NASA CONTRACTOR
REPORT

Report No. 61314

COMPUTER PROGRAM FOR CROSSED-BEAM STUDIES OF CLEAR AIR TURBULENCE PROGRAM DESCRIPTION (MLTCOR)

By A. Wachowski and M. R. Phillips

IIT Research Institute
10 West 35th Street
Chicago, Illinois 60616

September 1969

Final Report

Prepared for

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER
Marshall Space Flight Center, Alabama 35812

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
NASA CR-61314		
4. TITLE AND SUBTITLE: COMPUTER PROGRAM FOR CROSSED-BEAM STUDIES OF CLEAR AIR TURBULENCE PROGRAM DESCRIPTION (MLTCOR)		5. REPORT DATE: September 1969
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): A. Wachowski and M. R. Phillips		8. PERFORMING ORGANIZATION REPORT #: J6145
9. PERFORMING ORGANIZATION NAME AND ADDRESS: IIT Research Institute, 10 West 35th Street, Chicago, Illinois 60616		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO.: NAS8-21300
		13. TYPE OF REPORT & PERIOD COVERED: Contractor Report May 14, 1968, Aug. 13, 1969
12. SPONSORING AGENCY NAME AND ADDRESS: NASA-George C. Marshall Space Flight Center, Marshall Space Flight Center, Alabama 35812		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Distribution of this report is provided in the interest of information exchange. Responsibility for the contents resides in the author or organization that prepared it.

16. ABSTRACT

The multichannel correlation program (MLTCOR) described in this report is fairly general and was developed to calculate statistics for aerodynamic and atmospherical turbulence based on the crossed-beam technique. The piecewise concept was used in writing this program. A long-time series is logically broken up into a series of smaller pieces. Correlations, mean values, root-mean-square (RMS) values and variances are then calculated for each piece along with their standard statistical errors. A dynamic storage allocation scheme was used in the program to provide maximum storage for data and to avoid the use of fixed length data arrays. Correlations can be performed on essentially infinite length records. Time series data are brought into the computer in blocks to fill the available storage, and data for the maximum time lag are saved from the previous block to make correlations continuous across the core loads of data. The program is written in FORTRAN IV using modular techniques and dynamic storage allocation. The mathematical formulation was developed in-house by NASA and the programming and interfacing to MSFC facilities was accomplished by IITRI.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
	PUBLIC RELEASE E. D. GEISSLER Dir, Aero-Astrodynamics Lab, MSFC

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
U	U	135	

FOREWORD

This final report, entitled "Computer Program for Crossed-Beam Studies of Clear Air Turbulence, Program Description (MLTCOR)," presents the results of research undertaken by IIT Research Institute (IITRI) from 14 May 1968 to 13 August 1969. The research was performed for National Aeronautics and Space Administration (NASA), Marshall Space Flight Center, Alabama, under Contract NAS8-21300 (IITRI Project J6145).

ACKNOWLEDGEMENT

The authors would like to take this opportunity to make acknowledgement to F. R. Krause and R. R. Jayroe for their cooperation and technical assistance in developing the computer code for (MLTCOR) and also to J. A. Jones for making available, as needed, computational support.

CONTENTS

ILLUSTRATIONS

TABLES

COMPUTER PROGRAM FOR CROSSED-BEAM STUDIES OF CLEAR AIR TURBULENCE

PROGRAM DESCRIPTION (MLTCOR)

A. Wachowski
M. R. Phillips
IIT Research Institute

SUMMARY

The multichannel correlation program (MLTCOR) described in this report is fairly general and was developed to calculate statistics for aerodynamic and atmospherical turbulence based on the crossed-beam technique.

A dynamic storage allocation scheme was used in the program to provide maximum storage for data and to avoid the use of fixed length data arrays. Correlations can be performed on essentially infinite length records. Time series data are brought into the computer in blocks to fill the available storage, and data for the maximum time lag are saved from the previous block to make correlations continuous across the core loads of data. The program is written in FORTRAN IV using modular techniques and dynamic storage allocation.

The piecewise concept was used in writing this program. A long-time series is logically broken up into a series of smaller pieces. Correlations, mean values, root-mean-square (RMS) values and variances are calculated for each piece along with their standard statistical errors.

The program uses strong and very effective detrending and normalization techniques (see Appendix C) developed over the years to cope with problems encountered while attempting to derive meaningful information from aerodynamic and atmospheric data. The detrending and normalization techniques employed minimizes the effects of DC shifts and trends as well as drifting

gains which are unavoidable. Until recently, methods used were not adequate for extracting meaningful information for reliable data interpretation.

The associated errors are calculated as guidelines for interpreting the data (see Appendix D). The parameters can be monitored concurrently with "piecewise" averages for analyzing data behavior. When these error parameters exceed "built-in" confidence limits, this reflects a degree of stationarity that would not be acceptable to the previous accumulation of pieces.

The program provides for accumulating over separate periods of the data record with provisions for deleting individual data pieces within the accumulation period. With this provision data pieces can be discarded or accumulated in such a fashion that only the stationary pieces (within certain confidence limits) are used in the accumulation.

The mathematical formulation was developed in-house by NASA and the programming and interfacing to MSFC facilities was accomplished by IITRI.

1. MATHEMATICAL FORMULATION

The purpose of the computer program is to statistically analyze a given set of simultaneously recorded time histories which represent the output of a group of meteorological sensors. The desired statistical analysis is based on the mathematical model (Ref. 1) of a stationary and infinitely long-time history.

Within this model, accurate mean values, RMS values, correlation functions and covariance functions would be defined by the time integrals listed in Table I. Each of the correlation calculations would be performed for several combinations of signal pairs. One signal, x_j, is always to be taken from the group of records $j = 1, 2, 3$, that is to be delayed in time. The other signal, y_k, is to be taken from the remaining signals $k = k_1, k_2 \ldots k_N$, for which the need of a time delay is not anticipated.

The records of meteorological sensors are unfortunately neither stationary nor infinitely long. The actual calculations will therefore provide only various approximations to the mathematical model. To define these mathematical approximations adequately, it is necessary to define a number of terms and to introduce the symbols used in defining the operations to be performed on the input data.

A. Definition of Symbols

1. Independent Variables.-

t	Observation time
T	Integration time
ΔT	Piece length
i	Piece number
e	Sampling period
$\frac{1}{e}$	Sampling rate
b	Sample reduction factor
$\frac{1}{be}$	Effective sampling rate
$\bar{e} = be$	Effective sampling period
$M = \frac{\Delta T}{be}$	Number of samples per piece
τ	Time lag

TABLE I

MATHEMATICAL ANALYSIS OF STATIONARY, INFINITELY LONG-TIME HISTORIES

DESIRED STATISTICS	TIME INTEGRATION
Mean Values	$\langle x \rangle_j = \lim_{T_q - T_{q-1} \to \infty} \frac{1}{T_q - T_{q-1}} \int_{t=T_{q-1}}^{t=T_q} x_j(t)\, dt$ $\langle y \rangle_k = \lim_{T_q - T_{q-1} \to \infty} \frac{1}{T_q - T_{q-1}} \int_{t=T_{q-1}}^{t=T_q} y_k(t)\, dt$
Mean Square Values	$\langle x^2 \rangle_j = \lim_{T_q - T_{q-1} \to \infty} \frac{1}{T_q - T_{q-1}} \int_{T_{q-1}}^{T_q} x_j^2(t)\, dt$ $\langle y^2 \rangle_k = \lim_{T_q - T_{q-1} \to \infty} \frac{1}{T_q - T_{q-1}} \int_{T_{q-1}}^{T_q} y_k^2(t)\, dt$
Second Moment About Mean	$\langle \sigma^2 \rangle_j = \lim_{T_q - T_{q-1} \to \infty} \frac{1}{T_q - T_{q-1}} \int_{t=T_{q-1}}^{T_q} (x_j(t) - \langle x \rangle_j)^2\, dt$ $\langle \sigma^2 \rangle_k = \lim_{T_q - T_{q-1} \to \infty} \frac{1}{T_q - T_{q-1}} \int_{t=T_{q-1}}^{T_q} (y_k(t) - \langle y \rangle_k)^2\, dt$
Correlation Function	$R_{jk}(\tau) = \lim_{T_q - T_{q-1} \to \infty} \frac{1}{T_q - T_{q-1}} \int_{t=T_{q-1}}^{T_q} (x_j(t-\tau)\, y_k(t)\, dt$
Covariance Function	$C_{jk}(\tau) = R_{jk}(\tau) - \langle x \rangle_j \langle y \rangle_k$

τ_{max}	Maximum time lag
τ_{min}	Minimum time lag
$\Delta\tau$	Time lag increment
$L = \frac{\tau_{max} - \tau_{min}}{\Delta\tau}$	Number of lag points
$\beta = \frac{\Delta\tau}{\bar{e}}$	Number of samples per lag interval
J	Index of delayed channel
K	Index of undelayed channel
X	Delayed channel
Y	Undelayed channel
t_q	Accumulation start time
t_{q+1}	Accumulation end time

2. Operators.-

$(\quad)$	Statistic
$\overline{(\quad)}_i = \frac{1}{\Delta T} \int_{T=(i-1)\Delta T}^{T=i\Delta T} (\quad)dt$	Piecewise mean
$\overline{\overline{(\quad)}}_m = \frac{1}{m} \sum_{i=1}^{m} \overline{(\quad)}_i$	Accumulative mean
$\Delta^2 \overline{(\quad)}_m = \frac{1}{m-1} \sum_{i=1}^{m} \left(\overline{(\quad)}_i - \overline{\overline{(\quad)}}_m \right)^2$	Piecewise statistical error
$\Delta^2 \overline{\overline{(\quad)}}_m = \frac{1}{m} \Delta^2 \overline{(\quad)}_m$	Accumulative statistical error
$_\tau\overline{(\quad)} = \frac{1}{2\tau_{max}} \int_{-\tau_{max}}^{+\tau_{max}} \overline{(\quad)} d\tau$	Average over time lag

3. Special Notations.- To indicate that an average has been performed on a basic quantity, which is dependent upon a number of variables, a special notation is used. A subscript to the right of a symbol indicates that the subscript is variable, while a subscript to the left of a symbol indicates an average has been performed with respect to this subscript. Thus, the basic piecewise accumulative mean $\overline{(\ )}$ may be dependent on the delayed and undelayed channels j and k, and the time lag τ. This would be indicated as

$$\overline{(\ )}_{jk\tau}$$

The average over time lags would be indicated as

$$_{\tau}\overline{(\ )}_{jk} = \frac{1}{2\tau}\int_{-\tau_{max}}^{+\tau_{max}} \overline{(\ )}_{\tau jk}\, d\tau$$

This special notation is required to indicate some of the error terms calculated in the program.

B. Basic Computations

The processing of very long records through a computer with a limited storage capacity is possible by breaking the record into successive pieces of length ΔT. A time integral over such a single piece is then approximated by summation over the samples $n = 1, 2, \ldots M$, which are contained in the piece. Averages over longer periods may then be established by accumulating the information from all pieces, $i = 1, 2, \ldots, m$. The resultant "accumulative" mean can be averaged further by summing over all time lags (Ref.2) $\ell = -L + 1, -L + 2, \ldots, -1, 0, 1, \ldots + L$ and over several specially selected channels ($j = 1, 2, 3$ and $k = k_i, k_2, k_N$). Table II gives a list of such basic averages.

The deviations from stationarity may also be partially removed by assigning statistical weights and ordinate shifts (Ref. 3 and Appendix C) to each piece.

TABLE II

BASIC AVERAGES

AVERAGE	SAMPLING	SUMMATION
Piecewise Average (Single piece)	$t = n\bar{\varepsilon}$ $\Delta T = M\bar{\varepsilon}$	$\overline{(\ \ )}_i = \frac{1}{M}\sum_{m=1}^{M} (\ \ )_{n=(i-1)M+m}$
Accumulative Average (All previous pieces)	$i = 1,2,\ldots,m$ $T_q - T_{q-1} = m\Delta T$	$\overline{\overline{(\ \ )}}$ = Output of accumulation subroutine, Table III
Time Lag Average (All lags and pieces)	$i = 1,2,\ldots,m$ $\left\| \tau_{max} - \tau_{min} \right\|\ L\beta\bar{\varepsilon}$ $\pm\tau_{\ell} = \pm\tau_{min} + \ell\beta\bar{\varepsilon}$	${}_{\tau}\overline{\overline{(\ \ )}} = \frac{1}{2L}\sum_{\ell=-L+1}^{+L} \overline{\overline{(\ \ )}}\,(\tau_{\ell})$
Channel Average (Selected channels all pieces)	$j = 1,2,3$ $k = k_i;\ k_2;\ k_3;\ \therefore k_N$	${}_{jk}\overline{\overline{(\ \ )}}^2 = \frac{1}{N}\left\{\overline{\overline{(\ \ )}}^2_{jk_1} + \overline{\overline{(\ \ )}}^2_{jk_2} + \overline{\overline{(\ \ )}}^2_{jk_3} + \overline{\overline{(\ \ )}}^2_{jk_N}\right\}$

This provides a multitude of different accumulative averages, which differ from a straight time integral by the particular weight, and shifts that were chosen. Four such accumulation procedures (listed in Table III) are used since they have proved very effective in removing temporal trends of statistical averages.

The desired statistical averages listed in Table I cannot be calculated exactly, since any deviation from stationarity and infinite record length will introduce statistical errors. The standard statistical errors of the various averages listed in Table II can be calculated by employing the deviations from the piecewise means from the accumulative means. The associated standard errors are listed in Table IV. These standard errors are functionally dependent on integration time, $T = T_q - T_{q-1}$ and allows one to indirectly determine some dominant deviations from stationarity. Furthermore, these errors are required whenever the confidence limits of the various averages are requested.

Each new piecewise average i, is used to continuously update the accumulative averages over the previous m pieces. This leads to two recursion formulas for updating the accumulative averages (Ref.4) and the standard error of these averages.

The recursion relationships are as follows.

Accumulative averages:

$$\overline{\overline{(\quad)}}_{m+1} = \frac{m}{m+1}\,\overline{\overline{(\quad)}}_m + \frac{1}{m+1}\,\overline{(\quad)}_{m+1}$$

Standard error of accumulative average:

$$\Delta^2\left[\overline{\overline{(\quad)}}_{m+1}\right] = \frac{m-1}{m}\,\Delta^2\left[\overline{\overline{(\quad)}}_m\right] + \frac{m+1}{m^2}\left[\overline{(\quad)}_{m+1} - \overline{\overline{(\quad)}}_{m+1}\right]^2$$

TABLE III

ACCUMULATION PROCEDURES

TYPE	ACCUMULATION SUBROUTINE, $\overline{\overline{(\;\;)}}$
Straight Time Integration	$\overline{\overline{(\;\;)}}_m = \frac{1}{m} \sum_{i=1}^{m} \overline{(\;\;)}_i$
Statistical Weighting	$\overline{\overline{(\;\;)}}_w = \frac{1}{m} \sum_{i=1}^{m} \frac{\overline{(\;\;)}_i}{\bar{\sigma}_{ji}\ \bar{\sigma}_{ki}}$
Ordinate Shifts	$\overline{\overline{(\;\;)}}_d = \frac{1}{m} \sum_{i=1}^{m} \left\{ \overline{(\;\;)}_i\ (\tau_\ell) - {}_\tau\overline{(\;\;)}_i \right\}$
Combined Weighting and Shifting*	$\overline{\overline{(\;\;)}}_c = \frac{1}{m} \sum_{i=1}^{m} \frac{\overline{\overline{(\;\;)}}_i\ (\tau_\ell) - {}_\tau\overline{(\;\;)}_i}{\bar{\sigma}_{ji}\ \bar{\sigma}_{ki}}$

* If the piecewise means are not given as a function of time lag, the accumulations d and c are to be replaced with the substitutions $\overline{\overline{(\;\;)}}_d = \overline{\overline{(\;\;)}}_m$ and $\overline{\overline{(\;\;)}}_c = \overline{\overline{(\;\;)}}_w$.

TABLE IV

STANDARD ERRORS

TYPE	SUMMATION
Standard Error of Piecewise Average	$\Delta^2\left[\overline{(\;)}_m\right] = \frac{1}{m-1}\sum_{i=1}^{m}\left(\overline{(\;)}_i - \overline{\overline{(\;)}}_m\right)^2$
Standard Error of Accumulative Average	$\Delta^2\left[\overline{\overline{(\;)}}_m\right] = \frac{1}{m}\Delta^2\left[\overline{(\;)}_m\right] = \frac{1}{m(m-1)}\sum_{i=1}^{m}\left(\overline{(\;)}_i - \overline{\overline{(\;)}}_m\right)^2$
Standard Error of Time Lag Average	${}_{\tau}\overline{\Delta}^2_{jk} = {}_{\tau}\Delta^2\left[\overline{\overline{(\;)}}\right] = \frac{1}{2L}\sum_{\ell=-L+1}^{+L}\Delta^2\overline{\overline{(\;)}}_{jk}(\tau_\ell)$
Standard Error of Channel Average	${}_{k\tau}\overline{\overline{\Delta}}^2_j = \frac{1}{N}\left\{\overline{\Delta}^2_{jk_1} + \overline{\Delta}^2_{jk_2} + \overline{\Delta}^2_{jk_3} + \dots \Delta^2_{jk_N}\right\}$

The values for the first piece are assumed to be

$$\overline{\overline{(\quad)}}_1 = \overline{(\quad)}_1$$

and

$$\Delta^2 \left[\overline{\overline{(\quad)}}_1 \right] = 0$$

In summary, the purpose of the program is to analyze simultaneously recorded time histories of meteorological data by calculating an average of mean values, RMS values, and covariance functions, which approximate the mathematical model of stationary and infinitely long-time histories to the largest practical amount. Several averaging procedures (Table II) can be used which provide different approximations by assigning the statistical weights or ordinate shifts to each piece listed in Table III. The success of the various averaging procedures is then established by monitoring the associated standard errors (Table IV) as a function of integration time. A rough description of the actual deviations from stationary is provided by the weights and shifts that resulted in the smallest standard errors.

2. GENERAL DESCRIPTION

The basic program structure for MLTCOR is shown in Figure 1 and consists of LINK 1 - the input link, LINK 2 - the correlation link, and LINK 3 - the output link. Each link of the program is relatively independent of the others allowing for separate execution of each of the links. Common information required between links is stored on magnetic tape and read into storage when execution of an individual link is initiated. Since each link is relatively independent, they are executed as overlays with each link occupying the space of the previous one, and in this way providing for more data storage in each link.

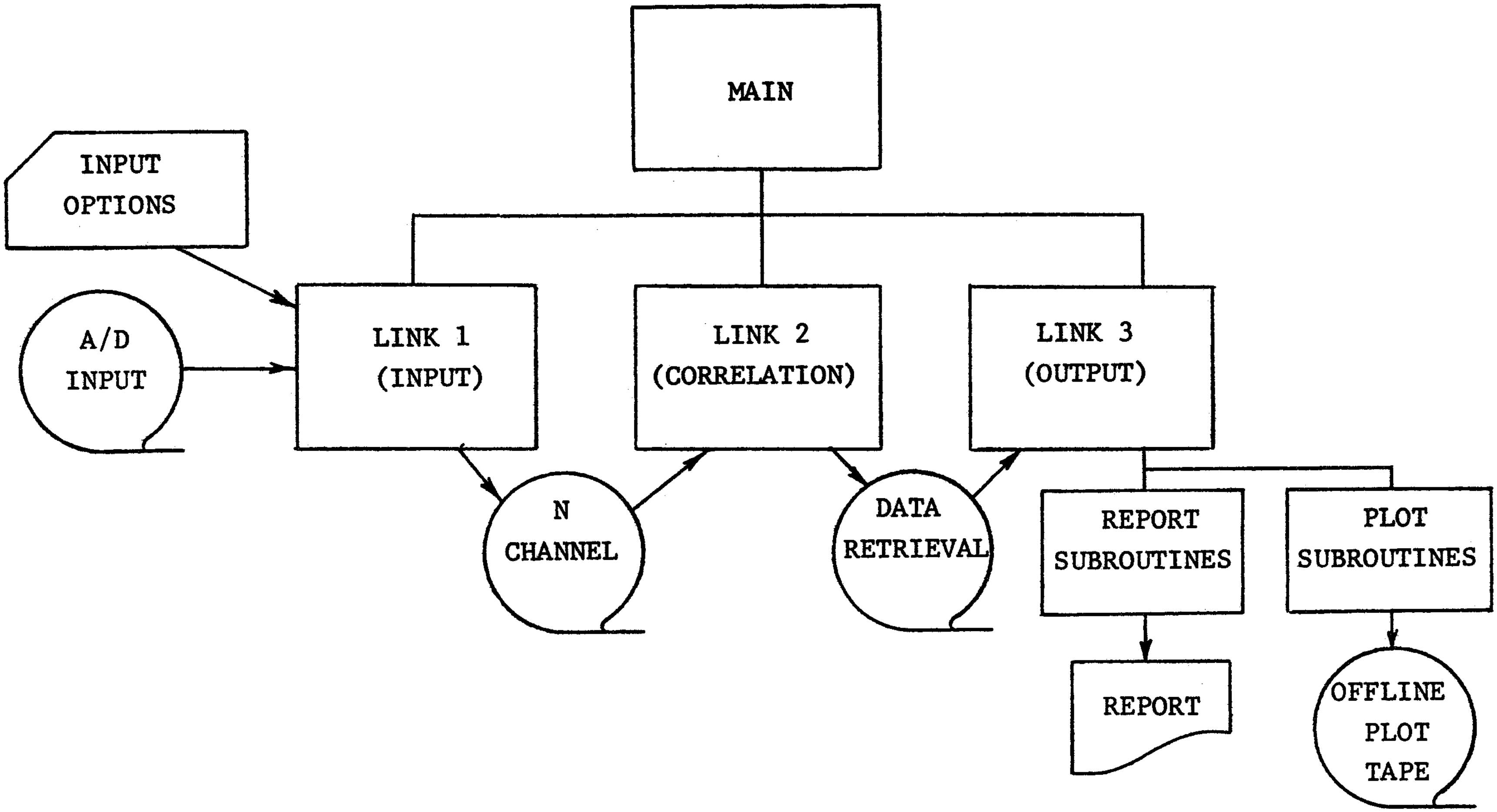


Figure 1 Basic Program Structure

The overlay diagram for the program is shown in Figure 2. The basic functions performed by each link are outlined in the figure and are described in more detail in the later sections.

The main program is a small executive program which controls the execution of the various links and provides for common storage. The flow chart for this program is shown in Figure 3. The main program allows for the execution of each link separately.

LINK 1 performs calibration of the data, sample reduction, and determination of a moving mean. The output from LINK 1 is a block intermediate tape for use in LINK 2. Blocking of the tape is used, i.e., more than one time sample per physical record, since it decreases the length of tape required to store the data and speeds the input/output time for reading and writing the data. The blocking of the intermediate tape in LINK 1 and unblocking in LINK 2 are automatically taken care of by the program.

LINK 2 is the main computational portion of the program and was designed to accommodate multiple auto and cross correlation requests with variable time lags. A special dynamic storage allocation scheme was used to provide maximum storage for data. This scheme avoids the use of fixed length data arrays in the program which would limit its usefulness. The dynamic storage allocation scheme makes it possible to tradeoff between the number of channels to be correlated, maximum time lags, and number of correlations. In fact if the correlations specified require too much storage, the number of correlations requested is automatically reduced until there is sufficient storage to run the problem.

The piecewise concept of analysis was used in creating the program. A long-time series is logically broken up into a series of smaller pieces. Correlations, mean values, RMS values and variances are then calculated for each piece along with their standard statistical errors. Calculations for each piece are accumulated and periodic printouts can be used to monitor piecewise statistics and errors.

