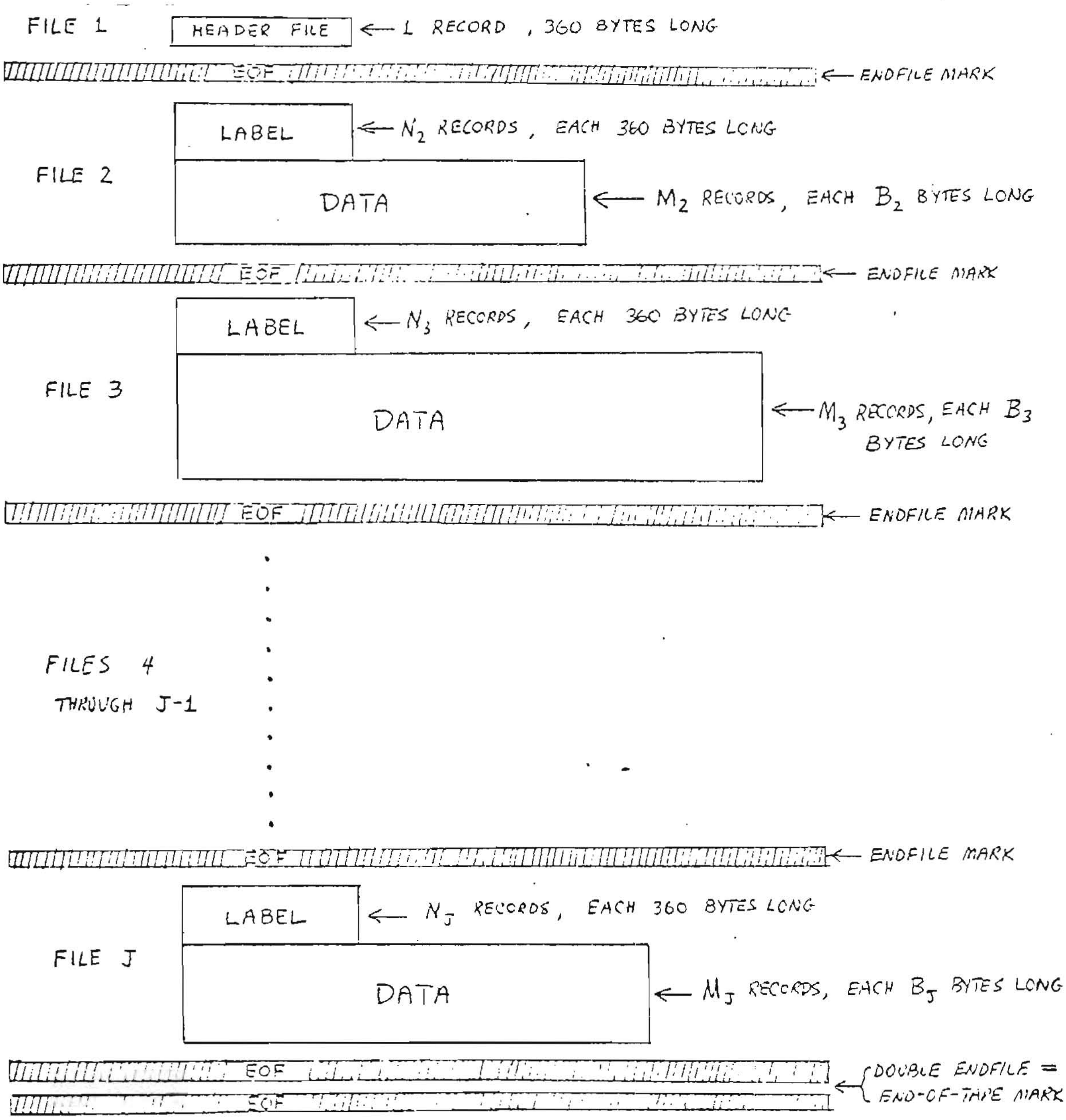
Figure 8-12. Tape Contents Summary (Last Page of Labelprint Listing)

Table 8-5. Key to Figure 8-12

Field No.	Contents
1	The number of physical records in the label portion of the file
2	The length in bytes of each physical record in label. Any number ≠ 360 is indicative of an error condition
3	The number of physical records in the data portion of the file
4	The length in bytes of each physical record in the data portion of the file
5	The number of irrecoverable read errors encountered within each file as the tape was read back to produce labelprint
6	Normal tape termination messages



NOTE
- N_i, M_i, B_i VALUES ARE FILE-TYPE DEPENDENT ($i = 2, J$)
- $20 \leq N_i \leq 30$ EXCEPT FOR TAPE HEADER FILE ($N_1 = 1$) AND RESEARCH - POSITION FILE ($N_i = 1$)

Figure 8-13. Schematic GO Tape Structure block at a time. Since the information added at any given step may or may not fill one or more entire block(s), a continuation character at the end of each logical record is used to flag the end of the label as follows. If any logical record is followed by at least one other, the EBCDIC character "C" is placed in byte no. 72 of that logical record to signify a continuation. The last logical record of the whole label contains the EBCDIC character "L" in byte no. 72. (The labelprint listings in Section 8.1.4 illustrate this point.) Note that the end-of-label flag need not occur on a block boundary; any logical records which appear after the "L" in the last block are undefined (they generally contain core garbage). The overall label-record structure is shown in Figure 8-14.

