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MULTISPECTRAL SCANNER DATA PROCESSING ALGORITHM DOCUMENTATION

by

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FORMERLY WILLOW RUN LABORATORIES, THE UNIVERSITY OF MICHIGAN

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Lyndon B. Johnson Space Center
NAS 9-9784, Task B 2.14

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

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Technical Report

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July 1973

NAS 9-9784, Task B 2.14

Lyndon B. Johnson Space Center
Earth Observations Division
Houston, Texas 77058

FOREWORD

This report describes part of a comprehensive and continuing program of research concerned with advancing the state-of-the-art in remote sensing of the environment from aircraft and satellites. The research is being carried out for the NASA's Lyndon B. Johnson Space Center, Houston, Texas, by the Environmental Research Institute of Michigan, formerly the Willow Run Laboratories of The University of Michigan. The basic objective of this multidisciplinary program is to develop remote sensing as a practical tool to provide the planner and decision-maker with extensive information quickly and economically.

Timely information obtained by remote sensing can be important to such people as the farmer, the city planner, the conservationist, and others concerned with problems such as crop yield and disease, urban land studies and development, water pollution, and forest management. The scope of our program includes: (1) extending the understanding of basic processes; (2) discovering new applications, developing advanced remote-sensing systems, and improving automatic data processing to extract information in a useful form; and (3) assisting in data collection, processing, analysis, and ground-truth verification.

The research described here was performed under NASA Contract NAS 9-9784, Task B 2.14 and covers the period from November 1, 1971 through January 31, 1973. Dr. Andrew Potter has been Project Manager. The program was directed by R. R. Legault, Associate Director of the Institute, and by J. D. Erickson, Principal Investigator and Head of the Multispectral Analysis Section. The Institute number for this report is 31650-149-T.

ABSTRACT

The procedures followed in multispectral scanner data evaluation may be divided into two categories: (1) data handling and calibration, and (2) recognition processing and subsequent evaluation of output. The report provides a description for the analyst of the algorithms employed in the current ERIM data processing scheme. Methods for suitable visual display of the results of this processing are also discussed.

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FIGURES

MULTISPECTRAL SCANNER DATA PROCESSING ALGORITHM DOCUMENTATION

1 SUMMARY

The classification and evaluation procedure of M-7 multispectral scanner data consists, in general, of two stages: pre-classification data handling and reformatting, and digital recognition processing and evaluation.

Pre-classification data handling and reformatting involves the following stage of processing:

(1) Tape duplication, to make rough corrections for channel skew because of differences between recording and playback tape equipment

(2) A-D conversion with "smoothing," to convert analog data to digital data of a specified form while combining overlapping data and reducing the instrumental noise level of the data

(3) Data misalignment correction

  (a) to evaluate the corrections necessary for channel skew, i.e., the misalignment of analog data on the physical tape because of improper alignment of the recording heads

  (b) to correct for scan line slew, i.e., the spatial misregistration of resolution elements between scan lines

(4) Clamping, scaling, and deskewing, to apply the channel deskewing corrections determined by the program AUTOCAL, and subsequently to calibrate dynamically each scan line based on information present in each line

The digital data tape is ready at this point for input into the classification programs. These classification procedures are:

(1) Visual data display, to allow the user to select training set regions and the actual region to be classified

(2) Signature extraction, to gather statistical information concerning the distribution of data values for a particular region in the target area in order to establish a decision criterion for the classification process

(3) Classification, to evaluate a set of resolution elements individually in terms of the signatures previously established, and associate each resolution element evaluated with one of the signatures, along with a measure of the likelihood of correct classification for each element

(4) Recognition display, to provide a spatially registered visual display of the output of the classification procedure by means of printed characters, with features allowing the reliability of the recognition output data to be evaluated as well as the overall reliability of both the multispectral scanner data and collected statistical signature data used by the classification algorithm

This set of procedures forms a sequence which, in most cases, generates an accurate representation of the distribution of substances and features in the target area of the scan. However, these procedures are not entirely automatic; at each stage the researcher must select various parameters necessary for proper execution of the algorithms defined in this report.

2
INTRODUCTION

Several basic algorithms are implemented in the ERIM multispectral data handling, processing, and evaluation system. This report outlines for the analyst the basic principles of the system without attempting a rigorous justification of the algorithms currently implemented.

Although other types of multispectral scanner data (such as ERTS scanner data) are processed by ERIM, most of the data to be evaluated are obtained from the M-7 scanner [1]. Since data obtained from this instrument are in analog form, a set of manipulations must be performed to put them into a format acceptable to the equipment used in actual processing and evaluation. This process is known as the A-D (analog-digital) conversion process. A-D conversion is not necessary for out-of-house data, since in most instances this information is already in digital form acceptable to our bulk-processing digital computer (a CDC 1604-B).

Section 3 deals with M-7 scanner data collection procedures, subsequent A-D techniques for reformatting the data, and corrections applied in the A-D process to compensate for possible instrumental inconsistencies. Section 4 discusses the methods by which additional corrections, calculated by techniques discussed in Section 3.3, are applied to the data, as well as factors inherent to the data itself. After these data preparation processes are completed, visual displays of the data are generated for use in evaluating the raw data and to aid the user in evaluating the best method available for futher data processing. These display methods are discussed in Section 5. Sections 6 and 7 deal with the methods by which the data is evaluated and classified, that is, the methods by which data points are grouped together and associated with a particular class which has been defined by a pre-determined distribution called a signature. Finally, Section 8 deals with the methods by which the results of classification or recognition processing are displayed.

3
ANALOG-DIGITAL DATA CONVERSION

3.1. M-7 SCANNER AND DATA COLLECTION

The M-7 scanner, housed in a C-47 aircraft along with analog recording equipment for bulk data storage, is a device which senses the radiation from an area and, by means of a system of optics, divides this radiation into a number of spectral regions (channels) covering the visible through infrared regions of the spectrum. Figure 1 outlines the general configuration of the M-7 scanner system and peripheral equipment.

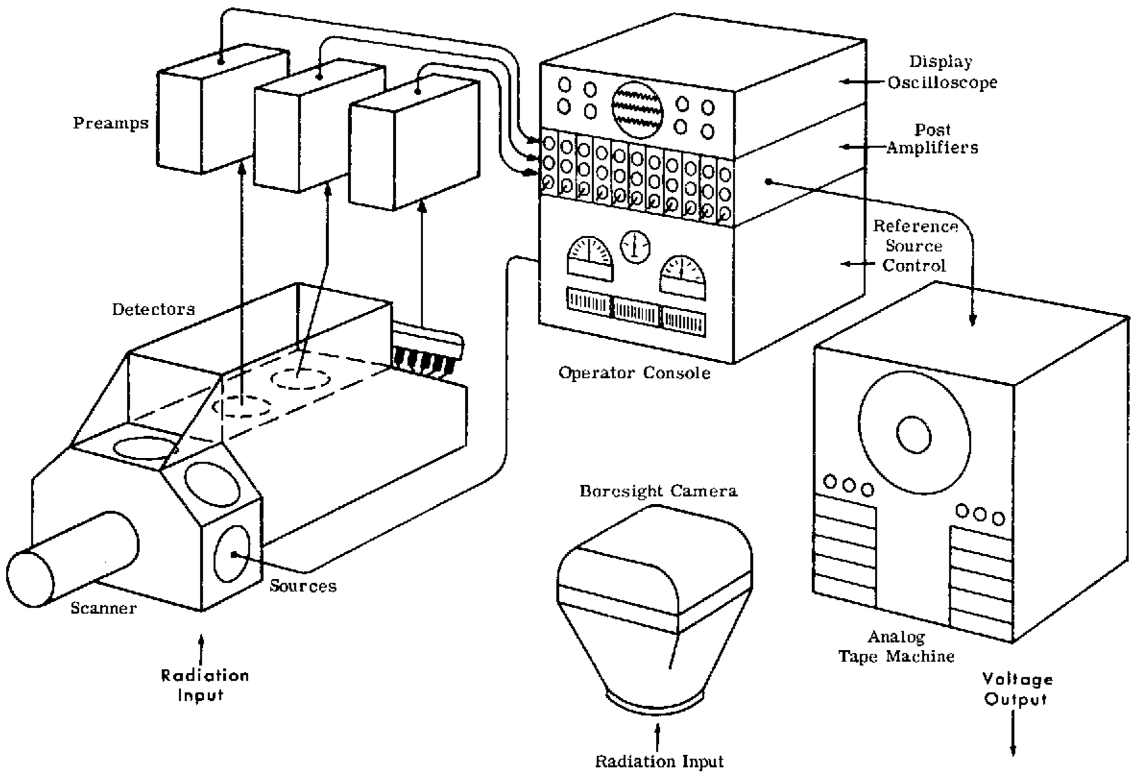
A scan mirror, internal to the scanner housing, is rotated in a plane essentially perpendicular to the direction of flight (see Fig. 1c), such that the sensors within the scanner are sequentially viewing (1) the scene below, (2) one of several internal calibration sources, or (3) the internal scanner housing, which provides a measure of the dark level reading of the sensors. Each rotation of the scan mirror generates a set of data called a scan line and effectively contains a measure of the radiation emanating from a swath of target area, such that the largest dimension of this rectangular swath is perpendicular to the direction of flight. This information from each of the spectral channels, along with additional synchronization information, is recorded continuously on the analog tape. After a desired set of successive scans (referred to as a run) has been recorded on an analog tape, the tape is brought to the ERIM data processing facility for digitization and subsequent processing.

3.2. ANALOG DATA AND TAPE DUPLICATION

The M-7 multispectral scanner data is recorded on analog tape and must go through A-D conversion to produce a digital equivalent compatible with the CDC 1604-B computer.

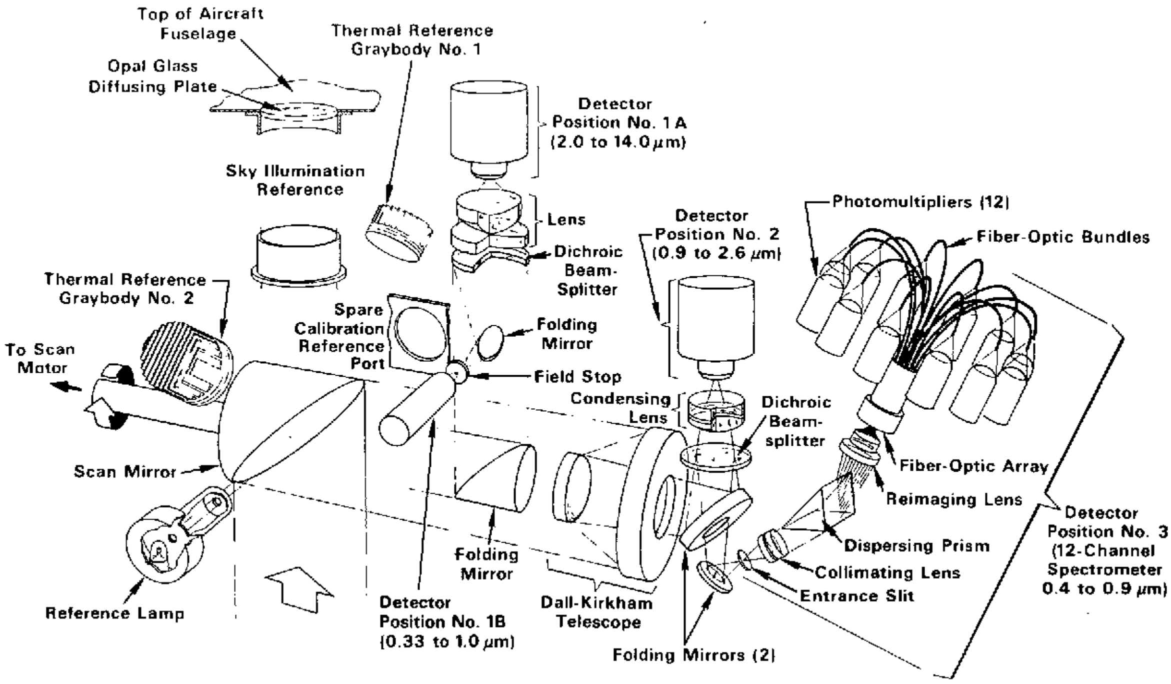
Because of the large quantity of data recorded on the analog tape, only certain areas of the total scan line are usually digitized. A CRT x-y display is used for a C-scan presentation of one channel at a time in the video region of the analog tape (the region where the sensor was actually viewing the scene and not some internal portion of the scanner). This C-scan presentation essentially provides a visual display of the radiation recorded by the scanner, making gross target features apparent. As this C-scan is being presented, a line count is also displayed so that scan line numbers for certain regions of interest can be identified for use in the digitizing procedure.

As the scan mirror rotates, a separate channel of information containing two synchronization pulses per scan line is recorded on the analog tape (Fig. 1d). One of these pulses, the



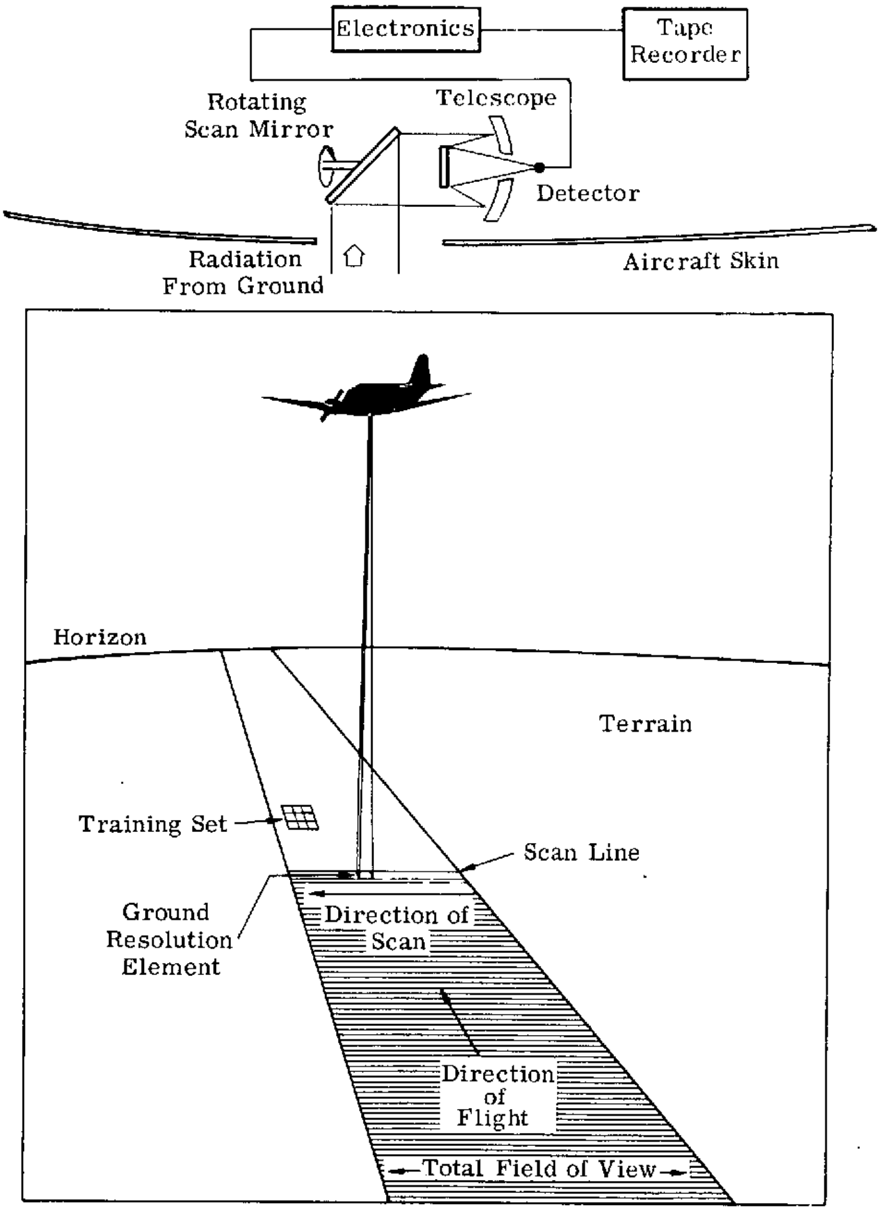
(a) Scanner System General Configuration

FIGURE 1. M-7 SCANNER CONFIGURATION



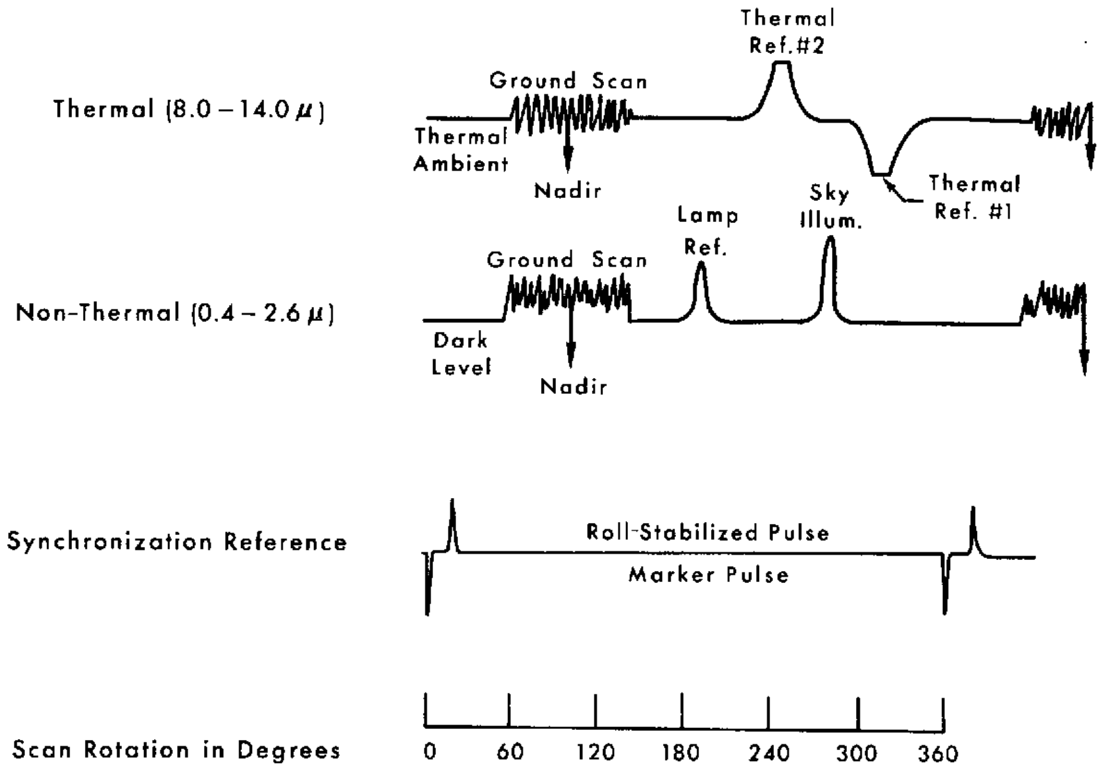
(b) Schematic Diagram of M-7 Scanner

FIGURE 1. M-7 SCANNER CONFIGURATION (Continued)



(c) Geometry of Airborne Scanning

FIGURE 1. M-7 SCANNER CONFIGURATION (Continued)



(d) Scanner Output Voltage Versus Time

FIGURE 1. M-7 SCANNER CONFIGURATION (Concluded)

marker sync pulse, denotes the time when the rotating scan mirror passes a fixed point relative to the scanner housing. The other sync pulse, called the roll stabilized pulse, indicates the time when the scan mirror passes a fixed point relative to the nadir. From the difference in the occurrence time of these two pulses, it is possible to measure the amount of aircraft roll from scan line to scan line. These differences may be digitized along with the multispectral data with special equipment that generates a separate channel called the time channel.

The tape recorder heads used to record the analog data in the aircraft generally have a different orientation relative to the direction of tape movement than the tape recorder used to play back the analog tape to the A-D converter. Because of this, a duplicate of the original analog data tape is made that introduces a time lag, usually different for each track, by means of variable delay transmission lines. This delay process allows more exact registration between data channels. The skew between any two channels is usually reduced to less than 2 μsec by this procedure. In theory, it is possible to correct for skew between channels by measurement of the differences in head alignment between the recording and playback equipment. In practice, however, the amount of time required for these measurements is prohibitive, and therefore the amount of delay to be applied to each channel during tape duplication is only approximated. Any further channel skew is calculated and corrected after the A-D conversion process is completed by the program AUTOCAL, discussed in Section 3.4. The corrected duplicate copy of the analog data tape is then used as input to the A-D processor for conversion to digital form.

Several regions along each scan must be digitized, because they contain information necessary to calibrate and cross-correlate the absolute data values in the video region, once these are in digital form. Built into the A-D converter is a resolution rate generator, which divides the region between two successive marker sync pulses into a specified number of regions each of which is digitized separately. However, it is not necessary to digitize the whole region between two sync pulses, since much of this is merely the scanner viewing the opaque inner wall of the instrument. The A-D converter may be gated manually such that only certain regions are digitized. The regions generally digitized are:

(1) video, that region where the sensor views the scene below the aircraft
(2) dark level, a portion of that region where the sensor views the dark interior of the scanner housing
(3) sun sensor, that region where the sensor views the radiation passing through a diffuse opal glass plate on the top of the aircraft
(4) calibration lamp, that region where the sensor views a radiance-transfer standard
(5) cold plate, that region where the sensor views a source of cool, known temperature
(6) hot plate, that region where the sensor views a source of known temperature, hotter than that of the cold plate

Figure 2 shows the time correlation between the analog data in a particular channel and the sync pulse channel, the digitizing gates, and the resolution rate generator pulses.

3.3. ANALOG-TO-DIGITAL CONVERSION WITH SMOOTHING

The actual digitizing procedure performed by the A-D converter is fairly simple:

(1) A resolution element which has been selected to be digitized by means of the gate settings is read by the analog tape recorder; the data value of each channel is strobed into a 48-bit buffer and shifted right the appropriate number of places as designated by a data resolution switch containing the number of significant bits to be used per data value. The data resolution switch is ordinarily set manually to 9 bits per data element, resulting in an accuracy of 2^{-9} over the analog voltage range.

(2) The completion of a 48-bit word causes the computer to transfer that word to storage in sequential, increasing addresses in core.

(3) The CDC 1604 computer is signalled when the final resolution element for a particular scan line has been digitized and transferred to the CDC 1604 computer; a flag is sent to the 1604 that the block of data is complete. The computer then writes the digitized information onto magnetic tape, one scan line per digital tape record. (Appendix I describes the format of the digital tape.)

Flight altitudes of 2000 ft and above ensure some overlap in successive scan lines, i.e., several successive scan lines contain data from portions of the same region on the ground. This results in a quantity of analog data much larger than is necessary for reasonable data processing and evaluation. Thus, as the analog-digital conversion is taking place, an on-line computer program, designated A2F3, is being executed on the digital computer. This program performs a function called smoothing, or filtering, which has a twofold purpose:

(1) The reduction of the number of scan lines by a factor between 3:1 and 16:1.

