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COMPUTER PROGRAMS FOR THE CALCULATION OF DIRECT AND CROSS POWER SPECTRAL DENSITY OF DISCRETE RANDOM DATA

By

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SUMMARY

Four computer programs, designed for use in power spectral density analysis of stationary random data, are described. The programs carry out the estimation of direct and cross power spectral density by the method of direct Fourier transformation using the Fast Fourier Transform algorithm and by the indirect method using the auto or cross correlation functions. A facility, based on low pass digital filtering and data "decimation," for varying the analysis bandwidth over the frequency range is included; this facility leads to an efficient method of calculating one-third octave bond, or other percentage frequency bandwidth, results and a routine for this is included.

The programs are written primarily in the FORTRAN language, with certain routines which have a major influence on execution time, or which use input/output facilities not available in FORTRAN, written in COMPASS assembly language for the CDC 3300 computer. Full program documentation is included, covering the needs of both program usage and program maintenance.

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1.0 INTRODUCTION

The processing of stationary random data has assumed considerable importance with the development of the concept of power spectral density analysis and its application in many branches of engineering. An automatic method of carrying out the analysis is essential in view of the large amount of data which is always involved, and various methods have been devised. A digital computer provides the means for the class of analysis methods known as digital techniques and this report describes the organization and use of a series of digital computer programs for carrying out power spectral density analysis.

Use of digital techniques requires that the random variables being analyzed, which in engineering applications are invariably continuous in time, be represented as series of discrete values obtained at constant time intervals. This requires the use of some analog/digital conversion equipment in which the data samples are obtained from the transducer signals and held in some form of storage medium; the computer programs described here concern only the analysis of these digitized data which are assumed to be stored on digital magnetic tape in a specific format.

Details of the various analog and digital methods of power spectral density analysis are given in References 2 and 3; the former also includes the extension of the theory to deal with cross spectral density of a pair of data signals. The digital method most commonly advocated is that wherein the autocorrelation (or the autocovariance) function at discrete points in time is calculated and then converted to power spectral density by means of a discrete cosine transform. The effect of finite length of the time data is reduced by the application of a spectral window - a process known as "smoothing" the "raw" estimates. For the cross spectral density [illegible] the cross-correlation function and the full Fourier transform is used. The [illegible] reason for the popularity of this method has been its economy in computer time and its flexibility in the choice of analysis parameters. Minimizing computer [illegible] is a very important consideration in the choice of an algorithm for computer implementation because of the large amount of data involved in providing a reasonable degree of statistical accuracy. Another method of calculating power spectral density is by summing the squared Fourier coefficients of a set of sub-series formed from the data (for details see Reference 1); the exorbitant amount of time required to calculate Fourier transforms made this method uneconomical until the discovery of an algorithm which can speed up the calculation by a factor of several hundreds (see Reference 4). The result is that the direct Fourier transform method now offers considerable savings in computer time over any other digital method. However, the constraint that the number of data elements in each sub-series is a power of two (or at least has many small factors) means that analysis parameters cannot be so freely chosen.

Because of the respective advantages of the two methods mentioned above, the programs described here include both methods; it is envisaged that the direct Fourier transform method will be used for the majority of analyses, but the correlation method will occasionally be of use when bandwidth requirements are rigid or the correlation

functions are also required. Auto or cross correlations could, however, be produced by the inverse transform of the direct or cross spectral densities which have been obtained by the direct method. The efficiency of this method of calculating correlation functions has not been investigated.

A further useful facility incorporated in the programs is the ability to divide the frequency range into a series of bands an octave wide and to have a different analysis bandwidth in each frequency band. The bandwidth in each band is always twice that in the adjacent lower band; this permits a higher resolution of the spectral density at low and intermediate frequencies without the penalty incurred due to unnecessary resolution at high frequencies in a constant bandwidth analysis of high resolution throughout the frequency range. This facility leads, by an averaging process, to a third octave band analysis and can be extended easily to any percentage frequency variable bandwidth analysis.

All the computer programs described in this report are written in the FORTRAN language, for a CDC 3300 computer, with the exception of some special subroutines in each program which are written in assembly language for the purpose of either a) increasing the speed of execution where it is important, or b) use of special I/O facilities not available in FORTRAN.

2.0 ANALYSIS METHODS AND PROGRAM SUB-DIVISIONS

2.1 General

The computer programs described in this report calculate direct and cross power spectral densities using two different, but related, methods of computation. In all, four complete programs are described which cover the following:

(i) Program Number WCP/68-20. Power spectral density analysis using a direct Fourier transform technique.

(ii) Program Number WCP/68-21. Direct and cross power spectral density analysis using a direct Fourier transform technique.

(iii) Program Number WCP/68-22. Power spectral density analysis using the auto correlation/Fourier transform method.

(iv) Program Number WCP/68-23. Cross power spectral density analysis using the cross correlation/Fourier transform method.

The mathematical details of methods (i) and (ii) are given in Reference 1 and those of (iii) and (v) are given in Reference 2. Equation numbers from References 1 and 2 will be quoted at subsequent points in this report in preference to reproducing the equations. The relative advantages between the direct Fourier transform and correlation methods have been given in Section 1. Program (ii) produces cross spectral density for a pair of time series and also the direct power spectral density for each of the two series; program (i) more efficiently calculates the power spectral density for a single time series.

Each program has the capability of dividing the frequency axis into a series of bands, on an octave basis, and producing results at different analysis bandwidths in each band, the bandwidth in a higher frequency band being twice the bandwidth in the adjacent lower band. Using this facility it is possible to obtain high resolution at low frequencies without the unnecessary effort incurred in a constant, narrow bandwidth analysis throughout the total frequency range of interest. The frequency scale may, of course, be specified as one band, in which case the analysis is carried out as constant bandwidth.

2.2 Analysis Options and Extensions

The form of the results from each program is described at the appropriate place in the following pages of this report. It is possible, however, easily to extend the programs by the addition of further subroutines to carry out other analyses which are occasionally of interest.

All the programs have the option of calculating the probability distribution functions of the time series being analyzed; a routine is required to output this in graphical form. Program (i) has the option of calculating third octave power spectral density functions already included, with provision for its graphical output. The following is a list of some possible extensions that could easily be made:

(a) Auto correlation and cross correlation functions output from programs (iii) and (iv), respectively.

(b) Joint probability density functions from programs (ii) and (iv).

(c) Spatial correlation as a function of frequency from program (ii).

(d) Transfer function from program (ii)

(e) Coherence function from program (ii).

(f) Time varying spectra (i.e., non-stationary) from program (i).

2.3 Program Sub-Divisions

All the computer programs divide naturally into four parts, the functions of each part being:

1. Separation of data into contiguous elements of the same series from an input data tape which contains many series (or channels of data) in a "multiplexed" packed-word form, and calculation of some statistical parameters from the series.

2. Low pass digital filtering of a set of data with a filter which has a cut-off frequency equal to one-half of the maximum recognizable frequency in the data (i.e., as determined by the sampling rate).

3. Calculation of the appropriate spectral density function and separation of the required frequency band from the results.

4. Output of results.

Parts 1 and 2 are common to all the programs, while parts 3 and 4 are unique to each program. An overall flow diagram giving the relationship of each part is given in Figure 1.

3.0 INPUT DATA TAPE FORMAT

The program sub-section which "demultiplexes" and unpacks the input data has been written assuming a fixed format for the input magnetic tapes. This format is based on the output format of a currently used analog-digital conversion and data acquisition program. It should be noted that any changes to the input data tape format will require changes to the section of the program described in 4.1 below in order to interpret the tapes successfully.

In general, there are two input data tapes corresponding to the A and B multiplexers, respectively, of the analog-digital data conversion equipment; tapes are recorded at a density of 800 bpi.

3.1 Heading and Identifying Records

Both tapes have the following heading records, as given in Table I.

TABLE I

INPUT DATA TAPE IDENTIFYING RECORDS

Record Number	Recording Mode	Number of 24-Bit Words	Record Contents
1	BCD	11	Words 1 to 8: REAL-TIME DATA REDUCTION PROGRAM Words 9 and 10: Date Word 11: Test Number
2	BIN	5	Word 1: Number of data samples per channel d Word 2: Number of A multiplexer channels Word 3: Number of B multiplexer channels Word 4: Number of words in each data record w Word 5: Number of sub-multiplexed groups g
3	BCD	2	Word 1: MUX A (or MUX B) Word 2: (4 blanks)
End of File Mark			

3.2 Data Records

Data records are all recorded in binary mode and are produced as sets in the following format. The first record of a set contains two words giving the first and last multiplexer channel numbers, signified by C_1 and C_2, respectively, (integer, numbering the channels 1 to 128) for the current sub-multiplexed group, for the multiplexer identified in the third heading record.

The data samples appear in the record in multiplexer channel order (from lowest numbered to highest) and the group is repeated throughout the record $2w/(C_2 - C_1 + 1)$ times. The total number of data records in a set is given by $d\,(C_1 - C_2 + 1)/2w$. Each set is terminated by an end of file mark.

Data sets may appear on the tape as two types:

(a) Type 1. Non-stacked: data for a series of different sub-multiplexed groups appears on the tape. This is the general output form for on-line data acquisition from live tests.

(b) Type 2. Stacked: data sets appear for the same sub-multiplexed group in a series. This is the case when data is acquired for several tests from the playback of 14 channel analog tape.

It should be noted that data types are never mixed on the same tape.

3.3 Data Sampling Rate

An overall sampling rate of 41,700 samples per second is assumed, based on the current maximum sampling rate of the analog-digital conversion equipment. The sampling rate h per channel is thus given by

$$h = \frac{41,700}{C_2 - C_1 + 1}$$

If the data is acquired at a different rate, the program change indicated in Section 4.1.3 must be made.

4.0 ROUTINES COMMON TO ALL PROGRAMS

As pointed out in Section 2.3, there are two program sub-sections which are common to all programs. These are described below:

4.1 Data Input, Demultiplexing and Statistics

4.1.1 List of Subroutines

The subroutines which comprise this subsection are, with their associated formal parameters, as follows. The usual FORTRAN conventions apply to parameter names; all routines are written in FORTRAN except MISCELL which is written in COMPASS assembly language.

(i) DEMUX (N1024R, ISTAT, INCRST)

N1024R is the number of 1024 word records of data samples to be demultiplexed from the input tape and stored on a scratch logical unit. Each entry to DEMUX deals with one or two channels depending on whether direct or cross power spectral density is being calculated. If there is insufficient input data then this parameter contains on exit the number of 1024 word records that is available.

ISTAT is a parameter indicating whether or not statistics are required for the demultiplexed data. ISTAT = 0 signifies no statistics are required, ISTAT = 1 signifies that statistical parameters mean, variance, skewness and kurtosis are required to be calculated. ISTAT > 1 requires the above parameters plus the amplitude probability distribution to be calculated.

INCRST is the cell interval, in millivolts, for the amplitude probability distribution. If ISTAT $\leq$ 1 it is not used.

(ii) SCANTAPE (ICHAN1, ICHAN2, M)

ICHAN1 and ICHAN2 are channel numbers of data to be demultiplexed from logical unit M. If the channels are on different input tapes or only one channel is required, ICHAN2 contains four BCD blanks.

(iii) FILLOUT

(iv) STATIST (IST, INC)

IST is the same statistics parameter as ISTAT in routine DEMUX, and INC is the same as INCRST.

(v) PPE (IACT)

IACT is an output parameter which returns the value of 1 or 2. If the value is 1 there is enough data remaining in a set after discovery of an irrecoverable tape parity error to restart the demultiplexing and provide the required N1024R records. If the value is 2 there is not enough data remaining to restart.

(vi) CHECKPAR (LUN, IS1, IS2)

LUN is a logical unit number on which the parity of the last output operation is to be checked out and the record re-written if an error exists. IS1 and IS2 are the second and third dimensions of a three-dimensional array from which the data is output.

(vii) ERRECOV (LABEL, LUN, NPE, J)

LABEL is an indicator to select an appropriate error message when an irrecoverable parity error has been found on logical unit LUN.

NPE is a counter to control the number of backspaces and re-reads before accepting the parity error.

J returns the value 1 or 2 depending on whether or not the parity error has been accepted (after 5 attempts to read the record). If J = 1 a message defined by LABEL has been output to the standard output unit (L.U. 61).

(viii) HISTOGRM (III, JJJ)

III is 1 or 2 indicating whether the data is for the first or second of a channel pair. JJJ is the cell interval value in millivolts for the amplitude probability histogram.

(ix) GAUL2

(x) MISCELL

4.1.2 COMMON Storage

In addition to subroutine parameters, data is transmitted between routines through common storage locations. A further use of common storage is the sharing of scratch storage between subroutines. The first 28 locations of blank COMMON are used to retain information in the demultiplexing routines and the remainder of blank COMMON is used as scratch storage. Throughout, labeled COMMON is used to transmit data. The first 28 locations of blank COMMON are defined in Table II.

TABLE II

FIRST 28 WORDS OF BLANK COMMON

Parameter Name	Definition
ITEST	4 character test identifier
ICHAN2	4 character channel identifier for 1st of a pair or a single channel
ICHAN2	4 character channel identifier for 2nd of a pair. Blank if only one channel being used.
IHALF	Parameter used in amplitude probability histograms
MD(2)	Indicators for whether or not input tapes on logical units 1 and 2 have had their leader records read and checked.
ID(13)	Contents of the first and third title records from the last input tape read
INF(7)	Contents of the second title record and the first pair of multiplexer channel indicators from the input tapes.
ISTACK	Indicator whether data is stacked or non-stacked on the input tape.
IFILE	Indicator for required file when data is stacked.

Labeled COMMON is used only by routine STATIST; this common block is defined for each program below.

4.1.3 Program Function

A flow diagram for the data input and demultiplexing routines is shown in Figure ^. The function of this program subsection may be described briefly as follows:

(i) Enter DEMUX to separate data for 1 or 2 channels. Determine whether there are one or two channels and if two whether they are on the same multiplexer.

(ii) Call SCANTAPE to find the start of the data for each channel. Note that if the two channels are on the same tape they will always be within the same submultiplexed group. On the first reference to an input tape read the title records and check that the test number and multiplexer identifier are correct. The BACKSKIP entry of routine MISCELL is used to skip backwards along a tape to an end of file mark and then to read forwards over the file mark. If load point is inadvertently found, a message is printed (see Section 10, message number 14) and the job is terminated.

(iii) Form the output identifying record (6 words) which includes channel sampling rate calculated from

$$C_{sr} = \frac{O_{sr}}{C_1 - C_2 + 1}$$

where C_{sr} is channel sampling rate, O_{sr} is the overall sampling rate, C_1 and C_2 are the upper and lower channel numbers in the submultiplexed group. As mentioned in Section 3.3, O_{sr} is set at 41,700. If this is to changed, the new value must replace 41,700 in the first statement after that numbered 1130 in routine DEMUX (see Appendix A). The identifying record is output to logical units 3 and 4.

(iv) Read in the multiplexed data using a double-buffering arrangment that allows parallel reading and processing of data. Convert channel number numeric from BCD to binary integer, using CONVERT entry of MISCELL, to calculate position of data samples in the input records.

(v) Call FILLOUT and thence GAUL 2 to separate the packed 12 bit samples into 24 bit integers with correct signs. Records of length 1024 words are formed from the demultiplexed data and are output to logical units 3 and 4 (for the first and second channels, respectively). Repeat (iv) and (v) until the required N1024R records have been output for each channel.

(vi) All tape read and write operations are carefully checked for parity errors. If an irrecoverable parity error is discovered on an input tape, the total amount of data in the set is checked in routine PPE to determine whether demultiplexing may be restarted for that channel and still provide the required number of records. If not, the input record containing the parity error is ignored. Parity errors on write operations are treated by calling the SKIPSIX entry of routine MISCELL to erase six inches of tape and the record is rewritten; this continues until the record is successfully written. Permanent parity errors on input tapes are indicated by an appropriate message output by routine ERRECOV to the standard output unit.

(vii) If ISTAT is not zero call routine STATIST. The demultiplexed data is read back from logical unit 3 and, in the case of two channels, logical unit 4, and statistical parameters are calculated together with the amplitude probability distributions if required. Statistical parameters are output to the standard output unit together with, for each channel, test and channel numbers and three lines of comment and identifying information which are input from the standard input unit as card images. A sample of this output is shown in Figure 6. Routine HISTOGRM is called fromSTATIST for output, where required, of amplitude probability plots to a CALCOMP plotter.

(viii) Return to calling program.

A detailed list of error messages and stops for all programs is collected together in Section 10. Control cards for the various logical units are given in Section 9, and listings for the routines comprising this program subsection are given in Appendix A.

4.2 Low Pass Filtering and Data Decimation

4.2.1 Filter Weights

The purpose and use of low pass filtering and data "decimation" has been pointed out in Section 1 and the mathematical details are given in Reference 1. The implementation in this program is that of a fixed frequency cutoff at h/4 hertz, where h is the data sampling rate on input to the filtering process. After the decimation process, the sampling rate becomes effectively h/2. With the stated cutoff frequency, Equation (6.8) of Reference 1 gives for a = 5, filter weights as shown in Table III.

TABLE III

FILTER WEIGHTS FOR $a = 5$

k	Filter Weight
0	2
± 1	$1 + \cos \pi/10$
± 2	0
± 3	$-\frac{1}{3}(1 + \cos 3\pi/10)$
± 4	0
± 5	1/5
± 6	0
± 7	$-\frac{1}{7}(1 + \cos 7\pi/10)$
± 8	0
± 9	$-\frac{1}{9}(1 + \cos 9\pi/10)$
± 10	0

4.2.2 List of Subroutines

The subroutines with their associated formal parameters, which comprise the program subsection are as follows:

(i) LPFILT (LUN)

LUN is the logical unit number which holds the data to be filtered and decimated. This routine also has an entry point named CUTOFF.

(ii) LOOP (I, K, J)

I and K are the lower and upper limits of the dimensions in the output array of the filtered points which are to be calculated for this call of LOOP.

J is 0 or 1, indicating whether to use the first or second column of a two-dimensional array (1024, 2) used for double buffering of the input data to the filter process.

(iii) ERROUT (LUN, IOBUF)

LUN is the logical unit on which a parity error has been detected during a write operation.

IOBUF is the first storage address from which the record, always 1024 words long, is being written.

(iv) PRODSUM

This is an entry point to assembly language routine MISCELL to carry out multiplication and summation of data and filter weights using fixed point arithmetic.

Routine ERRECOV is called from ERROUT to output a message when an irrecoverable parity error has been detected during an output operation, followed by a call to SKIPSIX to erase 6 inches of tape.

4.2.3 COMMON Storage

Blank COMMON storage is used to transfer data between routines LPFILT, LOOP, and PRODSUM. The filter weights given in Table III are calculated by an initializing call to LPFILT and stored in labeled COMMON array IWT; filter weights are used when calculating filtered points in routine PRODSUM.

4.2.4 Program Function

A flow diagram for the low pass filtering and decimation program is shown in Figure 3. The following description briefly explains the operations carried out by this program subsection:

(i) Enter LPFILT initially to calculate filter weights. For this entry point parameter LUN is not used. The non-zero filter weights given in Table III are calculated and then multiplied by 2^{22} and stored in fixed point form, i.e., as scaled 24 bit integers, in labeled COMMON array IWT.

(ii) Entry point CUTOFF. Data to be filtered is on logical unit LUN, and scratch unit 51 will be used to store the filtered data as they are obtained. At the end of the process the filtered results will be overwritten on the original data on LUN. Since records are always formed and written in lengths of 1024 words (24 bit integers) and

two input records thus yields one output record, due to the decimation process, the number of data records to be filtered should always be even. For repeated application of the process the initial number of records should have as many factors of two as the process is to be applied.

(iii) Skip over 6-word identifying record on LUN and initiate double buffering procedure for input of data. Call LOOP to form filtered points 1 to 507 of a record (overlap to the left of starting point is initially zero).

(iv) Routine LOOP assembles, for each filtered point, the data to form that point into a separate array and then calls PRODSUM to calculate the summed products using the scaled filter weights. Filtered data are stored in array ISAVE. Return to LPFILT.

(v) Store upper 10 points of previous input record into lower part of array containing next record (i.e., filter overlap across records) and call LOOP to form the points 508 to 512 which use the overlap.

(vi) Repeat (iii), (iv), and (v) for the points 513 to 1019 and 1020 to 1024. Write ISAVE (1024) to logical unit 51.

(vii) When an end of file is found on the input unit rewind LUN and 51 and copy contents of 51 into LUN. Return to calling program.

(viii) Throughout, all tape read/write operations are carefully checked for parity errors. If write parity errors are encountered routine ERROUT is used to call ERRECOV and SKIPSIX. If read parity errors are encounterd on LUN then a message is output to the standard output unit and the job terminates on a STOP instruction.

Program listings are given in Appendix B.

5.0 DIRECT POWER SPECTRAL DENSITY USING FFT

The Fast Fourier Transform algorithm and its application to the calculation of power spectral density is described in Reference 1. The particular implementation used in this program is that of the 4 - 2 algorithm where the data is treated as a series of arrays of size 4 by 4, with a residual set of size 2 by 2 if the total number of data is an odd power of 2.

5.1 Fast Fourier Transform Routine FFT42M

This routine calculates the discrete Fourier transform and inverse transform of a set of complex data. The size of the set must be an integral power of 2.

The routine is written in assembly language, with all arithmetic in floating point; a table of cosines is held in an array within the routine, which must be calculated and stored by an initializing call before the routine is used for the calculation of a transform. The transformed results are written over the input data to the routine. Definitions of the available entry points and formal parameters are as follows:

(i) COSTABLE (LG2NMX)

LG2NMX is the logarithm base 2 of the largest number of data to be transformed; this call must be the first of any to the routine, but is only required once.

(ii) FFT42M (LG2NMX, LG2N, INCT, REALDATA, QDATA, INOUT)

LG2NMX is defined in (i) above.

LG2N is the logarithm base 2 of the number of data to be transformed. LG2N $\leq$ LG2NMX is a requirement.

INCT specifies the increment in storage location between consecutive values of real parts and imaginary parts of the data, e.g., if real and imaginary parts of each element are stored in consecutive locations then INCT = 2; if real and imaginary parts are in separate arrays then INCT = 1.

REALDATA is the address of the real part of the first element of data to be transformed.

QDATA is the address of the imaginary part of the first element of data to be transformed. On exit from the routine REALDATA and QDATA contain the real and imaginary parts, respectively, of the transform.

INOUT is an indicator which determines whether the transform or inverse transform is required. If INOUT = 0, the transform is calculated and if INOUT $\neq$ 0 the inverse transform is calculated.

(iii) FFT

This entry point is used when the parameters are exactly the same as in the last call to FFT42M.

A flow diagram is shown in Figure 4 and a program listing in Appendix C.

5.2 Routines Comprising the Program

In addition to the subroutines described in Section 4 above and FFT42M, the following routines comprise the program to calculate power spectral density using FFT. All these routines are written in FORTRAN.

(i) MNPSDAF

This is the main program which calls the various sections.

(ii) PSDCNTLF

(iii) PSDFFT

(iv) AKBK

(v) THDOCT

(vi) PLOTPSDF

5.3 COMMON Storage

The first 28 words of blank COMMON are given in Table II and these definitions are retained throughout. The remainder of blank COMMON, which is used as scratch storage in the data demultiplexing section, is used to transfer data between the routines specified in 5.2 above. The use of this COMMON storage is detailed in Table IV.

Labeled COMMON storage, with label/DATA/, consists of one block allocated as shown in Table V.

5.4 Program Function

The functions of the various subroutines listed in 5.2 above are as follows. A flow diagram is given in Figure 5, and listings in Appendix D.

(i) Commence in main program MNPSDAF. Zero array MD to indicate input tapes at load point, call LPFILT with dummy parameter to generate filter weights.

TABLE IV

BLANK COMMON USAGE
(EXCEPT FIRST 28 WORDS) FOR PROGRAM MNPSDAF

Parameter Name	Definition
NCOUNT	Next available position in psd array PSD and frequency array FRQ, counting from the last word to the first, for the storage of results.
KOCT	Frequency bands (octave) counter starting from the highest frequency band during selective bandwidth analysis. KOCT varies from zero to number of bands - 1.
FU	Upper frequency of a frequency band.
FL	Lower frequency of a frequency band.
DF, TEMP 1, TEMP 2	Temporary storage.
IDATA(1024)	First data input buffer when reading demultiplexed/filtered data into core storage.
JDATA(1024)	Second input buffer, as IDATA above.
N(6)	Array for storing 6 word identifying record. Locations 4 and 5 of this array contain the channel sampling rate in floating point form.
REAL(1024)	The input data is converted to floating point and stored in this array and QDATA for use by routine FFT42M. This data is treated as the real part of the data being transformed.
QUAD(1024)	This array is used by routine FFT42M and is assumed to contain the imaginary part of the data being transformed.
AK(513)	For each frequency band the psd results are stored here in routine AKBK, before being selectively separated for retention in array PSD.
BK(513)	Frequencies, corresponding to psd values held in AK, are generated in this routine.
I,K,L	Counters for various DO loops.
KREC	Record number counter for each frequency band. Data input is controlled by this parameter.

TABLE V

LABELLED COMMON STORAGE (/DATA/)

Parameter Name	Definition
IWT(6)	Filter weights defined in 4.2.1 above. This array contains the six non-zero weights listed in Table III.
M	Log base 2 of the number of points to be used in each Fourier transform.
NOCT	Number of frequency bands into which the total frequency range is divided. Except for the lowest and highest bands, these are octave bands.
NREC	Number of 1024 word records of data which are to be used for the psd calculation in each frequency band.
S	Scale factor relating the input signal from the analog/digital equipment in millivolts to physical units.
NPTS	2**M
MPTS	NPTS/2 + 1
MBAR	512/NPTS. The number of group pairs into which each input record is divided.
PSD(513)	Array containing assembled psd values for all frequency bands.
FRQ(513)	Frequencies corresponding to the psd values in PSD.
F1	Lower limit of frequency scale on psd plot.
F2	Upper limit of frequency scale on psd plot.
NDECS	Number of decades on vertical scale of psd plot.
IPRINT	Print indicator; if non-zero the results are printed after being plotted.
ISCALE	Indicator for the suppression of plot scales; if non-zero, scales on the output plot are not drawn.

(ii) Read data for control of calculation and the output format of a series of data channels.

(iii) Call SETUP entry to PLOTPSDF routine to initialize and set origin on plotter. Check values of M, F1, F2, and NDECS for validity, i.e., $M \leq 10$, $F1 < F2$, $NDECS < 10$.

(iv) Call COSTABLE(M) to generate the cosine table for routine FFT42M. Then call FFT42M in order to set the correct parameters for subsequent use.

(v) Calculate the number of data required to be demultiplexed as N1024R records of 1024 integers.

(vi) Read channel numbers ICHAN1 and ICHAN2, corresponding sensitivities S and SS, and ISCALE. Note that for this program only ICHAN1 and S are used to define the channel. Check for end of channel set.

(vii) Call routine DEMUX to demultiplex data and compute statistics. On return check that required amount of data is available; calculate and print number of degrees of freedom, adjusted to conform to available data if necessary.

(viii) Call routine PSDCNTLF to compute the psd. Calculate NPTS, MPTS, and MBAR. Initialize KOCT = 0 and then call PSDFFT for the first (upper) frequency band.

(ix) In routine PSDFFT rewind unit 3 and input 6 word identifying record to array N. If the last frequency band is not being analyzed skip over the first data record (this record is unreliable after filtering because of the initial zeroes assumed in the overlap process).

(x) Zero out record counter KREC, parity error counters K and L, and arrays AK and BK in which to form the squared and summed Fourier coefficients.

(xi) Read a data record into IDATA and wait for completion before testing parity.

(xii) Check NPTS. If this value is 1024 then records are analyzed in pairs; if not, one record is analyzed at a time. Increment record counter by 1.

(xiii) $NPTS < 1024$. Read next record and analyze previous. The record is divided into MBAR pairs of sections each of length NPTS, e.g., if NPTS is 512 then MBAR is 1. Consecutive values of the data in each Section are converted to floating point and stored in arrays REAL and QUAD for the first and second sections of a pair, respectively.

(xiv) Call FFT to calculate the Fourier coefficients, and then routine AKBK to convert the coefficients to psd.

(xv) Routine AKBK. The real and imaginary components of the Fourier coefficients are separated from the combined transformed data, held in arrays REAL and QUAD, according to Equations (2.14) thru (2.17) of Reference 1. The two sets of coefficients are passed through a Hanning filter defined by Equation (2.18) of Reference 1 and the squared, hanned coefficients are summed in array AK. The zero frequency result is set to zero before "Hanning" the data. It is seen that each subsection of a record is transformed, converted to psd and results for corresponding frequencies summed in array AK.

(xvi) On return to PSDFFT, KREC is checked for equality with NREC. If so, return to PSDCNTLF, otherwise read a new data record, increment record counter and analyze the data record in (xiii) above in the same manner as specified in (xiv) and (xv). Repeat from (xiii) until KREC = NREC or an end of file on unit 3 is found.

(xvii) NPTS = 1024. In this case pairs of records are read into IDATA and JDATA, converted to floating point in REAL and QUAD and treated as in (xiv) and (xv) above. This is repeated until KREC = NREC or an end of file on unit 3 is found. It is seen that NREC should be an even value when M = 10.

(xviii) On return to routine PSDCNTLF compute the upper frequency of the second octave; compute the conversion factor for the psd values as a function of the channel sensitivity, number of transform points, bandwidth and number of subsections. Increment KOCT by 1, divide each psd by the conversion factor and generate corresponding frequencies in array BK.

(xix) Compute lower frequency FL of current band (however, if this is the last band, then set FL = 0) and select the psd and frequency for this band, defined by FU and FL, from AK and BK and store in labeled COMMON arrays PSD and FRQ starting at the upper, high frequency end of the arrays. NCOUNT is used as the counter for position in PSD and FRQ, set initially to 513.

(xx) Set upper frequency of next band to lower frequency of previous band. Check that NCOUNT is not less than 1, if it is print a message and exit, otherwise check KOCT for equality with NOCT. If no, call routine CUTOFF to filter and decimate data and then call PSDFFT, i.e., repeat from (ix). When KOCT = NOCT return to MNPSDAF.

(xxi) On return to MNPSDAF calculate bandwidth of the upper band from SRATE and NPTS and print number of frequency bands and upper bandwidth. In each lower band the bandwidth is halved because of the decimation process. If third octave output is desired (indicated by ITHD) call THDOCT, otherwise call ONECYC entry to PLOTPSDF to output the results.

(xxii) Routine PLOTPSDF. The largest value in array PSD is determined and the vertical scale on the plot is chosen such that NDECS decades are selected with the largest PSD value in the upper decade. The plot axes are both logarithmic base 10 with the frequency axis occupying the range F1 to F2 Hz. If ISCALE was read as zero from card input then a pair of axes with tick marks at appropriate points is drawn, otherwise corner masks only are produced. Test number and channel number are drawn on the plot. A sample plot is shown in Figure 8.

(xxiii) If IPRINT is zero frequency and psd are output to the standard output unit in tabular form together with test and channel number. A sample is shown in Figure 7.

(xxiv) On return to MNPSDAF the procedure is repeated from (vi). For third octave output see Section 5.7.

(xxv) In routine PSDFFT all data input from unit 3, except the heading record and the first skipped record, are checked for parity and the program halts with an operator message if an irrecoverable parity error is encountered.

5.5 Card Input Format

Data cards for this program are required as set out in Table VI.

If more than one channel is to be processed for the same test cards 2, 3, 4 and 5 are repeated for each channel. A set of data cards is terminated by a card with characters END in columns 1-3. A new card number 1 may be read in by inserting a card with NEWT in columns 1-4 following the last card (number 5) of a channel set.

5.6 Output Format

Three types of output are available.

(i) Printed statistics parameters and identifying comments. This is optionally chosen by parameter ISTAT. An example is shown in Figure 6.

(ii) Tabulated values of frequencies and power spectral densities. These are optionally available according to parameter IPRINT. An example is shown in Figure 7.

TABLE VI

DATA CARD INPUT FORMATS FOR MNPSDAF

Card Number	Variable Name	Card Columns	FORTRAN Format	Description
1	ITEST	1-4	A4	Test number - 4 characters
1	ISTACK	5-6	I2	Stacked test indicator: blank or zero for non-stacked.
1	IFILE	7-8	I2	File number for stacked data.
1	ISTAT	9-12	I4	Statistics control parameter, Blank or zero for no statistics output.
1	M	13-16	I4	Log base 2 of number of points to be transformed.
1	NREC	17-20	I4	Number of demultiplexed data records to be used for calculation of psd in each frequency band.
1	NOCT	21-24	I4	Number of frequency bands required.
1	F1	25-34	F10.0	Lower frequency on output plot scale.
1	F2	35-44	F10.0	Upper frequency on output plot scale.
1	NDECS	45-48	I4	Number of decades on output plot psd scale.
1	IPRINT	49-52	I4	Print output indicator; blank or zero for no tabulated printing of psd and frequencies.
1	ITHD	53-56	I4	Third octave output indicator; blank or zero for no third octave analysis.
2	ICHAN1	1-4	A4	Channel number - 3 numeric characters and alphabetic character A or B for the A or B multiplexer. Numeric characters between 001 and 128.
2	S	9-18	F10.0	Channel sensitivity in millivolts per measured unit.
2	ISCALE	29-30	I2	Plot output control; blank or zero for axes required drawn on plot.
3	IBUF	1-80	20A4	Comments and identifying information printed with statistics output. Note: If ISTAT is blank or zero, these cards must be omitted.
4	IBUF	1-80	20A4	
5	IBUF	1-80	20A4	

(iii) Plot of power spectral density versus frequency on logarithmic base 10 axes. The plots are six inches square and have test and channel numbers drawn. Frequency scale is determined by F1 and F2, and psd scale is chosen to fit the largest value in the results using NDECS decades. Axes drawing and tick marks are optionally specified or suppressed by parameter ISCALE. An example is shown in Figure 8.

If third octave output is specified then (ii) and (iii) above refer to the computed third octave results. A description of this calculation is given in Section 5.7 below.

5.7 One-Third Octave Band Results

One-third octave band power spectral density results are optionally available, selected by data item ITHD. One third octave band center frequencies are given by

$$f_n = 2^{n/3} \simeq 10^{3\,n/30}$$

where n is any integer, and the band edge frequencies are

$$f_1 = 2^{-1/6} f_m$$

$$f_2 = 2^{1/6} f_m$$

The lowest center frequency for which results may be obtained in a particular calculation is determined by the bandwidth of the lowest frequency band calculated. It is advantageous to specify several frequency bands in order to produce results at low frequencies. The function of computer subroutine THDOCT, which calculates one third octave band results, is as follows:

(i) Find the first frequency (non-zero FRQ) of calculated results.

(ii) Find first interval in FRQ.

(iii) Calculate lower edge frequency of lowest one-third octave band, based on USASI preferred frequencies (octave band based on 31.5 Hz center frequency).

(iv) Calculate the one-third octave band which is just greater than the first frequency interval.

(v) For each one-third octave band above this find all psd results, interpolating between frequencies in FRQ. The psd ordinates in each band, including the interpolated values on the edges of the band, are averaged to give one psd value at each center frequency; psd values and frequencies are stored in COMMON arrays AK and BK.

6.0 CROSS POWER SPECTRAL DENSITY USING FFT

The mathematical method for this calculation is given in Reference 1, and the details of the Fourier transform routine in 5.1 above. The organization of this program is very similar to the program for calculation of direct power spectral density described in Section 5; however, the calculation of cross spectral density by a Fourier transform method also provides the direct spectral density of each of the two channels involved. This is provided in the program as an option whereby in addition to the cross power spectral density the direct psd of either or both channels may be output. The extensions to various other random data analyses are listed in Section 2.2.

6.1 Routines Comprising the Program

In addition to the subroutines described in Section 4 and FFT42M, the following routines comprise the program - all written in FORTRAN:

(i) MNCPSDF

This is the main program.

(ii) CPSDCTLF

(iii) CPSDFFT

(iv) HANN

(v) PLTCPSDF (ICNTL)

Parameter ICNTL determines whether direct psd for either of the two data channels or the cross psd is required to be output according to the following:

ICNTL negative - first channel psd required
ICNTL zero - cross psd required
ICNTL positive - second channel psd required

6.2 COMMON Storage

Blank COMMON is the same as that described in Section 5.3 above with additions as shown in Table VII.

Labeled COMMON storage consists of one block as in 5.3, and is generally similar but with the following additions:

(a) Variable SS, the second data channel sensitivity, inserted between S and NPTS.

TABLE VII

ADDITIONS TO BLANK COMMON

Parameter Name	Definition
KBAR	Do loop counter used in CPSDFFT.
J	Temporary integer counter.
CK(513)	Real component of cross psd (unscaled).
DK(513)	Imaginary component of cross psd (unscaled).

(b) Arrays QSD(513), RSD(513), and SSD(513), inserted following FRQ. These arrays, and PSD, are defined as

PSD - first channel psd
QSD - second channel psd
RSD - real part cross psd
SSD - imaginary part cross psd

} Assembled for various frequency bands

6.3 Program Function

Program listings are given in Appendix E. The program organization is very similar to that described in Section 5, the main differences being in the input of extra data from both cards and tape. The routines listed above correspond in function with the routines listed in 5.2 (except for THDOCT which is not provided in this program), and the functional description given below merely points out where the programs differ.

(i) Read in extra parameter ICNTL from channel card.

(ii) The call to DEMUX will separate data for two channels and store the results on logical units 3 and 4 and print statistics for each channel if required.

(iii) In routine CPSDFFT data is read from units 3 and 4 into arrays IDATA and JDATA simultaneously and the Fourier coefficients calculated for pairs of records treating them as real and imaginary parts of complex data. There is no double buffering and consequently there is no difference in processing depending on the value of M.

(iv) In routine HANN the transformed results are separated into Fourier coefficients, are passed through a Hamming filter as before and then converted to direct psd for each channel and real and imaginary parts of cross psd according to Equations (3.10) to (3.12) of Reference 1; results are stored in arrays AK, BK, CK, and DK, for direct psd channel 1, direct psd channel 2, real part cross psd and imaginary part cross psd, respectively.

(v) Filtering and decimation requires two calls to CUTOFF with parameters 3 and 4, respectively.

(vi) The output routine PLTCPSDF is called a varying number of times depending on input variable ICNTL which determines whether direct psd for either channel is required as well as cross psd. The output format is the same as described in 5.4, with the cross psd being displayed in the form of magnitude and phase angle.

(vii) Parity checking on tape operations follows the same pattern as described in Section 5.4.

6.4 Card Input Format

The first card of a data card set is identical to card number 1 of Table VI with ICNTL taking the place of ITHD. Values of ICNTL and their effects on output of results are:

ICNTL = 0	Cross psd only
ICNTL = 1	First channel direct psd and cross psd
ICNTL = 2	Second channel direct psd and cross psd
ICNTL = 3	Both channels direct psd and cross psd

Card number 2 is defined in Table VIII.

Three cards of comment and identifying information for the first channel and three cards for the second channel must follow card 2, with repeated sets for other channel pairs following if required. The deck is terminated by an END card (columns 1-3) or a new card 1 may be input by a NEWT card (columns 1-4).

6.5 Output Format

Three types of output are provided:

(i) Printed statistics parameters and identifying comments for the two channels, optionally selected by parameter ISTAT. An example is shown in Figure 9. Note that if the statistics option is not selected the input comment cards are not required.

TABLE VIII

DATA CARD 2 INPUT FORMAT FOR MNCPSDF

Card Number	Variable Name	Card Columns	FORTRAN Format	Description
2	ICHAN1	1-4	A4	First channel number (See Table VI for permissible forms).
2	ICHAN2	5-8	A4	Second channel number.
2	S	9-18	F10.0	First channel sensitivity in millivolts per measured unit.
2	SS	19-28	F10.0	Second channel sensitivity, as above.
2	ISCALE	29-30	I2	Plot output control; non-zero to suppress axis display.

(ii) Tabulated values of frequencies and cross psd expressed in the form of magnitude and phase, the latter in degrees in the range $\pm \pi$. This tabulation is optionally available according to the value of parameter IPRINT. An example is shown in Figure 10.

(iii) Plots of cross power spectral density and power spectral density versus frequency on logarithmic base 10 axes. The cross psd plot contains three functions: magnitude versus frequency, absolute value of phase versus frequency and sign of the phase angle versus frequency (expressed as either 0 or 1 for positive or negative angles). Axis drawing, labeling and tick marks are optionally specified or suppressed by parameter ISCALE. An example is shown in Figure 11. Power spectral density plots are exactly as described in 5.6 (iii).

7.0 DIRECT POWER SPECTRAL DENSITY USING AUTOCORRELATION

The mathematical method for this calculation is given in Reference 2. The program organization follows that given in Section 5, but instead of the FFT routine an assembly language routine is provided which calculates the autocorrelation function and the Fourier transform of an arbitrary number of real data. The computer program is described below.

7.1 Routines Comprising the Program

The program is composed of the routines described in Section 4 together with the following:

(i) MNPSDA. This is the main program.

(ii) PSDCNTLA

(iii) PSDAUTO

(iv) CORLAT(I) Parameter I takes values 1 or 2 to indicate in which half of COMMON array IDATA data being analyzed is stored.

(v) PLOTPSDA

7.2 COMMON Storage

The first 28 words of blank COMMON are given in Table II and the definitions retained. The remainder of blank COMMON is used by the routines of Section 4 as scratch storage and by the above routines for data transfer. Of the remaining blank COMMON storage the definitions of variables NCOUNT through N given in Table IV are applicable. The remaining definitions are given in Table IX.

Labeled COMMON storage consists of one block with label/DATA/, and is defined in Table V, but with the following modifications:

(a) M is now the number of lags for the calculation of the autocorrelation function.

(b) NPTS, MPTS, and MBAR are not defined.

(c) Arrays PSD and FRQ have dimensions 1001.

TABLE IX

BLANK COMMON USAGE FOR PROGRAM MNPSDAA

Parameter Name	Definition
EXTX(1000)	This array is used to store the overlapping part of a record when the autocorrelation function is being calculated from a series of records read into array IDATA in sequence.
AK(1001)	Autocorrelation coefficients for M lags are summed in this array calculated over the number of records specified by NREC.
CK(1024)	The psd values, obtained from a Fourier transform of the autocorrelation coefficients, are held in this array before being selectively transferred to PSD.
I, K, L	Counters for various Do loops.
KREC	Record number counter for each frequency band. Data input is controlled by this parameter.
KBAR, J	Scratch storage.
XMEAN	Mean value for each set of data input, including filtered data.
SIGMA	Standard deviation for each data set.

7.3 Program Function

Program listings are given in Appendix F. The basic program organization is the same as that described in Section 5.4, the main differences being the substitution of routine CORLAT for FFT42M; the other routines have corresponding functions. The function of these routines are as follows:

(i) - (xi) Identical to the functions of Section 5.4, with the appropriate routines from the list of Section 7.1 inserted where required and with the following modifications:

(a) M is the number of lags in the autocorrelation process with a maximum value of 1000.

(b) Item (iv) is deleted.

(c) NPTS, MPTS and MBAR are not calculated.

(d) Array EXTX is cleared instead of BK.

(xii) Increment KREC by 1. Initiate input of next data record into the second half of IDATA and call routine CORLAT with parameter 1 to indicate analysis of data in first half of IDATA.

(xiii) Routine CORLAT calculates the contribution of a 1024 word data record to each of the M + 1 autocorrelation coefficients and also the contribution to the mean value for this set of data. The last M words of the previous record are assumed to be held in array EXTX and are used in the calculation of the autocorrelation coefficients, see Equation (7.32), Reference 2. The last M words of the current record are then placed in EXTX (overwriting the previous set) followed by exit from the routine. The products and summations for autocorrelation coefficients and mean (in COMMON variables AK and XMEAN, respectively) are carried out in 48 bit binary integer arithmetic.

(xiv) On return to PSDAUTO KREC is checked for equality with NREC. If they are not equal the input initiated in (xii) is checked for completion, transmission parity errors, and end of file. KREC is incremented by 1 and input of the next data record is initiated.

(xv) Call routine CORLAT with parameter 2, indicating analysis of data in the second half of IDATA, and on return compare KREC with NREC and if KREC is smaller repeat the procedure from (xii), otherwise go on to (xvi).

(xvi) When the required number of records have been read or an end of file detected use entry point FLOATAK of routine CORLAT to convert the M + 1 autocorrelation coefficients and data sum from 48 bit fixed point integers to 48 bit floating point numbers.