As explained in Section 8.1.4, the label records are in a mixture of EBCDIC and binary-integer formats (see Figure 8-3). Observers using computers with non-EBCDIC printers (e.g., ASCII) are reminded that an input character format conversion will be required to display the EBCDIC portions correctly.

8.2.2.2. Nonstandard Labels

Two special types of files have nonstandard labels: (1) The Tape Header file which begins each GO tape has only 1 block, of which only the first logical record is filled; see Figure 8-2 in Section 8.1.4. All information is in EBCDIC format. Note that the Tape Header File label has no "size parameters" field as all other labels do. (Note further that the Tape Header File has no data records.) (2) Reseau-position files generated from calibration images have only 1 block in their labels. Unlike the Tape Header file labels, however, reseau-position labels do have the standard size parameters in the first logical record, and generally one or more other logical records are present containing free-form identification information for the source of the reseau data.

8.2.2 Data Records

The length, number, and format of the records in the data portion of each file depend on the file type and are described below. In all files, the data records

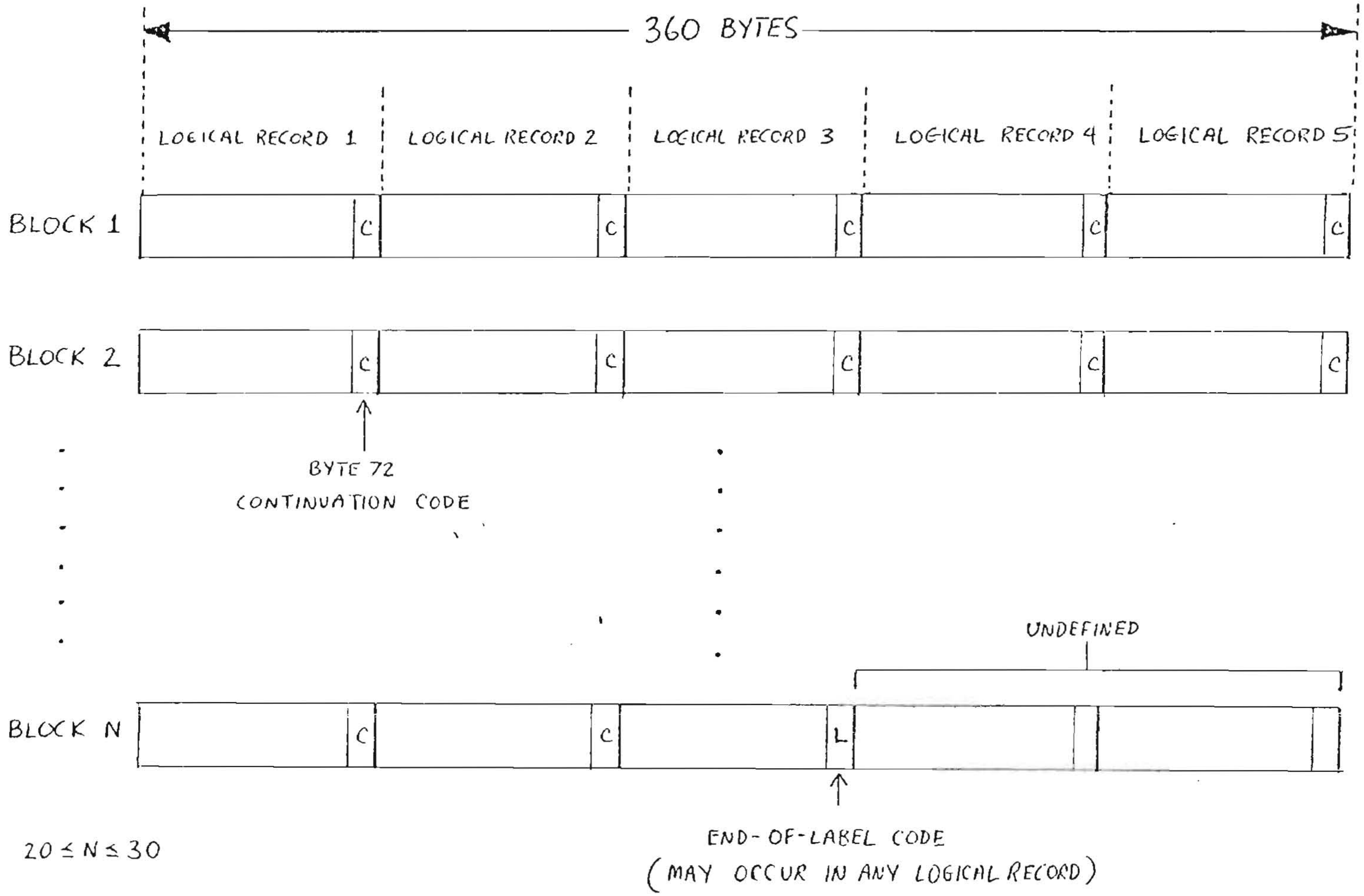


Figure 8-14. Standard IUESIPS Label Record Structure

are unblocked, i.e., logical record = physical record. Except for reseau-position files, all entries are binary integer quantities, in either one-byte or two-byte format.

8.2.2.1 Raw Images or Geometrically Corrected Images

There are 768 physical records, each containing the pixel values along one scan line of the image. Each record is 768 bytes long; each pixel value is represented by one 8-bit byte (range 0-255). See Figure 8-15(a).

8.2.2.2 Geometrically-and-Photometrically Corrected Images

There are 768 physical records, each containing the pixel values along one scan line of the image. Each record is 1536 bytes long; each pixel value is represented by two 8-bit bytes, i.e., one halfword binary integer (range ± 32767, with negatives represented in two's-complement form). See Figure 8-15(b).

8.2.2.3 Geometrically-and-Photometrically Corrected Image Segments

There are 55 physical records, each containing the pixel values along one line of the image segment. Each record is of length 2B bytes, where each of B pixel values is represented by two 8-bit bytes (range ±32767, with negatives in two's-complement form). B depends on which camera and aperture are used, but is always of the order of 400. The precise value of 2B may be read from the label size parameters (field no. 2 in Figure 8-6). See Figure 8-15(c).

8.2.2.4 Fine Error Sensor (FES) Images

There are M physical records, each containing the FES pixel values along one scan line of the FES image. Each record is 2M bytes long; each pixel value is represented by two 8-bit bytes (range ± 32767, with negatives in two's-complement form). M is determined by the telescope operations procedures. See Figure 8-15(d).

8.2.2.5 Reseau-Position Data Sets

There are 4 physical records, each of which is 1400 bytes long. The data represented are the precise locations of reseaux output from the program FNDRES.