(2) The filtering (or reduction) of instrumental noise present in the recording process.

This is accomplished by simple averaging of each data value over NSMOOTH lines, where NSMOOTH is the number of lines to be combined to form a single digitized line. If the distribution of instrumental noise associated with each scan line is assumed to be Gaussian, averaging cancels out much of this background.

The actual computational procedure uses the following areas within the computer:

(1) Input buffer of NWORDS locations where

NWORDS = (NSS * NCHAN + 4)/5

NSS = the number of resolution elements per scan line

NCHAN = the number of channels per resolution element

(2) Scratch buffer consisting of two memory locations, used for intermediate, partial unpacking

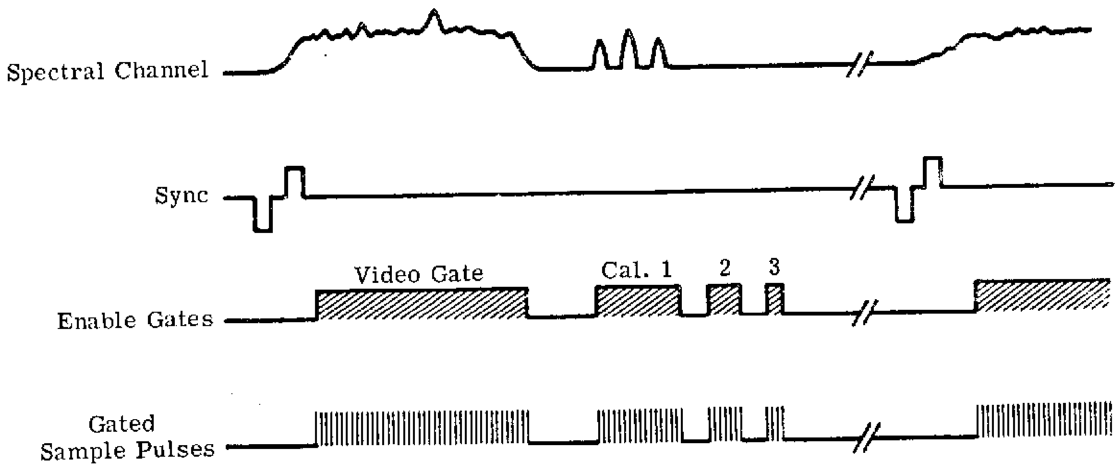


FIGURE 2. SCAN LINE WITH ENABLE GATES AND GATED SAMPLE PULSES

(3) Two averaging buffers consisting of NWORDS memory locations, each of which is used to accumulate the data value averages

(4) Output buffer of NWORDS memory locations, used for final repacking and output to magnetic tape

A memory location on the CDC 1604-B computer is composed of 48-bits; as scan lines are converted from analog to digital form they are directed to the computer memory and stored, 5 data values of 9 bits per word, with 3 bits unused (Fig. 3a). These data values are in 2's complement notation. Complement notation is described in Appendix I. The computational procedure used is:

(1) The first of NSMOOTH scan lines is read into the input buffer. Locations 1 through NWORDS are successively subjected to the following procedure:

  (a) Each of the 5 data values in location N (where $1 \le N \le NWORDS$) is biased upward by complementing its sign bit.

  (b) Each value is partially unpacked into one of two locations called partial unpacking buffers, the even samples into one location, the odd into the other. (See Fig. 3b.)

  (c) If NSMOOTH > 8, the data values are each divided by 2 and the remainder discarded, with an accompanying loss of significance.

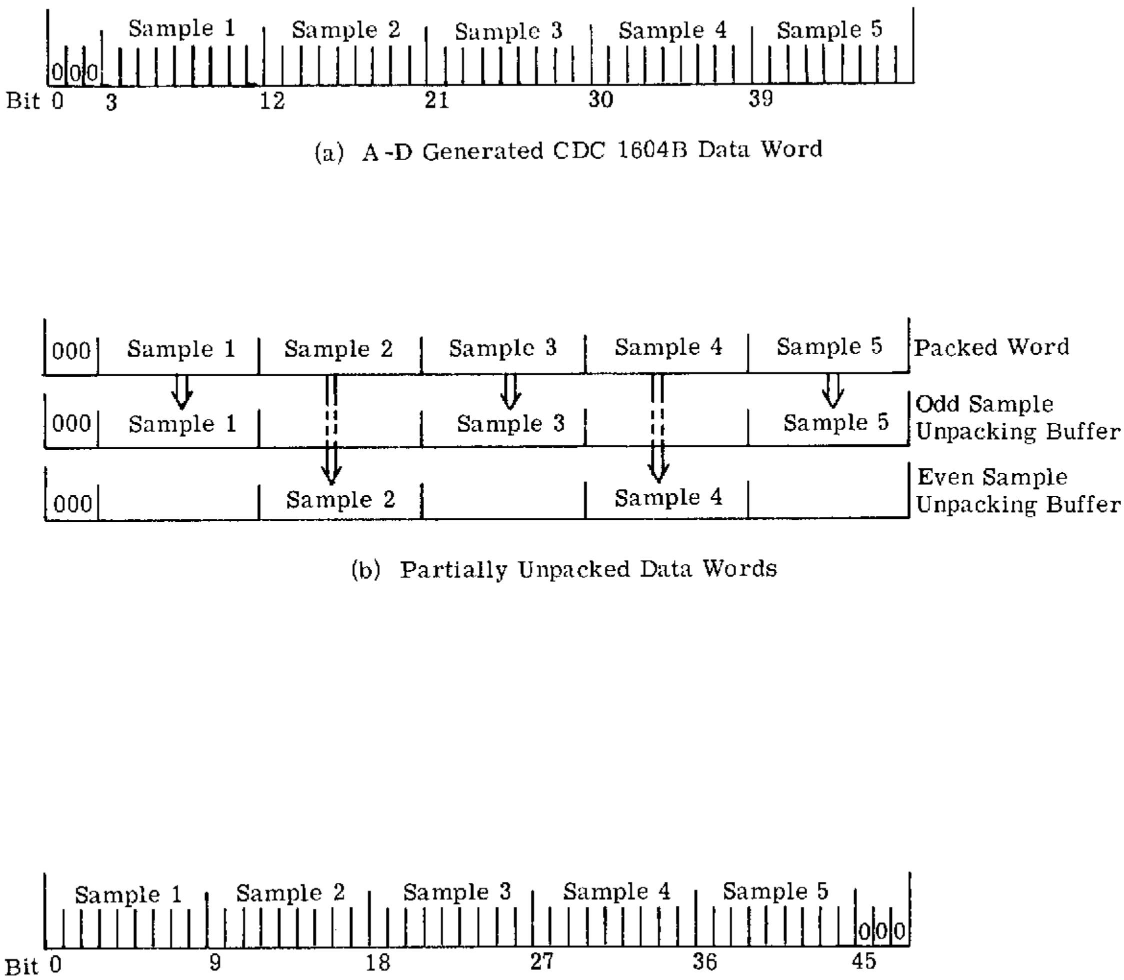
  (d) The contents of these two locations are then stored in one of two (even or odd) averaging buffers.

(2) Scan lines 2 through NSMOOTH are then successively read in, with steps 1a through 1d applied to each location of each scan line; however, step 1d is now modified such that the partial unpacking buffers are not stored in the averaging buffers, but are arithmetically added to them.

(3) After scan line NSMOOTH has been processed, the averages are truncated to 9 bits per data value and multiplied by 1/NSMOOTH, where this multiplier has been previously truncated to 9 bits. The product is then truncated to 9 bits.

(4) The odd and even data values are repacked into the output buffer in a slightly different format (Fig. 3c), the bias removed by recomplementing the leftmost bit of each data value, and the data values converted to 1's complement by adding +1 to all negative data values.

(5) Finally, the output buffer is written in ADTEST2 format (see Appendix II) on the output magnetic tape.



(a) A-D Generated CDC 1604B Data Word

(b) Partially Unpacked Data Words

(c) Packed Multispectral Data Output Word

FIGURE 3. PACKING OF MULTISPECTRAL DATA OUTPUT WORD

This procedure results in no loss of significance for smooths of 4- and 8-to-1; however, smooths of 9- through 16-to-1 initially lose 1 bit of significance, and smooths other than 4-, 8-, or 16-to-1 lose 1 bit of significance at the end of averaging.

3.4. AUTOCAL—EVALUATION OF CHANNEL SKEW AND SCAN LINE SLEW

After the A-D conversion process is completed, the resultant digital tape is used as input to a CDC 1604-B computer program, called AUTOCAL, which has a three-fold purpose:

(1) Calculation of an average scan line, corrected for slew effects (spatial misregistration) between scan lines

(2) From the calculated average scan line, a determination of the amount of skew present between channels, based on the position of the sun sensor peak in each channel (see Section 3.2)

(3) Calculation of a dark level value for each channel of data

THE ALGORITHM SEQUENCE

The user identifies the channel (ICHAN) to be used as a reference in the calculation of skews for the other channels, and the boundaries C1 and C2 defining the correlation region used in both the deslewing and deskewing procedures. The program individually processes successive scan lines by editing noise spikes from the data, correcting for slew, and accumulating the sum line.

SPIKE NOISE EDITING

Data differences—i.e., the differences between the data values in each channel for successive resolution elements along the scan line—are computed. A noise spike is characterized by two very large differences of opposite sign enclosed by two ordinary differences. If the minimum of the two large differences is greater than 5 times the maximum of its two neighboring differences and also greater than a high estimate of the expected difference, DEL(J), a noise spike is identified, and the data value then replaced by the average of the preceding and succeeding values in the same channel. DEL(J) is obtained from the first line by ranking the absolute differences, and then multiplying the 80-th percentile difference by 2. DEL(J) is included to cover the case in which both the neighboring differences are very small or even zero. A steeply rising or falling signal is not identified as a noise spike if the neighboring pulses are much the same size and if the middle differences are of the same sign.

SLEW CORRECTION

Assuming that the scan lines consist of N resolution elements and NCHAN channels per resolution element, data differences (as defined previously) in channel ICHAN from the first data line between points C1 and C2 are computed and stored in a vector Y. Channel ICHAN is defined as the reference channel; C1 and C2 have been previously defined; and $C1 < C2 \leq N$.

Thus Y is a vector containing elements Y_1 through Y_C where C = C2 - C1 + 1. Then a set of sums, S, is formed such that

$$S_i = \sum_{k=j}^{j+C+1} D_{k,ICHAN} \cdot Y_{k-j+1}$$

where i = 1, N - C + 1 and where $D_{k,ICHAN}$ is defined as the data difference between the k-th and (k + 1)-st resolution element in channel ICHAN for the second scan line. Since maximum correlation occurs when this sum is a maximum, the data line is shifted in such a way as to align this region of maximum correlation with the region from C1 to C2 on the first scan line. (If there were no slew, the region of maximum correlation would occur in the C1 to C2 region for each scan line.)

After all the scan lines have been processed, the program computes the average line in each channel by dividing each element of the sum line by the number of lines processed. This average line is used for the calculation of the skew of each channel. The standards are points C1 to C2 on the ICHAN average line. Each of the other lines is tested to find the region in which the length C2 - C1 + 1 correlates most closely with the standard. The method of correlation is, as before, the sum of products of differences, but instead of locating a local maximum, all possible sums with lags of -10 to +10 are tested and an absolute maximum obtained. The result of the correlation is output as a set of integers showing the number of points by which each channel precedes (negative) or follows (positive) the reference channel. Also, fractional slews for each channel are estimated by passing a parabola through the biggest sum and the two neighboring sums. The location of the base of the parabola determines the fractional slew, which differs from the integer slew by no more than 0.5, a figure achieved when two adjoining sums are equal and maximal.

Then a sum line, $A_{i,j}$, is cumulated from the first data line and the shifted data line, such that

$$A_{i,j} = \sum_{i=1}^{N} \sum_{j=1}^{NCHAN} (V_{1,i,j} + V_{2,i,j})$$

where V_1 is the first scan line and V_2 is the second scan line.

Processing of this kind proceeds with successive lines (all lines being slew-corrected with reference to the first scan line). Each new shifted scan line is cumulated with the sum line A, such that

$$A_{i,j} = \sum_{i=1}^{N} \sum_{j=1}^{NCHAN} (A_{i,j} + V_{m,i,j})$$

where V_m represents the m-th data line after shifting for slew correction.

Finally, a dark level for each channel is computed from the average line. This dark level for channel j is defined as

$$DARK_j = MAX(S_i)$$

where $S_i = \sum_{k=i}^{i+7} A_{i,j}$ for $i = 1$ to $N - 7$

Each value of the average line is subtracted from this DARK array, generating a corrected average line C, such that

$$C_{i,j} = DARK_j - A_{i,j} \quad \text{where } i = 1 \text{ to } N \text{ and } j = 1 \text{ to } NCHAN$$

The output from AUTOCAL provides information which may be used to provide further channel registration corrections and better boundaries for calibration regions, as inputs to the next stage of digital processing: clamping, scaling, and deskew (namely, the program CSD).

4
CLAMPING, SCALING, DESKEWING

Any or all of three types of corrections to the data contained in each scan line may be needed after an analog tape has been digitized:

(1) dark level correction
(2) multiplicative scaling based on one of the calibration sources
(3) deskewing of the channels to correct spatial misalignment

Dark level correction and calibration scaling both employ data values contained in each scan line to calculate the correction factors. The deskew correction factors obtained from the AUTOCAL program are now used as input to this correction program, called CSD.

The user must supply the following correction data to the program CSD for the generation of a new data tape:

(1) The line numbers of the scans to be corrected and the point numbers which represent the video portion of these scans

(2) N skew values where N is the number of data channels on the tape, and the reference channel is assumed to have a skew of zero

(3) For clamping (dark level correction), either

  (a) a clamp region—i.e., line and point numbers of a dark level region, from which a dark level value for each channel is calculated

  (b) actual clamp levels (dark levels) to be used

(4) For scaling

  (a) the point numbers of the region for the calibration signal of each line

  (b) the sampling region line numbers if time channel sampling (Section 3.2) is to be used

  (c) a smoothing constant representing the number of lines over which the peak in the calibration region is filtered by means of an exponential-type function

  (d) multiplicative scale factors (optional)

4.1. CLAMPING

The user either specifies a clamping region to set the dark levels of each individual scan line, or supplies a constant dark level value for each channel.

If the dynamic dark level correction method is selected, the points specified by the user within the clamping region are averaged channel by channel, and an array DARK(I), I = 1, NCHAN is generated for each line. If dynamic dark level correction is not used, DARK(I), I = 1, NCHAN remains constant throughout the run.

The correction is applied such that for DATA(N, J) where N = 1, NSS and J = 1 NCHAN is modified to read DATA(N, J) = DATA(N, J) - DARK(J).

4.2. SCALING

Three scaling options are available:

(1) dynamic scaling with a time channel criterion
(2) dynamic scaling without a time channel
(3) multiplicative constant scaling (user-specified)

The use of any of these options alone is possible, as is a combination of either 1 and 3 or 2 and 3.

If a time channel (Section 3.2) is available, the procedure is as follows:

(1) A region is specified by the user, and the range of values for that region is calculated.

(2) Each line of the entire scene to be processed is then tested to see if the value of the time channel for the particular line is within the range of time channel values for the region specified by the user in (1) above. If the value for the particular scan line is within this range, dynamic scale factors are calculated as for scaling option (2) above and applied to the scan line. If the time channel value for the scan line is outside the acceptable range (as defined by the user-specified region), the scale factors calculated for the previous line are applied to the current scan line.

Dynamic scale factors are calculated as follows:

(1) A value is calculated for each resolution element of the scaling region as specified by the user; this value is the sum of all the channel values for the resolution element.

(2) The maximum of these values is found, and data values in all channels at this peak element are filtered, by means of an exponential function to avoid noise spike problems, with the previous LSMOOTH lines where LSMOOTH is the number of user-specified lines for the smoothing process (default = 60).

(3) The smoothed values for each channel are then used to divide the data in the video region.

4.3. DESKEWING

For NSS resolution elements per scan line in the video region and NCHAN channels per resolution element, the user must supply NCHAN values into an array ISKEW(I) where I = 1, 10 (1 – I – 10 in increments of 1). The variable MINSKEW is set equal to the minimum value of all of the NCHAN skew values in the ISKEW array.

Then the ISKEW array is modified such that MINSKEW is subtracted from all of the NCHAN values of the ISKEW array.

When DATA(N, I) (the value of the J-th channel for the N-th resolution element where J = 1, NCHAN and N = 1, NSS) is stored for scaling, DATA(N, J) is not returned, but replaced by the value DATA [N + ISKEW(J), J].

5
DATA DISPLAY

Displays of the multispectral data are produced by means of the CDC 1604-B computer program GRAY2.

The user specifies a method by which the data values for an array called LEVEL are established. The LEVEL array contains data values which encompass the entire range of possible values for a given set of data (i.e., 0 → 511 for positive data, and -255 → 255 for bipolar data). These levels increase in value with increasing subscript, and a set of 2 characters is associated with a given level.

The following methods are used to perform level settings:

(1) Manual method: The user feeds levels directly to the program. The program performs elementary tests to ensure that the level values are monotonically increasing and encompass the entire range of possible data values.

(2) Automatic level set by random sampling: This method randomly selects points from a user-specified region (usually a subset of the region to be displayed) using a programmed random number generation routine. Then NLEVEL display levels (NLEVEL being a user-defined variable specifying the number of display levels) are set such that the distribution of the randomly-selected data values is uniform in each range delineated by the LEVEL values.

(3) MINMAX method: A minimum and a maximum range value, MIN and MAX respectively, are user-specified, along with NLEVEL; levels are generated such that the difference between values of the LEVEL array is DIFF = (MAX - MIN)/NLEVEL.

When the levels have been determined, association of each resolution element with one of the NLEVEL levels takes place in one of three modes.

Simple classification: The data value in the channel to be displayed for a given resolution element is compared to the i-th level where i = 1, NLEVEL. When the data value for the resolution element is greater than LEVEL(I - 1) but less than or equal to LEVEL(I), the resolution element is assigned the set of symbols associated with the I-th level for printing.

Two-channel interval criterion classification: The level to which a particular resolution element is classified is selected in the same manner as for the simple classification method; however, the value of the resolution element in a second channel (a control channel) is then tested. If the value in the control channel is less than a user-supplied maximum value, the resolution is assigned the I-th set of symbols for printing; however, if the value in the control channel is larger than the maximum allowed, the resolution is assigned a blank character for printing.

Two-channel level-equality criterion classification: The level to which a particular resolution element is classified is selected in the same manner as for the simple classification method; however, the value of the resolution element in a second channel (a control channel) is compared to the values of the array LEVEL. If the control channel value matches one of the LEVEL values, the resolution element is assigned the I-th set of symbols (where the element was classified as the I-th level initially); otherwise, the resolution is assigned a blank set of symbols for printing.

Each point of the scan line is processed in this manner (that is, associated with a particular level and thus with the particular set of print symbols characteristic of that level); then a computer printout is produced, such that one line of printed symbols bears a one-to-one correspondence to the data values for a given scan line. Figure 4 exemplifies the format of this visual multispectral data display. A discussion of recognition color mapping is contained in Section 7.

INTEGER RANGE		VOLTAGE RANGE		SYMBOL	ID
0	10	.0000	10.0000	•	MCV
11	20	11.0000	20.0000	■	DBS
21	30	21.0000	30.0000	x	BRV
31	40	31.0000	40.0000	■	TRV
41	50	41.0000	50.0000	■	POV
51	60	51.0000	60.0000	•	PYV
61	70	61.0000	70.0000	■	WATER
71	80	71.0000	80.0000	X	MBS
81	90	81.0000	90.0000	•	LBS
91	511	91.0000	511.0000		

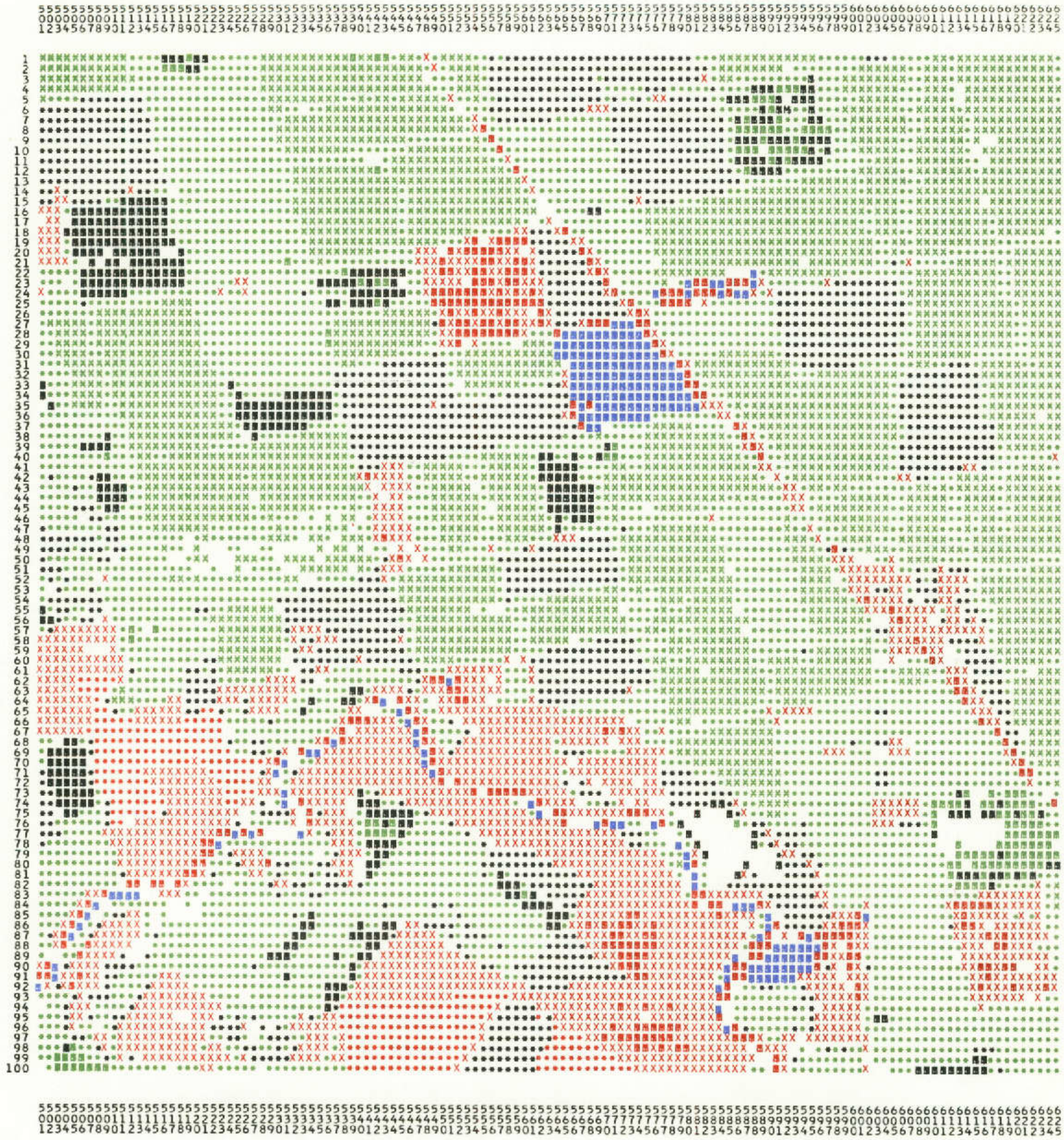


FIGURE 4. EXAMPLE RECOGNITION DISPLAY

6
SIGNATURE EXTRACTION

The end goal of multispectral data processing is determination of the object class of a given resolution element in the target area. This is accomplished by defining areas, called training sets, which are assumed to be homogeneous and representative of a particular object class. The data values in a training set region are combined such that the set of mean and covariance matrices, along with secondary statistical information, define what is called the signature of a particular training set. Once a representative number of training sets and their associated signatures have been obtained, classification procedures (the assignment of a given resolution element to a particular class, based on comparison of the resolution element's data values with the set of signatures) are instituted on the resolution elements of a particular subset of the data, called the scene, chosen by the user.