(xvii) Calculate mean value by dividing data sum by the number of the data and convert the autocorrelation function to that for a zero mean after dividing each coefficient by its appropriate value of n - r.

(xviii) Generate a series of cosines with arguments $i\pi/M$ for $i = 1, 2, 3, \ldots, M - 1$ in array EXTX and call entry point FTRANS of routine CORLAT.

(xix) FTRANS calculates the Fourier transform of the M + 1 autocorrelation coefficients (Equation (7.39), Reference 2), using the table of cosines stored in COMMON array EXTX.

(xx) On return from FTRANS the transformed values are smoothed using a Hanning spectral window (with weights 1/4, 1/2, 1/4, see Equation (7.46), Reference 2), and exit to PSDNTLA is effected.

(xxi) The remaining part of the program is identical to operations (xviii) - (xxv) of Section 5.4 with the following modifications:

(a) psd conversion factor depends on octave number and channel sensitivity only.

(b) Frequency values are generated in array FRE which is equivalenced to array IDATA.

(c) NCOUNT is set initially to 1001.

(d) Third octave routine is not used.

(e) Routine PLOTPSDA examines each value of PSD and if negative or zero is made equal to 10^{-7}, to avoid a negative or zero argument when calling the ALOG function.

7.4 Card Input Format

Card input formats are identical to those specified in Section 5.5 with the following modifications:

(a) M is the number of lags when calculating the autocorrelation function.

(b) ITHD is not included on Card 1.

7.5 Output Format

Output formats for printed and plotted results are identical to those described in Section 5.6. Figure 12 shows the power spectral density calculated using autocorrelation for the same data as that used for Figure 8.

8.0 CROSS POWER SPECTRAL DENSITY USING CROSS CORRELATION

The mathematical details of this calculation are given in Reference 2, and the program is described below.

8.1 Routines Comprising the Program

The program is composed of the routines described in Section 4 together with the following:

(i) MNCPSDA. This is the main program.

(ii) CPSDCTLA

(iii) CPSDAUTO

(iv) CORLATXY

(v) PLTCPSDA

8.2 COMMON Storage

The blank COMMON description given in Section 7.2 applies here together with the following additions:

(i) EXTY (1000) for storage of overlapping part of second channel records used in the cross-correlation calculation.

(ii) BK (1001) for storage of one set of cross-correlation coefficients.

(iii) YMEAN for summation of second channel data.

(iv) SIGMAY for storage of second channel variance.

(v) KREC and KBAR do not appear.

Labeled COMMON storage consists of one block with label/DATA/identical to that described in Section 6.3 but with the following modifications:

(a) RSD and SSD are deleted.

(b) PSD and QSD contain real and imaginary parts of the cross spectral density.

(c) Array dimensions are 1001.

8.3 Program Function

Program listings are given in Appendix G. The organization is similar to that described in Section 7.3, with the additions required for the handling of data from two data channels simulataneously.

Input data is similar to that given in Section 6.5 and the subroutines listed in Sections 7.1 and 8.1 have corresponding functions. The major differences occur between PSDAUTO and CPSDAUTO and between CORLAT and CORLATXY. In the former case, routine CPSDAUTO reads in pairs of data records from the two demultiplexed data channels held on logical units 3 and 4, respectively, before processing them; thus there is no parallel input and processing. In the case of CORLAT and CORLATXY the latter routine calculates cross-correlation coefficients for M positive and negative lags, using 48 bit integer arithmetic, which are stored in arrays AK and BK. Entry point FTRANS calculates the Fourier transform of the sums and differences of the cross-correlation coefficients using tables of cosine and sine values held in arrays EXTX and EXTY, respectively. After Fourier transformation a Hanning spectral window is applied to the real and imaginary parts of the cross psd in the usual manner.

The output routine PLTCPSDA plots and prints the results in terms of cross psd magnitude and phase as a function of frequency.

8.4 Card Input Format

Card input formats are identical to those specified in Section 6.5 with the following modifications:

(i) M is the number lags when calculating the cross correlation function (positive and negative lags)

(ii) ICNTL is deleted.

8.5 Output Format

Output formats for printed and plotted results are identical to those described in Section 6.6.

9.0 INSTRUCTIONS FOR USE OF THE PROGRAMS

9.1 Software Requirements

The programs are written in a combination of FORTRAN and assembly language (COMPASS) for the CDC 3300 computer and are intended to be run under the SCOPE operating system. Slight changes are necessary to permit the programs to be run under the MASTER time-sharing, multi-programming system; in this case, MASTER requires provision for output to a plotter.

In addition to the usual FORTRAN functions that are required, a series of routines to drive a Calcomp Model 565 plotter are called for by the various output routines; the required plotter routines have entry points named PLOT, SYMBL4 and NUMBER and their usage is described in Reference 5.

9.2 Hardware Requirements

The following hardware configuration is necessary to run the programs:

32K	Words storage (K = 1024)
1	Card reader
1	Printer
1	Plotter
5	Tape drives (4 in the case of programs to calculate direct psd only).

One extra tape drive to read the systems tape is desirable. Three of the tape drives are used as scratch units and may thus be replaced by alternative mass storage units such as discs or drums.

9.3 Logical Units

In addition to the SCOPE system units the logical units specified in Table X are used by the programs.

Tapes used on logical units 1 and 2 are always recorded at hyper-density (800 bpi), while the remaining tapes are used at standard density.

TABLE X

LOGICAL UNIT USAGE

Logical Unit Number	Usage	EQUIP Card
1	Multiplexer A input data tape	7/9 EQUIP, 1 = MTC0E0U03
2	Multiplexer B input data tape. (If only one multiplexer tape is being used, logical units 1 and 2 may be equated.)	7/9 EQUIP, 2 = MTC1E0U04
3	Scratch unit for 1st channel demultiplexed data.	7/9 EQUIP, 3 = MTC0E0U05
4	Scratch unit for 2nd channel demultiplexed data. (For the direct psd programs logical units 3 and 4 may be equated.)	7/9 EQUIP, 4 = MT01E0U06
51	Scratch unit used in the filtering process	7/9 EQUIP, 51 = MTC0E0U07

TABLE XI

BANDWIDTH AND DEGREES OF FREEDOM FORMULAE

	Bandwidth	Frequency Interval	Degrees of Freedom
FFT Method	2h/2**M	h/2**M	NREC/2**(M - 11)
Auto/Cross Correlation	$h/\overline{M}$	$h/(2*\overline{M})$	$2048*NREC/\overline{M}$

9.4 Choice of Analysis Parameters

The choice of certain of the parameters which govern the analyses is extremely important if meaningful results are to be obtained from the programs. These parameters are:

(i) M the log base 2 of the number of transform points in the FFT programs.

(ii) $\overline{M}$ the number of lags in auto-cross correlation programs.

(iii) NREC the number of 1024 word data records to be used.

(iv) NOCT the number of frequency bands into which the frequency axis is divided.

(v) h the data sampling rate.

These values determine the analysis bandwidths and statistical accuracy (measured by number of "degrees of freedom") as indicated in References 1 and 2. For the FFT based programs the number of transform points is constrained to be an integral power of 2 and thus, for given h, choice of bandwidth is not very flexible. It should be noted that for a given value of 2 * * M and $\overline{M}$ the bandwidth in the direct Fourier transform method is twice that of the auto/cross correlation method, but with the same number of degrees of freedom for the same length of data sample. A summary of the formulae for bandwidth, frequency interval and degrees of freedom in terms of the above parameters is given in Table XI. Since two values of psd are obtained per bandwidth the frequency interval between adjacent psd values is half the bandwidth.

It should be noted that, following FORTRAN terminology, a single asterisk means multiplication and a double asterisk raising to a power in Table XI.

For the analyses when NOCT = 1 constant bandwidth results according to the above formulae are obtained; when NOCT is greater than 1 the formulae of Table XI refer to the highest frequency band and for each lower band the bandwidth and frequency interval is effectively half that of the adjacent higher band since the sampling rate in each band is successively divided by 2 by the filtering and decimation process. The number of degrees of freedom is maintained constant in each band by the procedure of analyzing the same number of data points for each frequency band, i.e, the amount of time covered by the data in each band is always double that of the adjacent higher band. The total number of data points required for the analysis is given by NREC * 2 * * (NOCT + 9).

The frequency bands are always chosen on an octave power of 2 basis with the upper band containing a complete octave plus any residual up to the highest frequency represented by h/2 cycles per second. Similarly, the lowest band contains a full octave plus the residual down to zero frequency. The remaining bands all cover 1 complete octave.

10.0 ERROR MESSAGES

Throughout the various programs a variety of diagnostic messages are available to indicate the occurrence of errors (mainly parity on input/output or unacceptable input data) and other reportable conditions. The following is a list of all the diagnostic messages and their meanings under the headings of the subroutine names in which they occur. Throughout these messages a group of XXXX implies a number that will be supplied at program execution time.

Messages are always output to the standard output unit (Logical Unit 61) unless otherwise indicated below.

(a) DEMUX

1. NUMBER OF OUTPUT SAMPLES CALLED FOR XXX (XX RECORDS) EXCEEDS NUMBER AVAILABLE - XXXX

   This message is produced when not enough data samples for this channel are available on the appropriate multiplexer data tape to meet the number required.

2. END OF FILE DETECTED WHILE READING DATA TAPE

   An end of file has been detected before the required amount of data has been input from a multiplexer tape despite the indication from the initial records that there is enough data.

3. DATA ENDS AFTER XXXX RECORDS XXXX RECORDS CALLED FOR XXXX RECORDS WILL BE OUTPUT

   This message follows number 2 when insufficient input data has been found.

4. WORDS/INPUT RECORD - XXXX - EXCEEDS 2000

   The records from the input data tapes contain XXXX words which exceeds the available buffer sizes in DEMUX. After this diagnostic, program execution terminates.

(b) SCANTAPE. All the diagnostics in this section cause termination of program execution.

5. MISPLACED EOF ON INPUT TAPE LUN XXX

   The initial records on an input tape are not in correct order.

6. WRONG TAPE, ID(11) READ AS XXXX

The test identifier read from a card does not agree with that on the input tape.

7. WRONG TAPE, ID(12) READ AS XXXX

Input tape multiplexer identifier is not MUXA or MUXB as appropriate.

8. CHANNELS NOT PRESENT OR INCORRECTLY SPECIFIED

A channel number from card is not among those on the input tapes.

(c) STATIST

9. INCREMENT INVALID, INC = XXXX NO HISTOGRAMS

The cell interval for amplitude probability distributions is not in the range 80 to 4095.

(d) ERRECOV

10. PERSISTENT PARITY ERROR * * * * * *

A permanent parity error has been found on a tape. This message is always followed by a further message indicating on which logical unit and in which phase of the demultiplexing process the error occurred.

(e) P [illegible]

11. PPE CALLED, ENOUGH DATA LEFT TO RESTART

A parity error on an input data tape has been detected and enough data reamins in the submultiplexed group to allow the demultiplexing process to restart.

12. PPE CALLED, INSUFFICIENT DATA TO RESTART, OMIT RECORD AND CONTINUE

As above, but not enough data remains to restart so the record in error is omitted from the set of input records and the demultiplexing process continues.

(f) LPFILT

13. PARITY ERROR ON INPUT LOGICAL UNIT XXXX WRITTEN ERROR FREE. CLEAN TAPE HEADS AND RESTART JOB

An irrecoverable parity error has been detected on logical units 3 or 4 which are known to have been written error-free in routine FILLOUT. Execution terminates after this message.

(g) MISCELL (entry point BACKSKIP)

14. LOAD POINT FOUND ROUTINE BACKSKIP

In skipping backwards to an end of file the load point of the tape has been reached. Execution terminates.

(h) PSDFFT, PSDAUTO

15. PARITY ERROR READING LOGICAL UNIT 3 AFTER ERROR FREE WRITE. CLEAN TAPE HEAD AND REPEAT JOB.

This message appears on the CTO unit (comment to operator) and is self-evident. Execution terminates.

(i) CPSDFFT, CPSDAUTO

16. PARITY ERRORS ON READING LOGICAL UNITS 3 and 4 AFTER ERROR FREE WRITES. CLEAN TAPE HEADS AND REPEAT JOB.

This message appears on the CTO unit after a parity error on either logical unit 3 or 4. Execution terminates.

(j) PSDCNTLF, PSDCNTLA, CPSDCTLF, CPSDCTLA

17. TOO MANY POINTS IN PSD RANGE

This message appears when the number of psd values exceeds the available array space. It can only occur when NOCT is greater than 1. Results are generally meningless because some data in core storage will have been overwritten.

All the following diagnostics cause program termination:

(k) MNPSDAF, MNCPSDF

18. M GREATER THAN 10

The value of M read from the input data is too large.

(ℓ) MNPSDAA, MNCPSDA

19. M GREATER THAN 1000

The value of M read from the input data is too large.

(m) MNPSDAF, MNCPSDF, MNPSDAA, MNCPSDA

20. F1 = XXXX GREATER THAN F2

Lower frequency greater than upper frequency in required plotting range, read from input data.

21. MORE THAN 10 PLOT DECADES SPECIFIED

Value of NDECS read from the input data exceeds 10.

11.0 PROGRAM EXECUTION TIMES

The major factors which influence the execution times for the programs are the analysis bandwidth, number of frequency bands and the number of data samples used in each band. Of the total execution time, the time to plot the results on-line is generally significant and this varies with the degree of variability of the psd. A further variable is the amount of time spent searching the input tape(s) to find a particular channel of data. An exhaustive and detailed attempt to determine execution times has not been possible but the times given in Table XII for various analyses are representative. Details of the four analyses are given in Table XIII; times are in minutes and include plotting time but do not include time to read the program into the computer, mount tapes, and read data card number 1.

It is observed that in the analysis using 5 frequency bands the correlation method is faster than the Fourier transform method; since twice as many data points are required for the latter method to give the same number of degrees of freedom it is apparent that the gain in speed of the FFT is outweighed by the extra filtering time required for this particular case.

TABLE XII

PROGRAM EXECUTION TIMES

Program	Analysis No. 1	Analysis No. 2	Analysis No. 3	Analysis No. 4
MNPSDAF WCP/68-20	1.22	1.30	2.28	6.33
MNPSDAA WCP/68-21	1.57	2.84	3.54	5.23
MNCPSDF WCP/68-22	2.94	3.60	4.85	11.90
MNPSDAF WCP/68-23	3.40	4.67	5.77	8.95

TABLE XIII

TIMING ANALYSIS DETAILS

Analysis Number	No. of Transform Points	No. of Lags	Lowest Bandwidth (Hz)	No. of Frequency Bands	No. of Degrees of Freedom	No. of Data Samples	
						FFT	Correlation
1	512	256	23.4	1	40	10,240	5,120
2	512	256	23.4	1	104	25,492	13,321
3	512	256	6.86	3	64	8,192	4,096
4	256	128	3.43	5	64	8,192	4,096

12.0 CONCLUSIONS

A series of computer programs for power spectral density of discrete data have been described and documented. The methods include direct Fourier transformation and use of the correlation function, applied to both direct and cross spectral density; a facility for varying the analysis bandwidth over the frequency range has also been provided. Full details have been included for use of the programs and for program maintenance and extension. Further analyses which can be of interest have been indicated.

REFERENCES

1. Jolly, A. C., "Estimation of Direct and Cross Power Spectral Density of Discrete Data Using the Fast Fourier Transform," Wyle Laboratories Research Staff Report WR 69-4, March 1969.

2. Bendat, J. S. and A. G. Pressol, Measurement and Analysis of Random Data, John Wiley and Sons, Inc., New York, 1966.

3. Blackman, R. B. and J. W. Tukey, The Measurement of Power Spectra, Dover Publications, New York, 1958.

4. Cooley, J. W. and J. W. Tukey, "An Algorithm for the Machine Calculation of Complex Fourier Series," Mathematics of Computation, Volume 19, No. 90 (1965).

5. Newland, J. E., Reference Manual SCOOP Programming System for Digital Incremental Plotters, California Computer Products, Inc., 1966.

ACKNOWLEDGEMENTS

Grateful acknowledgement is accorded the following two members of Wyle Laboratories Research Staff:

Mr. B. D. Adcock for his efforts in writing the data demultiplexing and statistical routines described in Section 4.1.

Mr. D. J. Bozich for many helpful discussions.

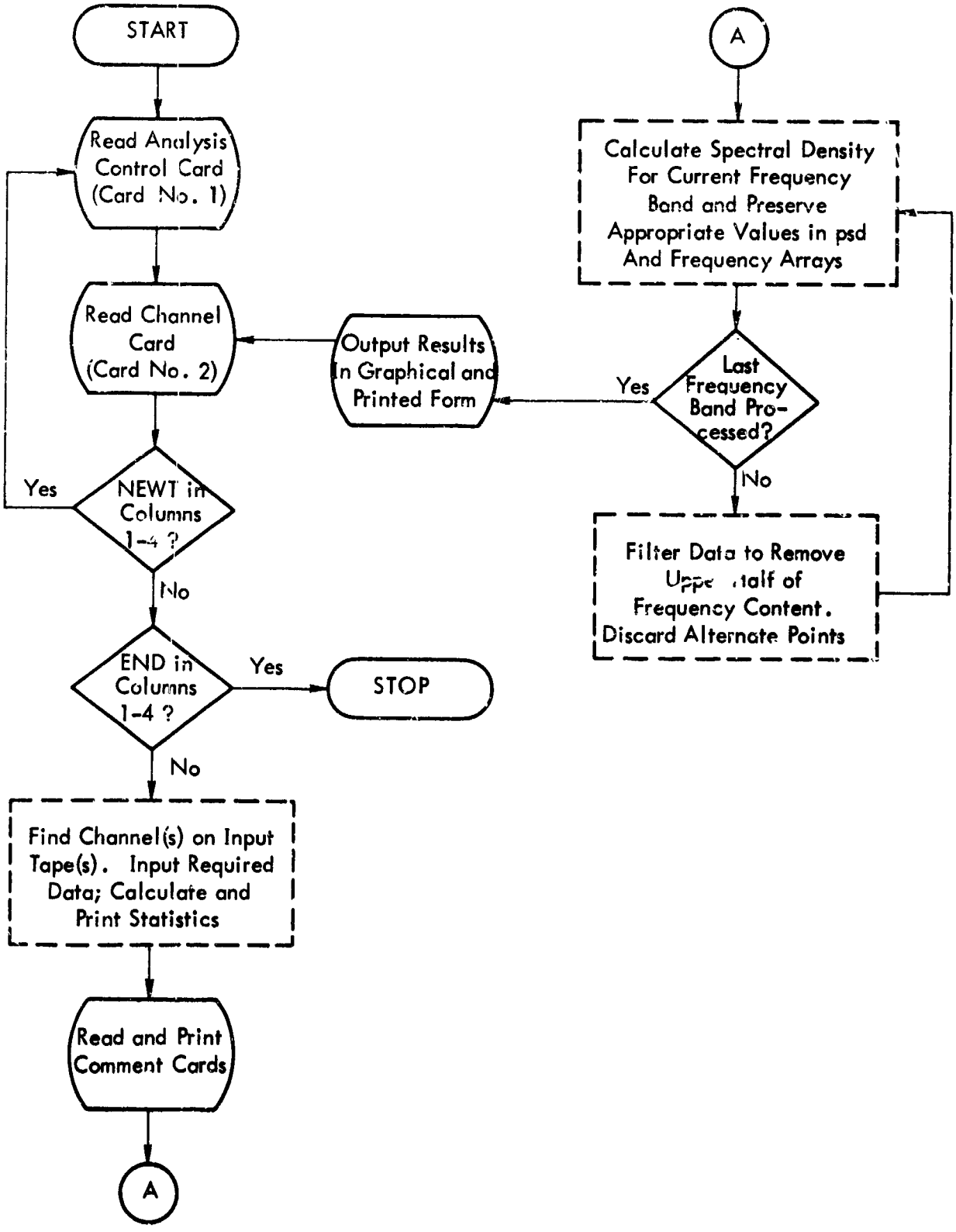


Figure 1. Flow Chart of General Program Organization

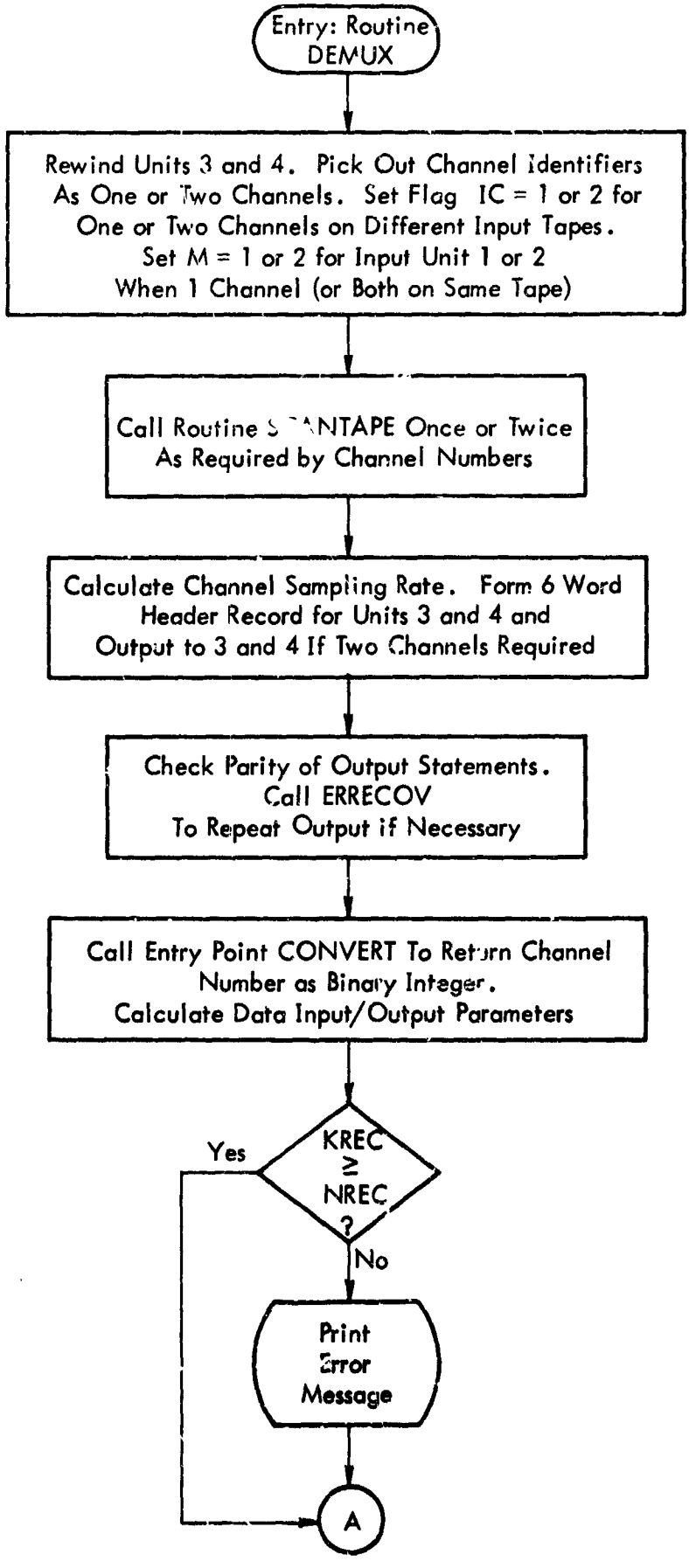


Figure 2. Flow Chart of Data Demultiplexing Routines

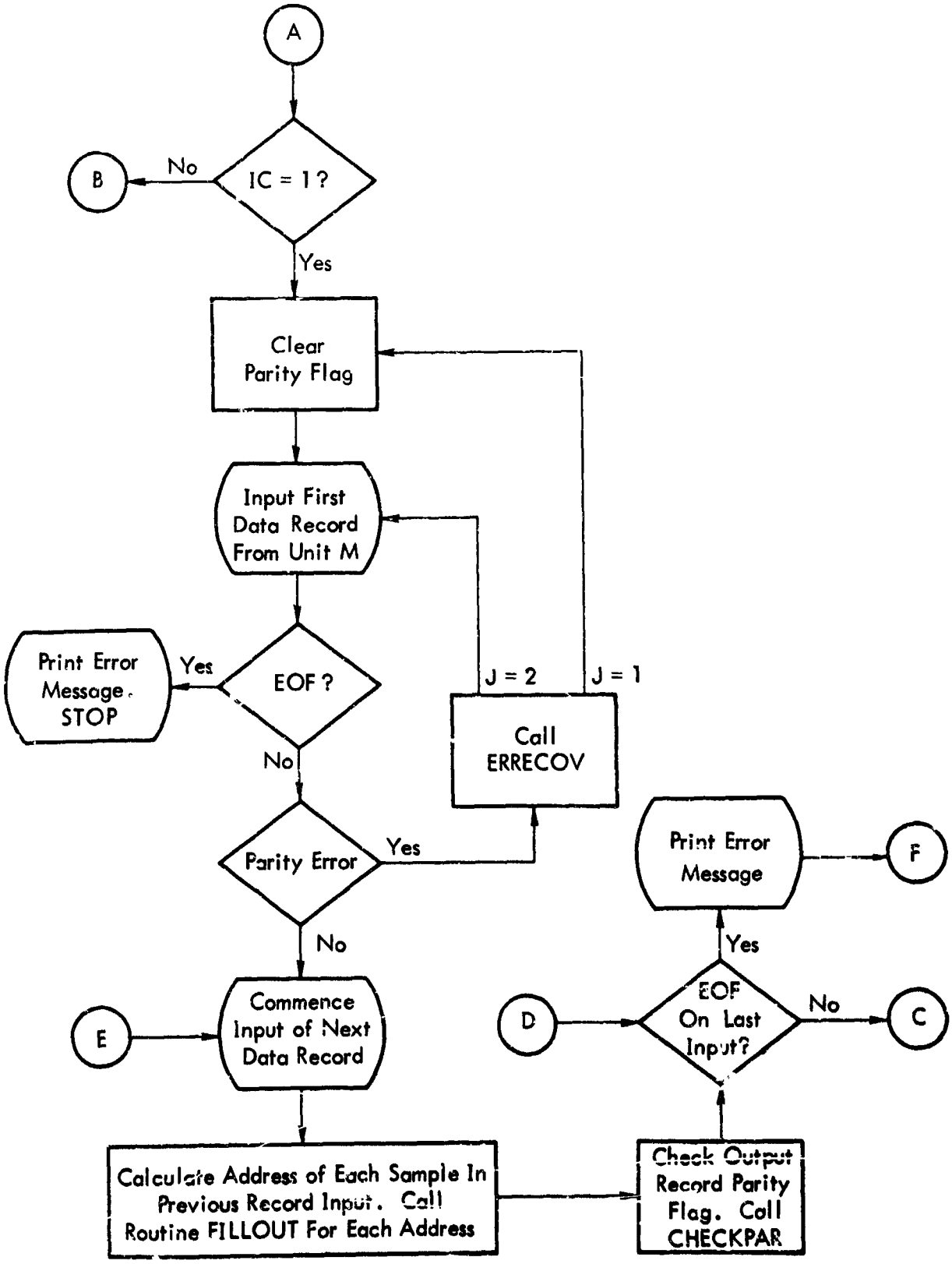


Figure 2. Continued

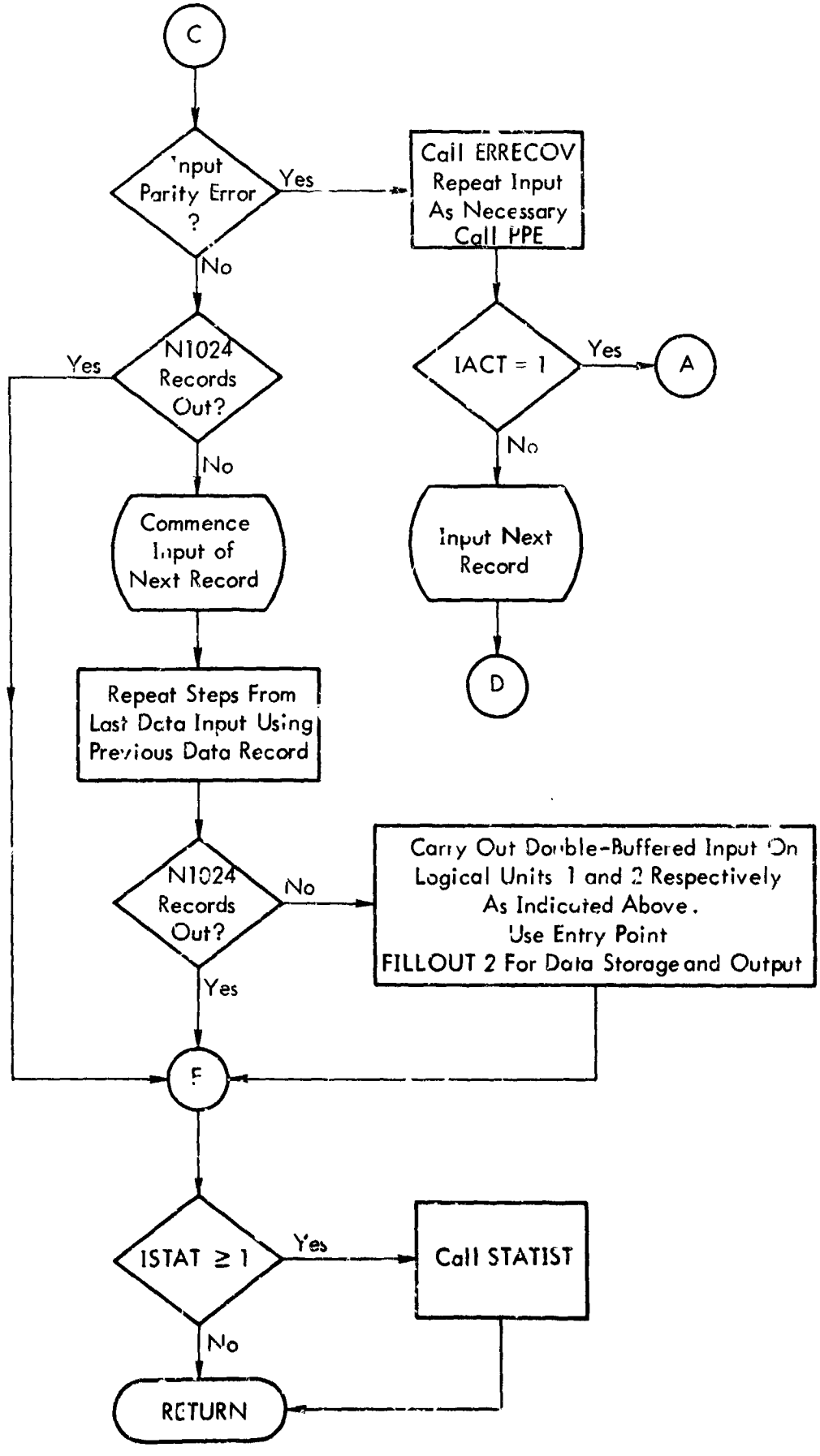
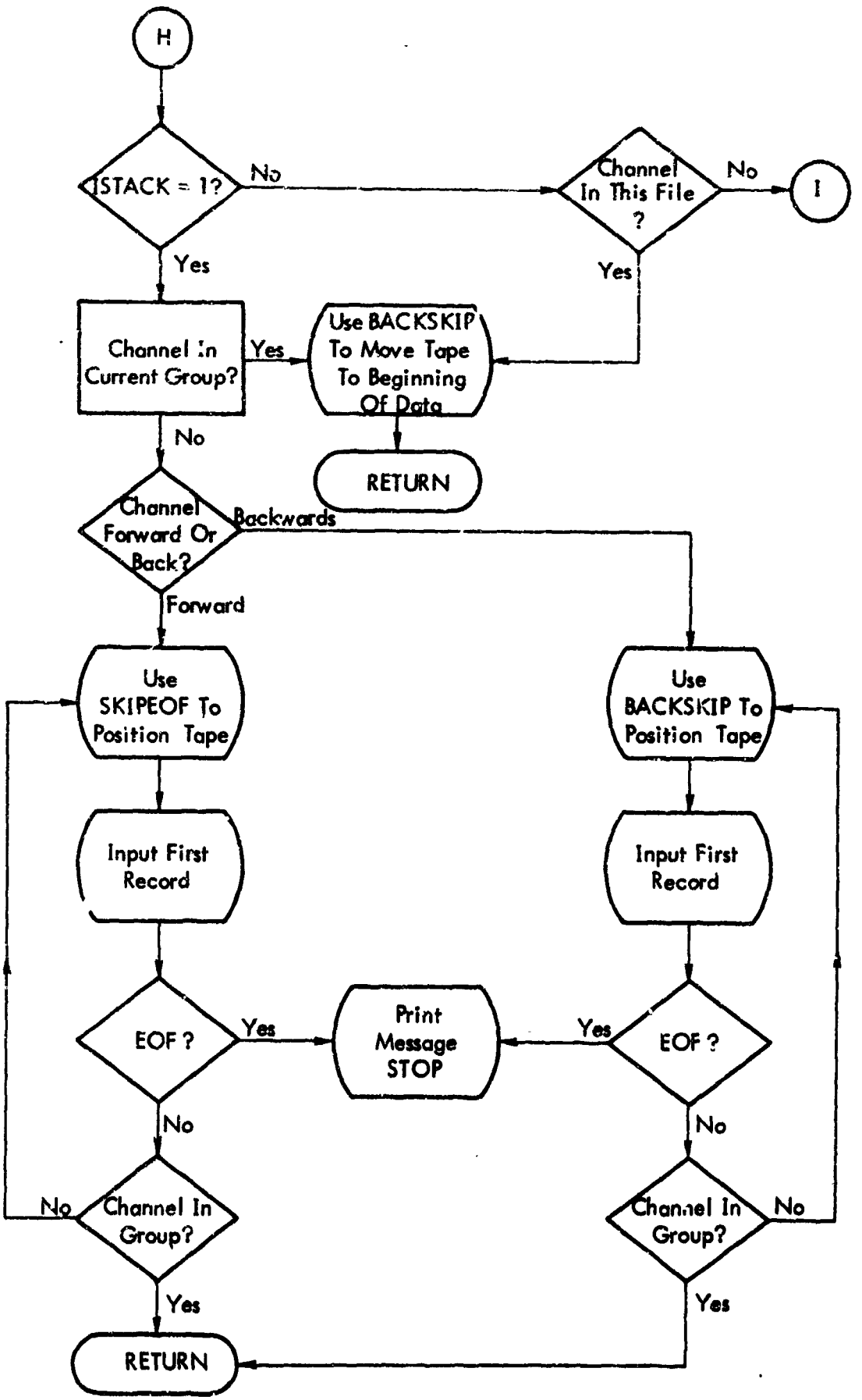


Figure 2. Continued



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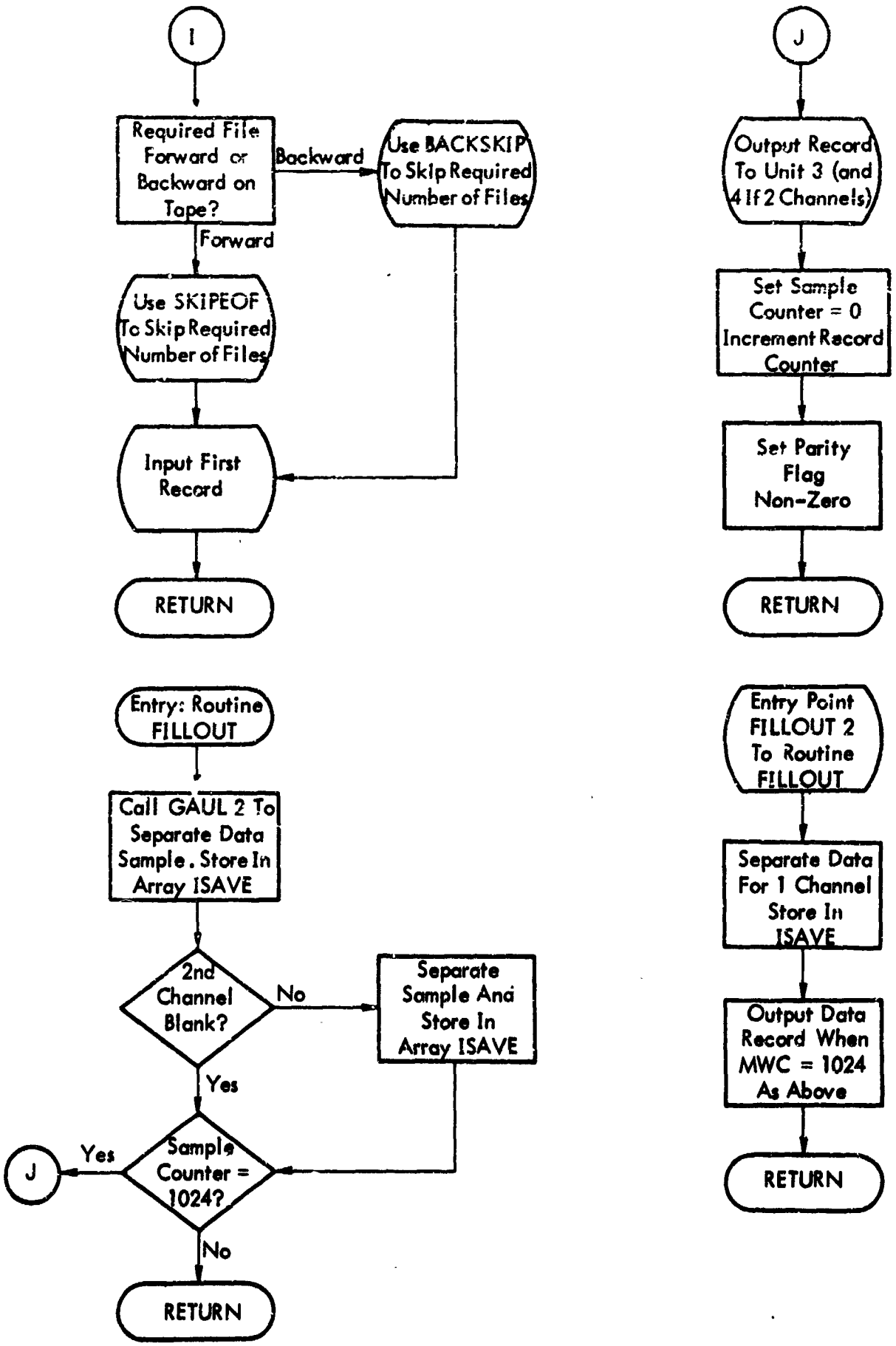

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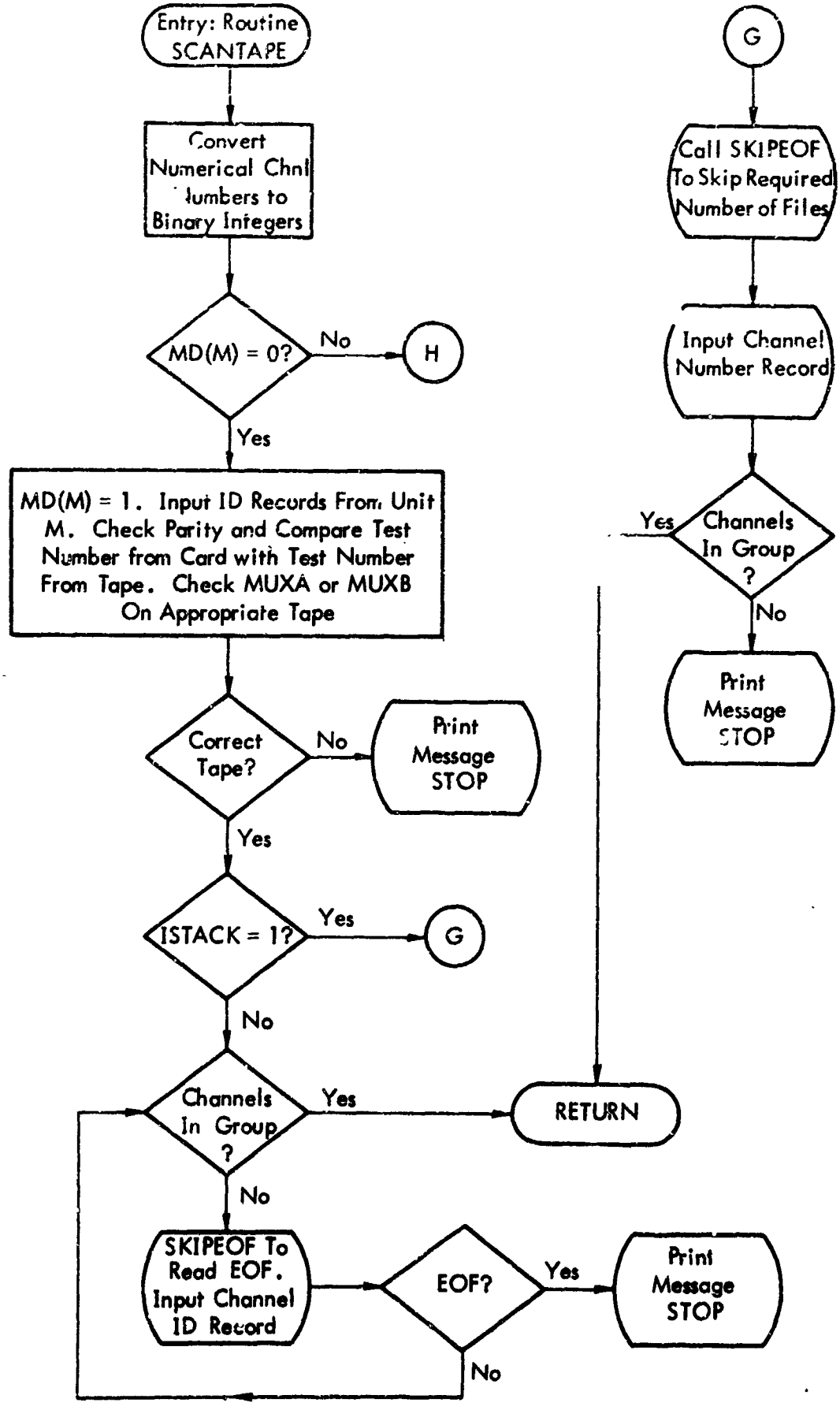