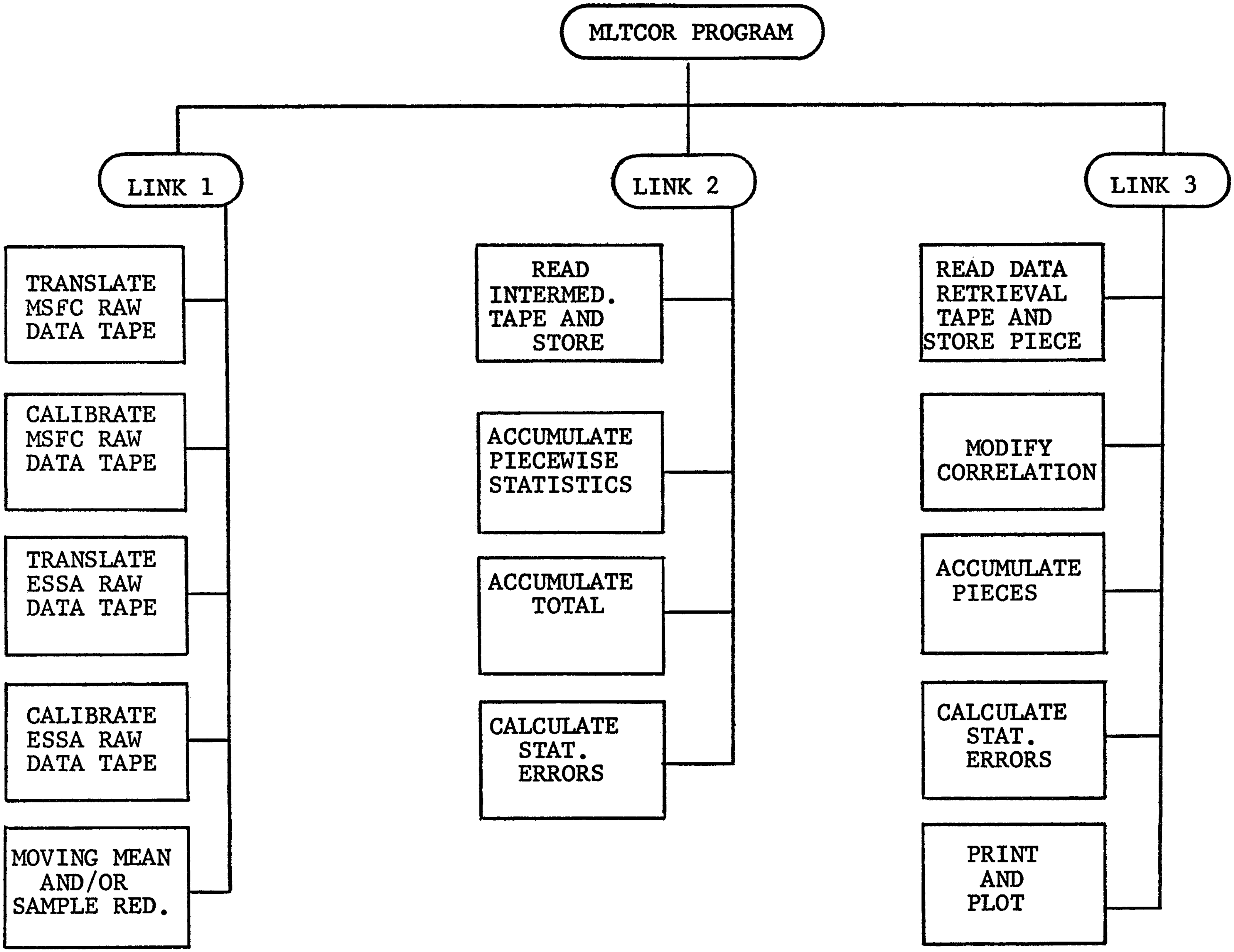


Figure 2 Overlay Diagram

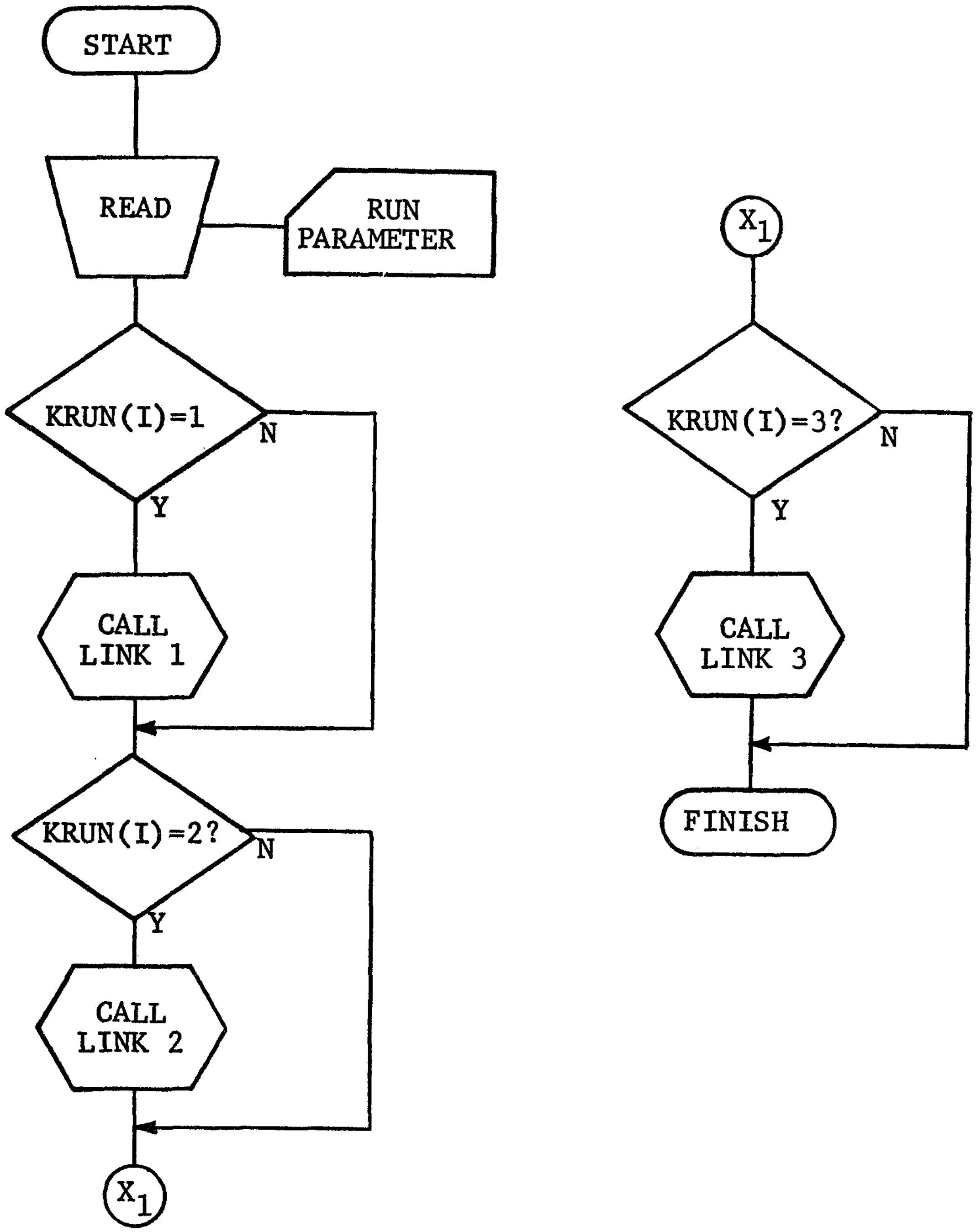


Figure 3 Main Program

Correlations can be performed in LINK 2 on essentially infinite records. Data are continuously brought into the computer in blocks to fill the available storage, and data for the maximum time lag are saved from the previous block to make correlations continuous across core loads of data. Calculating the lagged products for the correlations is the most time consuming portion of the program, therefore, the piecewise correlations and statistics are written out on a magnetic tape called the Information Retrieval Tape (IRT) so that the data may be retrieved in LINK 3.

The correlations formed in LINK 2 are read back in LINK 3 to form modified correlations. At this point a number of standard operations can be performed such as normalizing, detrending, or subtracting the product of the means to form the covariance. Any of these operations can be performed individually or in combination to form modified correlations. The modified piecewise statistics are then summed to form a new accumulation. Printouts or plots of the original or modified correlations can be made for each piece or for the full accumulation. Since only minor calculations are performed in LINK 3, a number of modified correlations can be obtained without rerunning the lagged products which were performed in LINK 2. It is expected that LINK 3 will be run more frequently than the other links to obtain various modified correlations.

3. DYNAMIC STORAGE ALLOCATION

In dealing with large systems on a computer a number of problems arise due to the limitations of internal storage. In many cases these limitations can be overcome through the use of auxiliary memory such as magnetic tape, disc, or drum. A penalty is paid in time for the use of these types of storage, and generally a method of more fully utilizing the high speed core storage of the machine, at the cost of program complexity, is well worthwhile. For many problems of a predictable nature (size of arrays, flow of processing) preplanned storage allocation is best. When the problem's flow of processing and array sizes are data dependent and variable, dynamic storage allocation is necessary.

Characteristics of dynamic storage allocation are:

- The program at run time is not directly executable, but requires parameters to be set to allocate storage.
- It is not known in advance where in memory data arrays will be held at execute time.

Most operating systems provide good methods of dynamic storage allocation for programs through the use of overlays. Subroutines can be placed on links and called in at execute time when needed as mentioned in the previous section. Unfortunately, FORTRAN IV does not provide the same flexibility for data. For example, an array for storing 1000 values for six channels would require the statement: Dimension X (6,1000). This would reserve 6000 locations of high speed core storage and limit the total number of channels to six and data points to 1000. If a problem required only two channels of data, then 2000 memory locations would be used and 4000 locations would be wasted. Furthermore, it would not be possible to run a problem with eight channels and only 700 data points per channel, even though there is sufficient total storage in the X array. This is due to the column method of array storage used in FORTRAN. A better method of usage is desired which places no arbitrary size restrictions on the problem, and utilizes high speed core memory as efficiently as possible.

The dynamic storage allocation method used in MLTCOR is based on the use of one large array or data pool to store all variable data arrays. This array called U(I) is dimensioned for 20,000 locations. Storage is allocated by assigning pointers which are fixed point numbers to indicate where an array is stored in U(I). The storage pointers are set from data values read in from cards. As used in LINK 2 of the program, U(1) to U(KESM), is used to store time lag information, and U(KESM) to U(KD) is used to store standard errors, accumulative sums, piece-wise sums and correlations. The remainder of the U array is used to store data points. This portion of the U array is treated as a two-dimensional array with dimensions (NCH,N) where N is the total number of data points and NCH is the number of channels. Both N and NCH can be variable.

The data stored in the U array and space reserved for results are used by variable dimension subroutines. The actual position of the information is communicated to the subroutines through the call statement. As example of a variable dimension subroutine which was actually used in the program is:

```
      SUBROUTINE ACCPC(S,S2,S3,DATA,N,NC)
C
C     ACCUMULATE SUM AND SUM OF SQUARES
C        WRITTEN BY A. WACHOWSKI
C     DIMENSION S(NC),S2(NC),DATA(NC,N)
      DIMENSION S3(NC)
      XN=N
      DO 1 L=1,NC
      S(L)=0.0
    1 S2(L)=0.0
C
      DO 3 J=1,NC
      DO 2 I=1,N
      S(J)=S(J) +DATA(J,I)
    2 S2(J)=S2(J)+DATA(J,I)*DATA(J,I)
      S(J)=S(J)/XN
      S2(J)=S2(J)/XN
      S3(J)=S2(J)-S(J)**2
    3 CONTINUE
      RETURN
      END
```

This subroutine calculates the average, the average of the squares, and the variance for N data points and NC channels. The arrays S,S2 and S3 are used to store the results for each channel. The actual call statement in the main subroutine of LINK 2 would be: CALL ACCPC(U(KMP), U(KRP), U(KPSM), U(KK), MSUB, NCH) the fixed point numbers indicating the storage location in the U array. This simple example illustrates how the ordinary subscripting capability for calculations is retained with the dynamic storage allocation scheme. The example is quite simple but shows how the other computational modules are written.

4. LINK 1 - THE INPUT LINK

LINK 1 of the MLTCOR program reads raw data, translates, calibrates, conditions, and writes a buffered output tape for subsequent input to LINK 2 for multiple correlations and statistical calculations. The flow chart for LINK 1 is shown in Figures 4 and 5. LINK 1 was programmed using modular techniques, variable dimensioning and dynamic storage allocation. All operations on the raw data will be done in the DATA storage array except the buffered output data. The data storage is dimensioned to 8000 words to store the maximum number of words that might be blocked on either of the two types of input tapes (ESSA or MSFC).

A. Input Tapes

There are two inputs to LINK 1 of the MLTCOR program:

- ESSA format which is the output of the data logging system located at ESSA, Boulder, Colorado (Figure 6).
- MSFC format which is the output of the digitizer located at NASA in Huntsville, Alabama (Figure 7).