This section will now describe the algorithms implemented for the extraction of signatures by the CDC 1604-B program SIG1.

In the calculation of a given signature, the algorithm implemented in SIG1 is as follows:

(a) All training sets must be assumed rectangular, and the user must supply scan line and point boundaries for each training set.

(b) The mean value in each channel, a covariance matrix, the standard deviation from the mean in each channel, and a correlation matrix, are accumulated by processing the points within the training set individually.

Given a two-dimensional DATA array, where DATA(I, J) refers to the value of the J-th channel of the I-th point to be processed, the processing of n data points will result in:

$$\mathrm{MEAN}(J) = \frac{1}{n}\sum_{I=1}^{n} \mathrm{DATA}(I, J)$$

For the covariance matrix entries for channels J and K (where J and K are less than or equal to NCHAN), the total number of channels used to calculate the signature is

$$\mathrm{COV}(J, K) = \frac{1}{n-1}\left[\sum_{I=1}^{n} \mathrm{DATA}(I, J) * \mathrm{DATA}(I, K)\right] - \mathrm{MEAN}(J) * \mathrm{MEAN}(K)$$

the standard deviations

$$\sigma_J = \sqrt{COV(J, J)}$$

and the correlation matrix

$$COR(J, K) = \frac{COV(J, K)}{\sigma_J \sigma_K}$$

(c) The values calculated for each training set are based on n data points being used. The program edits data points within the training set region so that extreme points are not used in the signature calculation.

The editing procedure begins with the establishment of editing criteria. Each component of the data point is compared to the edit values. If any component is outside the acceptable range then the whole data point is rejected.

The establishment of editing criteria requires an estimate of the parameters of the distribution being used so that extreme points or points not from that distribution may be excluded. A criterion based on a sample median and sample quartiles is preferable to one based on a sample mean and sample standard deviation because extreme points have much less effect on the median and quartiles. With the assumption of a form for the underlying population distribution and a probability threshold for exclusion, one can set upper and lower bounds using the median and quartiles. An underlying multivariate normal population is assumed, so the median as an estimate of the mean and the quartiles can be used to estimate the standard deviation.

To use the normal (z) distribution, it is necessary to assume that the median is the population mean value and that the average quartile deviation from the median represents a value $z_Q = 0.6745$ (see Fig. 5). Thus,

$$z_Q = \left[\frac{1/2(X_{3/4} - X_{1/4})}{\sigma}\right] = \frac{X_Q}{\sigma}$$

so

$$\sigma = \left(\frac{X_Q}{0.6745}\right)$$

Next, a probability threshold criterion for excluding points is picked, based on the above assumptions. For SIG1, only one point in a thousand is to be rejected if the data meet the assumptions. This is equivalent to saying that the point should be rejected if

$$|z| = \left|\frac{X - \text{Median}}{\sigma}\right| > 3.2905 \quad \text{(See Fig. 6)}$$

The SIG1 edit routine considers the individual channel values to be independent normal samples, computes bounds separately for each channel, and rejects an observation point if any one of its channel values exceeds its bounds. Thus, the probability of any one channel exceeding its bounds must be (1/NC) times the criterion value (0.001), where NC is the number of channels. Thus, if NC = 10, so $P(|z| > z_T) = 0.0001$, then the criterion is $z_T = 3.89$. Since the threshold X values, X_T, are given by:

$$X_T(NC) = \text{Median} \pm z_T(NC)\sigma$$

$$= \text{Median} \pm \left[\frac{z_T(NC)}{z_Q}\right] X_Q$$

$$= \text{Median} \pm \frac{z_T(NC)}{0.6745} X_Q$$

We have, for NC = 10,

$$X_T(NC) = \text{Median} \pm 5.767\ X_Q$$

Note that there is no dependence on the number of samples used, except indirectly in that the median and quartiles will more accurately estimate the true population parameters as more samples are used.

The algorithm employed to determine the editing criteria is as follows.

The first N data points in the area being processed are used to form the sample population. The value of N depends on the number of channels being used; N is given by the formula:

$$N = 2400/NC$$

also

$$0 < N \leq 600$$

Computer storage limitations account for the limit of an upper bound on N.

Then, for each channel, the median and quartile deviations are found. The editing bounds are calculated as:

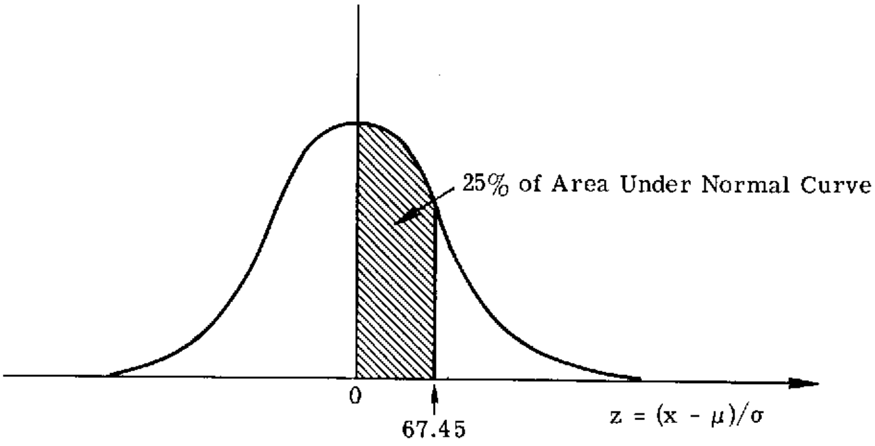


FIGURE 5. NORMAL DISTRIBUTION. Quartile deviation.

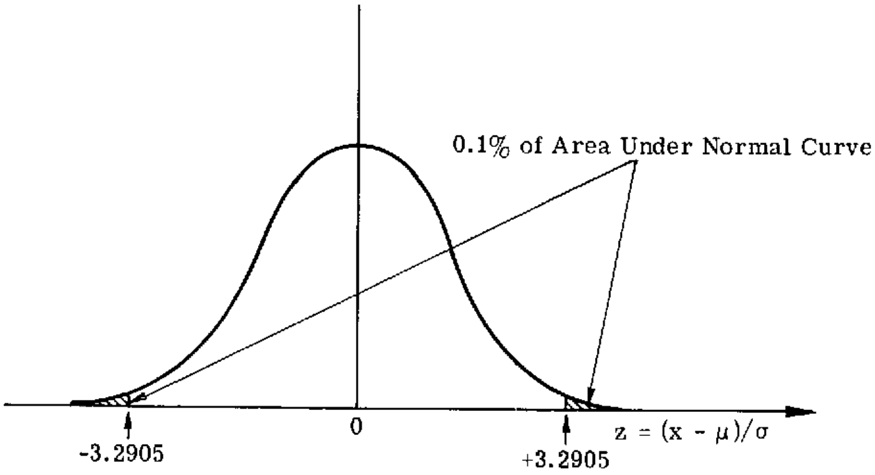


FIGURE 6. REJECTION CRITERIA

HI(I) = MEDIAN + QDEV * EDFACTOR(NC)

LO(I) = MEDIAN - QDEV * EDFACTOR(NC)

where EDFACTOR(NC) is the $\left[\frac{Z_T(NC)}{0.06745}\right]$ term from before.

The values for EDFACTOR for channels 1 - 24 are:

CHAN	1	2	3	4	5	6	7	8
EDFCTR	4.88	5.16	5.32	5.43	5.51	5.58	5.64	5.69
CHAN	9	10	11	12	13	14	15	16
EDFCTR	5.73	5.77	5.80	5.83	5.86	5.89	5.91	5.94
CHAN	17	18	19	20	21	22	23	24
EDFCTR	5.96	5.98	5.99	6.01	6.03	6.05	6.06	6.08

Where LO(J) and HI(J) are the lower and upper editing limits, respectively, in the J-th channel, the individual points are not deleted if

LO(J) ≤ DATA(I, J) ≤ HI(J)

for all channels, where DATA(I, J) is the value of the J-th channel for the I-th resolution element within the training set.

7
RECOGNITION PROCESSING

Once signatures have been extracted from a scene of multispectral data, it is then possible to attempt to associate a given resolution element with one of the known signatures. This process is called classification of multispectral scanner data, and is performed by the CDC 1604-B program EXPMAP.

With M signatures availables for a given scene of data to be classified, a value Q is computed for each of the M signatures for each resolution element to be processed, where

$$Q_i = (X - \mu_i)^T R_i^{-1} (X - \mu_i)$$

where X = the vector containing the data values in all the channels used
μ_i = the mean vector for the i-th signature
R_i = the covariance matrix for the i-th signature

The resolution element in question is said to be classified as the j-th signature class, when Z_j, where $Z_j = Q_j + \log |R_j|$, is greater than the Z_k computed for any of the other signatures.

Initially, before any classification processing takes place, the user must input an array S such that the k-th signature is associated with the element S_k, where $0 \le S_k < 511$ for all k. As the i-th resolution element is classified as belonging to signature k, a two-channel output scan line is being constructed such that the first channel contains the value S_k and the second channel the value EXP_i, where

$$EXP_i = Q_{ij} * 5.12 + 0.5 \quad \text{when } Q_{ij} \le 99.6$$

and Q_{ij} is the Q value computed above for the i-th resolution element and the j-th signature class. If $Q_{ij} > 99.6$, $EXP_i = 511$.

Thus the second channel can be used as a criterion denoting how well the classification procedure worked for each resolution element.

8
RECOGNITION MAPPING

After the classification or recognition procedure has been completed, display of the results in a useful manner is necessary so that signature selection and classification techniques can be evaluated. Since the output from the EXPMAP classification program is another digital tape of the standard format (described in Appendix II), the display of the data can be accomplished by the program GRAY2 (Section 5).

The two-channel modes described in Section 5 are used primarily for displaying recognition output tapes. The two-channel interval criterion mode is used to display only those points whose classification was reasonably certain, based on the value stored in the second channel by EXPMAP (Section 7). It is possible with this feature to generate displays with different cut-off values for this second channel, and therefore with different error bounds.

The two-channel level-equality criterion mode allows the user to evaluate the probability of correct classification over the scene for a given signature class. Consequently, the user might find that at the edges of a particular region the probability of correct classification was poorer than at the center of the region.

The visual display of recognition output is extremely helpful in evaluating the recognition process, since it allows a large amount of data display in a relatively small amount of output in a form easily scanned by the user and in which gross features become more prominent than individual resolution elements.

Figure 4 is an example of a color-coded recognition output visual display.

Appendix I
COMPLEMENT NOTATION

One's Complement

The one's complement of a binary number is defined as that number which results by replacing each digit 1 in the original number with the digit zero and replacing each zero with a 1. For example, the one's complement of the binary number 101 is the binary number 010. Note that the sum of a binary number and its one's complement is the binary number composed of all ones (e.g., 101 + 010 = 111).

Two's Complement

The two's complement of a number is defined as the one's complement increased by 1. Note that if an n-digit binary number is added to an m-digit binary number (where $n \geq m$), any carry to the $(n + 1)$st position is ignored. Thus a binary number added to its two's complement is a number consisting of all zeroes (101 + 011 = 000).

Appendix II
DIGITAL TAPE FORMAT

One set of scan lines as recorded on analog tape results in a set of digital records, terminated by an end-of-file, as follows:

(1) The first record, 2592 bits (54 CDC 1604-B words) in length, is called the title record and contains information pertinent to the data set which will follow. The content of this title record is:

1	word	Fortran code word (17777777777777777_8)
12	words	BCD title of data set
1	word	number of resolution elements per scan line (NSS)
1	word	beginning angle from nadir (BANG)
1	word	angular increment (DANG)
1	word	number of channels (NCHAN)
1	word	conversion factor (CONV)
1	word	data positive flag (IPOS)
1	word	data packed flag (IPACK)
24	words	descriptive information in BCD
10	words	unused

(2) The rest are data records, containing one scan line of data per record. The number of CDC 1604-B words per record is

$$\text{NWORDS} = \left[\frac{(\text{NSS} \times \text{NCHAN}) - 1}{5}\right] + 1$$

Each word contains five 9-bit data values (Fig. 3), such that the data values representing channels 1 through NCHAN for the i-th resolution element are contiguous.

(3) The data set is terminated by a standard end-of-file mark.