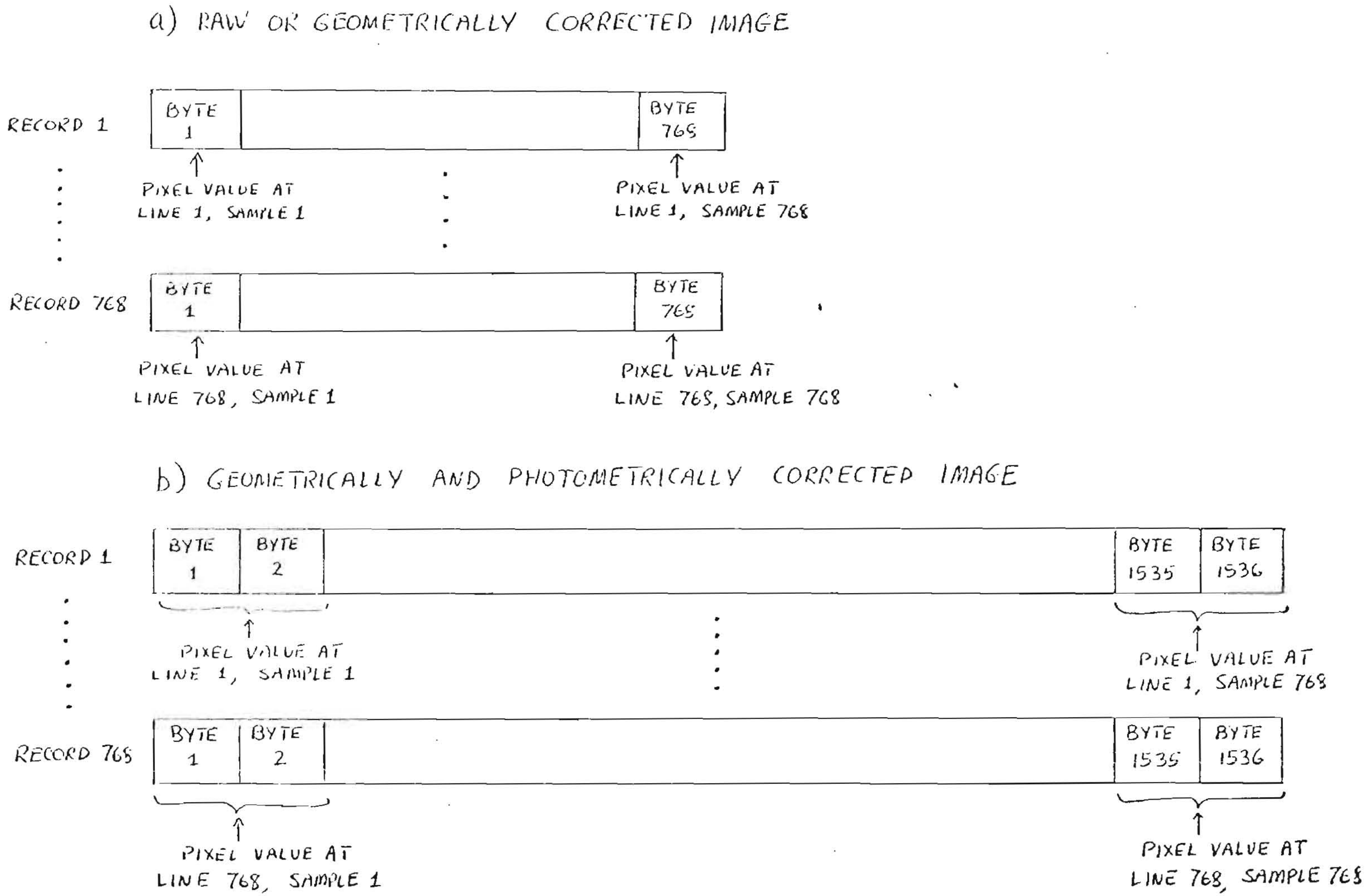


Figure 8-15 (a,b). Data Record Structures

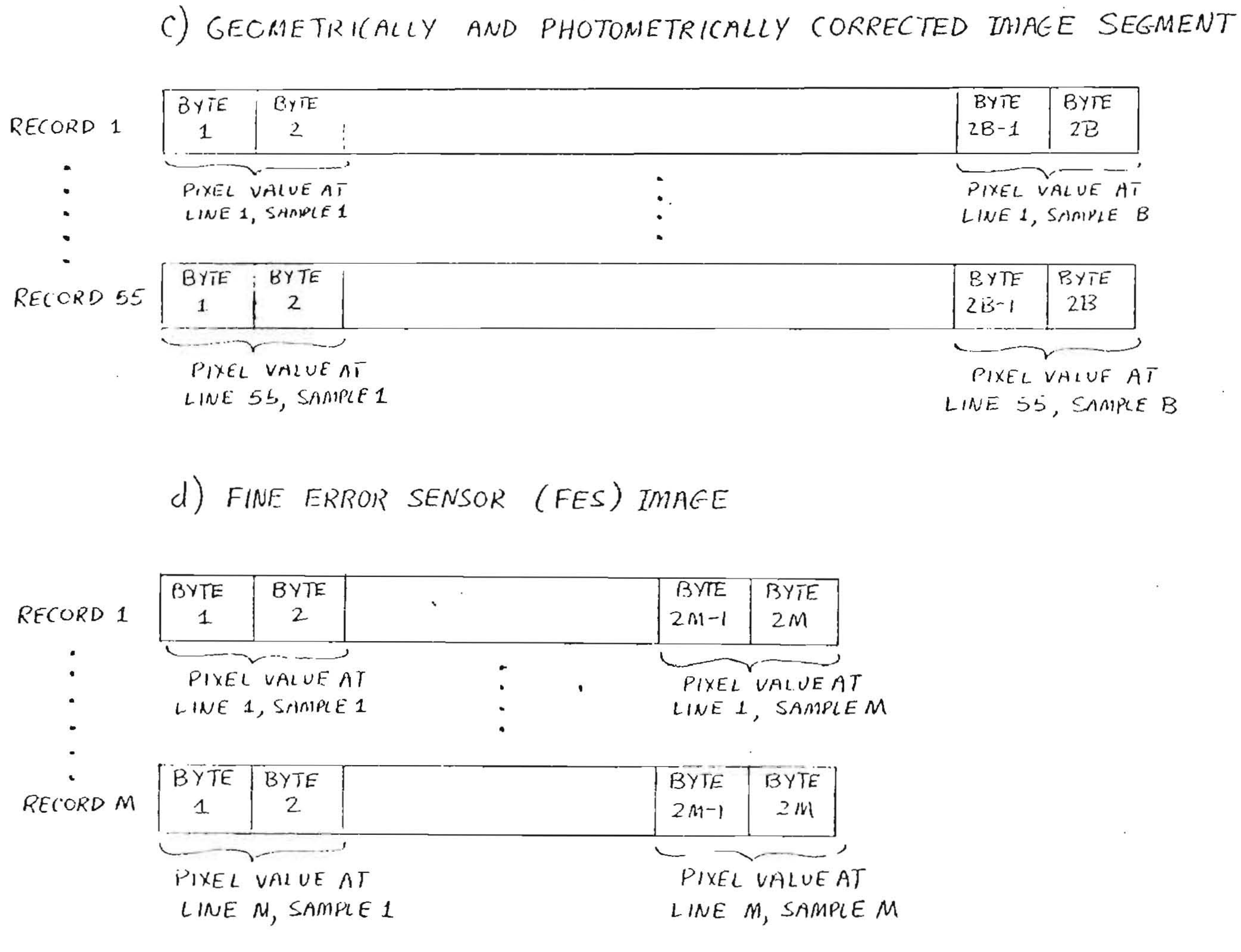


Figure 8-15 (c,d). Data Record Structures

A data set for camera n (n = 1, 2, 3, or 4) has blanks in all records except the nth, which contains the line and sample coordinates, in pairs of real numbers for each reseau mark, beginning at the upper left of the camera faceplate and proceeding left to right by rows. Each coordinate is written as a positive full-word (4-byte) floating point number (R*4). Since each line and sample coordinate pair thus occupies 8 bytes the number of bytes containing meaningful data in the nth record is 8 times the number of reseau marks identified; remaining bytes out to 1400 are zeroed out. See Figure 8-15(e) where a camera 3 (SWP) reseau set is illustrated, assuming a total of N reseau marks are identified.

8.2.2.6 Extracted Spectra

The number of records depends on which type of extracted spectrum is involved: (1) low dispersion spatially resolved spectrum, (2) low dispersion merged spectrum, or (3) high dispersion merged spectrum. The details for each case are given separately below, but there are also several elements common to all three:

1. All records are 1204 bytes long. As each entry is a two-byte or 16-bit halfword integer (range ± 32767, with negatives in two's complement form), there are 602 entries per record. The first entry (halfword) of each record is a record sequence number; the second entry is a count of the number of filled entries for that record.