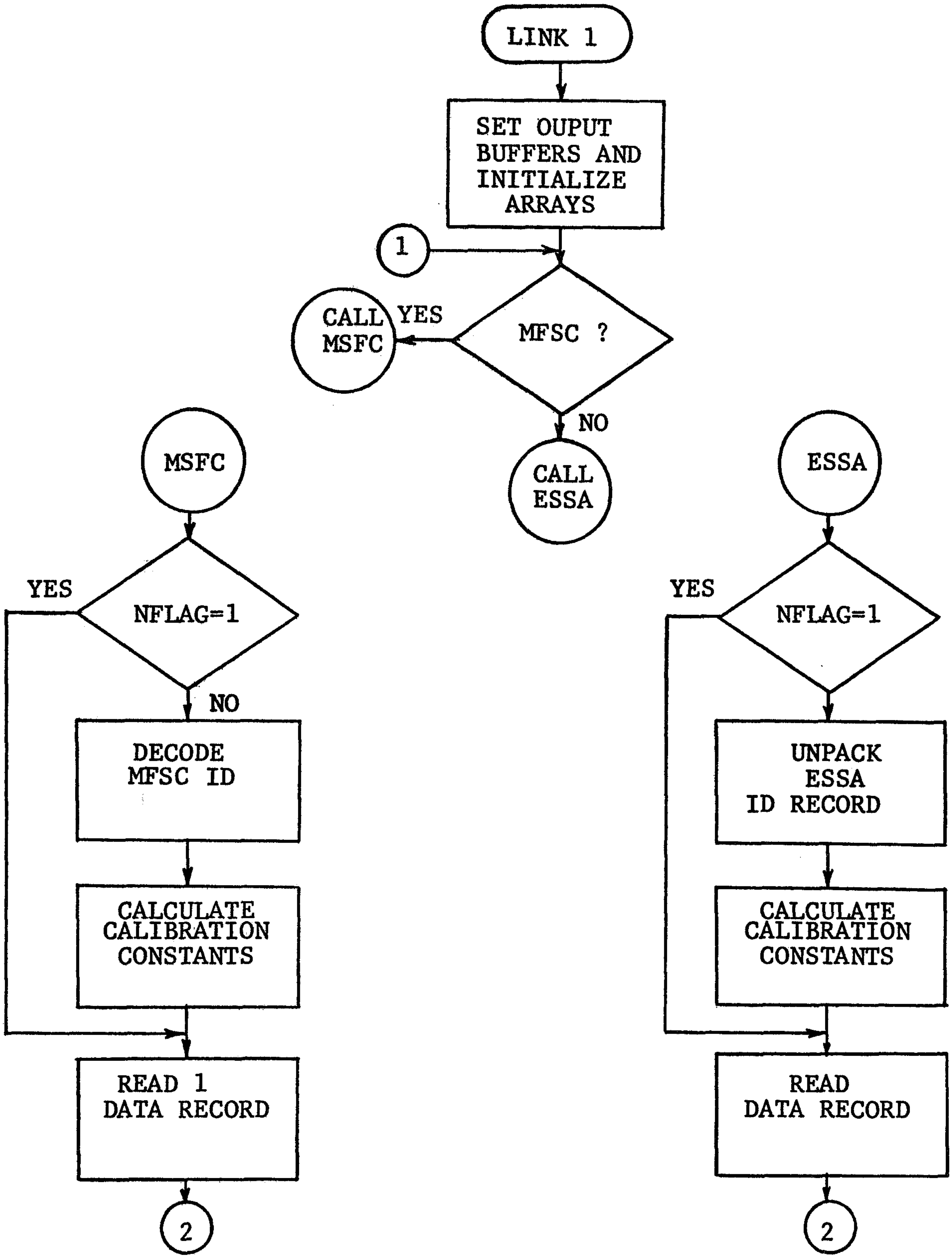


Figure 4 LINK 1-1

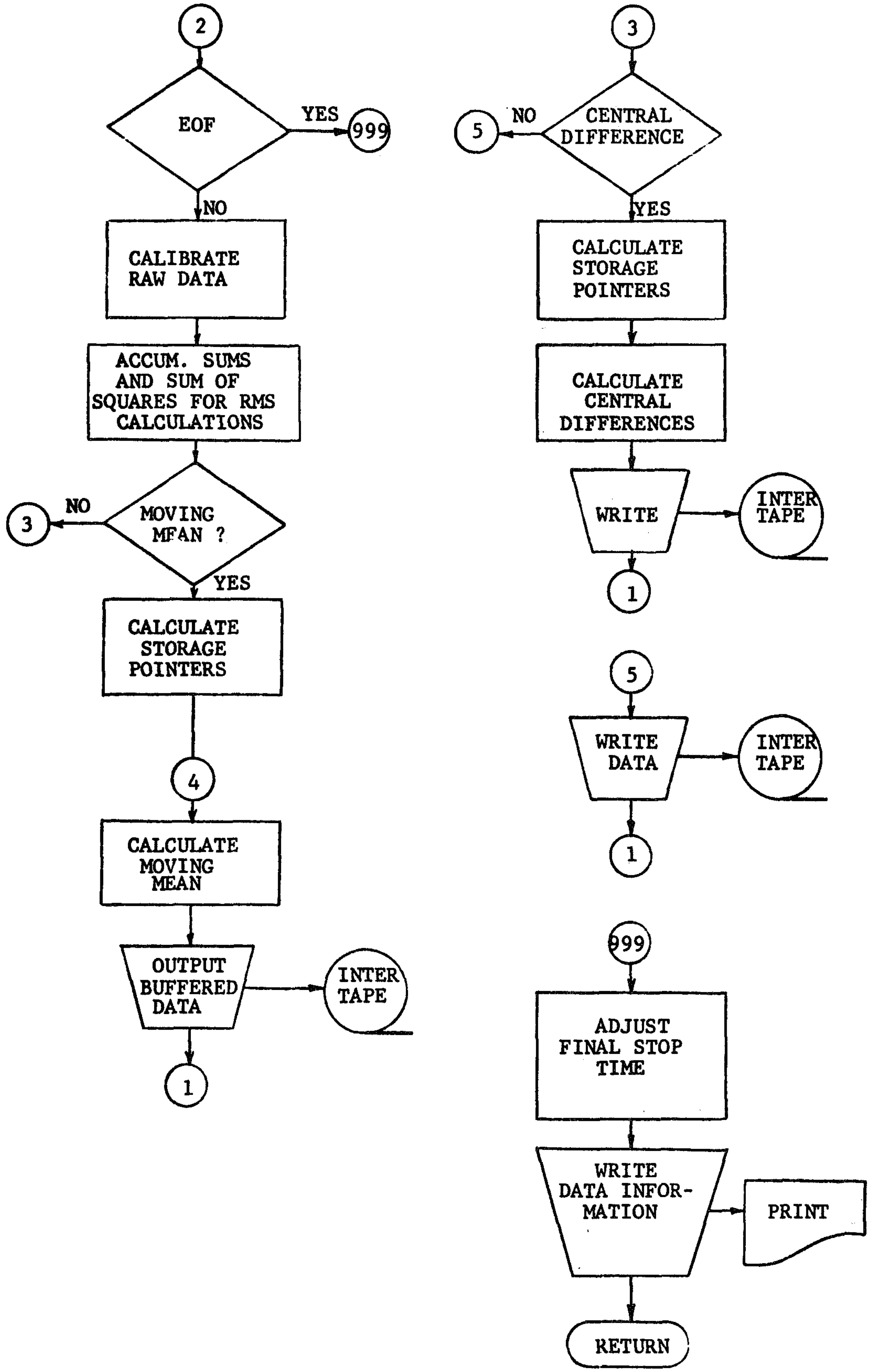


Figure 5 LINK 1-2

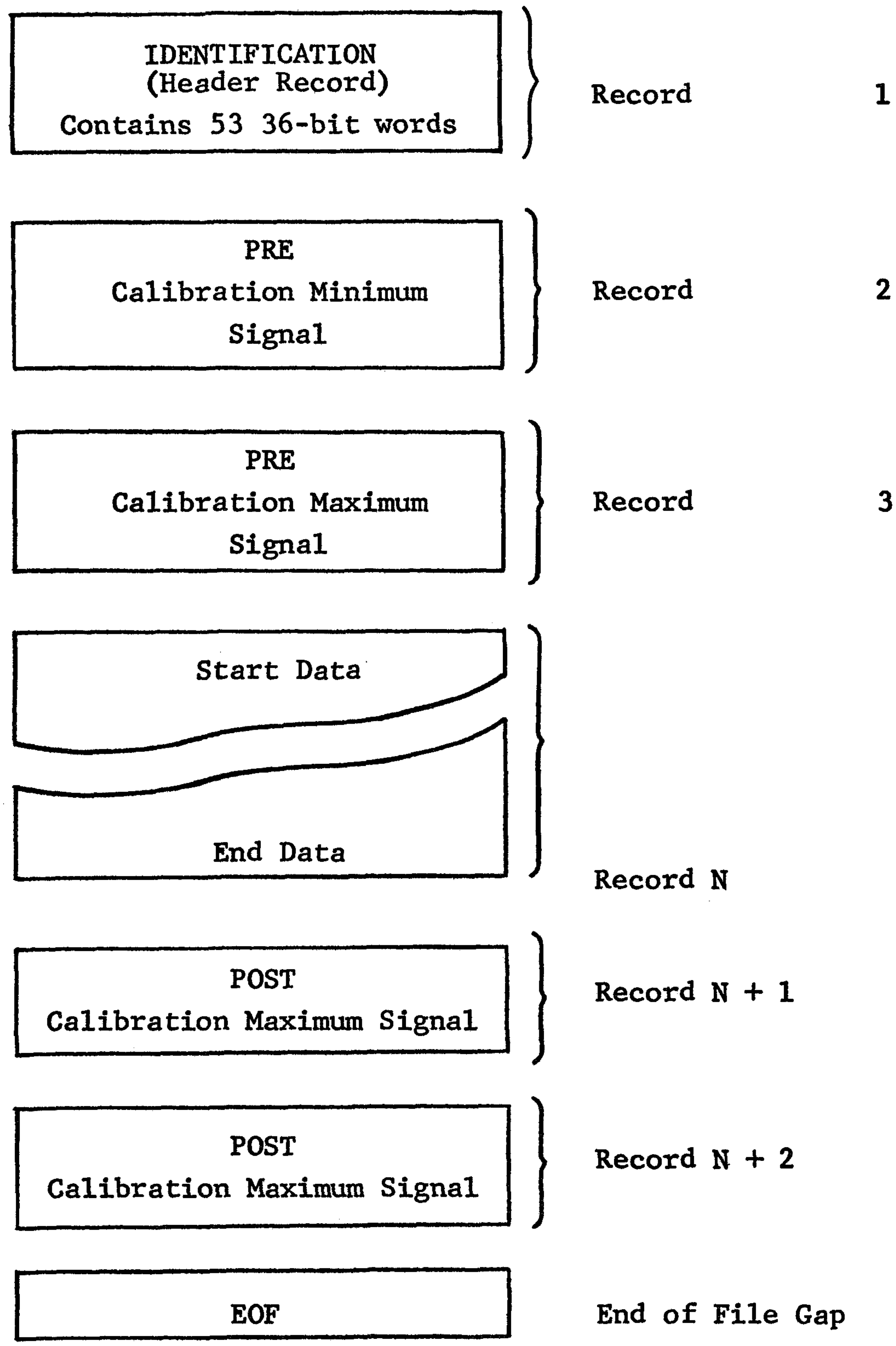


Figure 6 ESSA Data Logger Output Format

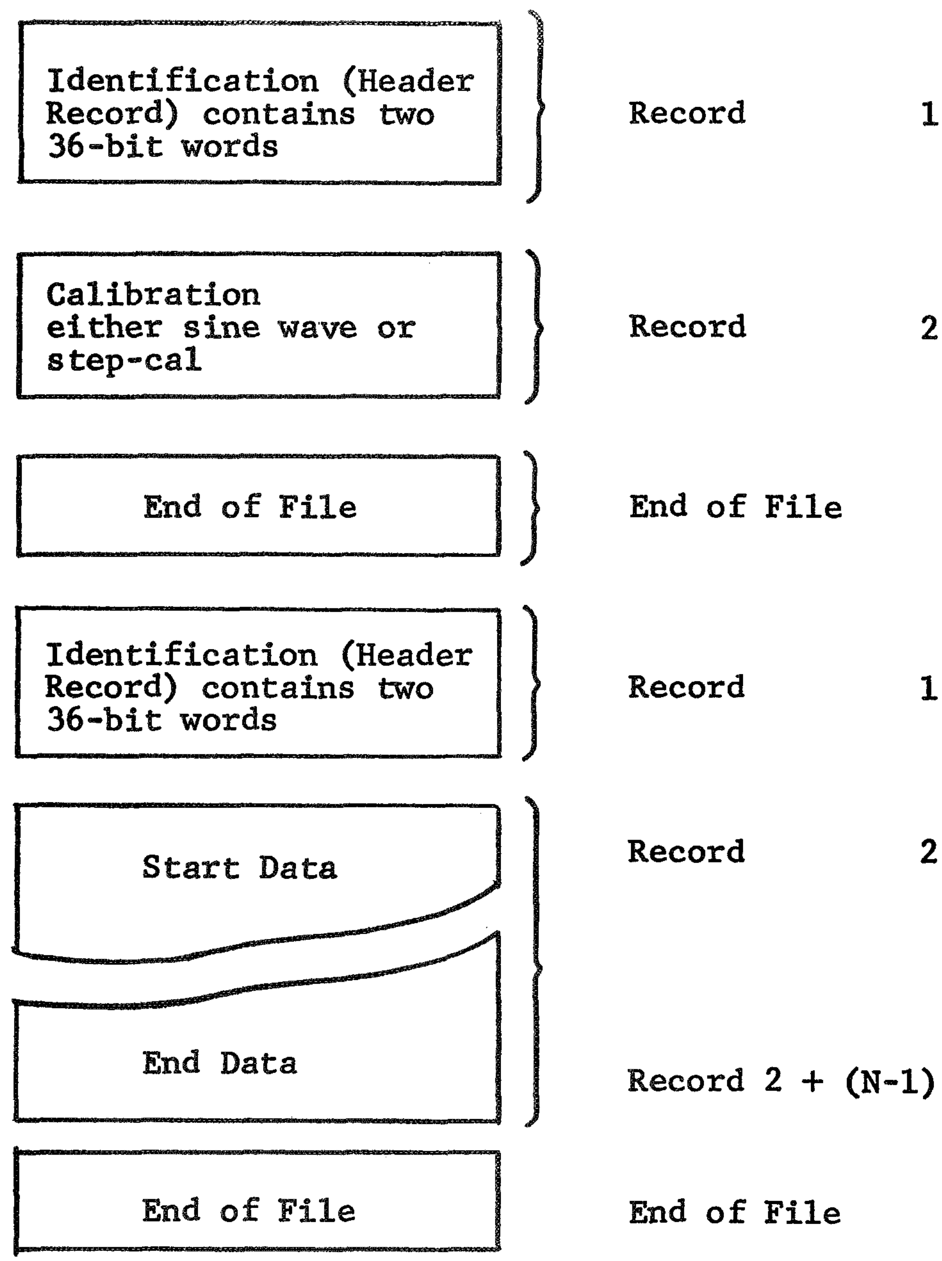


Figure 7 MSFC Digitizer Output Format

B. Input Problem Parameters

The problem parameters that are input to LINK 1 by the user are described here.

NBEAMS - Total number of beams in the fan system

NFLSKC - Number of files to skip for calibration data

NFLSKD - Number of files to skip for data

MVMEAN - Number of samples in the moving span if moving mean desired; If not MVMEAN = 0

NCENDF - Central differences NCENDF = 1 (Yes) NCENDF = 0 (No)

NOBEAM - Total number of beams to perform moving mean or central differences on

NWHICH - Beam numbers being affected

TIMSAM - Rate at which data are sampled at digitizing time

VALMAX - Maximum calibration value

VALMIN - Minimum calibration value

START - Start time on input tape (Max is 5)

STOP - Stop time on input tape (Max is 5)

NFILE - Number of files to skip on the ESSA formated tape for the calibration file

MSFC - MSFC format (1 = Yes, 0 = No)

IFREQ - LINK 1 output frequency; Example, IFREQ = 3; Every third sample output to tape

LTN - Logical tape number input data is loaded on

NBLK - Number of records/block desired on LINK 1 output tape

NSTART - Number of starts and stops (Max = 5)

NBOB - Always set to 0 (used in debugging)

PLYBCK - Playback rate (the ratio of the digitizer tape speed to the recorded data tape speed relative to real time)

C. Central Differences

Central differences are calculated from the data by

$$X_{(i)} = X_{(i+2)} - X_{(i)}$$

Where

i = 1,2,3,4 ....., N-2 samples
on the data record.

D. Moving Mean and Sample Reduction

Filtering is performed on the calibrated data by passing the data through a moving mean span preselected by the user, preferably an odd integer. This is performed on the entire data record or selected data intervals controlled by the input parameters (Section 7A). The data are passed through this span successively, one sample at a time. Each data sample, $X_{(K)}$, where

$$X_{(K)} = \frac{1}{N} \sum_{i = K - \frac{N-1}{2}}^{K + \frac{N-1}{2}} X(i)$$

K goes from $\left(\frac{N-1}{2}\right)$ to $Te - \left(\frac{N-1}{2}\right)$

where N = number of samples in the moving span, and T = integration time

is calculated and an option is provided to retrieve from the filtered data any sample rate for output to the intermediate tape by incrementing K through the data at the desired reduction rate. This performs the sample reduction.

E. Calibration

1. Sine Wave Calibration.- A calibration signal is put on the analog tape at some specified frequency with a peak-to-peak value of 1.414215 volts. The peak value of the digitized raw data counts is determined by calculating the RMS of the sine wave.

$$RMS = \left[\frac{1}{N}\left(\sum_{i=1}^{N} X^2(i)\right) - \left(\frac{\sum_{i=1}^{N} X(i)}{N}\right)^2\right]^{1/2}$$

where $X(i)$ = Raw data sample in digitizer counts

and N = number of samples used

The peak values are then determined by

$$Peak_{max} = RMS \times 1.414215$$

and

$$Peak_{min} = -RMS \times 1.414215$$

The calibration constant is then calculated by

$$C = \frac{Cal_{max} - Cal_{min}}{Peak_{max} - Peak_{min}}$$

Where

Cal_{max} = Maximum engineering unit input by user

Cal_{min} = Minimum engineering unit input by user.

The calibrated data for the AC signal then becomes

$$X'(i) = X(i)C$$

An option is provided to calibrate the step-cal, utilizing the sine wave, by making the following calculations

$$Peak_{max} = RMS$$

The calibration constant is then calculated for the step-cal by

$$C = \frac{Cal_{max} - 0}{Peak_{max} - 0}$$

where Cal_{max} = Maximum engineering unit input by user

Cal_{min} = Minimum engineering unit input by user.

The calibrated data for the DC signal then becomes

$$X'(i) = X(i)C$$

2. Step Calibration.- A calibration signal is put on the analog tape where the 100 percent signal level is 1 volt and the 0 percent level is 0 volts. This signal is then digitized where minimum raw counts are at the 0 volt level and maximum raw counts are at the 1 volt level. The minimum and maximum values are determined by

$$\bar{X}_{max} = \frac{1}{N} \sum_{i=1}^{N} X(i)_{max}$$

and,

$$\bar{X}_{min} = \frac{1}{N} \sum_{i=1}^{N} X(i)_{min}$$

and the calibration constant is then calculated by

$$C = \frac{Cal_{max} - Cal_{min}}{\bar{X}_{max} - \bar{X}_{min}}$$

In the step calibrations for the DC signal where the slope intercept is not zero, a correction is applied by calculating a bias.

$$BIAS = - \bar{X}_{max} + Cal_{max}\ C$$

The calibrated data for the DC signal becomes

$$X'(i) = X(i)C + BIAS.$$

F. Essa Data Logger Output

The ESSA digital output tape format consists of one or more files. Each file constitutes data for one test which is identified by a header record. The format of the header record is shown in Figure 8.

1. Tape Number	6 Characters
2. Organization	6 Characters
3. File count	6 Characters
4. Date	3 Digits for day of year 2 Digits for year 1 Digit spare
5. Time (Start)	Time in sec 6 Characters
6. Time (End)	Time in sec 6 Characters (Greenwich Time)
7. Name of variable	6 Character names 72 Characters total
12 Channels	
8. Calibration value minimum	Characters/Channel 12 Characters total
12 Channels	
9. Calibration value maximum	Characters/Channel 12 Characters total
12 Channels	
10. Sampling rate	6 Characters sample/sec
11 Sample reduction	6 Characters
12. Anemometer information	6 Characters 54 Characters total

Figure 8 ESSA Header Record

Individual data records consist of not more than 13 words of 12 bits each. The first word is a record count or time word; this is followed by 12 words - one for each channel. This record constitutes one sample time. The individual data records are grouped together in a block of some 30 records and are written as a single physical record on magnetic tape.

The first and last physical record contains 30 calibration records with minimum and maximum levels recorded.

G. MSFC Digitizer Output

The MSFC digital output tape format consists of calibration and data files. The calibration file contains an identification record and one or more data records with the calibration signal. The identification record is two 36-bit words (Figure 9). The calibration data record consists of a 24-bit time word and the remainder of the record is filled with 11-bit digitizer words not to exceed 8000 11-bit words. The data file is formated the same.

1.	Time Scale	BCI*	24 bits
2.	Data Type	BCI	6 bits
3.	Number of Scans	BCI	24 bits
4.	Number of Beams	BCI	12 bits

*BCI - Binary Coded Information

Figure 9 MSFC HEADER RECORD

5. LINK 2 - THE CORRELATION LINK

Flow charts for LINK 2 are shown in Figures 10 and 11. These are first level flow charts which present the general flow of control but not the detailed processing. Referring to Figure 10 the subroutine begins by restoring COMMON from the intermediate tape produced by LINK 1. The problem parameters are then read

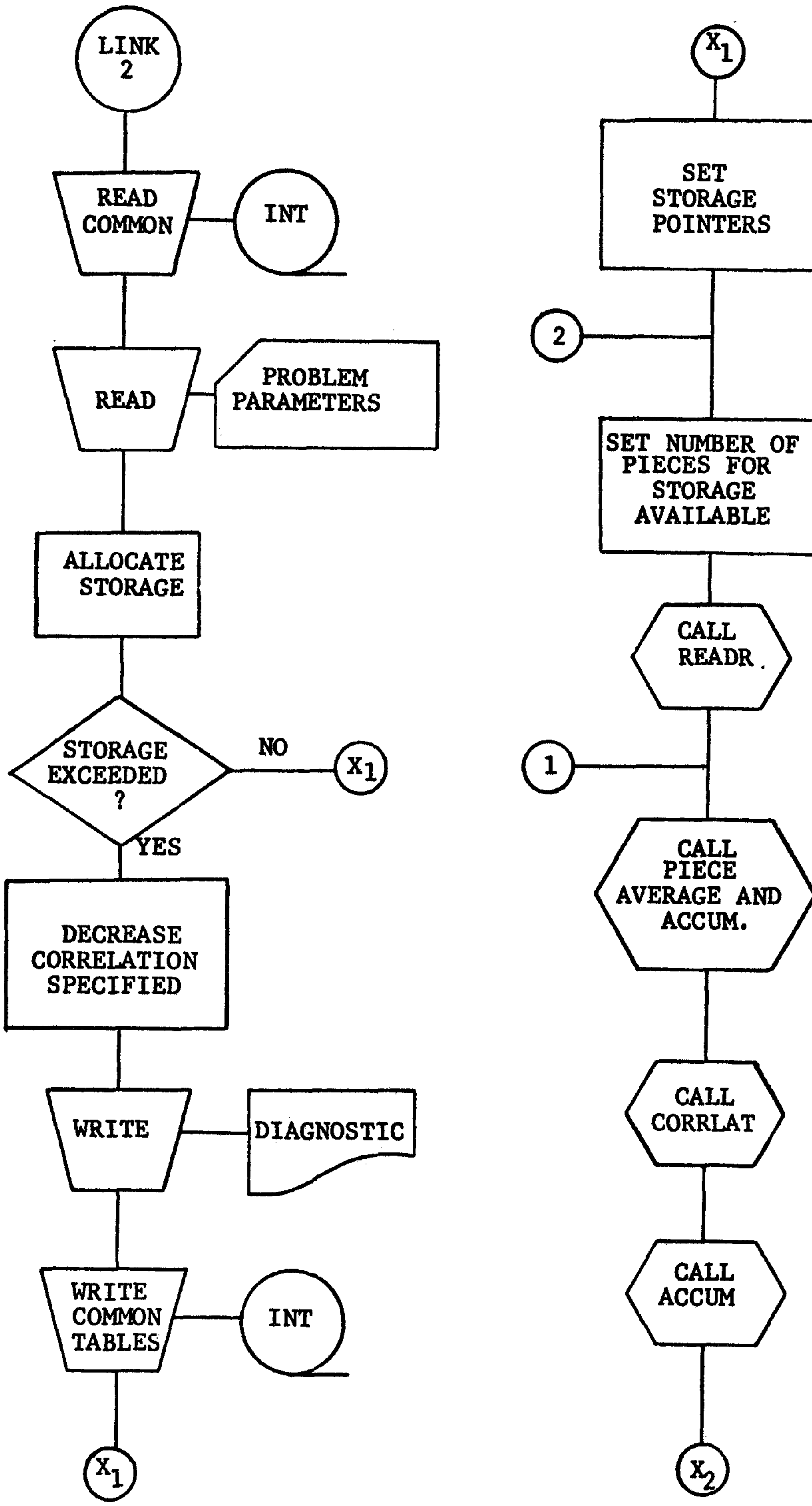


Figure 10 LINK 2-1

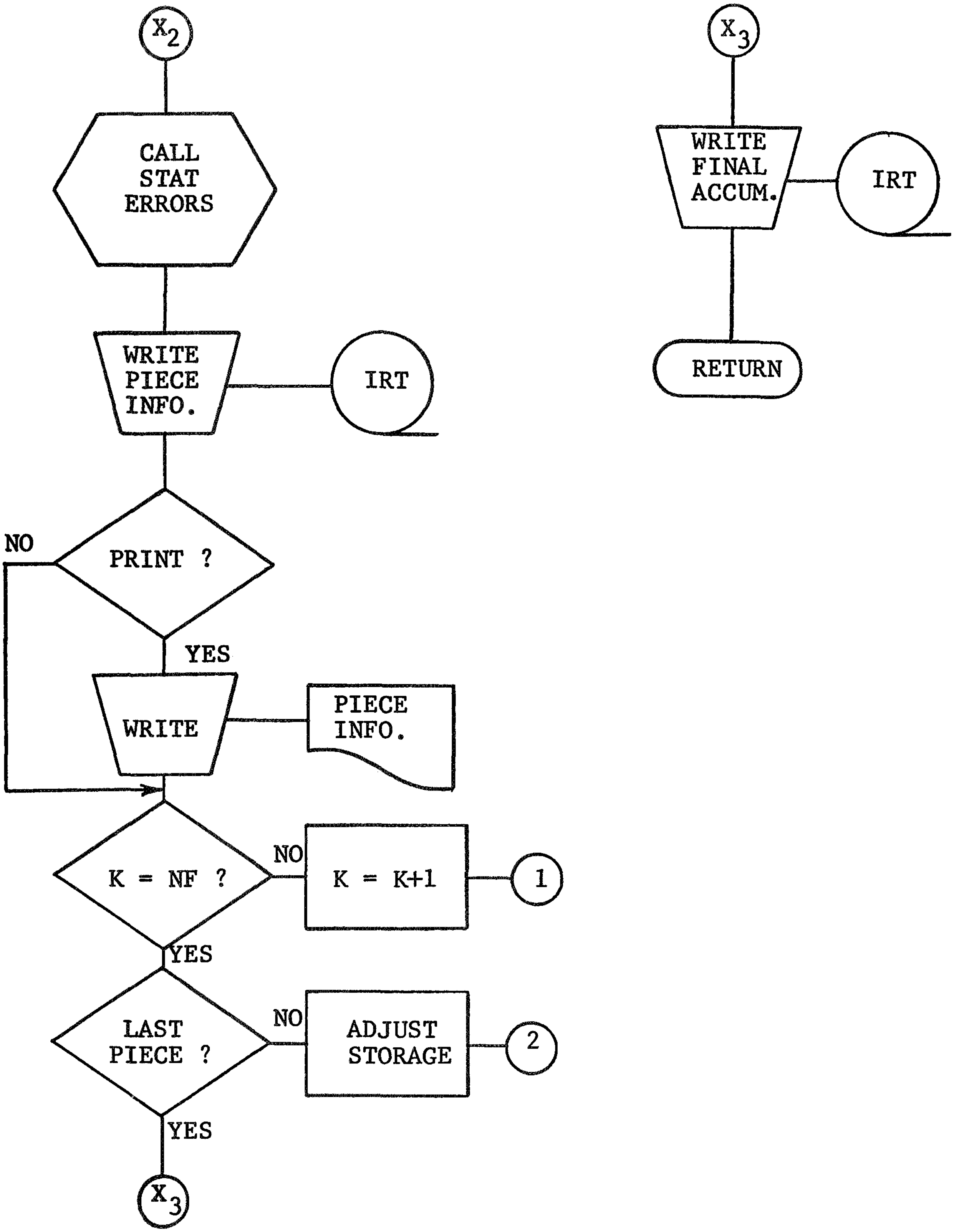


Figure 11 LINK 2-2

specifying piece length, print interval, time-lag range and increment, and finally the correlations to be performed.

A large degree of flexibility has been built into the program for the user in specifying correlations. To accommodate varying input tape formats and provide for efficient storage and processing, the correlation requests will be analyzed for the total number of channels required and a new internal channel number will be assigned for use within the program. Thus, a typical request may appear as:

J = 2, K = 5,6, 4 * 0

J = 3, K = 8,4,2,3,*0

where J is the delayed channel number on the input tape and the K's are the undelayed channels. The input tape may contain up to 12 channels but the correlation requests above require only six. The unused channels will not be stored during the computations and a new channel number will be assigned in the program as follows:

New	Old
1	2
2	3
3	4
4	5
5	6
6	8

The internal identification number simplifies handling in the program and will never be of concern to the user since all output is in terms of the original channel assignments on the input tape.

The typical correlation request is shown in Figure 12. A series of tables are built up in LINK 2 which are used to simplify processing. The first table NCHID (Figure 13) is formed from the J's and K's specified in the correlation requests. NCHID consists of all channels to be used, delayed or undelayed, in calculating the correlations. The channel numbers correspond to the position on the input data tape. The table NCRPC gives the number of

```
J = 2, K = 5, 6; 4*0
J = 3, K = 8,4,2,3*0
```

Figure 12 Correlation Request

	NCHID	NCRPC	NCTBL
1	2		
2	5	2	56
3	6	3	842
4	3		
5	8		
6	4		

SORT

	NCHID	NCRPC	NCTBL	NCD		NACR
1	2	2	45	1		0
2	3	3	136	2		2
3	4				NCRT-3	5
4	5					
5	6					
6	8					

Figure 13 Tables

correlations requested for a particular delayed channel and the table NCTBL gives the channel numbers of the delayed channels for a given delayed channel.

The table NCHID is sorted to put all channels in the order of increasing channel numbers and the tables NCRPC and NCTBL are constructed with the new channel numbers, which are assigned from the order of NCHID. Thus, for the example, the original channel 2 becomes channel 1, channel 3 becomes channel 2, etc. The total number of channels to be used is NCH.

After the channel numbers have been reassigned two new tables are formed called NCD and NACR. The table NCD consists of the total number of delayed channels and the new channel numbers. The table NACR is an accumulative count of the correlations requested.

The first location of this table is set to zero. Location 2 is set to the number of correlations for channel 1, location 3 is the total number of correlations for channel 1 + 2, etc. In general, the last location in the table indicates the total number of correlations, NCRT. For the above example, NCRT = 5. The table NACR is used to locate information on the correlations in the data pool or U array.

Figure 14 shows the total allocation of storage in the working array U. The array is broken up into 5 basic parts. The first part consists of miscellaneous constants, which is a series of time lags from $-\tau_{max}$ to τ_{max} and velocity lags. The second part is for storage of the standard errors of $\overline{\sigma^2}$, $\overline{X}$, and $\overline{X^2}$. The third part of the array U is devoted to the accumulations $\overline{\overline{\sigma^2}}$, $\overline{\overline{X}}$, $\overline{\overline{X^2}}$. The fourth portion of U is used to store the piecewise statistics of σ^2, $\overline{X}$, $\overline{X^2}$ and the correlations $\overline{XY}$ (R_{JK}) as well as the time lag average of the correlations ($_{\tau}\overline{XY}$). The remainder of the U array from U(KP) is used to store sample points for the channels to be used. It should be noted that all the above regions are variable in length and particularly the correlations (R_{JK})

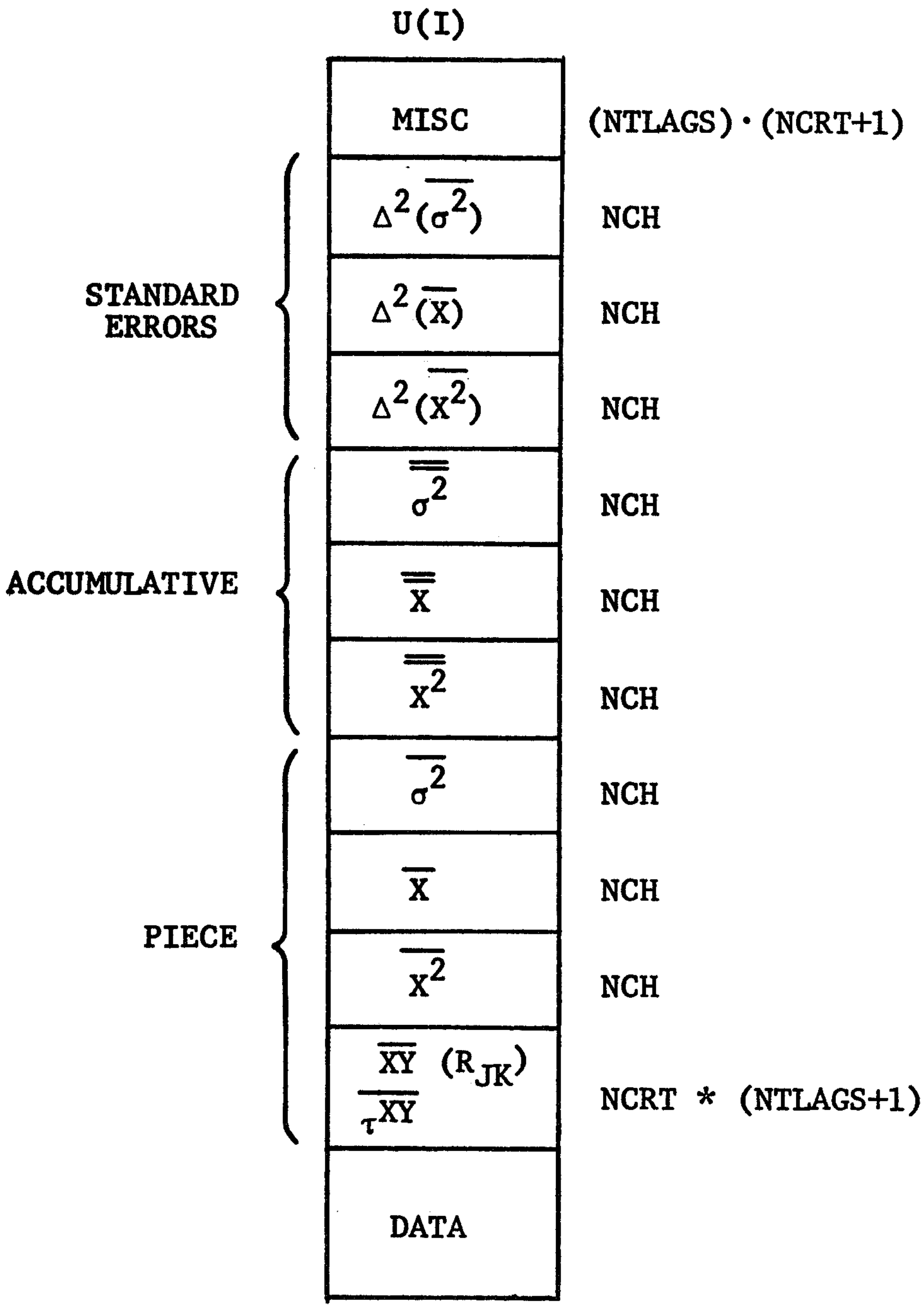


Figure 14 LINK 2 Storage Allocation

require the largest amount of storage NCRT * (NTLAGS + 1). NTLAGS is the total number of positive and negative lags for the correlations. The position pointer names and required space is shown in Table V.