Appendix III

PROGRAM LISTINGS

```
      PROGRAM SIG1
C  NEEDS PROCESS, UNPACK3, POSDEF
C  VERSION 1.0 (PROGRAMMERS W.L.BROWN + D.ZUK, 12/71)
***WARNING*** SUBR. POSDEF USES 2*NC**2 +NC + 3 SPACES IN ERASABLE
***FOR THIS REASON, THE 'DATA' ARRAY SHOULD BE KEPT FIRST IN COMMON

*****'SIG1' IS A SPECIAL VERSION OF 'IMPROVE' WHICH ENABLES ONE TO CAL-
C     CULATE STATISTICS FOR SEQUENTIAL, CONTIGUOUS TRAINING AREAS OF
C     EQUAL SIZE AS WELL AS 'NORMAL' TYPES OF TRAINING SETS
C  'SIG1' IS A GENERAL SIGNATURE-CALCULATING PROGRAM WHICH REPLACES
C     'CRECCAST' ... A FORM OF HISTOGRAM IS INCLUDED IN THE OUTPUT
C  DOES NOT ALLOW TRANSFORMATIONS

C  PACKED DATA TAPE ON 3, BCD OUTPUT ON 4
C  PUNCHED OUTPUT CAN BE WRITTEN ON ANY TAPE DRIVE OR ON '0'  TO DISCARD
C  BCD OUTPUT OF TAPE CHANNEL ICP ON 5 (ICP=0 TO OMIT OUTPUT ON 5)

C  INPUT MEDIUM IS T, F, 1, 2, 6, 7 OR 8
C  'INPUT MEDIUM' IS REQUESTED PRIOR TO READING IN PROGRAM CONSTANTS
C    AND THEN AGAIN PRIOR TO READING IN LINE, POINT DESIGNATIONS... THIS
C    ENABLES ONE TO USE THE SAME CONTROL CARDS AS FOR ' HIST1 ' AFTER
C    SECOND ASSIGNMENT OF INPUT MEDIUM IS MADE

C  UP TO 13 CHANNELS, 6000 SAMPLES/SCANLINE

C  SENSE SWITCH 1 TO TURN OFF EDITING
C  SENSE SWITCH 2 IF RUN CONTINUES OVER 2 OR MORE FILES
C  SENSE SWITCH 3 FOR OPTION TO CHANGE TITLES

C  FOR CHANNEL NOS. INSTEAD OF WAVELENGTH BANDS IN OUTPUT, ANSWER
C    'SPECTROMETER CHANNELS=' WITH 0 OR WITH '15'
C        SPECTROMETER IDENTIFICATIONS ARE...
C             --------------------       --------
C             SPECTROMETER CHANNEL       BANDPASS
C             --------------------       --------
C                      1                 .43 -  .47
C                      2                 .47 -  .49
C                      3                 .49 -  .51
C                      4                 .51 -  .53
C                      5                 .53 -  .56
C                      6                 .56 -  .59
C                      7                 .59 -  .63
C                      8                 .63 -  .67
C                      9                 .70 -  .90
C                     10                1.00 - 1.40
C                     11                1.50 - 1.80
C                     12                2.00 - 2.60
C                     13                9.30 - 11.7
C                     15                  NO LABEL

C  (BANDS ARE FOR M-7 SCANNER. CF. E. WORK 7/6/71 MEMO)
C  NC = NO. OF CHANNELS IN SUBSET. (OPTIONAL)
C  SUBSETS ARE READ BY (20I3)
C  ICP = TAPE CHANNEL TO BE PLOTTED ON TAPE UNIT 5
C    ICP = 0 BYPASSES WRITING ON TAPE 5

C  NTHERM = 1 FOR PLOTS OF TEMPERATURE (DEG. C.) VS. WAVELENGTH
C  NTHERM = 0 FOR VOLTS VS. WAVELENGTH
C  NTHERM =-1 FOR REFLECTANCE VS. WAVELENGTH
```

```
C   NTHERM =-2 FOR RADIANCE VS. WAVELENGTH (RADIANCE UNITS = WATT/SQ.CM./
C     CM./STER) X 10**ICST)
C   ICST = SCALING CONSTANT FOR THE PLOTS

C   LINE NO. = NSA, NSB, KS, NA, NB, KP, ID1, ID2 (6I5, 2A8)
C   LINE NO. .LE. 0 TO GET TO 'NO. OF FILES TO SKIP =' QUESTION
C     NO. OF FILES TO SKIP = -0 TO CHANGE CHANNEL SUBSET
C   NSB = NO. OF LAST LINE OF INTEREST (NSB=-1 TO GO TO EOF)
C   NSK = NO. OF SCANLINES IN EACH STATISTICAL SET
C     NSK = 0 FOR STANDARD 'IMPROVE'-TYPE RUN
C   'ID1' CAN BE STANDARD A8 IDENTIFICATION OR CAN BE THE TIME OF DAY
C     (FORMAT =  XXXX.X) CORRESPONDING TO FIRST AREA
C     LEAVE ID1, ID2 BLANK TO SIGNAL IRREGULARLY SHAPED AREAS, PUTTING IN
C     ID ONLY WITH THE LAST LINE + POINT DESIGNATIONS
C   ID2 CAN BE STANDARD A8 IDENTIFICATION OR CAN BE 'DELTA TIME' (F6.3)
C   DELTA TIME = TIME INTERVAL BETWEEN AREAS (NEEDS TO BE ENTERED ONLY
C     ONCE AFTER PROGRAM IS CALLED UNLESS IT IS DESIRED TO CHANGE IT)


      DIMENSION A(19), FLL(24), LAB(5), LABX(3), LBL(5,3), PCILE(21),
     1  SCAN(200), T(12)
      COMMON DATA(6000)
      COMMON FMT(19), IC(13), IT(9), LABEL(30,3), LINE(108), MINE(100),
     1  P(39), PP(3), Q(39), QP(3)
      COMMON B(13,13), STDEV(13), SUM(13), NGOOD(13), FN(13,13)
      COMMON BOT(13), CORR(13), ISCN(21,13), DATUM(13), FLHI(13),
     1  FLLO(13), ICODE(13), ICP, NC, R, S, TOP(13), V(200,13)
      COMMON RS(5), BANG2, DANG2, CC, NF, NR, MR, L80, ID1, ID2,
     1  BANG, DANG
      COMMON L90, KEY, NPTS, NLINES, NSA, NSB, KS, NA, NB, KP, IS,
     1 TITLE(12), TAG1(12), TAG2(12), NSS, NCHAN, KR,  CONV, IPOS,
     2 IPACK, INT
      EQUIVALENCE (LINE, SCAN), (T, TITLE)
      INTEGER DATA, FMT, Q, QP, R, REPLY, S, T, TAG1, TAG2, TITLE, U, W
      REAL ISCN
      LOC (TEST = 70)
      DATA( A=10., 8., 6., 4., 3., 2., 1.,   .8,   .6,   .4,   .3,   .2,   .1,
     1           .08,.06,.04,.03,.02,.01)
      DATA(FLL = .41, .43, .455, .47, .485, .50, .52, .55, .58,
     1.63, .68, .74, .85)
      DATA(LAB = 8H*.01*    ,8H*.1 *    ,8H*1.0*    ,8H*10.*    ,8H*100*    )
      DATA(LABX=  8H   12X    , 8H   19X    , 8H   27X    )
      DATA(LBL = 8H*2*    7X,8H*3*    6X,8H*4*    7X,8H*6*    6X,8H*8*    4X,
     1           8H*2*   12X,8H*3*    9X,8H*4*   12X,8H*6*    8X,8H*8*    7X,
     2           8H*2*   16X,8H*3*   12X,8H*4*   16X,8H*6*   12X,8H*8*    9X)
      DATA(PCILE(1) = 0.,5.,10.,15.,20.,25.,30.,35.,40.,45.,50.,55.,
     1  60.,65.,70.,75.,80.,85.,90.,95.,100.)
      DATA(SECOND = 1.)
      PARTMAP

        SLJ(1)

600     SLJ(*)                      .INITIALIZE FOR NEXT REGION
        LDA(NC)         SUB(1)      AJP(602)
      WRITE(4,105)

602   DO 610 JK=1,19
610     FMT(JK) = 8H

      CALL ZERO(B, FN(169))
```

```
      IP = 0
      IRREG = 0
      NFIRST = 0
      SLJ(600)
C          SET UP TO  CONSTRUCT LABELS FOR COMPUTER PLOTS
  1  DO 15 IL=1,3
      LABEL(1,IL) = LAB(1)

     DO 8 JL=3,7
  8   LABEL(JL,IL) = LBL(JL-2,IL)
      LABEL(8,IL) = LAB(2)

     DO 4 JL=10,14
  4   LABEL(JL,IL) = LBL(JL-9,IL)
      LABEL(15,IL) = LAB(3)

     DO 5 JL=17,21
  5   LABEL(JL,IL) = LBL(JL-16,IL)
      LABEL(22,IL) = LAB(4)

     DO 6 JL=24,28
  6   LABEL(JL,IL) = LBL(JL-23,IL)

     DO 7 JL=2,30,7
  7   LABEL(JL,IL) = LABX(IL)

 15   LABEL(29,IL) = LAB(5)
     SLJ4(600).                    INITIALIZE FOR FIRST REGION
     DELTA = 0.
     K = 1
     L = 0
     MSA = 0
     N3 = 3
     NSR = 0

101  FORMAT(6I5)
102  FORMAT(5E15.8)
103  FORMAT(20I3)
104  FORMAT(A1)
105  FORMAT(1H1)
106  FORMAT(12A8)
109  FORMAT(1H0)
118  FORMAT(1H1, 12A8, / 1H , F4.2, 3H TO F6.2, 12H MICRON BAND /)
121  FORMAT(/ 12X 1H0 10X 2H1. 10X 2H2. 10X 2H3. 10X 2H4. 10X 2H5.
    1  10X 2H6. 10X 2H7. 11X 11HMEAN(STDEV) /)
123  FORMAT(1H 14A8)
142  FORMAT(F8.1)
144  FORMAT(1H0 2X 14HCHANNEL NO. = 10X 13I7)
145  FORMAT(8H   LINES I5, 5H THRU I5, 8H  EVERY I3, 10H,   POINTS I4,
    1  5H THRU I5, 8H  EVERY I3 *(* F6.2 * DEGREES TO * F6.2 * DEGREES*
    2  * )*/)

      LDA(SECOND)    AJP(12A)
      SECOND = 0.

     WRITE(9,100)
100  FORMAT(3H**** JS1 ON TO TURN OFF EDITING* /
    1       3H**** JS2 ON TO CONTINUE SEGMENTS ACROSS EOF* /
    2       3H**** JS3 ON TO ALLOW TITLE CHANGES* /)
```

```
 12A  WRITE(9,107) 358, 528
107     FORMAT(* PUNCHED OUTPUT ON * 2R1)
      READ(9,104) W2
        W = 0
      IF DATA CONVERSION ERROR GO TO 12
      DECODE(1, 101, W2) W

  12  SLJ4(700).                    SELECT INPUT MEDIUM
      NFIRST = 1
      WRITE(S,108)
 108  FORMAT(*     NC   NSK  ICST   ICP NTHERM (5I5) * /)
      READ(R,101) NC, NS3, ICST, ICP, NTHERM
        NC = MINO(NC, 13)
        ITHERM = NTHERM + 3
        NTHERM = 0
        LDA(ITHERM)     SUB(4)       AJP1(14)
        NTHERM = 1

  14  CALL PROCESS(DATA,1,0,N3,R)
      IF(KEY.EQ.5) 12, 13

  13    ISBAD = 777B
        LDA(IPOS)        AJP1(L+2)
        LAC(0)           STA(ISBAD)
        BADPT = FLOAT(ISBAD)/CONV
        LDA(NCHAN)       INA(-2)      AJP2(94)
        NC = 1
        NC1 = 1
        NC2 = 1
  94    LDA(NC)          AJP1(11)
        NC = MINO(13, NCHAN)
  11    NC3 = MAXO(1, NC/2)
        NC4 = MINO(NC, NC3+1)
        NC1 = ICODE(NC3)
        NC2 = ICODE(NC4)

C  NC1 + NC2 ARE USED IN EDITING... IF THE SIGNALS IN BOTH OF THESE
C     USUALLY STRONG CHANNELS ARE 'BAD', POINT WILL BE DISCARDED

      WRITE(S,110) NC
 110  FORMAT(* SPECTROMETER CHANNELS(*I2*I3)= *)
      READ(R,103) (IC(I),I=1,NC)
        FLLO(1) = 0.

      DO 10 I=1,NC
        ICODE(I) = I
        LDAI(IC)         AJP(10)
        ITMP = (16*ITMP)/15
        IC(I) = (18*ITMP)/17
        FLLO(I) = FLL(IC(I))
        FLHI(I) = FLL(IC(I)+1)
  10  CONTINUE

        LDA(NC)          SUB(NCHAN)  AJP(13A)
      WRITE(S,111) NC
 111  FORMAT(* SUBSET OF CHANNELS(*I2*I3)= *)
      READ(R,103) (ICODE(I), I=1,NC)

 13A  SLJ4(700).                    SELECT INPUT MEDIUM
```

```
   2  CALL PROCESS (DATA,2)
        INT = 1
      ANGA = BANG2
        ANGB = ANGA + (FLOAT(NPTS)-1.)*DANG2
        LDA(KEY)     SUB(5)     AJP(12)

      IF(ID1 .EQ. 1H ) 21, 20
  20  IF DATA CONVERSION ERROR GO TO 21
      DECODE(1,142,ID1) TEMP
      DECODE(1,142,ID2) DEL
      LDA(DEL)        AJP(21)
      ID2 = 1H
      DELTA = DEL
  21    NSK = NS3
        AJP1(22)
        NSF = NSB
        NSK = NSB - NSA + 1
  22  IF(ID1 .EQ. 1H ) 23, 24
  23    IRREG = 1
      WRITE(4,145) NSA, NSF, KS, NA, NB, KP, ANGA, ANGB
        SLJ(25)
  24    IRREG = 0
  25    SLJ2(26)        SLJ(27)
  26    MSA = NSR
        NSR = 0
27      NSF = NSA + NSK - 1 - MSA
        MSA = 0
        EDIT = 10.
        SLJ1(29)
        EDIT = 0.
  29    NFIRST = 1

        SLJ3(39)        SLJ(37)

  39  WRITE(9, 117)
 117  FORMAT(* NEW TITLE * /)
  40  READ(9, 106) IT
      IF(IT(1) .EQ. 3HYES) 40, 41
  41  IF(IT(1) .EQ. 2HNO) 37, 42

  42  DO 43 I=1,9
43      TITLE(I) = IT(I)

  37  IF(NC .EQ. 1 .AND. NFIRST .GT. 0) 44, 45
44    WRITE(4,118) TITLE, FLLO(1), FLHI(1)
        SCALE = 12.
        FTHERM = 1.
        OFFSET = 1.

45      MGCOD = ((NSF-NSA)/KS+1)*((NB-NA)/KP+1)


   3  CALL PROCESS (DATA,3)

        LL = NCHAN*(NA-1)

      DO 49 ISS=NA,NB,KP
        LDA(IP)          SUB(200)     AJP3(47)
```

```
      DO 46 J=1,NC
        L = LL + ICODE(J)
        LDA4(DATA)      AJP1(46A)
        LDA(ISBAD)      STA4(DATA)
46A   DATUM(J) = FLOAT(DATA(L))/CONV
46    CONTINUE

        LL = LL+NCHAN*KP
      SLJ4(200).                          TEST POINTS AND CUMULATE TOTALS
        SLJ(49)

47      IP = IP + 1

      DO 48 J=1,NC
        L = LL + ICODE(J)
        LDA4(DATA)      AJP1(48A)
        LDA(ISBAD)      STA4(DATA)
48A   V(IP,J) = FLOAT(DATA(L))/CONV
48    CONTINUE

        LL = LL+NCHAN*KP
      IF(IP .EQ. 200) 51, 49
51    SLJ4(300).                          GET BOUNDS FOR COLLECTED POINTS

49    CONTINUE

      IF(NSF-IS) 52, 52, 50
50    IF(KEY-3) 3, 52, 90

52      NGOOD = NGOOD + MGOOD
        LDA(IRREG)      AJP1(2)
        LDA(IP)         SUB(200)      AJP2(53)
      SLJ4(300).                          GET BOUNDS FOR COLLECTED POINTS

53    DO 54 I=1,NC
54      SUM(I) = SUM(I)/FN(I,I)

      DO 55 I=1,NC

      DO 55 J=I,NC
        B(I,J) = B(I,J)/FN(I,J) - SUM(I)*SUM(J)
55      B(J,I) = B(I,J)

        LDA(NC)         SUB(1)        AJP1(60)
        LDA(NFIRST)     AJP(56)
        LDA(NTHERM)     AJP(56)

      WRITE(4,120)
120   FORMAT(/ 10X 3H-40 9X 3H-30 9X 3H-20 9X 3H-10 10X 1H0 10X 2H10
     1  10X 2H20 10X 2H30 10X 3H40 11HMEAN(STDEV) /)
        OFFSET = 61.
        FTHERM = 10.
56      P(2) = SUM(1)
        B(1,1) = AMAX1(B(1,1), 0.)
        STDEV(1) = SQRT(B(1,1))
        P(1) = P(2) - STDEV(1)
        P(3) = P(2) + STDEV(1)
        FSUM = SUM(1)*FTHERM
        FSTDV = STDEV(1)*FTHERM
```

```
      DO 57 J=1,3
        Q(J) = P(J)*SCALE + OFFSET
        Q(J) = MINO(Q(J), 108)
 57     Q(J) = MAXO(Q(J), 1)

      DO 58 J=1,108
 58     LINE(J) = 1H

        LINE(Q(1)) = 1H(
        LINE(Q(3)) = 1H)
        LINE(Q(2)) = 1HX
        LDA(NTHERM)     SUB(1)       AJP(59)
        LDA(NFIRST)     AJP(59)

      WRITE(4,121)
 59   WRITE(4,122) ID1, (LINE(J), J=1,96), FSUM, FSTDV
122   FORMAT(1HO 1X A8, 2X 96A1, F6.2, *(* F4.2 *)* /)
        SLJ(65)

 60     LDA(ICP)        AJP(61)
        LDA(NFIRST)     AJP(61)

      WRITE(5,118) T, FLLO(ICP), FLHI(ICP)
        N5 = 5
      SLJ4(800).        IDENTIFY UNITS OF COMPUTER PLOTS
 61   WRITE(4,123) T, ID1, ID2
      WRITE(4, 145) NSA, NSF, KS, NA, NB, KP, ANGA, ANGB
      WRITE(4, 144) (ICODE(I), I=1,NC)
      WRITE(4,124) (NGOOD(I),I=1,NC)
124   FORMAT( 12HOGOOD POINTS 17X 13I7 /)
      WRITE(4,125) (SUM(I), I=1,NC)
125   FORMAT(12HOMEAN VECTOR 17X 13F7.3)
        SING = 0.

      DO 62 I=1,NC
      IF(B(I,I) .LT. 0.) 63, 64

 63     SING = 1.
        B(I,I) = 0.
        STDEV(I) = 0.
        SLJ(62)

 64     STDEV(I) = SQRT(B(I,I))
 62   CONTINUE

      WRITE(4,126) (STDEV(I), I=1,NC)
126   FORMAT(20HOSTANDARD DEVIATION  9X 13F7.3)
      WRITE(4,127)
127   FORMAT(19HOCORRELATION MATRIX )

      DO 99 I=1,NC
        CALL ZERO(CORR(1), CORR(I))
        CORR(I) = 1.
        LDA1(STDEV)     AJP(67)
        I1 = I-1

      DO 66 J=1,I1
        LDA2(STDEV)     AJP(67)
 66     CORR(J) = B(J,I)/STDEV(I)/STDEV(J)
```

```
 67     LDA3(FLLO)      AJP(97)
      WRITE(4,128) FLLO(I), FLHI(I), (CORR(J), J=1,I)
 128  FORMAT(1HO 1X F4.2,4H TO F5.2, 14H MICRON BAND     13F7.3)
        SLJ(99)
 97   WRITE(4,146) ICODE(I), (CORR(J), J=1,I)
 146  FORMAT(1HO 24X I2, 2X 13F7.3)
 99   CONTINUE

        LDA(NGOOD)      SUB(NC)      AJP2(68).    TEST FOR SINGULAR MATRIX
      WRITE(4, 129) NGOOD(O), NC
 129  FORMAT(1HO I2, * POINTS AND* I3, * CHANNELS, SO SINGULAR *
     1  *COVARIANCE MATRIX *)
        SLJ(69)

 68     LDA(SING)       AJP(70)

      WRITE(4,130)
 130  FORMAT(/ * SINGULAR MATRIX *)
        SLJ(69)

 70   CALL POSDEF(B(O,1), NC, 13, 1, 1HO, SUM(O))

 69   WRITE(4,131)
 131  FORMAT(1H1 *MEAN VECTOR AND COVARIANCE MATRIX * /)
      WRITE(4,102) (SUM(I), I=1,NC), ((B(I,J), J=I,NC), I=1,NC)
      WRITE(4, 109)
      WRITE(4, 144)  (ICODE(J), J = 1, NC)
      WRITE(4, 113) (BOT(I), I=1,NC)
 113  FORMAT(1HO 8X*LOWER BOUND EDIT*2X 13F7.3/)
      WRITE(4, 112)
 112  FORMAT(1HO 11X*PERCENTILE*/12X*-----------*/)

      DO 114 JJ=1,21
      WRITE(4, 114) PCILE(JJ), (ISCN(JJ,J),J=1,NC)
 114  FORMAT(11X,F8.1, 8X 13F7.3)

      WRITE(4, 115) (TOP(I), I=1,NC)
 115  FORMAT(1HO 8X*UPPER BOUND EDIT*2X 13F7.3/)
      WRITE(4, 105)
      WRITE(4, 123) TITLE, ID1, ID2
      WRITE(4, 132)
 132  FORMAT(1HO 33X*SEMILOG PLOT OF MEAN +-1 STANDARD DEVIATION*)
        LDA3(FLLO)      AJP(71)

      WRITE(4,133)
 133  FORMAT(1H+ 104X 15HWAVELENGTH BAND / 108X 9H(MICRONS) )
        SLJ(72)

 71   WRITE(4,134)
 134  FORMAT(1HO 108X 7HCHANNEL )

 72     P2 = 0.
        P1 = 100.

      DO 73 I=1,NC
        P2 = AMAX1(SUM(I), P2)
 73     P1 = AMIN1(SUM(I), P1)

        P2 = 1.1*P2
        P1 = 0.9*P1
```

```
      P2 = AMIN1(100., P2)
      P1 = AMAX1(0.01, P1)

      FSCALE = ALOG10(P2/P1)
      NSCALE = 4./FSCALE
      NSCALE = MINO(4, NSCALE)
      NSCALE = MAXO(2, NSCALE)
      SCALE = 25*NSCALE
      FMID = SQRT(P2*P1)
      FSCALE = 50./SCALE
      P4 = FMID/(10.**FSCALE)
      P4 = AMAX1(P4, 0.02)

      ENI4(19)        LDA(P4)
     +THS4(A+1)       SLJ(92)

      JAC = L+1
      IAC = ((18-JAC)*7-1)/6
      IAC = MAXO(IAC, -1)
      SHIFT = 1. - ALOG10(A(JAD+1))*SCALE

    DO 80 I=1,NC
      II = ICODE(I)
      P(2) = SUM(I)
      P(1) = P(2) - STDEV(I)
      P(3) = P(2) + STDEV(I)
      LDA(NFIRST)     AJP(78)

      P(4) = 0.01

    DO 74 M=5,13
 74   P(M) = P(M-1) + 0.01

    DO 75 M=14,22
 75   P(M) = P(M-1) + 0.1

    DO 76 M=23,31
 76   P(M) = P(M-1) + 1.

    DO 77 M=32,36
 77   P(M) = P(M-1) +10.

 78 DO 81 J=1,36
      LDA2(P)         AJP(79)      AJP3(79)
      Q(J) = ALOG10(P(J))*SCALE + SHIFT
      Q(J) = MINO(Q(J), 108)
      Q(J) = MAXO(Q(J), 1)
        SLJ(81)
 79   Q(J) = 1
 81 CONTINUE

    DO 82 J=1,108
 82   LINE(J) = 1H

    DO 83 M=4,36
 83   LINE(Q(M)) = 1H.

      LINE(108)  = 1H
```

```
      DO 36 IPQ=Q(1),Q(3)
 36     LINE(IPQ) = 1H-

        LINE(Q(1)) = 1HI
        LINE(Q(3)) = 1HI
        LINE(Q(2)) = 1H*
        LDA3(FLLO)      AJP(84)

      WRITE(4,135) LINE, FLLO(I), FLHI(I)
135   FORMAT(/1H0 108A1, F4.2, 2H - F5.2/)
        LDA(ICP)        AJP(80)      SLJ(85)

 84   WRITE(4,136) LINE, II
136   FORMAT(/1H0 108A1, 2X I2 /)

 85     LDA(II)         SUB(ICP)     AJP1(80)
        PP(2) = P(2)
        PP(1) = P(1)
        PP(3) = P(3)

      DO 86 M=1,3
        QP(M) = PP(M)*12. + 1.
        QP(M) = MINO(QP(M), 100)
 86     QP(M) = MAXO(QP(M), 1)

      DO 87 J=1,100
 87     MINE(J) = 1H

        LDA(NFIRST)     AJP(88)

      WRITE(5,121)

 88   DO 38 IPQ=QP(1),QP(3)
 38     MINE(IPQ) = 1H-

        MINE(QP(1)) = 1HI
        MINE(QP(3)) = 1HI
        MINE(QP(2)) = 1H*
      WRITE(5,122)    ID1, (MINE(J), J=1,96), SUM(I), STDEV(I)
 80   CONTINUE


        MJM = 28/NSCALE + 2
        FMT(1) = 8H( 1X

      DO 89 JM=2,MJM
 89     FMT(JM) = LABEL(JM+IAD, NSCALE-1)
        FMT(MJM+1) = 8H)

      WRITE(4,FMT)

        N5 = 4
      SLJ4(800).          IDENTIFY UNITS OF COMPUTER PLOTS

        LDA(W)          AJP(65)
      WRITE(W,140) (TITLE(I), I=1,9), ID1, 57B
140   FORMAT( 8A8, A6, 2X, A8, 1X, R1)
      ENCODE(10,102,DATA) (SUM(I),I=1,NC),((B(I,J),J=I,NC),I=1,NC)
        NCARD = (NC + NC*(NC+1)/2 + 4)/5
        J = 0
```

```
      DO 155 I=1,NCARD
      WRITE(W,141) (DATA(L), L=J,J+9), I, 578
 141  FORMAT(9A8, A3, 3X, I2, 1X, R1)
 155    J = J + 10

  65    LDA(NSF)         SUB(NSB)      AJP1(156)
 161  SLJ4(600).                       RE-INITIALIZE FOR NEXT REGION
        SLJ(2).                        CALL PROCESS(DATA, 2)

 156    NSA = NSF + KS
        LDA(NSB)         SUB(NSF)      SUB(NSK)      AJP2(157)
        NSR = NSB - NSF
        NSF = NSB
        SLJ(158)

 157    NSF = NSF + NSK
 158    LDA(DELTA)       AJP(160)

      DECODE(1,142,ID1) XID
        XID = XID + DELTA
 159  ENCODE(1,142,ID1) XID
      DECODE(1,143,ID1) IH
 143  FORMAT(4X, I1, 3X)
        LDA(IH)          SUB(6)        AJP1(160)
        XID = XID + 40.
        SLJ(159)

 160  SLJ4(600).                       RE-INITIALIZE FOR NEXT REGION
      IF(NSF-NSA) 2,2,45


  90    NSB = IS - KS
        NSF = NSB
        NSR = NSF - NSA + 1
        MGOOD = ((NSB-NSA)/KS+1)*((NB-NA)/KP+1)
        LDA(NSR)         SUB(2)
        AJP3(161)        SLJ(52)


 200  SLJ(*).     TEST EACH POINT. IF IT PASSES THE TESTS, CUMULATE SUMS
      IF(DATUM(NC1) .EQ. BADPT .AND. DATUM(NC2) .EQ. BADPT) 200, 201
 201    SLJ1(203)

      DO 210 J=1,NC
      IF(DATUM(J) .GT. TOP(J) .OR. DATUM(J) .LT. BOT(J)) 200, 210
 210  CONTINUE

 203  DO 230 I=1,NC
        LDA1(DATUM)      SUB(BADPT)    AJP(230)
      SUM(I) = SUM(I) + DATUM(I)
        NGOOD(I) = NGOOD(I) + 1

      DO 220 J=I,NC
        LDA2(DATUM)      SUB(BADPT)    AJP(220)
        B(I,J) = B(I,J) + DATUM(I)*DATUM(J)