Figure 2. Continued

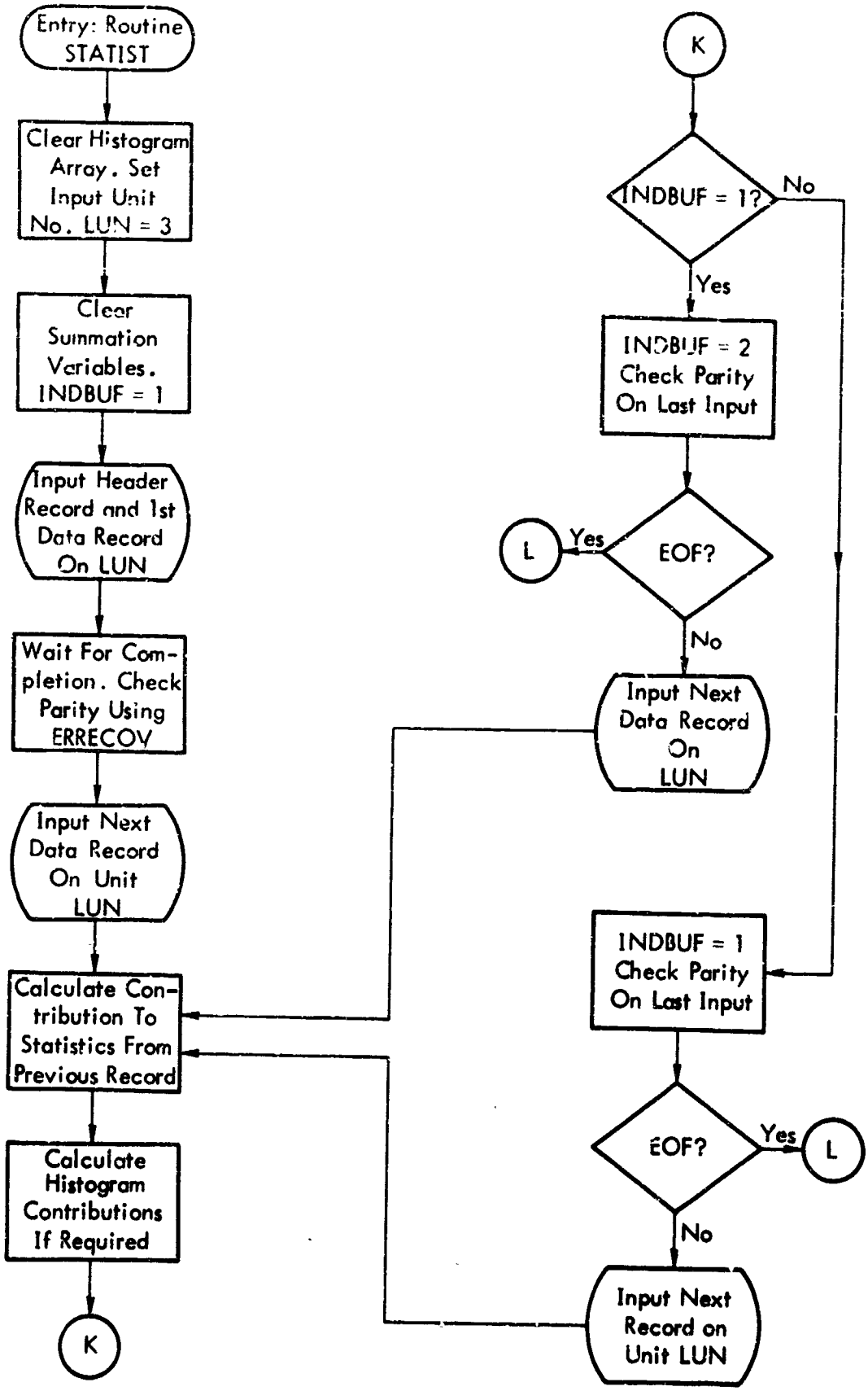


Figure 2. Continued

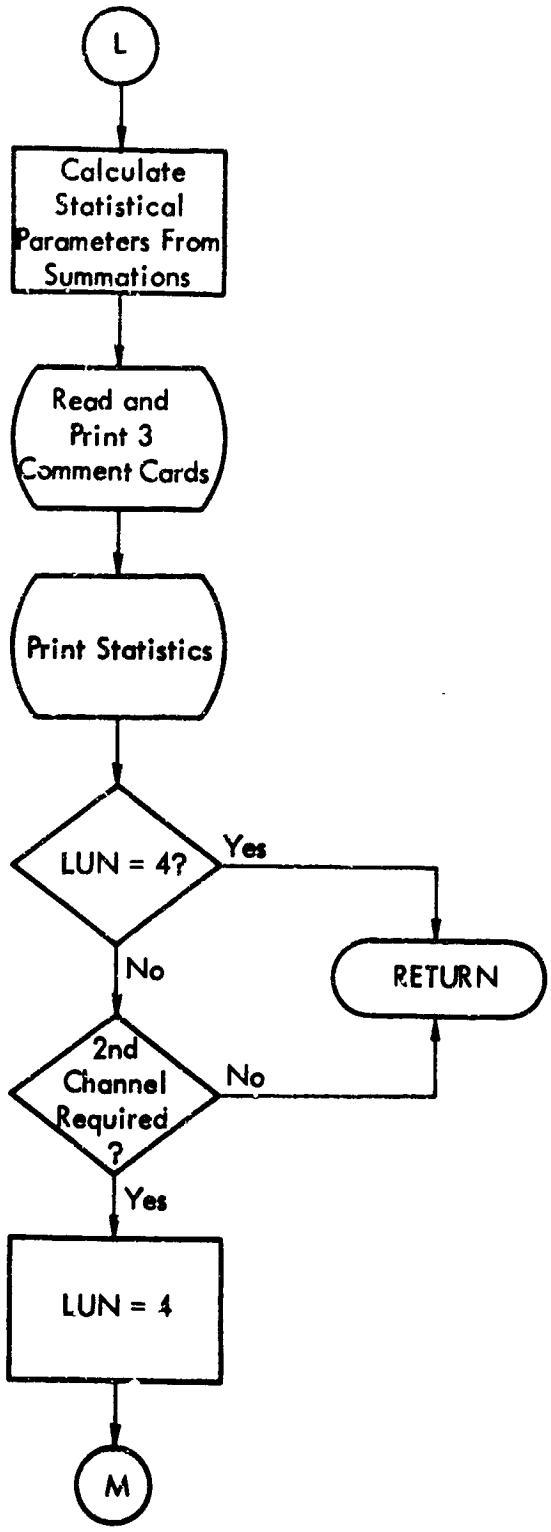


Figure 2. Concluded

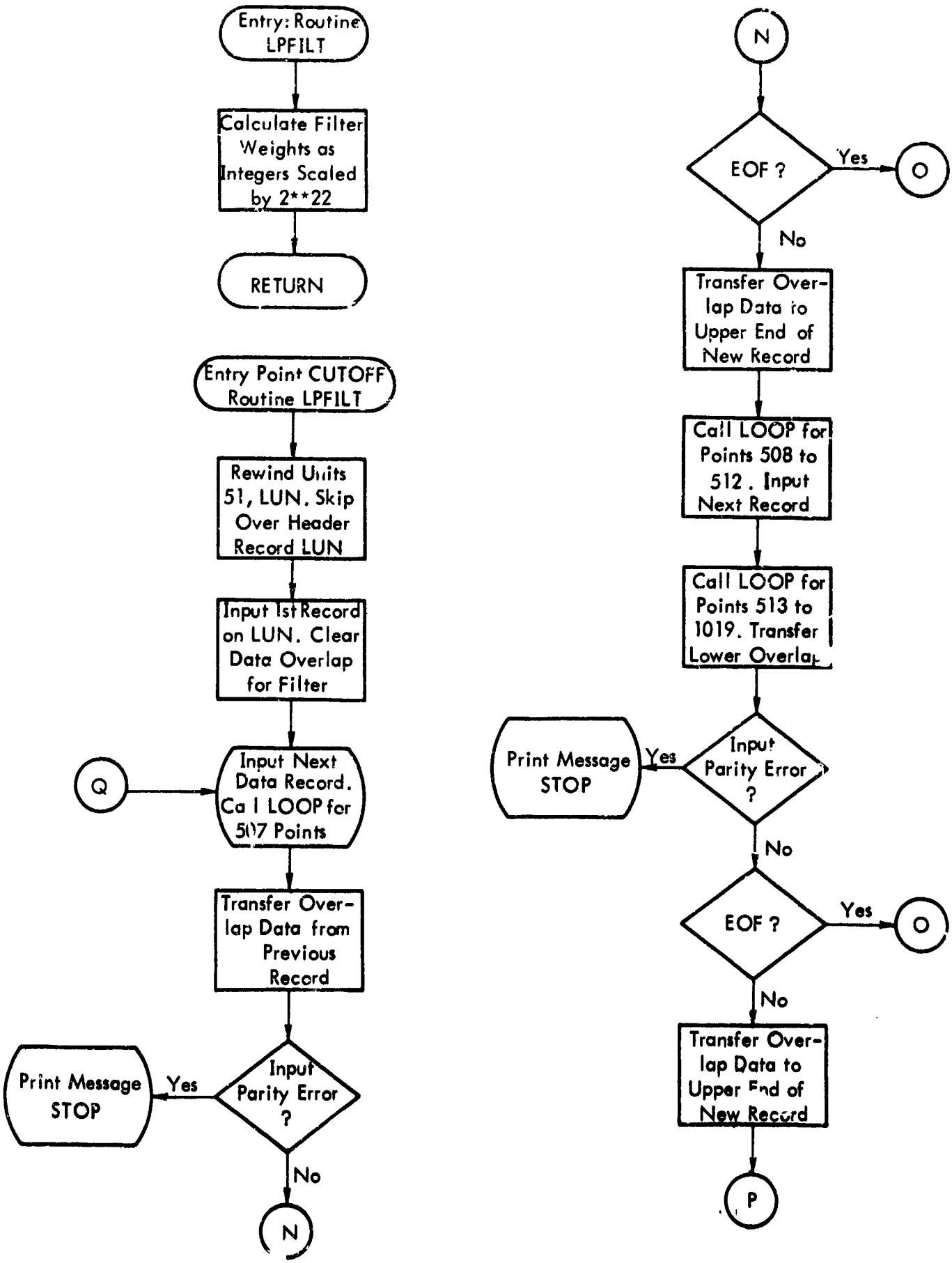


Figure 3. Flow Chart of Low-Pass Filtering Routines

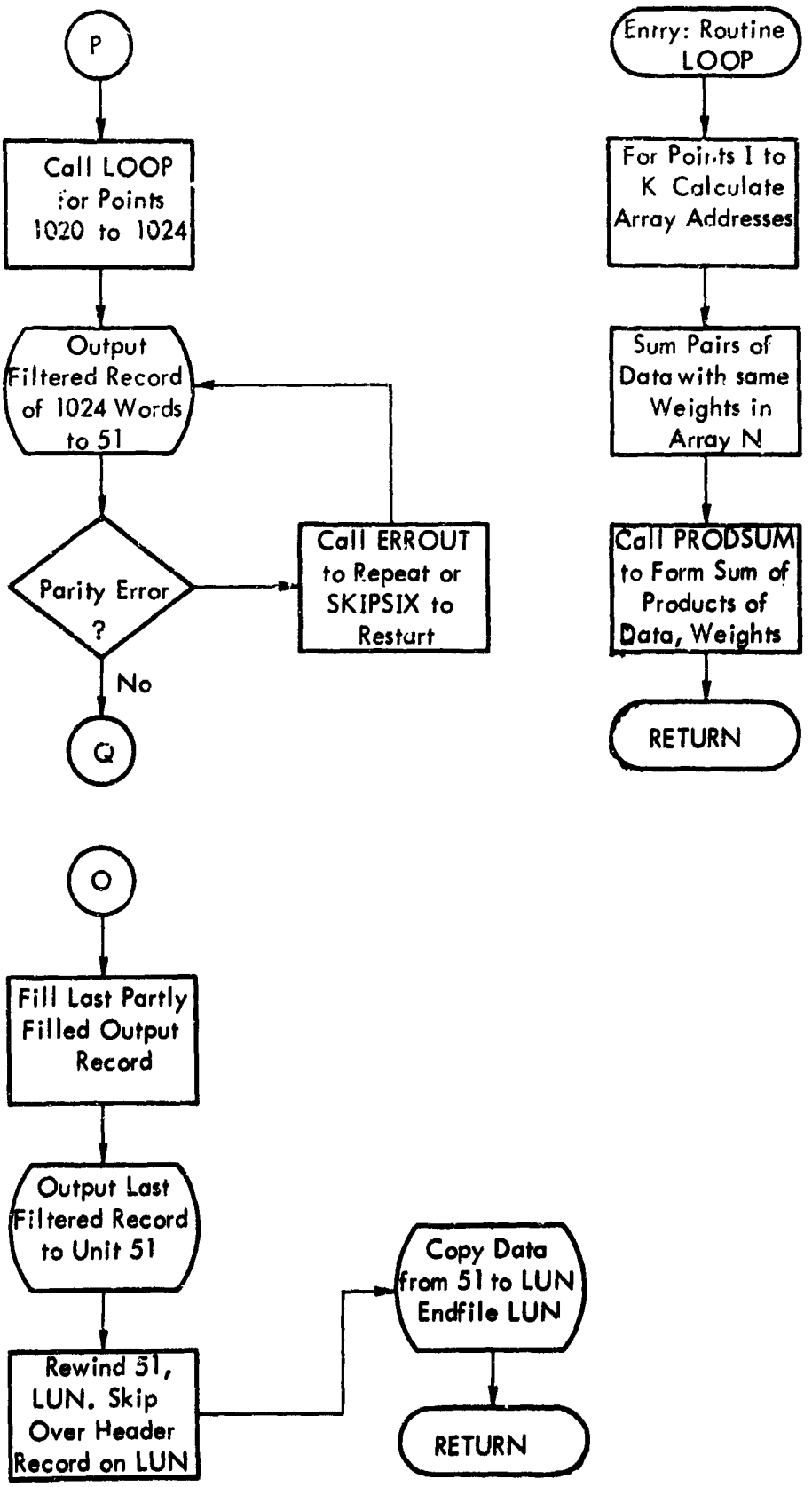


Figure 3. Concluded

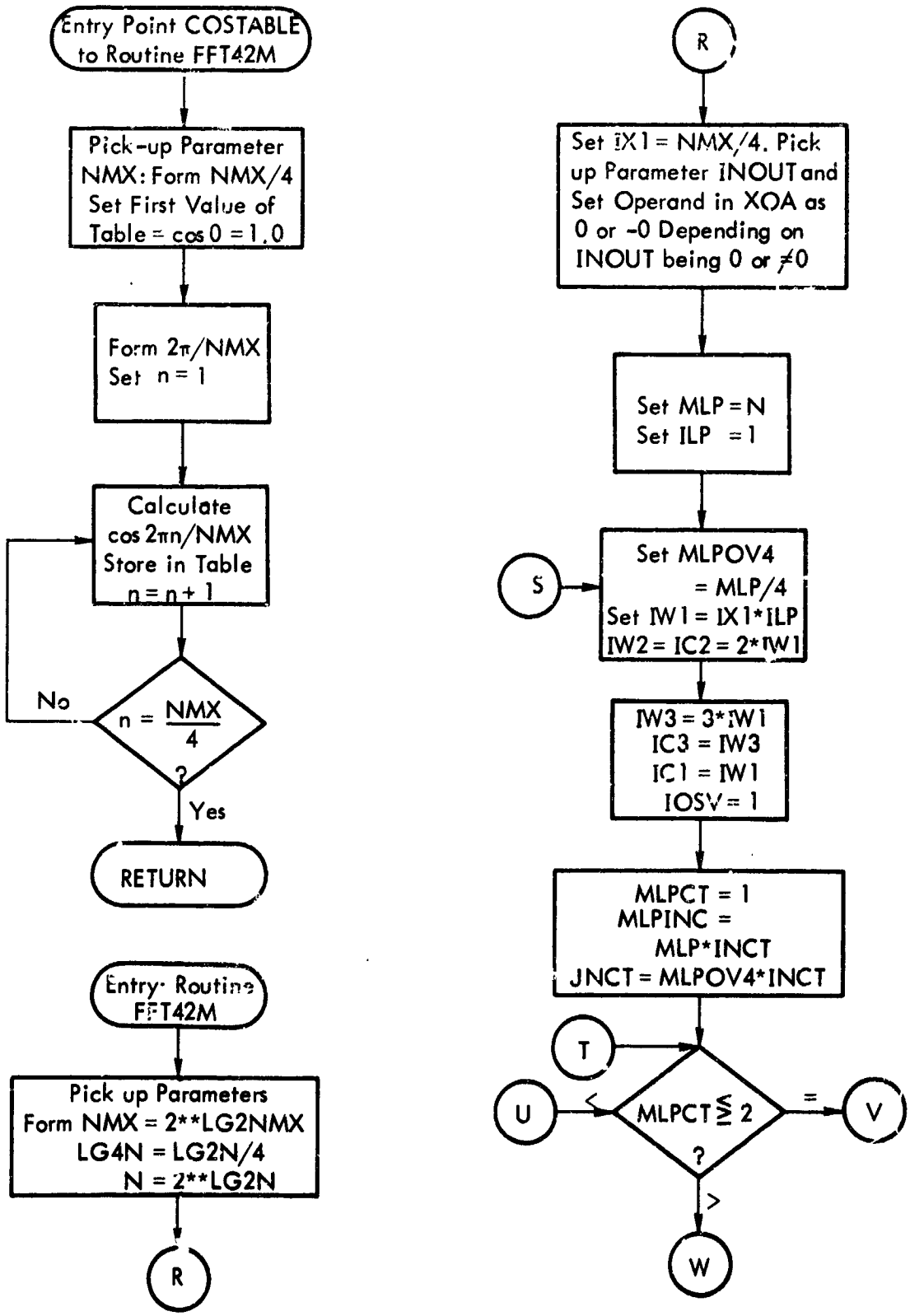
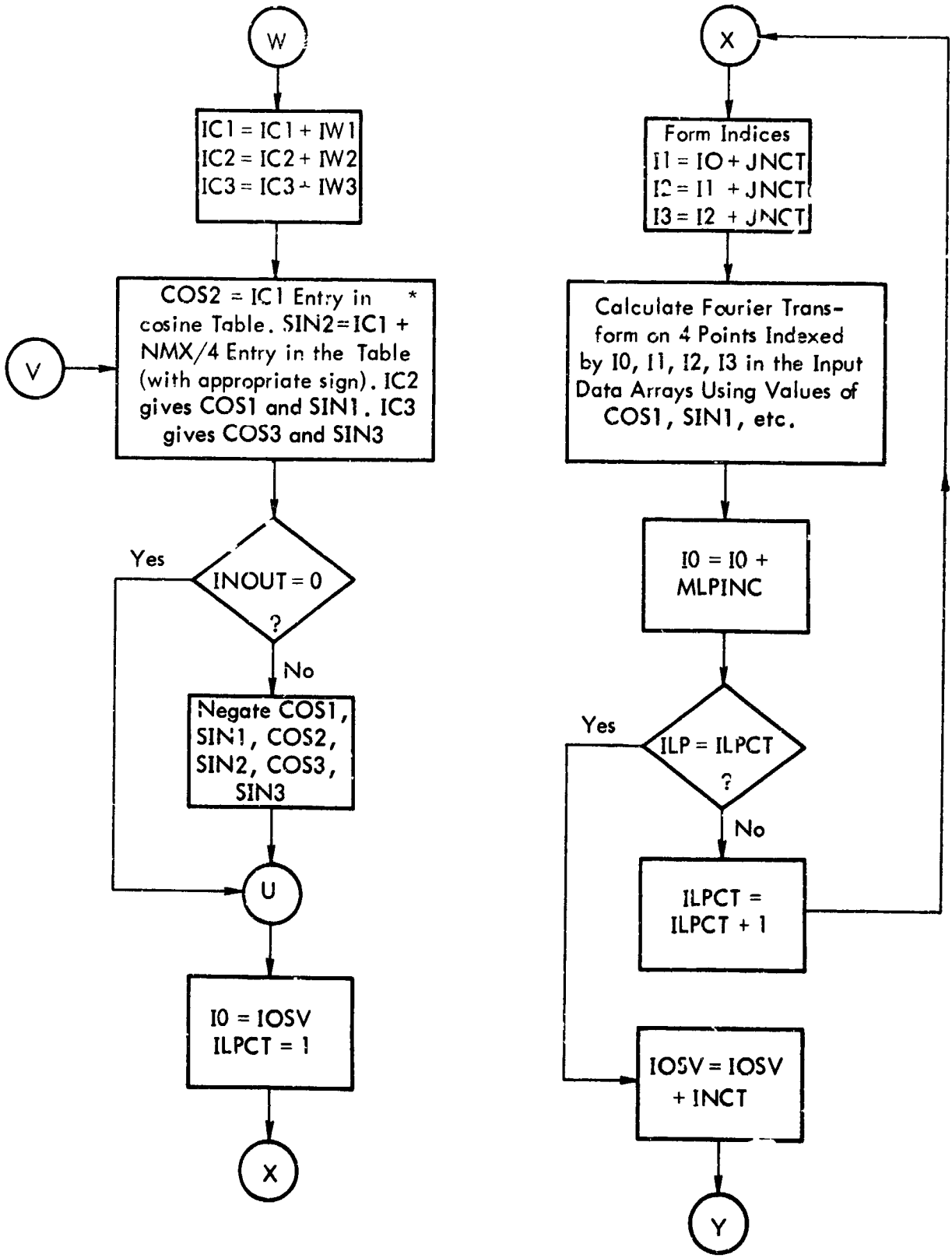


Figure 4. Flow Chart of Routine FFT42M



* This table occupies one quarter cycle and a table look-up routine provides the value from the table in the correct quadrant

Figure 4. Continued

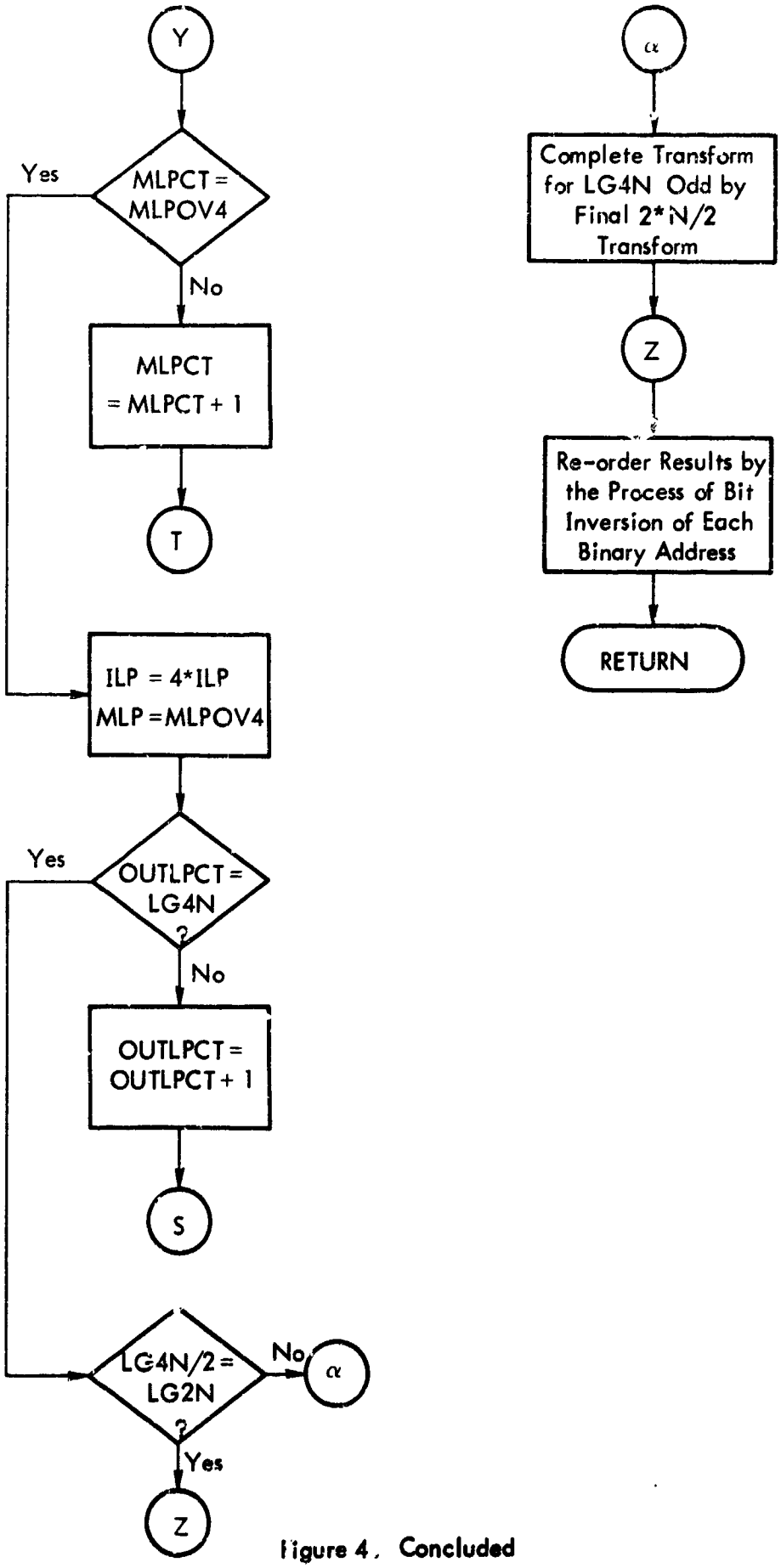


Figure 4. Concluded

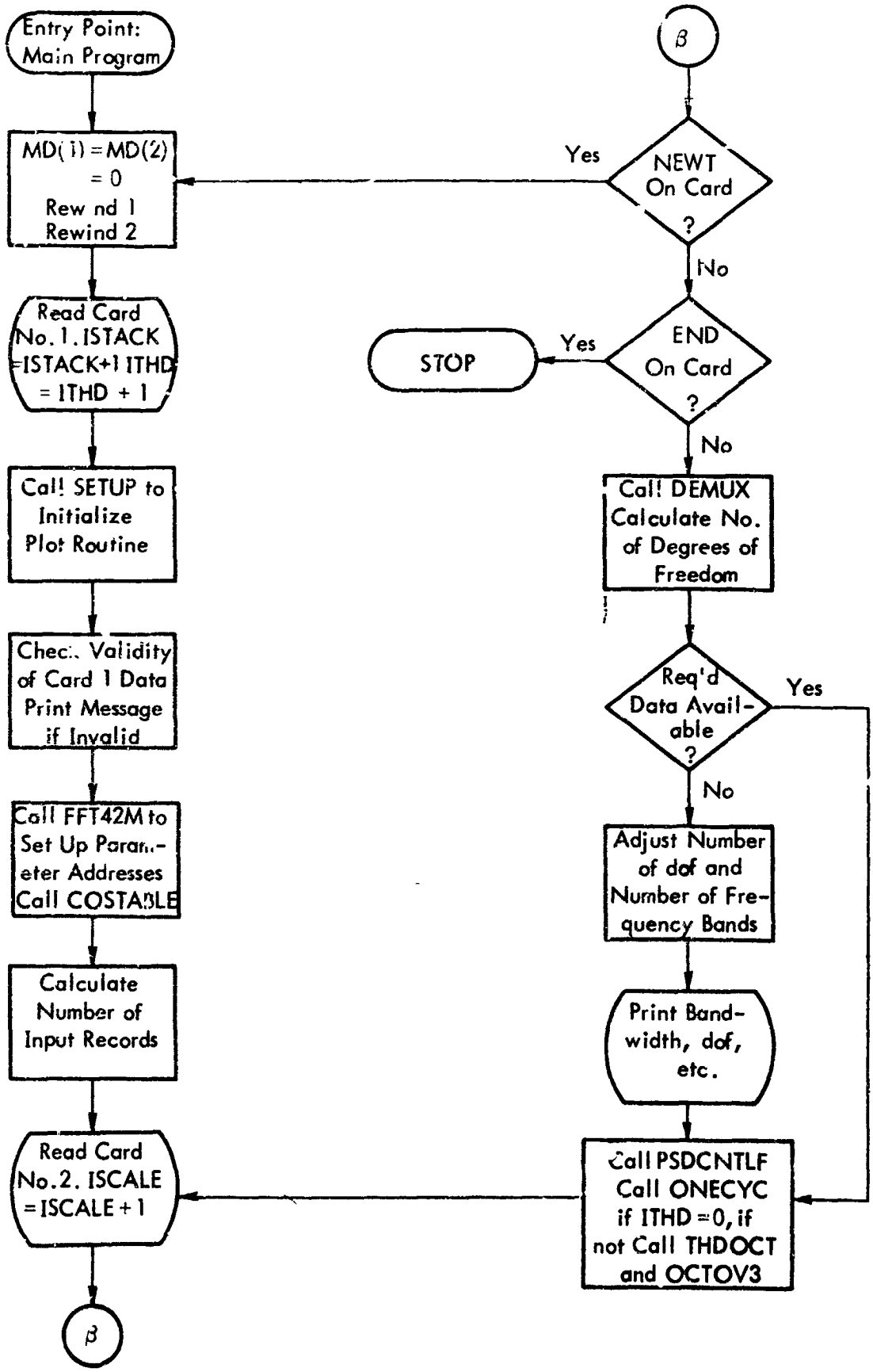


Figure 5. Flow Chart of Program WCP/68-20

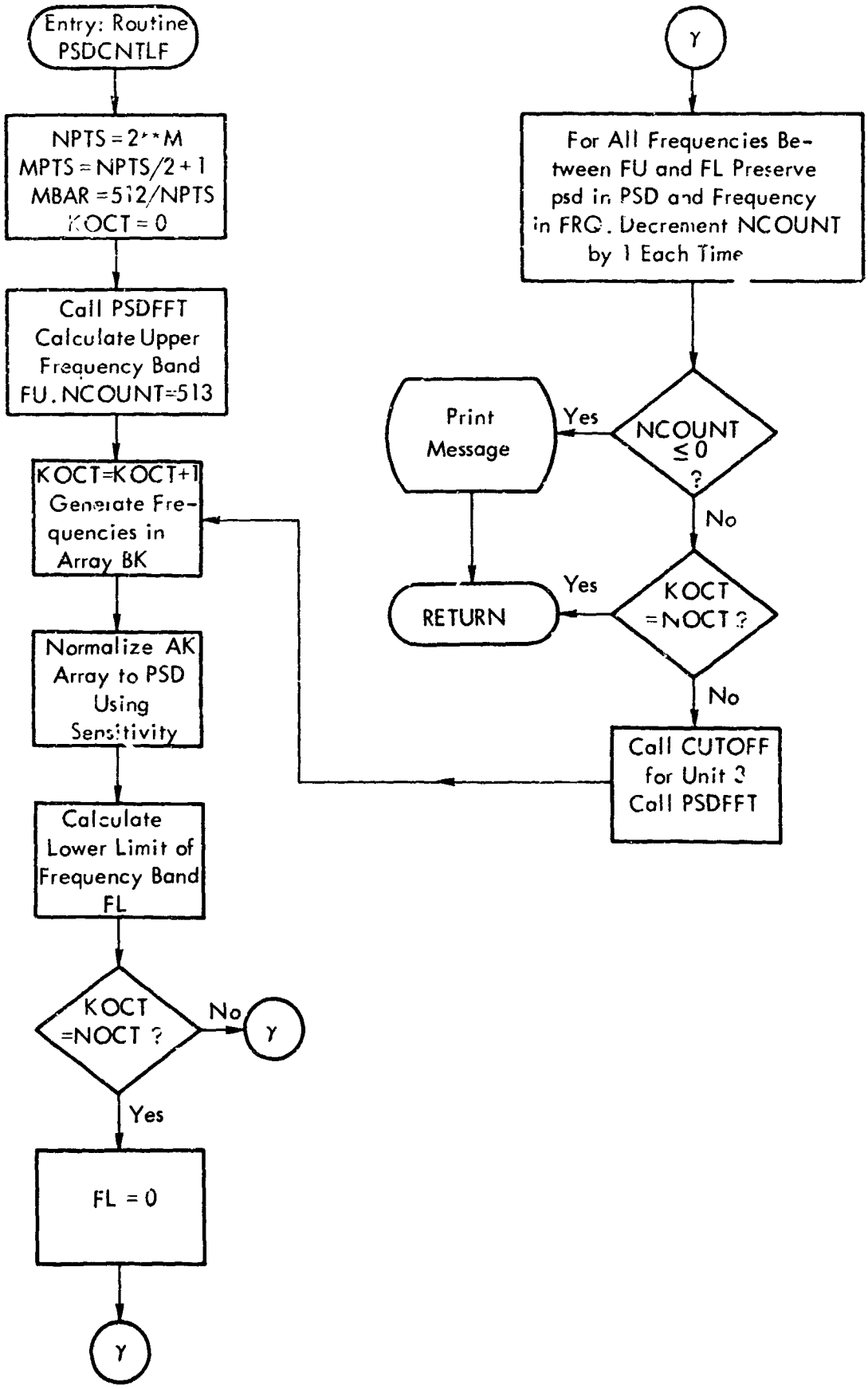


Figure 5. Continued

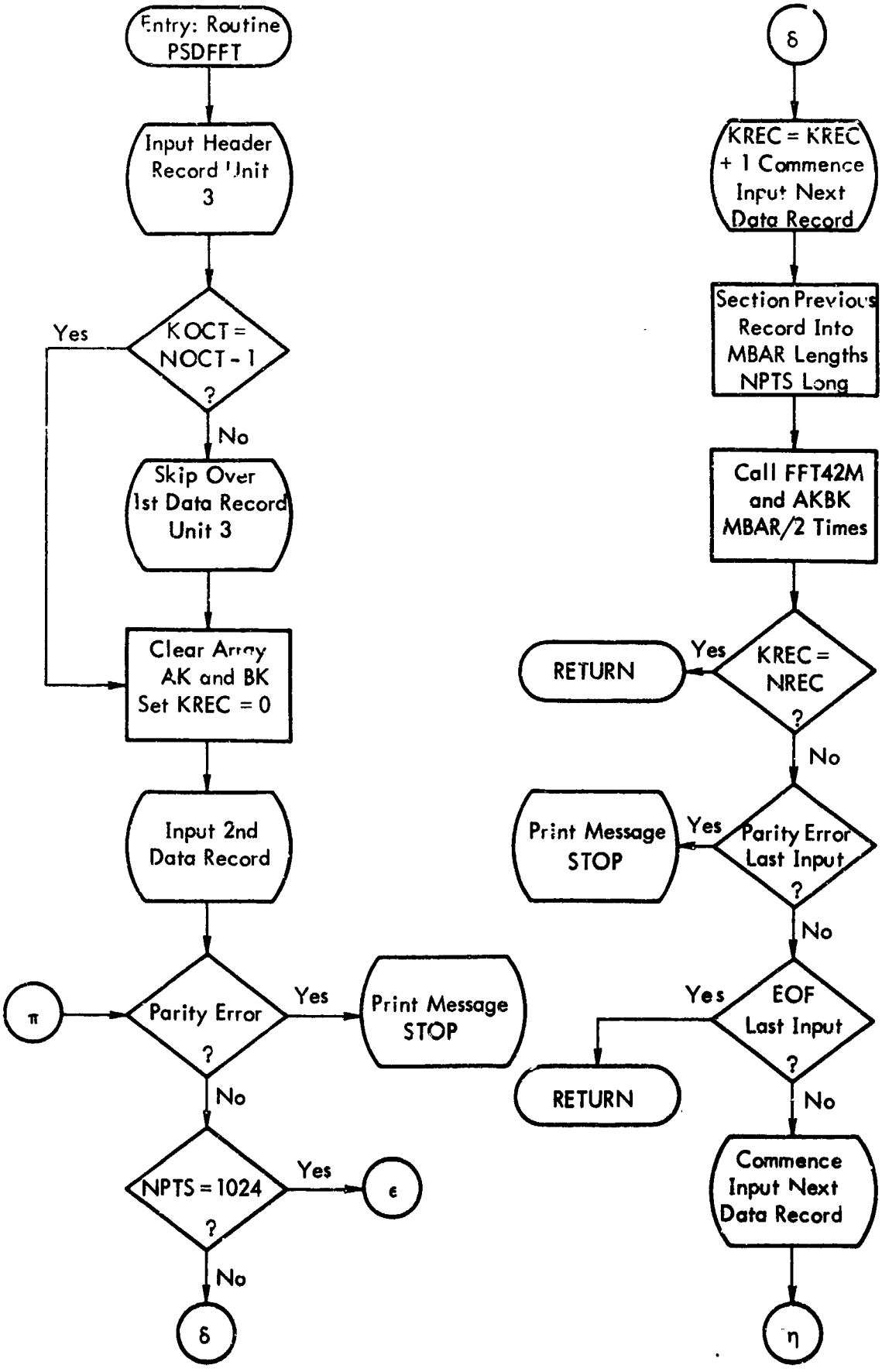


Figure 5. Continued

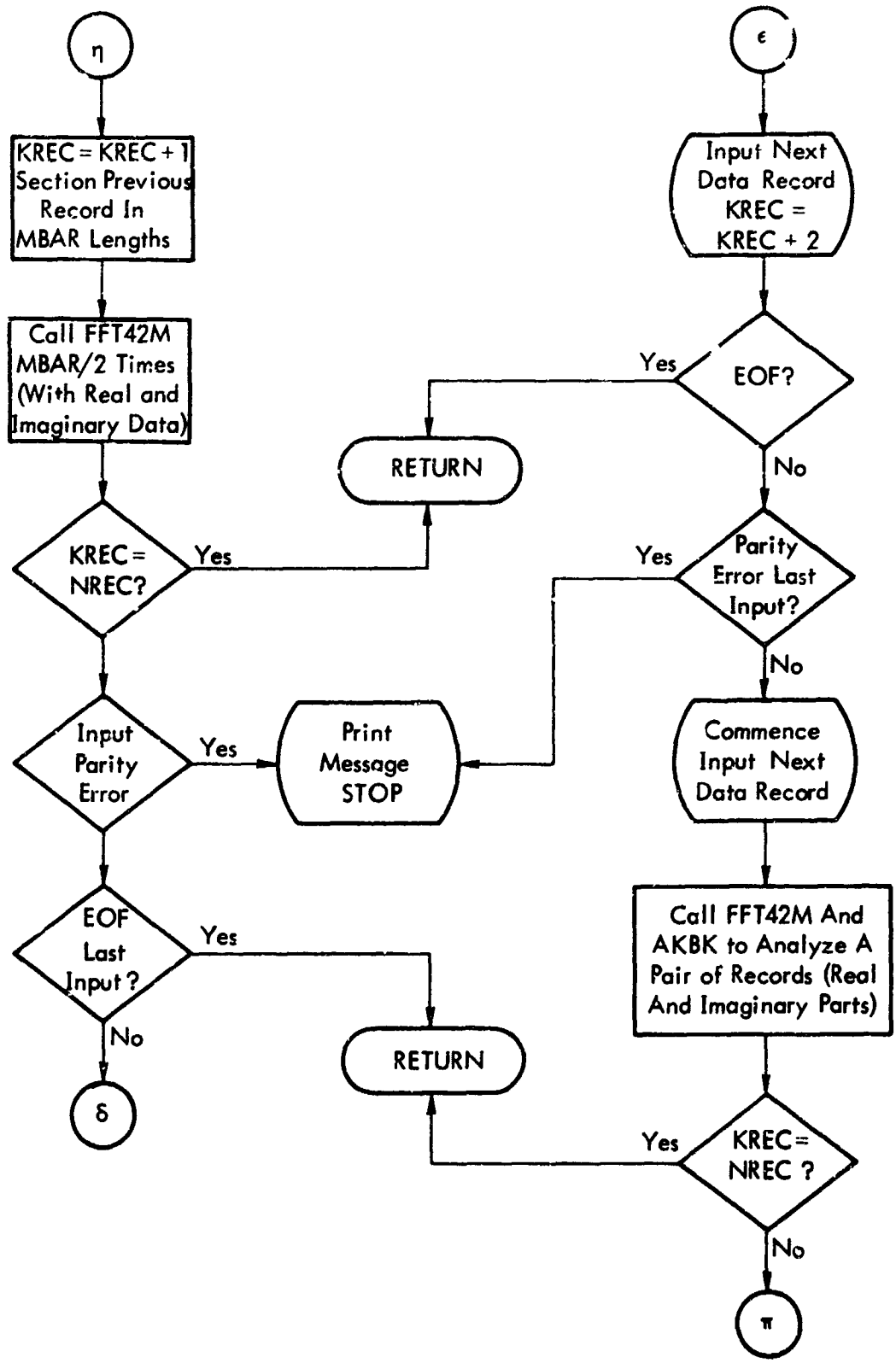


Figure 5. Concluded

```
*****************************************************************************

              TEST NUMBER ATF1            CHANNEL NUMBER 001B

                        EXAMPLE PSD CALCULATION
        STIFFENED PANEL                    ACCELEROMETER NO. 2
                  ACOUSTIC-STRUCTURAL IMPEDANCE EXPERIMENT

 MEAN =     32.5   STD. DEV =  257.3   SKEWNESS =     -0.08   KURTOSIS =     3.15
        SIGNAL R.M.S. =     2.573                 SENSITIVITY =   100.0

           80 DEGREES OF FREEDOM.
         NUMBER OF FREQUENCY BANDS =  1
         ANALYSIS BANDWIDTH IN UPPER FREQUENCY BAND = 40.7  HZ

*****************************************************************************
```

Figure 6. Sample Statistical Print-Out from Programs WCP/68-20 and WCP/68-22

TEST NO, TP16 CHANNEL NO, 001B

FREQ	P.S.D.	FREQ	P.S.D.	FREQ	P.S.D.	FREQ	P.S.D.
10,18	3,27272E-01	20,36	6,55023E-01	30,54	5,39882E-01	40,72	3,55479E-01
50,90	2,86747E-01	61,08	2,60597E-01	71,26	2,85459E-01	81,45	3,27116E-01
91,63	2,93474E-01	101,81	3,06046E-01	111,99	1,89908E-01	122,17	2,39259E-01
132,35	2,27702E-01	142,53	2,34374E-01	152,71	1,97797E-01	162,89	1,35883E-01
173,07	1,24456E-01	183,25	1,16320E-01	193,43	8,17617E-02	203,61	6,51235E-02
213,79	7,36620E-02	223,97	4,48867E-02	234,16	5,29235E-02	244,34	4,94600E-02
254,52	3,17451E-02	264,70	2,73058E-02	274,88	2,83044E-02	285,06	3,05503E-02
295,24	4,47512E-02	305,42	3,71852E-02	315,60	2,64897E-02	325,78	1,83166E-02
335,96	2,25900E-02	346,14	2,08524E-02	356,32	1,06904E-02	366,50	7,56936E-03
376,68	1,20491E-02	386,87	2,08826E-02	397,05	2,17190E-02	407,23	1,01889E-02
417,41	8,82472E-03	427,59	1,21047E-02	437,77	1,04684E-02	447,95	1,29630E-02
458,13	1,38349E-02	468,31	9,55559E-03	478,49	1,18190E-02	488,67	1,11145E-02
498,85	9,86376E-03	509,03	6,38536E-03	519,21	8,11379E-03	529,39	1,05376E-02
539,58	8,82697E-03	549,76	6,49580E-03	559,94	7,34050E-03	570,12	6,33458E-03
580,30	5,05188E-03	590,48	4,27930E-03	600,66	4,18318E-03	610,84	5,10179E-03
621,02	3,44616E-03	631,20	3,92114E-03	641,38	5,15924E-03	651,56	5,80173E-03
661,74	4,83819E-03	671,92	4,51957E-03	682,10	1,97103E-03	692,29	2,70530E-03
702,47	2,80435E-03	712,65	5,20962E-03	722,83	4,92498E-03	733,01	4,86730E-03
743,19	2,94237E-03	753,37	2,14134E-03	763,55	1,57577E-03	773,73	2,61374E-03
783,91	2,59920E-03	794,09	3,60463E-03	804,27	3,59165E-03	814,45	3,62717E-03
824,63	3,56087E-03	834,81	2,45631E-03	845,00	3,16180E-03	855,18	3,41073E-03
865,36	2,66824E-03	875,54	2,08849E-03	885,72	1,78864E-03	895,90	2,02494E-03
906,08	2,14970E-03	916,26	2,62113E-03	926,44	2,31730E-03	936,62	1,60192E-03
946,80	1,39745E-03	956,98	1,03577E-03	967,16	1,04272E-03	977,34	1,44897E-03
987,52	1,44410E-03	997,71	1,76883E-03	1007,89	1,67001E-03	1018,07	9,85414E-04
1028,25	1,14050E-03	1038,43	8,04246E-04	1058,79	1,05643E-03	1079,15	1,35746E-03
1099,51	1,24335E-03	1119,87	1,22083E-03	1140,23	1,23532E-03	1160,60	1,25762E-03
1180,96	9,54109E-04	1201,32	6,62461E-04	1221,68	1,06746E-03	1242,04	1,15373E-03
1262,40	9,19351E-04	1282,76	7,74418E-04	1303,13	7,76408E-04	1323,49	7,06742E-04
1343,85	5,72908E-04	1364,21	4,14375E-04	1384,57	5,62012E-04	1404,93	5,51377E-04
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1506,74	3,70374E-04	1527,10	3,39398E-04	1547,46	3,45936E-04	1567,82	4,15076E-04
1588,18	5,79447E-04	1608,54	5,19363E-04	1628,91	3,52326E-04	1649,27	3,34093E-04
1669,63	3,53789E-04	1689,99	3,85529E-04	1710,35	4,22004E-04	1730,71	3,83264E-04
1751,07	2,95691E-04	1771,44	3,08072E-04	1791,80	3,51893E-04	1812,16	3,37200E-04
1832,52	3,94981E-04	1852,88	3,94296E-04	1873,24	4,02613E-04	1893,60	3,91051E-04
1913,96	3,44581E-04	1934,33	2,67243E-04	1954,69	3,90024E-04	1975,05	5,18216E-04
1995,41	3,54758E-04	2015,77	4,11753E-04	2036,13	3,50097E-04	2056,49	3,11853E-04
2076,86	3,23379E-04	2117,58	2,26037E-04	2158,30	3,18674E-04	2199,02	3,38442E-04
2239,75	3,29412E-04	2280,47	2,01681E-04	2321,19	2,44511E-04	2361,91	2,10255E-04
2402,64	1,83997E-04	2443,36	1,79595E-04	2484,08	1,29935E-04	2524,80	1,54653E-04
2565,53	1,07521E-04	2606,25	1,94101E-04	2646,97	1,82639E-04	2687,70	3,16199E-04
2728,42	2,37889E-04	2769,14	2,18287E-04	2809,86	1,90877E-04	2850,59	2,39696E-04
2891,31	2,81846E-04	2932,03	2,61382E-04	2972,75	1,52241E-04	3013,48	1,68902E-04
3054,20	1,58617E-04	3094,92	1,91371E-04	3135,64	1,54114E-04	3176,37	1,43980E-04
3217,09	1,30099E-04	3257,81	1,46027E-04	3298,54	1,90429E-04	3339,26	2,19416E-04
3379,98	1,73171E-04	3420,71	1,04777E-04	3461,43	9,08607E-05	3502,15	1,24634E-04
3542,87	1,83320E-04	3583,59	2,13139E-04	3624,32	1,62250E-04	3665,04	7,79366E-05
3705,76	1,14757E-04	3746,48	1,27025E-04	3787,21	1,98803E-04	3827,93	1,34336E-04
3868,65	1,27401E-04	3909,38	1,21937E-04	3950,10	1,32537E-04	3990,82	8,08220E-05
4031,54	9,96838E-05	4072,27	9,24358E-05	4112,99	8,16839E-05	4153,71	9,61565E-05
4235,16	1,60798E-04	4316,60	1,31265E-04	4398,05	1,18650E-04	4479,49	1,09499E-04
4560,94	9,95098E-05	4642,38	6,46207E-05	4723,83	8,48456E-05	4805,27	[illegible],21956E-04
4886,72	1,12628E-04	4968,16	7,73412E-05	5049,61	8,07661E-05	5131,05	1,15869E-04
5212,50	1,32463E-04	5293,95	1,00832E-04	5375,39	6,34863E-05	5456,84	8,49918E-05
5538,28	1,21862E-04	5619,73	8,76122E-05	5701,17	6,63933E-05	5782,62	8,57406E-05
5864,06	1,13949E-04	5945,51	1,25130E-04	6026,95	8,35073E-05	6108,40	7,92900E-05