Total storage for the results is equal to:

$$KP = (NCRT + 1)\ (NTLAGS) + 9 \cdot NCH + NCRT \cdot (NTLAGS + 1)$$

Storage for data samples will be 20,000 - KP. Thus the storage in LINK 2 is controlled by the correlation request. The fewer the number of correlations requested the more storage can be allocated to data samples.

Referring to the flow chart for LINK 2 (Figures 10 and 11) the total storage requirement to run a problem is checked. This is given by the relationship;

$$(NCRT + 1)\ (NTLAGS) + 9 * NCH + NCRT * (NTLAGS + 1) + (MSUB + MAXINC) * NCH < 20000$$

where $MSUB = \frac{\Delta T}{\bar{e}}$ and

$$MAXINC = \frac{\tau_{max}}{\bar{e}}$$

which provides sufficient storage for at least one piece. If the storage is exceeded, then the correlation request is automatically reduced until there is sufficient room to run the problem. This is accomplished in the program simply by reducing the counter ND which is the total number of delayed channels. ND is used in determining NCRT from table NACR (Figure 13) and is also used in controlling the computation of the correlation. Consequently, simply reducing ND reduces the storage requirements and the computations performed. If the storage requirements are exceeded then the specifications are reduced and a diagnostic is printed. Reduction of ND to less than one will terminate the run. If there is sufficient storage to run the problem then the COMMON area and the

TABLE V

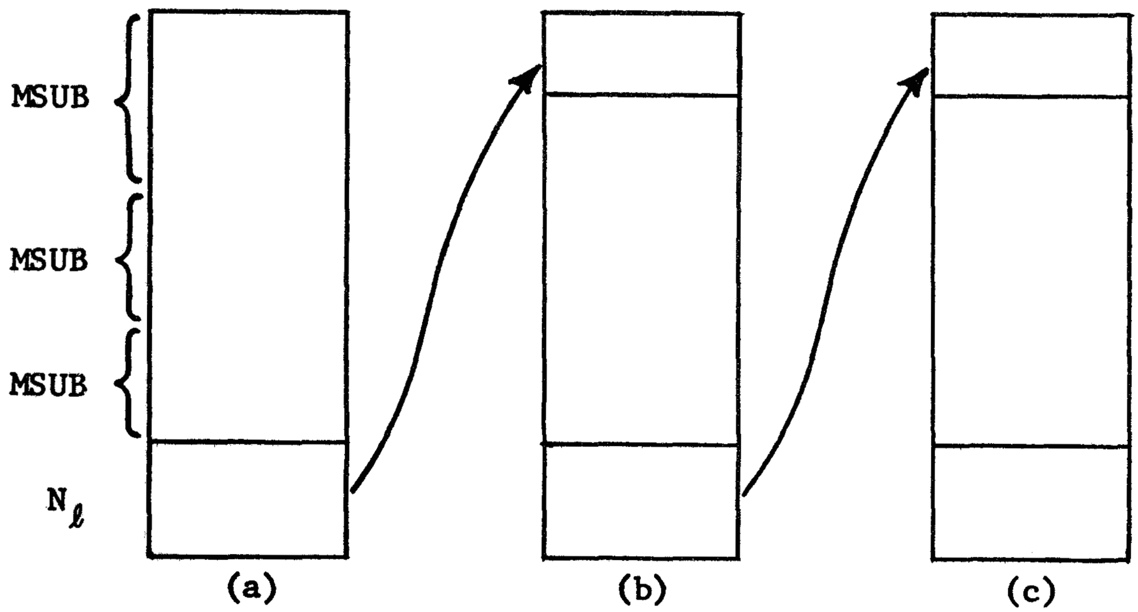
PIECEWISE STATISTICS

POSITION POINTER	VARIABLE	DIMENSION
1	LAG VALUES (Time, Velocity)	IF VELLAG $\neq$ 0 (NTLAGS)·(NCRT+1) IF VELLAG = 0 NTLAGS
KESM	$\Delta^2(\overline{\sigma^2})$	NCH
KEAM	$\Delta^2(\overline{X})$	NCH
KEASM	$\Delta^2(\overline{X^2})$	NCH
KASM	$\overline{\overline{\sigma^2}}$	NCH
KMA	$\overline{\overline{X}}$	NCH
KRA	$\overline{\overline{X^2}}$	NCH
KPSM	$\overline{\sigma^2}$	NCH
KMP	$\overline{X}$	NCH
KRP	$\overline{X^2}$	NCH
KTP	$\overline{XY}$	NCRT*(NTLAGS+1)
	$_\tau\overline{XY}$	

various tables formed from the correlation requests are written out onto the IRT which is used in LINK 3, and the storage pointers are set as shown in Table V.

Connector 2 (Figure 10) begins the main part of the program. A read subroutine is called to fill the working array U, starting at KD, from the intermediate tape from LINK 1. If all channels are not used by the program during a run, the data will not be stored by the subroutine. Thus, if only two channels are to be correlated, all storage will be used to store the corresponding X and Y data points. If more than one undelayed channel is used, then X, Y_1, Y_2, etc., would be stored. After the working storage is filled, the number of pieces in core storage is set and the actual calculations begin at connector 1. The calculation modules are written as variable dimension subroutines. The CALL statement to these subroutines pass the actual storage location of data and results stored in U. Only the piecewise correlations are performed in this link and written onto the IRT. Statistical errors are calculated for only nontime dependent averages. Periodic printouts can be controlled by the variable IPRINT set by the user, which gives the frequency of printout.

In general, more than one piece will be held in core storage at one time. This depends, of course, on the number of correlations requested and the total number of channels required but generally the data portion of the U array will appear as in Figure 15a. MSUB is the number of data points for the piece length ΔT. N_ℓ is the number of data points required for the maximum time lag, τ_{max}. Thus, data storage will appear as in Figure 15a at the beginning of LINK 2. There will be a number of pieces of length MSUB and enough data points, N_ℓ, to complete the correlation calculations for the last piece. When the correlation for the last piece has been performed then the N_ℓ data points are moved, as shown in Figure 15b, to the beginning of the data area and sufficient data is read in to fill the entire data area again.



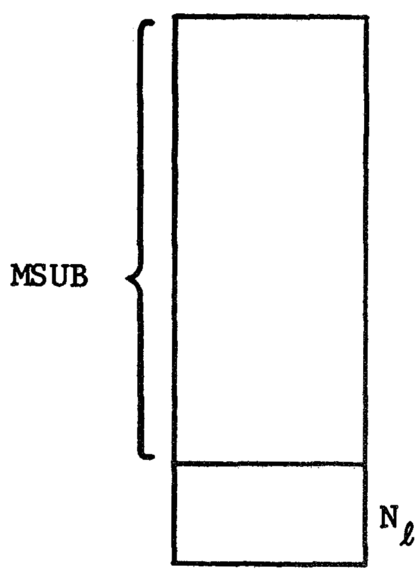


Figure 15 Storage Use

The averaging operations and correlations are performed again. This procedure is continued for successive core loads as shown in Figure 15c. By this method, of operation correlations are kept continuous across core loads of data since the data for the maximum time lag is saved from the previous block. In general, as shown in Figure 15d, the channel averages for a piece represents MSUB data points while the correlations are over MSUB + N_ℓ data points. As long as there is sufficient room to store one piece, MSUB + N_ℓ, the correlations can be performed without the loss of any information.

6. LINK 3 - THE OUTPUT LINK

Link 3 of the MLTCOR program performs a number of functions other than output. It is in this link of the program that the basic correlations formed in LINK 2 are modified to aid in determining nonstationary trends. Standard operations can be performed on the correlations such as normalizing, (dividing by the product of the standard deviations for each channel) detrending, (which consists of subtracting the time lag average from the correlations) and the covariance (formed by subtracting the product of the means of the two channels from the correlations). Any combination of these standard operations can be performed on the correlations read in from the IRT.

The flow chart for LINK 3 is shown in Figures 16 and 17. LINK 3 can be run a number of times with the same output from LINK 2. The first operation performed by the program is reading all COMMON variables from the IRT and the correlation control tables which were set in LINK 2. The user is then allowed to read in from data cards the piece numbers of pieces that are to be deleted in forming the modified accumulations. The options for forming the modified correlations are read on another data card. The accumulation period, $t_{q+1} - t_q$ are next set from data cards. The format for these data cards is described in Section 7.

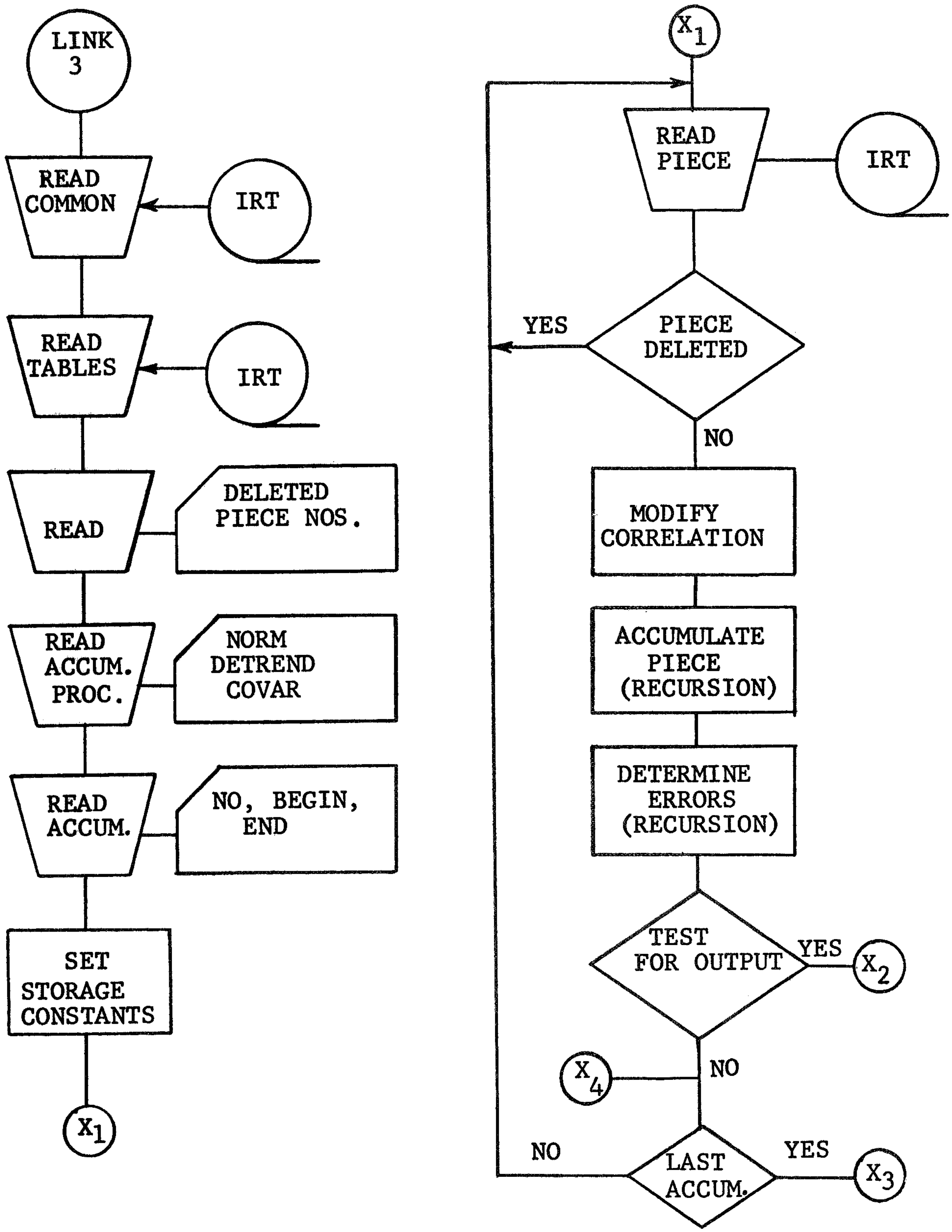
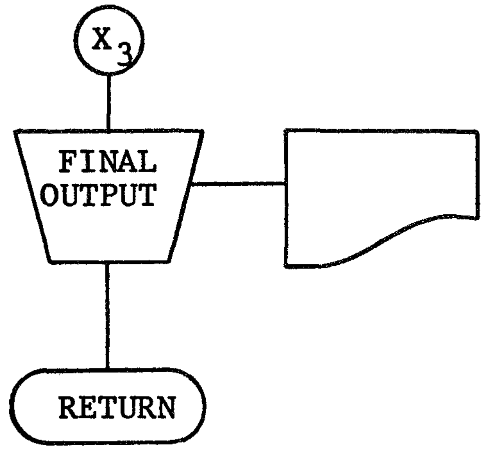


Figure 16 LINK 3-1



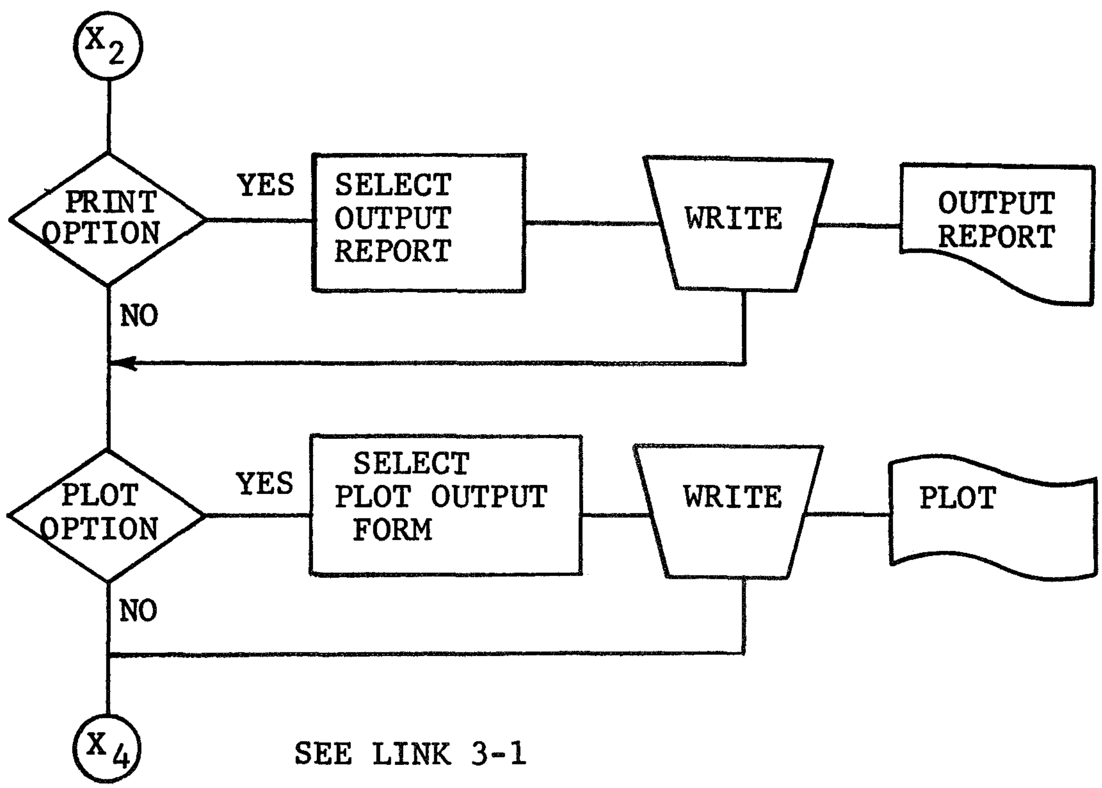


Figure 17 LINK 3-2

With the information supplied above it is possible to set constants for the allocation of core storage. The same dynamic storage allocation scheme that was used in LINK 2 is used in LINK 3 except that a large block of storage is not required for the raw data. In fact it is only necessary to store one set of piecewise correlations at a time. The remainder of storage is used for modified correlations and error terms. The allocation of storage for LINK 3 is shown in Table VI. Column 1 of Table VI gives the name of the fixed point variable used as the storage pointer for the U array. Column 2 defines the quantities calculated with the dimension shown in column 3. The piecewise statistics calculated in LINK 2 are also stored in LINK 3. The same storage pointer names used in LINK 2, shown in Table V, are used in LINK 3.

In LINK 2 the accumulative correlations, time lag averages and the corresponding standard errors were not calculated since in general these quantities will vary depending on the deleted pieces. These quantities are calculated in LINK 3 for the unmodified correlations and stored at KATP and KEXP as shown in Figure 18, which shows the total storage allocation for LINK 3.

Referring to Figure 16 and 17 the main loop of LINK 3 begins at connector X1. The piecewise correlations are read from the IRT and stored as shown in Figure 18. The piece number is checked to see if it is to be deleted. If it is deleted another piece is read and checked. If the piece is not deleted, then the correlations are accumulated and then modified. The modifications that can be made are given by

$$c'(\tau) = \left(\frac{\left[\overline{x_j\, y_k(\tau)} - \bar{x}_j \cdot \bar{y}_k\right] - \left[\overline{{}_\tau x_j\, y_k} - \bar{x}_j \cdot \bar{y}_k\right]}{\sigma_j \cdot \sigma_k} \right)_{\tau^*}$$

depending on the following logical variables.

TABLE VI

MODIFIED CORRELATIONS

POSITION POINTER	VARIABLE	DIMENSION
1	Number of pieces selected	NTP
LTLAG	Time lags	NTLAGS
LVLAG	Velocity lags	NCRT * NTLAGS (if velocity lags requested)
ICHA	$\overline{\overline{\Delta}}^2 = {}_{JK}\overline{\Delta}^2$	NCD
IESM	$\Delta^2(\overline{\sigma}^2)$	NCH
IEAM	$\Delta^2(\overline{X})$	NCH
IEASM	$\Delta^2(\overline{X^2})$	NCH
IEXP	$\Delta^2(\overline{XY})_m$ ${}_{\tau}\Delta^2(\overline{XY})_m$	NCRT*(NTLAGS+1)
LASM	$\overline{\overline{\sigma^2}}$	NCH
LMA	$\overline{\overline{X}}$	NCH
LRA	$\overline{\overline{X^2}}$	NCH
LXA	$\overline{\overline{XY}}_m$ ${}_{\tau}\overline{\overline{XY}}_m$	NCRT*(NTLAGS+1)
MPSM	$\overline{\sigma^2}$	NCH
MMP	$\overline{X}$	NCH
MRP	$\overline{\overline{x^2}}$	NCH
MTP	$\overline{XY}_m$ ${}_{\tau}\overline{XY}_m$	NCRT*(NTLAGS+1)
KEXP	$\Delta^2(\overline{XY})$ ${}_{\tau}\Delta^2(\overline{XY})$	NCRT*(NTLAGS+1)
KATP	$\overline{\overline{XY}}$ ${}_{\tau}\overline{\overline{XY}}$	NCRT*(NTLAGS+1)

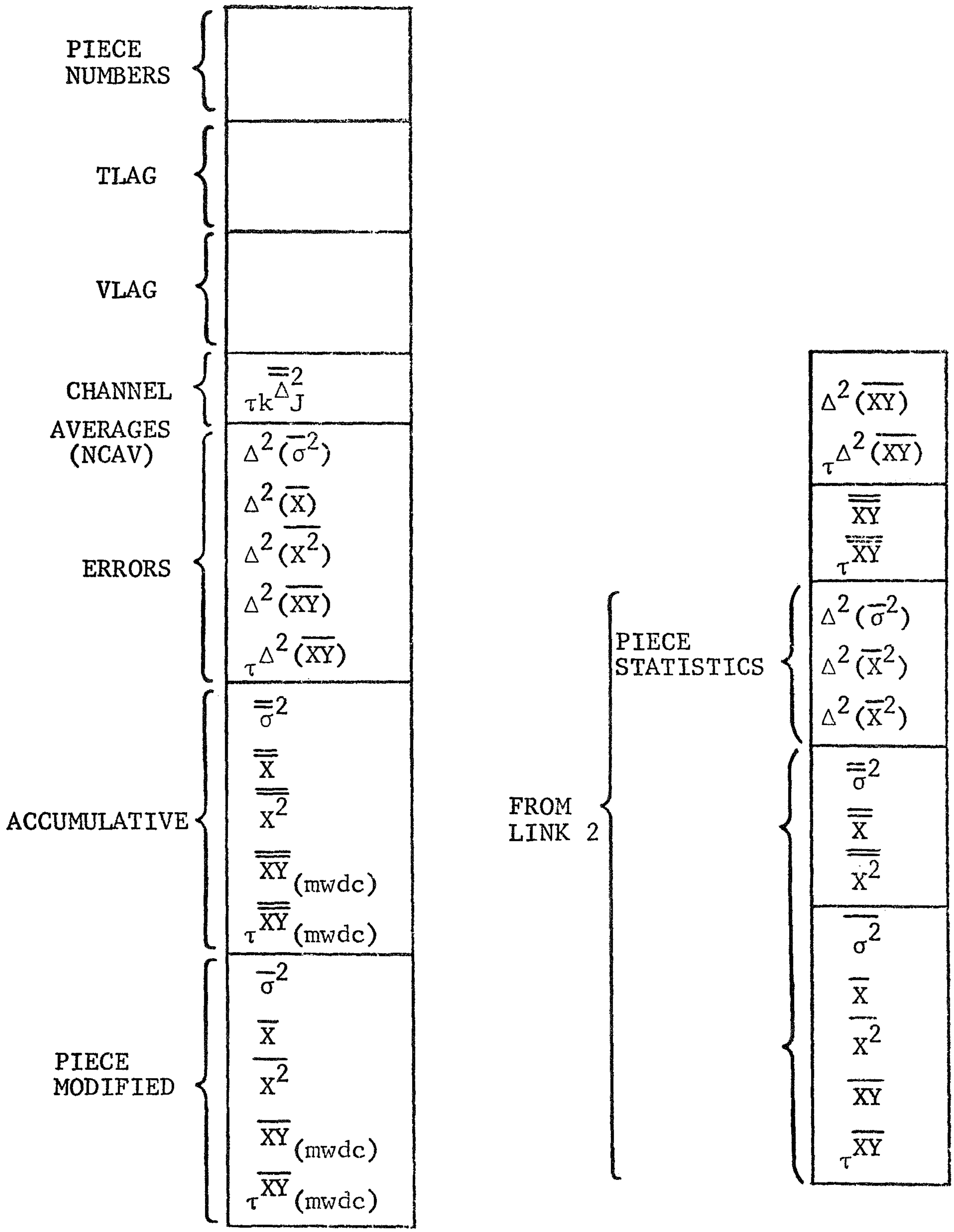


Figure 18 LINK 3 Storage Allocation

COVAR = .FALSE . $\overline{x}_j \cdot \overline{y}_k = 0$

NORM = .FALSE . $\sigma_j = 1.$

$\sigma_k = 1.$

DTREND= .FALSE. $\tau\overline{x_j \cdot y_k} - \overline{x}_j \cdot \overline{y}_k = 0$

PREMLT= .FALSE. $\tau^* = 1.$

If these variables are true, then the quantities take on their respective values.

These modified correlations are then used to determine the standard errors. The final part of the program is a test for the different types of output and for the final accumulation. Up to five accumulation periods may be specified by the user and after each segment the accumulation regions must be cleared to start a new accumulation. The output from LINK 3 is discussed in Section 7B.