        FN(I,J) = FN(I,J) + 1.
 220  CONTINUE

 230  CONTINUE
```

```
          SLJ(200)

 300     SLJ(*).     GET BOUNDS FOR COLLECTED POINTS, THEN CUMULATE SUMS
          SLJ1(311)

         DO 310 J=1,NC
         CALL MEDIAN(V(0,J), SCAN, IP, CENTER, QDEV)
         ISCN(1,J) = SCAN(1)

         DO 330 JJ=1,20
           NUMB = JJ*(IP-1)/20 + 1
 330     ISCN(JJ+1,J) = SCAN(NUMB)

           QDEV = AMAX1(QDEV, 0.867/CONV, EDIT)
           TOP(J) = CENTER + 5.77*QDEV
 310       BOT(J) = CENTER - 5.77*QDEV

C            .001 LEGITIMATE PTS. EXCLUDED. VARIANCE DECREASE .LT. 1 O/O

 311     DO 320 N=1,IP

         DO 315 J=1,NC
 315       DATUM(J) = V(N,J)

         SLJ4(200).         TEST POINTS AND CUMULATE SUMS
 320     CONTINUE

           SLJ(300)

 700     SLJ(*).            SELECT INPUT MEDIUM
         WRITE(9, 701)
 701     FORMAT(* INPUT MEDIUM= *)
         READ(9, 104) REPLY
           LDA(REPLY)       ALS(6)
           STA(R).          R=INPUT MEDIUM
           S = 9
         IF(REPLY .NE. 1HT) 702, 700
 702       LIU1(TEST)       IJP1(700)     .IF BATCH, SAVE TYPEWRITER OUTPUT
           S = 23
           SLJ(700)

 800     SLJ(*).            IDENTIFY UNITS OF COMPUTER PLOT
         GO TO (153, 152, 151), ITHERM

 151     WRITE(N5,137)
 137     FORMAT(// 1H9 56X *VOLTS* )
           SLJ(800)

 152     WRITE(N5,138) ICST
 138     FORMAT(/ 1H9 67X, I2 / 1H9 52X *REFLECTANCE X 10 * )
           SLJ(800)

 153     WRITE(N5,139) ICST
 139     FORMAT(/ 1H9 77X, I2 / 1H9 42X *RADIANCE (WATT/SQ.CM./CM./STER) X
        110 * )
           SLJ(800)

  92     CALL STOP(7HBAD RUN)
         END  $  PAGE
```

```
      FUNCTION    POSDEF(A, NN, IDA, ISW, CC, MEAN, NTAPE)
C   USES  2*N**2 + N + 3  SPACES IN ERASABLE
      DIMENSION A(IDA,IDA), MEAN(IDA), E(1)
      REAL MEAN
      INTEGER CC, L, N, B, Q, D
      DATA(L=4)
      LOC(ERAS = 63)
      LIN(II,JJ) = N*(JJ-1) + II

      N = NN
      IF(N.EQ.1) 25, 2
2     N1 = N + 1
      N2 = N*N + 1
      ENA(E)  SUB(ERAS)
      SCM(-0B) STA(B)
      ADD(N1) STA(Q)
      ADD(N2)  STA(D)
      ENA(NTAPE)      AJP(1)
        L = NTAPE

1     CALL MXMCV(0, A, E(D), N, N, IDA, N)
      CALL JACOBIN(E(D),N,N,E(B), E(Q), -1)
      WRITE(L,105) CC
 105  FORMAT(A1, *EIGENVALUES (YVAR)     YMU          COEFFICIENTS OF THE
     1X'S * /)

      POSDEF = 0.
      DO 24 I = 1,N
      VAR = E(D + LIN(I,I))
      IF(VAR) 5, 5, 6
5       POSDEF = 1.
6     YMU = 0.
      IF(ISW) 10, 15, 10
 10   DO 12 J = 1,N
 12     YMU = YMU + E(Q + LIN(J,I))*MEAN(J)
 15   WRITE(L,115) VAR, YMU,(E(Q + LIN(J,I)), J=1,N)
 115  FORMAT(1H 2E13.5, 2X 13F7.4 / (29X 13F7.4))
 24   CONTINUE
25    RETURN
      END
```

```
      MACHINE A2F3 (CHAN, SMOOTH, A,B,C,D,E,F,G,H)
      LOC (Z=0,POINT=30,ERP=24,MTR=25,RNX=11,RDB=100,WRB=300,CNT=60)
      RSV (A1=0)

*********************
*  SIMPLE MESSAGES  *
*********************

      CON (MES1=2062612363702040B,N1=2045462061216400B). BATCH - NO A/D
      CON (MES2=2061026620615167B,N2=2065515146510000B). A2F ARG ERROR
      CON (MES4=2023712343653732B,N3=0000000000000000B). TITLE
      CON (MES6=2020204461453020B)                     .    MANY
      CON (MESCORE=2223465161676520B,M2=4371447123000000B).STORAGE LIMIT
      CON (WONKITY=2026464542712330B,M3=1452733220462423B).OUTPUT TAPE
      CON (M4      =4724232023614765B,M5=2045462320516561B).NOT READY
      CON (M6      =6430730000000000B)
      CON (DONE    =6446456520267123B,M7=7020236147653700B).DONE WITH TAP
      CON (WARN    =2046632361432061B,M8=7167227300000000B).OCTAL ARGS.

***********************
*  TAPE SELECT CODES  *
***********************
```

```
                                                                        A2F30220
      CON (T0=0)                                          .DUMMY        A2F30230
      CON (T1=01400000000420118,T2=02400000000420218)     .1 2          A2F30240
      CON (T3=03400000000420318,T4=04400000000420418)     .3 4          A2F30250
      CON (T5=05400000000430118,T6=06400000000430218)     .5 6          A2F30260
      CON (T7=07400000000430318,T8=10400000000430418)     .7 8          A2F30270
                                                                        A2F30280
***********                                                             A2F30290
*   MASKS  *                                                            A2F30300
***********                                                             A2F30310
                                                                        A2F30320
      CON (MASK11=0 777 000 777 000 777 B)                              A2F30330
      CON (MASK12=0 377 000 377 000 377 B)                              A2F30340
      CON (MASK21=0 000 777 000 777 000 B)                              A2F30350
      CON (MASK22=0 000 377 000 377 000 B)                              A2F30360
      CON (MASK3= 4 003 777 777 777 777 B)                              A2F30370
      CON (MASKO= 4 003 774 003 774 003 B)                              A2F30380
      CON (MASKE= 7 774 003 774 003 777 B)                              A2F30390
      CON (MASK  =0 400 400 400 400 400 B)                              A2F30400
                                                                        A2F30410
      CON (MASKP1=  000 000 000 000 777 0B)                             A2F30420
      CON (MASKP2=  000 000 000 777 000 0B)                             A2F30430
      CON (MASKP3=  000 000 777 000 000 0B)                             A2F30440
      CON (MASKP4=  000 777 000 000 000 0B)                             A2F30450
      CON (MASKP5=  777 000 000 000 000 0B)                             A2F30460
                                                                        A2F30470
      CON (MASK1=0, MASK2=0)                                            A2F30480
                                                                        A2F30490
****************************                                            A2F30500
*   JOB STATISTICS MESSAGES  *                                          A2F30510
****************************                                            A2F30520
                                                                        A2F30530
      LOC (NUMSTIX=14)                                                  A2F30540
      CON (ERRORS=0, SHORT=0, BURNED=0, LOST=0, LONG=0, STRETCH=0)      A2F30550
      CON (SCANS=0, LINES=0, SIZE=0, NSS=0, NCHAN=0, SMOOTH=0)          A2F30560
                                                                        A2F30570
      CON (JJ=0, J1=2361476520655151B, J2=4651220000000000B).TAPE ERRORSA2F30580
      CON (J3=0, J4=2020234646202270B, J5=4651230000000000B).  TOO SHORTA2F30590
      CON (J6=0, J7=2020612320222361B, J8=5123000000000000B).  AT START A2F30600
      CON (J9=0, J0=2043462223000000B, JA=0000000000000000B). LOST      A2F30610
      CON (JB=0, JC=2023517144446564B, JD=0000000000000000B). TRIMMED   A2F30620
      CON (JE=0, JF=2022235165236370B, JG=6564000000000000B). STRETCHED A2F30630
      CON (JH=0, JI=2263614522000000B, JK=0000000000000000B).SCANS      A2F30640
      CON (JL=0, JM=4371456522000000B, JN=0000000000000000B).LINES      A2F30650
      CON (JO=0, JP=2646516422214371B, JQ=4565000000000000B).WORDS/LINE A2F30660
      CON (JR=0, JS=2261444743652221B, JT=4371456500000000B).SAMPLES/LINA2F30670
      CON (JU=0, JV=6370614545654320B, JW=6461236100000000B).CHANNEL DATA2F30680
      CON (JX=0, JY=2346200120224446B, JZ=4623700000000000B).TO 1 SMOOTHA2F30690
                                                                        A2F30700
***************                                                         A2F30710
*   OTHER JUNK  *                                                       A2F30720
***************                                                         A2F30730
                                                                        A2F30740
      CON(ENDREEL=1765405165654317B)                                    A2F30750
      CON(SPACES =2020202020202020B)                                    A2F30760
      CON(FIRST  =0000000177777777B)                                    A2F30770
      HOL(SMOTHD =SMOOTHED)                                             A2F30780
                                                                        A2F30790
**********************                                                  A2F30800
*   BEGIN MAIN PROGRAM  *                                               A2F30810
**********************                                                  A2F30820
                                                                        A2F30830
1ENT  SLJ (*)          SLJ (L+11)       .EXIT/ENTRY                     A2F30840
0ARG  BSS (1)                           .CHANNELS                       A2F30850
```

```
9ARG  BSS (1)                              .SMOOTHING FACTOR                      A2F30860
1ARG  BSS (8)                              .TAPES                                 A2F30870
      LIL1(POINT)      ENA (MES1)          .TEST FOR NEW RESIDENT                 A2F30880
      IJP1(L+1)        SLJ (L+4)           .GO AHEAD IF OLD RESIDENT              A2F30890
      LDQ1(Z+2)        STQ (L+2)           .                                      A2F30900
      ENI1(ERP)        SIL1(L+1)           .                                      A2F30910
      BSS (1)                              .EXIT IF IN BATCH                      A2F30920
      ENA (8)          ENI1(8)             .OK. DO ARGUMENTS                      A2F30930
      THS1(1ARG)       SLJ (L+4)           .ERROR IF ARGUMENT LARGER THAN 8       A2F30940
 1AER ENA (0)          ENI1(7)             .ARGUMENT ERROR                        A2F30950
      STA1(1ARG)       IJP1(L)             .CLEAR FOR NEXT CALL                   A2F30960
      ENA (MES2)       SLJ4(ERP)           .TYPE MESSAGE/EXIT                     A2F30970
      ENA (0)          ENI1(8)             .GET NUMBER OF ARGUMENTS               A2F30980
      THS1(1ARG)       SLJ (1AER)          .                                      A2F30990
      SIU1(2EOT)       ENI2(TO)            .SAVE COUNT, GET ADDRESS OF TABLE      A2F31000
 2ARG LDA1(1ARG)       SAL (L+2)           .GET ARGUMENT                          A2F31010
      AJP (1AER)       AJP3(1AER)          .ERROR IF ZERO OR NEGATIVE             A2F31020
      SIL1(L+1)        LDQ2(*)             .SET SELECT CODE                       A2F31030
      STQ1(9SEL)       ENI3(*)             .SAVE COUNT                            A2F31040
      EQS3(1ARG)       SLJ (L+2)           .SEARCH FOR DUPLICATE ARGUMENTS        A2F31050
      SLJ (1AER)                           .ERROR IF DUPLICATE ARG FOUND          A2F31060
      ENA (0)          STA1(1ARG)          .CLEAR ARGUMENT                        A2F31070
      IJP1(2ARG)       ENI1(NUMSTIX-1)     .LOOP FOR MORE TAPES                   A2F31080
      STA1(ERRCRS)     IJP1(L)             .CLEAR JOB STATISTICS                  A2F31090
      LDA (0ARG)       AJP (1AER)          .ERROR IF NCHAN .EQ. 0                 A2F31100
      THS (16)         SLJ (1AER)          .ERROR IF NCHAN .GT. 16                A2F31110
      AJP3(1AER)       STA (NCHAN)         .IF NCHAN .GT.-0, STORE IT             A2F31120
      SAL (4IA)        ALS (1)             .                                      A2F31130
      SAU (6IA)        INA (1)             .                                      A2F31140
      SAU (2TST)       SCM (-0B)           .                                      A2F31150
      SAU (2IA)        LAC (NCHAN)         .                                      A2F31160
      SAL (1IA)        SAU (3IA)           .                                      A2F31170
      ENA (A1+1)       ADD (NCHAN)         .                                      A2F31180
      SCM (-0B)        SAU (1AGN)          .                                      A2F31190
      LDA (9ARG)       STA (SMOOTH)        .STORE SMOOTH FACTOR                   A2F31200
      THS (16)         SLJ (1AER)          .ERROR IF SMOOTH .GT. 16               A2F31210
      INA (-3)         AJP3(1AER)          .ERROR IF SMOOTH .LE. 2                A2F31220
      INA (2)          SAU (101E)          .SET UP SMOOTH LOOP LIMIT              A2F31230
      ENI1(2)          ENA (7)             .                                      A2F31240
      THS1(0ARG)       SLJ (L+2)           .TEST FOR SMOOTH OR CHAN OVER 7        A2F31250
      ENA (WARN)       SLJ4(MTR)           .ISSUE WARNING MESSAGE                 A2F31260
      ENI1(0)          ENQ (1)             .                                      A2F31270
      ENA (0)          DVI (SMOOTH)        .                                      A2F31280
      SCA6(2)          SCL (MASK3)         .                                      A2F31290
      IJP6(L+1)        ENI1(1)             .                                      A2F31300
      IJP6(L+1)        ENI6(1)             .                                      A2F31310
      SIU1(100S)       SIU1(101S)          .                                      A2F31320
      LDQ1(MASK11)     STQ (MASK1)         .                                      A2F31330
      LDQ1(MASK21)     STQ (MASK2)         .                                      A2F31340
      SIL6(200)        SIL6(200M)          .                                      A2F31350
      STA (IKR)        ENI6(A1)            .                                      A2F31360
      ENQ6(-17416B)    ENA (MESCORE)       .                                      A2F31370
      QJP6(ERP)        ENA6(1200)          .CRASH IF TOO NEAR END OF CORE         A2F31380
      SAL (Z+5)        SAL (0STX)          .STORE END OF INITIAL READ BUFF        A2F31390
      SCM (-0B)        SAL (2K)            .                                      A2F31400
      LDA (Z+7)        SAU (9EOT)          .                                      A2F31410
      SAU (1OUT)       ENQ (37777B)        .SAVE INTERRUPT ROUTINE ADDRESS        A2F31420
      ENA (1ENT)       LIL1(CNT+5)         .                                      A2F31430
      MEQ7(CNT+7)      SLJ (L+3)           .FIND A2F IN TABLE                     A2F31440
      INI1(1)          SIL1(CNT+5)         .REMOVE REMAINING ENTRIES              A2F31450
      ENA (A1)         SAL (CNT+3)         .SET END OF A2F                        A2F31460
      SIL (1FLG)       SIU (8NXT)          .STORE ZERO                            A2F31470
      SIL (1EOT)       ENA (37777B)        .                                      A2F31480
      SAL (7NXT)       SAU (9NXT)          .STORE 37777                           A2F31490
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      SAL (2FLG)       SAL (0FLG)       .STORE NON-ZERO
      ENA (WRB)        SAU (1WRT)       .MORE ADDRESSES
      ENA (WRB+54)     SAU (0WRT)       .
      SAL (Z+4)        ENI1(A1)         .
      ENQ (0)          STQ1(Z)          .CLEAR CORE
      ISK1(37777B)     SLJ (L-1)        .
      ENA (2WRT)       SAU (0TAP)       .
      ENA (0END)       SAL (1TYP)       .
      ENA (0IN)        SAU (0A2D)       .
      EXF (101B)       EXF (2000B)      .CLEAR FAULT INT., STOP CLOCK

**********************
*  FIRST TAPE RECORD  *
**********************

      ENA (MES4)       SLJ4(MTR)        .TYPE *TITLE*
      ENA (9)          SLJ4(RNX)        .
      ENI1(32)         ENA (0)          .
      STA1(WRB+21)     IJP1(L)          .CLEAR LAST OF BUFFER
      STA (WRB+18)                      .
      ENI3(11)         ENI2(95)         .*LOOP
      ENI1(7)                           .*TO
      LDA2(RDB)        LRS (6)          .*PACK
      INI2(-1)         IJP1(L-1)        .*THE
      STQ3(WRB+1)      IJP3(L-3)        .*TITLE
      LDA (NSS)        STA (WRB+13)     .
      LDA (1.)         STA (WRB+14)     .
      LDA (1.)         STA (WRB+15)     .
      LDA (NCHAN)      STA (WRB+16)     .
      LDA (51.2)       STA (WRB+17)     .
      ENA (1)          STA (WRB+19)     .
      LDA (SMOTHD)     STA (WRB+20)     .
      LDA (FIRST)      STA (WRB)        .
      ENI6(0)          SLJ4(0SEL)       .SELECT A TAPE
      LDA (0TAP)       SAU (L+1)        .
      EXF (*)          EXF (11100B)     .INTERRUPT ON END OF WRITE
      ENA (T1)         SAL (Z+1)        .
      EXF1(T0)         EXF (50341B)     .START TYPEWRITER AND CONVERTER
      EXF5(A1)         ENI4(0)          .START CHANNEL 5

*******************
*  GET FIRST SCAN  *
*******************

      EXF7(10B)        SLJ (0STX)       .EXIT IF TYPEWRITER DONE
      EXF7(50324B)     SLJ (L-1)        .
      LIU6(Z+5)        EXF (50341B)     .GET ADDRESS, START CONVERTER
      EXF5(A1)                          .RESTART CHANNEL
0AGN  RAO (SCANS)      STA (BURNED)     .COUNT SCAN
      STA (LOST)                        .
1AGN  ENA6(*)          AJP3(L-5)        .REJECT SCAN IF TOO SHORT

************************
*  INITIALIZE ADDRESSES  *
************************

1IA   SIU6(3TST)       ENA6(*)          .
      SCM (-0B)        SAU (1IN5)       .TEST A1 UNDERSIZE
2IA   INA (*)          SAU (1TST)       .TEST A1 OVERSIZE
      INA (A1+1)       SAU (2IN6)       .DISPLACEMENT FOR STRETCHING A2
      SCM (-0B)        SAU (1IN6)       .DISPLACEMENT FOR STRETCHING A1
3IA   INA (*)          MUI (5)          .
      DVI (NCHAN)      STA (WRB+13)     .NUMBER OF SAMPLES
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      STA (NSS)       MUI (NCHAN)      .                                A2F32130
      CVI (5)                          .                                A2F32140
      CJP (L+1)       INA (1)          .NUMBER OF WORDS PER LINE        A2F32150
      STA (SIZE)      SAL (5NXT)       .                                A2F32160
      SAL (1NXT)      INA (-1)         .                                A2F32170
      SAU (1INX)      SAL (1INX)       .                                A2F32180
      SAL (5IA)       INA (A1)         .                                A2F32190
      SAU (1IN7)      INA (1)          .LIMIT FOR STRETCHING A1         A2F32200
      SCM (-0B)       SAU (1IN4)       .                                A2F32210
4IA   SAL (1K)        ENA6(*)          .TEST FOR STRETCHING NEEDED IN A1 A2F32220
      SAU (2FLG)      SAU (1IN1)       .START OF A2                     A2F32230
      SAL (1IN3)      SAL (2IN2)       .                                A2F32240
5IA   SAU (1K)        INA (*)          .                                A2F32250
      SAU (2IN7)      INA (1)          .LIMIT FOR STRETCHING A2         A2F32260
      SCM (-0B)       SAU (2IN4)       .TEST FOR STRETCHING NEEDED IN A2 A2F32270