2. The first record is a scale-factor record containing data pertinent to all following records. The contents of and explanation for this record are given in Table 8-6.

3. The remaining records containing the actual spectral data are arranged in groups. There is one group for every order (or pseudo-order in the case of low dispersion spatially-resolved spectra).

e) RESEAU - POSITION DATA SET (N RESEAU MARKS, CAMERA 3)

RECORD 1 (ALL BYTES ZEROED OUT)

BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7	BYTE 8	....	BYTE 8N	BYTE 8N+1	.....	BYTE 1400

RECORD 2 (ALL BYTES ZEROED OUT)

BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7	BYTE 8	....	BYTE 8N	BYTE 8N+1	.....	BYTE 1400

RECORD 3 (CAMERA 3 RESEAUX)

BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7	BYTE 8	.... etc.	BYTE 8N	BYTE 8N+1	.... etc.	BYTE 1400

Bytes 1–4: LINE COORDINATE (R*4) FOR RESEAU MARK NO. 1

Bytes 5–8: SAMPLE COORDINATE (R*4) FOR RESEAU MARK NO. 1

Byte 8N: LAST BYTE FILLED FOR N RESEAU MARKS

Bytes 8N+1 – 1400: ZEROED OUT

RECORD 4 (ALL BYTES ZEROED OUT)

BYTE 1	BYTE 2	BYTE 3	BYTE 4	BYTE 5	BYTE 6	BYTE 7	BYTE 8	....	BYTE 8N	BYTE 8N+1	....	BYTE 1400

Figure 8-15 (e). Data Record Structures