7. USAGE

A. Input

Almost all the card input to the MLTCOR is provided by use of the NAMELIST statement except for one alphanumeric title card. The NAMELIST statement is described in the FORTRAN IV manual, but in general it essentially allows the user free form input of parameters. The general form of a card group would be:

```
COL. 1
    $NAME
    X = 1.0, y = 2.0, ... etc.
    $END
```

The description which follows is taken from the IBM FORTRAN IV manual, Form C28-6390-2, and explains the general form that data items may take.

1. Variable name = constant
   where variable name may be an array element name or a simple variable name. Subscripts must be integer constants.

2. Array name = set of constants (separated by commas)
   where k*constant may be included to represent k constants (k must be an unsigned integer). The number of constants must be equal to the number of elements in the array.

3. Subscripted variable = set of constants (separated by commas)
   where k*constant may be included to represent k constants (k must be an unsigned integer). A data item of this form results in the set of constants being placed in consecutive array elements, starting with the element designated by the subscripted variable.

Constants used in the data items may take any of the following forms:

a. integers
b. real numbers
c. double-precision numbers
d. complex numbers, which must be written in the usual form, (C1, C2), where C1 and C2 are real numbers
e. logical constants, which must be written as T or .TRUE., and F or .FALSE.

Logical and complex constants may be associated only with logical and complex variables, respectively. The various input variable and options are explained here.

NAMELIST NAME	DATA	SUBROUTINE
$LINKNØ		MAIN
KRUN	Restart constant Example: KRUN = 1,2,3 runs all three links in sequence. KRUN = 2 will run only LINK 2.	
$NAMDAT		
NBEAMS	Number of beams or sensors Example: NBEAMS= 7 indicates there are seven sensors or seven beams on input tape.	
NFLSKC	Number of files to be skipped before reading MSFC calibration records Example: NFLSKC = 3 indicates calibration data are in file 4.	
NFLSKD	Number of files to be skipped before reading MSFC data records Example: NFLSKD = 2 indicates data are in file 3.	
MVMEAN	Moving mean span desired for filtering data (preferably an odd integer) Example: MVMEAN = 11; the filter span to be used will be 11 points; if MVMEAN = 0, this option will be bypassed.	

NCENDF Central differences

Example:

NCENDF = 1; central differences are calculated; if NCENDF = 0 this option will be bypassed.

NOBEAM The total number of beams on which to be operated

Example:

NOBEAM = 3 indicates three beams of NBEAMS on which to be operated; if MVMEAN = 0 this option is ignored.

NWHICH Which beams of the NBEAMS on which to be operated

Example:

NWHICH = 1,3,4 indicates beams 1,3, and 4 only; if MVMEAN = 0 this option is ignored.

TIMSAM Sample rate of input data

Example:

TIMSAM = 0.1 indicates data were sampled at ten samples per sec.

VALMAX Maximum value for calibrations

Example:

VALMAX = 1.0, 1.0, 1.0 indicates three channels are calibrated to maximum value of 1.0.

VALMIN Minimum value for calibrations

Example:

VALMIN = -1.0, -1.0, -1.0

START Start time on raw data input tape (there can be up to five start times)

Example:

START = 1.0, 1.5, 2.0, 2.5, 6.0 indicates five starting points on the input tape.

STOP Stop time on raw data input tape (There can be up to five stop times)

Example:

STOP = 1.4, 2.0, 2.4, 5.9, 6.5 indicates the five stop times for each respective start time in the example above.

NFILE Number of files to be skipped before reading ESSA data
Example:
NFILE = 3 indicates ESSA data are in file 4.

MSFC Flag to the program indicating MSFC formated tape
Example:
MSFC = 1 will translate MSFC formated tapes; if
MSFC = 0, program will translate ESSA formated tapes.

IFREQ Desired output sample rate to intermediate tape
Example:
IFREQ = 1; every sample will be output to the intermediate tape.
IFREQ = 10; every tenth sample will be output to the intermediate tape; IFREQ must be ≥ 1.

LTN Logical tape unit input tape is mounted on
Example:
LTN = 10 indicates tape unit 10 is being used for input.

NBLK Number of records per block on ESSA output tape
This variable is used to block the output intermediate tape and to adjust the record size of MSFC output tape.
Example:
NBLK = 30 indicates ESSA tapes are blocked 30 records per block and the intermediate output tape will be blocked 30 records per block.

NSTART Number of starts and stops
Example:
NSTART = 3 indicates there are three start and stop times.

NBOB N/A; this should always be 0
Example:
NBOB = 0

PLYBCK Slow down rate of the analog tape relative to the digitizer tape

Example:

PLYBCK = 8.0 indicates the analog tape was run at one-eighth the speed of the digitizer tape.

NSTEP Flag for step calibrations

Example:

NSTEP = 1 indicates data are DC, but a sine wave signal is used to calibrate.

$ TIMES — LINK 2

TSTART Start time

TIMMAX Maximum integration time

DELTAT Piece length

IPRINT Print frequency

Example:

IPRINT = 10 printout every tenth piece

$ DELAY — LINK 2

TAUMIN Minimum lag time

TAUMAX Maximum lag time

DELTAU Lag time resolution

VELLAG Velocity lag control

Example:

VELLAG = 0 for no velocity lags

= 1 calculate velocity lags

SEPART Beam separation

$CORR — ASSIGN LINK 2

J Delayed channel number.

K Undelayed channel numbers (No more than six)

Example:

j = 1, K = 2,3,4, 3*0

This card group is repeated for as many correlations as required. J = 0 signals the last correlation request thus a minimum of two $CORR groups are required.

		SUBROUTINE
$DELETE		LINK 3
NUMPCE	Piece numbers (maximum of ten numbers per group) This card group is repeated as often as required. NUMPCE = 10*0 signals the last card group Example: NUMPCE = 5,7,8,10,12,14, 4*0	
NPRINT	Print frequency for LINK 3	
$MODIFY	Logical variables	LINK 3
DTREND	If true, detrend	
NORM	If true, normalize	
COVAR	If true, form covariance	
PREMLT	If true, multiply by τ	
PLOT	If true, plot on SC 4020	
$ACCUM		LINK 3
NO	Accumulation number	
BEGIN	Start time	
END	End time Up to five accumulations may be specified; the last group is indicated by NO = 0 Example: NO = 1, BEGIN = 0.0, END = 1.5	

The last data card for LINK 3 is a comments card which describes the type of accumulation procedure used. This is an alphanumeric data card with up to 72 columns available for a comment. It differs from the other data cards in that there is no NAMELIST associated with it and it should be the last card of the data decks.

B. Output

The output from the MLTCOR program has been organized into a series of standard reports that are printed out from the three basic links. These reports were prepared with the use of a special program called SOFT (Simple Output Format Translator).

The SOFT program translates report specifications in a simplified form to FORTRAN IV format statements which will produce the desired output. The SOFT program is a standard SHARE program available from IBM, SHARE distribution number 3379. The types of reports that can be expected from the various links of the program are shown in Figures 19 through 23. These output reports are the principal form of output from the program but it is possible to request plots of the correlations and modified correlations for an SC 4020, Cathode Ray Tube Output Recorder. These plots are requested by setting PLOT = T in the $MODIFY namelist group of parameters. Examples of these plots are shown in Figures 24 through 27.

EXPERIMENT NUMBER= 000000 ORGANIZATION=G84 TAPE NUMBER=000001

PAGE NUMBER=*** FILE NUMBER= IDATE=080 69 RUN NUMBER=000000

CALIBRATION IDENTIFICATION

CHANNEL NUMBER	BEGIN RECORD TIME	END RECORD TIME	MINIMUM VALUE	MAXIMUM VALUE	CALIBRATION SLOPE	CALIBRATION INTERCEPT	ENGINEERING MINIMUM	ENGINEERING MAXIMUM
1	140000	150000	-1971.2	1983.2	0.00253	14.98486	10.00000	20.00000
2	140000	150000	-2036.4	2047.0	0.00073	-0.00389	-1.50000	1.50000
3	140000	150000	-2047.0	2047.0	0.00244	15.00006	10.00000	20.00000
4	140000	150000	-2047.2	2040.3	0.00245	15.00841	10.00000	20.00000
5	140000	150000	-2010.5	2018.2	0.00248	14.99051	10.00000	20.00000
6	140000	150000	-0.8	-0.0	0.00000	0.00000	0.00000	0.00000
7	140000	150000	-5.4	-5.0	0.00000	0.00000	0.00000	0.00000
8	140000	150000	1534.7	1534.7	0.00000	-0.00000	0.00000	0.00000
9	140000	150000	-2.0	-1.0	0.00000	0.00000	0.00000	0.00000

MODIFICATION OF ORIGINAL TIME SERIES

CHANNEL NUMBER	SAMPLING RATE	ORIGINAL SAMPLE REDUCTION	ADDITIONAL SAMPLE REDUCTION	MOVING MEAN	CENTRAL DIFFERENCE	CHANNEL VARIABLE	BEGIN RECORD TIME	END RECORD TIME
1	10.00	0.00	1	0	0	YT	140000	150000
2	10.00	0.00	1	0	0	ST	140000	150000
3	10.00	0.00	1	0	0.	XT	140000	150000
4	10.00	0.00	1	0	0	FT	140000	150000
5	10.00	0.00	1	0	0	GT	140000	150000
6	10.00	0.00	1	0	0	000000	140000	150000
7	10.00	0.00	1	0	0	000000	140000	150000
8	10.00	0.00	1	0	0	000000	140000	150000
9	10.00	0.00	1	0	0	RCNT	140000	150000

Figure 19 LINK 1 Reports

EXPERIMENT NUMBER= 000000 ORGANIZATION=000000 TAPE NUMBER=000000

PAGE NUMBER=**** FILE NUMBER=000000 DATE=000000 RUN NUMBER=000000

AVERAGES WITH ZERO TIME DELAY

PIECE NUMBER= 6
ACCUMULATION NUMBER= 6
ACCUMULATION START= 0.00
ACCUMULATION TIME= 3749.76
PIECE LENGTH= 624.96

CHANNEL NUMBER	PIECEWISE MEAN VALUE	PIECEWISE ROOT-MEAN SQUARE-VALUE	ACCUMULATIVE MEAN VALUE	MEAN STANDARD ERROR	ACCUMULATIVE ROOT MEAN SQUARE VALUE	MEAN-SQUARED STANDARD ERROR
1	-0.01301364	0.08416948	-0.01155653	0.00000111	0.06076186	0.00000077
2	-0.04709072	0.06046378	-0.04388484	0.00000639	0.05322358	0.00000005
3	-0.01699706	0.01910937	-0.01555780	0.00000029	0.01784660	0.00000000
4	-0.06015912	0.06511997	-0.05967946	0.00000009	0.06236742	0.00000001
5	0.00501663	0.02143924	0.00779503	0.00000119	0.04546366	0.00000097

AVERAGES WITH ZERO TIME DELAY

PIECE NUMBER= 6
ACCUMULATION NUMBER= 6
ACCUMULATION START= 0.00
ACCUMULATION TIME= 3749.76
PIECE LENGTH= 624.96

CHANNEL NUMBER	PIECEWISE MEAN VALUE	PIECEWISE STANDARD DEVIATION	ACCUMULATIVE MEAN VALUE	MEAN STANDARD ERROR	ACCUMULATIVE STANDARD DEVIATION	STANDARD ERROR VARIANCE
1	-0.01301364	0.00115252	-0.01155653	0.00000111	0.00059215	0.00000076
2	-0.04709072	0.00023972	-0.04388484	0.00000639	0.00014582	0.00000002
3	-0.01699706	0.00001271	-0.01555780	0.00000079	0.00001250	0.00000000
4	-0.06015912	0.00010358	-0.05967946	0.00000009	0.00005460	0.00000000
5	0.00501663	0.00007241	0.00779503	0.00000119	0.00033337	0.00000097

Figure 20 LINK 2 Channel Averages

EXPERIMENT NUMBER= Q00000 ORGANIZATION=Q00000 TAPE NUMBER=Q00000

PAGE NUMBER=*** FILE NUMBER=Q00000DATE=Q00000 RUN NUMBER=Q00000

AVERAGES WITH TIME DELAY

PIECE NUMBER=	6	AREA UNDER	
ACCUMULATION NUMBER=	6	CORRELATION=	0.00243350
ACCUMULATION START=	0.00	CORRELATED	
ACCUMULATION TIME=	3749.76	CHANNELS	
PIECE LENGTH=	624.96	1 AND 1	

TIME DELAY	VELOCITY DELAY	PIECEWISE CORRELATION
-20.00000	0.000	0.00090
-19.00000	0.000	0.00078
-18.00000	0.000	0.00056
-17.00000	0.000	0.00028
-16.00000	0.000	-0.00001
-15.00000	0.000	-0.00024
-14.00000	0.000	-0.00038
-13.00000	0.000	-0.00041
-12.00000	0.000	-0.00034
-11.00000	0.000	-0.00026
-10.00000	0.000	-0.00021
-9.00000	0.000	-0.00019
-8.00000	0.000	-0.00017
-7.00000	0.000	-0.00002
-6.00000	0.000	0.00037
-5.00000	0.000	0.00113
-4.00000	0.000	0.00275
-3.00000	0.000	0.00424
-2.00000	0.000	0.00566
-1.00000	0.000	0.00670
0.00000	0.000	0.00708
1.00000	0.000	0.00670
2.00000	0.000	0.00566
3.00000	0.000	0.00424
4.00000	0.000	0.00275
5.00000	0.000	0.00113
6.00000	0.000	0.00037
7.00000	0.000	-0.00002
8.00000	0.000	-0.00017
9.00000	0.000	-0.00019
10.00000	0.000	-0.00021
11.00000	0.000	-0.00026
12.00000	0.000	-0.00034
13.00000	0.000	-0.00041
14.00000	0.000	-0.00038
15.00000	0.000	-0.00024
16.00000	0.000	-0.00001
17.00000	0.000	0.00028
18.00000	0.000	0.00056
19.00000	0.000	0.00078
20.00000	0.000	0.00090

Figure 21 Piecewise Correlations

EXPERIMENT NUMBER= 000000 ORGANIZATION=000000 TAPE NUMBER=000000

PAGE NUMBER=*** FILE NUMBER=000000 DATE=000000 RUN NUMBER=000000

AVERAGES WITH TIME DELAY

PIECE NUMBER= 7
ACCUMULATION NUMBER= 1
ACCUMULATION START= 0.00
ACCUMULATION TIME= 4375.00
PIECE LENGTH= 625.00

AREA UNDER CORRELATION= 0.00120206
AREA UNDER MODIFIED CORRELATION= -0.00420377
ACCUMULATIVE AREA UNDER CORRELATION= 0.00069064
ACCUMULATIVE AREA UNDER MODIFIED CORRELATION= -0.00318567
CORRELATED CHANNELS 1 AND 1

TIME DELAY	VELOCITY DELAY	PIECEWISE CORRELATION	PIECEWISE MODIFIED CORRELATION	ACCUMULATIVE CORRELATION	STANDARD ERROR	ACCUMULATIVE MODIFIED CORRELATION	STANDARD ERROR
-20.0000	0.000	0.00079	-0.06292	0.00024	0.00000	-0.13279	0.00081
-19.0000	0.000	0.00070	-0.07583	0.00022	0.00000	-0.13187	0.00068
-18.0000	0.000	0.00051	-0.10220	0.00016	0.00000	-0.13693	0.00042
-17.0000	0.000	0.00026	-0.13834	0.00009	0.00000	-0.14633	0.00019
-16.0000	0.000	-0.00002	-0.17707	0.00002	0.00000	-0.15667	0.00017
-15.0000	0.000	-0.00025	-0.21000	-0.00004	0.00000	-0.16425	0.00038
-14.0000	0.000	-0.00040	-0.23071	-0.00006	0.00000	-0.16705	0.00068
-13.0000	0.000	-0.00044	-0.23706	-0.00005	0.00000	-0.16615	0.00084
-12.0000	0.000	-0.00038	-0.22858	-0.00002	0.00000	-0.16629	0.00067
-11.0000	0.000	-0.00031	-0.21791	-0.00002	0.00000	-0.17387	0.00040
-10.0000	0.000	-0.00025	-0.21031	-0.00005	0.00000	-0.19038	0.00021
-9.0000	0.000	-0.00023	-0.20699	-0.00012	0.00000	-0.21198	0.00017
-8.0000	0.000	-0.00019	-0.20129	-0.00016	0.00000	-0.22714	0.00021
-7.0000	0.000	-0.00003	-0.17840	-0.00012	0.00000	-0.21750	0.00024
-6.0000	0.000	0.00039	-0.11921	0.00010	0.00000	-0.14240	0.00021
-5.0000	0.000	0.00118	-0.00799	0.00056	0.00000	-0.04644	0.00015
-4.0000	0.000	0.00282	0.22451	0.00155	0.00000	0.20268	0.00007
-3.0000	0.000	0.00432	0.43787	0.00246	0.00000	0.43218	0.00004
-2.0000	0.000	0.00577	0.64229	0.00333	0.00000	0.65182	0.00005
-1.0000	0.000	0.00682	0.79101	0.00396	0.00000	0.81125	0.00009
0.0000	0.000	0.00720	0.84589	0.00419	0.00000	0.86958	0.00011
1.0000	0.000	0.00682	0.79101	0.00396	0.00000	0.81125	0.00009
2.0000	0.000	0.00577	0.64229	0.00333	0.00000	0.65182	0.00005
3.0000	0.000	0.00432	0.43787	0.00246	0.00000	0.43218	0.00004
4.0000	0.000	0.00282	0.22451	0.00155	0.00000	0.20268	0.00007
5.0000	0.000	0.00118	-0.00799	0.00056	0.00000	-0.04644	0.00015
6.0000	0.000	0.00039	-0.11921	0.00010	0.00000	-0.14240	0.00021
7.0000	0.000	-0.00003	-0.17840	-0.00012	0.00000	-0.21750	0.00024
8.0000	0.000	-0.00019	-0.20129	-0.00016	0.00000	-0.22714	0.00021
9.0000	0.000	-0.00023	-0.20699	-0.00012	0.00000	-0.21198	0.00017
10.0000	0.000	-0.00025	-0.21031	-0.00005	0.00000	-0.19038	0.00021
11.0000	0.000	-0.00031	-0.21791	-0.00002	0.00000	-0.17387	0.00040
12.0000	0.000	-0.00038	-0.22858	-0.00002	0.00000	-0.16629	0.00067
13.0000	0.000	-0.00044	-0.23706	-0.00005	0.00000	-0.16615	0.00084
14.0000	0.000	-0.00040	-0.23071	-0.00006	0.00000	-0.16705	0.00068
15.0000	0.000	-0.00025	-0.21000	-0.00004	0.00000	-0.16425	0.00038
16.0000	0.000	-0.00002	-0.17707	0.00002	0.00000	-0.15667	0.00017
17.0000	0.000	0.00026	-0.13634	0.00009	0.00000	-0.14633	0.00019
18.0000	0.000	0.00051	-0.10220	0.00016	0.00000	-0.13693	0.00042
19.0000	0.000	0.00070	-0.07583	0.00022	0.00000	-0.13187	0.00068
20.0000	0.000	0.00079	-0.06292	0.00024	0.00000	-0.13279	0.00081

Figure 22 LINK 3 Modified Correlation

```
+EXPERIMENT NUMBER= 000000        ORGANIZATION=000000  TAPE NUMBER=000000 +
+                                                                         +
+      PAGE NUMBER=*** FILE NUMBER=000000DATE=000000   RUN NUMBER=000000 +
```

```
++++++++++++++++++++++++++++++++++INTEGRATED ERROR ANALYSIS++++++++++++++++++++++++++++++
+  CORRELATED CHANNELS= 1 AND  1+             + MODIFIED +          +ACCUMULATION PROCEDURE USED=  +
+  ACCUMULATION NUMBER=     1    +CORRELATION+CORRELATION+  CHANNEL  +  THEY WERE ALL USED         +
+  END OF ACCUMULATION= 4375.00 +STATISTICAL+STATISTICAL+STATISTICAL+                             +
+START OF ACCUMULATION=    0.00 +   ERROR   +   ERROR   +   ERROR   +                             +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++AVERAGING TIME++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
+              +  4375.000    +  0.0000002+  0.0022959+  0.0022959+                              +
```

FINAL TABULATION OF RESULTS

CORRELATED CHANNELS	MEAN VALUE	ROOT MEAN SQUARE VALUE	TIME DELAY	VELOCITY DELAY	CORRELATION	MODIFIED CORRELATION
1	-0.0116188	0.0040538				
1	-0.0116188	0.0040538				
			-20.000000	0.000000	0.0002378	-0.1327852
			-19.000000	0.000000	0.0002162	-0.1318671
			-18.000000	0.000000	0.0001630	-0.1369294
			-17.000000	0.000000	0.0000893	-0.1463339
			-16.000000	0.000000	0.0000150	-0.1566706
			-15.000000	0.000000	-0.0000386	-0.1642489
			-14.000000	0.000000	-0.0000589	-0.1670547
			-13.000000	0.000000	-0.0000487	-0.1661454
			-12.000000	0.000000	-0.0000197	-0.1662904
			-11.000000	0.000000	-0.0000192	-0.1738694
			-10.000000	0.000000	-0.0000545	-0.1903777
			-9.000000	0.000000	-0.0001160	-0.2119777
			-6.000000	0.000000	-0.0001607	-0.2271428
			-7.000000	0.000000	-0.0001153	-0.2175049
			-6.000000	0.000000	0.0001048	-0.1623974
			-5.000000	0.000000	0.0005638	-0.0464379
			-4.000000	0.000000	0.0015505	0.2026835
			-3.000000	0.000000	0.0024601	0.4321819
			-2.000000	0.000000	0.0033304	0.6518241
			-1.000000	0.000000	0.0039620	0.8112452
			0.000000	0.000000	0.0041936	0.8695849
			1.000000	0.000000	0.0039620	0.8112452
			2.000000	0.000000	0.0033304	0.6518241
			3.000000	0.000000	0.0024601	0.4321819
			4.000000	0.000000	0.0015505	0.2026835
			5.000000	0.000000	0.0005638	-0.0464379
			6.000000	0.000000	0.0001048	-0.1623974
			7.000000	0.000000	-0.0001153	-0.2175049
			8.000000	0.000000	-0.0001607	-0.2271428
			9.000000	0.000000	-0.0001160	-0.2119777
			10.000000	0.000000	-0.0000545	-0.1903777
			11.000000	0.000000	-0.0000192	-0.1738694
			12.000000	0.000000	-0.0000197	-0.1662904
			13.000000	0.000000	-0.0000487	-0.1661454
			14.000000	0.000000	-0.0000589	-0.1670547
			15.000000	0.000000	-0.0000386	-0.1642489
			16.000000	0.000000	0.0000150	-0.1566706
			17.000000	0.000000	0.0000893	-0.1463339
			18.000000	0.000000	0.0001630	-0.1369294
			19.000000	0.000000	0.0002162	-0.1318671
			20.000000	0.000000	0.0002378	-0.1327852