Figure 7. Printed Results from Routines PLOTPSDF and PLOTPSDA

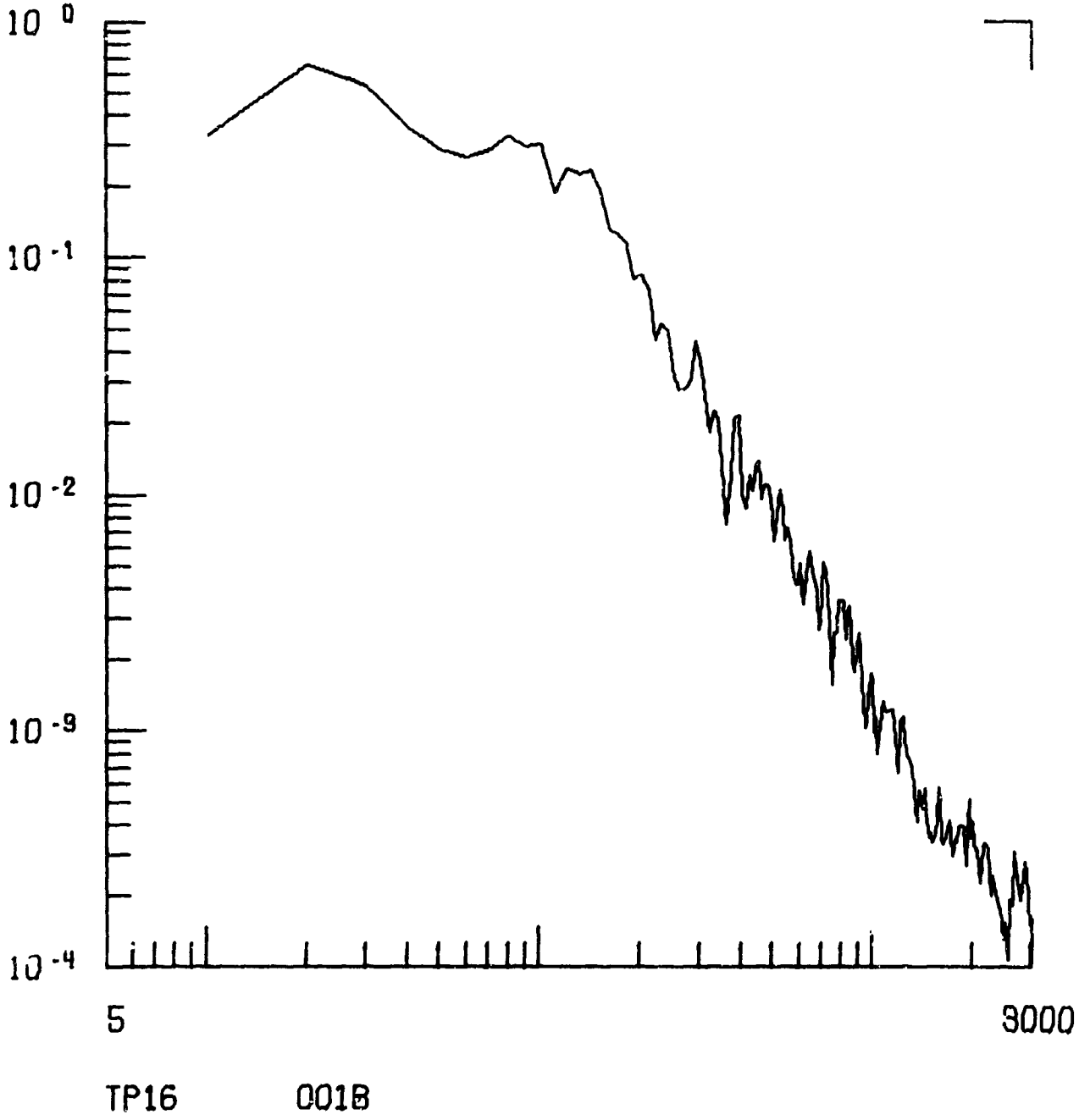

Figure 8. Graphical Output from Program WCP/68-20

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*****************************************************************************

                TEST NUMBER ATF1          CHANNEL NUMBER 002A

     TAPE REEL NUMBER 1,                 LASER DOPPLER DATA,
                      POINT   NUMBER     1

  MEAN =     23.4   STD. DEV =  284.4    SKEWNESS =     -0.00   KURTOSIS =      2.97
        SIGNAL R.M.S. =     2.844                 SENSITIVITY =   100.0

                TEST NUMBER ATF1          CHANNEL NUMBER 004B

     TAPE REEL NUMBER 1,                 LASER DOPPLER DATA,
                      POINT   NUMBER     2

  MEAN =     18.1   STD. DEV = 1141.7    SKEWNESS =     -0.08   KURTOSIS =      3.11
        SIGNAL R.M.S. =    11.417                 SENSITIVITY =   100.0

            64 DEGREES OF FREEDOM,
         NUMBER OF FREQUENCY BANDS =  3
         ANALYSIS BANDWIDTH IN UPPER FREQUENCY BAND = 40.7  HZ

*****************************************************************************
```

Figure 9. Sample Statistical Print-Out from Programs WCP/68-21 and WCP/68-23

TEST NO. ATF1 CROSS PSD CHANNELS 002A AND 004B

FREQ	P.S.D.	PHASE	FREQ	P.S.D.	PHASE	FREQ	P.S.D.	PHASE
5.09	1.02528E-03	5.1	10.18	2.51007E-04	-13.0	15.27	6.33498E-05	-9.3
20.36	2.71709E-04	-20.3	25.45	2.35134E-03	-51.4	30.54	2.99999E-03	-85.8
35.63	3.04118E-03	-125.7	40.72	3.33407E-03	176.4	45.81	3.62688E-03	150.5
50.90	4.32358E-03	76.7	55.99	7.73976E-03	111.5	61.08	3.26748E-03	34.2
66.17	2.78632E-03	7.0	71.26	1.51625E-03	-71.1	76.35	5.00140E-03	172.9
81.45	4.56562E-03	158.8	86.54	3.96024E-03	130.3	91.63	7.68525E-03	141.1
96.72	3.02815E-03	84.4	101.81	4.73465E-03	127.3	106.90	1.83363E-03	114.4
111.99	1.67341E-03	-57.6	117.08	2.16254E-03	9.6	122.17	2.69627E-03	-162.1
127.26	3.54468E-03	123.7	132.35	4.40249E-03	6.5	137.44	1.11496E-02	-7.4
142.53	1.09667E-02	-10.6	147.62	6.92950E-03	-13.0	152.71	2.66286E-03	.2
157.80	7.63152E-04	47.0	162.89	2.92050E-03	-155.6	167.98	6.21812E-03	-136.9
173.07	1.29284E-03	-72.3	178.16	1.31970E-03	177.2	183.25	2.80144E-03	166.1
188.34	9.71314E-04	168.6	193.43	9.07523E-04	14.4	198.52	9.57825E-04	57.8
203.61	1.13520E-03	4.0	208.70	2.04918E-03	172.0	213.79	1.35724E-03	173.9
218.88	4.13765E-04	103.8	223.97	5.73967E-04	-42.8	229.06	7.05877E-04	-65.2
234.16	2.53995E-03	-165.1	239.25	2.58272E-03	-172.9	244.34	1.77704E-03	5.7
249.43	3.89346E-03	-3.0	254.52	3.98940E-03	-31.7	259.61	3.65788E-03	-37.8
264.70	1.07961E-03	-5.7	269.79	1.25608E-03	-161.3	274.88	8.09466E-04	169.8
279.97	1.84814E-03	75.5	285.06	2.19155E-03	38.5	290.15	4.09768E-04	-94.5
295.24	5.40177E-04	147.0	300.33	5.44443E-04	174.4	305.42	6.34729E-04	110.1
310.51	4.55983E-04	96.2	315.60	3.22616E-03	-162.9	320.69	6.34584E-04	176.0
325.78	1.92140E-03	118.7	330.87	2.74124E-03	137.5	335.96	1.94847E-03	-172.2
341.05	1.75322E-03	-148.1	346.14	4.04885E-03	-150.5	351.23	4.11904E-03	-147.8
356.32	3.43525E-04	-94.0	361.41	2.93862E-03	-2.0	366.50	4.17917E-04	-84.5
371.59	2.97240E-03	-19.7	376.68	2.55521E-03	178.3	381.77	1.12955E-02	-174.7
386.87	8.55090E-03	-149.3	391.96	2.53707E-03	-165.3	397.05	5.12192E-03	-157.7
402.14	1.63139E-03	-156.6	407.23	2.12573E-03	-166.4	412.32	3.44616E-03	-157.5
417.41	2.48872E-03	-52.0	422.50	3.66601E-03	-17.5	427.59	4.16530E-04	-101.9
432.68	1.71527E-03	-149.9	437.77	1.66086E-03	154.0	442.86	1.36662E-03	41.7
447.95	2.52524E-03	52.2	453.04	1.23106E-03	-6.1	458.13	1.11563E-03	139.5
463.22	2.73286E-03	132.0	468.31	2.54869E-03	50.7	473.40	2.54313E-03	18.4
478.49	1.11009E-03	104.8	483.58	7.09082E-04	-117.6	488.67	2.65271E-03	-27.7
493.76	9.29854E-04	15.1	498.85	1.34078E-03	-139.3	503.94	1.98043E-03	-12.4
509.03	6.12544E-03	-13.2	514.12	7.00809E-03	-13.8	519.21	2.94694E-03	-6.3
529.39	6.11895E-04	-22.6	539.58	2.11278E-03	154.5	549.76	1.40489E-03	139.7
559.94	2.87820E-03	-36.6	570.12	4.92961E-03	-32.3	580.30	2.27580E-03	-43.9
590.48	2.45820E-03	-139.6	600.66	2.84843E-03	5.4	610.84	7.91308E-03	4.2
621.02	8.22985E-03	-21.1	631.20	4.36092E-03	-128.3	641.38	1.46561E-03	-105.4
651.56	6.76528E-03	-6.8	661.74	2.35337E-03	-28.4	671.92	3.60334E-03	10.0
682.10	2.60333E-03	28.0	692.29	5.79105E-03	58.0	702.47	1.29793E-02	17.3
712.65	4.92466E-03	-17.9	722.83	5.01113E-03	-119.3	733.01	7.43671E-03	-157.2
743.19	4.26860E-04	-152.0	753.37	5.81741E-03	57.2	763.55	1.11515E-02	25.7
773.73	2.51053E-03	-122.2	783.91	7.68959E-03	173.6	794.09	2.80063E-03	115.4
804.27	5.35920E-03	93.4	814.45	1.10380E-02	153.3	824.63	1.27892E-02	132.6
834.81	1.36740E-02	78.9	845.00	6.10094E-03	144.9	855.18	5.60706E-03	122.9
865.36	1.04788E-02	138.3	875.54	2.65939E-02	6.4	885.72	2.92487E-02	1.0
895.90	8.50858E-03	-33.1	906.08	1.79165E-03	-16.8	916.26	5.82670E-03	-101.2
926.44	1.44901E-02	172.0	936.62	1.19946E-02	147.5	946.80	1.19355E-02	159.1
956.98	5.64910E-03	69.2	967.16	4.99363E-03	104.2	977.34	4.42674E-03	169.8
987.52	1.62190E-03	-135.5	997.71	3.08019E-03	82.6	1007.89	8.03796E-03	-4.0
1018.07	4.75735E-03	150.2	1028.25	3.91626E-03	101.8	1038.43	3.82066E-03	-147.0
1058.79	4.26221E-03	-41.2	1079.15	2.26328E-03	2.1	1099.51	5.74626E-03	-129.9
1119.87	7.30945E-03	-22.5	1140.23	5.08067E-03	-41.8	1160.60	2.18820E-03	-118.0
1180.96	4.10854E-03	168.9	1201.32	3.50163E-03	150.9	1221.68	2.25711E-03	140.4
1242.04	1.79769E-03	54.9	1262.40	1.76965E-03	58.3	1282.76	1.68903E-03	53.7

Figure 10. Printed Results from Routines PLTCPSDF and PLTCPSDA

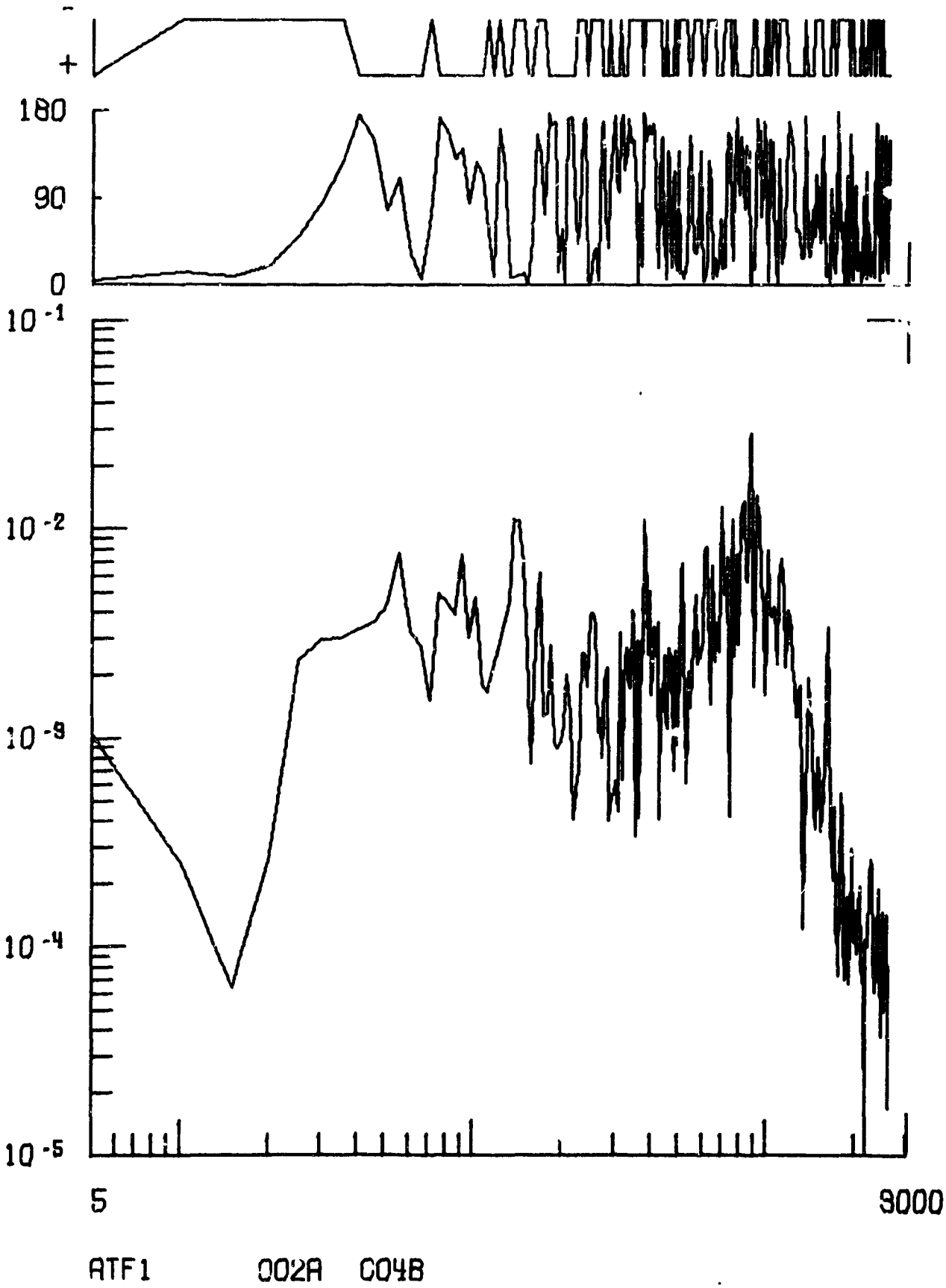

Figure 11. Graphical Output from Programs WCP/68-21 and WCP/68-22

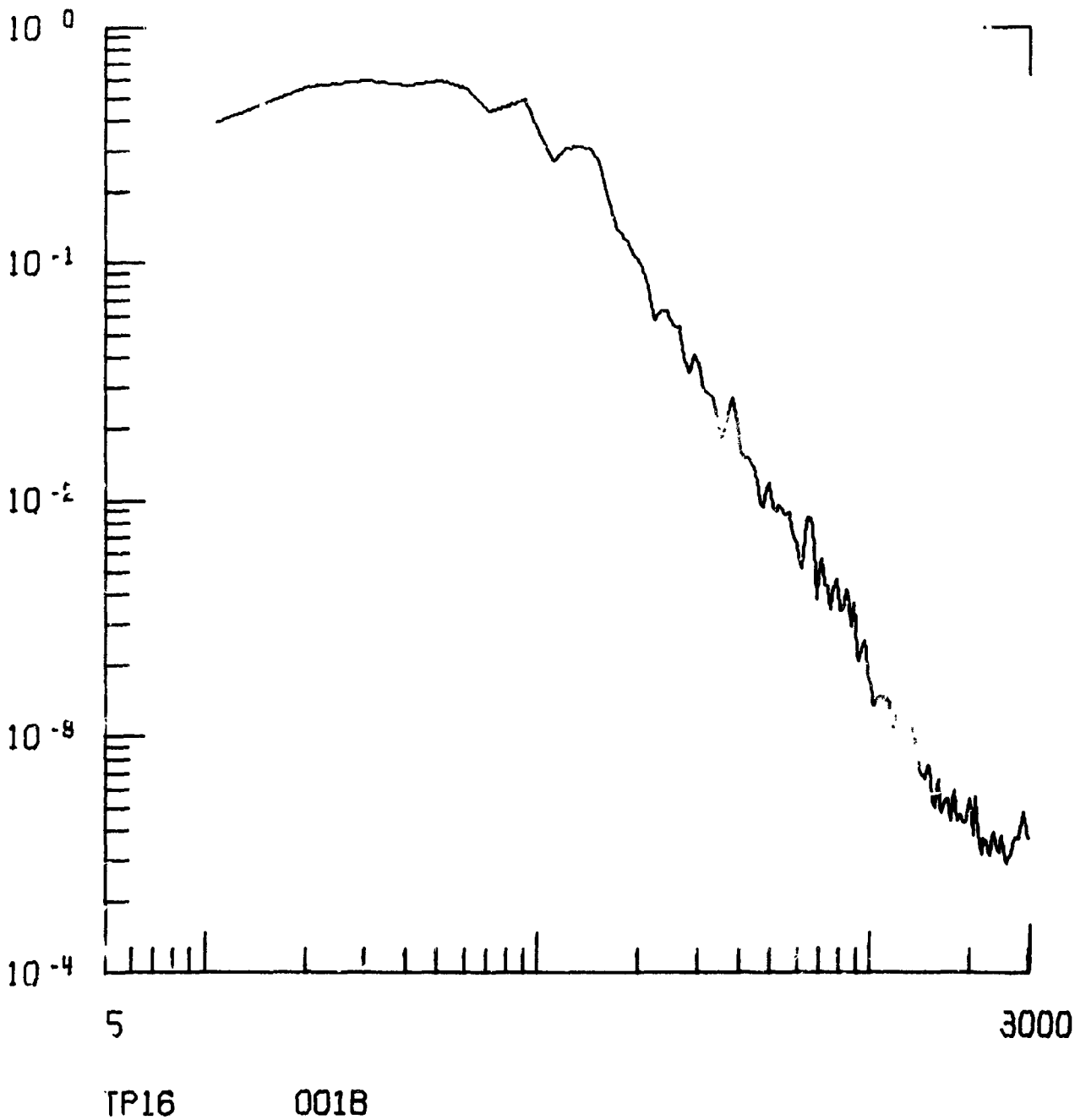

Figure 12. Graphical Output from Program WCP/68-21

APPENDIX A

Listing of Data Demultiplexing Routines

```
      SUBROUTINE DEMUX(N1024R,ISTAT,INCPST)
      COMMON ITEST,ICHAN1,ICHAN2,IHALF,MD(2)
      COMMON ID(13),INF(7),ISTACK,IFILE,IDATA(2000,2),INDD,IREC
      COMMON N1,N2,N3,N4,N5,N6,N7,N8,N9,N10,N11,N12,N13,N14,N15,N16,N17
      COMMON N18,MMM,IG,JG,KG,MCHAN2,I
      COMMON ISAVE(1024,2,2)
      COMMON JS,JJS,KS,MWC,IFLAG(2),IDONE
      DIMENSION IDREC(6)
      EQUIVALENCE ( IDREC(4) , SRATE) ,(IDREC(1),IDATA(2))
      REWIND 3
      REWIND 4
      MCHAN1=AND(ICHAN1,77B)
      MCHAN2=AND(ICHAN2,77B)
      IF(MCHAN1.EQ.4H000A.AND.MCHAN2.EQ.4H000A)100,19
 19   IF(MCHAN1.EQ.4H000A.AND.MCHAN2.EQ.4H000 )100,20
 20   IF(MCHAN1.EQ.4H000B.AND.MCHAN2.EQ.4H000B)110,29
 29   IF(MCHAN1.EQ.4H000B.AND.MCHAN2.EQ.4H000 )110,30
 30   IF(MCHAN1.EQ.4H000A.AND.MCHAN2.EQ.4H000B)500,40
 40   K = ICHAN2
      J = ICHAN1
      LUN = 2
      GO TO 521
 500  K = ICHAN1
      J = ICHAN2
      LUN = 1
 521  IC = 2
      MMM = 1
C
C     SUBROUTINE SCANTAPE SEARCHES REQUIRED MULTIPLEXER TAPE FOR THE
C     BEGINNING OF THE SUMBUX GROUP FOR THAT TEST AND CHANNEL PAIR,
C     ENTRY SEARCH IS  USED FOR ALL SEARCHES OTHER THAN THE FIRST ON
C     THAT MULTIPLEXER
C
      CALL SCANTAPE(K,4H    ,1)
      CALL SCANTAPE(J,4H    ,2)
      GO TO 1130
C
C     CASE OF BOTH CHANNELS ON THE SAME MUX TAPE, OR ONE CHANNEL ONLY
C     M=1, MUXA
C     M=2, MUXB
C
 100  M=1
      GO TO 112
 110  M=2
 112  CALL SCANTAPE(ICHAN1,ICHAN2,M)
C
C     WRITE TITLE ID ON OUTPUT TAPE (LU 3) AND SCRATCH TAPE (LU 4, IF REQUIRED)
C
      IC = 1
 1130 IDREC(3)=ICHAN1
      SRATE=41700.0 / (FLOAT(INF(7)*INF(6)) + 1.0)
      IDREC(6) = 0
      IDREC(1) = ID(11)
      IDREC(2) = ID(13)
      NPE = 0
 1134 BUFFER OUT (3,1)(IDREC(1),IDREC(6))
 1135 GO TO (1135,1137,1137,1136),UNITSTF(3)
 1136 CALL ERRECOV(8,3,NPE,J)
      GO TO (1137,1134),J
 1137 CONTINUE
```

```
      IF(MCHAN2.EQ.4H000 ) 1144,1138
 1138 IDREC(3) = ICHAN2
      NPE = 0
 1139 BUFFER OUT(4,1)(IDREC(1),IDREC(6))
 1140 GO TO (1140,1142,1142,1141),UNITSTF(4)
 1141 CALL ERRECOV(8,4,NPE,J)
      GO TO (1142,1139),J
 1142 CONTINUE
 1144 IDONE=0
 120  IREC=0
C
C     CYCLING INDEXES -
C        N1 = SAMPLES/RECORD INPUT DATA
C        N2 = NUMBER OF CHANNELS IN A SUBMUX GROUP
C        N3 = SAMPLES/CHANNEL/RECORD INPUT DATA
C        N4 = SAMPLE INITIAL INCREMENT FOR CHANNEL 1
C        N5 = SAMPLE INITIAL INCREMENT FOR CHANNEL 2
C        N6 = UPPER LIMIT OF SAMPLE-COUNTING LOOP
C        N7 = SAMPLE ADDRESS FOR CHANNEL 1 SAMPLE
C        N8 = SAMPLE ADDRESS FOR CHANNEL 2 SAMPLE
C
C       N10 = 1 FOR LOWER HALF OF WORD, 0 FOR UPPER ( CHANNEL 1 SAMPLE )
C       N11 = 1 FOR LOWER HALF OF WORD, 0 FOR UPPER ( CHANNEL 2 SAMPLE )
C       N12 = NUMBER OF SAMPLES OUTPUT PER CHANNEL
C       N14 = NUMBER OF INPUT RECORDS ON MUX TAPE
C
C
C       N17 = WORD ADDRESS, CHANNEL 1 SAMPLE
C       N18 = WORD ADDRESS, CHANNEL 2 SAMPLE
C
      CALL CONVERT(ICHAN1,K)
      CALL CONVERT(ICHAN2,J)
      N1=2*INF(4)
      N2=INF(7) - INF(6) + 1
      N3=N1/N2
      N4 = K-INF(6)+2
      N5 = J-INF(6)+2
      N6=N1-N2
      N9 = INF(4)
      N12=N1024R*1024
      N14=(INF(1)*N2)/(2*INF(4))
      IF(N12.GT.INF(1))130,132
 130  WRITE(61,131)N12,N1024R,INF(1)
      N1024R=INF(1)/2048
      WRITE(61,1310)N1024R
 132  IF(INF(4).GT.2000) 133,135
 133  WRITE(61,134) INF(4)
      STOP
 135  MWC=0
      JS=L=1
      IFLAG(1)=IFLAG(2)=0
      GO TO(150,5021) IC
C
C     BUFFER IN FIRST RECORD OF DATA
C
 150  NPE1=0
 151  BUFFER IN(M,1)(IDATA(1,1),IDATA(N9,1))
 152  GO TO (152,160,153,155),UNITSTF(M)
 153  WRITE(61,154)
      STOP
 155  CALL ERRECOV(5,M,NPE1,J)
      GO TO (156,151),J
```

```
 156  IDONE=IDONE+1
      GO TO 150
C
C     FIRST RECORD INPUT - COMMENCE MAIN CYCLE DOUBLE-BUFFERING AND
C     SIMULTANEOUS PROCESSING
C
 160  NPE2=0
 162  BUFFER IN(M,1)(IDATA(1,2),IDATA(N9,2))
      IF(NPE2.EQ.0)163,220
 163  INDD=1
      DO 200 I=0,N6,N2
      N7=N4+I
      N8=N5+I
      N17=N7/2
      N18=N8/2
      N10=AND(N7,1)
      N11=AND(N8,1)
      MWC=MWC+1
      CALL FILLOUT
 200  CONTINUE
C
C     HAVING PROCESSED THE DATA IN BUFFER IDATA(1), AND HAVING PRESENTLY
C     PARTIALLY FILLED ONE HALF OF OUTPUT BUFFER ISAVE, CHECK ON WHETHER
C     THE OTHER HALF HAS BEEN BUFFERED-OUT BUT NOT PARITY CHECKED.
C     IF SO, PERFORM PARITY CHECK AT THIS STAGE.
C
      IF(IFLAG(JJS).EQ.1)205,220
 205  CALL CHECKPAR(3,1,JJS)
      IF(MCHAN2.EQ.4H000 )215,210
 210  CALL CHECKPAR(4,2,JJS)
 215  IFLAG(JJS)=0
C
C     CHECK PARITY OF BUFFER IN TO IDATA(2), BUFFER IN NEXT RECORD TO
C     IDATA(1) WHILST PROCESSING DATA OF IDATA(2)
C
 220  GO TO (220,270,221,240),UNITSTF(M)
 221  WRITE(61,222) IREC,N1024R
      GO TO 610
 240  CALL ERRECOV(07,M,NPE2,J)
      GO TO (250,162)J
 250  CALL PPE(      IACT)
      GO TO (120,260),IACT
 260  NPE2=0
      BUFFER IN(M,1)(IDATA(1,2),IDATA(N9,2))
      GO TO 220
 270  IF (IREC-N1024R)275,271,271
 271  CALL CHECKPAR(3,1,JJS)
      IF (MCHAN2 .EQ. 4H000  )610,273
 273  CALL CHECKPAR(4,2,JJS)
      GO TO 610
 275  NPE1=0
 276  BUFFER IN(M,1)(IDATA(1,1),IDATA(N9,1))
      IF(NPE1.EQ.0) 280,320
 280  INDD=2
      DO 300 I=0,N6,N2
      N7=N4+I
      N8=N5+I
      N17=N7/2
      N18=N8/2
      N10=AND(N7,1)
      N11=AND(N8,1)
      MWC=MWC+1
```

```
      CALL FILLOUT
 300  CONTINUE
      IF(IFLAG(JJS).EQ.1) 305,320
 305  CALL CHECKPAR(3,1,JJS)
      IF(MCHAN2.EQ.4H000 )315,310
 310  CALL CHECKPAR(4,2,JJS)
 315  IFLAG(JJS)=0
C
C     CHECK PARITY OF BUFFER IN TO IDATA(1), AND RETURN TO BEGINNING OF
C     CYCLE TO BUFFER IN NEXT RECORD TO IDATA(2) WHILST PROCESSING THE
C     DATA OF IDATA(1)
C
 320  GO TO (320,370,271,330),UNITSTF(M)
 330  CALL ERRECOV(07,M,NPE1,J)
      GO TO (340,276),J
 340  CALL PPE(      IACT)
      GO TO (120,350),IACT
 350  NPE1=0
      BUFFER IN(M,1)(IDATA(1,1),IDATA(N9,1))
      GO TO 320
 370  IF (IREC-N1024R)160,271,271
C
C     CASE OF TWO CHANNELS REQUIRED ON DIFFERENT MULTIPLEXER TAPES
C
 5021 CONTINUE
C
C     CHANNEL 1 DATA IS ALWAYS OUTPUT ON LU 3
C     CHANNEL 2 DATA IS ALWAYS OUTPUT ON LU 4
C
 550  NPE=0
 551  BUFFER IN(LUN,1)(IDATA(1,1),IDATA(N9,1))
 552  GO TO (552,560,153,554),UNITSTF(LUN)
 554  CALL ERRECOV(05,LUN,NPE,J)
      GO TO (555,551),J
 555  IDONE=IDONE+1
      GO TO 550
 560  GO TO (561,562),MMM
 561  DO 564 I=0,N6,N2
      N7=N4+I
      N17=N7 / 2
      N10 = AND(N7,1)
      MWC=MWC+1
      CALL FILLOUT 2
 564  CONTINUE
      GO TO 5709
 562  DO 565 I=0,N6,N2
      N7=N5+I
      N17=N7 / 2
      N10=AND(N7,1)
      MWC=MWC+1
      CALL FILLOUT 2
 565  CONTINUE
 5709 CONTINUE
      IF (IREC-N1024R)571,600,600
 571  CONTINUE
      NPE=0
 575  BUFFER IN(LUN,1)(IDATA(1,1),IDATA(N9,1))
      IF(NPE.EQ.0)580,585
 580  IF(IFLAG(JJS).EQ.1) 581,585
 581  K = MMM+2
      CALL CHECKPAR(K,1,JJS)
      IFLAG(JJS)=0
```

```
585   GO TO(585,560,609,587),UNITSTF(LUN)
587   CALL ERRECOV(07,LUN,NPE,J)
      GO TO (588,575),J
575   CALL PPE(      IACT)
      GO TO (589,590),IACT
589   NWC=0
      IFLAG(1)=IFLAG(2)=0
      JS=1
      IREC=0
      GO TO 550
590   NPE=0
      BUFFER IN(LUN,1)(IDATA(1,1),IDATA(N9,1))
      GO TO 585
600   IF(MMM.EQ.1)601,608
601   LUN = EOR(LUN,3)
      CALL CHECKPAR(3,1,JJS)
      IFLAG(1) = IFLAG(2) = 0
      JS = 1
      MMM=2
      IREC=0
      IDONE=0
      NWC=0
      GO TO 550
609   GO TO (601,608), MMM
C
C     THE DEMULTIPLEXING IS COMPLETE, WITH CHANNEL 1 STORED ON LUN 3
C     (OUTPUT TAPE)                    AND CHANNEL 2 (IF USED) ON LUN 4
C     (SCRATCH TAPE), ALL IN 1024-WORD RECORDS
C
608   CALL CHECKPAR(4,1,JJS)
610   N12 = 1024*IREC
      ENDFILE 3
      ENDFILE 4
      REWIND 3
      REWIND 4
C
C     STATISTICS OPTION, CALLED IF REQUIRED FROM OPTION PARAMETER
C
C     ISTAT = 0, STATISTICS NOT REQUIRED
C     ISTAT = 1, FOUR STATISTICAL MOMENTS (BOTH CHANNELS) ONLY
C     ISTAT = 2, DITTO. PLUS AMPLITUDE DISTRIBUTION PLOTS
C
C     INCRST IS PARAMETER CONTROLLING THE SIGNAL INCREMENTS FOR THE
C     AMPLITUDE(AND CROSS AMPLITUDE)HISTOGRAMS.  IT IS EXPRESSED DIRECTLY
C     IN MILLIVOLTS, AND SHOULD BE NOT LESS THAN 80 MV NOR GREATER THAN
C     4095 MV
C
      IF(ISTAT.GE.1)650,015
650   CALL STATIST(ISTAT,INCRST)
 15   RETURN
C
C     FORMAT STATEMENTS
C
131   FORMAT(//,36H NUMBER OF OUTPUT SAMPLES CALLED FOR,I10,5X,1H(,I3,2X
     *36HRECORDS), EXCEEDS NUMBER AVAILABLE -,I10)
134   FORMAT(///,30X,20HWORDS/INPUT RECORD -,I5,3X,14H- EXCEEDS 2000)
154   FORMAT (/// 10X 45HEND OF FILE DETECTED WHILST READING DATA TAPE)
222   FORMAT(///,10X,15HDATA ENDS AFTER,I5,3X, 8HRECORDS ,        I5,3X,
     118HRECORDS CALLED FOR,//)
1310  FORMAT(/,I8,2X,22HRECORDS WILL BE OUTPUT)
      END
```

```
      SUBROUTINE FILLOUT
C
C     SUBROUTINE SELECTS THE REQUIRED SAMPLES FROM THE BUFFER (USING
C     SUBR. GAUL2 TO UNPACK THE 24-BIT WORDS), HANDLING ONE SAMPLE
C     PER CALL. SAMPLES ARE MULTIPLIED BY TWO TO CONVERT TO MILLIVOLTS
C     AND ARE STORED IN ARRAY ISAVE.
C     WHEN A 1024-WORD SECTOR OF ISAVE IS FULL, IT IS BUFFERED OUT TO THE
C     REQUIRED TAPE UNIT
C
C     OUTPUT LOGICAL UNIT NUMBERS
C        LU 3  -  OUTPUT TAPE ALWAYS FOR CHANNEL 1
C        LU 4  -  SCRATCH TAPE ALWAYS FOR CHANNEL 2
C
      COMMON IDUMMY(28)
      COMMON IDATA(2000,2),INDD,IREC,N1,N2,N3,N4,N5,N6,N7,N8,N9,N10,N11
      COMMON N12,N13,N14,N15,N16,N17,N18,        MMM,IG,JG,KG,MCHAN2
      COMMON I,ISAVE(1024,2,2),JS,JJS,KS,MWC,IFLAG(2),IDONE
      IG=IDATA(N17,INDD)
      CALL GAUL2
      IF(N10) 90,50,90
   50 ISAVE(MWC,1,JS)=2*JG
      GO TO 100
   90 ISAVE(MWC,1,JS)=2*KG
  100 IF(MCHAN2.EQ.4H000 ) 260,110
  110 IG=IDATA(N18,INDD)
      CALL GAUL2
      IF(N11) 150,120,150
  120 ISAVE(MWC,2,JS)=2*JG
      GO TO 260
  150 ISAVE(MWC,2,JS)=2*KG
  260 IF(MWC.EQ.1024)262,261
  261 RETURN
C
C     TWO 1024-WORD SECTORS OF ISAVE ARE FULL. ONE FOR EACH CHANNEL.
C     THESE WILL BE BUFFERED OUT WHILST THE OTHER TWO 1024-WORD SECTORS
C     ARE BEING FILLED (DOUBLE-DOUBLE BUFFERING). PROVIDED THE LAST
C     BUFFERING OUT OPERATION FROM THESE LATTER TWO SECTORS HAS BEEN
C     PARITY-CHECKED. IF THIS HAS NOT BEEN DONE, CHECK PARITY AT THIS
C     STAGE.
C
  262 JJS=JS
      JS=ECR(JS,3)
      MWC=0
      IF(IFLAG(JS).EQ.0)270,300
  270 BUFFER OUT(3,1)(ISAVE(1,1,JJS),ISAVE(1024,1,JJS))
      IF(MCHAN2.EQ.4H000 )290,280
  280 BUFFER OUT(4,1)(ISAVE(1,2,JJS),ISAVE(1024,2,JJS))
  290 IFLAG(JJS)=1
      IREC=IREC+1
      RETURN
  300 CALL CHECKPAR(3,1,JS)
      IF(MCHAN2.EQ.4H000 )310,305
  305 CALL CHECKPAR(4,2,JS)
  310 IFLAG(JS)=0
      GO TO 270
      ENTRY FILLOUT2
C
C     ENTRY FILLOUT2 FOR THE CASE OF TWO CHANNELS ON SEPARATE MUX TAPES
C
      IG=IDATA(N17,1)
```

```
      CALL GAUL2
      IF(N10) 510,500,510
500   ISAVE(MWC,1,JS)=2*JG
      GO TO 520
510   ISAVE(MWC,1,JS)=2*KG
520   IF(MWC.EQ.1024)521,261
521   JJS=JS
      JS=ECR(JS,3)
      MWC=0
      IF(IFLAG(JS).EQ.1)530,540
530   LLUN1=MMM+2
535   BUFFER OUT(LLUN1,1)(ISAVE(1,1,JJS),ISAVE(1024,1,JJS))
      IFLAG(JJS)=1
      IREC=IREC+1
      RETURN
540   LLUN1=MMM+2
      CALL CHECKPAR(LLUN1,1,JS)
      IFLAG(JS)=0
      GO TO 535
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR FILLOUT

NO ERRORS

```
      SUBROUTINE STATIST(IST,INC)
C
C     STATISTICS OPTION, CALLED IF REQUIRED FROM OPTION CARD
C
C     ISTAT=0, STATISTICS NOT REQUIRED
C     ISTAT = 1, FOUR STATISTICAL MOMENTS (BOTH CHANNELS) ONLY
C     ISTAT = 2, DITTO, PLUS AMPLITUDE DISTRIBUTION PLOTS
C
C     INCRST IS PARAMETER CONTROLLING THE SIGNAL INCREMENTS FOR THE
C     AMPLITUDE(AND CROSS AMPLITUDE)HISTOGRAMS.  IT IS EXPRESSED DIRECTLY
C     IN MILLIVOLTS, AND SHOULD BE NOT LESS THAN 80 MV NOR GREATER THAN
C     4095 MV
C
C     STATISTICAL COMPUTATIONS ARE CARRIED OUT IN 48-BIT FLOATING-POINT
C
      COMMON ITEST,ICHAN1,ICHAN2,              IHALF,JDUMMY(24)
      COMMON IBUF(1024,2),KDUMMY(1953),IREC,N1,N2,N3,N4,N5,N6,N7,N8,N9
      COMMON N10,N11,N12,N13,N14,N15,N16,N17,N18,          LDUMMY(4)
      COMMON MCHAN2,I,IA(2,103)
      COMMON /DATA/ IWT(6),M,NOCT,NREC,SS(2)
      WRITE (61,4)
    4 FORMAT (//X 80(1H*))
      DO 5 K=1,103
      DO 5 KK=1,2
    5 IA(KK,K) = 0
      IF(INC.NE.0)9,30
    9 IHALF=4095/INC+1
      IF(INC.LT.80.OR.INC.GT.4095)10,30
   10 WRITE(61,11)INC
      INC=0
   30 LUN=3
      ICH=1
   31  SUMX= SUMX2= SUMX3= SUMX4=0.0
      BUFFER IN(LUN,1) (IBUF(1),IBUF(2))
      NSAMP=N12
   40 NPE1=0
   41 BUFFER IN(LUN,1)(IBUF(1,1),IBUF(1024,1))
   42 GO TO (42,46,43,44) UNITSTF(LUN)
   43 STOP
   44 CALL ERRECOV(09,LUN,NPE1,J)
      GO TO (45,41),J
   45 NSAMP=NSAMP-1024
      GO TO 40
C
C     CONSIDER DATA ONE CHANNEL AT A TIME
C     FIRST PASS - COMPUTE MEAN MV SIGNAL AND, IF AMPLITUDE DISTRIBUTION
C     IS REQUIRED, LOAD ARRAY IA WITH THE STATISTICAL FREQUENCIES OF THE
C     MILLIVOLT INCREMENTS INC, FOR CHANNEL 1
C
   46 NPE2=0
   47 BUFFER IN(LUN,1)(IBUF(1,2),IBUF(1024,2))
      IF(NPE2.EQ.0)48,80
   48 INDBUF=1
   50 DO 70 I=1,1024
      X=FLOAT(IBUF(I,INDBUF))
      X2=X*X
      X3=X2*X
      X4=X3*X
      SUMX=SUMX + X
      SUMX2=SUMX2 + X2
```

```
      SUMX3=SUMX3 + X3
      SUMX4=SUMX4 + X4
      IF(IST.GE.2.AND.INC.NE.0)51,70
 51   IF(X.GT.0.0) 52,53
 52   INDA=IHALF+(IBUF(I,INDBUF)/INC+1)
      GO TO 55
 53   INDA=IHALF  -(IABS(IBUF(I,INDBUF))/INC)
 55   IA(ICH,INDA)=IA(ICH,INDA)+1
 70   CONTINUE
      IF(INDBUF.EQ.1)80,86
 80   GO TO (80,83,99,81),UNITSTF(LUN)
 81   CALL ERRECOV(10,LUN,NPE2,J)
      GO TO (82,47),J
 82   NSAMP=NSAMP-1024
      NPE2=0
      BUFFER IN(LUN,1)(IBUF(1,2),IBUF(1024,2))
      GO TO 80
 83   NPE1=0
 84   BUFFER IN(LUN,1)(IBUF(1,1),IBUF(1024,1))
      IF(NPE1.EQ.0)85,86
 85   INDBUF=2
      GO TO 50
 86   GO TO (86,46,99,87),UNITSTF(LUN)
 87   CALL ERRECOV(10,LUN,NPE1,J)
      GO TO (88,84),J
 88   NSAMP=NSAMP-1024
      NPE1=0
      BUFFER IN(LUN,1)(IBUF(1,1),IBUF(1024,1))
      GO TO 86
C
C     FIRST PASS COMPLETE,  COMPUTE STATISTICAL MOMENTS, AND RETURN FOR
C     SECOND PASS FOR CHANNEL 2 IF REQUIRED.
C
C     FIRST STATISTICAL MOMENT     (SM1)  = MEAN
C     SECOND STATISTICAL MOMENT    (SM2)  = SAMPLE VARIANCE
C     THIRD STATISTICAL MOMENT     (SM3)  = SAMPLE SKEWNESS
C     FOURTH STATISTICAL MOMENT    (SM4)  = SAMPLE KURTOSIS
C     STANDARD DEVIATION          (SDEV)  = SQRT(VARIANCE)
C
 99   ENN = FLOAT(NSAMP)
      SM1 = SUMX / ENN
      SM2 = SUMX2/ENN - (SUMX/ENN)**2
      IF(SM2.LE.0.001) 100,101
 100  SDEV=0.0
      SM3=0.0
      SM4=0.0
      GO TO 102
 101  SDEV=SQRT(SM2)
      SM3=(SUMX3-3.0*SUMX2*SUMX/ENN+3.0*SUMX*SUMX*SUMX/(ENN*ENN)-SUMX*
     *SUMX*SUMX/(ENN*ENN))/(SDEV*SM2*ENN)
      SM4=(SUMX4-4.0*SUMX3*SUMX/ENN+6.0*SUMX2*SUMX*SUMX/(ENN*ENN)-4.0*
     *SUMX*SUMX*SUMX*SUMX/(ENN*ENN*ENN)+SUMX*SUMX*SUMX*SUMX/(ENN*ENN*ENN
     *))/(SM2*SM2*ENN)
 102  CONTINUE
      NPF1 = LUN-2
      SM2 = SDEV/SS(NPF1)
      IF(LUN.EQ.3)170,175                                                  ********
 170  K = ICHAN1
      GO TO 177
 175  K = ICHAN2
 177  WRITE (61,171) ITEST,K
      DO 250 K=1,3
```

```
      READ (60,260) (IBUF(I),I=1,20)
      WRITE (61,261) (IBUF(I),I=1,20)
250   CONTINUE
      WRITE (61,270) SM1,SDEV,SM3,SM4,SM2,SS(NPE1)
171   FORMAT (1H0, 16X 11HTEST NUMBER, X A4, 10X 14HCHANNEL NUMBER,XA4/)
260   FORMAT (20A4)
261   FORMAT (2X 20A4)
270   FORMAT (1H0, 2X 7HMEAN = , F7.1, 3X 11HSTD. DEV = , F6.1, 3X
     111HSKEWNESS = , F6.2, 3X 11HKURTOSIS = , F8.2, /
     210X 16HSIGNAL R.M.S. = , F8.3, 15X 14HSENSITIVITY = , F7.1)
      IF (LUN-4)178,176,178
178   IF(MCHAN2.EQ.4H000 )176,172
172   LUN=4                                                          ********
      ICH=2
      GO TO 31
C
C     STATISTICAL MOMENTS HAVE BEEN COMPUTED AND OUTPUT FOR BOTH CHANNELS
C     NOW PREPARE AND OUTPUT HISTOGRAMS OF AMPLITUDE DISTRIBUTION
C
176   GO TO (200,201),IST
200   REWIND 3
      REWIND 4
      RETURN
201   IF(INC.EQ.0)200,202
202   CALL HISTOGRM(1,INC)
      IF(MCHAN2.EQ.4H000 )200,203
203   CALL HISTOGRM(2,INC)
      RETURN
11    FORMAT(//,10X,24HINCREMENT INVALID, INC =,I5,5X,13HNO HISTOGRAMS)
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR STATIST

NO ERRORS