4. Within each group, the first record contains the scaled wavelengths $\underline{L}_i$ for each point extracted within that order. The second record contains the data quality flag ϵ_i for each point. The third record contains the scaled fluxes I_i for each point in the first spectrum extracted for that order. If more spectra for that order are being merged (example: the background, net, and calibrated net spectra may be merged with the gross spectrum), there is one additional record of scaled flux points for each spectrum merged.

5. The scaling operations needed to convert the scaled flux and wavelength entries to their true floating-point values are as follows:

$$F_i = I_i * J * 2^{-K} \qquad (8\text{-}1)$$

where F_i = floating point flux for i^{th} point (in FN), I_i = the corresponding integer flux, and J and K are scaling constants pertinent to all orders of that particular spectrum (i.e., gross, background, or net, etc.). J and K are contained within the scale-factor record: see Table 8-6.

$$\lambda_i = \lambda_o + UNIT * L_i \qquad (8\text{-}2)$$

where λ_i = true wavelength of i^{th} point (in Å), L_i = scaled integer wavelength for i^{th} point, UNIT = 0.002 Å for high dispersion and 0.2 Å for low dispersion, and λ_o is an order-dependent offset wavelength given for each order in the scale factor record. If high dispersion, λ_o is largest integer value less than or equal to actual wavelength of first data point in that order; if low dispersion, $\lambda_o = 0$.