      ENA6(0)         INA6(0)          .                                A2F32280
      SCM (-0B)       INA (A1)         .                                A2F32290
      SAU (2IN5)      SCM (-0B)        .TEST FOR A2 UNDERSIZE           A2F32300
6IA   INA (*)         SAU (100M)       .START OF M                      A2F32310
      SAU (101M)      SAU (200M)       .                                A2F32320
      SAU (2IN1)      SAL (2IN3)       .                                A2F32330
      SAU (0K)        ADD (SIZE)       .                                A2F32340
      SAU (100N)      SAU (101N)       .START OF N                      A2F32350
      SAU (200)       ADD (SIZE)       .                                A2F32360
      SAU (7WRT)      ADD (SIZE)       .START OF TAPE CORRECTION AREA   A2F32370
      SAU (6NXT)      SAU (0WRT)       .START OF FIRST OUTPUT BUFFER    A2F32380
      SAL (6WRT)      SAU (2NXT)       .                                A2F32390
      INA (-1)        SAL (3K)         .LAST WORD OF TAPE CORRECTION AREAA2F32400
      SAU (0NXT)                       .                                A2F32410
                                                                        A2F32420
************************                                                A2F32430
*  WAIT FOR GOOD SCAN  *                                                A2F32440
************************                                                A2F32450
                                                                        A2F32460
      EXF7(10B)       SLJ (0STX)       .EXIT IF TYPEWRITER DONE         A2F32470
      EXF7(50324B)    SLJ (L-1)        .WAIT FOR END OF LINE            A2F32480
      LIU6(Z+5)       EXF (50341B)     .SAVE SIZE, RESTART CONVERTER    A2F32490
1TST  ENA6(*)         AJP2(2BIG)       .JUMP IF OVERSIZE                A2F32500
2TST  INA (*)         AJP2(0K)         .JUMP IF SIZE IS OK              A2F32510
      EXF5(A1)        SIU6(L+3)        .TOO SMALL, START OVER, SAVE SIZE A2F32520
      ENA (0)         STA6(Z)          .CLEAR LEFTOVER DATA             A2F32530
3TST  ISK6(*)         SLJ (L-1)        .LOOP (CLEAR AN EXTRA WORD)      A2F32540
      ENI6(*)         SLJ (0AGN)       .RESTORE SIZE, GO RE-INITIALIZE  A2F32550
2BIG  EXF5(A1)        SLJ (0AGN)       .TOO BIG, GO RE-INITIALIZE       A2F32560
                                                                        A2F32570
**********************************                                      A2F32580
*  GOOD SCAN, START EVERYTHING  *                                       A2F32590
**********************************                                      A2F32600
                                                                        A2F32610
0K    ENI5(*)         SIL5(Z+5)        .START BUFFER FOR NEXT SCAN      A2F32620
1K    EXF5(*)         ENA6(*)          .                                A2F32630
      AJP2(L+1)       RAO (STRETCH)    .IF SCAN WAS SHORT, COUNT STRETCH A2F32640
2K    RAO (SCANS)     ENA6(*)          .COUNT SCAN                      A2F32650
      AJP3(L+1)       RAO (LONG)       .IF SCAN WAS LONG, COUNT A TRIM  A2F32660
3K    ENA (-0)        STA (*)          .STORE THE TAPE CORRECTION WORD  A2F32670
      ENA (0INT)      EXF4(WRB)        .START THE TAPE                  A2F32680
      EXF (50342B)    EXF (10B)        .SELECT CONVERTER AND CONSOLE INTSA2F32690
      SAL (Z+7B)      SLJ (1FLG)       .CONNECT THE INT. ROUTINE AND GO A2F32700
                                                                        A2F32710
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*************************************                                   A2F32720
*                                   *                                   A2F32730
*  PROCESS THE DATA (FROM ADTEST2)  *                                   A2F32740
*  (INDENTED CARDS ARE UNMODIFIED)  *                                   A2F32750
*       (MAY NOT USE INDEX 6)       *                                   A2F32760
*     (SMOOTHS OF 3 THROUGH 16)     *                                   A2F32770
*                                   *                                   A2F32780
*************************************                                   A2F32790
                                                                        A2F32800
                                                                        A2F32810
*******************************                                         A2F32820
*  GET INPUT BUFFER TO EMPTY  *                                         A2F32830
*******************************                                         A2F32840
                                                                        A2F32850
 100  ISK7(OFLG)       SLJ  (L+3)      .WHICH BUFFER                    A2F32860
 1FLG ENA (A1)         ISK  (*)        .WAIT FOR BUFFER 1               A2F32870
      SAL  (OFLG)      SLJ  (L+3)      .                                A2F32880
 2FLG ENA  (*)         ISK  (*)        .WAIT FOR BUFFER 2               A2F32890
 OFLG SIL  (OFLG)      ENI  (*)        .                                A2F32900
      EXF7(10B)        SLJ  (OOUT)     .EXIT IF DONE                    A2F32910
 1INX ENI1(*)          ENI2(*)         .PLACE BUF SIZE IN INDEX REGISTERSA2F32920
                                                                        A2F32930
******************************                                          A2F32940
*  FIRST PASS - STORE VALUES  *                                         A2F32950
******************************                                          A2F32960
                                                                        A2F32970
        IJP4(100C)       SAU(L+1)    .SET UP                            A2F32980
        LDA2(*)          SCM(MASK)   .BIAS DATA UPWARD BY 5.0 VOLTS     A2F32990
100S  ARS  (*)         LDQ  (MASK2)    .SHIFT RIGHT FOR MAXIMUM CAPACITY A2F33000
100M  STL2(*)          LDQ  (MASK1)    .STORE EVEN COMPONENTS           A2F33010
100N  STL2(*)          IJP2(L-3)       .STORE ODD COMPONENTS            A2F33020
      SLJ  (100D)                      .CONTINUE                        A2F33030
                                                                        A2F33040
**************************************                                  A2F33050
*  REMAINING PASSES - ADD TO STORAGE  *                                 A2F33060
**************************************                                  A2F33070
                                                                        A2F33080
 100C   INI4(1)          SAU(L+1)    .SET UP                            A2F33090
        LDA2(*)          SCM(MASK)   .BIAS DATA UPWARD BY 5.0 VOLTS     A2F33100
101S  ARS  (*)         STA  (DATUM)    .SHIFT RIGHT FOR MAXIMUM CAPACITY A2F33110
      LDQ  (DATUM)     LDL  (MASK2)    .BRING EVEN VALUES INTO ACCUMULATOA2F33120
101M  RAD2(*)          LDL  (MASK1)    .ODD VALUES INTO ACCUMULATOR     A2F33130
101N  RAD2(*)          IJP2(L-4)       .CONTINUE                        A2F33140
                                                                        A2F33150
*****************************                                           A2F33160
*  RELEASE THE INPUT BUFFER  *                                          A2F33170
*****************************                                           A2F33180
                                                                        A2F33190
100D  ISK7(OFLG)       SLJ  (L+2)      .WHICH BUFFER                    A2F33200
      SIL1(2FLG)       SLJ  (L+2)      .RELEASE BUFFER 2                A2F33210
      SIL1(1FLG)       ARS  (0)        .RELEASE BUFFER 1                A2F33220
101E  ISK4(*)          SLJ  (100)      .CONTINUE                        A2F33230
                                                                        A2F33240
***************************                                             A2F33250
*  GET EMPTY OUTPUT BUFFER  *                                           A2F33260
***************************                                             A2F33270
                                                                        A2F33280
      ENA7(7NXT)       INA  (1)        .                                A2F33290
5NXT  SAU  (200S)      INA  (*)        .STORE START OF NEW BUFFER       A2F33300
      SAL  (7NXT)      SAL  (L+3)      .STORE END OF NEW BUFFER         A2F33310
      INA  (-37777B)   AJP3(L+2)       .DOES NEW BUFFER EXIST           A2F33320
6NXT  ENA  (*)         SLJ  (L-3)      .NO-GET FIRST ONE                A2F33330
        -              ISK7(*)         .WAIT FOR BUFFER EMPTY           A2F33340
                                                                        A2F33350
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************************************************************          A2F33360
*  MOVE RESULT FROM TEMPORARY STORAGE TO OUTPUT BUFFER     *          A2F33370
*              (CHANGING THE FORMAT)                       *          A2F33380
************************************************************          A2F33390
                                                                      A2F33400
200   LDA1(*)          ARS (*)          .GET ODD VALUES               A2F33410
      SCL (MASKO)      MUI (IKR)        .CLEAR BITS AND SCALE ODD VALUES  A2F33420
      LDA (MASK11)     STL (DATUM)      .STORE ODD VALUES             A2F33430
200M  LDA1(*)          ARS (*)          .GET EVEN VALUES              A2F33440
      SCL (MASKE)      MUI (IKR)        .CLEAR BITS AND SCALE EVEN VALUES A2F33450
      LDA (DATUM)      ADL (MASK21)     .COMBINE EVEN AND ODD VALUES  A2F33460
        SCM(MASK)        STA(DATUM)   .REMOVE 5.0 VOLT BIAS           A2F33470
        LDQ(DATUM)       LDL(MASK)                                    A2F33480
        ARS(8)           STQ(DATUM)   .GENERATE SIGN-BIT INDICATOR    A2F33490
        RS8(DATUM)       LDQ(DATUM)   .DECREMENT (-) VALUES BY 1      A2F33500
      QLS (3)          LDL (MASKP3)     .                             A2F33510
      QLS (12)         ADL (MASKP1)     .                             A2F33520
      QLS (6)          ADL (MASKP4)     .                             A2F33530
      QLS (12)         ADL (MASKP2)     .                             A2F33540
      QLS (6)          ADL (MASKP5)     .                             A2F33550
200S  STA1(*)          IJP1(200)        .STORE OUTPUT VALUE           A2F33560
                                                                      A2F33570
***************************                                           A2F33580
*  RELEASE OUTPUT BUFFER  *                                           A2F33590
***************************                                           A2F33600
                                                                      A2F33610
7NXT  ENA (10)         SAL (*)          .MARK FULL BUFFER             A2F33620
8NXT  EXF (*)          ENI4(0)          .FORCE INTERRUPT IF TAPE WAITING  A2F33630
      RAO (LINES)      SLJ (100)        .COUNT LINE AND CONTINUE      A2F33640
                                                                      A2F33650
**********************************                                    A2F33660
*                                *                                    A2F33670
*  INTERRUPT DISPATCHING ROUTINE *                                    A2F33680
*                                *                                    A2F33690
**********************************                                    A2F33700
                                                                      A2F33710
0INT  STA (ASAVE)      EXF (218)        .SAVE AC, CLEAR FORCED INTERRUPT  A2F33720
1TAP  EXF7(*)          SLJ (L+2)        .TEST FOR TAPE READY TO WRITE A2F33730
0TAP  SLJ (*)          EXF (*)          .EXIT/ENTRY, SELECT INTERRUPT A2F33740
1TYP  EXF7(10B)        SLJ (*)          .TEST FOR END OF RUN          A2F33750
1A2D  EXF7(50324B)     SLJ (L+2)        .TEST FOR END OF SCAN         A2F33760
0A2D  SLJ (*)          EXF (50342B)     .EXIT/ENTRY, SELECT INTERRUPT A2F33770
1INT  LDA (ASAVE)      SLJ (Z+7)        .RETURN                       A2F33780
                                                                      A2F33790
**************                                                        A2F33800
* END OF RUN *                                                        A2F33810
**************                                                        A2F33820
                                                                      A2F33830
0END  ENA (1INT)       SAL (1TYP)       .END OF RUN-CHANGE JUMP       A2F33840
      SIL (1FLG)       SIL (2FLG)       .CLEAR FLAGS IN PROCESSING ROUTINEA2F33850
      EXF (11B)        EXF (50000B)     .CLEAR INTERRUPT AND CONVERTER A2F33860
      LDA (Z+5)        SAU (L+1)        .STOP CHANNEL 5               A2F33870
      EXF5(*)          SLJ (1INT)       .EXIT                         A2F33880
                                                                      A2F33890
************************                                              A2F33900
*                      *                                              A2F33910
*  FILL INPUT BUFFERS  *                                              A2F33920
*    (START AT 0IN)    *                                              A2F33930
*                      *                                              A2F33940
************************                                              A2F33950
                                                                      A2F33960
                                                                      A2F33970
2IN   RAC (SCANS)      SIL (2FLG)       .ACCEPT THE SCAN-RELEASE THE BUFF A2F33980
                                                                      A2F33990
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************
* BUFFER 1 *
************

1IN1   ENA (*)           SAL (Z+5)      .SET ADDRESS OF END OF BUFFER
       ISK7(1FLG)        SLJ (L+4)      .IS THE BUFFER EMPTY
       EXF (50341B)      SLJ4(0A20)     ..FULL-START AND GO WAIT
1INQ   RAO (LOST)        RAO (SCANS)    ..COUNT LOST SCAN
       SLJ (L-3)                        ..GET NEXT SCAN
       EXF (50341B)      EXF5(A1)       .EMPTY-START CONVERTER AND CHANNEL
       SLJ4(0A20)                       .GO WAIT FOR END OF LINE
       EXF7(51B)         SLJ (L+2)      .TEST FOR CHANNEL ACTIVE
       RAO (LONG)        SLJ (1IN)      .NOT ACTIVE-LONG SCAN-ACCEPT IT
1IN3   LIU6(Z+5)         EXF5(*)        .SAVE ADDRESS-STOP CHANNEL
1IN4   ENA6(*)           AJP2(1IN)      .TEST FOR FULL SCAN
1IN5   ENA6(*)           AJP2(L+2)      .SHORT...STRETCH OR SCRATCH
       RAO (SHORT)       SLJ (1INQ)     ..SCRATCH IT
1IN6   LDA6(*)           STA6(Z)        ..STRETCH IT
1IN7   ISK6(*)           SLJ (L-1)      ..CONTINUE
       RAO (STRETCH)     ARS (0)        ..
1IN    RAO (SCANS)       SIL (1FLG)     .ACCEPT THE SCAN-RELEASE THE BUFF

************
* BUFFER 2 *
************

2IN1   ENA (*)           SAL (Z+5)      .SET ADDRESS OF END OF BUFFER
       ISK7(2FLG)        SLJ (L+4)      .IS THE BUFFER EMPTY
       EXF (50341B)      SLJ4(0A20)     ..FULL-START AND GO WAIT
2INQ   RAO (LOST)        RAO (SCANS)    ..COUNT LOST SCAN
       SLJ (L-3)                        ..GET NEXT SCAN
2IN2   EXF (50341B)      EXF5(*)        .EMPTY-START CONVERTER AND CHANNEL
       SLJ4(0A20)                       .GO WAIT FOR END OF LINE
0IN    EXF7(51B)         SLJ (L+2)      .TEST FOR CHANNEL ACTIVE
       RAO (LONG)        SLJ (2IN)      .NOT ACTIVE-LONG SCAN-ACCEPT IT
2IN3   LIU6(Z+5)         EXF5(*)        .SAVE ADDRESS-STOP CHANNEL
2IN4   ENA6(*)           AJP2(2IN)      .TEST FOR FULL SCAN
2IN5   ENA6(*)           AJP2(L+2)      .SHORT...STRETCH OR SCRATCH
       RAO (SHORT)       SLJ (2INQ)     ..SCRATCH IT
2IN6   LDA6(*)           STA6(Z)        ..STRETCH IT
2IN7   ISK6(*)           SLJ (L-1)      ..CONTINUE
       RAO (STRETCH)     SLJ (2IN)      ..

***********************
*                     *
* TAPE WRITING LOGIC  *
*                     *
***********************


****************************
*  GET A BUFFER OF OUTPUT  *
****************************

ONXT   ENA (*)           INA (1)        .
1NXT   SAU (1WRT)        INA (*)        .STORE START OF NEXT BUFFER
       SAU (9NXT)        SAU (OWRT)     .STORE END OF NEXT BUFFER
       SAU (ONXT)        SAU (4NXT)     .
       INA (-37777B)     AJP3(3NXT)     .DOES NEW BUFFER EXIST
2NXT   ENA (*)           SLJ (1NXT)     .NO, CHANGE TO FIRST ONE
3NXT   ENA (20B)         SIU (8NXT)     .CLEAR FORCED INTERRUPT
4NXT   ISK7(*)           SLJ (OWRT)     .IF NEW BUFFER FULL, GO TO WRITE
       SAU (8NXT)        SLJ4(OTAP)     .WAIT FOR BUFFER FULL INTERRUPT
       SLJ (3NXT)                       .GO TEST IT AGAIN
```

```
*****************
* WRITE A RECORD *
*****************

0WRT   ENA (*)          SAL (Z+4)       .SET END
1WRT   EXF4(*)          SLJ4(0TAP)      .START WRITE, WAIT FOR DONE
2WRT   EXF7(*)          SLJ (5WRT)      .TEST FOR PARITY ERROR
3WRT   EXF7(*)          SLJ (5WRT)      .TEST FOR LENGTH ERROR
4WRT   EXF7(*)          SLJ4(0EOT)      .CHANGE TAPE IF END OF REEL
9NXT   SIL (*)          SLJ (0NXT)      .RELEASE BUFFER, GO GET NEXT ONE

**********************
* CORRECT TAPE ERRORS *
**********************

5WRT   EXF7(*)          SLJ (9WRT)      .TEST FOR END OF TAPE
6WRT   EXF (*)          ENA (*)         .SELECT BCD, SET END OF CLEAR BUFF
       SAL (Z+4)        SLJ4(0BKS)      .BACKSPACE
7WRT   EXF4(*)          SLJ4(0TAP)      .WRITE BLANK TAPE
8WRT   EXF7(*)          SLJ (9WRT)      .TEST FOR END OF TAPE
8WRT1  EXF (*)          SLJ4(0BKS)      .NOT END, BIN MODE AND BACKSPACE
       RAO (ERRORS)     SLJ (0WRT)      .COUNT ERROR, GO RE-WRITE
9WRT   SLJ4(0BKS)                       .BACKSPACE
       SLJ4(0EOT)                       .CHANGE TAPE
       RAO (ERRORS)     SLJ (0WRT)      .COUNT ERROR, GO RE-WRITE


****************************
*                          *
*  TAPE CONTROL SUBROUTINES *
*                          *
****************************

**********************
* BACKSPACE ONE RECORD *
**********************

1BKS   EXF (*)          SLJ4(0TAP)      .BACKSPACE/WAIT READY
0BKS   SLJ (*)          SLJ (L-1)       .EXIT/ENTRY

*********************************************
* END OF TAPE - UNLOAD TAPE AND GET A NEW ONE *
*********************************************

0EOT   SLJ (*)          EXF (*)         .EXIT/ENTRY, SELECT BCD