```
      SUBROUTINE SCANTAPE(ICHAN1,ICHAN2,M)
C
C     SUBROUTINE SCANTAPE SEARCHES REQUIRED MILTIPLEXER TAPE FOR THE
C     BEGINNING OF THE SUBMUX GROUP FOR THAT TEST AND CHANNEL PAIR.
C     ENTRY SEARCH IS  USED FOR ALL SEARCHES OTHER THAN THE FIRST ON
C     THAT MULTIPLEXER
C
      COMMON ITEST,IDUM(3),MD(2)
      COMMON ID(13),INF(7),ISTACK,IFILE
      COMMON JDUMMY(8131)
      DIMENSION IFILKP(2)     ,JDUM(2)
      CALL CONVERT(ICHAN1,JCHAN1)
      CALL CONVERT(ICHAN2,JCHAN2)
      IF(MD(M)) 69,5,69
    5 MD(M)=1
      IFILKP(M)=IFILE
      NPE=0
   10 BUFFER IN(M,0)(ID(1),ID(11))
   11 GO TO (11,14,12,13),UNITSTF(M)
   12 WRITE(61,112)M
      STOP
   13 CALL ERRECOV(1,M,NPE,J)
      GO TO (14,10),J
   14 NPE=0
   15 BUFFER IN(M,1)(INF(1),INF(5))
   17 GO TO (17,19,12,18),UNITSTF(M)
   18 CALL ERRECOV(2,M,NPE,J)
      GO TO (19,16),J
   19 NPE=0
   20 BUFFER IN(M,0)(ID(12),ID(13))
   21 GO TO (21,23,12,22),UNITSTF(M)
   22 CALL ERRECOV(3,M,NPE,J)
      GO TO (23,20),J
   23 GO TO (24,26),M
   24 IF(ID(12).EQ.4HMUXA)27,25
   25 WRITE(61,125)ID(12)
      STOP
   26 IF(ID(12).EQ.4HMUXB)27,25
   27 NPE=0
      BUFFER IN(M,1)(INF(6),INF(7))
   28 GO TO (28,12,29,12),UNITSTF(M)
   29 BUFFER IN(M,1)(INF(6),INF(7))
   30 GO TO (30,32,12,31),UNITSTF(M)
   31 CALL ERRECOV(4,M,NPE,J)
      GO TO (32,29),J
   32 IF(ITEST.EQ.ID(11))40,33
   33 WRITE(61,133)ID(11)
      STOP
C
C     CHECK WHETHER TESTS ARE STACKED OR NON-STACKED ON TAPE
C     ISTACK = 1, NON-STACKED
C     ISTACK = 2, STACKED
C
   40 GO TO (41,60),ISTACK
C
C     CASE OF NON-STACKED JOBS
C
   41 IF(JCHAN1.GE.INF(6).AND.JCHAN1.LE.INF(7))42,44
   42 IF(JCHAN2.GE.INF(6).AND.JCHAN2.LE.INF(7))40,43
   43 IF(JCHAN2.EQ.0)40,44
```

```
 44    CALL SKIPEOF(M)
       NPE=0
 45    BUFFER IN(M,1)(INF(6),INF(7))
 46    GO TO (46,41,47,48),UNITSTF(M)
  47   WRITE(61,147)
       STOP
 48    CALL ERRECOV(4,M,NPE,J)
       GO TO (41,45),J
C
C      RETURN WHEN TAPE IS RUN ON TO THE BEGINNING OF THE REQUIRED GROUP
C
  49   RETURN
C
C      CASE OF STACKED JOBS
C
 60    IF(IFILE.EQ.1)66,61
 61    IFILE1=IFILE-1
       DO 62 I=1,IFILE1
       BUFFER IN(M,1) (INF(6),INF(7))
       CALL SKIPEOF(M)
 62    CONTINUE
       NPE=0
 63    BUFFER IN(M,1)(INF(6),INF(7))
 64    GO TO (64,66,12,65),UNITSTF(M)
 65    CALL ERRECOV(4,M,NPE,J)
       GO TO (66,63),J
 66    IF(JCHAN1.GE.INF(6).AND.JCHAN1.LE.INF(7))67,47
 67    IF(JCHAN2.GE.INF(6).AND.JCHAN2.LE.INF(7))49,68
 68    IF(JCHAN2.EQ.0)49,47
C
C      ENTRY SEARCH
C
C      ENTRY SEARCH - FOR SEARCHES OTHER THAN THE FIRST ONE ON THAT MUX TAPE
C
  69   GO TO (200,250),ISTACK
C
C      CASE OF NON-STACKED JOBS
C      FIRST CHECK IF THE REQUIRED CHANNELS ARE IN THE SAME SUBMUX GROUP AS
C      THAT LAST PROCESSED
C
 200   IF(JCHAN1.GE.INF(6).AND.JCHAN1.LE.INF(7))201,203
 201   IF(JCHAN2.GE.INF(6).AND.JCHAN2.LE.INF(7))2060,202
 202   IF(JCHAN2.EQ.0)2060,203
 203   IF(JCHAN1.LT.INF(6).AND.JCHAN2.LT.INF(6))212,204
 204   IF(JCHAN1.GT.INF(7).AND.JCHAN2.GT.INF(7))207,205
 205   IF(JCHAN1.GT.INF(7).AND.JCHAN2.EQ.0)207,206
 206   WRITE(61,1206)
       STOP
 2060  CALL BACKSKIP(M)
       BUFFER IN(M,1)(JDUM(1),JDUM(2))
 2062  GO TO (2062,49,12,49),UNITSTF(M)
C
C      REQUIRED GROUP IS FURTHER ALONG THE TAPE
C
 207   CALL SKIPEOF(M)
       NPE=0
 208   BUFFER IN(M,1)(INF(6),INF(7))
 209   GO TO (209,41,47,210),UNITSTF(M)
 210   CALL ERRECOV(4,M,NPE,J)


       GO TO (41,208),J
```

```
C
C       REQUIRED GROUP IS BACK ALONG THE TAPE
C
 212    CALL BACKSKIP(M)
 2120   CALL BACKSKIP(M)
        NPE=0
 213    BUFFER IN(M,1)(INF(6),INF(7))
 214    GO TO (214,216,12,215),UNITSTF(M)
 215    CALL ERRECOV(4,M,NPE,J)
        GO TO (216,213),J
 216    IF(JCHAN1.GE.INF(6).AND.JCHAN1.LE.INF(7))217,2120
 217    IF(JCHAN2.GE.INF(6).AND.JCHAN2.LE.INF(7))49,218
 218    IF(JCHAN2.EQ.0)49,206
C
C       CASE OF STACKED JOBS
C
  250   IF(IFILE = IFILKP(M)) 251,2500,255
C
C       REQUIRED FILE IS THE ONE PROCESSED LAST TIME
C
 2500   CALL BACKSKIP(M)
        BUFFER IN (M,1)(JDUM(1),JDUM(2))
 2501   GO TO (2501,66,12,66),UNITSTF(M)
C
C       REQUIRED FILE IS BACK ALONG THE TAPE
C
 251    IFILE1=IFILKP(M)-IFILE+1
        DO 252 I=1,IFILE1
        CALL BACKSKIP(M)
 252    CONTINUE
        NPE=0
        IFILKP(M)=IFILE
        GO TO 63
C
C       REQUIRED FILE IS FURTHER ALONG THE TAPE
C
 255    IFILE1=IFILE-IFILKP(M)
        DO 256 I = 1,IFILE1
        BUFFER IN(M,1) (INF(6),INF(7))
        CALL SKIPEOF(M)
 256    CONTINUE
        IFILKP(M)=IFILE
        NPE=0
        GO TO 63
 [illegible]3  FORMAT(///,10X,31HMISPLACED EOF ON INPUT TAPE LUN,I5)
 [illegible]   FORMAT(///,10X,26HWRONG TAPE, ID(12) READ AS,4X,A4)
 133    FORMAT(///,10X,26HWRONG TAPE, ID(11) READ AS,4X,A4)
 147    FORMAT(///,10X,45HCHANNELS NOT PRESENT OR INCORRECTLY SPECIFIED)
 1206   FORMAT(///,10X,43HSOMETHING WRONG WITH CHANNEL SPECIFICATIONS)
        END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR SCANTAPE

NO ERRORS

```
      SUBROUTINE ERRECOV(LABEL,LUN,NPE,J)
      COMMON IDUMMY(4029),IREC
      NPE=NPE+1
      IF(NPE.LE.5)10,20
10    BACKSPACE LUN
      J=2
      RETURN
20    J=1
      WRITE(61,21)
      GO TO (30,32,34,36,38,40,42,44,46,48),LABEL
30    WRITE(61,31)LUN
      RETURN
32    WRITE(61,33)LUN
      RETURN
34    WRITE(61,35)LUN
      RETURN
36    WRITE(61,37)LUN
      RETURN
38    WRITE(61,39)LUN
      RETURN
40    WRITE(61,41)LUN
      RETURN
 42   WRITE(61,43)IREC,LUN
      RETURN
44    WRITE(61,45)LUN
      RETURN
46    WRITE(61,47)LUN
      RETURN
 48   WRITE(61,49)LUN
      RETURN
21    FORMAT(//,10X,32HPERSISTENT PARITY ERROR   ******)
31    FORMAT(10X,36HBUFFERING-IN 1ST TITLE RECORD ON LUN,I5,//)          LABEL  1
33    FORMAT(10X,36HBUFFERING-IN 2ND TITLE RECORD ON LUN,I5,//)          LABEL  2
35    FORMAT(10X,36HBUFFERING-IN 3RD TITLE RECORD ON LUN,I5,//)          LABEL  3
37    FORMAT(10X,37HBUFFERING-IN CHANNEL ID RECORD ON LUN,I5,//)         LABEL  4
 39   FORMAT(10X,36HBUFFERING-IN FIRST DATA RECORD ON LU,I5,3X,7HRESTARTLABEL  5
     1)
 41   FORMAT(10X,19HBUFFERING-OUT ON LU,I5,5X,14HSTOPSIX CALLED)        LABEL  6
 43   FORMAT(10X,38HBUFFERING-IN, MAIN CYCLE, INPUT RECORD,I5,5X,2HLU,  LABEL  7
     1I5)
 45   FORMAT(10X,30HBUFFERING-OUT TITLE ID ONTO LU,I5)                   LABEL  8
 47   FORMAT(10X,49HBUFFERING-IN 1ST RECORD 1ST PASS STATISTICS ON LU,  LABEL  9
     1I5)
 49   FORMAT(10X,49HBUFFERING-IN MAIN CYCLE 1ST PASS STATISTICS ON LU,  LABEL 10
     1I5)
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR ERRECOV

NO ERRORS

```
      SUBROUTINE CHECKPAR(LUN,IS1,IS2)
C
C     SUBROUTINE CHECKS PARITY OF LAST BUFFER-OUT OPERATION ON LOGICAL
C     UNIT LUN OF THE ARRAY ISAVE(1-1024,IS1,IS2)
C
      COMMON IDUMMY(4054)
      COMMON ISAVE(1024,2,2)
      NPE=0
   10 GO TO (10,17,11,12),UNITSTF(LUN)
   11 STOP 11
   12 CALL ERRECOV(06,LUN,NPE,J)
      GO TO (14,13),J
   13 BUFFER OUT(LUN,1)(ISAVE(1,IS1,IS2),ISAVE(1024,IS1,IS2))
      GO TO 10
   14 CALL SKIPSIX(LUN)
      NPE=0
      GO TO 13
   17 RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR CHECKPAR

NO ERRORS

```
      SUBROUTINE PPE(     IACT)
C
C     THIS SUBROUTINE HANDLES THE CASE OF A PERSISTENT PARITY ERROR WHILST
C     BUFFERING IN FROM THE MUX TAPE. THE NUMBER OF RECORDS SO FAR PROCESSED
C     IS IREC, AND IDONE RECORDS HAVE PREVIOUSLY BEEN ABANDONNED. N10 IS THE
C     TOTAL NUMBER OF RECORDS AVAILABLE ON THE INPUT TAPE, AND N14 IS THE
C     NUMBER OF RECORDS WHICH NEED PROCESSING. THE SUBROUTINE RETURNS
C     IACT=1 IF THERE IS ENOUGH DATA TO RESTART AND IACT=2 IF THERE IS NOT.
C
      COMMON IDUMMY(4029)
      COMMON IREC,N1,N2,N3,N4,N5,N6,N7,N8,N9,N10,N11,N12,N13,N14,N15,N16
      COMMON N17,N18,N19,N20,JDUMMY(4),MCHAN2
      COMMON KDUMMY(4103)
      COMMON IDONE
      DIMENSION IDUM(6)
      IF((N14-IDONE-IREC).GT.N13)20,30
 20   WRITE(61,21)
      REWIND 3
      BUFFER IN(3,1) (IDUMMY(2089),IDUMMY(2095))
      IF(MCHAN2.EQ.4H000 .OR.MCHAN2.EQ.1) 23,221
 221  REWIND 4
      BUFFER IN(4,1) (IDUMMY(2089),IDUMMY(2095))
 23   IACT=1
      IDONE=IDONE+IREC
      IREC=0
      RETURN
 30   WRITE(61,31)
      IREC=IREC-1
      IACT=2
      RETURN
 21   FORMAT(//,10X,39HPPE CALLED, ENOUGH DATA LEFT TO RESTART)
 31   FORMAT(//,10X,66HPPE CALLED, INSUFFICIENT DATA TO RESTART, OMIT RE
     1CORD AND CONTINUE)
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PPE

NO ERRORS

APPENDIX B

Listing of Low Pass Filtering Routines

```
      SUBROUTINE LPFILT(LUN)
C ***
C     THIS ROUTINE CARRIES OUT LOW PASS DIGITAL FILTERING WITH CUT-OFF FREQUENCY
C     1/2 THE MAXIMUM FREQUENCY CONTAINED IN THE DATA. INPUT DATA IS STORED ON
C     LOGICAL UNIT LUN AND IS OVERWRITTEN BY THE FILTERED DATA ON EXIT, WHICH IS
C     CALCULATED FOR EVERY 2 ITH POINT OF THE INPUT DATA.
C ***
      COMMON IDUM(2088),N(6),IDATA(2000,2),N7,N8,N9,N10,N11,N12,
     1N13,N14,NDSH(7),I,ISAVE(1024),T1
      COMMON /DATA/ IWT(6)
C ***
C     ENTRY POINT FOR CALCULATION OF FILTER WEIGHTS.
C ***
      T2 = SQRT(6.2831853)
      IWT(6) = IFIX(2.0**23/T2)
      DO 10 I=1,5
      T1=FLOAT(11-2*I)
      T1 = (1.0+COS(T1*0.314159265))/(T1*T2)
 10   IWT(I)=IFIX(T1*2.0**22)
      IWT(2)=-IWT(2)
      IWT(4)=-IWT(4)
      RETURN
C ***
C     THIS ENTRY POINT CARRIES OUT THE FILTERING PROCESS FOR AN EVEN NUMBER OF
C     RECORDS OF 1024 24 BIT INTEGERS HELD ON LOGICAL UNIT LUN.
C ***
      ENTRY CUTOFF
      REWIND 51
      REWIND LUN
      BUFFER IN(LUN,1)(N(1),N(6))
      DO 20 I=1,9
 20   IDATA(I,1)=0
      BUFFER IN(LUN,1)(IDATA(11,1),IDATA(1034,1))
      N12=0
 160  BUFFER IN(LUN,1)(IDATA(11,2),IDATA(1034,2))
      CALL LOOP(1,507,0)
      DO 30 I=1,10
 30   IDATA(I,2)=IDATA(I+1024,1)
      N8=1
 40   GO TO (40,50,60,70)UNITSTF(LUN)
 60   N12=1
 50   DO 80 I=1,10
 80   IDATA(I+1034,1)=IDATA(I+10,2)
      CALL LOOP(508,512,0)
      IF(N12)350,90,350
 90   BUFFER IN(LUN,1)(IDATA(11,1),IDATA(1034,1))
 350  CALL LOOP(513,1019,1)
      DO 100 I=1,10
 100  IDATA(I,1)=IDATA(I+1024,2)
      N8=2
 120  GO TO (120,130,140,70)UNITSTF(LUN)
 140  N12 = 1
 130  DO 110 I=1,10
 110  IDATA(I+1034,2)=IDATA(I,1)
      CALL LOOP(1020,1024,1)
 190  BUFFER OUT(51,1)(ISAVE(1),ISAVE(1024))
 150  GO TO (150,360,360,210)UNITSTF(51)
 210  CALL ERROUT(51,ISAVE(1))
      GO TO 190
 360  IF(N12)170,160,170
```

```
170   ENDFILE 51
      REWIND 51
      REWIND LUN
      BUFFER IN(51,1)(IDATA(1,1),IDATA(1024,1))
      BUFFER IN(LUN,1)(N(1),N(6))
220   BUFFER IN(51,1)(IDATA(1,2),IDATA(1024,2))
      BUFFER OUT(LUN,1)(IDATA(1,1),IDATA(1024,1))
240   GO TO (240,270,230,280)UNITSTF(51)
270   GO TO (270,300,300,290)UNITSTF(LUN)
290   CALL ERROUT(LUN,IDATA(1,1))
300   BUFFER IN(51,1)(IDATA(1,1),IDATA(1024,1))
      BUFFER OUT(LUN,1) (IDATA(1,2),IDATA(1024,2))
310   GO TO (310,330,230,280)UNITSTF(51)
330   GO TO (330,220,220,340)UNITSTF(LUN)
340   CALL ERROUT(LUN,IDATA(1,2))
      GO TO 220
230   ENDFILE LUN
      RETURN
280   LUN = 51
70    WRITE(61,910)LUN
910   FORMAT (1H0, 5X 34HPARITY ERROR ON INPUT LOGICAL UNIT, I5, / 6X
     1 53HWRITTEN ERROR FREE  CLEAN TAPE HEADS AND RESTART JOB.)
      STOP
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR LPFILT

```
      SUBROUTINE LOOP(I,K,J)
C ***
C     THIS ROUTINE CARRIES OUT SUMMATIONS AND MULTIPLICATIONS FOR EACH FILTERED
C     POINT
C ***
      COMMON IDUM(2088),N(6),IDATA(2000,2),N7,N8,N9,N10,N11,N12,
     1N13,N14,NDSH(7),M,ISAVE(1024),T1
      DO 10 NCT=I,K
      N7=NCT*NCT-1024*J+10
      N9=J+1
      DO 20 KCT=1,5
      N10=11-2*KCT
      N11=N7+N10
      N10=N7-N10
 20   N(KCT)=IDATA(N10,N9)+IDATA(N11,N9)
      N(6)=IDATA(N7,N9)
      CALL PRODSUM
      ISAVE(NCT)=N7
 10   CONTINUE
      RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR LOOP

```
      SUBROUTINE ERROUT(LUN,IOBUF)
      DIMENSION IOBUF(1024)
40    DO 10 I=1,5
      BACKSPACE LUN
      BUFFER OUT(LUN,1)(IOBUF(1),IOBUF(1024))
20    GO TO (20,30,30,10)UNITSTF(LUN)
10    CONTINUE
      CALL ERRECOV(6,LUN,K,I)
      CALL SKIPSIX(LUN)
      BUFFER OUT(LUN,1)(IOBUF(1),IOBUF(1024))
50    GO TO (50,30,30,40)UNITSTF(LUN)
30    RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR ERROUT

NO ERRORS

```
EXTERNAL SYMBOLS
    CIC


ENTRY-POINT SYMBOLS
    PRCDSUM         00153
    SKIPSIX         00044
    BACKSKIP        00056
    SKIPEOF         00026
    CONVERT         00000


LENGTH OF SUBPROGRAM        00202
LENGTH OF COMMON            13726
LENGTH OF DATA              00006
```

```
COMPASS-32    (2.3)                MISCELL                                                                    PAGE     2
                                                  COMMON
     00000                              IDUM      BSS       2088
     04050                              N         BSS       6
     04056                              GAP       BSS       4000
     13716                              N7        BSS       1
     13717                              JDUM      BSS       5
     13724                              TEM       BSS       2
                                                  DATA
     00000                              IWT       BSS       6
                                                  PRG

                                                  COMPASS SUBROUTINE FOR (1) TAPEHANDLING, AND (2) HOLLERITH - INTEGER
                                                  CONVERSION

                                                  ENTRY     CONVERT,SKIPEOF,BACKSKIP,SKIPSIX
                                                  EXT       CIO

                                                  ENTRY CONVERT, FOR CHANNEL ID HOLLERITH TO INTEGER CONVERSION
     00000  01077777 01 0  77777 0  CONVERT  UJP       **
     00001  54100000 54 0 P00000 1           LDI       CONVERT,1
     00002  14600002 14 1  00002 2           ENA       2
     00003  34000000 34 0 P00000 0           RAD       CONVERT
     00004  14600000 14 1  00000 2           ENA       0
     00005  40000025 40 0 P00025 0           STA       SUM
     00006  20500000 20 1  00000 1           LDA,I     0,1
     00007  40000024 40 0 P00024 0           STA       TEMP
     00010  36000177 36 0 P00177 0           SCA       =060606060
     00011  03000022 03 0 P00022 0           AZJ,EQ    STOREA
     00012  22000120 22 0 P00024 0           LACH      TEMP
     00013  50000176 50 0 P00176 0           MUA       =D100
     00014  34000025 34 0 P00025 0           RAD       SUM
     00015  22000121 22 0 P00024 1           LACH      TEMP+1
     00016  50000175 50 0 P00175 0           MUA       =D10
     00017  34000025 34 0 P00025 0           RAD       SUM
     00020  22000122 22 0 P00024 2           LACH      TEMP+2
     00021  30000025 30 0 P00025 0           ADA       SUM
     00022  40500001 40 1  00001 1  STOREA   STA,I     1,1
     00023  01400000 01 1 P00000 0           UJP,I     CONVERT
     00024                              TEMP      BSS       1
     00025                              SUM       BSS       1

                                                  ENTRY SKIPEOF, TO SKIPTAPE TO NEXT END-OF-FILE

     00026  01077777 01 0  77777 0  SKIPEOF  UJP       **
     00027  54100026 54 0 P00026 1           LDI       SKIPEOF,1
     00030  20500000 20 1  00000 1           LDA,I     0,1
     00031  44000036 44 0 P00036 0           SWA       BCKSP+1
     00032  44000041 44 0 P00041 0           SWA       SKP+1
     00033  14600001 14 1  00001 2           ENA       1
     00034  34000026 34 0 P00026 0           RAD       SKIPEOF
     00035  00777777 00 1 X77777 3  BCKSP    RTJ       CIO
     00036  06077777 06 0  77777 0           06        **
     00037  01000035 01 0 P00035 0           UJP       BCKSP
     00040  00700035 00 1 X00035 3  SKP      RTJ       CIO
```

```
00041  07000000 07 0  00000 0            07        0,0
00042  01000040 01 0 P00040 0            UJP       SKP
00043  01400026 01 1 P00026 0            UJP,I     SKIPEOF

                                         ENTRY SKIPS    TO ERASE AND SKIP A LENGTH OF TAPE IF PERSISTENT PARITY
                                         ERROR IN RL    R-OUT OPERATION

00044  01000000 01 0  00000 0  SKIPSIX   UJP       0,0
00045  54100044 54 0 P00044 1            LDI       SKIPSIX,1
00046  20500000 20 1  00000 1            LDA,I     0,1
00047  44000053 44 0 P00053 0            SWA       ERA+1
00050  14600001 14 1  00001 2            ENA       1
00051  34000044 34 0 P00044 0            RAD       SKIPSIX
00052  00700040 00 1 X00040 3  ERA       RTJ       CIO
00053  12000000 12 0  00000 0            12        0,0
00054  01000052 01 0 P00052 0            UJP       ERA
00055  01400044 01 1 P00044 0            UJP,I     SKIPSIX

                                         ENTRY BACKSKIP, SKIPS TAPE BACKWARDS TO NEXT EOF AND PREPARES TO READ
                                         NEXT RECORD FORWARDS

00056  01077777 01 0  77777 0  BACKSKIP UJP       **
00057  54100056 54 0 P00056 1            LDI       BACKSKIP,1
00060  20500000 20 1  00000 1            LDA,I     0,1
00061  44000067 44 0 P00067 0            SWA       INP+1
00062  44000103 44 0 P00103 0            SWA       BCK+1
00063  44000115 44 0 P00115 0            SWA       FOR+1
00064  14600001 14 1  00001 2            ENA       1
00065  34000056 34 0 P00056 0            RAD       BACKSKIP
00066  00700052 00 1 X00052 3  INP       RTJ       CIO
00067  03200000 03 0  00000 2            03        0,2
00070  01000066 01 0 P00066 0            UJP       INP
00071  00000024 00 0 P00024 0            00        TEMP
00072  00000002 00 0  00002 0                      2
00073  00000130 00 0 P00130 0                      INTER
00074  20000140 20 0 P00140 0            LDA       INDIC
00075  03000074 03 0 P00074 0            AZJ,EQ    *-1
00076  14700000 14 1  00000 3            ENQ       0
00077  41000140 41 0 P00140 0            STQ       INDIC
00100  15477776 15 1  77776 0            INA,S     -1
00101  03100122 03 0 P00122 1            AZJ,NE    LP
00102  00700066 00 1 X00066 3  BCK       RTJ       CIO
00103  10200000 10 0  00000 2            10        0,2
00104  01000102 01 0 P00102 0            UJP       BCK
00105  00000130 00 0 P00130 0                      INTER
00106  20000140 20 0 P00140 0            LDA       INDIC
00107  03000106 03 0 P00106 0            AZJ,EQ    *-1
00110  14700000 14 1  00000 3            ENQ       0
00111  41000140 41 0 P00140 0            STQ       INDIC
00112  15477776 15 1  77776 0            INA,S     -1
00113  03100122 03 0 P00122 1            AZJ,NE    LP
00114  00700102 00 1 X00102 3  FOR       RTJ       CIO
00115  01000000 01 0  00000 0            01        0,0
00116  01000114 01 0 P00114 0            UJP       FOR
```

```
00117  00000024 00 0 P00024 0            00        TEMP
00120  00000002 00 0  00002 0                      2
00121  01400056 01 1 P00056 0            UJP,I     BACKSKIP
00122  00700114 00 1 X00114 3  LP        RTJ       CIO
00123  02000075 02 0  00075 0            02        61,0
00124  01000122 01 0 P00122 0            UJP       LP
00125  00000141 00 0 P00141 0            00        MSG
00126  00000012 00 0  00012 0                      10
00127  00000000 00 0  00000 0            HLT
00130  01077777 01 0  77777 0  INTER     UJP       **
00131  17500030 17 1  00030 1            ANQ,S     00030B
00132  13000030 13 0  00030 0            SHAQ      24
00133  12077774 12 0  77774 0            SHA       -3
00134  03100136 03 0 P00136 1            AZJ,NE    *+2
00135  14600001 14 1  00001 2            ENA       1
00136  40000140 40 0 P00140 0            STA       INDIC
00137  01400130 01 1 P00130 0            UJP,I     INTER
00140          00000000        INDIC    OCT       0
00141          00604346        MSG      BCD       10,0 LOAD POINT FOUND ROUTINE BACKSKIP
00142          21246047
00143          46314563
00144          60264664
00145          45246051
00146          46646331
00147          45256022
00150          21234262
00151          42314760
00152          60606060
                                        ENTRY     PRODSUM
00153  01077777 01 0  77777 0  PRODSUM  UJP       **
00154  25000200 25 0 P00200 0            LDAQ      =200.0
00155  45013724 45 0 C13724 0            STAQ      TEM
00156  14100000 14 0  00000 1            ENI       0,1
00157  20104050 20 0 C04050 1  L1        LDA       N,1
00160  50100000 50 0 000000 1            MUA       IWT,1
00161  13000030 13 0  00030 0            SHAQ      24
00162  32013724 32 0 C13724 0            ADAQ      TEM
00163  45013724 45 0 C13724 0            STAQ      TEM
00164  15100001 15 0  00001 1            INI       1,1
00165  04100006 04 0  00006 1            ISE       6,1
00166  01000157 01 0 P00157 0            UJP       L1
00167  13000001 13 0  00001 0            SHAQ      1
00170  40013716 40 0 C13716 0            STA       N7
00171  14600001 14 1  00001 2            ENA       1
00172  03600174 03 1 P00174 2            AQJ,GE    *+2
00173  34013716 34 0 C13716 0            RAD       N7
00174  01400153 01 1 P00153 0            UJP,I     PRODSUM
                                        END

 LITERALS
00175          00000012          00176          00000144          00177          60606060
00200          0000000000000000
```

```
ENTRY-POINT SYMBOLS
    GALL2          00000


LENGTH OF SUBPROGRAM        00007
LENGTH OF COMMON            07724
LENGTH OF DATA              00000
```

```
                                                ENTRY     GAUL2

                                                SUBROUTINE GAUL2
                                                SUBROUTINE GAUL WITH ARGUMENTS IN COMMON

                                                ROUTINE TO SEPARATE PACKED 12 BIT INTEGERS INTO 24 BIT INTEGERS WITH
                                                CORRECT SIGN - ONE PAIR PER CALL
                                                COMMON
00000                                   L       BSS       4049
07721                                   I       BSS       1
07722                                   J       BSS       1
07723                                   K       BSS       1
                                                PRG
00000  01077777 01 0  77777 0   GAUL2           UJP       **
00001  20007721 20 0 C07721 0                   LDA       I
00002  13077763 13 0  77763 0                   SHAQ      -12
00003  40007722 40 0 C07722 0                   STA       J
00004  12477763 12 1  77763 0                   SHQ       -12
00005  41007723 41 0 C07723 0                   STQ       K
00006  01400000 01 1 P00000 0                   UJP,I     GAUL2
                                                END

                                               NUMBER OF LINES WITH DIAGNOSTICS          0
```

APPENDIX C

Listing of Routine FFT42M

```
EXTERNAL SYMBOLS
    COSF
    FDPBCXS
    FLOAT


ENTRY-POINT SYMBOLS
    FFT             01144
    N               01730
    FFT42M          01053
    COSTABLE        01002


LENGTH OF SUBPROGRAM        02076
LENGTH OF COMMON            00000
LENGTH OF DATA              00000
```

```
                                          ENTRY     COSTABLE,FFT42M,FFT,N
                                          EXT       COSF,FLOAT
                                          REM       ENTRY POINT COSTABLE SETS UP THE COSINE TABLE,
                                          REM       FFT42M COMPUTES THE TRANSFORM.
00000                             COSINE  BSS       514
01002  01077777 01 0  77777 0  COSTABLE  UJP       **
01003  47101624 47 0 P01624 1            STI       END,1
01004  47201625 47 0 P01625 2            STI       END+1,2
01005  54201002 54 0 P01002 2            LDI       COSTARLE,2
01006  20600000 20 1  00000 2            LDA,I     0,2
01007  44001011 44 0 P01011 0            SWA       *+2
01010  14600001 14 1  00001 2            ENA       1
01011  12077777 12 0  77777 0            SHA       **
01012  15200001 15 0  00001 2            INI       1,2
01013  47201053 47 0 P01053 2            STI       FFT42M,2
01014  40001766 40 0 P01766 0            STA       RTO                    NMX
01015  12077775 12 0  77775 0            SHA       -2                     NMX/4
01016  15477776 15 1  77776 0            INA,S     -1                     (NMX/4)-1
01017  53500000 53 1  00000 1            TAI       1
01020  25001721 25 0 P01721 0            LDAQ      PLUS1
01021  45000000 45 0 P00000 0            STAQ      COSINE
01022  14200002 14 0  00002 2            ENI       2,2
01023  00777777 00 1 X77777 3            RTJ       FLOAT
01024  77001766 77 0 P01766 0            77        RTO
01025  45001766 45 0 P01766 0            STAQ      RTO                     NMX IN FLOATING POINT.
01026  25001047 25 0 P01047 0            LDAQ      X+2
01027  63001766 63 0 P01766 0            FDV       RTO
01030  45001051 45 0 P01051 0            STAQ      X+4
01031  25001045 25 0 P01045 0  LPST      LDAQ      X
01032  60001051 60 0 P01051 0            FAD       X+4
01033  45001045 45 0 P01045 0            STAQ      X
01034  00777777 00 1 X77777 3            RTJ       COSF
01035  77001045 77 0 P01045 0            77        X
01036  45200000 45 0 P00000 2            STAQ      COSINE,2
01037  15200002 15 0  00002 2            INI       2,2
01040  02501031 02 1 P01031 1            IJU       LPST,1
01041  14600000 14 1  00000 2            ENA       0
01042  14700000 14 1  00000 3            ENQ       0
01043  45001045 45 0 P01045 0            STAQ      X
01044  01001624 01 0 P01624 0            UJP       END
01045          00000000           X     DECD      0.0
01046          00000000
01047          20036270                 DECD      6.283185307
01050          77325041
01051          00000000                 DECD      0.0
01052          00000000

                                          REM    ENTRY FFT42M FOR CALCULATION OF TRANSFORM.
                                          REM    PARAMETERS LG2NMX, LG2N, INCT, REALDATA, IMAGDATA,INOUT.

01053  01077777 01 0  77777 0  FFT42M    UJP       **
01054  47101624 47 0 P01624 1            STI       END,1
01055  47201625 47 0 P01625 2            STI       END+1,2
01056  47301623 47 0 P01623 3            STI       END-1,3
```

```
01057  54101053 54 0 P01053 1          LDI      FFT42M,1
01060  20500000 20 1  00000 1          LDA,I    0,1
01061  44001063 44 0 P01063 0          SWA      *+2
01062  14400001 14 1  00001 0          ENA,S    1
01063  12077777 12 0  77777 0          SHA      **                    FORM NMX=2**LG2NMX
01064  40001726 40 0 P01726 0          STA      NMX
01065  12077775 12 0  77775 0          SHA      -2
01066  40001727 40 0 P01727 0          STA      NMXOV4               NMX/4
01067  20500001 20 1  00001 1          LDA,I    1,1                  LG2N TO A,
01070  40001740 40 0 P01740 0          STA      LG2N
01071  44001075 44 0 P01075 0          SWA      SHIFT2
01072  12077776 12 0  77776 0          SHA      -1                    LG2N/4=LG4N
01073  40001725 40 0 P01725 0          STA      LG4N
01074  14400001 14 1  00001 0          ENA,S    1
01075  12077777 12 0  77777 0  SHIFT2  SHA      **                    FORM N = 2**LG2N
01076  40001730 40 0 P01730 0          STA      N
01077  40001731 40 0 P01731 0          STA      MLP
01100  21001726 21 0 P01726 0          LDQ      NMX
01101  14600000 14 1  00000 2          ENA      0
01102  51001730 51 0 P01730 0          DVA      N                     IX1 = NMX/4N
01103  40001741 40 0 P01741 0          STA      IX1
01104  20500002 20 1  00002 1          LDA,I    2,1
01105  40001736 40 0 P01736 0          STA      INCT
01106  20100003 20 0  00003 1          KEA      3,1                   ADDRDSS OF RDAK DATA ARRAY,
 11 7  12     6 12       6             SHA      6
01110  12077771 12 0  77771 0          SHA      -6
01111  15477775 15 1  77775 0          INA,S    -2
01112  14300000 14 0  00000 3          ENI      0,3
01113  44702014 44 1 P02014 3  SETADDR SWA,I    REALADD,3
01114  10300030 10 0  00030 3          ISI      24,3
01115  01001113 01 0 P01113 0          UJP      SETADDR
01116  20100004 20 0  00004 1          LDA      4,1                   ADDRESS OF IMAG DATA ARRAY,
01117  12000006 12 0  00006 0          SHA      6
01120  12077771 12 0  77771 0          SHA      -6
01121  15477775 15 1  77775 0          INA,S    -2
01122  14300000 14 0  00000 3          ENI      0,3
01123  44702045 44 1 P02045 3  SETADDI SWA,I    IMAGADD,3
01124  10300030 10 0  00030 3          ISI      24,3
01125  01001123 01 0 P01123 0          UJP      SETADDI
01126  20100005 20 0  00005 1          LDA      5,1
01127  53600000 53 1  00000 2          TAI      2
01130  21200000 21 0  00000 2          LDQ      0,2
01131  41001737 41 0 P01737 0          STQ      INOUT
01132  14600000 14 1  00000 2          ENA      0
01133  04700000 04 1  00000 3          QSE      0
01134  14677777 14 1  77777 2          ENA      -0
01135  44001320 44 0 P01320 0          SWA      FFACTOR
01136  44001321 44 0 P01321 0          SWA      FFACTOR+1
01137  44001325 44 0 P01325 0          SWA      GFACTOR
01140  44001326 44 0 P01326 0          SWA      GFACTOR+1
01141  15100006 15 0  00006 1          INI      6,1
01142  47101053 47 0 P01053 1          STI      FFT42M,1
01143  01001154 01 0 P01154 0          UJP      NEWSTRT
                                       REM    ENTRY POINT FFT    IS USED FOR CALLS WITH SAME PARAMETERS,
```

```
01144  01077777 01 0  77777 0  FFT       UJP      **
01145  20001144 20 0 P01144 0            LDA      FFT
01146  44001053 44 0 P01053 0            SWA      FFT42M
01147  47101624 47 0 P01624 1            STI      END,1
01150  47201625 47 0 P01625 2            STI      END+1,2
01151  47301623 47 0 P01623 3            STI      END-1,3
01152  20001730 20 0 P01730 0            LDA      N
01153  40001731 40 0 P01731 0            STA      MLP
01154  14600001 14 1  00001 2  NEWSTRT   ENA      1
01155  40001733 40 0 P01733 0            STA      ILP
01156  40001734 40 0 P01734 0            STA      OUTLPCT
01157  20001731 20 0 P01731 0  OUTLOOP   LDA      MLP
01160  12077775 12 0  77775 0            SHA      -2
01161  40001735 40 0 P01735 0            STA      MLPOV4
01162  50001736 50 0 P01736 0            MUA      INCT
01163  40001747 40 0 P01747 0            STA      JNCT
01164  20001741 20 0 P01741 0            LDA      IX1
01165  50001733 50 0 P01733 0            MUA      ILP
01166  40001732 40 0 P01732 0            STA      IW1
01167  40001744 40 0 P01744 0            STA      IC1
01170  30001732 30 0 P01732 0            ADA      IW1                    2*IW1=IW2
01171  40001742 40 0 P01742 0            STA      IW2
01172  40001745 40 0 P01745 0            STA      IC2
01173  30001732 30 0 P01732 0            ADA      IW1                    3*IW1=IW3
01174  40001743 40 0 P01743 0            STA      IW3
01175  40001746 40 0 P01746 0            STA      IC3
01176  20001731 20 0 P01731 0            LDA      MLP
01177  50001736 50 0 P01736 0            MUA      INCT                   MLP*INCT=MLPINC
01200  40001750 40 0 P01750 0            STA      MLPINC
01201  14400001 14 1  00001 0            ENA,S    1
01202  40001751 40 0 P01751 0            STA      IOSV
01203  40001752 40 0 P01752 0            STA      MLPCT
01204  20001752 20 0 P01752 0  MIDLOOP   LDA      MLPCT
01205  15477775 15 1  77775 0            INA,S    -2
01206  03001221 03 0 P01221 0            AZJ,EQ   AEQ2
01207  03301252 03 0 P01252 3            AZJ,LT   ALT2
01210  20001744 20 0 P01744 0            LDA      IC1
01211  30001732 30 0 P01732 0            ADA      IW1
01212  40001744 40 0 P01744 0            STA      IC1
01213  20001745 20 0 P01745 0            LDA      IC2
01214  30001742 30 0 P01742 0            ADA      IW2
01215  40001745 40 0 P01745 0            STA      IC2
01216  20001746 20 0 P01746 0            LDA      IC3
01217  30001743 30 0 P01743 0            ADA      IW3
01220  40001746 40 0 P01746 0            STA      IC3
01221  20001744 20 0 P01744 0  AEQ2      LDA      IC1
01222  00701627 00 1 P01627 3            RTJ      TBLOOK
01223  45001762 45 0 P01762 0            STAQ     COS2
01224  25001770 25 0 P01770 0            LDAQ     STO
01225  45002010 45 0 P02010 0            STAQ     SIN2
01226  20001745 20 0 P01745 0            LDA      IC2
01227  00701627 00 1 P01627 3            RTJ      TBLOOK
01230  45001760 45 0 P01760 0            STAQ     COS1
01231  25001770 25 0 P01770 0            LDAQ     STO
```