Figure 23 Final Tabulation

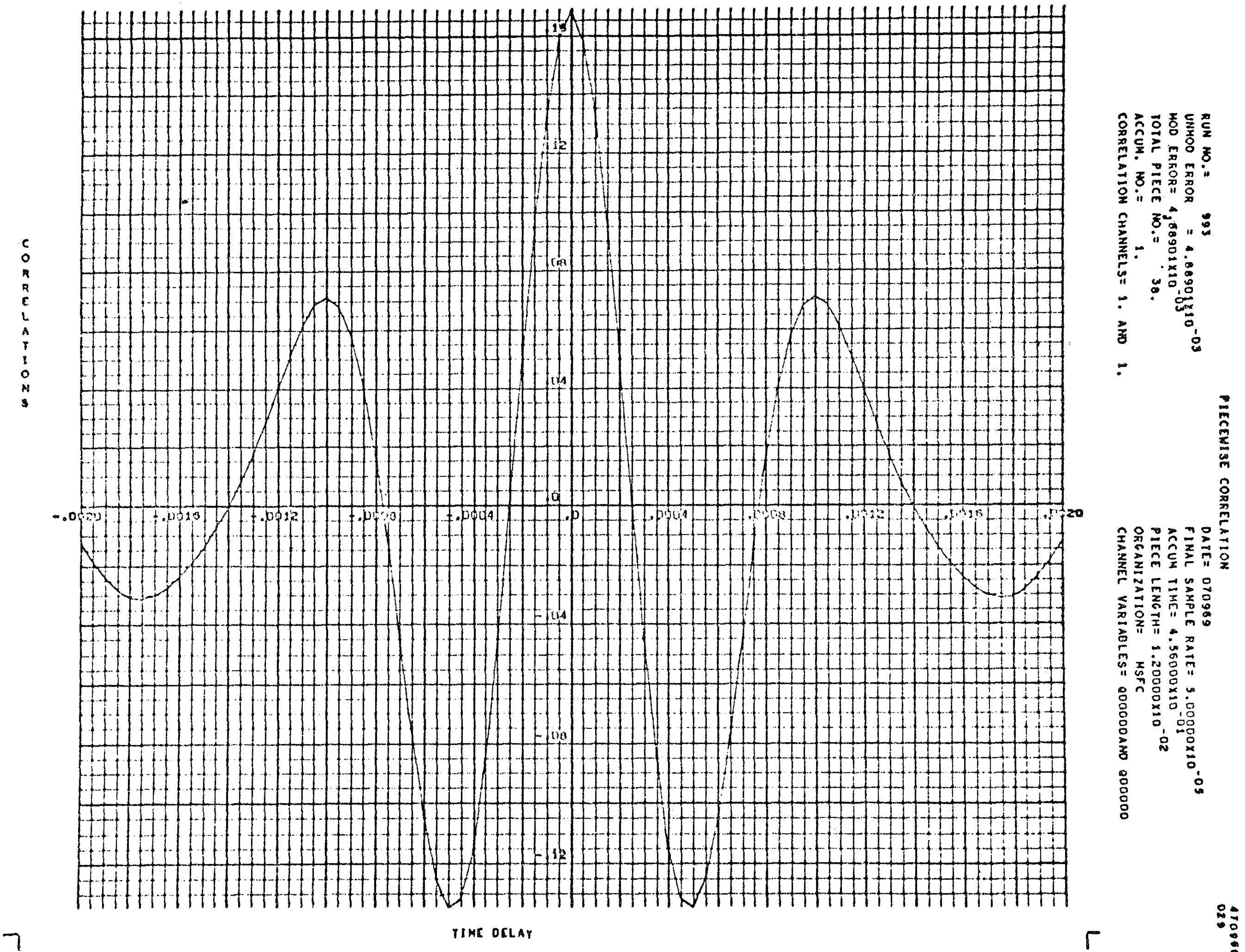


Figure 24 Piecewise Correlation

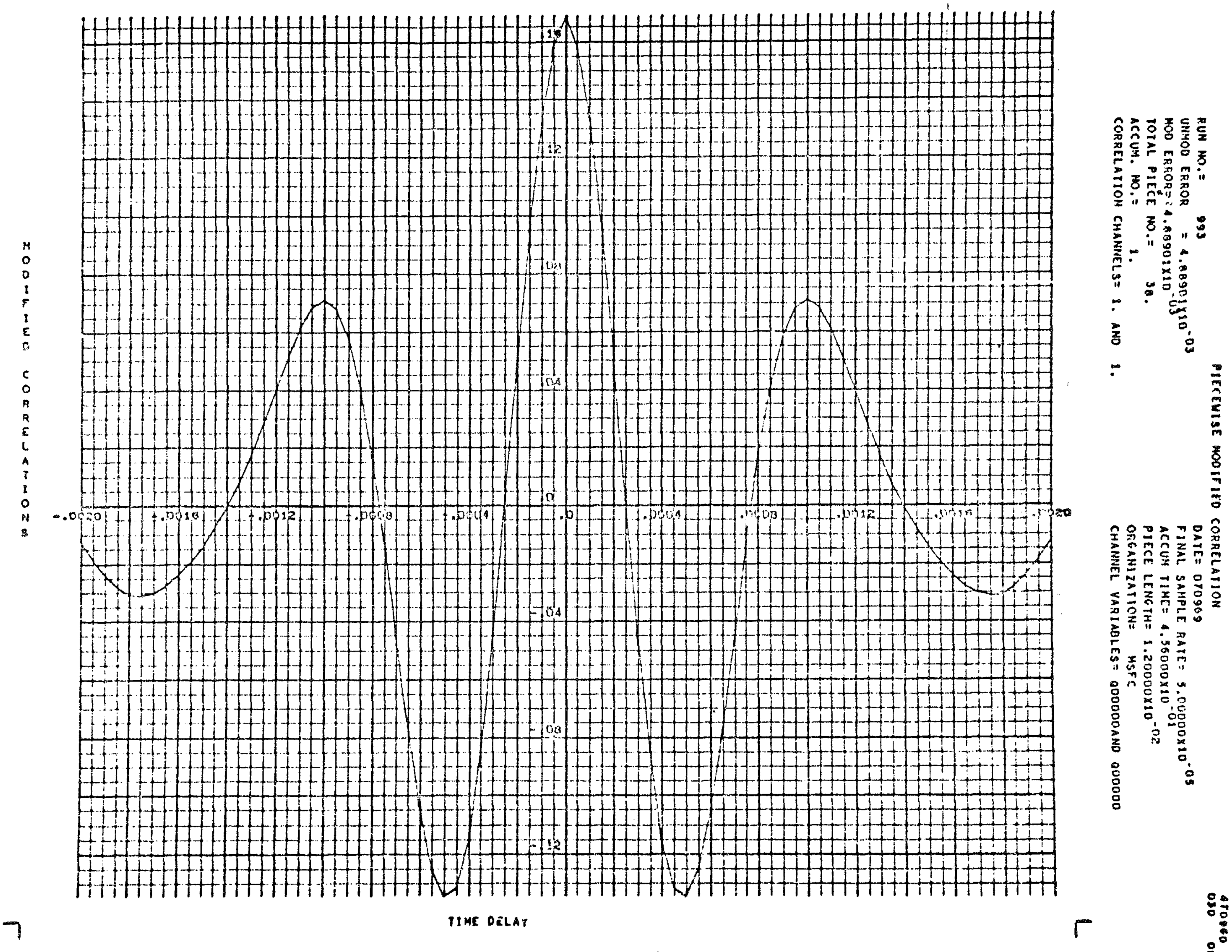


Figure 25 Piecewise Modified Correlation

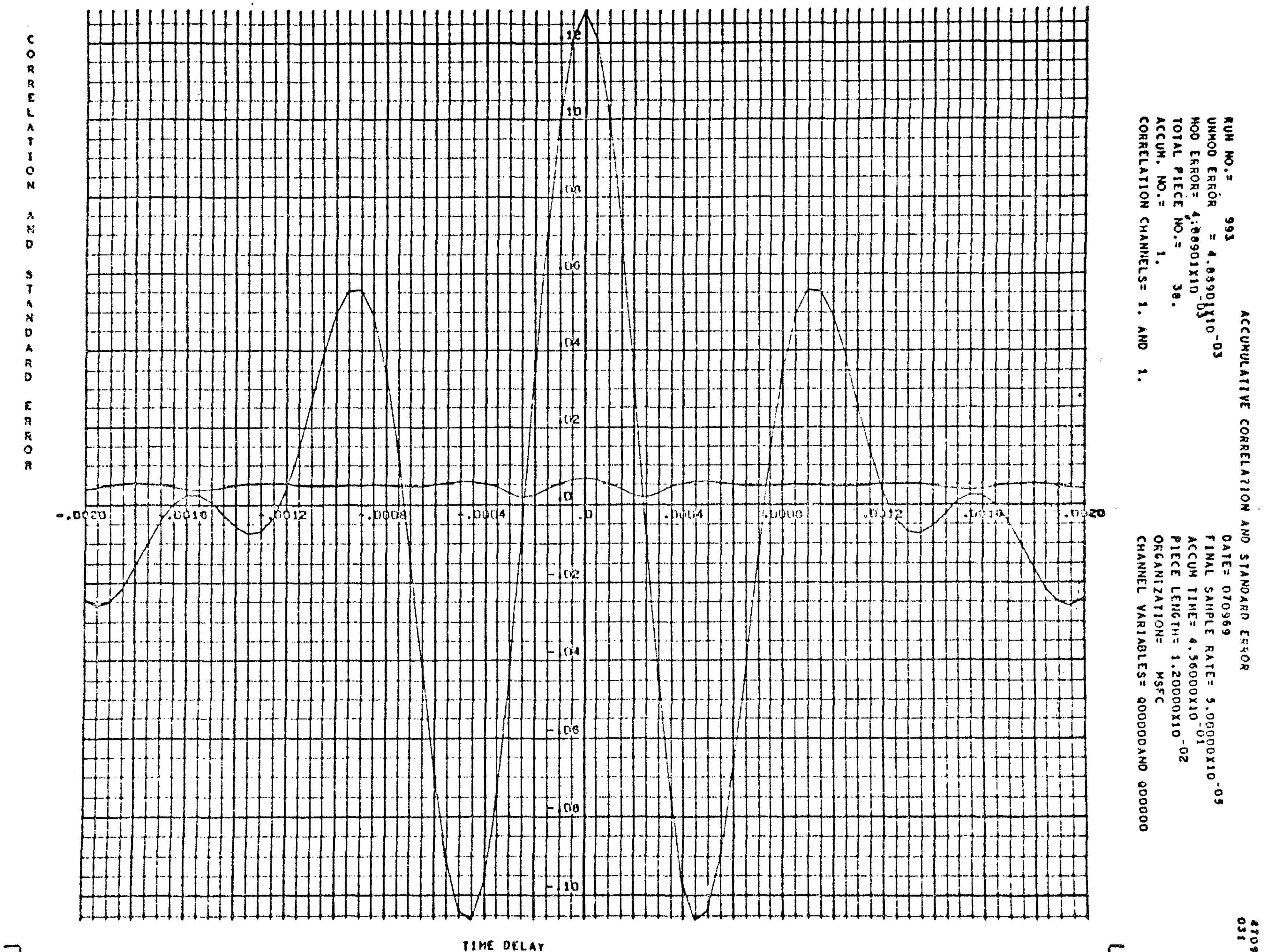


Figure 26 Accumulative Correlation and Standard Error

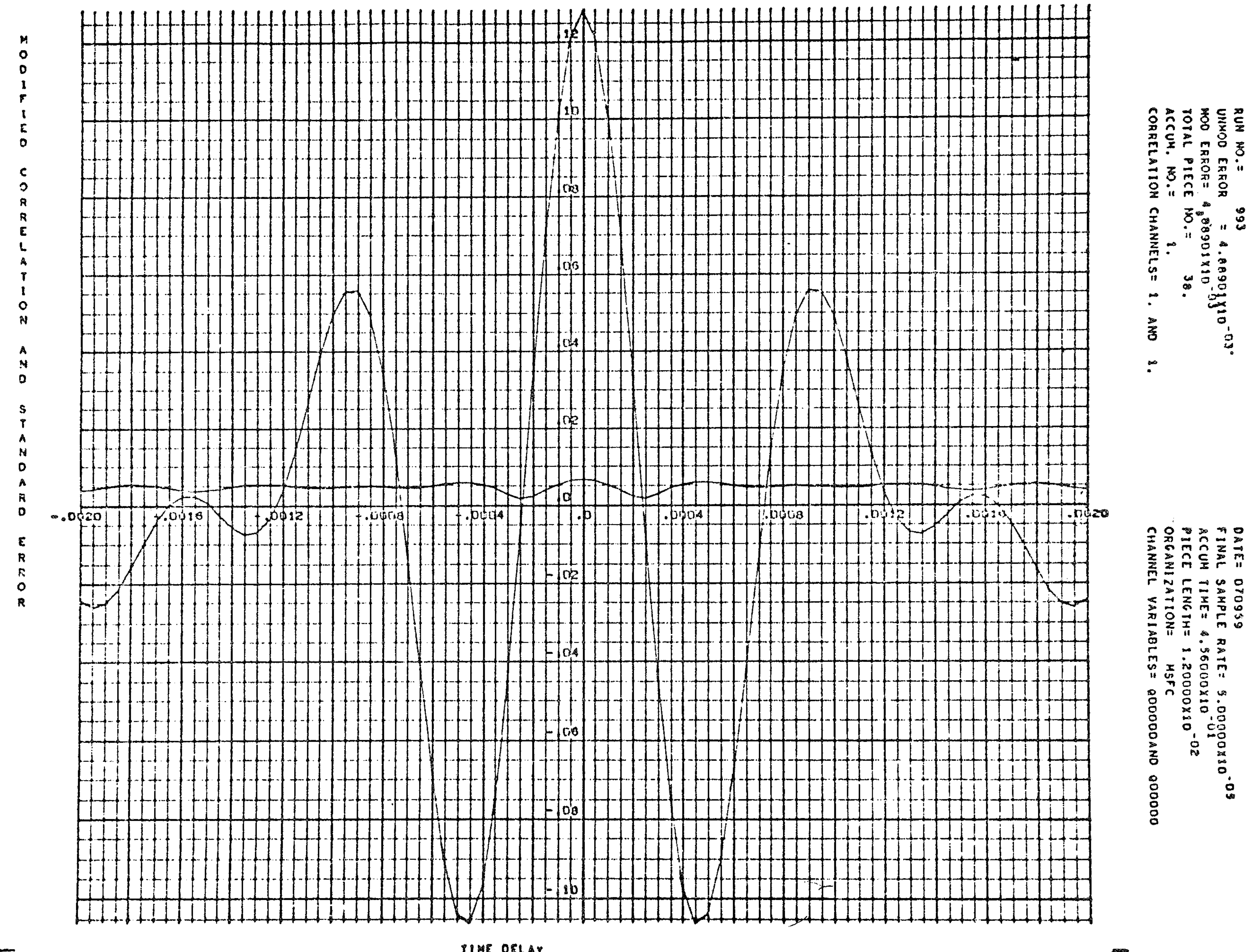


Figure 27 Accumulative Modified Correlation and Standard Error

REFERENCES

1. F. R. Krause and R. R. Jayroe, Development of New Computer Code for Cross-Beam Data, 1968.
2. R. R. Jayroe and M. Y. Su, Optimum Averaging Time of Meteorological Data with Time Dependent Means, 1968.
3. F. R. Krause and B. C. Hablutzel, Noise Elimination by Piecewise Cross Correlation of Photometer Outputs, 1968.
4. F. R. Krause, J. A. Jones, M. T. Fisher, and J. Pooley, Digital Analysis of Random Processes by Piecewise Estimated Covariance Functions, 1967.

Blank Page

APPENDIX A

MLTCOR COMPUTER PROGRAM USERS MANUAL

1. INTRODUCTION

The purpose of this manual is to establish a thorough understanding of how to use the MLTCOR program and explain in detail the input parameters, and some of the system features of the IBM 7094 and the Univac 1108 EX VIII. Restrictions and problems a user might encounter are explained in detail. Program diagnostics are listed and are self-explanatory. These help the user to identify problems in jobs that have been set up.

2. INPUT PROBLEM PARAMETERS

A. LINK 1

1. KRUN — Restart constant.
   Example:
   KRUN = 1,2,3; runs all three links in sequence.
   KRUN = 2; will run only LINK 2.

2. NBEAMS — Number of beams or sensors.
   Example:
   NBEAMS = 7; indicates there are 7 sensors or 7 beams on input tape.

3. NFLSKC — Number of files to be skipped before reading MSFC Calibration records.
   Example:
   NFLSKC = 3; indicates calibration data are in file 4.

4. NFLSKD — Number of files to be skipped before reading MSFC data records.
   Example:
   NFLSKD = 2; indicates data are in file 3.

5. MVMEAN Moving mean span desired for filtering data. (Preferably an odd integer).
Example:
MVMEAN = 11; the filter span to be used will be 11 points. If MVMEAN = 0, this option will be by-passed.

6. NCENDF Central differences.
Example:
NCENDF = 1; central differences are calculated.
NCENDF = 0; this option will be by-passed.

7. NOBEAM The total number of beams on which to be operated.
Example:
NOBEAM = 3; indicates 3 beams of NBEAMS on which to be operated.
If MVMEAN = 0, this option is ignored.

8. NWHICH Which beams of the NBEAMS on which to be operated.
Example:
NWHICH = 1,3,4; indicates beams 1,3, and 4 only.
If MVMEAN = 0; this option is ignored.

9. TIMSAM Sample rate of input data.
Example:
TIMSAM = .1; indicates data were sampled at 10 samples per second.

10. VALMAX Maximum value for calibrations.
Example:
VALMAX = 1.0, 1.0, 1.0; indicates three channels are calibrated to maximum value of 1.0.

11. VALMIN Minimum value for calibrations.
Example:
VALMIN = -1.0, -1.0, -1.0; indicates three channels are calibrated to minimum value of -1.0.

12. *START Start time on raw data input tape. (There can be up to 5 start times).
Example:
START = 1.0, 1.5, 2.0, 2.5, 6.0; indicates 5 starting points on the input tape.

13. *STOP Stop time on raw data input tape. (There can be up to 5 stop times).
Example:
STOP = 1.4, 2.0, 2.4, 5.9, 6.5; indicates the 5 stop times for each respective start time in the example above.

14. NFILE — Number of files to be shipped before reading ESSA data.
Example:
NFILE = 3; indicates ESSA data are in file 4.

15. MSFC — Flag to the program indicating MSFC formated tape.
Example:
MSFC = 1; will translate MSFC formated tapes.
If MSFC = 0, program will translate ESSA formated tapes.

16. IFREQ — Desired output sample rate to intermediate tape.
Example:
IFREQ = 1; every sample will be output to the intermediate tape.
IFREQ = 10; every tenth sample will be output to the intermediate tape. IFREQ must be $\geq$ 1.

17. LTN — Logical tape unit input tape is mounted on.
Example:
LTN = 10; indicates tape unit 10 is being used for input.

18. *NBLK — Number of records per block on ESSA output tape. This variable is used to block the output intermediate tape and to adjust the record size of MSFC output tape.
Example:
NBLK = 30; indicates ESSA tapes are blocked 30 records per block and the intermediate output tape will be blocked 30 records per block.

19. NSTART — Number of starts and stops.
Example:
NSTART = 3; indicates there are 3 start and stop times.

20. *NBOB — N/A. This should always be 0.
Example:
NBOB = 0.

21. PLYBCK — Slow down rate of the analog tape relative to the digitizer tape.
Example:
PLYBCK = 8.0; indicates the analog tape was run at 1/8 the speed of the digitizer tape.

22. NSTEP — Flag for step calibrations.
Example:
NSTEP = 1; indicates data are DC, but a sine wave signal is used to calibrate.

23. NDEBUG Intermediate printout of time series data.
Example:
NDEBUG = 0; no printout
NDEBUG = 1; ID's and calibration data printed.
NDEBUG = 2; ID's calibration and time series data printed.

24. RUN Identifies run number.
Example:
RUN = 6H 207

25. ORGAN Identifies organization.
Example:
ORGAN = 6H MSFC

B. LINK 2

1. COVAR Removes the mean from each data piece. This option is a logical operation and should be set to true (T) or false (F)
Example:
COVAR = T; mean for each data piece will be removed.

2. START Start time for LINK 2 if different from LINK 1, or if restarting program at LINK 2. There can be up to 5 start times.

3. STOP Stop time for LINK 2. Same as above.

4. DELTAT Data piece length.
Example:
Deltat = 450.0; piece length of each correlation will be 450.0 seconds long.

5. IPRINT Intermediate printout option
Example:
IPRINT = 10; every tenth piece calculated will be printed.

6. TAUMIN Minimum lag time of correlations.
Example:
TAUMIN = 0.0; there will be no time displacement of correlated data for the first lag point.

7. TAUMAX Same as above except for the maximum lag time.

8. DELTAU Interval between lag points. This also determines the number of lag points used.

9. *VELLAG — This should be set to "0" or "1". 1 if velocity as a function of time lags are desired. 0 if not.

10. SEPART — Physical separation of the correlated beams. These should be specified in the same order as correlations are specified.
Example:
SEPART = 128.0, 180.0; the first two beams correlated are separated by 128.0 meters.

11. *J — Undelayed channel to be correlated.
Example:
J = 5; channel 5 will be the undelayed channel.

12. K — Delayed channel to be correlated. There can be up to six undelayed channels.
Example:
K = 1,2,3,4,5,6

C. LINK 3

1. NUMPCE — Piece numbers to be deleted from the accumulation of pieces.
Example:
NUMPCE = 6, 18, 19, 31; these pieces will be deleted from the accumulations. There can be up to ten deletions.

2. NPRINT — Intermediate printout of correlations from LINK 3. Same as IPRINT in LINK 2.

3. NORM — Correlations will be normalized if this option is set to (T). Set to (F) if correlations are not to be normalized. This is a logical operation.
Example:
NORM = T; correlations will be normalized

4. DTREND — Removes the trend in the data being correlated. Logical operation same as above.

5. PREMLT — Multiplies the correlation value by its associated time lag. Logical operation same as above.

6. PLOT — Plots all correlations. Logical operation same as above.

7. *NO — Accumulation number

8. BEGIN — Time to begin accumulation

9. END Time to end accumulation

10. Blank card or card containing alphanumeric data explaining the type of modifications used on the data.

3. INPUT/OUTPUT TAPES (7094)

A. System Tapes

(1) A1:(N/A); System residence containing library subroutines.

(2) A2:(5): Card input (namelist data).

(3) A5:(8); Program residence containing source or object program.

(4) A6:(10); LINK 1 output.

(5) A8:(N/A); 4020 plotting output.

(6) B1:(6); Reports output (LINK 2 and LINK 3).

(7) B3:(2); Overlay tape.

(8) B5:(9); Non-system input.

(9) B6:(11); LINK 2 output.

Input/Output Tapes (1108)

All system usage is located on mass drum storage. Users input and output tapes are selected at run time as specified on the 1108 run cards optional to the programer. (See job set-up).

4. DIAGNOSTIC

A. LINK 1

(1) End of file on input tape (B5).

(2) Irrecoverable parity error on tape (B5).

(3) System messages.

B. LINK 2

(1) Storage exceeded.

(2) Correlations not specified correctly.

(3) Time span and piece off.

(4) Time span greater than pieces.

(5) Insufficient data in time interval.

(6) Duplicate channels.

(7) System messages.

C. LINK 3

(1) System messages.

5. USERS RESTRICTIONS AND NOTES

A. LINK 1

(1) At digitizing time, the number of words per physical record should not exceed 6000. This will allow enough area in the dynamic storage for data conditioning.

(2) The logical record lengths of the intermediate tapes are controlled by the NBLK constant. For ESSA tapes this <u>must</u> be the number of records per blocked record on the input tape. For MSFC NBLK controls the number of records per blocked record output. These blocked records should <u>not</u> exceed 512 words. Usually NBLK = 30.

B. LINK 2

(1) To eliminate storage overflow, the following calculation should be made:

$$\left[12800 - \left(\text{NTLAGS} + \text{NCRT} \times \text{NTLAGS} \times \text{VELLAG} + 9 \times \text{NCH} + \text{NCRT} \times (\text{NTLAGS} + 1) + \text{MAXINC} \times \text{NCH}\right)\right] / (\text{MSUB} \times \text{NCH}) \geq 1$$

Where:

NTLAGS	two times number of lags plus one
NCRT	total number of correlations
VELLAG	input constant
NCH	total number of channels being used
MAXINC	maximum time lag divided by time sampled
MSUB	number of samples per piece

C. LINK 3 - None

NOTES LINK 1

(1) (12. and 13.) Stop time will be adjusted to the last time on input tape on termination of LINK 1, and passed on to LINK 2 if LINK 1 and LINK 2 are run in sequence. If LINK 2 is run as a restart it is the responsibility of the user to get the stop time from LINK 1 output.

(2) (18.) If NBLK is selected such that the number of words per plocked record exceeds 512 core locations, some constants and machine instructions are destroyed.

(3) (20.) This constant is used to print out time, 1/square root of time, mean and RMS values for each channel.

NOTES LINK 2

(1) (9.) Considerable amount of storage is needed for these values if several correlations are requested. If core storage is marginal this should be set to "0" and the number of correlations times the number of lags will be saved.