       ENA (SPACES)     SAL (Z+4)       .SET END OF EOT RECORD
       EXF4(ENDREEL)    SLJ4(0TAP)      .WRITE ENDTAPE RECORD/WAIT READY
1EOT   EXF (*)          ENI6(*)         .UNLOAD TAPE, PUT COUNTER IN INDEX
2EOT   ISK6(*)          ARS (0)         .CYCLE TAPE COUNTER
3EOT   SIL6(1EOT)       SLJ4(0SEL)      .STORE COUNTER, SELECT NEW UNIT
       SLJ (0EOT)                       .RETURN

**************
* SELECT TAPES *
**************

9SEL   BSS (8)                          .TAPE SELECT CODE TABLE
0SEL   SLJ (*)          LDA6(9SEL)      .EXIT/ENTRY, GET SELECT CODE
       SAU (L+1)        SCL (77B)       .STORE XC0U1
       EXF (*)          SAU (1TAP)      .STORE XC000, SELECT TAPE
       INA (1)          SAU (5SEL)      .STORE XC001
       SAU (8WRT1)      INA (1)         .
       SAL (0EOT)       SAU (6WRT)      .STORE XC002
```

```
      INA (1)          SAU (2WRT)       .STORE XC003
      INA (1)          SAL (OTAP)       .STORE XC004
      INA (1)          SAU (3WRT)       .STORE XC005
      INA (1)          SAU (1BKS)       .STORE XC006
      INA (1)          SAU (1EOT)       .STORE XC007
      SAU (4WRT)       SAU (5WRT)       .
      SAU (8WRT)       ARS (0)          .
5SEL  EXF7(*)          SLJ (0SEL)       .RETURN IF TAPE READY

****************
*              *
*  END THE RUN *
*              *
****************


*************************************
* NEW TAPE NOT READY, CRASH THE RUN *
*************************************

      EXF (11B)        EXF (50000B)     .CLEAR INTERRUPT AND CONVERTER
      EXF7(11B)        EXF1(T1)         .
      LDA (Z+5)        SAU (L+1)        .STOP CHANNEL 5
      EXF5(*)          ENA (L+2)        .
      SAU (Z+7)        SLJ (Z+7)        .LEAVE INTERRUPT MODE
      ENI(0)           ENI(0)           .DO NOTHING TO CATCH JUMP
      ENA (WONKITY)    SLJ4(MTR)        .WRITE *NO TAPES* MESSAGE
9ECT  ENA (*)          SAL (Z+7)        .
      SLJ4(0Z)                          .PRINT STATISTICS
      SLJ (1ENT)                        .EXIT

***************************
*  AFTER INCOMPLETE START *
***************************

0STX  EXF5(*)          EXF (50000B)     .CLEAR CHANNEL 5
      SLJ4(0Z)                          .PRINT STATISTICS
      SLJ (1ENT)                        .EXIT

*********************
*  AFTER NORMAL RUN *
*********************

0OUT  LIU1(8NXT)       IJP1(L+2)        .WAIT FOR LAST TAPE WRITE
      SLJ (L-1)                         .
      LDA (OTAP)       SCL (77B)        .
      SAU (L+1)        SAL (L+1)        .
      EXF (*)          EXF7(*)          .CLEAR TAPE INTERRUPT SELECT
      INA (3)          SAU (2OUT)       .STORE EOF SELECT CODE
      INA (4)          SAL (3OUT)       .STORE UNLOAD SELECT CODES
1OUT  ENA (*)          SAL (Z+7)        .RESTORE INTERRUPT
2OUT  EXF (*)          SLJ4(0Z)         .WRITE EOF, GO PRINT STATISTICS
      ENA (DONE)       SLJ4(MTR)        .ASK IF USER WANTS TAPE UNLOADED
      ENA (9)          SLJ4(RNX)        .GO GET REPLY
      LDA (RDB)        INA (-30B)       .
3OUT  AJP1(1ENT)       EXF (*)          .UNLOAD TAPE IF YES
      SLJ (1ENT)                        .

*********************
*  PRINT STATISTICS *
*********************

0Z    SLJ (*)                           .EXIT/ENTRY
      ENI5(NUMSTIX)    ENA (0)          .
```

```
1Z      THS5(ERRORS)    SLJ (0Z)          .SEARCH/EXIT                      A2F35920
        ENA5(JJ)        INA5(0)           .GENERATE ADDRESS                 A2F35930
        INA5(0)         LDQ5(ERRORS)      .GET VARIABLE                     A2F35940
        SAL (3Z)        SAL (4Z)          .SAVE ADDRESS                     A2F35950
        QJP3(5Z)        LDA (SPACES)      .JUMP IF MINUS, GET BLANKS IF NOT A2F35960
        STA7(4Z)        ENI2(6)           .SET BLANKS                       A2F35970
 2Z     LDA5(ERRORS)    ENQ (0)           .                                 A2F35980
        DVI (10)        STA5(ERRORS)      .GET LEAST SIGNIFICANT DIGIT      A2F35990
        QJP1(L+1)       ENQ (12B)         .SET TO 12B IF ZERO               A2F36000
 3Z     LDL (77B)       LDQ (*)           .PACK DIGIT                       A2F36010
 4Z     LRS (6)         STQ (*)           .                                 A2F36020
        LDA5(ERRORS)    AJP (L+2)         .EXIT IF NUMBER DONE              A2F36030
        IJP2(2Z)        SLJ (5Z)          .LOOP/SET MANY IF OVERFLOW        A2F36040
        LDA (SPACES)    LLS (6)           .                                 A2F36050
        LRS (6)         IJP2(L)           .FILL WITH LEADING BLANKS         A2F36060
        STQ7(4Z)        SLJ (L+2)         .STORE AND GO PRINT               A2F36070
 5Z     LDA (MES6)      STA7(4Z)          .SET /   MANY /                   A2F36080
        ENA7(4Z)        SLJ4(MTR)         .PRINT LINE                       A2F36090
        SLJ (1Z)                          .LOOP FOR MORE                    A2F36100
                                                                            A2F36110
        END                                                                 A2F36120
```

```
      PROGRAM CSD1(IARG1,IARG2,IARG3)
C  NEEDS PROCESS, UNPACK3, BUFPACK.
C  INPUT ON 3, OUTPUT ON 4.
C  PROGRAM HAS 'CONTINUE FILE' OPTION
C  'TIME' CHANNEL SHOULD BE LAST CHANNEL ON TAPE.

C  DESIGNED PRIMARILY FOR DOING DYNAMIC CLAMPING TO THE DARK LEVEL,
C    AND DYNAMIC SCALING TO THE SUN SENSOR.
C  SCALE FACTORS ARE COMPUTED ONLY WHEN AIRCRAFT ROLL (AS INDICATED
C    BY THE SIGNAL IN A DIGITIZED 'TIME' CHANNEL) IS WITHIN CERTAIN
C    LIMITS. LIMITS WILL BE COMPUTED BY THE PROGRAM.
C  HAS 'DESKEWING' CAPABILITY ('SKEWS =' 0 FOR NO DESKEWING)
C    THE 'CLAMPING REGION' WILL NOT BE DESKEWED PRIOR TO CLAMPING DATA
C    'SCALING REGION' IS DESKEWED PRIOR TO SCALING (MINIMUM SKEW .EQ. 0)
C                        -----------
C  SAMPLE REGION LINE NO.= 0 TO SKIP COMPUTATION OF LIMITS
C  A SCALE FACTOR OF ' 0. ' WILL SIGNAL THAT PREVIOUS VALUE SHOULD BE
C    USED (' 1.0 ' WILL BE USED IF NO PREVIOUS VALUE WAS ENTERED).
C    ONLY ONE ' 0.' NEEDS TO BE ENTERED IF ALL SCALE FACTORS ARE TO
C    BE LEFT UNCHANGED.
C  NO. OF FILES TO SKIP = -0 TO TERMINATE THE RUN

       DIMENSION ISKS(12)
      DIMENSION IVSS(12)
       DIMENSION IKEY(6), KEYWD(6)
      DIMENSION DATA(6000), SHIFT(5)
      DATA(KEYWD(0)=00004546237144658,00454647517145238,202020202020202
     18,20454663436144478,20454622636143658,00000000006346458)
      COMMON ICODE(12), ISKEW(13), IVC(12), IVS(12), NHI(12), NLO(12),
     1  USC(12), VC(12), VCL(12), VSC(12), VSS(12), WSS(12)
      COMMON DEL(5), ID(12), JV(50), POS(5), SAMP(500), X(50)
      DATA(SHIFT = 9, 18, 27, 36, 45), (MAX = 777B), (MIN = -400B)
      COMMON V(6000), RESERVE(12), ID1, ID2, BANG, DANG
      COMMON L90, KEY, NPTS, NLINES, NSA, NSB, KS, NA, NB, KP, NEWR,
     1 TITLE(12), TAG1(12), TAG2(12), NSS, NCHAN, KR, CONV, IPOS,
     2 IPACK, INT
      EQUIVALENCE (DATA(1), V(1)), (MINSKEW, ISKEW(0))
      INTEGER DATA, DEL, POS, SAMP, SHIFT, TAG1, TAG2, TITLE, VC, X
      LOC(RLB = 13, TEST = 70, ZRO = 0)
      PARTMAP
```

```
      CALL CORECON
       N5=5
      CALL ZERO(VSC, VSC(12), 1.)
       ICRASH = 1
        FF = 59.0
       IEND = 0000000000654564B
       LDA(IARG1)   SUB(IEND)    AJPO(44)  .   JUMP TO END ROUTINE

        LIU1(TEST)     IJP1(1)     SLJ(2)
  1   WRITE(19,101)
101   FORMAT(/ * EXECUTION BEGINS * /)
       SLJ(L+2)   .   SKIP NEXT INSTRUCTION

  2     EXF(1000B)     SLJ3(3)     .IF NOT BATCH, START REAL-TIME CLOCK
       +ENA(77776B)   STA(IKEY)
        STA(IKEY+1)   STA(IKEY+5)
       ENA(00000)   STA(IKEY+2)
        DO 500 I=0,2
       +ENI6(00006B)   LDA1(IARG1)
       EQS6(KEYWD)   SLJ(503A)
        ENA(00001)   STA6(IKEY)
       SLJ(500)   ENIO(0)
503A   AJPO(500)   STA(IKEY+2)
 500   CONTINUE
       ENA(00000)   STA(IARG1)
       STA(IARG2)   STA(IARG3) .  ZERO OUT PAR FIELDS
       +LDA(IKEY+5)   AJP3(3)
       ENA(00000)    STA(IKEY+2)
  3   CALL PROCESS(DATA, 1)
        LDA(KEY)        SUB(5)       AJP(91)
      CALL ZERO(WSS, WSS(12))
       ENA(77776B)    STA(IKEY+3)
       STA(IKEY+4)    STA(IKEY+6)
        IFIRST=1
      WRITE(9,107) 37B
107   FORMAT(* NEW TITLE* R1/)
        LDA(NCHAN)    INA(77776B)
       +SSK(IKEY)    INA(00001)
        STA(NC)
       IF(NC .LT. 13)11,97
 11    CONTINUE
       READ(9,108) ID
108   FORMAT(12A8)
        LIU1(TEST)     IJP1(21)    SLJ(22)
 21   WRITE(9,108) ID
 22   IF(ID(1) .EQ. 3HYES) 11, 12
 12   IF(ID(1) .NE. 2HNO) 13, 17

 13   DO 14 I=1,12
 14     TITLE(I) = ID(I)

 17     INT = 1
        IUNIT = 3
        IPOS2 = 1
        ISTART = 0
        LSTART = 0
        NOTITLE = 0
        KBAD = 0
        NBAD = 777B
      CALL ZERO(NHI, NLO(12))
      WRITE(9,117) NC
117   FORMAT(* SKEWS(*I2*I5)= *)
      READ(9,103) ISKEW
```

```
 103    FORMAT(15I5)
          LIU1(TEST)       IJP1(17A)    SLJ(17C)
  17A WRITE(9,103) (ISKEW(I), I=1,NC)
  17C     MINSKEW = 10
          MAXSKEW = -10

      DO 6 J=1,NC
          MINSKEW = MINO(MINSKEW, ISKEW(J))
   6      MAXSKEW = MAXO(MAXSKEW, ISKEW(J))
          MAXSKEW = MAXSKEW - MINSKEW
        WRITE(9,105)
 105  FORMAT(*CLAMP REGION, VCLAMP.  2I4,12F6.3*/)
        READ(9,106)    NACL, NBCL, VCL
 106    FORMAT(2I4,12F6.4)
        WRITE(9,109)
 109    FORMAT(*SCALE REGION, VSCALE.  2I4,12F6.4 */)
        READ(9,106) NASS, NBSS, USC
         NBCL=MINO(NBCL, NSS-MAXSKEW)
         NBSS = MINO(NBSS, NSS-MAXSKEW)
        IF(NASS .GT.7000) 510,511
 510    WRITE(9,520)
 520    FORMAT(*SMOOTHING CONSTANT = *)
        READ(9,225) FF
225     FORMAT(F10.0)
        NASS=NASS-7000
  511   LDA(NBSS)     ENQ(00001B)
        AJP1(512)     STQ(IKEY+4)
        SLJ(514).
 512     SUB(NASS)     AJP3(97)
 514    LDA(NBCL)     AJP1(513)
        IPOS2 = IPOS
        AJP1(517)
        KBAD =-255
        NBAD = 255
  517   STQ(IKEY+3)    SLJ(24)
 513    SUB(NACL)   AJP3(97)
  24     NCST = (NACL - 1)*NCHAN
        CONV2 = 0.0
        FVS = 1.0/CONV
        FFCONV = FF * CONV
          DCONV2 = 1.0 / ((1.0 + FF) * CONV)
         IKEY(6) = IKEY(4) + IKEY(5) - 1
        N = NC + 1
        LDA(0)    ENQ(00001)
        +THS6(ISKEW)    ENQ(77776B)    .      CHECK FOR ANY DESKEWING
        STQ(JSKEW)


C  DETERMINE ACCEPTABLE LIMITS FOR SIGNALS IN 'TIME' CHANNEL
       NEWR = 0
       +SSK(IKEY+4)    SLJ(18)
        SSK(IKEY)    SLJ(18)
        LDA(IKEY+2)    AJP0(18)
       STA(NSA)
       NSB= NSA+120
       IFIRST=1
       KS=2
       NA= NSS/3
       NB= NA + MINO(50,NA)
       KP=1
      CALL ZERO(WSS, WSS(12))
194   FSS = NB - NA + 1
      NL = NSB - NSA
```

```
      NL = NL/KS + 1
      NP = 500/NL
        LIU1(TEST)      IJP1(36)      SLJ(37)
 36   WRITE(9,103) NSA, NSB, KS, NA, NB, KP
 37   ASSIGN 99 TO N90
      CALL SETEOF(N90)
      CALL FSKIP(0, NSA - NEWR, IUNIT)
      NEWR = NSA
      KM = KS - 1
        LDA(ZRO)        SCL(77777777777777000B)
        STA(ISRAN)
      CALL RANIF(ISRAN)
        SLJ4(320)       .SET UP UNPACKING
      ISP = 0
      KR = 0

      DO 94 NSCAN = NSA, NSB, KS

        DO 93 K = 1, KR
          NEWR = NEWR + 1
          LDA(IUNIT)  SLJ4(RLB).       READ ONE BINARY RECORD
 93   CONTINUE

        KR = KM
        NEWR = NEWR + 1
        SLJ4(300).       UNPACK CHANNEL NCHAN INTO X

        DO 94 J = 1, NP
      K = IFIX(RAN1F(-1) * FSS - .000001) + NA
      ISP = ISP + 1
 94       SAMP(ISP) = X(K)
        SLJ(99A)

 99     NSB = NEWR
 99A  CALL SORT1(SAMP, ISP, -1)
        NMID = ISP/2
        NQTR = ISP/8
        NLOW = NMID - NQTR
        NHIG = NMID + NQTR
        MIN = SAMP(NLOW)
        MAX = SAMP(NHIG)
 41     ANGLE = 3*(MAX - MIN + 1)
        ANGLE = ANGLE/20.
      WRITE(9, 115) MIN, MAX, ANGLE
115   FORMAT(* INTEGER RANGE(* I3 * TO * I3 *) COVERS* F4.1 * DEGREES*/)
 42   CALL RSTEOF

 18   CALL PROCESS(DATA,2)
        NB = MIN0(NB, NSS-MAXSKEW)
        NBI = MAX0(NB, NBSS)
        NKP = KP*NCHAN - NC + (ISKEW(1) - ISKEW(NC))*NCHAN
        LIU1(TEST)      IJP1(26)      SLJ(27)
 26   WRITE(9,103) NSA, NSB, KS, NA, NB, KP
 27     NST = (NA - 1 + ISKEW(1) - MINSKEW) * NCHAN
        NPSS = (NBSS - NASS)/KP + 1
        LDA(NOTITLE)    AJP1(46)
        FP = KP
        FANG = (NA - 1)
        BANG = BANG + FANG*DANG
        DANG = FP*DANG
        KSS = (NB-NA)/KP + 1
        MSS = KSS*NC

      WRITE(4) TITLE, KSS, BANG, DANG, NC, CONV, IPOS2, 1, TAG1, TAG2
```

```
      +SSK(IKEY+1)    SLJ(32)
 46   WRITE(N5, 114) TITLE, KSS, BANG, DANG, NC, CONV, IPOS2, NASS,
     1 NBSS, NACL, NBCL, KP
114  FORMAT(1H1 12A8 / I8 * PTS./SCANLINE,*7X*BANG=* F6.3,7X*DANG= *
     1 F6.3/ I10* CHANNELS,*7X*CONV =*F4.1* (QUANTA/VOLT),*7X*IPOS =*
     2 I1/8X*STABLE SOURCE LOCATED BETWEEN POINT NUMBERS*I5* AND *I5
     3 *,  CLAMPING REGION BETWEEN* I5 * AND * I5 *,   EVERY* I3  /)
 32     VC(0) = 0
      WRITE(9,108) 8HOPTIONS ,8HUSED
      DO 531 J=0,5
      LDA2(IKEY)    AJP3(531)
      WRITE(9,108) KEYWD(J)
 531    CONTINUE
      LDA(IKEY+2)    AJP1(532)
       WRITE(9,108) 8HNO TIME , 8HSAMPLING
 532  DO 4 J=1,NC
       ICODE(J) = J
       ISKEW(NC-J+1) = ISKEW(NC-J+1) - ISKEW(NC-J)
       VC(J) = VCL(J)*CONV + 0.5
       LDA2(USC)    AJPO(4A)
       VSC(J) = USC(J)
      GO TO 401
 4A   USC(J) = VSC(J)
401   VSS(J) = USC(J)
4     IVSS(J) = (VSS(J))*FLOAT(2**15)
      ISKEW(1) = 0

      +SSK(IKEY+1)    SLJ(533)
     +SSK(IKEY+3)    SLJ(29)
      WRITE(N5,121)  (VCL(J),J=1,NC)
 29   SSK(IKEY+4)    SLJ(29Y)
      WRITE(N5,121)  (VSC(J), J=1,NC)
 29Y  SSK(IKEY+5)    SLJ(29A).
      SLJ(533)
 29A   WRITE(N5,121)    (VSS(J) ,J=1,NC)

121   FORMAT(7X,12F6.3)
533  DO 7 J=1,NC
      ISKEW(J) = ISKEW(J)*NCHAN + 1
  7   ISKS(J) = ISKEW(J)
      +SSK(ICRASH)    SLJ(530A)
      CALL EXIT
530A   CONTINUE

     +SSK(IKEY+3)    SLJ(541)  .    JUMP IF NO CLAMP
      NKPS = 0
        NSTS=0
        NB1S = KSS
      NAS=1
        KPS=1
      NASS = (NASS-NA+1)
      NSST =(NASS-1) * NC
        CALL ZERO(ISKS,ISKS(12),1)
      GO TO 542
 541   NSTS = NST
      NKPS = NKP
       NB1S = NB1
      NSST =(NASS-1)*NCHAN
      NAS = NA
       KPS = KP
 542   CONTINUE

     CALL BUFFON
```

```
      DO 50 NSCAN = NSA,NSB,KS
       CALL PROCESS(DATA, 3)
         LDA(KEY)         SUB(4)        AJP(90)

         CALL ZERO(IVC, IVC(12))
        JSCL = -1
        +SSK(IKEY+4)    SLJ(67)
        LDA(IKEY+2)    AJPO(67)
         SSK(IKEY)    SLJ(67)
         N = (NA-1)*NCHAN

       DO 60 I=1,KSS
         M = N
         N = M + NCHAN
         IDAT = DATA(M)
         JDAT = DATA(N)
         LDA(IDAT)         AJP(60)
         SUB(JDAT)         AJP(65)
  60   CONTINUE
       GO TO 68

  65   IF(IDAT .LE. MAX .AND. IDAT .GE. MIN) 67, 68
   68    JSCL =1
        +SSK(IFIRST)    SLJ(50)
  67     K = 0
        +SSK(IKEY+3)    SLJ(501)
         N = NCST

       DO 10 IP=NACL,NBCL

       DO  9 J=1,NC
         N = N + 1
   9     IVC(J) = IVC(J) + DATA(N)

         +SSK(IKEY)    SLJ(10)
         N = N + 1
  10   CONTINUE

         NVC = (NBCL - NACL + 1)

       DO 30 J=1,NC
  30     IVC(J) = IVC(J)/NVC - VC(J)


C  CLAMP THE DATA

        +SSK(IFIRST)    SLJ4(2STCL)
         N = NST
       DO 35 IS=NA,NB1,KP

       DO 34 J=1,NC
         K = K + 1
         N = N + ISKEW(J)
 2CL     LDA6(DATA)       SUB2(IVC)    .CLAMP NORMAL POLARITY DATA
         STA3(DATA)
        +SSK(IKEY+6)    SLJ4(7CST).  IF CLAMP ONLY, COLLECT STATISTICS
  34    CONTINUE

  35     N = N + NKP

 501    +SSK(IKEY+5)    SLJ(16)
```

```
 521    +SSK(IKEY+4)    SLJ(502)
        SSK(JSCL)    SLJ(16)

C   COMPUTE SCALE FACTORS

       CALL BUFWAIT

         JVMAX = 0
       CALL ZERO(JV, JV(50))
         N = NSST

       DO 19 IP = 1, NPSS

       DO 19 J = 1, NC
         N = N + 1
  19     JV(IP) = JV(IP) + DATA(N)


       DO 20 IP = 1, NPSS
  20     JVMAX = MAXO(JVMAX, JV(IP))

         K = NPSS + 1
         LDA(JVMAX)
        +EQS3(JV)        SLJ(50).     LOCATE PEAK OF SUN SENSOR
         N = (NASS + (K-2)*KP)*NC

       DO 25 J=1,NC
         N = N + 1
         KVS = WSS(J)*CONV2
         WSS(J) = KVS + DATA(N)
         WSS(J) = WSS(J)*FVS
         AJP(25A)        SLJ(25C)
  25A    VSS(J) = 1.
         SLJ(25)
  25C    VSS(J) = VSC(J)/WSS(J)
  25   CONTINUE
        DO 347 I=1,NC
  347   IVSS(J) = VSS(J) * FLOAT(2**15)

C   SCALE THE DATA

  16     K = 0
       NN = NSTS

        DO 338 IS=NAS,NB1S,KPS

        DO 340 J=1,NC
        NN = NN + ISKS(J)
        N = NN
         K = K + 1
        LDA6(DATA)    MUI2(IVSS).
        ARS(15)    STA3(DATA).              SHIFT RIGHT AND STORE
        SLJ4(7CST).
 340    CONTINUE
 338    NN = NN + NKPS

 505      IFIRST = -1
        CONV2 = FFCONV
        FVS = DCONV2
        MMSCAN = NSCAN
```

```
      +SSK(IKEY+1)    SLJ(506).    JUMP IF NOPRINT IS SPECIFIED
      SSK(IKEY+3)    SLJ(15)      .  PRINT CLAMP VALUES IF CLAMPING
     WRITE(N5, 102) NSCAN, (IVC(J), J=1,NC)
 102 FORMAT(1H , 13I6)
      MMSCAN = 0

  15  +SSK(IKEY+4)    SLJ(506).   PRINT SCALE FACTORS IF DYNAMIC SCALING
      WRITE(N5,119) MMSCAN, (VSS(J), J=1,NC)
 119  FORMAT(1H ,I5,1X,12F6.3)

 506  CONTINUE
     CALL BUFPACK(DATA,MSS)
  50   LDA(KEY)        SUB(3)       AJP(90)


  90 WRITE(9, 125) 378
 125 FORMAT(* CONTINUE FILE* R1)
     READ(9, 108) IREP
     IF(IREP .EQ. 3HYES)43, 44
  43   NOTITLE = 1
     GO TC 18
  44   NOTITLE = 0
     ENDFILE 4
      +SSK(IKEY+1)    SLJ(3)
     WRITE(N5,110) TITLE
 110 FORMAT(1H1, 12A8)

     WRITE(N5,111) (ICODE(J), J=1,NC)
 111 FORMAT(1H0 * CHANNEL* 12I6/)

      WRITE(N5,122)  8H .GT.     , NBAD,(NHI(J),J=1,NC)
 122  FORMAT(A8,I4,12I6)

      WRITE(N5,122)  8H .LT.     , KBAD,(NLO(J),J=1,NC)

     GO TO 3

  91 ENDFILE 4
     REWIND 4
       LIU1(TEST)      IJP1(95)     SLJ(96)
  95 WRITE(19, 133)
 133 FORMAT(* EXECUTION TERMINATED* /)
      RETURN
  96 UNLOAD 3
     ENDFILE N5
     ENDFILE N5
        RETURN
  97  WRITE(9,1001)
 1001 FORMAT(*   ERROR IN PROGRAM INPUTS.  END OF JOB*)
      ICRASH = -1
      N5 = 9
      GO TO 46

 7CST SLJ(*)   ENIO(0)
      +THS(KBAD)       SLJ(39)
       NLO(J) = NLO(J) + 1
       LDA(KBAD)       SLJ(40)
  39  +THS(NBAD)       SLJ(92)
```

```
      SLJ(7CST)
  40    STA3(DATA)
      SLJ(7CST)
  92    NHI(J) = NHI(J) + 1
        LDA(NBAD)        SLJ(40)

 300    SLJ(*)           .UNPACK 'TIME' CHANNEL INTO X
 305  CALL READANY(3, 1, DATA(1), DATA(NWD), NW)
      IF(NW) 98, 306, 307
  98    LDA(N90)         SAU(L+1)
        SLJ(*)
 306  UNLOAD 3
      PAUSE 12345
      GO TC 305
 307    I = ISTART
        L = LSTART

      DO 310 K=1,NB
        LDA4(SHIFT)    SAL(310A)
 310A   LDQ1(DATA)      LLS(*)
        SCL(77777777777770008)       STA3(X)
        I = I + DEL(L)
 310    L = POS(L)

      GO TC 300

 320    SLJ(*)           .SET UP UNPACKING, AS IN GRAYMAP