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01232  45002006 45 0 P02006 0          STAQ    SIN1
01233  20001746 20 0 P01746 0          LDA     IC3
01234  00701627 00 1 P01627 3          RTJ     TRLOOK
01235  45001764 45 0 P01764 0          STAQ    COS3
01236  25001770 25 0 P01770 0          LDAQ    ST0
01237  45002012 45 0 P02012 0          STAQ    SIN3
01240  20001737 20 0 P01737 0          LDA     INOUT
01241  03001252 03 0 P01252 0          AZJ,EQ  ALT2
01242  14100000 14 0  00000 1          ENI     0,1
01243  25102006 25 0 P02006 1  AGAIN   LDAQ    SIN1,1
01244  16477777 16 1  77777 0          XOA,S   -0
01245  16577777 16 1  77777 1          XOQ,S   -0
01246  45102006 45 0 P02006 1          STAQ    SIN1,1
01247  15100002 15 0  00002 1          INI     2,1
01250  04100006 04 0  00006 1          ISE     6,1
01251  01001243 01 0 P01243 0          UJP     AGAIN
01252  20001751 20 0 P01751 0  ALT2    LDA     IOSV
01253  40001753 40 0 P01753 0          STA     I0
01254  14600001 14 1  00001 2          ENA     1
01255  40001754 40 0 P01754 0          STA     ILPCT
01256  21001747 21 0 P01747 0  INLOOP  LDQ     JNCT
01257  20001753 20 0 P01753 0          LDA     I0
01260  12000001 12 0  00001 0          SHA     1                    2*I0
01261  53500000 53 1  00000 1          TAI     1
01262  12400001 12 1  00001 0          SHQ     1                    2*JNCT
01263  53040000 53 0  40000 0          AQA                        2*I1
01264  53600000 53 1  00000 2          TAI     2
01265  47201755 47 0 P01755 2          STI     I12,2
01266  53040000 53 0  40000 0          AQA                          I2
01267  53700000 53 1  00000 3          TAI     3
01270  47301756 47 0 P01756 3          STI     I22,3
01271  53040000 53 0  40000 0          AQA                        2*I3
01272  40001757 40 0 P01757 0          STA     I32
01273  25177777 25 0  77777 1  RL1     LDAQ    **,1
01274  60377777 60 0  77777 3          FAD     **,3
01275  45001766 45 0 P01766 0          STAQ    RT0
01276  25177777 25 0  77777 1  IL1     LDAQ    **,1
01277  60377777 60 0  77777 3          FAD     **,3
01300  45001770 45 0 P01770 0          STAQ    ST0
01301  25177777 25 0  77777 1  RL2     LDAQ    **,1
01302  61377777 61 0  77777 3          FSB     **,3
01303  45001776 45 0 P01776 0          STAQ    RT2
01304  25177777 25 0  77777 1  IL2     LDAQ    **,1
01305  61377777 61 0  77777 3          FSB     **,3
01306  45002000 45 0 P02000 0          STAQ    ST2
01307  54301757 54 0 P01757 3          LDI     I32,3
01310  25277777 25 0  77777 2  RL3     LDAQ    **,2                 DR(I,1)
01311  60377777 60 0  77777 3          FAD     **,3
01312  45001772 45 0 P01772 0          STAQ    RT1
01313  25277777 25 0  77777 2  IL3     LDAQ    **,2
01314  60377777 60 0  77777 3          FAD     **,3
01315  45001774 45 0 P01774 0          STAQ    ST1
01316  25277777 25 0  77777 2  RL4     LDAQ    **,2
01317  61377777 61 0  77777 3          FSB     **,3
```

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01320  16477777 16 1  77777 0  FFACTOR  XOA,S    **
01321  16577777 16 1  77777 1            XOQ,S    **
01322  45002002 45 0 P02002 0            STAQ     RT3
01323  25277777 25 0  77777 2  IL4       LDAQ     **,2
01324  61377777 61 0  77777 3            FSB      **,3
01325  16477777 16 1  77777 0  GFACTOR   XOA,S    **
01326  16577777 16 1  77777 1            XOQ,S    **
01327  45002004 45 0 P02004 0            STAQ     ST3
01330  25001766 25 0 P01766 0            LDAQ     RT0
01331  60001772 60 0 P01772 0            FAD      RT1                 RT3+RT1
01332  45177777 45 0  77777 1  RL5       STAQ     **,1
01333  25001770 25 0 P01770 0            LDAQ     ST0                 ST0+ST1
01334  60001774 60 0 P01774 0            FAD      ST1
01335  45177777 45 0  77777 1  IL5       STAQ     **,1
01336  25001766 25 0 P01766 0            LDAQ     RT0
01337  61001772 61 0 P01772 0            FSB      RT1
01340  45277777 45 0  77777 2  RL6       STAQ     **,2
01341  25001770 25 0 P01770 0            LDAQ     ST0
01342  61001774 61 0 P01774 0            FSB      ST1
01343  45277777 45 0  77777 2  IL6       STAQ     **,2
01344  25001776 25 0 P01776 0  AFROMX    LDAQ     RT2
01345  60002004 60 0 P02004 0            FAD      ST3
01346  54101 56 54 0 P01756 1            LDI      I22,1
01347  45177 77 45 0  77777 1  RL7       STAQ     **,1
01350  25002000 25 0 P02000 0            LDAQ     ST2
01351  61002002 61 0 P02002 0            FSB      RT3
01352  45177777 45 0  77777 1  IL7       STAQ     **,1
01353  25001776 25 0 P01776 0            LDAQ     RT2
01354  61002004 61 0 P02004 0            FSB      ST3
01355  45377777 45 0  77777 3  RL8       STAQ     **,3
01356  25002000 25 0 P02000 0            LDAQ     ST2
01357  60002002 60 0 P02002 0            FAD      RT3
01360  45377777 45 0  77777 3  IL8       STAQ     **,3
01361  20001752 20 0 P01752 0            LDA      MLPCT
01362  04600001 04 1  00001 2            ASE      1
01363  01001365 01 0 P01365 0            UJP      **2
01364  01001445 01 0 P01445 0            UJP      ENDILP
01365  25277777 25 0  77777 2  IL9       LDAQ     **,2
01366  62002006 62 0 P02006 0            FMU      SIN1
01367  45001766 45 0 P01766 0            STAQ     RT0                 UT1*SIN1
01370  25277777 25 0  77777 2  IL10      LDAQ     **,2
01371  62001760 62 0 P01760 0            FMU      COS1
01372  45001772 45 0 P01772 0            STAQ     RT1                 UT1*COS1
01373  25277777 25 0  77777 2  RL9       LDAQ     **,2
01374  62002006 62 0 P02006 0            FMU      SIN1
01375  45001776 45 0 P01776 0            STAQ     RT2                 TT1*SIN1
01376  25277777 25 0  77777 2  RL10      LDAQ     **,2
01377  62001760 62 0 P01760 0            FMU      COS1                TT1*COS1
01400  61001766 61 0 P01766 0            FSB      RT0
01401  45277777 45 0  77777 2  RL11      STAQ     **,2
01402  25001772 25 0 P01772 0            LDAQ     RT1
01403  60001776 60 0 P01776 0            FAD      RT2
01404  45277777 45 0  77777 2  IL11      STAQ     **,2
01405  25177777 25 0  77777 1            LDAQ     **,1
```

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01406  62002010 62 0 P02010 0          FMU     SIN2          UT2*SIN2
01407  45001766 45 0 P01766 0          STAQ    RT0
01410  25177777 25 0  77777 1          LDAQ    **,1
01411  62001762 62 0 P01762 0          FMU     COS2          UT2*COS2
01412  45001772 45 0 P01772 0          STAQ    RT1
01413  25177777 25 0  77777 1  RL12    LDAQ    **,1
01414  62002010 62 0 P02010 0          FMU     SIN2
01415  45001776 45 0 P01776 0          STAQ    RT2           TT2*SIN2
01416  25177777 25 0  77777 1          LDAQ    **,1
01417  62001762 62 0 P01762 0          FMU     COS2
01420  61001766 61 0 P01766 0          FSB     RT0
01421  45177777 45 0  77777 1          STAQ    **,1
01422  25001772 25 0 P01772 0          LDAQ    RT1
01423  60001776 60 0 P01776 0          FAD     RT2
01424  45177777 45 0  77777 1  IL12    STAQ    **,1
01425  25377777 25 0  77777 3          LDAQ    **,3
01426  62002012 62 0 P02012 0          FMU     SIN3
01427  45001766 45 0 P01766 0          STAQ    RT0           UT3*SIN3
01430  25377777 25 0  77777 3          LDAQ    **,3
01431  62001764 62 0 P01764 0          FMU     COS3
01432  45001772 45 0 P01772 0          STAQ    RT1           UT3*COS3
01433  25377777 25 0  77777 3  RL13    LDAQ    **,3
01434  62002012 62 0 P02012 0          FMU     SIN3
01435  45001776 45 0 P01776 0          STAQ    RT2
01436  25377777 25 0  77777 3          LDAQ    **,3
01437  62001764 62 0 P01764 0          FMU     COS3
01440  61001766 61 0 P01766 0          FSB     RT0
01441  45377777 45 0  77777 3          STAQ    **,3
01442  25001772 25 0 P01772 0          LDAQ    RT1
01443  60001776 60 0 P01776 0          FAD     RT2
01444  45377777 45 0  77777 3  IL13    STAQ    **,3
01445  20001750 20 0 P01750 0  ENDILP  LDA     MLPINC
01446  34001753 34 0 P01753 0          RAD     I0
01447  20001754 20 0 P01754 0          LDA     ILPCT
01450  21001733 21 0 P01733 0          LDQ     ILP
01451  03401455 03 1 P01455 0          AQJ,EQ  ENDMLP
01452  15400001 15 1  00001 0          INA,S   1
01453  40001754 40 0 P01754 0          STA     ILPCT
01454  01001256 01 0 P01256 0          UJP     INLOOP
01455  20001736 20 0 P01736 0  ENDMLP  LDA     INCT
01456  34001751 34 0 P01751 0          RAD     I0SV
01457  20001752 20 0 P01752 0          LDA     MLPCT
01460  21001735 21 0 P01735 0          LDQ     MLPOV4
01461  03401465 03 1 P01465 0          AQJ,EQ  ENDOLP
01462  15400001 15 1  00001 0          INA,S   1
01463  40001752 40 0 P01752 0          STA     MLPCT
01464  01001204 01 0 P01204 0          UJP     MIDLOOP
01465  20001733 20 0 P01733 0  ENDOLP  LDA     ILP
01466  12000002 12 0  00002 0          SHA     2
01467  40001733 40 0 P01733 0          STA     ILP
01470  20001735 20 0 P01735 0          LDA     MLPOV4
01471  40001731 40 0 P01731 0          STA     MLP
01472  20001734 20 0 P01734 0          LDA     OUTLPCT
01473  21001725 21 0 P01725 0          LDQ     LG4N
```

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01474  03401500 03 1 P01500 0          AOJ,EQ    EOFT
01475  15400001 15 1  00001 0          INA,S     1
01476  40001734 40 0 P01734 0          STA       OUTLPCT
01477  01001157 01 0 P01157 0          UJP       OUTLOOP
01500  20001725 20 0 P01725 0  EOFT    LDA       LG4N
01501  12000001 12 0  00001 0          SHA       1
01502  21001740 21 0 P01740 0          LDQ       LG2N
01503  03401535 03 1 P01535 0          AOJ,EQ    INVERT
01504  20001730 20 0 P01730 0          LDA       N
01505  12077776 12 0  77776 0          SHA       -1
01506  15477776 15 1  77776 0          INA,S     -1
01507  53700000 53 1  00000 3          TAI       3
01510  14100004 14 0  00004 1          ENI       4,1                 I
01511  14200002 14 0  00002 2          ENI       2,2                 J
01512  25277777 25 0  77777 2  TWOSUM  LDAQ      **,2
01513  60177777 60 0  77777 1          FAD       **,1
01514  45001766 45 0 P01766 0          STAQ      RT0
01515  25277777 25 0  77777 2  IMDATA  LDAQ      **,2
01516  60177777 60 0  77777 1          FAD       **,1
01517  45001772 45 0 P01772 0          STAQ      RT1
01520  25401512 25 1 P01512 0          LDAQ,I    TWOSUM
01521  61401513 61 1 P01513 0          FSB,I     TWOSUM+1
01522  45401513 45 1 P01513 0          STAQ,I    TWOSUM+1
01523  25401515 25 1 P01515 0          LDAQ,I    IMDATA
01524  61401516 61 1 P01516 0          FSB,I     IMDATA+1
01525  45401516 45 1 P01516 0          STAQ,I    IMDATA+1
01526  25001766 25 0 P01766 0          LDAQ      RT0
01527  45401512 45 1 P01512 0          STAQ,I    TWOSUM
01530  25001772 25 0 P01772 0          LDAQ      RT1
01531  45401515 45 1 P01515 0          STAQ,I    IMDATA
01532  15200004 15 0  00004 2          INI       4,2
01533  15100004 15 0  00004 1          INI       4,1
01534  02701512 02 1 P01512 3          IJD       TWOSUM,3
01535  54101730 54 0 P01730 1  INVERT  LDI       N,1
01536  15177775 15 0  77775 1          INI       -2,1
01537  14600000 14 1  00000 2          ENA       0
01540  40001770 40 0 P01770 0          STA       ST0                 J
01541  14600001 14 1  00001 2  INVLP   ENA       1
01542  34001770 34 0 P01770 0          RAD       ST0
01543  40001766 40 0 P01766 0          STA       RT0                 L1
01544  14400000 14 1  00000 0          ENA,S     0
01545  40001772 40 0 P01772 0          STA       RT1                 N1
01546  14400030 14 1  00030 0          ENA,S     24
01547  31001740 31 0 P01740 0          SRA       LG2N
01550  44001552 44 0 P01552 0          SWA       *+2
01551  14600001 14 1  00001 2          ENA       1
01552  12077777 12 0  77777 0          SHA       **
01553  50001770 50 0 P01770 0          MUA       ST0
01554  40001776 40 0 P01776 0          STA       RT2                 J1
01555  54201740 54 0 P01740 2          LDI       LG2N,2
01556  15277776 15 0  77776 2          INI       -1,2
01557  03201562 03 0 P01562 2  AD      AZJ,GE    *+3
01560  20001766 20 0 P01766 0          LDA       RT0
01561  34001772 34 0 P01772 0          RAD       RT1                 N1+L1
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01562  20001766 20 0 P01766 0          LDA     RT0
01563  34001766 34 0 P01766 0          RAD     RT0                2*L1
01564  14600002 14 1  00002 2          ENA     2
01565  50001776 50 0 P01776 0          MUA     RT2
01566  40001776 40 0 P01776 0          STA     RT2                2*J1
01567  02601557 02 1 P01557 2          IJD     AD,2
01570  20001772 20 0 P01772 0          LDA     RT1                N1
01571  21001770 21 0 P01770 0          LDQ     ST0                J
01572  03701622 03 1 P01622 3          AQJ,LT  ENDINV
01573  03401622 03 1 P01622 0          AQJ,EQ  ENDINV
01574  20001770 20 0 P01770 0          LDA     ST0
01575  50001736 50 0 P01736 0          MUA     INCT
01576  15400001 15 1  00001 0          INA,S   1
01577  53600000 53 1  00000 2          TAI     2                  J1
01600  53640000 53 1  40000 2          IAI     2
01601  20001772 20 0 P01772 0          LDA     RT1
01602  50001736 50 0 P01736 0          MUA     INCT
01603  15400001 15 1  00001 0          INA,S   1
01604  53700000 53 1  00000 3          TAI     3                  N1
01605  53740000 53 1  40000 3          IAI     3
01606  25377777 25 0  77777 3  AE      LDAQ    **,3
01607  45001776 45 0 P01776 0          STAQ    RT2
01610  25277777 25 0  77777 2  AF      LDAQ    **,2
01611  45401606 45 1 P01606 0          STAQ,I  AE
01612  25001776 25 0 P01776 0          LDAQ    RT2
01613  45401610 45 1 P01610 0          STAQ,I  AF
01614  25377777 25 0  77777 3  AG      LDAQ    **,3
01615  45001776 45 0 P01776 0          STAQ    RT2
01616  25277777 25 0  77777 2  AH      LDAQ    **,2
01617  45401614 45 1 P01614 0          STAQ,I  AG
01620  25001776 25 0 P01776 0          LDAQ    RT2
01621  45401616 45 1 P01616 0          STAQ,I  AH
01622  02501541 02 1 P01541 1  ENDINV  IJD     INVLP,1
01623  14377777 14 0  77777 3          ENI     **,3
01624  14177777 14 0  77777 1  END     ENI     **,1
01625  14277777 14 0  77777 2          ENI     **,2
01626  01001053 01 0 P01053 0          UJP     FFT42M
01627  01077777 01 0  77777 0  TBLOOK  UJP     **
01630  40001766 40 0 P01766 0          STA     RT0                STORE N TEMPORARILY
01631  21001727 21 0 P01727 0          LDQ     NMXOV4
01632  03401677 03 1 P01677 0          AQJ,EQ  FSTOD
01633  03701677 03 1 P01677 3          AQJ,LT  FSTOD
01634  20001727 20 0 P01727 0          LDA     NMXOV4
01635  30001727 30 0 P01727 0          ADA     NMXOV4
01636  31001766 31 0 P01766 0          SBA     RT0
01637  03201667 03 0 P01667 2          AZJ,GE  SNDOD
01640  20001726 20 0 P01726 0          LDA     NMX
01641  31001727 31 0 P01727 0          SBA     NMXOV4
01642  31001766 31 0 P01766 0          SBA     RT0
01643  03201655 03 0 P01655 2          AZJ,GE  TRDOD
01644  16477777 16 1  77777 0          XOA,S   =0
01645  53500000 53 1  00000 1          TAI     1                  M
01646  20001726 20 0 P01726 0          LDA     NMX
01647  31001766 31 0 P01766 0          SBA     RT0
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COMPASS-32    (2,3)                FFT42M                                                    12/23/68  PAGE    10
01650  53600000 53 1  00000 2            TAI     2                          NDASH
01651  25001721 25 0 P01721 0            LDAQ    PLUS1
01652  45001770 45 0 P01770 0            STAQ    ST0                        M FACTOR
01653  45001774 45 0 P01774 0            STAQ    ST1                        N FACTOR
01654  01001707 01 0 P01707 0            UJP     READ
01655  53500000 53 1  00000 1  TRDQD     TAI     1                          M
01656  20001766 20 0 P01766 0            LDA     RT0
01657  31001727 31 0 P01727 0            SBA     NMXOV4
01660  31001727 31 0 P01727 0            SBA     NMXOV4
01661  53600000 53 1  00000 2            TAI     2                          N
01662  25001721 25 0 P01721 0            LDAQ    PLUS1
01663  45001770 45 0 P01770 0            STAQ    ST0
01664  25001723 25 0 P01723 0            LDAQ    MINUS1
01665  45001774 45 0 P01774 0            STAQ    ST1
01666  01001707 01 0 P01707 0            UJP     READ
01667  53600000 53 1  00000 2  SNDQD     TAI     2
01670  20001766 20 0 P01766 0            LDA     RT0
01671  31001727 31 0 P01727 0            SBA     NMXOV4
01672  53500000 53 1  00000 1            TAI     1
01673  25001723 25 0 P01723 0            LDAQ    MINUS1
01674  45001770 45 0 P01770 0            STAQ    ST0
01675  45001774 45 0 P01774 0            STAQ    ST1
01676  01001707 01 0 P01707 0            UJP     READ
01677  53600000 53 1  00000 2  FSTQD     TAI     2
01700  20001727 20 0 P01727 0            LDA     NMXOV4
01701  31001766 31 0 P01766 0            SBA     RT0
01702  53500000 53 1  00000 1            TAI     1
01703  25001723 25 0 P01723 0            LDAQ    MINUS1
01704  45001770 45 0 P01770 0            STAQ    ST0
01705  25001721 25 0 P01721 0            LDAQ    PLUS1
01706  45001774 45 0 P01774 0            STAQ    ST1
01707  53100000 5  0  00000 1  READ      TIA     1
01710  53540000 53 1  40000 1            IAI     1
01711  53200000 53 0  00000 2            TIA     2
01712  53640000 53 1  40000 2            IAI     2
01713  25100000 25 0 P00000 1            LDAQ    COSINE,1                   SIN(X)
01714  62001770 62 0 P01770 0            FMU     ST0
01715  45001770 45 0 P01770 0            STAQ    ST0
01716  25200000 25 0 P00000 2            LDAQ    COSINE,2                   COS(X)
01717  62001774 62 0 P01774 0            FMU     ST1
01720  01001627 01 0 P01627 0            UJP     TBLOOK
01721          20014000        PLUS1     DECD    1.0
01722          00000000
01723          57763777        MINUS1    DECD    -1.0
01724          77777777
01725          00000000        LG4N      OCT     0
01726          00000000        NMX       OCT     0
01727          00000000        NMXOV4    OCT     0
01730          00000000        N         OCT     0
01731          00000000        MLP       OCT     0
01732          00000000        IW1       OCT     0
01733          00000000        ILP       OCT     0
01734          00000000        OUTLPCT   OCT     0
01735          00000000        MLPOV4    OCT     0
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01736          00000000        INCT      OCT       0
01737          00000000        INOUT     OCT       0
01740          00000000        LG2N      OCT       0
01741          00000000        IX1       OCT       0
01742          00000000        IW2       OCT       0
01743          00000000        IW3       OCT       0
01744          00000000        IC1       OCT       0
01745          00000000        IC2       OCT       0
01746          00000000        IC3       OCT       0
01747          00000000        JNCT      OCT       0
01750          00000000        MLPINC    OCT       0
01751          00000000        IOSV      OCT       0
01752          00000000        MLPCT     OCT       0
01753          00000000        I0        OCT       0
01754          00000000        ILPCT     OCT       0
01755          00000000        I12       OCT       0
01756          00000000        I22       OCT       0
01757          00000000        I32       OCT       0
01760          00000000        COS1      DECD      0.0
01761          00000000
01762          00000000        COS2      DECD      0.0
01763          00000000
01764          00000000        COS3      DECD      0.0
01765          00000000
01766          00000000        RT0       DECD      0.0
01767          00000000
01770          00000000        ST0       DECD      0.0
01771          00000000
01772          00000000        RT1       DECD      0.0
01773          00000000
01774          00000000        ST1       DECD      0.0
01775          00000000
01776          00000000        RT2       DECD      0.0
01777          00000000
02000          00000000        ST2       DECD      0.0
02001          00000000
02002          00000000        RT3       DECD      0.0
02003          00000000
02004          00000000        ST3       DECD      0.0
02005          00000000
02006          00000000        SIN1      DECD      0.0
02007          00000000
02010          00000000        SIN2      DECD      0.0
02011          00000000
02012          00000000        SIN3      DECD      0.0
02013          00000000
02014  00001273 00 0 P01273 0   REALADD   HLT       RL1
02015  00001274 00 0 P01274 0             HLT       RL1+1
02016  00001301 00 0 P01301 0             HLT       RL2
02017  00001302 00 0 P01302 0             HLT       RL2+1
02020  00001310 00 0 P01310 0             HLT       RL3
02021  00001311 00 0 P01311 0             HLT       RL3+1
02022  00001316 00 0 P01316 0             HLT       RL4
02023  00001317 00 0 P01317 0             HLT       RL4+1
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```
02024  00001332 00 0 P01332 0            HLT     RL5
02025  00001340 00 0 P01340 0            HLT     RL6
02026  00001347 00 0 P01347 0            HLT     RL7
02027  00001355 00 0 P01355 0            HLT     RL8
02030  00001373 00 0 P01373 0            HLT     RL9
02031  00001376 00 0 P01376 0            HLT     RL10
02032  00001401 00 0 P01401 0            HLT     RL11
02033  00001413 00 0 P01413 0            HLT     RL12
02034  00001416 00 0 P01416 0            HLT     RL12+3
02035  00001421 00 0 P01421 0            HLT     RL12+6
02036  00001433 00 0 P01433 0            HLT     RL13
02037  00001436 00 0 P01436 0            HLT     RL13+3
02040  00001441 00 0 P01441 0            HLT     RL13+6
02041  00001512 00 0 P01512 0            HLT     TWOSUM
02042  00001513 00 0 P01513 0            HLT     TWOSUM+1
02043  00001606 00 0 P01606 0            HLT     AE
02044  00001610 00 0 P01610 0            HLT     AF
02045  00001276 00 0 P01276 0  IMAGADD    HLT     IL1
02046  00001277 00 0 P01277 0            HLT     IL1+1
02047  00001304 00 0 P01304 0            HLT     IL2
02050  00001305 00 0 P01305 0            HLT     IL2+1
02051  00001313 00 0 P01313 0            HLT     IL3
02052  00001314 00 0 P01314 0            HLT     IL3+1
02053  00001323 00 0 P01323 0            HLT     IL4
02054  00001324 00 0 P01324 0            HLT     IL4+1
02055  00001335 00 0 P01335 0            HLT     IL5
02056  00001343 00 0 P01343 0            HLT     IL6
02057  00001352 00 0 P01352 0            HLT     IL7
02060  00001360 00 0 P01360 0            HLT     IL8
02061  00001365 00 0 P01365 0            HLT     IL9
02062  00001370 00 0 P01370 0            HLT     IL10
02063  00001404 00 0 P01404 0            HLT     IL11
02064  00001405 00 0 P01405 0            HLT     IL11+1
02065  00001410 00 0 P01410 0            HLT     IL11+4
02066  00001424 00 0 P01424 0            HLT     IL12
02067  00001425 00 0 P01425 0            HLT     IL12+1
02070  00001430 00 0 P01430 0            HLT     IL12+4
02071  00001444 00 0 P01444 0            HLT     IL13
02072  00001515 00 0 P01515 0            HLT     IMDATA
02073  00001516 00 0 P01516 0            HLT     IMDATA+1
02074  00001614 00 0 P01614 0            HLT     AG
02075  00001616 00 0 P01616 0            HLT     AH
                                        END
```

NUMBER OF LINES WITH DIAGNOSTICS 0

APPENDIX D

Listing of Routines MNPSDAF, PSDCNTLF, PSDFFT, AKBK, THDOCT, and PLOTPSDF

```
      PROGRAM MNPSDAF
C ***
C     ****************      PROGRAM NO. WCP/68-20      ************************
C     THIS PROGRAM IS THE MAIN CONTROL PROGRAM FOR PROCESSING RANDOM DATA
C     ACQUIRED ON THE A/D SYSTEM CONNECTED TO THE CDC 3300 COMPUTER, THE
C     MOST USUAL PROCESSING IS THE CALCULATION OF POWER SPECTRAL DENSITY
C     FOR WHICH SEVERAL SETS OF SUBROUTINES ARE AVAILABLE, VARIOUS OTHER
C     PROCESSING TECHNIQUES ARE POSSIBLE.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IHALF,MD(2),ID(13),INF(7),ISTACK,IFILE,
     1NCOUNT,NOCT,FU,FL,DF,TEMP1,TEMP2,IDATA(1024),JDATA(1024),N(6),
     2REAL(1024),QUAD(1024),AK(513),BK(513),I,K,L,J
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,NPTS,MPTS,MBAR,PSD(513),
     1FRQ(513),F1,F2,NDECS,IPRINT,ISCALE
      EQUIVALENCE (SRATE,N(4))
      CALL LPFILT(N1024R)
   10 MD(1)=MD(2)=0
      REWIND 1
      REWIND 2
      READ(60,900)ITEST,ISTACK,IFILE,ISTAT,M,NREC,NOCT,F1,F2,NDECS,
     1IPRINT,ITHD
      ISTACK = ISTACK+1
      CALL SETUP
      IF(M-10)11,11,12
   12 WRITE(61,13)
   13 FORMAT (1H0, 10X 17HM GREATER THAN 10)
      STOP
   11 IF(F1-F2)14,15,15
   15 WRITE(61,16)F1,F2
   16 FORMAT (1H0, 10X 4HF1 =, E15.5, 2X 15HGREATER THAN F2, E15.5)
      STOP
   14 IF(NDECS-10)17,18,18
   18 WRITE(61,19)
   19 FORMAT (1H0, 10X 35HMORE THAN 10 PLOT DECADES SPECIFIED      )
      STOP
   17 CALL COSTABLE(M)
      CALL FFT42M(M,M,1,REAL(1),QUAD(1),J)
      ID(11)=ITEST
      ITHD=ITHD+1
      N1024R=2**(NOCT-1)*NREC
      N1024S=N1024R
   20 READ(60,910)ICHAN1,ICHAN2,S,SS,ISCALE
      ISCALE = ISCALE+1
      IF(ICHAN1.EQ.4HEND )120,30
   30 IF(ICHAN1.EQ.4HNEWT)10,40
   40 CALL DEMUX(N1024R,ISTAT,0)
      I=2**(11-M)*NREC
      IF(N1024R-N1024S)50,60,60
   50 K=N1024R
      J=1
   70 K=K/2
      J=J+1
      IF(K-NREC)80,80,70
   80 NOCT=J
      K=2**(11-M)*K
      J=J-1
      WRITE(61,920)K,I,J
      GO TO 90
   60 WRITE(61,930)I
   90 CALL PSDCNTLF
```

```
      SRATE = 2.0*SRATE/FLOAT(NPTS)
      WRITE (61,950) NOCT,SRATE
      WRITE (61,940)
      GO TO (100,110)ITHD
100   CALL ONECYC
      GO TO 20
110   CALL THDOCT
      CALL OCTOV3
      GO TO 20
120   STOP
900   FORMAT (A4, 2I2, 4I4, 2F10.0, 3I4)
910   FORMAT (2A4, 2F10.0, I2)
920   FORMAT (1H0, 10X I5, 47HDEGREES OF FREEDOM IN LOWER BAND AND 1STOC
     1TAVE , / 10X I5, 26HDEGREES OF FREEDOM IN NEXT, I3, X 23HOCTAVES A
     2ND UPPER BAND,)
930   FORMAT (1H0, 10X I5,X19HDEGREES OF FREEDOM,)
940   FORMAT (1H0, 80(1H*))
950   FORMAT (11X 27HNUMBER OF FREQUENCY BANDS = ,I3, / 11X
     1 44HANALYSIS BANDWIDTH IN UPPER FREQUENCY BAND = , F5.1, 2X 2HHZ )
      END

        3200 FORTRAN DIAGNOSTIC RESULTS - FOR   MNPSDAF

NO ERRORS
```

```
      SUBROUTINE PSDCNTLF
C ***
C     THIS ROUTINE CONTROLS THE CALCULATION OF FILTERED DATA AND POWER SPECTRAL
C     DENSITY. APPROPRIATE OCTAVE RANGES ARE STORED IN ARRAYS PSD AND FRQ.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),REAL(1024),QUAD(1024),AK(513),
     2FK(513),I,S,L,KREC
      EQUIVALENCE (SRATE,N(4))
      COMMON /DATA/ IAT(6),M,NOCT,NREC,S,NPTS,MPTS,MBAR,PSD(513),
     1FRQ(513),F1,F2,NRECS,IPRINT,ISCALE
      NPTS=2**M
      MPTS=NPTS/2+1
      MBAR=512/NPTS
      KOCT=0
      CALL PSDFFT
      FU=SRATE/2.0
      DF=2.0
 10   IF(DF-FU)20,30,30
 20   DF=DF+DF
      GO TO 10
 30   FU=DF/2.0
      NCOUNT=513
      DO 40 I=1,513
 40   FRQ(I)=0.0
      S = 4.0*S*S
 50   KOCT=KOCT+1
      DF = SRATE/2.0**KOCT
      TEMP1 = S*DF*FLOAT(1024*KREC)
      AK(1)=0.0
      DF = DF*2.0/FLOAT(NPTS)
      DO 60 I=2,MPTS
      AK(I)=AK(I)/TEMP1
 60   AK(I)=AK(I-1)+DF
      FL=FU/2.0
      L = MPTS+2
      IF(KOCT-NOCT)80,70,70
 70   FL=0.0
 80   DO 100 J=2,MPTS
      L = L-1
      IF(AK(J)-FL)110,90,90
 90   IF(NCOUNT-513)120,130,120
 120  IF(AK(J)-FRQ(NCOUNT+1))130,100,100
 130  PSD(NCOUNT)=AK(J)
      FRQ(NCOUNT)=AK(J)
      NCOUNT=NCOUNT-1
 100  CONTINUE
 110  FU=FL
      IF(NCOUNT)140,140,150
 150  IF(KOCT-NOCT)170,160,160
 170  CALL CUTOFF(3)
      CALL PSDFFT
      GO TO 50
 140  WRITE(A1,900)
 900  FORMAT (1H0,10X  29HTOO MANY POINTS IN PSD RANGE.)
 160  RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PSDCNTLF

```
      SUBROUTINE PSDFFT
C ***
C     THIS SUBROUTINE CALCULATES POWER SPECTRAL DENSITY FOR A GIVEN SET OF DATA
C     BY FOURIER ANALYSIS,  THE DATA IS ON LOGICAL UNIT 3 AND THE SUMS OF
C     SQUARED AND HANNED FOURIER COEFFICIENTS ARE RETURNED IN COMMON ARRAY AK,
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),REAL(1024),QUAD(1024),AK(513),
     2BK(513),I,K,L,KREC,KBAR,J
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,NPTS,MPTS,MBAR,PSD(513),
     1FRQ(513),F1,F2,NDECS,IPRINT,ISCALE
      REWIND 3
      BUFFER IN(3,1)(N(1),N(6))
      IF (KOCT-NOCT+1)5,15,15
    5 BUFFER IN(3,1)(IDATA(1),IDATA(10))
   15 KREC=K=L=0
      DO 10 I=1,MPTS
   10 AK(I)=BK(I)=0.0
   20 BUFFER IN(3,1)(IDATA(1),IDATA(1024))
   30 GO TO (30,40,50,60)UNITSTF(3)
   60 CALL ERRECOV(7,J,K,I)
      IF(I-1)20,260,20
  260 WRITE(59,900)
  900 FORMAT (5X 36HPARITY ERROR READING LOGICAL UNIT 3 ,/ 5X
     155HAFTER ERROR FREE WRITE, CLEAN TAPE HEAD AND REPEAT JOB, //)
      STOP
   40 IF(NPTS-1024)80,90,90
   80 KREC=KREC+1
      BUFFER IN(3,1)(JDATA(1),JDATA(1024))
      DO 100 J=1,MBAR
      KBAR=2*(J-1)
      DO 110 I=1,NPTS
      K=KBAR*NPTS+I
      L=K+NPTS
      REAL(I)=FLOAT(IDATA(K))
  110 QUAD(I)=FLOAT(IDATA(L))
      CALL FFT
      CALL AKBK
  100 CONTINUE
      K=0
      IF (KREC-NREC)120,50,50
  120 GO TO (120,130,50,140)UNITSTF(3)
  140 CALL ERRECOV(7,J,K,I)
      IF(I-1)270,260,270
  270 BUFFER IN(3,1)(JDATA(1),JDATA(1024))
      GO TO 120
  130 BUFFER IN(3,1)(IDATA(1),IDATA(1024))
      KREC=KREC+1
      DO 190 J=1,MBAR
      KBAR=2*(J-1)
      DO 200 I=1,NPTS
      K=KBAR*NPTS+I
      L=K+NPTS
      REAL(I)=FLOAT(JDATA(K))
  200 QUAD(I)=FLOAT(JDATA(L))
      CALL FFT
      CALL AKBK
  190 CONTINUE
      K = 0
      IF(KREC-NREC)30,50,50
```

```
90    BUFFER IN(3,1)(JDATA(1),JDATA(1024))
      KREC=KREC+2
      DO 210 I=1,1024
210   REAL(I)=FLOAT(IDATA(I))
      K=0
220   GO TO (220,230,230,240)UNITSTF(3)
240   CALL ERRECOV(7,J,K,I)
      IF (I-1)280,260,280
280   BUFFER IN(3,1)(JDATA(1),JDATA(1024))
      GO TO 220
230   BUFFER IN(3,1)(IDATA(1),IDATA(1 24))
      DO 250 I=1,1024
250   QUAD(I)=FLOAT(JDATA(I))
      CALL FFT
      CALL AKBK
      K = 0
      IF(KREC-NREC)30,50,50
50    RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PSDFFT

NO ERRORS

```
      SUBROUTINE AKBK
C ***
C     THIS ROUTINE FORMS THE SUMS OF SQUARED AND HANNED FOURIER COEFFICIENTS
C     IN COMMON ARRAY AK
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(37),IDATA(1024),JDATA(1024),N(6),
     1REAL(1024),QUAD(1024),AK(513),BK(513),I,K,L,KREC,KBAR,J,CK(513),
     2DK(513),A,B,C,D
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,NPTS,MPTS,MBAR,PSD(513),
     1FRQ(513),F1,F2,NDECS,IPRINT,ISCALE
      K=MPTS+MPTS
      DO 10 I=2,MPTS
      J=K-I
      CK(I)=REAL(I)+REAL(J)
      DK(I)=QUAD(I)-QUAD(J)
      REAL(I)=REAL(J)-REAL(I)
   10 QUAD(I)=QUAD(I)+QUAD(J)
      CK(1)=DK(1)=REAL(1)=QUAD(1)=0.0
      K=MPTS-1
      A=0.5 *(CK(MPTS)-CK(K))
      B=0.5 *(DK(MPTS)-DK(K))
      C=0.5 *(REAL(MPTS)-REAL(K))
      D=0.5 *(QUAD(MPTS)-QUAD(K))
      AK(MPTS)=AK(MPTS)+A*A+B*B+C*C+D*D
      DO 20 I=2,K
      L=I+1
      J=I-1
      A=CK(I)-0.5*(CK(J)+CK(L))
      B=DK(I)-0.5*(DK(J)+DK(L))
      C=REAL(I)-0.5*(REAL(J)+REAL(L))
      D=QUAD(I)-0.5*(QUAD(J)+QUAD(L))
   20 AK(I) = AK(I)+A*A+B*B+C*C+D*D
      RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR AKBK

NO ERRORS

```
      SUBROUTINE THDOCT
C ***
C     THIS ROUTINE CONVERTS 1 CYCLE BAND PSD ANALYSIS TO ONE-THIRD OCTAVE BAND
C     ANALYSIS STARTING AT A SPECIFIED CENTER FREQUENCY, RESULTS ARE RETURNED IN
C     COMMON ARRAYS PSD AND FRQ.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),REAL(1024),QUAD(1024),AK(513),
     2BK(513),I,K,L,J,NN
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,NPTS,MPTS,MBAR,PSD(513),
     1FRQ(513),F1,F2,NDECS,IPRINT,ISCALE
      MUP = 513
      DO 10 I=1,MUP
      IF(FRQ(I))20,10,20
 10   CONTINUE
      RETURN
 20   DF=FRQ(I+1)-FRQ(I)
      SRT = SQRT(2.0)
      FL = 31.5/SRT
      TEMP2=2.0**(1.0/6.0)
      TEMP1=TEMP2*TEMP2
      DEL1=TEMP1-1.0
      DEL2=TEMP1*DEL1
      DEL3=2.0*(1.0-1.0/TEMP1)
 30   IF(FL*DEL1-DF)40,70,70
 40   IF(FL*DEL2-DF)50,80,80
 50   IF(FL*DEL3-DF)60,90,90
 60   FL=FL+FL
      GO TO 30
 70   FL=FL*TEMP2
      GO TO 100
 80   FL = FL*SRT
      GO TO 100
 90   FL = FL*32.0**(1.0/6.0)
 100  NCOUNT=0
      J=1
 110  DEL1=FL/TEMP2
      DEL2=FL*TEMP2
      DO 120 K=J,MUP
      IF(DEL1-FRQ(K))130,130,120
 120  CONTINUE
      RETURN
 130  DO 150 J=K,MUP
      IF(DEL2-FRQ(J))140,160,150
 150  CONTINUE
      J = MUP
      DEL2=FRQ(MUP)
 160  DF=FRQ(K)-FRQ(K-1)
      TEMP4=PSD(K-1)+(DEL1-FRQ(K-1))*(PSD(K)-PSD(K-1))/DF
      DEL3=(FRQ(K)-DEL1)*(TEMP4+PSD(K))/2.0
      TEMP4=PSD(J-1)+(DEL2-FRQ(J-1))*(PSD(J)-PSD(J-1))/(FRQ(J)-FRQ(J-1))
      DEL3=DEL3+(DEL2-FRQ(J-1))*(TEMP4+PSD(J-1))/2.0
      IF(J-K-1)180,180,170
 170  L=J-2
      DO 190 NN=K,L
 190  DEL3 = DEL3+(FRQ(NN+1)-FRQ(NN))*(PSD(NN+1)+PSD(NN))/2.0
 180  NCOUNT=NCOUNT+1
      AK(NCOUNT) = FL
      BK(NCOUNT)=DEL3/(DEL2-DEL1)
      FL=FL*TEMP1
```

```
      IF(DEL2-FRQ(MUP))110,200,200
200   IF (FRQ(MUP)-AR(NCOUNT))210,220,220
210   NCOUNT = NCOUNT+1
220   RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR THDOCT

NO ERRORS

```
      SUBROUTINE PLOTPSDF
C ***
C     THIS ROUTINE PLOTS PSD AGAINST FREQUENCY ON LOGARITHMIC AXES, ENTRY
C     ONECYC FOR PSD PLOT AND ENTRY OCTOV3 FOR 1/3 OCTAVE PLOTS,  ENTRY SETUP
C     FOR INITIALIZING THE FREQUENCY SCALE CALCULATION.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),REAL(1024),QUAD(1024),AK(513),
     2BK(513),I,K,L,J,NN
      EQUIVALENCE(ZSCALE,REAL(1))
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,NPTS,MPTS,MBAR,PSD(513),
     1FRQ(513),F1,F2,NDECS,IPRINT,ISCALE
      ENTRY SETUP
      TEMP4=ALOG10(F1)
      TEMP2=ALOG10(F2)
      K1=IFIX(TEMP4)+1
      L=IFIX(TEMP2)
      FL = FLOAT(K1)-TEMP4
      FU=TEMP2-FLOAT(L)
      XSCALE=6.0/(FLOAT(L-K1)+FU+FL)
      TEMP4=TEMP4*XSCALE
      K1=K1-1
      DE=10.0**K1
      YSCALE=6.0/FLOAT(NDECS)
      CALL PLOT(-11.5,0.0,-3)
      CALL PLOT(1.5,0.0,-3)
      RETURN
      ENTRY OCTOV3
      J=513-NCOUNT
      DO 10 I=1,NCOUNT
      K=J+I
      PSD(K)=BK(I)
 10   FRQ(K)=AK(I)
      NCOUNT=514-NCOUNT
      GO TO 20
      ENTRY ONECYC
 20   FU=0.0
      NCOUNT = NCOUNT+1
      DO 30 I=NCOUNT,513
      IF(PSD(I)-FU)30,30,40
 40   FU=PSD(I)
 30   CONTINUE
      K=IFIX(ALOG10(FU))
      IF(FL-1.0)50,60,60
 50   ZSCALE=FLOAT(NDECS-K)
      K=K-1
      GO TO 70
 60   ZSCALE=FLOAT(NDECS-K-1)
 70   CALL PLOT(0.0,0.0,3)
      FU=1.0
      DO 80 I=1,NDECS
      J=K-NDECS+I
      FL=FLOAT(I-1)*YSCALE
      CALL SYMBL4(-0.65,FL-0.07,0.14,2H10,0.0,2)
      CALL NUMBER(-0.45,FL,0.1,J,0.0,2HI3)
      GO TO (90,80)ISCALE
 90   CALL PLOT(0.0,FL,3)
      L=0
 100  DF=10.0**(I-1)
      L=L+1
```

```
      FU=FL+DF
      FL=YSCALE*ALOG10(FU)
      CALL PLOT(0,0,FL,2)
      IF(L-9)120,110,120
110   CALL PLOT(0,25,FL,2)
      CALL PLOT(0,0,FL,2)
      GO TO 80
120   CALL PLOT(0,15,FL,2)
      CALL PLOT(0,0,FL,2)
      GO TO 100
80    CONTINUE
      J=K+1
      CALL SYMBL4(-0,65,5,925,0,14,2H10,0,0,2)
      CALL NUMBER(-0,45,6,0,0,1,J,0,0,2HI3)
      GO TO (140,130)ISCALE
130   CALL PLOT(0,0,5,7,3)
      CALL PLOT(0,0,6,0,2)
      CALL PLOT(0,3,6,0,2)
      GO TO 150
140   CALL PLOT(5,7,6,0,3)
      CALL PLOT(6,0,6,0,2)
      CALL PLOT(6,0,5,7,2)
150   GO TO (170,160)ISC
160   CALL PLOT(6,0,0,3,3)
      CALL PLOT(6,0,0,0,2)
      CALL PLOT(5,7,0,0,2)
      CALL PLOT(0.3,0,0,3)
      CALL PLOT(0,0,0,0,2)
      CALL PLOT(0,0,0,3,2)
      GO TO 180
170   CALL NUMBER(-0,1,-0,4,0,14,F1-0,0,4HF2,0)
      CALL PLOT(0,0,0,0,3)
      FL=F1
      DF=DE
      L=K1
190   FL=FL+DF
      FU=ALOG10(FL)
      TEMP1=XSCALE*FU-TEMP4
      IF(TEMP1-6,0)200,210,210
200   CALL PLOT(TEMP1,0,0,2)
      K=IFIX(FU+0,0005)
      IF(K-L)230,230,220
280   L=K
      DF=10,0**L
      CALL PLOT(TEMP1,0,25,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
230   CALL PLOT(TEMP1,0,15,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
210   CALL PLOT(6,0,0,0,2)
      CALL PLOT(6,0,0,3,2)
      CALL NUMBER(5,7,-0,4,0,14,F2,0,0,4HF5,0)
180   CALL SYMBL4(0,0,-0,9,0,14,ITEST,0,0,4)
      CALL SYMBL4(1,25,-0,9,0,14,ICHAN1,0,0,4)
      DO 240 I=NCOUNT,513
      IF(FRQ(I)-F1)240,250,250
240   CONTINUE
250   TEMP1=XSCALE*ALOG10(FRQ(I))-TEMP4
      TEMP2=YSCALE*(ALOG10(PSD(I))+ZSCALE)
      IF(TEMP2)260,270,270
260   TEMP2=0,0
```

```
270   CALL PLOT(TEMP1,TEMP2,3)
      DO 280 J=I,513
      IF (FRQ(J)-F2)330,330,280
330   TEMP1=XSCALE*ALOG10(FRQ(J))-TEMP4
      TEMP2=YSCALE*(ALOG10(PSD(J))+ZSCALE)
      IF(TEMP2)290,300,300
290   TEMP2=0.0
300   CALL PLOT(TEMP1,TEMP2,2)
280   CONTINUE
      CALL PLOT(0.0,10.0,-3)
      IF(IFRINT)310,320,310
310   WRITE(61,900)ITEST,ICHAN1
900   FORMAT (1H1, 44X 8HTEST NO., 2X A4, 15X 11HCHANNEL NO., 2X A4 , //
     1 8X 4(4HFREQ, 6X 6HP.S.D., 14X))
      WRITE(61,910)(FRQ(I),PSD(I),I=NCOUNT,513)
910   FORMAT (2X 4(F10.2,E15.5,5X))
320   RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PLOTPSDF

NO ERRORS

APPENDIX E

Listing of Routines MNCPSDF, CPSDCTLF, CPSDFFT, HANN, PLTCPSDF