Figures 8-16 through 8-18 describe the data record structure for the three file types referred to above.

Table 8-6. Scale Factor Record (First Data Record in Extracted-Spectrum File)

Halfword no.	Contents
1	Record count (≡ 0 for this record)
2	Data entry count (≡ 600 for this record)
3	λ_{min} (nearest Å) of whole spectrum
4	λ_{max} (nearest Å) of whole spectrum
5	NORDER, the number of orders (or pseudo-orders) present
6	Camera number
7	Image number
8	Number of records per group (i.e., per order)
9-20	Spare (zero filled)
21	I_{min} } for first extracted spectrum
22	I_{max} } for first extracted spectrum
23	J } for first extracted spectrum
24	K } for first extracted spectrum
25-28	(I_{min}, I_{max}, J, K) for second extracted spectrum, if any. (If none, zero filled.)
29-56	Sets of (I_{min}, I_{max}, J, K) for additional spectra, if present. (If none, zero filled.)
57-102	Spare (zero filled)
103-(102 + NORDER)	λ_0 (offset wavelength) for each order (or pseudo-order) present.
(103 + NORDER)-202	Spare (zero filled)
203-(202 + NORDER)	M (order number) for each order (or pseudo-order) present.
(203 + NORDER)-302	Spare (zero filled)
303-(302 + NORDER)	Number of extracted points in each order (or pseudo-order) present.
(303 + NORDER)-602	Spare (zero filled)

1204 BYTES

		HALFWORD 1	HALFWORD 2	HALFWORD 3	HALFWORD 4	HALFWORD 5	HALFWORD 6	. . . . .	HALFWORD 602	
	RECORD 1	0	600	λ_{min}	λ_{max}	CAM. NO.	IMAGE NO.	etc	0	SCALE RECORD
"ORDER" 73	RECORD 2	1	NO. POINTS	L_1	L_2	L_3	L_4	etc	0	SCALED λ's
	RECORD 3	2	NO. POINTS	ϵ_1	ϵ_2	ϵ_3	ϵ_4	etc . . .	0	ϵ's
	RECORD 4	3	NO. POINTS	I_1	I_2	I_3	I_4	etc	0	SCALED FLUXES
"ORDER" 74	RECORD 5	4	NO. POINTS	L_1	L_2	L_3	L_4	etc	0	SCALED λ's
	RECORD 6	5	NO. POINTS	ϵ_1	ϵ_2	ϵ_3	ϵ_4	etc	0	ϵ's
	RECORD 7	6	NO. POINTS	I_1	I_2	I_3	I_4	etc	0	SCALED FLUXES
	⋮					⋮			⋮	
"ORDER" 127	RECORD 164	163	NO. POINTS	L_1	L_2	L_3	L_4	etc	0	SCALED λ's
	RECORD 165	164	NO. POINTS	ϵ_1	ϵ_2	ϵ_3	ϵ_4	etc	0	ϵ's
	RECORD 166	165	NO. POINTS	I_1	I_2	I_3	I_4	etc	0	SCALED FLUXES

NOTE
- THE 55 PSEUDO-ORDERS ARE "ORDERS" 73 – 127 HERE. EACH IS ONE SCAN.
- WITHIN EACH "ORDER", THE L_i, ϵ_i, I_i, & NO. POINTS REFER TO DATA FOR THAT "ORDER".
- WITHIN EACH "ORDER", THE CORRESPONDING L_i, ϵ_i, I_i VALUES ARE FOUND IN THE SAME HALF WORD OF SUCCESSIVE RECORDS.

Figure 8-16. Data Record Structure for Spatially Resolved Low Dispersion Spectrum

1204 BYTES

	HALFWORD 1	HALFWORD 2	HALFWORD 3	HALFWORD 4	HALFWORD 5	HALFWORD 6	......	HALFWORD 602	
RECORD 1	0	600	λ_{min}	λ_{max}	CAM. NO.	IMAGE NO.	etc		SCALE RECORD
RECORD 2	1	NO. POINTS	L_1	L_2	L_3	L_4	etc		SCALED λ's
RECORD 3	2	NO. POINTS	ϵ_1	ϵ_2	ϵ_3	ϵ_4	etc		ϵ's
RECORD 4	3	NO. POINTS	G_1	G_2	G_3	G_4	etc		SCALED GROSS
RECORD 5	4	NO. POINTS	B_1	B_2	B_3	B_4	etc		SCALED BKGD
RECORD 6	5	NO. POINTS	N_1	N_2	N_3	N_4	etc		SCALED NET
RECORD 7	6	NO. POINTS	A_1	A_2	A_3	A_4	etc		SCALED ABNET