(2) (11.) There can only be one "J" for each set of "K's". These can be repeated until there has been 12 correlations specified.

(3) (11.) If auto correlations are requested then a DC trend is calculated by removing the square of the means from the area in under the correlation for each auto correlation, and square rooting the value. The area in under the curve replaces $\overline{X}^2$ in the standard error calculations.

NOTES LINK 3

(1) (7.) There can be up to five accumulation spans and each span number identified by number 7,8,9 can be repeated up to five times.

6. JOB SETUP

JOB SET-UP (7094)

```
$JOB            NASA-JAYROE BIN 309,470960,00,11,14MCE
$EXECUTE        IBJOB
$IBJOB          FIOCS,MAP
$FILE           -UNIT03-,NONE
$FILE           -UNIT08-,NONE
$FILE           -UNIT13-,NONE
$FILE           -UNIT14-,NONE
$FILE           -UNIT15-,NONE
$IEDIT          SYSCK1,SCHF01
$IBFTC MLTCOR                                                   MLTC0000

      .
      .
      .
      .
      .
      .
      END
$DATA
 $LINKNO
 KRUN=1,2,3,4
 $END
 $NAMDAT
 NBEAMS=2
 NFLSKC=0
 NFLSKD=1
 MVMEAN=0
 NCENDF=0
 NOBEAM=2
 NWHICH=1,2
 TIMSAM=.00005
 VALMAX=1.0,1.0,1.0,1.0,1.0
 VALMIN=-1.0,-1.0
 START=0.0
 STOP=.5
 NFILE=0
 MSFC=1
 IFREQ=1
 LTN=9
 NBLK=40
 NSTART=1
 NBOB=1
 PLYBCK=1.
 NSTEP=0
 NDEBUG=1
 $END
```

```
$IDINFO
RUN=6H   993
ORGAN=6H  MSFC
$END
$CVARNC
COVAR=T
$END
$TIMES
STOP=.4900
DELTAT=.012
IPRINT=0
$END
$DELAY
TAUMIN=0.0
TAUMAX=.002
DELTAU=.00005
VELLAG=0
SEPART=.01,.02,.03,.04,.05
$END
$CORR
J=1,K=1,5*0
$END
$CORR
J=0,K=6*0
$END
$DELETE
 NUMPCE=10*0
NPRINT=5
$END
$MODIFY
  NORM=F,DTREND=F,PREMLT=F,PLOT=T
$END
$ACCUM
  NO=1, BEGIN=0.0 , END=.444
$END
$ACCUM
  NO=0, BEGIN=0.0, END=0.0
$END
  NO MODIFICATION
-
-
```

JOB SET-UP (1108)

```
-RUN,T CSU204,470960,JAYROEBIN309,10,999
-ASG,T 9,T,36124
-ASG,T 10,T
-ASG,T 12,T
-FOR,IS  MLTCOR,MLTCOR

       .
       .
       .
       .
       .
       .
       END
-MAP,IL MAIN,MAIN
 SEG MLTCOR
 IN MLTCOR,DEC002
 SEG AA*, (MLTCOR)
 IN DEC003
 SEG BB*,(MLTCOR)
 IN DECK 21
 SEG CC*,(MLTCOR)
 IN DECK31
-XQT,D MAIN
 $LINKNO
 KRUN=1,2,3,4
 $END
 $NAMDAT
 NBEAMS=9
 NFLSKC=0
 NFLSKD=0
 MVMEAN=0
 NCENDF=0
 NOBEAM=0
 NWHICH=0
 TIMSAM=1.0
 VALMAX=1.0
 VALMIN=1.0
 START=0.0
 STOP=180.0
 NFILE=0
 MSFC=0
 IFREQ=1
 LTN=9
 NBLK=40
 NSTART=1
 NBOB=0
 PLYBCK=1.00
 NSTEP=0
 NDEBUG=2
 $END
```

```
 $IDINFO
 RUN=6H    100
 ORGAN =6H  MSFC
 $END
 $CVARNC
 COVAR=F
 $END
 $TIMES
 DELTAT =40.0
 IPRINT=0
 $END
 $DELAY
 TAUMIN=0.0
 TAUMAX=20.0
 DELTAU=1.0
 VELLAG=0
 $END
 $CORR
 J=4,K=4,5*0
 $END
 $CORR
 J=0,K=6*0
 $END
 $DELETE
 NUMPCE=10*0
 NPRINT=1
 $END
 $MODIFY
 NORM=F,DTREND=F,PREMLT=F,PLOT=T
 $END
 $ACCUM
 NO=1,BEGIN=0.0,END=120.0
 $END
 $ACCUM
 NO=0,BEGIN=0.0,END=0.0
 $END
   STRAIGHT TIME
-PMD,E
- FIN
- FIN
- FIN
- FIN
```