```
      PROGRAM MNCPSDF
C ***
C     ****************      PROGRAM NO. WCP/68-22      ************************
C     THIS PROGRAM IS THE MAIN CONTROL PROGRAM FOR PROCESSING RANDOM DATA
C     ACQUIRED ON THE A/D SYSTEM CONNECTED TO THE CDC 3300 COMPUTER. THE
C     MOST USUAL PROCESSING IS THE CALCULATION OF POWER SPECTRAL DENSITY
C     FOR WHICH SEVERAL SETS OF SUBROUTINES ARE AVAILABLE, VARIOUS OTHER
C     PROCESSING TECHNIQUES ARE POSSIBLE.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IHALF,MD(2),ID(13),INF(7),ISTACK,IFILE,
     1NCOUNT,KOCT,FU,FL,DF,TEMP1,TEMP2,IDATA(1024),JDATA(1024),N(6),
     2REAL(1024),QUAD(1024),AK(513),BK(513),I,K,L,J
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,SS,NPTS,MPTS,MBAR,PSD(513),
     1 FRQ(513),QSD(513),RSD(513),SSD(513),NDECS,IPRINT,F1,F2,ISCALE
      EQUIVALENCE (SRATE,N(4))
      CALL LPFILT(N1024R)
   10 MD(1)=MD(2)=0
      REWIND 1
      REWIND 2
      READ(60,900)ITEST,ISTACK,IFILE,ISTAT,M,NREC,NOCT,F1,F2,NDECS,
     1IPRINT,ICNTL
      ISTACK = ISTACK+1
      CALL SETUP(ICNTL)
      ICNTL=ICNTL+1
      IF(M-10)11,11,12
   12 WRITE(61,13)
   13 FORMAT (1H0, 10X 17HM GREATER THAN 10)
      STOP
   11 IF(F1-F2)14,15,15
   15 WRITE(61,16)F1,F2
   16 FORMAT (1H0, 10X 4HF1 =, E15.5, 2X 15HGREATER THAN F2, E15.5)
      STOP
   14 IF(NDECS-10)17,18,18
   18 WRITE(61,19)
   19 FORMAT (1H0, 10X 35HMORE THAN 10 PLOT DECADES SPECIFIED      )
      STOP
   17 CALL COSTABLE(M)
      CALL FFT42M(M,M,1,REAL(1),QUAD(1),0)
      ID(11)=ITEST
      ITHD=ITHD+1
      N1024R=2**(NOCT-1)*NREC
      N1024S=N1024R
      N1 = ITIME(M)
   20 READ(60,910)ICHAN1,ICHAN2,S,SS,ISCALE
      ISCALE = ISCALE+1
      IF(ICHAN1.EQ.4HEND )120,30
   30 IF(ICHAN1.EQ.4HNEWT)10,40
   40 CALL DEMUX(N1024R,ISTAT,0)
      I=2**(11-M)*NREC
      IF(N1024R-N1024S)50,60,60
   50 K=N1024R
      J=1
   70 K=K/2
      J=J+1
      IF(K-NREC)80,80,70
   80 NOCT=J
      K=2**(11-M)*K
      J=J-1
      WRITE(61,920)K,I,J
      GO TO 90
```

```
60    WRITE(61,930)I
 90   CALL CPSDCTLF
      SRATE = 2.0*SRATE/FLOAT(NPTS)
      WRITE (61,950) NOCT,SRATE
      WRITE (61,940)
      GO TO (100,110,130,140) ICNTL
100   CALL ONECYC(0)
      N2 = ITIME(M)-N1
      WRITE (61,1000) N2
1000   FORMAT (1H0, 25X 6HTIME =, I10)
      GO TO 20
110   CALL ONECYC(-1)
      GO TO 100
130   CALL ONECYC( 1)
      GO TO 100
140   CALL ONECYC(-1)
      GO TO 130
120   STOP
900   FORMAT (A4, 2I2, 4I4, 2F10.0, 3I4)
910   FORMAT (2A4, 2F10.0, I2)
920   FORMAT (1H0, 10X I5, 47HDEGREES OF FREEDOM IN LOWER BAND AND 1STOC
     1TAVE , / 10X I5, 26HDEGREES OF FREEDOM IN NEXT, I3, X 23HOCTAVES A
     2ND UPPER BAND,)
930   FORMAT (1H0, 10X I5,X19HDEGREES OF FREEDOM,)
940   FORMAT (1H0, 80(1H*))
950   FORMAT (11X 27HNUMBER OF FREQUENCY BANDS = ,I3, / 11X
     1 44HANALYSIS BANDWIDTH IN UPPER FREQUENCY BAND = , F5.1, 2X 2HHZ )
      END

          3200 FORTRAN DIAGNOSTIC RESULTS - FOR   MNCPSDF

NO ERRORS
```

```
      SUBROUTINE CPSDCTLF
C ***
C     THIS ROUTINE CONTROLS THE CALCULATION OF FILTERED DATA AND CROSS AND
C     DIRECT PSD FROM PAIRS OF DATA CHANNELS STORED ON LOGICAL UNITS 3 AND 4.
C     RESULTS ARE STORED IN ARRAYS PSD, QSD, RSD, AND SSD.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,   IDATA(1024),JDATA(1024),N(6),REAL(1024),QUAD(1024),
     2AK(513),BK(513),I,K,L,KREC,KBAR,J,CK(513),DK(513)
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,SS,NPTS,MPTS,MBAR,PSD(513),
     1 FRQ(513),QSD(513),RSD(513),SSD(513),NDECS,IPRINT,F1,F2,ISCALE
      DIMENSION FRE(813)
      EQUIVALENCE (SRATE,N(4)),(FRE(1),REAL(1))
      NPTS=2**M
      MPTS=NPTS/2+1
      MBAR=1024/NPTS
      S1 = 4.0*SS*SS
      SS = 4.0*S*SS
      S = 4.0*S*S
      KOCT=0
      CALL CPSDFFT
      FU=SRATE/2.0
      DF=2.0
 10   IF (DF-FU)20,30,30
 20   DF=DF*DF
      GO TO 10
 30   FU=DF/2.0
      NCOUNT = 513
      DO 40 I=1,513
 40   FRQ(I)=0.0
 50   KOCT=KOCT+1
      DF = SRATE/2.0**KOCT
      FRE(1)=0.0
      TEMP1 = DF*FLOAT(1024*KREC)
      DF = DF*2.0/FLOAT(NPTS)
      DO 60 I=2,MPTS
      AK(I)=AK(I)/TEMP1
      BK(I)=BK(I)/TEMP1
      CK(I)=CK(I)/TEMP1
      FRE(I) = FRE(I-1)+DF
 60   DK(I)=DK(I)/TEMP1
      FL=FU/2.0
      L = MPTS*2
      IF(KOCT-NOCT)80,70,70
 70   FL=0.0
 80   DO 100 I=2,MPTS
      J = L-I
      IF(FRE(J)-FL)110,90,90
 90   IF(NCOUNT-513)120,130,120
 120  IF(FRE(J)-FRQ(NCOUNT+1))130,100,100
 130  PSD(NCOUNT)=AK(J)/S
      QSD(NCOUNT) = BK(J)/S1
      RSD(NCOUNT)=CK(J)/SS
      SSD(NCOUNT)=DK(J)/SS
      FRQ(NCOUNT)=FRE(J)
      NCOUNT=NCOUNT+1
 100  CONTINUE
 110  FU=FL
      IF(NCOUNT)140,140,150
 150  IF(KOCT-NOCT)170,160,160
```

```
170   CALL CUTOFF(3)
      CALL CUTOFF(4)
      CALL CPSDFFT
      GO TO 50
140   WRITE(61,900)
900   FORMAT (1H0, 10X 29HTOO MANY POINTS IN PSD RANGE.)
160   RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR CPSDCTLF

NO ERRORS

```
      SUBROUTINE CPSDFFT
C ***
C     THIS ROUTINE CALCULATES POWER SPECTRAL  DENSITIES FOR A PAIR OF CHANNELS
C     FROM THEIR FOURIER COEFFICIENTS, CROSS AND AUTO PSD-S ARE SUMMED FOR EACH
C     SUB-RECORD AND RETURNED IN COMMON ARRAYS
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,   IDATA(1024),JDATA(1024),N(6),REAL(1024),QUAD(1024),
     2AK(513),BK(513),I,K,L,KREC,KBAR,J,CK(513),DK(513)
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,SS,NPTS,MPTS,MBAR,PSD(513),
     1 FRQ(513),QSD(513),RSD(513),SSD(513),NDECS,IPRINT,F1,F2,ISCALE
      REWIND 3
      REWIND 4
      BUFFER IN(3,1)(N(1),N(6))
      BUFFER IN(4,1) (JDATA(1),JDATA(10))
      IF (KOCT-NOCT+1)5,15,15
    5 BUFFER IN(3,1)(IDATA(1),IDATA(10))
      BUFFER IN(4,1)(JDATA(1),JDATA(10))
   15 KREC=0
      DO 10 I=1,MPTS
   10 AK(I)=BK(I)=CK(I)=DK(I)=0.0
   20 BUFFER IN(3,1)(IDATA(1),IDATA(1024))
      BUFFER IN(4,1)(JDATA(1),JDATA(1024))
      K=L=0
   30 GO TO (30,40,50,60)UNITSTF(3)
   60 CALL ERRECOV(7,3,K,I)
      IF(I-1)70,80,70
   80 WRITE(59,900)
  900 FORMAT (5X  46HPARITY ERRORS ON READING LOGICAL UNITS 3 AND 4, /
     1 5X 57HAFTER ERROR FREE WRITES, CLEAN TAPE HEADS AND REPEAT JOB,)
      STOP
   70 BUFFER IN(3,1)(IDATA(1),IDATA(1024))
      GO TO 30
   40 GO TO (40,90,50,100)UNITSTF(4)
  100 CALL ERRECOV(7,4,L,I)
      IF(I-1)110,80,110
  110 BUFFER IN(4,1)(JDATA(1),JDATA(1024))
      GO TO 40
   90 KREC=KREC+1
      DO 120 J=1,MBAR
      KBAR=J-1
      DO 140 I=1,NPTS
      K=KBAR*NPTS+I
      REAL(I)=FLOAT(IDATA(K))
  140 QUAD(I)=FLOAT(JDATA(K))
      CALL FFT
      CALL HANN
  120 CONTINUE
      IF(KREC-NREC)20,50,50
   50 RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR CPSDFFT

NO ERRORS

```
      SUBROUTINE HANN
C ***
C     THIS ROUTINE CALCULATES THE FOUR SETS OF FOURIER COEFFICIENTS FOR A PAIR
C     OF RECORDS WHICH HAVE BEEN SIMULTANEOUSLY FOURIER ANALYSED. RESULTS ARE
C     SUMMED IN ARRAYS AK,BK,  CK AND DK.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,    IDATA(1024),JDATA(1024),N(6),REAL(1024),QUAD(1024),
     2AK(513),BK(513),I,K,L,KREC,KBAR,J,CK(513),DK(513)
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,SS,NPTS,MPTS,MBAR,PSD(513),
     1 FRQ(513),QSD(513),RSD(513),SSD(513),NDECS,IPRINT,F1,F2,ISCALE
      DIMENSION TMP1(513),TMP2(513)
      EQUIVALENCE (TMP1(1),IDATA(1)),(TMP2(1),JDATA(1))
      K=MPTS+MPTS
      DO 10 I=2,MPTS
      J=K-I
      L=I+1
      TMP1(L)=REAL(I)+REAL(J)
      TMP2(L)=QUAD(I)+QUAD(J)
      REAL(L)=REAL(J)-REAL(I)
   10 QUAD(L)=QUAD(I)+QUAD(J)
      L = MPTS+1
      K = MPTS+2
      A=0.5*(TMP1(L)-TMP1(K))
      B=0.5*(TMP2(L)-TMP2(K))
      C = 0.5*(REAL(L)+REAL(K))
      D=0.5*(QUAD(L)-QUAD(K))
      AK(MPTS)=AK(MPTS)+A*A+B*B
      BK(MPTS)=BK(MPTS)+C*C+D*D
      CK(MPTS)=CK(MPTS)+A*D+B*C
      DK(MPTS)=DK(MPTS)+B*D-A*C
      DO 20 I=1,K
      L=I+1
      J=I+2
      A=TMP1(L)=0.5*(TMP1(I)+TMP1(J))
      B=TMP2(L)=0.5*(TMP2(I)+TMP2(J))
      C=REAL(L)=0.5*(REAL(I)+REAL(J))
      D=QUAD(L)=0.5*(QUAD(I)+QUAD(J))
      AK(L)=AK(L)+A*A+B*B
      BK(L)=BK(L)+C*C+D*D
      CK(L)=CK(L)+A*D+B*C
      DK(L)=DK(L)+B*D-A*C
   20 CONTINUE
      RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR HANN

NO ERRORS

```
      SUBROUTINE PLTCPSDF(ICNTL)
C ***
C     THIS ROUTINE PLOTS PSD AGAINST FREQUENCY ON LOGARITHMIC AXES, ENTRY
C     ONECYC FOR PSD PLOT AND ENTRY OCTOV3 FOR 1/3 OCTAVE PLOTS,  ENTRY SETUP
C     FOR INITIALIZING THE FREQUENCY SCALE CALCULATION.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,   IDATA(1024),JDATA(1024),N(6),REAL( 024),QUAD(1024),
     2AK(513),BK(513),I,K,L,J,NN
      COMMON /DATA/ IWT(6),M,NOCT,NREC,S,SS,NPTS,MPTS,MBAR,PSD(513),
     1 FRQ(513),QSD(513),RSD(513),SSD(513),NDECS,IPRINT,F1,F2,ISCALE
      EQUIVALENCE (ZSCALE,REAL(1))
      ENTRY SETUP
      TEMP4=ALOG10(F1)
      TEMP2=ALOG10(F2)
      K1=IFIX(TEMP4)+1
      L=IFIX(TEMP2)
      FL = FLOAT(K1)-TEMP4
      FU=TEMP2-FLOAT(L)
      XSCALE=6.0/(FLOAT(L-K1)+FU+FL)
      TEMP4=TEMP4*XSCALE
      K1=K1+1
      DE=10.0**K1
      YSCALE=6.0/FLOAT(NDECS)
      CALL PLOT(-11.5,0.0,-3)
      CALL PLOT(2.0,0.0,-3)
      RETURN
      ENTRY OCTOV3
      J=513-NCOUNT
      DO 10 I=1,NCOUNT
      K=J+I
      PSD(K)=BK(I)
 10   FRQ(K)=AK(I)
      NCOUNT=514-NCOUNT
      GO TO 20
      ENTRY ONECYC
 20   FU=0.0
      NCOUNT = NCOUNT+1
      CALL SYMBL4(0.0,-0.9,0.14,ITEST,0.0,4)
      IF(ICNTL)330,340,350
 330  NN = ICHAN1
      DO 450 I=NCOUNT,513
 450  AK(I) = PSD(I)
      GO TO 360
 350  NN = ICHAN2
      DO 460 I=NCOUNT,513
 460  AK(I) = QSD(I)
 360  CALL SYMBL4(1.25,-0.9,0.14,NN,0.0,4)
      GO TO 370
 340  CALL SYMBL4(1.25,-0.9,0.14,ICHAN1,0.0,4)
      CALL SYMBL4(2.00,-0.9,0.14,ICHAN2,0.0,4)
      DO 470 I=NCOUNT,513
      AK(I) = SQRT(RSD(I)*RSD(I)+SSD(I)*SSD(I))
      IF (RSD(I))480,490,500
 490  IF(SSD(I))520,530,540
 520  SSD(I)=-1.5707963
      GO TO 470
 540  SSD(I)=1.5707963
      GO TO 470
 530  SSD(I)=0.0
```

```
      GO TO 470
500   TEMP1=0.0
      GO TO 510
450   IF(SSD(I))550,560,560
550   TEMP1=-3.1415926535
      GO TO 510
560   TEMP1=3.1415926535
510   SSD(I)=ATAN(SSD(I)/RSD(I))+TEMP1
470   SSD(I)=SSD(I)*57.2957795
370   DO 30 I=NCOUNT,513
      IF(AK (I)-FU)30,30,40
40    FU=AK (I)
30    CONTINUE
      K=IFIX(ALOG10(FU))
      IF(FU-1.0)50,60,60
 50   ZSCALE=FLOAT(NDECS-K)
      K=K-1
      GO TO 70
60    ZSCALE=FLOAT(NDECS-K-1)
70    CALL PLOT(0.0,0.0,3)
      FU=1.0
      DO 80 I=1,NDECS
      J=K-NDECS+I
      FL=FLOAT(I-1)*YSCALE
      CALL SYMBL4(-0.65,FL-0.07,0.14,2H10,0.0,2)
      CALL NUMBER(-0.45,FL,0.1,J,0.0,2HI3)
      GO TO (90,80)ISCALE
90    CALL PLOT(0.0,FL,3)
      L=0
100   DF=10.0**(I-1)
      L=L+1
      FU=FL+DF
      FL=YSCALE*ALOG10(FU)
      CALL PLOT(0.0,FL,2)
      IF(L-9)120,110,120
110   CALL PLOT(0.25,FL,2)
      CALL PLOT(0.0,FL,2)
      GO TO 80
120   CALL PLOT(0.15,FL,2)
      CALL PLOT(0.0,FL,2)
      GO TO 100
80    CONTINUE
      J=K+1
      CALL SYMBL4(-0.65,5.925,0.14,2H10,0.0,2)
      CALL NUMBER(-0.45,6.0,0.1,J,0.0,2HI3)
      GO TO (140,130)ISCALE
130   CALL PLOT(0.0,5.7,3)
      CALL PLOT(0.0,6.0,2)
      CALL PLOT(0.3,6.0,2)
      GO TO 150
140   CALL PLOT(5.7,6.0,3)
      CALL PLOT(6.0,6.0,2)
      CALL PLOT(6.0,5.7,2)
150   GO TO (170,160)ISCALE
160   CALL PLOT(6.0,0.3,3)
      CALL PLOT(6.0,0.0,2)
      CALL PLOT(5.7,0.0,2)
      CALL PLOT(0.3,0.0,3)
      CALL PLOT(0.0,0.0,2)

      CALL PLOT(0.0,0.3,2)
      GO TO 180
```

```
170   CALL NUMBER(-0,[illegible]=0,4,0,14,F1,0,0,4HF2,0)
      CALL PLOT(0,0,0,0,3)
      FL=F1
      DF=DF
      L=K1
190   FL=FL+DF
      FU=ALOG10(FL)
      TEMP1=XSCALE*FU-TEMP4
      IF(TEMP1-6,0)200,210,210
200   CALL PLOT(TEMP1,0,0,2)
      K=IFIX(FU+0,0005)
      IF(K-L)230,230,220
220   L=K
      DF=10,0**L
      CALL PLOT(TEMP1,0,25,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
230   CALL PLOT(TEMP1,0,15,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
210   CALL PLOT(6,0,0,0,2)
      CALL PLOT(6,0,0,3,2)
      CALL NUMBER(5,7,-0,4,0,14,F2,0,0,4HF5,0)
180   DO 240 I=NCOUNT,513
      IF(FRQ(I)-F1)240,250,250
240   CONTINUE
250   TEMP1=XSCALE*ALOG10(FRQ(I))-TEMP4
      TEMP2=YSCALE*(ALOG10(AK (I))+ZSCALE)
      IF(TEMP2)260,270,270
260   TEMP2=0,0
270   CALL PLOT(TEMP1,TEMP2,3)
      DO 280 J=I,513
      IF (FRQ(J)-F2)285,285,280
285   TEMP1=XSCALE*ALOG10(FRQ(J))-TEMP4
      TEMP2=YSCALE*(ALOG10(AK (J))+ZSCALE)
      IF(TEMP2)290,300,300
290   TEMP2=0,0
300   CALL PLOT(TEMP1,TEMP2,2)
280   CONTINUE
      IF (ICNTL)380,440,380
380   IF(IPRINT)310,320,310
310   WRITE(61,900)ITEST,NN
900   FORMAT (1H1, 20X 8HTEST NO,, 2X A4, 15X 11HCHANNEL NO,, 2X A4 , //
     1 8X 4(4HFREQ, 6X 6HP,S,D,, 14X))
      WRITE(61,910)(FRQ(I),AK (I),I=NCOUNT,513)
910   FORMAT (2X 4(F10,2,E15,5,5X))
320   CALL PLOT(0,0,10.0,-3)
      RETURN
440   CALL PLOT(0,0,6,25,-3)
      CALL PLOT(6,0,0,0,2)
      CALL PLOT(6,0,0,3,2)
      CALL PLOT(0,0,0,0,3)
      CALL PLOT(0,0,1,25,2)
      CALL PLOT(0,1,1,25,2)
      CALL PLOT(0,05,0,625,3)
      CALL PLOT(0,0 ,0.625,2)
      GO TO (441,442)ISCALE
441   CALL NUMBER(-0,55,1,18,0,14,180,0,0,2HI3)
      CALL NUMBER(-0,55,0,55,0,14, 90,0,0,2HI3)
      CALL NUMBER(-0,55,-0,07,0,14,  0,0,0,2HI3)
442   ZSCALE=1,25/180,0
      TEMP2=ZSCALE*ABS(SSD(I))
```

```
      TEMP1=XSCALE*ALOG10(FRQ(I))-TEMP4
      CALL PLOT (TEMP1,TEMP2,3)
      DO 390 J=I,513
      IF (FRQ(J)-F2)395,395,390
395   TEMP2=ZSCALE*ABS(SSD(J))
      TEMP1=XSCALE*ALOG10(FRQ(J))-TEMP4
      CALL PLOT(TEMP1,TEMP2,2)
390   CONTINUE
      CALL PLOT(0,0,1,5,-3)
      CALL PLOT(0,0,0,4,2)
      GO TO (392,391)ISCALE
392   CALL SYMBL4(-0,25,0,4,0,2,1H-,0,0,1)
      CALL SYMBL4(-0,25,0,0,0,2,1H+,0,0,1)
391   TEMP1=0,0
      TEMP2=0,4
      FL = TEMP1
      IF (SSD(I))394,393,393
394   FL = TEMP2
393   CALL PLOT(XSCALE*ALOG10(FRQ(I))-TEMP4,FL,3)
      DO 400 J=I,513
      IF (FRQ(J)-F2)405,405,400
405   FL=XSCALE*ALOG10(FRQ(J))-TEMP4
      IF(SSD(J))410,420,420
410   CALL PLOT(FL,TEMP2,2)
      GO TO 400
420   CALL PLOT(FL,TEMP1,2)
400   CONTINUE
      CALL PLOT(0,0,3,0,-3)
      IF(IPRINT)430,320,430
430   WRITE(61,920)ITEST,ICHAN1,ICHAN2
920   FORMAT (1H1, 20X 8HTEST NO,, 2X A4, 2X  9HCROSS PSD, 2X 8HCHANNELS
     1, 2X A4, 2X 3HAND, 2X A4 , //  8X  3(4HFREQ, 6X 6HP,S,D.,9 X
     2 5HPHASE,  8X))
      WRITE(61,930)(FRQ(I),AK (I),SSD(I),I=NCOUNT,513)
930   FORMAT (2X 3(F10.2,E15,5,F10,1,3X))
      RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PLTCPSDF

NO ERRORS

APPENDIX F

Listing of Routines MNPSDAA, PSDCNTLA, PSDAUTO, PLOTPSDA and CORLAT

```
      PROGRAM MNPSDAA
C ***
C     ****************     PROGRAM NO. WCP/68-21     ************************
C     THIS PROGRAM IS THE MAIN CONTROL PROGRAM FOR PROCESSING RANDOM DATA
C     ACQUIRED ON THE A/D SYSTEM CONNECTED TO THE CDC 3300 COMPUTER. THE
C     MOST USUAL PROCESSING IS THE CALCULATION OF POWER SPECTRAL DENSITY
C     FOR WHICH SEVERAL SETS OF SUBROUTINES ARE AVAILABLE. VARIOUS OTHER
C     PROCESSING TECHNIQUES ARE POSSIBLE.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IHALF,MD(2),ID(13),INF(7),ISTACK,IFILE
      COMMON                                NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024,2),N(6),EXTX(1000),AK(1001),CK(1024),I,K,L,KREC,
     2KBAR,J,XMEAN,SIGMA
      COMMON/DATA/IWT(6),M,NOCT,NREC,S,PSD(1001),FRQ(1001),F1,F2,NDECS
     1,IPRINT,ISCALE
      EQUIVALENCE (SRATE,N(4))
      CALL LPFILT(N1024R)
   10 MD(1)=MD(2)=0
      REWIND 1
      REWIND 2
      READ(60,900)ITEST,ISTACK,IFILE,ISTAT,M,NREC,NOCT,F1,F2,NDECS,
     1IPRINT
      ISTACK = ISTACK+1
      CALL SETUP
      IF (M-1000)11,11,12
   12 WRITE(61,13)
   13 FORMAT (1H0, 10X 19HM GREATER THAN 1000        )
      STOP
   11 IF(F1-F2)14,15,15
   15 WRITE(61,16)F1,F2
   16 FORMAT (1H0, 10X 4HF1 =, E15.5, 2X 15HGREATER THAN F2, E15.5)
      STOP
   14 IF(NDECS-10)17,18,18
   18 WRITE(61,19)
   19 FORMAT (1H0, 10X 35HMORE THAN 10 PLOT DECADES SPECIFIED       )
      STOP
   17 ID(11)=ITEST
      N1024R=2**(NOCT-1)*NREC
      N1024S=N1024R
   20 READ(60,910)ICHAN1,ICHAN2,S,SS,ISCALE
      ISCALE = ISCALE+1
      IF(ICHAN1.EQ.4HEND )120,30
   30 IF(ICHAN1.EQ.4HNEWT)10,40
   40 CALL DEMUX(N1024R,ISTAT,0)
      I = 2048*NREC/M
      IF(N1024R-N1024S)50,60,60
   50 K=N1024R
      J=1
   70 K=K/2
      J=J+1
      IF(K-NREC)80,80,70
   80 NOCT=J
      K = 2048*K
      J=J-1
      WRITE(61,920)K,I,J
      GO TO 90
   60 WRITE(61,930)I
   90 CALL PSDCNTLA
      SRATE = SRATE/FLOAT(M)
      WRITE (61,950) NOCT,SRATE
```

```
      WRITE (61,940)
      CALL ONECYC
      GO TO 20
120   STOP
900   FORMAT (A4, 2I2, 4I4, 2F10.0, 2I4)
910   FORMAT (2A4, 2F10.0, I2)
920   FORMAT (1H0, 10X I5, 47HDEGREES OF FREEDOM IN LOWER BAND AND 1STOC
     1TAVE , / 10X I5, 26HDEGREES OF FREEDOM IN NEXT, I3, X 23HOCTAVES A
     2ND UPPER BAND,)
930   FORMAT (1H0, 10X I5,X19HDEGREES OF FREEDOM,)
940   FORMAT (1H0, 80(1H*))
950   FORMAT (11X 27HNUMBER OF FREQUENCY BANDS = ,I3, / 11X
     1 44HANALYSIS BANDWIDTH IN UPPER FREQUENCY BAND = , F5.1, 2X 2HHZ )
      END

        3200 FORTRAN DIAGNOSTIC RESULTS - FOR   MNPSDAA

NO ERRORS
```

```
      SUBROUTINE PSDCNTLA
C ***
C     THIS ROUTINE CONTROLS THE CALCULATION OF FILTERED DATA AND POWER SPECTRAL
C     DENSITY (USING LAGGED PRODUCTS), APPROPRIATE OCTAVE RANGES ARE STORED IN
C     ARRAYS PSD AND FRQ.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024,2),N(6),EXTX(1000),AK(1001),CK(1024),I,K,L,KREC,
     2KBAR,J,XMEAN,SIGMA
      COMMON/DATA/IWT(6),M,NOCT,NREC,S,PSD(1001),FRQ(1001)
      DIMENSION FRE(1001)
      EQUIVALENCE(SRATE,N(4)),(FRE(1),IDATA(1))
      KOCT=0
      CALL PSDAUTO
      FU=SRATE/2.0
      DF=2.0
 10   IF(DF-FU)20,30,30
 20   DF=DF+DF
      GO TO 10
 30   FU=DF/2.0
      NCOUNT=1001
      DO 40 I=1,1001
 40   FRQ(I)=0.0
      S = 2.0*S*S*SRATE
 50   KOCT=KOCT+1
      TEMP1=2.0**KOCT
      DF=SRATE/(TEMP1*FLOAT(M))
      TEMP1=TEMP1/S
      FRE(1)=DF
      DO 60 I=2,M
 60   FRE(I)=FRE(I-1)+DF
      FL=FL/2.0
      L = M+1
      IF(KOCT-NOCT)80,70,70
 70   FL=0.0
 80   DO 100 J=1,M
      L = L-1
      IF(FRE(J)-FL)110,90,90
 90   IF (NCOUNT-1001)120,130,120
 120  IF (FRE(J)-FRQ(NCOUNT+1))130,100,100
 130  PSD(NCOUNT)=CK(J)*TEMP1
      FRQ(NCOUNT)=FRE(J)
      NCOUNT=NCOUNT-1
 100  CONTINUE
 110  FU=FL
      IF(NCOUNT)140,140,150
 150  IF(KOCT-NOCT)170,160,160
 170  CALL CUTOFF(3)
      CALL PSDAUTO
      GO TO 50
 140  WRITE(61,900)
 900  FORMAT (1H0, 10X 29HTOO MANY POINTS IN PSD RANGE.)
 160  RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PSDCNTLA

0 ERRORS

```
      SUBROUTINE PSDAUTO
C ***
C     THIS ROUTINE CALCULATES POWER SPECTRAL DENSITY FROM THE AUTOCORRELATION
C     FUNCTION FOR A GIVEN DATA CHANNEL WHICH IS HELD ON LOGICAL UNIT 3.
C     PSD IS RETURNED IN COMMON ARRAY CK
C
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,NOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024,2),N(6),EXTX(1000),AK(1001),CK(1024),I,K,L,KREC,
     2KBAR,J,XMEAN,SIGMA
      COMMON/DATA/IWT(6),M,NOCT,NREC
      REWIND 3
      BUFFER IN(3,1)(N(1),N(6))
      IF (KOCT*NOCT+1)5,15,15
    5 BUFFER IN(3,1)(IDATA(1,1),IDATA(10,1))
   15 KREC=L=0
      XMEAN=0.0
      K=M+1
      DO 10 I=1,K
   10 AK(I) = EXTX(I) = 0.0
   20 BUFFER IN(3,1)(IDATA(1,1),IDATA(1024,1))
   30 GO TO (30,40,50,60)UNITSTF(3)
   60 CALL ERRECOV(7,3,L,I)
      IF(I-1)20,70,20
   70 WRITE(59,900)
  900 FORMAT (5X 36HPARITY ERROR READING LOGICAL UNIT 3 ,/ 5X
     1 55HAFTER ERROR FREE WRITE, CLEAN TAPE HEAD AND REPEAT JOB.  //)
      STOP
   40 KREC=KREC+1
      BUFFER IN(3,1)(IDATA(1,2),IDATA(1024,2))
      CALL CORLAT(1)
      K=0
      IF (KREC-NREC)90,50,50
   90 GO TO (90,100,50,110)UNITSTF(3)
  110 CALL ERRECOV(7,3,K,I)
      IF(I-1)120,70,120
  120 BUFFER IN(3,1)(IDATA(1,2),IDATA(1024,2))
      GO TO 90
  100 KREC=KREC+1
      BUFFER IN(3,1)(IDATA(1,1),IDATA(1024,1))
      CALL CORLAT(2)
      L=0
      IF(KREC-NREC)30,50,50
   50 CALL FLOATAK
      K = 1024*KREC
      L=M+1
      XMEAN=XMEAN/FLOAT(K)
      XMEAN=XMEAN*XMEAN
      DO 140 I=1,L
  140 AK(I)=AK(I)/FLOAT(K-I+1)-XMEAN
      XMEAN = 3.14159265/FLOAT(M)
      SIGMA = AK(1)
      EXTX(1) = 1.0
      DO 180 J=2,M
  180 EXTX(J) = COS(FLOAT(J-1)*XMEAN)
      CALL FTRANS
      TEMP1 = CK(1)+0.5*CK(2)
      K=M-1
      TEMP2 = CK(M)+CK(K)
      XMEAN=CK(1)
```

```
      DO 170 I=2,K
      CTM=CK(I)
      CK(I) = CK(I)+0.5*(CK(I+1)+XMEAN)
170   XMEAN=CTM
      CK(1)=TEMP1
      CK(M)=TEMP2
      RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PSDAUTO

NO ERRORS

```
      SUBROUTINE PLOTPSDA
C ***
C     THIS ROUTINE PLOTS PSD AGAINST FREQUENCY ON LOGARITHMIC AXES. ENTRY
C     SETUP FOR INITIALIZING THE FREQUENCY SCALE CALCULATION AND ORIGIN SETTING.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,NOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024,2),N(6),EXTX(1000),A(1001),C(1024),I,K,L,KREC,
     2KBAR,J,XMEAN,SIGMA
      COMMON/DATA/IWT(6),M,NOCT,NREC,S,PSD(1001),[illegible],F1,F2,NDECS
     1,IPRINT,ISCALE
      DIMENSION BK(1001)
      EQUIVALENCE (BK(1),IDATA(1))
      EQUIVALENCE (ZSCALE,IDUM(3))
      ENTRY SETUP
      TEMP4=ALOG10(F1)
      TEMP2=ALOG10(F2)
      K1=IFIX(TEMP4)+1
      L=IFIX(TEMP2)
      FL = FLOAT(K1)-TEMP4
      FU=TEMP2-FLOAT(L)
      XSCALE=6.0/(FLOAT(L-K1)+FU-FL)
      TEMP4=TEMP4*XSCALE
      K1=K1-1
      DF=10.0**K1
      YSCALE=6.0/FLOAT(NDECS)
      CALL PLOT(-11.5,0.0,-3)
      CALL PLOT(2.0,0.0,-3)
      RETURN
      ENTRY ONECYC
      FU = 0.0
      NCOUNT = NCOUNT+1
      DO 30 I=NCOUNT,1001
      IF (PSD(I))35,35,45
   35 PSD(I) =1.0E-70
      GO TO 30
   45 IF(PSD(I)-FU)30,30,40
   40 FU=PSD(I)
   30 CONTINUE
      K=IFIX(ALOG10(FU))
      IF (FU-1.0)50,60,60
   50 ZSCALE=FLOAT(NDECS-K)
      K=K-1
      GO TO 70
   60 ZSCALE=FLOAT(NDECS-K-1)
   70 CALL PLOT(0.0,0.0,3)
      FU=1.0
      DO 80 I=1,NDECS
      J=K+NDECS+I
      FL=FLOAT(I-1)*YSCALE
      CALL SYMBL4(-0.65,FL-0.07,0.14,2H10,0.0,2)
      CALL NUMBER(-0.45,FL,0.1,J,0.0,2HI3)
      GO TO (90,80)ISCALE
   90 CALL PLOT(0.0,FL,3)
      L=0
  100 DF=10.0**(I-1)
      L=L+1
      FU=FL+DF
      FL=YSCALE*ALOG10(FU)
      CALL PLOT(0.0,FL,2)
      IF(L-9)120,110,120
```

```
110   CALL PLOT(0,25,FL,2)
      CALL PLOT(0,0,FL,2)
      GO TO 80
120   CALL PLOT(0,15,FL,2)
      CALL PLOT(0,0,FL,2)
      GO TO 100
80    CONTINUE
      K=K+1
      CALL SYMBL4(-0,65,5,925,0,14,2H10,0,0,2)
      CALL NUMBER(-0,45,6,0,0,1,J,0,0,2HI3)
      GO TO (140,130)ISCALE
130   CALL PLOT(0,3,5,7,3)
      CALL PLOT(0,3,6,0,2)
      CALL PLOT(0,3,6,0,2)
      GO TO 150
140   CALL PLOT(5,7,6,0,3)
      CALL PLOT(6,0,6,0,2)
      CALL PLOT(6,0,5,7,2)
150   GO TO (170,160)ISCALE
160   CALL PLOT(6,0,0,3,3)
      CALL PLOT(6,0,0,0,2)
      CALL PLOT(5,7,0,0,2)
      CALL PLOT(0,3,0,0,3)
      CALL PLOT(0,0,0,0,2)
      CALL PLOT(0,0,0,3,2)
      GO TO 180
170   CALL NUMBER(-0,1,-0,4,0,14,F1,0,0,4HF2,0)
      CALL PLOT(0,0,0,0,3)
      FL=F1
      DF=DE
      L=K1
190   FL=FL+DF
      FU=ALOG10(FL)
      TEMP1=XSCALE*FU-TEMP4
      IF(TEMP1-6,0)200,210,210
200   CALL PLOT(TEMP1,0,0,2)
      K=IFIX(FU+0,0005)
      IF(K-L)230,230,220
220   L=K
      DF=10,0**L
      CALL PLOT(TEMP1,0,25,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
230   CALL PLOT(TEMP1,0,15,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
210   CALL PLOT(6,0,0,0,2)
      CALL PLOT(6,0,0,3,2)
      CALL NUMBER(5,7,-0,4,0,14,F2,0,0,4HF5,0)
180   CALL SYMBL4(0,0,-0,9,0,14,ITEST,0,0,4)
      CALL SYMBL4(1,25,-0,9,0,14,ICHAN1,0,0,4)
      DO 240 I=NCOUNT,1001
      IF(FRQ(I)-F1)240,250,250
240   CONTINUE
250   TEMP1=XSCALE*ALOG10(FRQ(I))-TEMP4
      TEMP2=YSCALE*(ALOG10(PSD(I))+ZSCALE)
      IF(TEMP2)260,270,270
260   TEMP2=0,0
270   CALL PLOT(TEMP1,TEMP2,3)
      DO 280 J=I,1001
      IF (FRQ(J)-F2)330,330,280
330   TEMP1=XSCALE*ALOG10(FRQ(J))-TEMP4
```

```
      TEMP2=YSCALE*(ALOG10(PSD(J))+ZSCALE)
      IF(TEMP2)290,300,300
290   TEMP2=0.0
300   CALL PLOT(TEMP1,TEMP2,2)
280   CONTINUE
      CALL PLOT(0.0,10.0,-3)
      IF(IPRINT)310,320,310
310   WRITE(61,900)ITEST,ICHAN1
900   FORMAT (1H1, 44X 8HTEST NO., 2X A4, 15X 11HCHANNEL NO., 2X A4 , //
     1 8X 4(4HFREQ, 6X 6HP.S.D., 14X))
      WRITE(61,910)(FRQ(I),PSD(I),I=NCOUNT,1001)
910   FORMAT (2X 4(F10.2,E15.5,5X))
320   RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PLOTPSDA