NOTE
- G_i = i^{th} SCALED GROSS FLUX
- B_i = i^{th} SCALED BACKGROUND FLUX (BKGD)
- N_i = i^{th} SCALED NET FLUX
- A_i = i^{th} SCALED ABSOLUTELY CALIBRATED NET FLUX (ABNET)

Figure 8-17. Data Record Structure for Merged Low Dispersion Spectra

1204 BYTES

Order	Record	HALFWORD 1	HALFWORD 2	HALFWORD 3	HALFWORD 4	HALFWORD 5	HALFWORD 6	.....	HALFWORD 602	
	RECORD 1	0	600	λ_{min}	λ_{max}	CAM. NO.	IMAGE NO.	etc	0	SCALE RECORD
ORDER 125	RECORD 2	1	NO. POINTS	L_1	L_2	L_3	L_4	etc		SCALED λ's
	RECORD 3	2	NO. POINTS	ϵ_1	ϵ_2	ϵ_3	ϵ_4	etc		ε's
	RECORD 4	3	NO. POINTS	G_1	G_2	G_3	G_4	etc		SCALED GROSS
	RECORD 5	4	NO. POINTS	I_1	I_2	I_3	I_4	etc		SCALED INTERORDER
	RECORD 6	5	NO. POINTS	N_1	N_2	N_3	N_4	etc		SCALED NET
	RECORD 7	6	NO. POINTS	A_1	A_2	A_3	A_4	etc		SCALED ABRNET
	⋮	⋮				⋮			⋮	
ORDER M	RECORD R-5	R-6	NO. POINTS	L_1	L_2	L_3	L_4	etc		SCALED λ's
	RECORD R-4	R-5	NO. POINTS	ϵ_1	ϵ_2	ϵ_3	ϵ_4	etc		ε's
	RECORD R-3	R-4	NO. POINTS	G_1	G_2	G_3	G_4	etc		SCALED GROSS
	RECORD R-2	R-3	NO. POINTS	I_1	I_2	I_3	I_4	etc		SCALED INTERORDER
	RECORD R-1	R-2	NO. POINTS	N_1	N_2	N_3	N_4	etc		SCALED NET
	RECORD R	R-1	NO. POINTS	A_1	A_2	A_3	A_4	etc		SCALED ABRNET

NOTE
- G_i = i^{th} SCALED GROSS FLUX (IN EACH GIVEN ECHELLE ORDER)
- I_i = i^{th} SCALED INTERORDER FLUX (IN EACH GIVEN ECHELLE ORDER)
- N_i = i^{th} SCALED NET FLUX (IN EACH GIVEN ECHELLE ORDER)
- A_i = i^{th} SCALED ABSOLUTELY CALIBRATED, RIPPLE CORRECTED NET FLUX, ABRNET (IN EACH GIVEN ECHELLE ORDER)
- NO. POINTS = NO. OF EXTRACTED DATA POINTS (IN EACH GIVEN ECHELLE ORDER)

M = { 66 (SWP), 72 (LWR) }

R = { 361 (SWP), 325 (LWR) }

Figure 8-18. Data Record Structure for Merged High Dispersion Spectra

SECTION 9 - IMAGE PROCESSING SYSTEM MODIFICATIONS

In this section are listed in chronological order the modifications to IUESIPS which have had an affect on the output products comprising the GO Data Package at GSFC. Table 9-1 lists the effective date of each modification along with a brief explanation of its nature.

Table 9-1. Chronology of Modification to IUESIPS Output Products (1 of 4)

Date	Modification
7 April 1978	• Eliminate auto-scaling of net ripple-corrected CalComp plot (set $F_{MAX} = 10^5$)
20 April 1978	• Extend SWP low dispersion extraction to $\lambda = 2000$ Å
25 April 1978	• Change F_{MAX} to 2×10^5 for net ripple-corrected plot
4 May 1978	• Add processing dates to CalComp plots
8 May 1978	• Eliminate "CUTMERGE" step from high dispersion processing
10 May 1978	• Eliminate plot of unsmoothed background in high dispersion
15 May 1978	• Determine dispersion relations via new "WAVECAL2" (uses fractional pixel locations)
18 May 1978	• Correct 1-pixel error in "OSCRIBE" overlay program
22 May 1978	• Use new averaged ITFs (contains SWP error; see 7 July 1979)
	• Use "EXTLOW" for low dispersion extraction instead of "COMPARE"
	• Accomplish registration by shifting dispersion constants instead of image
	• Correct 2-pixel error in reseau flagging
	• Flag "saturated pixels" (DN = 255) in plots, and change to plotting without lifting pen
1 June 1978	• Improve reseau flagging in smoothed spectra
9 June 1978	• Use reseaux measured on low dispersion image for both low and high dispersion wavelength calibrations (SWP)
16 June 1978	• Delete 55-line image segment from photowrites (low dispersion)