      ISTART = (NCHAN + 4)/5
      LSTART = NCHAN + 5*(1 - ISTART)

      DO 325 L = 1, 5
        NEXTPOS = NCHAN + L
        DEL(L) = (NEXTPOS - 1)/5
 325    POS(L) = NEXTPOS - 5*DEL(L)

      NWD = (NCHAN*NSS + 4)/5
      GO TO 320

2STCL  SLJ(*)    LDA(2CLN).
       +SSK(IVC+2)    LDA(2CLR).    CHECK FIR REVERSE POLARITY DATA
       STA(2CL)      SLJ(2STCL)
2CLN   LDA6(DATA)    SUB2(IVC).  CLAMP NORMAL POLARITY DATA
2CLR      LDA2(IVC)    SUB6(DATA).   CLAMP REVERSE POLARITY DATA

  502  SSK(IKEY+3)   SLJ(507).    JUMP IF DESKEWING ONLY
       SLJ(505)
  507  LDA(JSKEW)    AJP3(97).   CONTINUE IF DESKEWING ONLY
       N = NST
       K=0
       DO 535  IS=NA,NB1,KP

       DO 534  J=1,NC
       K=K+1
       N = N + ISKEW(J)
       LDA6(DATA)    STA3(DATA)
  534  CONTINUE
  535  N =  N + NKP
       GO TO 505
      END
```

```
      PROGRAM AUTOCAL
C   USES PROCESS, NEW FSKIP, COMMENT, UNPACK3
C   INPUT ON 3, OUTPUT ON 4
C   CORRELATION REFERENCE CHANNEL IS A TYPED INPUT
C   ANSWER 'LINE NO. =' WITH   NSA  NSB   KS    NA    NB      BY 5I5
C   ANSWER  'CORRELATION REGION =' WITH   C1   C2      BY 2I5
C   THE CORRELATION REGION SHOULD HAVE ELBOW ROOM INSIDE   NA   NB
C   TO PERMIT CORRELATION,  AND   NA   NB  SHOULD HAVE ELBOW ROOM
C   INSIDE    1  NSS   TO PERMIT SLEW CORRECTION.
C   A PREVICUS GRAYMAP OF THE CALIBRATION DATA IS VERY DESIRABLE.
C   SENSE SWITCH 2 ON TO PRINT CHANNEL CORRELATION INFORMATION
C   OUTPUT OF THE PROGRAM IS SLEW-CORRECTED AND DARK-LEVEL CORRECTED
C   AVERAGE LINE, DARK LEVEL, AND INTEGER AND FRACTIONAL CHANNEL SKEW
C   VIDEO DATA USED FOR SLEW COMPUTATION IS NOT DARK LEVEL CORRECTED
C   TO TURN OFF SLEW CORRECTION, MAKE C1 .LT. 0
C   IF KS IS -1, EVERY FIFTH ICHAN POINT ON NSA WILL BE TYPED

      DIMENSION DEL(16),NOFF(16), OFFSET(16), Y(400), PROD(101),Z(2000),
     1DARK(16)
      COMMON DATA(6000), X(2000)
      COMMON RESERVE(8), NF, NR, MR, L80, ID1, ID2, BANG, DANG, L90
      COMMON KEY, NPTS, NLINES, NSA, NSB, KS, NA, NB, KP, IS, TITLE(12),
     1  TAG1(12), TAG2(12), NSS, NCHAN, IDA, CONV, IPOS, IPACK, INT
      EQUIVALENCE(X,Z), (Y,PROD), (Y(102),NOFF), (Y(115), OFFSET)
      INTEGER X, Y, DATA, DEL, DEL0, DEL1, DEL2, DEL3, TEST, FIRST, AVE,
     1  AVEMAX, SUM, SUM0, C1, C2, CX, C2X, CD, DATAI, PROD, PRODMAX
      SET INDEX K1 = L, K2 = M, K3 = N
      DATA(NSKEW = 10)

1     WRITE(9,101)
101     FORMAT(*CORRELATION REFERENCE CHANNEL =*)
      READ(9,102) ICHAN
102     FORMAT(8I5)
      WRITE(9,106)
106     FORMAT(*ARE YOU USING CALIBRATION DATA...*)
      READ(9,107) ICAL
107     FORMAT(A8)
      IF(ICAL.EQ.3HYES) 6, 8
6       ICAL = 1
        GO TO 21
8     ICAL = 0

C   READ AND PRINT TITLE AND OTHER INFORMATION
21    CALL PROCESS(DATA, 1, 1)

C   READ AND PRINT LINE AND COLUMN NUMBERS
2     CALL PROCESS(DATA, 2, 1)

      NVAL = NPTS*NCHAN
      IF(NVAL.GT.2000) 4, 5
4       WRITE(9,104)
104     FORMAT(20HNPTS*NCHAN .GT. 2000)
        GO TO 2
5     CALL ZERO(X, X(NVAL))
      NY = NB - NA + 1
      IF(NY.GT.400) 58, 59
58      WRITE(9,158)
158     FORMAT(*NB - NA + 1  .GT.  400*)
        GO TO 2
```

```
59     WRITE(9,103)
103      FORMAT(*CORRELATION REGION =*)
       READ(9,102) IC1, C2
       C1 = IABS(IC1)
       IF(C1.EQ.0) 12, 13
12       C1 = MINO(NA+3, NB-3)
         C1 = MAXO(C1, NA)
         C2 = NB - 3
13     C2 = MAXO(C2, C1+1)
       C2 = MINO(C2, NB)
       WRITE(4,167) C1, C2
167      FORMAT(6X *CORRELATION REGION =* I7, I5/)
       CX = (C1-NA)*NCHAN + ICHAN
       NC = C2 - C1
       C2X = (C2-NA)*NCHAN + ICHAN - NCHAN
       MX = MINO(C1-NA, NSKEW) + 1

       KINC = NCHAN
       KSTART = (NA-1)*NCHAN
       NA2 = MAXO(NA, 3)
       NB2 = MINO(NB, NSS-2)
       FIRST = 1
       INT = 1
       NRANGE = MINO(NSKEW, C1-NA) + MINO(NSKEW, NB-C2) + 1
       WRITE(4,105)
105      FORMAT(*0 LINE     NA     NB*/)

C  UNPACK A LINE OF INTEGER DATA INTO THE ARRAY DATA
3      CALL PROCESS(DATA, 3)
       IF(KS.LT.0) 400, 71
71     IF(KEY.EQ.4) 35, 75

C  ESTIMATE ADJACENT-POINT DIFFERENCE ON THE HIGH SIDE
75     LDA(FIRST)  AJP(11)
       DO 10 J = 1, NCHAN
       K1 = KSTART + J
       K2 = K1 + KINC
       DO 7 I = 1, NPTS-1
         Y(I) = IABS(DATA(K2)-DATA(K1))
         K1 = K1 + KINC
7        K2 = K2 + KINC
       CALL SORT1(Y, NY, -1)
10     DEL(J) =  Y(4*NPTS/5) * 2

C  EDIT NOISE SPIKES OUT OF THE DATA
11     DO 20 J = 1, NCHAN
       K1 = (NA2-1)*NCHAN + J
       K0 = K1 - KINC
       K2 = K1 + KINC
       K3 = K2 + KINC
       DEL0 = DATA(K0) - DATA(K0-KINC)
       DEL1 = DATA(K1) - DATA(K0)
       DEL2 = DATA(K2) - DATA(K1)
       DO 25 I = NA2, NB2, KP
         DEL3 = DATA(K3) - DATA(K2)
         LDA(DEL1)  SCM(DEL2)  AJP2(24)    .IF DEL1, DEL2 SAME SIGN, TO 24
           TEST = MINO(IABS(DEL1), IABS(DEL2))
           LEVEL = MAXO(IABS(DEL0), IABS(DEL3), DEL(J))
           IF(TEST.GT.LEVEL*5) 22, 24
```

```
22          K1 = K2 - KINC
            DATA(K1) = (DATA(K1+NCHAN) + DATA(K1-NCHAN))/2
24        DEL0 = DEL1
          DEL1 = DEL2
          DEL2 = DEL3
          K2 = K2 + KINC
25        K3 = K3 + KINC
20      CONTINUE

C   CORRECT FOR SLEW OF THE CALIBRATION DATA
        LDA(IC1)  AJP3(62)
        LDA(ICAL)  AJP(62)
        LDA(FIRST)  AJP1(31)
        IF(NLINES.EQ.2 .OR. NLINES.EQ.6) 60, 65
60      L = CX
        NL = NLINES - 1
        DO 61 K = 1, NC
          M = L + NCHAN
          Y(K) = (X(M)-X(L))/NL
61        L = M

65      CD = KSTART + CX
        SLJ4(200).    SUM  Y(K) * DEL DATA(L)    FOR ICHAN AT CAL REGION
        SUMO = SUM
        CD = CD + NCHAN
        SLJ4(200).
        IF(SUM.GT.SUMO) 26, 27

26      SUMO = SUM
        NA = NA + 1
        NB = NB + 1
        IF(NB.GT.NSS) 56, 28
56        WRITE(9,157) NA, NB, NSS, IS
157       FORMAT(*CALIBRATION HAS SLEWED OFF END. NA =* I4, *,  NB =* I4,
     1      *,  NSS =* I4, *,   LINE NO.* I5)
          GO TO 2
28      CD = CD + NCHAN
        SLJ4(200).
        IF(SUM.GT.SUMO) 26, 31

27      CD = CD - NCHAN
33      CD = CD - NCHAN
        SLJ4(200).
        IF(SUM.GT.SUMO) 32, 31
32        SUMO = SUM
          NA = NA - 1
          NB = NB - 1
          IF(NA.LT.1) 56, 33
31      KSTART = (NA-1)*NCHAN
        NA2 = MAX0(NA, 3)
        NB2 = MIN0(NB, NSS-2)
        IF(SENSE SWITCH 2) 69, 70
 69       WRITE(9,131) NA,NB
70      WRITE(4,131) IS, NA, NB
131       FORMAT(3I6)

C   UPDATE THE SUMS OF THE DESIGNATED POINTS
62      FIRST = 0
        K = KSTART
        DO 29 L = 1, NVAL
```

```
          K = K + 1
29        X(L) = X(L) + DATA(K)
        IF(KEY.EQ.2) 3, 35

C   AUTOMATIC DESKEWING CALCULATION
35      LC = MAXO(CX - ICHAN - NSKEW*NCHAN, 0)
        DO 50 J = 1, NCHAN
        IF(J.EQ.ICHAN) 50, 40
40      PRODMAX = 7400000000000008
        LCJ = LC + J
        DO 48 M = 1, NRANGE
          PROD(M) = 0
          L = LCJ
          DO 47 K = CX, C2X, NCHAN
            N = L + NCHAN
            PROD(M) = PROD(M) + (X(K+NCHAN)-X(K)) * (X(N)-X(L))
47          L = N
          IF(PROD(M) .GT. PRODMAX) 41, 48
41          PRODMAX = PROD(M)
            M2 = M
48        LCJ = LCJ + NCHAN

        IF(M2.EQ.1 .OR. M2.EQ.NRANGE) 42, 43
42        BIAS = 0.
          GO TO 44
43      M1 = M2 - 1
        M3 = M2 + 1
        BIASN = PROD(M3) - PROD(M1)
        BIASD = 2 * (2*PROD(M2) - PROD(M1) - PROD(M3))
        BIAS = BIASN/BIASD
44      NOFF(J) = M2 - MX
        OFFSET(J) = FLOAT(NOFF(J)) + BIAS
        IF(SENSE SWITCH 2) 30, 50
30        WRITE(4,150) BIASN, BIASD, BIAS, CX, C2X, LC, LCJ, NRANGE, MX,
       1  M1, M2, M3, PRODMAX, (PROD(M), M=1,NRANGE)
150       FORMAT(1H0 3F12.4, 9I8/(8I15))
50      CONTINUE

        NOFF(ICHAN) = 0
        OFFSET(ICHAN) = 0.

C   ESTABLISH DARK LEVEL FOR EACH CHANNEL
        FN = NLINES
        FN = 1./(FN*CONV)
        LDA(ICAL)  AJP(72)
        DO 55 J = 1, NCHAN
        SLJ4(300).       COMPUTE DARK LEVEL
55      DARK(J) = FLOAT(AVEMAX)/8. * FN
        WRITE(4,155) (DARK(J), J=1,NCHAN)
155       FORMAT(*0DARK * 12F8.3)
        WRITE(4,156)
156       FORMAT(1H )

C   COMPUTE AVERAGE POINTS SUBTRACTED FROM THE DARK LEVEL
        K = 0
        DO 36 I = 1, NPTS
        DO 36 J = 1, NCHAN
          K = K + 1
36        Z(K) =  DARK(J) - FLOAT(X(K))*FN
        GO TO 74
```

```
72      DO 73 K = 1, NVAL
73        Z(K) = FLOAT(X(K))*FN

74      K1 = 1
        K2 = NCHAN
        DO 37 I = NA, NB, KP
          WRITE(4,137) I, (Z(K), K=K1,K2)
137       FORMAT(I6, 12F8.3)
          K1 = K1 + NCHAN
37        K2 = K2 + NCHAN
        WRITE(4,144) (NCFF(J), J=1,NCHAN)
144       FORMAT(*OSKEW* I5, 11I8)
        WRITE(4,145) (OFFSET(J), J=1,NCHAN)
145       FORMAT(6X 12F8.3)
        GO TO 2

200     SLJ(*)     .SUM OF   Y(K) * DEL DATA(L)   FOR ICHAN AT CAL REGION
        SUM = 0
        L = CD
        DO 201 K = 1, NC
          M = L + NCHAN
          SUM = SUM + Y(K)*(DATA(M)-DATA(L))
201       L = M
        GO TO 200

 300    SLJ(*).      DARK LEVEL COMPUTATION
        AVE = 0
        L = J
        DO 51 I = 1, 8
          AVE = AVE + X(L)
51        L = L + NCHAN
        AVEMAX = AVE
        K = J
        DO 54 I = 9, NPTS
          AVE = AVE - X(K) + X(L)
          K = K + NCHAN
          L = L + NCHAN
54        AVEMAX = MAX0(AVEMAX, AVE)
        GO TO 300

C   PROGRAM TO TYPE EVERY FIFTH ICHAN VALUE ON LINE NSA
400     L = ICHAN
        LINC = 5*NCHAN
        LINC2 = LINC + LINC
        DO 401 I = 1, NSS, 10
          WRITE(9,402) I, DATA(L), DATA(L+LINC)
 402      FORMAT(I3, 2I5)
 401      L = L + LINC2
        GO TO 2
        END
```

```
        PROGRAM EXPMAP
C   VERSION 1.0 2/8/72, ZUK
C   NEEDS MAPTRAN, 4-ARG BUFPACK, PROCESS AND UNPACK3
C   LIBRARY ON 1, CONTROL DATA ON 2, ADTESTED SCANNER DATA ON 3,
C     2-CHANNEL RECOGNITION AND EXPONENT OUTPUT ON 4, HISTOGRAMS ON 5
C   PROVIDES FOR MAPPING WITH PREPROCESSED DATA. FOR UNTRANSFORMED
C   DATA, NTRAN = 1 AND DATUM(J) = CORRECT SUBSET OF DATA(I,J).
C   NT = NO. OF SIGNATURES
C   ND = NO. OF CHANNELS ON TAPE
C   NN = NO. OF CHANNELS IN SIGNATURE DECK
C   NV = NO. OF CHANNELS IN SIGNATURE USED
```

```
C   SQ FT = NO. OF SQ FT PER RESOLUTION ELEMENT
C   S(I) = INTEGER REPRESENTING SIGNATURE I
C   TAG(I), TAGA(I) = 16-CHARACTER IDENTIFICATION FOR HISTOGRAMS
C   ISUB = SIGNATURE DECK CORRESPONDS TO A SUBSET OF DATA CHANNELS
C     CODE(J) DEFINES THIS SUBSET
C   JSUB = USED SIGNATURE IS A SUBSET OF THE SIGNATURE DECK
C     ICODE(J) DEFINES THIS SUBSET (ORIGINAL CHANNEL NUMBERS)
C   NTRAN = NO. OF TRANSF'NS COMPUTED. UNTRANSFORMED COUNTS AS 1.
C   NTRAN NEGATIVE TO SIGNAL A SPECIAL OPERATION

      DIMENSION AMAP(6000), H(2280), ITABLE(52)
      COMMON A(20,12), B(12,12,20), D(20), DATA(6000), EIG(12), ID(10),
     1  IBIN(21,52), IC(12), ICODE(12), IPT(100), NP(21), S(21), S2(21),
     2  TAG(21), TAGA(21), Z(12)
      COMMON CODE(12), DATUM(12), NN, NTRAN
      COMMON R(5), BAN2, DAN2, CC, NF, NR, MR, L80, ID1, ID2, BANG, DANG
      COMMON L90, KEY, NPTS, NLINES, NSA, NSB, KS, NA, NB, KP, IS,
     1 TITLE(12), TAG1(12), TAG2(12), NSS, NCHAN, KR,  CONV, IPOS,
     2 IPACK, INT
      EQUIVALENCE (B, H), (DATA, AMAP)
      INTEGER CODE
      INTEGER AMAP, REPLY, S, TAG, TAGA, TAG1, TAG2, TITLE
      INTEGER SEC, SEC60
      DATA (ITABLE(1)= 511, 490, 480, 470, 460, 450, 440, 430, 420, 410,
     1400, 390, 380, 370, 360, 350, 340, 330, 320, 310, 300, 290, 280,
     2270, 260, 250, 240, 230, 220, 210, 200, 190, 180, 170, 160, 150,
     3140, 130, 120, 110, 100, 90, 80, 70, 60, 50, 40, 30, 20, 10, 0)
      LIB(BUFWAIT)
      LOC(TEST = 70)
      PARTMAP

   20 FORMAT(20I5)
   21 FORMAT(10A8)
   22 FORMAT(5E15.8)

        SLJ1(504)
      CALL CORECON
      DUMMY = 0.
 501  CALL PROCESS(DATA, 1, 0, 3, 2)
      WRITE(5, 1000) TITLE
      CONV10 = CONV/10.
 503  CALL PROCESS(DATA, 2)
        ENA(BUFWAIT)    SAL(L80)
      CALL BUFFON
      IF (MR.GE.0) 17, 642

  17  READ(2, 200) NT, ND, NN, NV, LTRAN, SQ FT
 200   FORMAT(5I3,3X,5E12.0)
         EXPLIM = 99.6

 622   FKS = KS
       FKP = KP
       ACRE = SQ FT * FKS * FKP / 43560.
       NT1 = NT + 1
       ISUB = ND - NN
       JSUB = NN - NV
       NTRAN = IABS(LTRAN)

       IF(ISUB) 305, 306, 305
C   * READ A SUBSET OF DATA CHANNELS IF DESIRED.
305       READ(2,20) (CODE(J), J=1,NN)
       CALL SORT1(CODE, NN, -1)
         GO TO 308
306    DO 307 J = 1,NN
```

```
307       CODE(J) = J

308     IF(JSUB.GT.0) 330, 331
C   * READ A SUBSET OF SIGNATURE CHANNELS.
 330    READ(2, 20) (ICODE(J), J=1,NV)
        CALL SORT1(ICODE, NV, -1)
          GO TO 337
331     DO 332 J = 1, NV
332       ICODE(J) = CODE(J)

337     L = 1
        DO 340 J = 1, NN
        IF(ICODE(L).EQ.CODE(J)) 341, 340
341       IC(L) = J
          L = L + 1
340     CONTINUE

314     S(NT+1)=511
        TAG(NT+1) = 8HNOT CLAS
        TAGA(NT+1) = 6HSIFED

7       LSTART = 1

C   * * * *  READ SIGNATURE DECKS AND ASSOCIATED INFORMATION  * * * *
        DO 108 I=1,NT
         READ(2,21) ID
        IF(ID(1).EQ.4HSAME) 108, 55
C   READ SIGNATURE DECK
55       READ(2,22) ((A(I,J),J=1,NN),((B(J,K,I),K=J,NN),J=1,NN))
C   READ INTEGER VALUE ASSOCIATED WITH SIGNATURE, NAME OF SIGNATURE,
        READ(2, 600) S(I), TAG(I), TAGA(I)
 600     FORMAT(I5,2A8,3F12.0)

C   REARRANGE THE MATRIX ACCORDING TO THE SUBSET.

104     DO 2 J=1,NV
        JJ = ICODE(J)

        DO 2 K=J,NV
        KK = ICODE(K)
        B(J,K,I) = B(JJ,KK,I)
2       B(K,J,I) = B(J,K,I)

C   CHECK TO SEE IF THE MATRIX IS POSITIVE DEFINITE.
        IF(DIAG(B(0,1,I), EIG, DUMMY, -NV, 12)) 23, 334, 23
23        WRITE(9,124) TAG(I), TAGA(I), (EIG(J), J=1,NN)
124       FORMAT(*MATRIX * 2A8, * IS NOT POSITIVE DEFINITE. EIGENVALUES *
      1   *ARE*/ (12E10.3))
          STOP
334     CALL INVERSE(B(0,1,I), B(0,1,I), NV, 12, 12, D(I), ISERR)
        WRITE(5, 123) TAG(I), TAGA(I), S(I), D(I)
123       FORMAT(2A8, I5, E15.5)
 336    D(I) = ALOG(D(I))
C
C   ARRANGE THE MATRIX B SO THAT IT FITS CORRECTLY INTO THE LINEAR
C   MATRIX H.
        L = LSTART + 1
        H(LSTART) = B(1,1,I)
        DO 105 J=2,NV
        J1 = J - 1
        DO 107 K= 1,J1
          H(L) = B(K,J,I) * 2.
107       L = L + 1
        H(L) = B(J,J,I)
```

```
105    L = L + 1

108    LSTART = LSTART + 144

       CALL ZERO(NP(1),NP(NT+1))
C
C  **  OUTPUT DATA IS ASSUMED TO BE PACKED AND POSITIVE.
       NCHA1 = 2
       NSS1=(NB-NA)/KP+1
         TAG1(1) = 8HRECOGNIT
         TAG2(1) = 8HION MAP
         TAG1(2) = 8HEXPONENT
         TAG2(2) = 8H / 10
       WRITE(4) TITLE, NSS1, BAN2, DAN2, NCHA1, CONV, 1, 1, TAG1, TAG2

652    CALL ZERO(IBIN,IBIN(1092))
       CALL TIMER(3HSET)

C  READ AND UNPACK THE INPUT DATA.
 642   CALL PROCESS(DATA, 3)
         LDA(KEY)        INA(-4)      AJP(51A)
       CALL TIMER(2HGO)

       I=1
       N=0
       WORD=0

        DO 10 IP = NA, NB, KP
        IPP=(IP-1)*ND
C  MAPTRAN TAKES THE DATA (AND IF NECESSARY TRANSFORMS IT) POINT BY
C  POINT AND PUTS IT INTO THE SMALL ARRAY DATUM.
       CALL MAPTRAN(DATA(IPP))
       N=N+1
       LSTART = 1
       GMIN = 1.E10
       IMIN = NT1

C  * *  RECOGNITION CALCULATIONS  * *
       DO 12 IM=1,NT
       L = LSTART
       JJ = IC(1)
       Z(1) = DATUM(JJ) - A(IM,JJ)
       SUM = Z(1) * Z(1) * H(L)
       L = L + 1
C
       DO 11 J=2,NV
         JJ = IC(J)
         Z(J) = DATUM(JJ) - A(IM,JJ)
         SUM2 = 0.

         DO 13 K=1,J
           SUM2 = SUM2 + Z(K)*H(L)
13         L = L + 1

11       SUM = SUM + Z(J)*SUM2

       IF(SUM.GT.EXPLIM) 12, 24
24     GM = SUM + D(IM)
       IF(GM.LT.GMIN) 14, 12
14       IMIN = IM
         GMIN = GM
         GSUM = SUM
12     LSTART = LSTART + 144
```

```
C   AMAP IS THE OUTPUT ARRAY
        AMAP(N)=S(IMIN)
        N=N+1
        AMAP(N) = GSUM*CONV10 + .5

C   SEARCH FOR MAKING A HISTOGRAM.
          ENI2(52)
        +THS2(ITABLE)  SLJ(900)
900     J=J+1
        IBIN(IMIN,J) = IBIN(IMIN,J) + 1
C   NP = NUMBER OF POINTS RECOGNIZED FOR EACH SIGNATURE.
        NP(IMIN) = NP(IMIN) + 1
10      CONTINUE

C   WRITE THE DATA.
        CALL BUFPACK(AMAP, N, AMAP, 4)
        CALL TIMER(4HSTCP)

C   LINES NOT FINISHED GO TO 642
C   LINES FINISHED GO TO 51
        IF(KEY .EQ. 2) 642, 51

  51A    NSB = IS - 1
  51    WRITE(9, 1022)
 1022 FORMAT(* CONTINUE FILE...*)
        READ(2,1021) REPLY
1021     FORMAT(A1,12A8)
        IF(REPLY .EQ. 1HY) 503, 504
C ** YES OR Y GO TC 503
504     ENDFILE 4
        CALL BUFFOFF

        CALL TIMER(SEC, SEC60)
          IHRS = SEC/3600
          MINTS = (SEC - 3600*IHRS)/60
          ISEC = (SEC -3600*IHRS - 60*MINTS)
          NLINES = (NSB - NSA)/KS + 1
        WRITE(5, 780) NLINES, NSS, ND, NPTS, NV, NT, IHRS, MINTS, ISEC
 780    FORMAT(/* INPUT...* I10* LINES,*I5* PTS/LINE,*I5* CHANNELS*/
       1 * PROCESSED...*I5* POINTS,*I5* CHANNELS,*I5* SIGNATURES*/
       2  10X *TOTAL TIME= * I5* HRS,* I5* MINUTES,*I5* SECONDS*//)
  80    WRITE(5, 32)
32      FORMAT(//7X,4HNAME,14X,*VOLTAGE    NUMBER    ACREAGE*/)

        DO 72 J=1,NT+1
        FNP=NP(J)
        AREA=FNP*ACRE
        FS=S(J)
        S2(J)=FS/CONV
        WRITE(5, 81) TAG(J), TAGA(J), S2(J), NP(J), AREA
81      FORMAT( 5X   2A8,3X,F4.1,I12,F12.2)
72      CONTINUE

C   * * *  HISTCGRAM  * * *

 651    DO 660 I=1,NT
        FNP=NP(I)
        AREA=FNP*ACRE

C   WRITE HEADER

        WRITE(5, 1000) TITLE
1000     FORMAT(1H1,10X,12A8)
```

```
      WRITE(5, 1001) TAG(I), TAGA(I), S2(I), NP(I), AREA, D(I)
 1001 FORMAT(//7X 4HNAME 14X *VOLTAGE   NUMBER    ACREAGE  LN(DET)*/
     1  5X 2A8, 3X F4.1 I12, 2F12.2)

        FTAB = (FLOAT(ITABLE(1)))/CONV10
        GTAB = (FLOAT(ITABLE(51)))/CONV10

      WRITE(5, 1002) FTAB, IBIN(I,1), GTAB, IBIN(I,52)
 1002 FORMAT(1H *NO. OF POINTS .GT.*F5.1* =* I8 *,  NO. OF POINTS .LT.*
     1  F5.1 * =* I8 //* EXPONENT* 2H**)
      IJK=0

C  DETERMINE THE BIN WITH THE LARGEST NUMBER OF POINTS
      DO 662 J=2,51
 662  IJK = MAXO(IJK, IBIN(I,J))

        ENI2(50)
C  CALCULATE PERCENT IN EACH BIN.
664   IJP2(665)  SLJ(660)
 665  PCT = (FLOAT(IBIN(I,J+2))/FLOAT(NP(I)))*100.
      K=(100*IBIN(I,J+2))/IJK
      CALL ZERO(IPT(1),IPT(100),1H )
      IF(K.GT.0) 667, 668
C  FILL ARRAY AND WRITE.
667   CALL ZERO(IPT(1),IPT(K),1H*)
 668  FTAB = (FLOAT(ITABLE(J+2)))/CONV10
      GTAB = (FLOAT(ITABLE(J+1)))/CONV10
      WRITE(5, 1005) FTAB, GTAB, (IPT(K),K=1,100), PCT
 1005 FORMAT(1H F4.1 * TO * F5.1, 100A1 F6.2)
      GO TO 664
 660  WRITE(5, 2006)
 2006 FORMAT(// 4H  *** CHANNEL 2 IS EXPONENT/10.*)

  65  IF(REPLY .EQ. 1HD) 506, 501
C  IF DONE, GO TO 506...OTHERWISE, GO TO 501

506   ENDFILE 4
      ENDFILE 4
        LIUI(TEST)     IJP1(721)
      ENDFILE 5
      ENDFILE 5
      UNLOAD  2
      UNLOAD  3
      UNLOAD  4
      UNLOAD  5

721   WRITE(19,1030)
1030   FORMAT(* EXECUTION TERMINATED*)
      STOP
```