NO ERRORS

```
EXTERNAL SYMBOLS
    FDF@CXS


ENTRY-POINT SYMBOLS
    FTRANS          00157
    FLCATAK         00117
    CORLAT          00000


LENGTH OF SUBPROGRAM        00244
LENGTH OF COMMON            17732
LENGTH OF DATA              00011
```

```
COMPASS-32    (2.3)                CORLAT                                                    01/28/69  PAGE     2
                                                  ENTRY     CORLAT,FLOATAK
                                                  COMMON
      00000                          DUMMY        BSS       40
      00050                          IDATA        BSS       1024
      02050                          JDATA        BSS       1024
      04050                          N            BSS       6
      04056                          EXTX         BSS       2000
      07776                          AK           BSS       2002
      13720                          CK           BSS       2048
      17720                          I            BSS       1
      17721                          K            BSS       1
      17722                          L            BSS       1
      17723                          KREC         BSS       1
      17724                          KBAR         BSS       1
      17725                          J            BSS       1
      17726                          XMEAN        BSS       2
      17730                          SIGMA        BSS       2
                                                  DATA
      00000                          IWT          BSS       6
      00006                          M            BSS       1
      00007                          NOCT         BSS       1
      00010                          NREC         BSS       1
                                                  PS

                                        ENTRY POINT CORLAT FOR CALCULATING THE CONTRIBUTION OF A 1024 24-BIT WORD
                                        RECORD, HELD IN IDATA OR JDATA, TO THE AUTOCORRELATION FUNCTION FOR M LAGS
                                        48-BIT INTEGER SUMMATIONS OF THE AUTOCORRELATION COEFFICIENTS ARE STORED
                                        IN ARRAY AK, PART OF THE RECORD REPRESENTING THE LAG OVERLAP IS RETAINED
                                        IN EXTX.

      00000  01077777 01 0  77777 0  CORLAT   UJP       **
      00001  54100000 54 0 P00000 1           LDI       CORLAT,1
      00002  20500000 20 1  00000 1           LDA,I     0,1
      00003  15477776 15 1  77776 0           INA,S     -1
      00004  03000007 03 0 P00007 0           AZJ,EQ    *+3
      00005  14602050 14 1 C02050 2           ENA       JDATA
      00006  01000010 01 0 P00010 0           UJP       *+2
      00007  14600050 14 1 C00050 2           ENA       IDATA
      00010  44000034 44 0 P00034 0           SWA       PKUPDATA
      00011  44000035 44 0 P00035 0           SWA       PKUPDATA+1
      00012  44000056 44 0 P00056 0           SWA       ENDATA1
      00013  44000076 44 0 P00076 0           SWA       ENDATA2
      00014  44000107 44 0 P00107 0           SWA       RECYCLE6
      00015  14600001 14 1  00001 2           ENA       1
      00016  34000000 34 0 P00000 0           RAD       CORLAT
      00017  14100000 14 0  00000 1           ENI       0,1
      00020  20000006 20 0 D00006 0           LDA       M
      00021  44000102 44 0 P00102 0           SWA       MCOUNTX
      00022  15600001 15 1  00001 2           INA       1
      00023  12000001 12 0  00001 0           SHA       1
      00024  44000070 44 0 P00070 0           SWA       MCOUNT
      00025  44000130 44 0 P00130 0           SWA       MCOUNTY
      00026  14602000 14 1  02000 2           ENA       1024
      00027  44000043 44 0 P00043 0           SWA       JCOUNT
```

```
00030  14300000 14 0  00000 3  RECYCLE1 ENI      0,3
00031  53100000 53 0  00000 1           TIA      1
00032  12077776 12 0  77776 0           SHA      -1
00033  53600000 53 1  00000 2           TAI      2
00034  20377777 20 0  77777 3  PKUPDATA LDA      **,3
00035  50277777 50 0  77777 2           MUA      **,2
00036  13000030 13 0  00030 0           SHAQ     24
00037  32107776 32 0 C07776 1           ADAQ     AK,1
00040  45107776 45 0 C07776 1           STAQ     AK,1
00041  15300001 15 0  00001 3           INI      1,3
00042  15200001 15 0  00001 2           INI      1,2
00043  05377777 05 0  77777 3  JCOUNT   ISG      **,3
00044  01000034 01 0 P00034 0           UJP      PKUPDATA
00045  53100000 53 0  00000 1           TIA      1
00046  03000105 03 0 P00105 0           AZJ,EQ   MNC
00047  12077776 12 0  77776 0           SHA      -1
00050  53700000 53 1  00000 3           TAI      3
00051  20000006 20 0 D00006 0           LDA      M
00052  15477776 15 1  77776 0           INA,S    -1
00053  53600000 53 1  00000 2           TAI      2
00054  15377776 15 0  77776 3  RECYCLE3 INI      -1,3
00055  20204056 20 0 C04056 2           LDA      EXTX,2
00056  50377777 50 0  77777 3  ENDATA1  MUA      **,3
00057  13000030 13 0  00030 0           SHAQ     24
00060  32107776 32 0 C07776 1           ADAQ     AK,1
00061  45107776 45 0 C07776 1           STAQ     AK,1
00062  15277776 15 0  77776 2           INI      -1,2
00063  04300000 04 0  00000 3  ICOUNT   ISE      0,3
00064  01000054 01 0 P00054 0           UJP      RECYCLE3
00065  15100002 15 0  00002 1  RTN      INI      2,1
00066  14477776 14 1  77776 0           ENA,S    -1
00067  34000043 34 0 P00043 0           RAD      JCOUNT
00070  05177777 05 0  77777 1  MCOUNT   ISG      **,1
00071  01000030 01 0 P00030 0           UJP      RECYCLE1
00072  14100000 14 0  00000 1           ENI      0,1
00073  14602000 14 1  02000 2           ENA      1024
00074  31000006 31 0 D00006 0           SRA      M
00075  53600000 53 1  00000 2           TAI      2
00076  20277777 20 0  77777 2  ENDATA2 LDA      **,2
00077  40104056 40 0 C04056 1           STA      EXTX,1
00100  15100001 15 0  00001 1           INI      1,1
00101  15200001 15 0  00001 2           INI      1,2
00102  05177777 05 0  77777 1  MCOUNTX  ISG      **,1
00103  01000076 01 0 P00076 0           UJP      ENDATA2
00104  01400000 01 1 P00000 0           UJP,I    CORLAT

                                CALCULATE CONTRIBUTION TO THE MEAN FOR THIS RECORD, SUM IN XMEAN (48 BIT)

00105  14300000 14 0  00000 3  MNC      ENI      0,3
00106  14600000 14 1  00000 2           ENA      0
00107  30377777 30 0  77777 3  RECYCLE6 ADA      **,3
00110  15300001 15 0  00001 3           INI      1,3
00111  05302000 05 0  02000 3           ISG      1024,3
00112  01000107 01 0 P00107 0           UJP      RECYCLE6
```

```
00113  13077747 13 0  77747 0            SHAQ       -24
00114  32017726 32 0 C17726 0            ADAQ       XMEAN
00115  45017726 45 0 C17726 0            STAQ       XMEAN
00116  01000065 01 0 P00065 0            UJP        RTN

                                   ENTRY FLOATAK TO CARRY OUT 48-BIT INTEGER TO FLOATING POINT CONVERSION
                                   FOR XMEAN AND AUTOCORRELATION ARRAY AK.

00117  01077777 01 0  77777 0  FLOATAK  UJP        **
00120  25017726 25 0 C17726 0            LDAQ       XMEAN
00121  00700133 00 1 P00133 3            RTJ        FLOAT48
00122  45017726 45 0 C17726 0            STAQ       XMEAN
00123  14100000 14 0  00000 1            ENI        0,1
00124  25107776 25 0 C07776 1  RECYCLE5  LDAQ       AK,1
00125  00700133 00 1 P00133 3            RTJ        FLOAT48
00126  45107776 45 0 C07776 1            STAQ       AK,1
00127  15100002 15 0  00002 1            INI        2,1
00130  05177777 05 0  77777 1  MCOUNTY   ISG        **,1
00131  01000124 01 0 P00124 0            UJP        RECYCLE5
00132  01400117 01 1 P00117 0            UJP,I      FLOATAK
00133  01077777 01 0  77777 0  FLOAT48   UJP        **
00134  14200001 14 0  00001 2            ENI        1,2
00135  03200141 03 0 P00141 2            AZJ,GE     SCALE
00136  16477777 16 1  77777 0            XOA,S      -0
00137  16577777 16 1  77777 1            XOQ,S      -0
00140  14200000 14 0  00000 2            ENI        0,2
00141  13702057 13 1  02057 3  SCALE     SCAQ       2057B,3
00142  13077764 13 0  77764 0            SHAQ       -11
00143  45000044 45 0 C00044 0            STAQ       DUMMY+36
00144  14700000 14 1  00000 3            ENQ        0
00145  53300000 53 0  00000 3            TIA        3
00146  12000014 12 0  00014 0            SHA        12
00147  32000044 32 0 C00044 0            ADAQ       DUMMY+36
00150  02200153 02 0 P00153 2            IJI        *+3,2
00151  16477777 16 1  77777 0            XOA,S      -0
00152  16577777 16 1  77777 1            XOQ,S      -0
00153  01400133 01 1 P00133 0            UJP,I      FLOAT48
                                   ENTRY POINT FTRANS TO FOURIER TRANSFORM THE AUTOCORRELATION ARRAY.
                                   FXTX ARRAY CONTAINS A TABLE OF COSINES WITH ARGUMENTS AT INTERVALS OF
                                     PI/M. CALCULATION IN FLOATING POINT WITH RESULTS RETURNED IN ARRAY CK.

                                         ENTRY      FTRANS
00154  60077777 60 0  77777 0  SGPOS    FAD        **
00155  61077777 61 0  77777 0  SGNEG    FSB        **
00156                          SGTMP    BSS        1
00157  01077777 01 0  77777 0  FTRANS   UJP        **
00160  20000006 20 0 D00006 0            LDA        M
00161  12000001 12 0  00001 0            SHA        1
00162  44000232 44 0 P00232 0            SWA        IMCOUNT
00163  15600002 15 1  00002 2            INA        2
00164  44000241 44 0 P00241 0            SWA        MCOUNTZ
00165  15477775 15 1  77775 0            INA,S      -2
00166  15607776 15 1 C07776 2            INA        AK
00167  44000154 44 0 P00154 0            SWA        SGPOS
```

```
00170  44000155 44 0 P00155 0            SWA        SGNFG
00171  20000155 20 0 P00155 0            LDA        SGNFG
00172  40000156 40 0 P00156 0            STA        SGTMP
00173  20000154 20 0 P00154 0            LDA        SGPOS
00174  40000236 40 0 P00236 0            STA        RPLC
00175  14100002 14 0  00002 1            ENI        2,1
00176  14600000 14 1  00000 2  RECYCLE7  ENA        0
00177  14700000 14 1  00000 3            ENQ        0
00200  45113716 45 0 C13716 1            STAQ       CK-2,1
00201  47117725 47 0 C17725 1            STI        J,1
00202  14200002 14 0  00002 2            ENI        2,2
00203  20000236 20 0 P00236 0            LDA        RPLC
00204  21000156 21 0 P00156 0            LDQ        SGTMP
00205  40000156 40 0 P00156 0            STA        SGTMP
00206  41000236 41 0 P00236 0            STQ        RPLC
00207  53200000 53 0  00000 2  RECYCLE8  TIA        2
00210  50017725 50 0 C17725 0            MUA        J
00211  13077775 13 0  77775 0            SHAQ       -2
00212  13000030 13 0  00030 0            SHAQ       24
00213  51000006 51 0 D00006 0            DVA        M
00214  17400001 17 1  00001 0            ANA,S      1
00215  44000222 44 0 P00222 0            SWA        PLORMN
00216  13000031 13 0  00031 0            SHAQ       25
00217  53700000 53 1  00000 3            TAI        3
00220  25207776 25 0 C07776 2            LDAQ       AK,2
00221  62304056 62 0 C04056 3            FMU        EXTX,3
00222  04077777 04 0  77777 0  PLORMN    ISE        **
00223  01000225 01 0 P00225 0            UJP        *+2
00224  01000227 01 0 P00227 0            UJP        *+3
00225  16477777 16 1  77777 0            XOA,S      -0
00226  16577777 16 1  77777 1            XOQ,S      -0
00227  60113716 60 0 C13716 1            FAD        CK-2,1
00230  45113716 45 0 C13716 1            STAQ       CK-2,1
00231  15200002 15 0  00002 2            INI        2,2
00232  05277777 05 0  77777 2  IMCOUNT   ISG        **,2
00233  01000207 01 0 P00207 0            UJP        RECYCLER
00234  60113716 60 0 C13716 1            FAD        CK-2,1
00235  60007776 60 0 C07776 0            FAD        AK
00236                          RPLC     BSS        1
00237  45113716 45 0 C13716 1            STAQ       CK-2,1
00240  15100002 15 0  00002 1            INI        2,1
00241  05177777 05 0  77777 1  MCOUNTZ   ISG        **,1
00242  01000176 01 0 P00176 0            UJP        RECYCLE7
00243  01000157 01 0 P00157 0            UJP        FTRANS
                                         END

                    NUMBER OF LINES WITH DIAGNOSTICS        0
```

APPENDIX G

Listing of Routines MNCPSDA, CPSDCTLA, CPSDAUTO, PLTCPSDA, and CORLATXY

```
      PROGRAM MNCPSDA
C ***
C     ****************      PROGRAM NO, WCP/68-23      ************************
C     THIS PROGRAM IS THE MAIN CONTROL PROGRAM FOR PROCESSING RANDOM DATA
C     ACQUIRED ON THE A/D SYSTEM CONNECTED TO THE CDC 3300 COMPUTER. THE
C     MOST USUAL PROCESSING IS THE CALCULATION OF POWER SPECTRAL DENSITY
C     FOR WHICH SEVERAL SETS OF SUBROUTINES ARE AVAILABLE, VARIOUS OTHER
C     PROCESSING TECHNIQUES ARE POSSIBLE.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IHALF,MD(2),ID(13),INF(7),ISTACK,IFILE
      COMMON                                NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),EXTX(1000),EXTY(1000),AK(1001),
     2BK(1001),CK(1024),I,K,L,J,XMEAN,YMEAN,SIGMAX,SIGMAY
      COMMON/DATA/IWT(6),M,NOCT,NREC,S,SS,PSD(1001),QSD(1001),FRQ(1001),
     1F1,F2,NDECS,IPRINT,ISCALE
      EQUIVALENCE (SRATE,N(4))
      CALL LPFILT(N1024R)
   10 MD(1)=MD(2)=0
      REWIND 1
      REWIND 2
      READ(60,900)ITEST,ISTACK,IFILE,ISTAT,M,NREC,NOCT,F1,F2,NDECS,
     1IPRINT
      ISTACK = ISTACK+1
      CALL SETUP
      IF (M-1000)11,11,12
   12 WRITE(61,13)
   13 FORMAT (1H0, 10X 19HM GREATER THAN 1000        )
      STOP
   11 IF(F1-F2)14,15,15
   15 WRITE(61,16)F1,F2
   16 FORMAT (1H0, 10X 4HF1 =, E15.5, 2X 15HGREATER THAN F2, E15.5)
      STOP
   14 IF(NDECS-10)17,18,18
   18 WRITE(61,19)
   19 FORMAT (1H0, 10X 35HMORE THAN 10 PLOT DECADES SPECIFIED       )
      STOP
   17 ID(11)=ITEST
      N1024R=2**(NOCT-1)*NREC
      N1024S=N1024R
   20 READ(60,910)ICHAN1,ICHAN2,S,SS,ISCALE
      ISCALE = ISCALE+1
      IF(ICHAN1.EQ.4HEND )120,30
   30 IF(ICHAN1.EQ.4HNEWT)10,40
   40 CALL DEMUX(N1024R,ISTAT,0)
      I = 2048*NREC/M
      IF(N1024R-N1024S)50,60,60
   50 K=N1024R
      J=1
   70 K=K/2
      J=J+1
      IF(K-NREC)80,80,70
   80 NOCT=J
      K = 2048*K
      J=J-1
      WRITE(61,920)K,I,J
      GO TO 90
   60 WRITE(61,930)I
   90 CALL CPSDCTLA
      SRATE = SRATE/FLOAT(M)
      WRITE (61,950) NOCT,SRATE
```

```
      WRITE (61,940)
      CALL ONECYC
      GO TO 20
120   STOP
900   FORMAT (A4, 2I2, 4I4, 2F10.0, 2I4)
910   FORMAT (2A4, 2F10.0, I2)
920   FORMAT (1H0, 10X I5, 47HDEGREES OF FREEDOM IN LOWER BAND AND 1STOC
     1TAVE , / 10X I5, 26HDEGREES OF FREEDOM IN NEXT, I3, X 23HOCTAVES A
     2ND UPPER BAND,)
930   FORMAT (1H0, 10X I5,X19HDEGREES OF FREEDOM,)
940   FORMAT (1H0, 80(1H*))
950   FORMAT (11X 27HNUMBER OF FREQUENCY BANDS = ,I3, / 11X
     1 44HANALYSIS BANDWIDTH IN UPPER FREQUENCY BAND = , F5.1, 2X 2HHZ )
      END

        3200 FORTRAN DIAGNOSTIC RESULTS - FOR   MNCPSDA

NO ERRORS
```

```
      SUBROUTINE CPSDCTLA
C ***
C     THIS ROUTINE CONTROLS THE CALCULATION OF FILTERED DATA AND CROSS POWER
C     SPECTRAL DENSITY (USING LAGGED PRODUCTS), APPROPRIATE OCTAVE RANGES ARE
C     STORED IN ARRAYS
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),EXTX(1000),EXTY(1000),AK(1001),
     2BK(1001),CK(1024),I,K,L,J,XMEAN,YMEAN,SIGMAX,SIGMAY
      COMMON/DATA/IWT(6),M,NOCT,NREC,S,SS,PSD(1001),QSD(1001),FRQ(1001),
     1F1,F2,NDECS,IPRINT,ISCALE
      DIMENSION FRE(1001)
      EQUIVALENCE (SRATE,N(4)),(FRE(1),IDATA(1))
      KOCT=0
      CALL CPSDAUTO
      FU=SRATE/2.0
      DF=2.0
 10   IF(DF-FU)20,30,30
 20   DF=DF+DF
      GO TO 10
 30   FU=DF/2.0
      NCOUNT=1001
      DO 40 I=1,1001
 40   FRQ(I)=0.0
      S = 4.0*S*SS*SRATE
 50   KOCT=KOCT+1
      TEMP1=2.0**KOCT
      DF=SRATE/(TEMP1*FLOAT(M))
      TEMP1=TEMP1/S
      TEMP2 = 0.5*TEMP1
      FRE(1)=DF
      DO 60 I=2,M
 60   FRE(I)=FRE(I-1)+DF
      FL=FU/2.0
      L = M+1
      IF(KOCT-NOCT)80,70,70
 70   FL=0.0
 80   DO 100 I=1,M
      J = L-I
      IF(FRE(J)-FL)110,90,90
 90   IF(NCOUNT-1001)120,130,120
 120  IF(FRE(J)-FRQ(NCOUNT+1))130,100,100
 130  PSD(NCOUNT)=AK(J)*TEMP1
      QSD(NCOUNT)=BK(J)*TEMP2
      FRQ(NCOUNT)=FRE(J)
      NCOUNT=NCOUNT-1
 100  CONTINUE
 110  FU=FL
      IF(NCOUNT)140,140,150
 150  IF(KOCT-NOCT)170,160,160
 170  CALL CUTOFF(3)
      CALL CUTOFF(4)
      CALL CPSDAUTO
      GO TO 50
 140  WRITE(A1,900)
 900  FORMAT (1H0, 10A 20HTOO MANY POINTS IN PSD RANGE.)
 160  RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR CPSDCTLA

```
      SUBROUTINE CPSDAUTO
C ***
C     THIS ROUTINE CALCULATES CROSS POWER SPECTRAL DENSITY FROM THE CROSS
C     CORRELATION FUNCTION FOR A PAIR OF DATA CHANNELS HELD ON LOGICAL UNITS 3
C     AND 4. REAL AND IMAGINARY PARTS OF THE CROSS PSD ARE RETURNED IN ARRAYS
C     AK AND BK.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FD,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),EXTX(1000),EXTY(1000),AK(1001),
     2BK(1001),CK(1024),I,K,L,J,XMEAN,YMEAN,SIGMAX,SIGMAY
      COMMON/DATA/IWT(6),M,NOCT,NREC,S,SS,PSD(1001),QSD(1001),FRQ(1001)
     1F1,F2,NSECS,IPRINT,ISCALE
      DIMENSION BK(1024)
      EQUIVALENCE (BK(1),IDATA(1))
      REWIND 3
      REWIND 4
      BUFFER IN(3,1)(N(1),N(6))
      BUFFER IN(4,1) (JDATA(1),JDATA(10))
      IF (KOCT-NOCT+1)5,15,15
 5    BUFFER IN(3,1)(IDATA(1),IDATA(10))
      BUFFER IN(4,1)(JDATA(1),JDATA(10)
 15   KREC=K=L=0
      XMEAN=YMEAN=0.0
      L=M+1
      DO 10 I=1,J
 10   AK(I) = BK(I) = EXTX(I) = EXTY(I) = 0.0
 30   BUFFER IN(3,1)(IDATA(1),IDATA(1024))
      BUFFER IN(4,1)(JDATA(1),JDATA(1024))
 40   GO TO (40,50,60,70)UNITSTF(3)
 70   CALL ERRECOV(7,3,K,I)
      IF(I-1)80,90,80
 90   WRITE(59,900)
 900  FORMAT (5X 46HPARITY ERRORS ON READING LOGICAL UNITS 3 AND 4, /
     1 5X 57HAFTER ERROR FREE WRITES, CLEAN TAPE HEADS AND REPEAT JOB.)
      STOP
 80   BUFFER IN(3,1)(IDATA(1),IDATA(1024))
      GO TO 40
 50   GO TO (50,100,60,110)UNITSTF(4)
 110  CALL ERRECOV(7,4,L,I)
      IF(I-1)120,90,120
 120  BUFFER IN(4,1)(JDATA(1),JDATA(1024))
      GO TO 50
 100  KREC=KREC+1
      CALL CORLATXY
      IF(KREC-NREC)30,60,60
 60   FD=FLOAT(1024*KREC)
      CALL FLOATAK
      XMEAN=XMEAN/FD
      YMEAN=YMEAN/FD
      DF=XMEAN*YMEAN
      XMEAN=XMEAN*XMEAN
      YMEAN=YMEAN*YMEAN
      SIGMAX=FD*1.0
      SIGMAY=BK(1)/SIGMAX - YMEAN
      SIGMAX=CK(1)/SIGMAX - XMEAN
      L=M+1
      FD=FD+1.0
      DO 130 I=J,L
      FH=FD-FLOAT(I)
      AK(I)=AK(I)/FH-DF
```

```
      BK(I)=BK(I)/FM=DF
      TEMP1 = AK(I)+BK(I)
      BK(I)=AK(I)-BK(I)
130   AK(I) = TEMP1
      PI = 3.14159265/FLOAT(M)
      DO 140 I=2,M
      FD = FLOAT(I-1)*PI
      EXTX(I) = COS(FD)
140   EXTY(I) = SIN(FD)
      EXTX(1) = 1.0
      EXTY(1) = 0.0
      CALL FTRANS
      K=M-1
      AK(1) = CK(1)+0.5*CK(2)
      AK(M) = CK(1)+CK(K)
      BK(1) = DK(1)+0.5*DK(2)
      BK(M) = DK(M)+DK(K)
      DO 170 I=2,K
      J=I+1
      L=I-1
      AK(I) = CK(I)+0.5*(CK(J)+CK(L))
170   BK(I) = DK(I)+0.5*(DK(J)+DK(L))
      RETURN
      END

        3250 FORTRAN DIAGNOSTIC RESULTS - FOR   CPSDAUTO

NO ERRORS
```

```
      SUBROUTINE PLTCPSDA
C ***
C     THIS ROUTINE PLOTS PSD AGAINST FREQUENCY ON LOGARITHMIC AXES, ENTRY
C     ONECYC FOR PSD PLOT AND ENTRY OCTOV3 FOR 1/3 OCTAVE PLOTS,  ENTRY SETUP
C     FOR INITIALIZING THE FREQUENCY SCALE CALCULATION.
C ***
      COMMON ITEST,ICHAN1,ICHAN2,IDUM(25),NCOUNT,KOCT,FU,FL,DF,TEMP1,
     1TEMP2,IDATA(1024),JDATA(1024),N(6),EXTX(1000),EXTY(1000),AK(1001),
     2BK(1001),CK(1024),I,K,L,J,XMEAN,YMEAN,SIGMAX,SIGMAY,NN
      EQUIVALENCE (ZSCALE,EXTX(1))
      COMMON/DATA/IWT(6),M,NOCT,NREC,S,SS,PSD(1001),QSD(1001),FRQ(1001),
     1F1,F2,NDECS,IPRINT,ISCALE
      ENTRY SETUP
      TEMP4=ALOG10(F1)
      TEMP2=ALOG10(F2)
      K1=IFIX(TEMP4)+1
      L=IFIX(TEMP2)
      FL = FLOAT(K1)-TEMP4
      FU=TEMP2-FLOAT(L)
      XSCALE=6.0/(FLOAT(L-K1)+FU+FL)
      TEMP4=TEMP4*XSCALE
      K1=K1-1
      DE=10.0**K1
      YSCALE=6.0/FLOAT(NDECS)
      CALL PLOT(-11.5,0.0,-3)
      CALL PLOT(2.0,0.0,-3)
      RETURN
      ENTRY ONECYC
      FU=0.0
      NCOUNT = NCOUNT+1
      CALL SYMBL4(0.0,-0.9,0.14,ITEST,0.0,4)
      CALL SYMBL4(1.25,-0.9,0.14,ICHAN1,0.0,4)
      CALL SYMBL4(2.00,-0.9,0.14,ICHAN2,0.0,4)
      DO 470 I=NCOUNT,1001
      AK(I) = SQRT(PSD(I)*PSD(I)+QSD(I)*QSD(I))
      IF (PSD(I))480,490,500
 490  IF(QSD(I))520,530,540
 520  CSD(I)=-1.5707963
      GOTO 470
 540  CSD(I)=1.5707963
      GO TO 470
 530  CSD(I)=0.0
      GO TO 470
 500  TEMP1=0.0
      GO TO 510
 480  IF(QSD(I))550,560,560
 550  TEMP1=-3.1415926535
      GO TO 510
 560  TEMP1=3.1415926535
 510  CSD(I)=ATAN(QSD(I)/PSD(I))+TEMP1
 470  CSD(I)=QSD(I)*57.2957795
      DO 30 I=NCOUNT,1001
      IF(AK (I)-FU)30,30,40
 40   FU=AK (I)
 30   CONTINUE
      K=IFIX(ALOG10(FU))
      IF(FU-1.)50,60,60


 50   ZSCALE=FLOAT(NDECS-K)
```

```
      K=K-1
      GO TO 70
60    ZSCALE=FLOAT(NDECS-K-1)
70    CALL PLOT(0,0,0,0,3)
      FU=1,0
      DO 80 I=1,NDECS
      J=K-NDECS+I
      FL=FLOAT(I-1)*YSCALE
      CALL SYMBL4(-0,65,FL-0,07,0,14,2H10,0,0,2)
      CALL NUMBER(-0,45,FL,0,1,J,0,0,2HI3)
      GO TO (90,80)ISCALE
90    CALL PLOT(0,0,FL,3)
      L=0
100   DF=10,0**(I-1)
      L=L+1
      FU=FL+DF
      FL=YSCALE*ALOG10(FU)
      CALL PLOT(0,0,FL,2)
      IF(L-9)120,110,120
110   CALL PLOT(0,25,FL,2)
      CALL PLOT(0,0,FL,2)
      GO TO 80
120   CALL PLOT(0,15,FL,2)
      CALL PLOT(0,0,FL,2)
      GO TO 100
80    CONTINUE
      J=K+1
      CALL SYMBL4(-0,65,5,925,0,14,2H10,0,0,2)
      CALL NUMBER(-0,45,6,0,0,1,J,0,0,2HI3)
      GO TO (140,130)ISCALE
130   CALL PLOT(0,0,5,7,3)
      CALL PLOT(0,0,6,0,2)
      CALL PLOT(0,3,6,0,2)
      GO TO 150
140   CALL PLOT(5,7,6,0,3)
      CALL PLOT(6,0,6,0,2)
      CALL PLOT(6,0,5,7,2)
150   GO TO (170,160)ISCALE
160   CALL PLOT(6,0,0,3,3)
      CALL PLOT(6,0,0,0,2)
      CALL PLOT(5,7,0,0,2)
      CALL PLOT(0,3,0,0,3)
      CALL PLOT(0,0,0,0,2)
      CALL PLOT(0,0,0,3,2)
      GO TO 180
170   CALL NUMBER(-0,1,-0,4,0,14,F1,0,0,4HF2,0)
      CALL PLOT(0,0,0,0,3)
      FL=F1
      DF=DE
      L=K1
190   FL=FL+DF
      FU=ALOG10(FL)
      TEMP1=XSCALE*FU-TEMP4
      IF(TEMP1-6,0)200,210,210
200   CALL PLOT(TEMP1,0,0,2)
      K=IFIX(FU+0,0005)
      IF(K-L)230,230,220
220   L=K
      DF=10,0**L
      CALL PLOT(TEMP1,0,25,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
```

```
230   CALL PLOT(TEMP1,0,15,3)
      CALL PLOT(TEMP1,0,0,2)
      GO TO 190
210   CALL PLOT(6,0,0,0,2)
      CALL PLOT(6,0,0,3,2)
      CALL NUMBER(5,7,-0,4,0,14,F2,0,0,4HFF,0)
180   DO 240 I=NCOUNT,1001
      IF(FRQ(I)-F1)240,250,250
240   CONTINUE
250   TEMP1=XSCALE*ALOG10(FRQ(I))-TEMP4
      TEMP2=YSCALE*(ALOG10(AK (I))+ZSCALE)
      IF(TEMP2)260,270,270
260   TEMP2=0,0
270   CALL PLOT(TEMP1,TEMP2,3)
      DO 280 J=I,1001
      IF (FRQ(J)-F2)285,285,280
285   TEMP1=XSCALE*ALOG10(FRQ(J))-TEMP4
      TEMP2=YSCALE*(ALOG10(AK (J))+ZSCALE)
      IF(TEMP2)290,300,300
290   TEMP2=0,0
300   CALL PLOT(TEMP1,TEMP2,2)
280   CONTINUE
      CALL PLOT(0,0,6,25,-3)
      CALL PLOT(6,0,0,0,2)
      CALL PLOT(6,0,0,3,2)
      CALL PLOT(0,0,0,0,3)
      CALL PLOT(0,0,1,25,2)
      CALL PLOT(0,1,1,25,2)
      CALL PLOT(0,05,0.625,3)
      CALL PLOT(0,0,0,625,2)
      GO TO(441,442)ISCALE
441   CALL NUMBER(-0,55,1,18,0,14,180,0,0,2HI3)
      CALL NUMBER(-0,55,0,55,0,14, 90,0,0,2HI3)
      CALL NUMBER(-0,55,-0,07,0,14,  0,0,0,2HI3)
442   ZSCALE=1,25/180,0
      TEMP2=ZSCALE*ABS(QSD(I))
      TEMP1 = XSCALE*ALOG10(FRQ(J))-TEMP4
      CALL PLOT (TEMP1,TEMP2,3)
      DO 390 J=I,1001
      IF (FRQ(J)-F2)395,395,390
395   TEMP2=ZSCALE*ABS(QSD(J))
      TEMP1=XSCALE*ALOG10(FRQ(J))-TEMP4
      CALL PLOT(TEMP1,TEMP2,2)
390   CONTINUE
      CALL PLOT(0,0,1,5,-3)
      CALL PLOT(0,0,0,4,2)
      GO TO(392,391)ISCALE
392   CALL SYMBL4(-0,25,0,4,0,2,1H-,0,0,1)
      CALL SYMBL4(-0,25,0,0,0,2,1H+,0,0,1)
391   TEMP1=0,0
      TEMP2=0,4
      FL = TEMP1
      IF (QSD(I))394,393,393
394   FL = TEMP2
393   CALL PLOT(XSCALE*ALOG10(FRQ(I))-TEMP4,FL,3)
      DO 400 J=I,1001
      IF (FRQ(J)-F2)405,405,400
405   FL=XSCALE*ALOG10(FRQ(J))-TEMP4
      IF(QSD(J))410,420,420


410   CALL PLOT(FL,TEMP2,2)
```

```
      GO TC 400
420   CALL PLOT(FL,TEMP1,2)
400   CONTINUE
      CALL PLOT(0,0.3,0,-3)
      IF(IFRINT)430,320,430
430   WRITE(61,920)ITEST,ICHAN1,ICHAN2
920   FORMAT (1H1, 20X 8HTEST NO,, 2X A4, 2X  9HCROSS PSD, 2X 8HCHANNELS
     1, 2X A4, 2X 3HAND, 2X A4 , //  8X  3(4HFREQ, 6X 6HP.S.D.,9 X
     2 5HPHASE,  8X))
      WRITE(61,930)(FRQ(I),AK (I),OSD(I),I=NCOUNT,1001)
930   FORMAT (2X 3(F10.2,E15.5,F10.1,3X))
320   RETURN
      END
```

3200 FORTRAN DIAGNOSTIC RESULTS - FOR PLTCPSDA

NO ERRORS

```
EXTERNAL SYMBOLS
    FDFBCXS


ENTRY-POINT SYMBOLS
    FTRANS          00171
    FLCATAK         00126
    CORLATXY        00000


LENGTH OF SUBPROGRAM        00266
LENGTH OF COMMON            27572
LENGTH OF DATA              00011
```

```
COMPASS.32    (2,3)                CORLATXY                                                    12/23/68  PAGE     2
                                                ENTRY     CORLATXY,FLOATAK,FTRANS
                                                COMMON
     00000                          DUMMY      BSS       40
     00050                          IDATA      BSS       1024
     02050                          JDATA      BSS       1024
     04050                          N          BSS       6
     04056                          EXTX       BSS       2000
     07776                          EXTY       BSS       2000
     13716                          AK         BSS       2002
     17640                          BK         BSS       2002
     23562                          CK         BSS       2048
     27562                          I          BSS       1
     27563                          K          BSS       1
     27564                          L          BSS       1
     27565                          J          BSS       1
     27566                          XMEAN      BSS       2
     27570                          YMEAN      BSS       2
                                                DATA
     00000                          IWT        BSS       6
     00006                          M          BSS       1
     00007                          NOCT       BSS       1
     00010                          NREC       BSS       1
                                                PRG

                                        ENTRY POINT CORLATXY FOR CALCULATING THE CONTRIBUTION OF A PAIR OF 1024
                                        24-BIT WORD RECORDS, HELD IN IDATA AND JDATA, TO THE CROSS CORRELATION
                                        FUNCTION FOR M POSITIVE AND NEGATIVE LAGS. 48-BIT INTEGER SUMMATIONS ARE
                                        STORED IN ARRAYS AK AND BK FOR POSITIVE AND NEGATIVE LAGS RESPECTIVELY
                                        PARTS OF THE RECORDS REPRESENTING LAG OVERLAP ARE RETAINED IN EXTX AND
                                        EXTY.

     00000  01077777 01 0  77777 0  CORLATXY UJP       **
     00001  20000006 20 0 D00006 0           LDA       M
     00002  44000100 44 0 P00100 0           SWA       MCOUNTX
     00003  15600001 15 1  00001 2           INA       1
     00004  12000001 12 0  00001 0           SHA       1
     00005  44000064 44 0 P00064 0           SWA       MCOUNT
     00006  44000145 44 0 P00145 0           SWA       MCOUNTY
     00007  14602000 14 1  02000 2           ENA       1024
     00010  44000032 44 0 P00032 0           SWA       JCOUNT
     00011  14100000 14 0  00000 1           ENI       0,1
     00012  14300000 14 0  00000 3  RECYCLE1 ENI       0,3
     00013  53100000 53 0  00000 1           TIA       1
     00014  12077776 12 0  77776 0           SHA       -1
     00015  53600000 53 1  00000 2           TAI       2
     00016  20300050 20 0 C00050 3  RECYCLE2 LDA       IDATA,3
     00017  50202050 50 0 C02050 2           MUA       JDATA,2
     00020  13000030 13 0  00030 0           SHAQ      24
     00021  32113716 32 0 C13716 1           ADAQ      AK,1
     00022  45113716 45 0 C13716 1           STAQ      AK,1
     00023  20200050 20 0 C00050 2           LDA       IDATA,2
     00024  50302050 50 0 C02050 3           MUA       JDATA,3
     00025  13000030 13 0  00030 0           SHAQ      24
     00026  32117640 32 0 C17640 1           ADAQ      BK,1
```

```
00027  45117640 45 0 C17640 1            STAQ      BK,1
00030  15300001 15 0  00001 3            INI       1,3
00031  15200001 15 0  00001 2            INI       1,2
00032  04377777 04 0  77777 3  JCOUNT    ISE       **,3
00033  01000016 01 0 P00016 0            UJP       RECYCLE2
00034  53100000 53 0  00000 1            TIA       1
00035  03000103 03 0 P00103 0            AZJ,EQ    MNC
00036  12077776 12 0  77776 0            SHA       -1
00037  53700000 53 1  00000 3            TAI       3
00040  20000006 20 0 D00006 0            LDA       M
00041  15477776 15 1  77776 0            INA,S     =1
00042  53600000 53 1  00000 2            TAI       2
00043  15377776 15 0  77776 3  RECYCLE3 INI       =1,3
00044  20204056 20 0 C04056 2            LDA       EXTX,2
00045  50302050 50 0 C02050 3            MUA       JDATA,3
00046  13000030 13 0  00030 0            SHAQ      24
00047  32113716 32 0 C13716 1            ADAQ      AK,1
00050  45113716 45 0 C13716 1            STAQ      AK,1
00051  20207776 20 0 C07776 2            LDA       EXTY,2
00052  50300050 50 0 C00050 3            MUA       IDATA,3
00053  13000030 13 0  00030 0            SHAQ      24
00054  32117640 32 0 C17640 1            ADAQ      BK,1
00055  45117640 45 0 C17640 1            STAQ      BK,1
00056  15277776 15 0  77776 2            INI       =1,2
00057  04300000 04 0  00000 3            ISE       0,3
00060  01000043 01 0 P00043 0            UJP       RECYCLE3
00061  15100002 15 0  00002 1  RTN       INI       2,1
00062  14477776 14 1  77776 0            ENA,S     =1
00063  34000032 34 0 P00032 0            RAD       JCOUNT
00064  04177777 04 0  77777 1  MCOUNT    ISE       **,1
00065  01000012 01 0 P00012 0            UJP       RECYCLE1
00066  14100000 14 0  00000 1            ENI       0,1
00067  14602000 14 1  02000 2            ENA       1024
00070  31000006 31 0 D00006 0            SBA       M
00071  53600000 53 1  00000 2            TAI       2
00072  20200050 20 0 C00050 2  RECYCLE4 LDA       IDATA,2
00073  40104056 40 0 C04056 1            STA       EXTX,1
00074  20202050 20 0 C02050 2            LDA       JDATA,2
00075  40107776 40 0 C07776 1            STA       EXTY,1
00076  15100001 15 0  00001 1            INI       1,1
00077  15200001 15 0  00001 2            INI       1,2
00100  04177777 04 0  77777 1  MCOUNTX   ISE       **,1
00101  01000072 01 0 P00072 0            UJP       RECYCLE4
00102  01400000 01 1 P00000 0            UJP,I     CORLATXY
```

CALCULATE CONTRIBUTIONS TO MEANS FOR THESE TWO RECORDS9 48-BIT INTEGER SUMS RETAINED IN XMEAN AND YMEAN.

```
00103  14300000 14 0  00000 3  MNC       ENI       0,3
00104  14600000 14 1  00000 2            ENA       0
00105  30300050 30 0 C00050 3  RECYCLE5 ADA       IDATA,3
00106  15300001 15 0  00001 3            INI       1,3
00107  04302000 04 0  02000 3            ISE       1024,3
00110  01000105 01 0 P00105 0            UJP       RECYCLE5
```

```
00111  13077747 13 0  77747 0            SHAQ      -24
00112  32027566 32 0 C27566 0            ADAQ      XMEAN
00113  45027566 45 0 C27566 0            STAQ      XMEAN
00114  14300000 14 0  00000 3            ENI       0,3
00115  14600000 14 1  00000 2            ENA       0
00116  30302050 30 0 C02050 3  RECYCLE6   ADA       JDATA,3
00117  15300001 15 0  00001 3            INI       1,3
00120  04302000 04 0  02000 3            ISE       1024,3
00121  01000116 01 0 P00116 0            UJP       RECYCLE6
00122  13077747 13 0  77747 0            SHAQ      -24
00123  32027570 32 0 C27570 0            ADAQ      YMEAN
00124  45027570 45 0 C27570 0            STAQ      YMEAN
00125  01000061 01 0 P00061 0            UJP       RTN
```

ENTRY POINT FLOATAK TO CARRY OUT 48-BIT INTEGER TO FLOATING POINT CONVERSION FOR XMEAN, YMEAN AND CROSS CORRELATION ARRAYS AK AND BK.

```
00126  01077777 01 0  77777 0  FLOATAK   UJP       **
00127  25027566 25 0 C27566 0            LDAQ      XMEAN
00130  00700150 00 1 P00150 3            RTJ       FLOAT48
00131  45027566 45 0 C27566 0            STAQ      XMEAN
00132  25027570 25 0 C27570 0            LDAQ      YMEAN
00133  00700150 00 1 P00150 3            RTJ       FLOAT48
00134  45027570 45 0 C27570 0            STAQ      YMEAN
00135  14100000 14 0  00000 1            ENI       0,1
00136  25113716 25 0 C13716 1  RECYCLE7   LDAQ      AK,1
00137  00700150 00 1 P00150 3            RTJ       FLOAT48
00140  45113716 45 0 C13716 1            STAQ      AK,1
00141  25117640 25 0 C17640 1            LDAQ      BK,1
00142  00700150 00 1 P00150 3            RTJ       FLOAT48
00143  45117640 45 0 C17640 1            STAQ      BK,1
00144  15100002 15 0  00002 1            INI       2,1
00145  04177777 04 0  77777 1  MCOUNTY   ISE       **,1
00146  01000136 01 0 P00136 0            UJP       RECYCLE7
00147  01400126 01 1 P00126 0            UJP,I     FLOATAK
00150  01077777 01 0  77777 0  FLOAT48   UJP       **
00151  14200001 14 0  00001 2            ENI       1,2
00152  03200156 03 0 P00156 2            AZJ,GE    SCALE
00153  16477777 16 1  77777 0            XOA,S     -0
00154  16577777 16 1  77777 1            XOQ,S     -0
00155  14200000 14 0  00000 2            ENI       0,2
00156  13702057 13 1  02057 3  SCALE     SCAQ      2057B,3
00157  13077764 13 0  77764 0            SHAQ      -11
00160  45000044 45 0 C00044 0            STAQ      DUMMY+36
00161  14700000 14 1  00000 3            ENQ       0
00162  53300000 53 0  00000 3            TIA       3
00163  12000014 12 0  00014 0            SHA       12
00164  32000044 32 0 C00044 0            ADAQ      DUMMY+36
00165  02200170 02 0 P00170 2            IJI       *+3,2
00166  16477777 16 1  77777 0            XOA,S     -0
00167  16577777 16 1  77777 1            XOQ,S     -0
00170  01400150 01 1 P00150 0            UJP,I     FLOAT48
```

ENTRY POINT FTRANS TO FOURIER TRANSFORM THE SUMMED AND DIFFERENCED CROSS

CORRELATIONS ARRAYS. ARRAYS EXTX AND EXTY CONTAIN COSINE AND SINE TABLES.

```
00171  01077777 01 0  77777 0  FTRANS    UJP       **
00172  20000006 20 0 D00006 0            LDA       M
00173  12000001 12 0  00001 0            SHA       1
00174  44000251 44 0 P00251 0            SWA       IMCOUNT
00175  15600002 15 1  00002 2            INA       2
00176  44000260 44 0 P00260 0            SWA       MCOUNTZ
00177  15477775 15 1  77775 0            INA,S     -2
00200  15613716 15 1 C13716 2            INA       AK
00201  44000263 44 0 P00263 0            SWA       SGPOS
00202  44000264 44 0 P00264 0            SWA       SGNEG
00203  20000264 20 0 P00264 0            LDA       SGNEG
00204  40000265 40 0 P00265 0            STA       SGTMP
00205  20000263 20 0 P00263 0            LDA       SGPOS
00206  40000255 40 0 P00255 0            STA       RPLC
00207  14100002 14 0  00002 1            ENI       2,1
00210  14600000 14 1  00000 2  RECYCLE8  ENA       0
00211  14700000 14 1  00000 3            ENQ       0
00212  45123560 45 0 C23560 1            STAQ      CK-2,1
00213  45100046 45 0 C00046 1            STAQ      IDATA-2,1
00214  47127565 47 0 C27565 1            STI       J,1
00215  14200002 14 0  00002 2            ENI       2,2
00216  20000255 20 0 P00255 0            LDA       RPLC
00217  21000265 21 0 P00265 0            LDQ       SGTMP
00220  40000265 40 0 P00265 0            STA       SGTMP
00221  41000255 41 0 P00255 0            STQ       RPLC
00222  53200000 53 0  00000 2  RECYCLE9  TIA       2
00223  50027565 50 0 C27565 0            MUA       J
00224  13077775 13 0  77775 0            SHAQ      -2
00225  13000030 13 0  00030 0            SHAQ      24
00226  51000006 51 0 D00006 0            DVA       M
00227  17400001 17 1  00001 0            ANA,S     1
00230  44000241 44 0 P00241 0            SWA       PLORMN
00231  13000031 13 0  00031 0            SHAQ      25
00232  53700000 53 1  00000 3            TAI       3
00233  25217640 25 0 C17640 2            LDAQ      BK,2
00234  62307776 62 0 C07776 3            FMU       EXTY,3
00235  60100046 60 0 C00046 1            FAD       IDATA-2,1
00236  45100046 45 0 C00046 1            STAQ      IDATA-2,1
00237  25213716 25 0 C13716 2            LDAQ      AK,2
00240  62304056 62 0 C04056 3            FMU       EXTX,3
00241  04077777 04 0  77777 0  PLORMN    ISE       **
00242  01000244 01 0 P00244 0            UJP       *+2
00243  01000246 01 0 P00246 0            UJP       *+3
00244  16477777 16 1  77777 0            XOA,S     -0
00245  16577777 16 1  77777 1            XOQ,S     -0
00246  60123560 60 0 C23560 1            FAD       CK-2,1
00247  45123560 45 0 C23560 1            STAQ      CK-2,1
00250  15200002 15 0  00002 2            INI       2,2
00251  04277777 04 0  77777 2  IMCOUNT   ISE       **,2
00252  01000222 01 0 P00222 0            UJP       RECYCLE9
00253  60123560 60 0 C23560 1            FAD       CK-2,1
00254  60013716 60 0 C13716 0            FAD       AK
```

```
00255                          RPLC     BSS      1
00256  45123560 45 0 C23560 1          STAQ     CK=2,1
00257  15100002 15 0  00002 1          INI      2,1
00260  04177777 04 0  77777 1  MCOUNTZ ISE      **,1
00261  01000210 01 0 P00210 0          UJP      RECYCLE8
00262  01400171 01 1 P00171 0          UJP,I    FTRANS
00263  60077777 60 0  77777 0  SGPOS   FAD      **
00264  61077777 61 0  77777 0  SGNEG   FSB      **
00265                          SGTMP   BSS      1
                                       END
```

NUMBER OF LINES WITH DIAGNOSTICS 0