Table 9-1. Chronology of Modification to IUESIPS Output Products (2 of 4)

Date	Modification
20 June 1978	• Produce one doubly-oscribed photowrite image for the double-aperture case, instead of 2 singly-oscribed images • Change LWR high dispersion oscribe overlay to pass through order 83 (MgII 2795, 2803)
1 July 1978	• Use reseaux measured on low dispersion image for both low and high dispersion wavelength calibrations (LWR)
6 July 1978	• Create all oscribes on "GEOM'D" images (not photometrically corrected images) • Change LWR ripple parameters to K = 231,150 A = 0.09 instead of K = 231,300 A = 0.08
1 August 1978	• Create "extended source" reduction capability in low dispersion (HT = 15, DIST = 11)
4 August 1978	• Change IUEPLOT to streamline x-axis and plot key to symbols used
8 August 1978	• Correct bug in "ETOEM" to transmit image number to extracted spectrum files
9 August 1978	• Begin using improved low dispersion wavelength calibration line libraries
15 August 1978	• Change standard LWR pixel offsets to transfer dispersion relations from small-to-large aperture as follows: ΔS = -17.5 samples, ΔL = -19.5 lines replaces ΔS = -21.1 samples, ΔL = -25.1 lines
17 August 1978	• For "extended source" reduction, change min and max plotted fluxes for "log net" to 3.0 and 6.0 (replacing 2.0 and 5.0)
9 September 1978	• Begin using automatic order-finding software (DSPCON), where possible, to determine thermal registration

Table 9-1. Chronology of Modification to IUESIPS Output Products (3 of 4)

Date	Modification
25 September 1978	• Move background location to "DIST = 11" for low dispersion "point-source" reductions in large aperture (e.g., suppress geocoronal Lyα)
9 November 1978	• 2 A/inch high dispersion CalComp eliminated except by special authorization
10 December 1978	• Photometrically correct only a circular region of image ("FICOR5") in SWP high and low dispersion, LWR low dispersion
13 December 1978	• Change "EXTLOW" to write "omega", "hback", "distance", and (in the case of auto registration) the line & sample shift values into the labels of extracted spectra
	• Change "DATEXTH2" to write line & sample shifts into label in auto registration case
19 December 1978	• Eliminate processing of order 65 in SWP high dispersion
3 January 1979	• Photometrically correct only a circular region of image ("FICOR 5") in LWR high dispersion (FICOR 5 now used throughout)
30 March 1979	• 10 Å/inch high dispersion CalComp eliminated in cases where 2 A/inch plot is authorized
5 April 1979	• Correctly enter line & sample shifts into label for the case of MANUAL registration
	• Suppress excess label-plotting on CalComp plots
25 May 1979	• Add plotter registration benchmark symbols at start and end of each plot
2 June 1979	• Add tape contents summary log at end of G.O. tape labelprints
8 June 1979	• Correct error in integer-scaling routine ("ITOE") for extracted-spectrum files, so that all negative fluxes are converted properly
15 June 1979	• Create "extended source" reduction capability in high dispersion (HT = 7)

Table 9-1. Chronology of Modification to IUESIPS Output Products (4 of 4)

Date	Modification
19 June 1979	• Eliminate redundant tape files in the case of calibration-image reduction
30 June 1979	• Begin plotting high dispersion net ripple-corrected spectra with "CUTMERGE" to suppress noise at ends of orders and allow auto-scaling of flux axis (applies ONLY to CalComp plots; G.O. tapes unchanged)'
2 July 1979	• Begin writing identifying header file on G.O. tapes (for data management accounting purposes)
7 July 1979	• Correct error in SWP ITF
8 July 1979	• Change ΔS and ΔL pixel offsets for large aperture dispersion relations to correspond to actual object placement point. (see IUE NEWSLETTER No. 5)
27 July 1979	• Begin use of new CalComp plotter hardware. Plots are more precise and on wider paper, but still 10-inch full scale grid
6 August 1979	• Change ΔS and ΔL pixel offsets for large aperture dispersion relations to correspond to physical center of large aperture. (In coordination with telescope operations change, so that offsets still correspond to object placement. Change refers to to all data acquired as of 1 August 1979. See IUE NEWSLETTER No. 5)
28 September 1979	• Modify the program "OSCRIBE" to generate overlay more efficiently and suppress overlay entirely outside of tube face.
30 October 1979	• Begin use of mean dispersion constants for low dispersion spectra. See IUE Newsletter No. 7.

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