APPENDIX B
PROGRAM LISTINGS

```
$JØB            NASA-JAYRØE BIN 309,47096C,00,11,I4MCE
$EXECUTE        IBJØB
$IBJØB          FIØCS,MAP
$FILE           -UNIT03-,NØNE
$FILE           -UNIT12-,NØNE
$FILE           -UNIT13-,NØNE
$FILE           -UNIT14-,NØNE
$FILE           -UNIT15-,NØNE
$IBFTC MLTC2R                                                                   MLTC0000
C      SC(1)= TAPE NUMBER
C      SC(2)= ØRGANIZATIØN
C      SC(3)= FILE CØUNT
C      SC(5)= START TIME
C      SC(6)= STØP TIME
C      SC(6+1)= NAME ØF VARIABLE ØNE
C         .
C         .
C         .
C      SC(6+N) = NAME ØF NTH VARIABLE
C      SC(6+N+1) = MINIMUM VALUE VARIABLE ØNE
C         .
C         .
C         .
C      SC(6+2N)= MINIMIM VALUE ØF NTH VARIABLE
C      SC(6+2N+1)= MAXIMUM VALUE VARIABLE ØNE
C         .
C         .
C         .
C      SC(6+3N)= MAXIMUM VALUE ØF NTH VARIABLE
C      SC(7+3N)= SAMPLING RATE
C      SC(8+3N)= SAMPLE REDUCTIØN AT REAL TIME
C      WHERE N= NØ ØF BEAMS ØR SENSØRS
       CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKE,MVMEAN,
     2TIMSAM,NWDS,IFREC,MSEC,NFILE,RMS(12),VMEAN(12),NØRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NBLK,NSTART,
     3CØMTIM
       DIMENSIØN KRUN(4)
       DIMENSIØN NWHICH(12)
       NAMELIST/LINKNØ/KRUN
       NAMELIST/IDINFØ/RUN,ØRGAN
       NAMELIST/NAMDAT/NBEAMS,NFLSKC,NFLSKE,MVMEAN,NCENDF,NØBEAM,NWHICH,
     2TIMSAM,VALMAX,VALMIN,
     1START,STØP,NFILE,MSEC,IFREC,LTN,NBLK,NSTART,NBØB,PLYBCK,NSTEP
     2,NDEBUG
       DØ 10 II=1,4
       KRUN(II)=0
 10    CØNTINUE
       CALL SCLØCK (DATE,TIME,FSEC,E60SEC)
       CØMTIM=E60SEC
C      READ INPUT CARDS UNDER NAMELIST
       READ (5,LINKNØ)
       WRITE (6,LINKNØ)
       READ (5,NAMDAT)
       WRITE (6,NAMDAT)
       IF (MSEC) 21,21,20
 20    READ (5,IDINFØ)
       SC(1)=RUN
       SC(2)=ØRGAN
 21    CØNTINUE
       NWDS=(NBEAMS+1)*NBLK
```

```
      TIMSAM=TIMSAM/PLYBCK
      SPØT=0.0
      I=1
      IF (KRUN(I) .EQ. 1) GØ TØ 1
      GØ TØ 4
1     I=I+1
      CALL LINK1 (NBØØ,NCENDF,PLYBCK,NWHICH,NØBEAM,NSTEP,NDEBLG,SPØT)
4     IF (KRUN(I) .EQ. 2) GØ TØ 2
      GØ TØ 5
2     I=I+1
      CALL LINK2(KRUN,SPØT)
5     IF (KRUN(I) .EQ. 3) GØ TØ 3
      GØ TØ 6
3     CØNTINUE
      I=I+1
      CALL LINK3(KRUN(I))
6     CØNTINUE
      IF (KRUN(I) .EQ. 4) GØ TØ 7
      GØ TØ 8
7     CØNTINUE
8     CØNTINUE
      CALL SCLØCK (DATE,TIME,ESEC,E60SEC)
      CØMTIM=(E60SEC-CØMTIM)/60.0
      WRITE (6,1199) CØMTIM
 1199 FØRMAT (40H0C.P.U. TIME REQUIRED FØR THIS 7094 RUN=F10.5)
      STØP
      END



$IBFTC DECK0J                                                     DECK000C
      SUBRØUTINE ØUT1(N,EXPNØ,ØRG,NØTAPE,NØPAGE,NØFILE,IDATE,NØRUN)
      WRITE(N,1000) EXPNØ,ØRG,NØTAPE,NØPAGE,NØFILE,IDATE,NØRUN
 1000 FØRMAT(1H1,74(1H+),/21H +EXPERIMENT NUMBER= ,A6,7X,13HØRGANIZATIØN FM 1000
     2=,A6,14H  TAPE NUMBER=,A6,2H +,/2H +,72X,1H+,/2H +,6X,12HPAGE NUMB FM 1000
     3ER=,I3,13H FILE NUMBER=,A6,5HDATE=,A6,14H   RUN NUMBER=,A6,2H +,/1
     4H ,74(1H+))
      RETURN
      END
```

```
$ØRIGIN        ALPHA,SYSUT2,REW
$IBFTC LINK11                                                                       LINK0000
      SUBRØUTINE LINK1 (NBØB,NCENDF,PLYBCK,NWHICH,NØBEAM,NSTEP,NDEBUG,
     1SPØT)
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKC,MVMEAN,
     2TIMSAM,NWDS,IFREC,MSFC,NFILE,RMS(12),VMEAN(12),NØRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NBLK,NSTART
      DIMENSIØN NWHICH(1)
      DIMENSIØN BUFØUT(512)
      DIMENSIØN DATA(9000)
      DIMENSIØN VVMEAN(12),RRMS(12)
      DIMENSIØN CØM(1)
      EQUIVALENCE (START(1),CØM(1))
      DATA NFLAG/0/
      DATA NCØUNT/0/
C     INITILIZE VARIABLES FØR RMS CALCULATIØNS
 1121 FØRMAT (1H1,117H  TIME         CH1         CH2         CH3         CH4
     1   CH5         CH6         CH7         CH8         CH9         CH10       CH11
     2   )
      NUMCØM=175
      NTØTNØ=0
      NFIN=NWDS-NBEAMS
      DØ 253 J=1,NBEAMS
      VMEAN(J)=0.0
      VVMEAN(J)=0.0
      RMS(J)=0.0
      RRMS(J)=0.0
  253 CØNTINUE
 1    CØNTINUE
      IF (MSFC) 302,302,300
  300 CALL TPMSFC (DATA,IERR,PLYBCK,NSTEP,NDEBUG)
      GØ TØ (301,999,999,301,999),IERR
  302 CØNTINUE
      CALL TPESSA (DATA,IERR,NDEBUG)
      GØ TØ (301,999,999,301,999),IERR
  301 CØNTINUE
      IF (NFLAG .GT. 0) GØ TØ 400
      WRITE(10) (CØM(I),I=1,NUMCØM)
      NFLAG=1
  400 CØNTINUE
      I=0
  150 I=I+1
      DØ 160 J=1,NBEAMS
      I=I+1
      DATA(I)=DATA(I)*SLØPE(J)+BIAS(J)
  160 CØNTINUE
      IF (I .GE. NWDS) GØ TØ 151
      GØ TØ 150
  151 CØNTINUE
C     CALCULATE MEANS AND RMS VALUES HERE
      IF (IERR .EQ. 2) GØ TØ 401
      IF (NDEBUG .EQ. 0) GØ TØ 401
      I=0
  250 I=I+1
      DØ 251 J=1,NBEAMS
      I=I+1
      RMS(J)=RMS(J)+DATA(I)**2
      VMEAN(J)=VMEAN(J)+DATA(I)
  251 CØNTINUE
      IF (I .GE. NWDS) GØ TØ 152
```

```
      GØ TØ 250
 152  CØNTINUE
      NTØTNØ=NTØTNØ+NWDS
 401  CØNTINUE
      IF (MVMEAN) 144,141,145
C     CALCULATE INTEGERS FØR INDEXING IN MØVING MEAN SUBRØUTINE
 145  FACTØR=(MVMEAN/2)+1
      TIMCØR=FACTØR*TIMSAM
      NFACTR=MVMEAN*(NBEAMS+1)
      ITEMP=(NWDS/NFACTR)*NFACTR+NWDS
      NEWWDS=ITEMP+NFACTR
      NDLSPN=NFACTR
      INDEX=NWDS+1
      INDEX2=INDEX+NFACTR-1
      INDEX6=(NBEAMS+1)*IFREQ
      INDEX3=ITEMP-INDEX6
      INDEX7=ITEMP-NWDS
      AVERAG=MVMEAN
      MVMEAN=-MVMEAN
      INDEX5=ITEMP-(NBEAMS+1)*(IFREQ-1)
      M=1
      II=INDEX
 144  CØNTINUE
      I=0
      II = II-1
      IF (MVMEAN) 140,141,140
 140  II=II+1
      I=I+1
      DATA(II)=DATA(I)
 142  IF (I .GT. NWDS) GØ TØ 1
      IF (II .EQ. NEWWDS) GØ TØ 143
      GØ TØ 140
 143  CALL VMØVMN (DATA,ITEMP,TIMCØR,NDLSPN,INDEX,AVERAG,NWHICH,NØBEAM)
      INDEX4=INDEX-ITEMP+INDEX5+(NBEAMS+1)*(IFREQ-1)
      INDEX5=INDEX4+NBEAMS
 602  DØ 600 II=INDEX4,INDEX5
      BUFØUT(M)=DATA(II)
      M=M+1
 600  CØNTINUE
      IF (M .LT. NWDS) GØ TØ 603
      IF (NDEBUG .LE. 1) GØ TØ 2000
      WRITE (6,1121)
      DØ 2011 IX=1,NBLK
      IY=IX*(NBEAMS+1)
      IZ=IY-NBEAMS
      WRITE (6,1112) (BUFØUT(MM),MM=IZ,IY)
 2011 CØNTINUE
 2000 CØNTINUE
      WRITE(10)  (BUFØUT(MM),MM=1,NWDS)
      SPØT=BUFØUT(NFIN)
      M=1
 603  CØNTINUE
      IF (INDEX4 .GE. INDEX3) GØ TØ 601
      INDEX4=INDEX4+INDEX6
      INDEX5=INDEX4+NBEAMS
      GØ TØ 602
 601  III=ITEMP
      DØ 146 II=INDEX,INDEX2
      III=III+1
      DATA(II)=DATA(III)
 146  CØNTINUE
```

```
      II=INDEX2
      GØ TØ 140
  141 CØNTINUE
C     SET UP INDEXING FØR CENTRAL DIFFERENCES
      IF (NCENDF) 202,200,201
  201 NCEN1=(NBEAMS+1)*2
      NCEN2=NWDS+1
      NCEN3=2*NWDS
      NCEN4=NWDS+NCEN1
      NCEN5=2*NWDS+NCEN1
      NFIN=NCEN3-NBEAMS
      NCENDF=-NCENDF
      II=NCEN2
  202 I=0
      II=II-1
  203 II=II+1
      I=I+1
      DATA(II)=DATA(I)
      IF (I .GT. NWDS) GØ TØ 1
      IF (II .EQ. NCEN5) GØ TØ 204
      GØ TØ 203
  204 II=NCEN2-1
  154 II=II+1
      DØ 206 J=1,NØBEAM
      IV=II+NWHICH(J)
      NCEN7=IV+NCEN1
      DATA(IV)=DATA(NCEN7)-DATA(IV)
  206 CØNTINUE
      II=II+NBEAMS
      IF (II .GE. NCEN3) GØ TØ 205
      GØ TØ 154
  205 CØNTINUE
      IF (NDEBUG .LE. 1) GØ TØ 2001
      WRITE (6,1114)
 1114 FØRMAT (20H0CENTRAL DIFFERENCES)
      WRITE (6,1121)
      DØ 2012 IX=1,NBLK
      IY=IX*(NBEAMS+1)+NWDS
      IZ=IY-NBEAMS
      WRITE (6,1112) (DATA(II),II=IZ,IY)
 2012 CØNTINUE
 1115 FØRMAT (1H ,F10.5)
 2001 CØNTINUE
      WRITE (10)      (DATA(II),II=NCEN2,NCEN3)
      SPØT=DATA(NFIN)
      NCEN6=NCEN3
      DØ 207 II=NCEN2,NCEN4
      NCEN6=NCEN6+1
      DATA(II)=DATA(NCEN6)
  207 CØNTINUE
      II=NCEN4
      GØ TØ 203
  200 CØNTINUE
      IF (NDEBUG .LE. 1) GØ TØ 2002
      WRITE (6,1121)
      DØ 2010 IX=1,NBLK
      IY=IX*(NBEAMS+1)
      IZ=IY-NBEAMS
      WRITE (6,1112) (DATA(I),I=IZ,IY)
 2010 CØNTINUE
 2002 CØNTINUE
```

```
      WRITE (1C)(DATA(I),I=1,NWDS)
      SPØT=DATA(NFIN)
  212 IF (NBØB) 1,1,209
  209 NCØUNT=NCØUNT+1
      IF (NCØUNT .GE. NBØB) GØ TØ 210
      GØ TØ 1
  21C AVRAGE=NTØTNØ/(NBEAMS+1)
      DØ 211 J=1,NBEAMS
      VVMEAN(J)=VMEAN(J)/AVRAGE
      RRMS(J)=SQRT((RMS(J)/AVRAGE)-VVMEAN(J)**2)/SQRT(AVRAGE)
  211 CØNTINUE
      SQRTT=1.C/SQRT(DATA(1))
      WRITE (6,1112) DATA(1),SQRTT,(VVMEAN(J),RRMS(J),J=1,NBEAMS)
      NCØUNT=C
      GØ TØ 1
  999 CØNTINUE
      STØP(NSTART)=SPØT
C     FINISH RMS CALCULATIØNS
      IF (NDEBUG .EQ. 0) GØ TØ 2003
      AVRAGE=NTØTNØ/(NBEAMS+1)
      DØ 2C8 J=1,NBEAMS
      VMEAN(J)=VMEAN(J)/AVRAGE
      RMS(J)=SQRT((RMS(J)/AVRAGE)-VMEAN(J)**2)
  208 CØNTINUE
      WRITE (6,1112) (VMEAN(J),RMS(J),J=1,NBEAMS)
 2CC3 CØNTINUE
      WRITE (6,1112) (SLØPE(I),BIAS(I),I=1,NBEAMS)
 1112 FØRMAT (1H 12F10.6)
      WRITE (6,1120) (START(I),STØP(I),I=1,NSTART)
 1120 FØRMAT (44H START AND STØP TIMES ØN LINK ØNE ØUTPUT ARE, 2F12.6)
      CALL ØLT1(6,EXPNØ,SC(2),SC(1),NØPAGE,SC(3),SC(4),NØRUN)
      CALL ØLT2(6,NBEAMS,SC(5),SC(6),AVGMIN,AVGMAX,SLØPE,BIAS,VALMIN,
     1VALMAX)
      CALL ØLT3(6,NBEAMS,SC(43),SC(44),IFREQ,MVMEAN,NCENDF,SC(8),
     1SC(5),SC(6),NWHICH,NØBEAM)
      TIFREQ=IFREQ
      TIMSAM=TIMSAM*TIFREQ
      END FILE 1C
      REWIND 1C
      REWIND 9
      RETURN
      END
```

```
$IBFTC DECK1A                                                                   DECK0000
      SUBRØUTINE TPESSA (DATA,IERR,NDEBUG)
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKC,MVMEAN,
     2TIMSAM,NWDS,IFREC,MSEC,NFILE,RMS(12),VMEAN(12),NØRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NBLK,NSTART
      EQUIVALENCE (IZI,ZZI)
      DIMENSIØN DATA(1)
      DIMENSIØN IDATA(400),IMK(3)
C     SET INITIAL FLAG CØNDITIØNS
      DATA NFLAG/0/
      DATA NFLAG1/0/
      DATA NCAL/0/
      DATA ISL/1/
      DATA IMK/Ø400000000000,Ø40000000,Ø4000/
      DATA NCØM/Ø10000/
      DATA NCØUNT/-1/
      IF (NFLAG) 408,302,408
 408  IF (NFLAG1) 1,409,55
 409  I=0
      GØ TØ 1
 302  CØNTINUE
      NPAR=0
C     UNPAK RETURNS AN ARRAY SC CØNTAINING HEADER INFØRMATIØN
      IF (NFILE) 89,90,89
 89   DØ 88 NSKIP=1,NFILE
      CALL SKRECD(LTN,1,RD)
      CALL SKFPIN (LTN,1,RD)
 88   CØNTINUE
 90   CØNTINUE
      CALL UNPAK
      NUPER=18
      NUPER1=NUPER+1
      NUPER2=53
      IF (NDEBUG .EQ. 0) GØ TØ 2001
      WRITE (6,1111)
      WRITE (6,1113) (SC(JI),JI=1,18)
      WRITE (6,1112) (SC(JI),JI=19,53)
 1111 FØRMAT (15H0DEBUG PRINTØUT)
 1112 FØRMAT (1H 12F10.3)
 1121 FØRMAT (1H1,117H  TIME         CH1         CH2         CH3         CH4
     1   CH5         CH6         CH7         CH8         CH9         CH10        CH11
     2   )
 1113 FØRMAT (1H A6)
 1114 FØRMAT (1H ,10F12.3)
 2001 CØNTINUE
      DØ 100 J=1,11
      JJ=19+J
      VALMIN(J)=SC(JJ)
 100  CØNTINUE
      DØ 101 J=1,11
      JJ=31+J
      VALMAX(J)=SC(JJ)
 101  CØNTINUE
      JJ=43
      SMRECR=SC(JJ+1)
      TIMSAM=(1.0/SC(JJ))*(SC(JJ+1)+1.0)
      I=0
 1    IERR=0
      CALL RECTPR (LTN,2,IERR,NW,NWDS,IDATA)
      NCØUNT=NCØUNT+1
```

```
      TIMFAC=FLØAT(NCØUNT*NBLK)*TIMSAM
      II=C
      IF (NW-NWDS) 7,6,7
 7    CØNTINUE
 6    CØNTINUE
      GØ TØ (5,3,4,5,3),IERR
 3    WRITE (6,99)
 99   FØRMAT (27HOEND ØF FILE ØN INPUT TAPE )
      GØ TØ 999
 98   FØRMAT (42HOIRRECØVERABLE PARITY ERRØR ØN TAPE          )
 4    WRITE (6,98)
      NPAR=NPAR+1
      IF (NPAR .GE. 10) GØ TØ 999
      GØ TØ 1
C     TERMINATE RUN HERE
C     TRANSLATE TIME
 55   I=C
 5    CØNTINUE
      IF (NFLAG .EQ. C) GØ TØ 110
      IF (DATI .LT. START(ISL)) I=I-1
 11C  I=I+1
 40C  II=II+1
      IF=II+2
      LW=IF/3
      IP=IF-3*(LW)
      IBT=12*IP
      IDAT=C
      CALL  FLD(IDAT,24,12,IBT,IDATA(LW))
      DATI=IDAT
      DATI=DATI*TIMSAM+TIMFAC
      IF (NFLAG) 11.12,11
 11   IF (DATI .LT. START(ISL)) GØ TØ 8
      IF (DATI .GT. STØP(ISL)) GØ TØ 10
      GØ TØ 12
 8    II=II+NBEAMS
      IF (II .GE. NWDS) GØ TØ 1
      GØ TØ 40C
 10   IF (ISL .GE. NSTART) GØ TØ 4C7
      ISL=ISL+1
      GØ TØ 8
 4C7  IERR=2
      GØ TØ 999
 12   CØNTINUE
      DATA(I)=DATI
C     TRANSLATE DATA FRØM WØRC
      DØ 198 J=1,NBEAMS
      I=I+1
      II=II+1
      IF=II+2
      LW=IF/3
      IP=IF-3*(LW)
      IBT=12*IP
      IDAT=0
      CALL FLD (IDAT,24,12,IBT,IDATA(LW))
      ZZI=AND(IMK(3),IDAT)
      IF (IZI .EQ. 0) GØ TØ 5C0
      IDAT=IDAT-NCØM
 50C  DATA(I)=IDAT
 198  CØNTINUE
      IF (II-I) 401,4C2,403
 402  IF (II .GE. NWDS) GØ TØ 404
```

```
      GØ TØ 110
403   IF (II .GE. NWDS) GØ TØ 405
      GØ TØ 110
401   IF (I .GE. NWDS) GØ TØ 406
      GØ TØ 110
404   NFLAG1=0
      GØ TØ 111
405   NFLAG1=-1
      GØ TØ 111
406   NFLAG1=1
      GØ TØ 111
111   CØNTINUE
      IF (NFLAG .EQ. 1) GØ TØ 999
      IF (NCAL) 130,120,129
120   CØNTINUE
      WRITE (6,1121)
      DØ 2010 IX=1,NBLK
      IY=IX*(NBEAMS+1)
      IZ=IY-NBEAMS
      WRITE (6,1112) (DATA(I),I=IZ,IY)
2010  CØNTINUE
      DØ 199 I=1,NBEAMS
      AVGMAX(J)=0.0
      AVGMIN(J)=0.0
199   CØNTINUE
      I=0
201   I=I+1
      DØ 200 J=1,NBEAMS
      I=I+1
      AVGMIN(J)=AVGMIN(J)+DATA(I)
200   CØNTINUE
      IF (I .GE. NWDS) GØ TØ 207
      GØ TØ 201
207   CØNTINUE
      DVISØR=NWDS/(NBEAMS+1)
      DØ 202 J=1,NBEAMS
      AVGMIN(J)=AVGMIN(J)/DVISØR
202   CØNTINUE
      NCAL=1
      I=0
      GØ TØ 1
129   CØNTINUE
      DØ 2011 IX=1,NBLK
      IY=IX*(NBEAMS+1)
      IZ=IY-NBEAMS
      WRITE (6,1112) (DATA(I),I=IZ,IY)
2011  CØNTINUE
      I=0
203   I=I+1
      DØ 204 J=1,NBEAMS
      I=I+1
      AVGMAX(J)=AVGMAX(J)+DATA(I)
204   CØNTINUE
      IF (I .GE. NWDS) GØ TØ 208
      GØ TØ 203
208   CØNTINUE
      DØ 205 J=1,NBEAMS
      AVGMAX(J)=AVGMAX(J)/DVISØR
205   CØNTINUE
      DØ 206 J=1,NBEAMS
      SLØPE(J)=(VALMAX(J)-VALMIN(J))/(AVGMAX(J)-AVGMIN(J))
```

```
      BIAS(J)=VALMAX(J)-AVGMAX(J)*SLØPE(J)
 206  CØNTINUE
      NCAL=-1
      I=1
      NCØUNT=-1
      DATI=-DATI
      NFLAG=1
      GØ TØ 1
 130  CØNTINUE
 999  RETURN
      END
```

```
$IBFTC DECK1B                                                          DECK0000
      SUBRØUTINE UNPAK
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKD,MVMEAN,
     2TIMSAM,NWDS,IFREQ,MSFC,NFILE,RMS(12),VMEAN(12)
C     READ ID IN BCD MØDE
      IERR=0
      CALL RECTPR (LTN,3,IERR,NW,53,SC)
C     SC(1) THRU SC(6+N) ARE ALPHNUMERIC FIELD DATA TØ BE
C     WRITTEN ØUT A FØRMATED
C     SC(6+N THRU SC(8+3N) ARE BCD TØ BE CØNVERTED TØ FLØATING PØINT
      N=19
      NN=53
      DØ 10 I=N,NN
      CALL TRNLAT(SC(I))
 10   CØNTINUE
      RETURN
      END
```

```
$IBFTC DECK1C                                                        DECK0000
      SUBROUTINE TRNLAT(SC)
      DIMENSION N(6),NTBL(14),NN(6)
      DATA NTBL(1)/001/
      DATA NTBL(2)/002/
      DATA NTBL(3)/003/
      DATA NTBL(4)/004/
      DATA NTBL(5)/005/
      DATA NTBL(6)/006/
      DATA NTBL(7)/007/
      DATA NTBL(8)/010/
      DATA NTBL(9)/011/
      DATA NTBL(10)/000/
      DATA NTBL(11)/060/
      DATA NTBL(12)/040/
      DATA NTBL(13)/020/
      DATA NTBL(14)/033/
      NFLAG=1
      DO 50 I=1,6
      NN(I)=0
      N(I)=0
 50   CONTINUE
      CALL FLD (N(1),30,6,30,SC)
      CALL FLD (N(2),30,6,24,SC)
      CALL FLD (N(3),30,6,18,SC)
      CALL FLD (N(4),30,6,12,SC)
      CALL FLD (N(5),30,6,6,SC)
      CALL FLD (N(6),30,6,0,SC)
      NSCL=0
      DO 100 J=1,6
      IF (N(J) .EQ. NTBL(14)) NSCL=J-1
      IF (N(J) .EQ. NTBL(12)) NFLAG=-NFLAG
 100  CONTINUE
      IF (NSCL .GT. 0) GO TO 200
      TSCL=1.0
      GO TO 201
 200  TSCL=10**NSCL
 201  CONTINUE
      JJ=1
      DO 110 J=1,6
      DO 109 K=1,9
      IF (N(J) .EQ. NTBL(K)) NN(JJ)=K
 109  CONTINUE
      IF (N(J) .EQ. NTBL(10)) NN(JJ)=0
      IF (N(J) .EQ. NTBL(11)) NN(JJ)=0
      IF (N(J) .EQ. NTBL(12)) NN(JJ)=0
      IF (N(J) .EQ. NTBL(13)) NN(JJ)=0
      IF (N(J) .EQ. NTBL(14)) JJ=JJ-1
      JJ=JJ+1
 110  CONTINUE
      NN(2)=NN(2)*10
      NN(3)=NN(3)*100
      NN(4)=NN(4)*1000
      NN(5)=NN(5)*10000
      NN(6)=NN(6)*100000
      NDUMMY=NN(1)+NN(2)+NN(3)+NN(4)+NN(5)+NN(6)
      SC=NDUMMY
      SC=(SC/TSCL)*FLOAT(NFLAG)
      RETURN
      END
```

```
$IBFTC DECK1D                                                          DECK000C
      SUBRØUTINE VMØVMN (DATA,ITEMP,TIMCØR,NDLSPN,INDEX,AVRAGE,
     1NWHICH,NØBEAM)
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKC,MVMEAN,
     2TIMSAM,NWDS,IFREC,MSFC,NFILE,RMS(12),VMEAN(12)
      DIMENSIØN NWHICH(1)
      DIMENSIØN SUM(12)
      DIMENSIØN DATA(1)
      LSPAN=NDLSPN*NWDS
      I=INDEX-1
  111 I=I+1
C     CALCULATE TIME
      DATA(I)=DATA(I)+TIMCØR
      M=I
      DØ 102 J=1,NBEAMS
      SUM(J)=0.0
  102 CØNTINUE
  103 M=M+1
      DØ 104 J=1,NØBEAM
      MM=M+NWHICH(J)-1
      JJ=NWHICH(J)
      SUM(JJ)=SUM(JJ)+DATA(MM)
  104 CØNTINUE
      M=M+NBEAMS
      IF (M .GE. LSPAN) GØ TØ 112
      GØ TØ 103
  112 CØNTINUE
      LSPAN=LSPAN+NBEAMS+1
      DØ 110 J=1,NØBEAM
      II=I+NWHICH(J)
      JJ=NWHICH(J)
      DATA(II)=SUM(JJ)/AVRAGE
  110 CØNTINUE
      I=I+NBEAMS
      IF (I .GE. ITEMP) GØ TØ 113
      GØ TØ 111
  113 CØNTINUE
      RETURN
      END
```

```
$IBFTC DECK1E                                                       DECK0000
      SUBRØUTINE TPMSFC (DATA,IERR,PLYBCK,NSTEP,NDEBUG)
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKD,MVMEAN,
     2TIMSAM,NWDS,IFREQ,MSEC,NFILE,RMS(12),VMEAN(12),NØRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NBLK,NSTART
      EQUIVALENCE (IZI,ZZI)
      DIMENSIØN DATA(1)
      DIMENSIØN IDATA(2700),IMK(3)
 1112 FØRMAT (1H I5)
 1113 FØRMAT (1H F10.5)
 1114 FØRMAT (1H02I4)
      DATA IRECFG/0/
      DATA IFLAG/0/
      DATA NCAL/0/
      DATA IMK/Ø200000000000,Ø2000000C,Ø2000/
      DATA ITIME1/0/
      DATA NCYL/0/
      DATA NCTR/0/
      DATA ISL/1/
      I=1
      IF (IRECFG) 114,15,1
 15   IF (IFLAG) 16,11,16
 11   IF (NFLSKC .EQ. 0) GØ TØ 1
      CALL SKFPIN (LTN,NFLSKC,RD)
      GØ TØ 1
 16   REWIND LTN
      IF (NFLSKD .EQ. 0) GØ TØ 1
      CALL SKFPIN(LTN,NFLSKD,RD)
      GØ TØ 1
 1    IERR=0
      NCØUNT=0
      CALL REDTPR (LTN,2,IERR,NW,2700,IDATA)
      II=1
      GØ TØ (5,3,4,5,3),IERR
 3    WRITE (6,10) RTIME
 10   FØRMAT (29H0END-ØF-FILE ØN INPUT TAPE AT,F12.5)
      IF (NCAL .GE. 1) GØ TØ 110
      GØ TØ 999
 4    WRITE (6,12)
 12   FØRMAT (42H0IRRECØVERABLE PARITY ERRØR ØN INPUT TAPE   )
      GØ TØ 1
 5    IFLAG=1
      IF (NW-2) 3,6,8
 6    CØNTINUE
C     UNPACK ID RECØRD
      NWD1=IDATA(1)
      NWD2=IDATA(2)
      NBEAMS=0
      NSCANS=0
      CALL  FLD (NBEAMS,24,12,0,NWD2)
      CALL  FLD (NSCANS,12,24,12,NWD2)
      NBEAMS=INTBCD(NBEAMS)
      NSCANS=INTBCD(NSCANS)
      NDWS1=NBEAMS*NSCANS
      NDWS=NBEAMS*NSCANS+NSCANS
      NSCALE=0
      CALL  FLD (NSCALE,30,6,24,NWD1)
      TIMSCL=10**NSCALE
      NCAL=0
      CALL  FLD (NCAL,30,6,30,NWD1)
```

```
      IF (NCAL .EQ. 0) NDATA=NWDS
      IF (NCAL .GE. 1) NDATA=NDWS
      IF (NDEBUG .EQ. 0) GØ TØ 2000
      WRITE (6,1112) NBEAMS,NSCANS,NDWS1,NDWS,NCAL,NWDS,IERR,NSCALE
 2000 CØNTINUE
C     READ DATA
      GØ TØ 1
 8    CØNTINUE
C     READ DATA WØRD AND PLACE IN DATA(I) ARRAY
      ITIME=0
C     TRANSLATE TIME
      CALL  FLD (ITIME,12,24,0,IDATA)
      IF (ITIME-ITIME1) 2010,2011,2011
 2010 NCTR=NCTR+1
      NCYL=1000000*NCTR
 2011 ITIME1=ITIME
      RTIME=ITIME+NCYL
      RTIME=(RTIME/TIMSCL)/PLYBCK
      IF (NDEBUG .EQ. 0) GØ TØ 2001
      WRITE (6,1113) RTIME
 2001 CØNTINUE
      RTIME=RTIME-TIMSAM
 114  RTIME=RTIME+TIMSAM
      IF (IRECFG) 17,18,17
 17   IF (RTIME .LT. START(ISL)) GØ TØ 200
      IF (RTIME .GT. STØP(ISL)) GØ TØ 201
      GØ TØ 18
 200  II=II+NBEAMS
      NCØUNT=NCØUNT+NBEAMS
      IF (NCØUNT .GE. NDWS1) GØ TØ 1
      GØ TØ 114
 201  IF (ISL .GE. NSTART) GØ TØ 202
      ISL=ISL+1
      GØ TØ 200
 202  IERR=2
      GØ TØ 999
 18   DATA(I)=RTIME
      I=I+1
      DØ 100 J=1,NBEAMS
      II=II+1
      LW=II/3+1
      IP=II-3*(LW-1)
      IBT=12*IP+2
      IDAT=0
      CALL FLD (IDAT,26,10,IBT,IDATA(LW))
      DATA(I)=IDAT
      IZI=AND(IMK(IP+1),IDATA(LW))
      IF (IZI .NE. 0) DATA(I)=-DATA(I)
      I=I+1
 100  CØNTINUE
      NCØUNT=NCØUNT+NBEAMS
      IF (I .GE. NDATA) GØ TØ 116
      IF (NCØUNT .GE. NDWS1) GØ TØ 1
      GØ TØ 114
 116  IF (NCØUNT .LT. NDWS1) GØ TØ 118
      IF (NCAL .GE. 1) GØ TØ 110
      IRECFG=1
      GØ TØ 110
 118  IF (NCAL .GE. 1) GØ TØ 110
      IRECFG=-1
 110  CØNTINUE
```

```
      IF (NCAL-1) 14,13,21
 13   CALL SINCAL (DATA,NDATA,NSTEP,IERR)
      GØ TØ (1,22,22,1,22),IERR
 21   CALL STPCAL (DATA,NDATA)
 22   IRECFG=1
      ITIME1=0
      NCTR=0
      NCYL=0
      I=1
      GØ TØ 15
 14   CØNTINUE
 999  RETURN
      END
```

```
$IBFTC DECK1F                                                    DECK0000
      FUNCTIØN INTBCD(NDUMMY)
      N1=0
      N2=0
      N3=0
      N4=0
      N5=0
      N6=0
      CALL  FLD (N1,30,6,30,NDUMMY)
      CALL  FLD (N2,30,6,24,NDUMMY)
      CALL  FLD (N3,30,6,18,NDUMMY)
      CALL  FLD (N4,30,6,12,NDUMMY)
      CALL  FLD (N5,30,6,6,NDUMMY)
      CALL  FLD (N6,30,6,0,NDUMMY)
      IF (N1 .EQ. 48) N1=0
      IF (N2 .EQ. 48) N2=0
      IF (N3 .EQ. 48) N3=0
      IF (N4 .EQ. 48) N4=0
      IF (N5 .EQ. 48) N5=0
      IF (N6 .EQ. 48) N6=0
      N2=N2*10
      N3=N3*100
      N4=N4*1000
      N5=N5*10000
      N6=N6*100000
      N=N1+N2+N3+N4+N5+N6
      INTBCD=N
      RETURN
      END
```

```
$IBFTC DECK1G                                                    DECK0000
      SUBRØUTINE SINCAL (DATA,NDATA,NSTEP,IERR)
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKE,MVMEAN,
     2TIMSAM,NWDS,IFREQ,MSEC,NFILE,RMS(12),VMEAN(12),NØRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NBLK,NSTART
      DIMENSIØN DATA(1)
      DIMENSIØN CØNST(12)
      DØUBLE PRECISIØN XMEAN(12)
      DØUBLE PRECISIØN SUM(12)
      DATA NTØTAL/0/
      DATA NFLAG/0/
      IF (NFLAG .GT. 0) GØ TØ 121
      DØ 122 IJ=1,12
      XMEAN(IJ)=0.0
      SUM(IJ)=0.0
  122 CØNTINUE
      NFLAG=1
  121 CØNTINUE
      GØ TØ (141,120,120,141,120),IERR
  141 CØNTINUE
      IF (NSTEP) 109,108,109
  108 FACTØR=1.414215
      FACTR1=2.0
      GØ TØ 110
  109 FACTØR=1.0
      FACTR1=1.0
  110 CØNTINUE
      I=0
  103 I=I+1
      DØ 104 J=1,NBEAMS
      I=I+1
      XMEAN(J)=XMEAN(J)+DATA(I)
      SUM(J)=SUM(J)+DATA(I)**2
  104 CØNTINUE
      NTØTAL=NTØTAL+1
      IF (I .GE. NDATA) GØ TØ 107
      GØ TØ 103
  107 CØNTINUE
      RETURN
  120 CØNTINUE
      TØTAL=NTØTAL
      DØ 105 J=1,NBEAMS
      CØNST(J)=(SUM(J)/TØTAL)-((XMEAN(J)/TØTAL)**2)
      CØNST(J)=SQRT(CØNST(J))*FACTØR
      SLØPE(J)=(VALMAX(J)-VALMIN(J))/(FACTR1*CØNST(J))
      BIAS(J)=(-SLØPE(J)*CØNST(J))+VALMAX(J)
      AVGMIN(J)=-CØNST(J)+BIAS(J)/SLØPE(J)
      AVGMAX(J)=CØNST(J)+BIAS(J)/SLØPE(J)
  105 CØNTINUE
      RETURN
      END
```

```
$IBFTC DECK1H                                                          DECK000C
      SUBRØUTINE STPCAL (DATA,NDATA)
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LIN,NBEAMS,NFLSKC,NFLSKD,MVMEAN,
     2TIMSAM,NWDS,IFREQ,MSEC,NFILE,RMS(12),VMEAN(12),NØRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NELK,NSTART
      DIMENSIØN DATA(1)
      DØ 10 J=1,NBEAMS
      AVGMIN(J)=0.0
      AVGMAX(J)=0.0
   10 CØNTINUE
      I=1
      NCØUNT=0
      NBAD=0
   11 I=I+1
      TEMP=DATA(I)
   17 II=I+NBEAMS+1
      NTEST=ABS(DATA(II)-TEMP)
      IF (NTEST .GT. 100) GØ TØ 15
      NCØUNT=NCØUNT+1
      DØ 30 J=1,NBEAMS
      AVGMIN(J)=AVGMIN(J)+DATA(I)
      I=I+1
   30 CØNTINUE
      GØ TØ 11
   15 NBAD=NBAD+1
      IF (NBAD .EQ. 10) GØ TØ 50
      I=I+NBEAMS+1
      GØ TØ 17
   50 CØNTINUE
      DIVIDE=NCØUNT
      DØ 60 J=1,NBEAMS
      AVGMIN(J)=AVGMIN(J)/DIVIDE
   60 CØNTINUE
      NCØUNT=0
      NBAD=0
      I=I-1
   12 I=I+1
      TEMP=DATA(I)
   18 II=I+NBEAMS+1
      NTEST=ABS(DATA(II)-TEMP)
      IF (NTEST .GT. 100) GØ TØ 16
      NCØUNT=NCØUNT+1
      DØ 31 J=1,NBEAMS
      AVGMAX(J)=AVGMAX(J)+DATA(I)
      I=I+1
   31 CØNTINUE
      IF (I .GE. NDATA) GØ TØ 51
      GØ TØ 12
   16 NBAD=NBAD+1
      IF (NBAD .EQ. 10) GØ TØ 51
      I=I+NBEAMS+1
      GØ TØ 18
   51 CØNTINUE
      DIVIDE=NCØUNT
      DØ 61 J=1,NBEAMS
      AVGMAX(J)=AVGMAX(J)/DIVIDE
   61 CØNTINUE
      DØ 62 J=1,NBEAMS
      SLØPE(J)=(VALMAX(J)-VALMIN(J))/(AVGMAX(J)-AVGMIN(J))
      BIAS(J)=VALMAX(J)-AVGMAX(J)*SLØPE(J)
```

```
 62    CØNTINUE
       RETURN
       END



$IBFTC DECK1I                                                                DECK0000
       SUBRØUTINE ØUT2(N,NBEAMS,BETIME,ENTIME,VALMIN,VALMAX,SLØPE,
      1                  XINTER,ENGMIN,ENGMAX)
       DIMENSIØN VALMIN(1),VALMAX(1),
      1          SLØPE(1),XINTER(1),ENGMIN(1),ENGMAX(1)
       WRITE(N,1020)
 1020 FØRMAT( //1H ,16(1H+),26HCALIBRATIØN IDENTIFICATIØN,55(1H+),/50H + FM 1020
     2CHANNEL+BEGIN RECØRD+END RECØRD+MINIMUM+MAXIMUM+,6X,11HCALIBRATIØN FM 1020
     3,6X,1H+,6X,11HENGINEERING,6X,1H+,/17H + NUMBER+   TIME,5X,7H+  TIM FM 1020
     4E,4X,65H+ VALUE + VALUE +   SLØPE    + INTERCEPT +  MINIMUM  +  MAX FM 1020
     5IMUM  +,/1H ,97(1H+))                                             FM 1020
       DØ 1 I=1,NBEAMS
 1     WRITE(N,1040) I,BETIME,ENTIME,VALMIN(I),VALMAX(I),
      1              SLØPE(I),XINTER(I),ENGMIN(I),ENGMAX(I)
 1040 FØRMAT(4H +  ,I2,7H    +   ,A6,6H   +  ,A6,2H  ,2(1H+,F7.1),
     14(1H+,F11.5)
     2,1H+)                                                            FM 1040
       WRITE(N,1060)
 1060 FØRMAT(1H ,97(1H+))                                              FM 1060
       RETURN
       END



$IBFTC DECK1J                                                                DECK0000
       SUBRØUTINE ØUT3(N,NBEAMS,SAMRTE,SSARED,IADRED,IMØVMN,ICDIFF
      1                  ,CHANVR,BETIME,ENTIME,NWHICH,NØBEAM)
       DIMENSIØN CHANVR(1),NWHICH(1)
       DIMENSIØN MVMEAN(12),NCENDF(12)
       WRITE(N,1080)
 1080 FØRMAT( //1H ,15(1H+),36HMØDIFICATIØN ØF ØRIGINAL TIME SERIES,31(1 FM 1080
     2H+),/83H +CHANNEL+SAMPLING+ØRIGINAL +ADDITIØNAL+MØVING+  CENTRAL + FM 1080
     3CHANNEL + BEGIN + END   +,/83H + NUMBER+  RATE  +  SAMPLE +   SAMP FM 1080
     4LE + MEAN +DIFFERENCE+VARIABLE+RECØRD +RECØRD +,/2H +,16X,22H+REDU FM 1080
     5CTIØN+ REDUCTIØN+,6X,1H+,10X,1H+,8X,17H+ TIME  + TIME  +,/1H ,82(1 FM 1080
     6H+))                                                              FM 1080
       DØ 2 I=1,NBEAMS
       NCENDF(I)=0
 2     MVMEAN(I)=0
       DØ 3 I=1,NØBEAM
       J=NWHICH(I)
       NCENDF(J)=-ICDIFF
 3     MVMEAN(J)=-IMØVMN
       DØ 1 I=1,NBEAMS
 1     WRITE(N,1100)  I,SAMRTE,SSARED,IADRED,MVMEAN(I),
      2              NCENDF(I),
      1              CHANVR(I),BETIME,ENTIME
 1100 FØRMAT(4H +  ,I2,4H   +,F8.2,2H+ ,F8.2,3H+  ,I6,3H  +,I6,3H+
     2,I6,5H  +  ,A6,2H+ ,A6,2H+ ,A6,1H+)
       WRITE(N,1120)
 1120 FØRMAT(1H ,82(1H+))                                              FM 1120
       RETURN
       END
```

```
$ØRIGIN         ALPHA,SYSUT2,REW
$IBFTC LINK22  LIST,NØDC,DECK
      SUBRØUTINE LINK2(KRUN,SF?I)
C
C      LINK2 -CØRRELATIØN LINK -
C
C        ALL BASIC SUMS AND CØRRELATIØNS ARE PERFØRMED
C        IN THIS LINK
C
C        REGIØNS FØR  CHANNEL ASSIGNMENTS
C
      INTEGER VELLAG
      DIMENSIØN NCHID(12),NEWID(12),NCTBL(12, 6),NCRPC(12)
     1,NACR(13),NCD(12)
      DIMENSIØN XASTRK(12)
      DIMENSIØN VLAG(1)
      DIMENSIØN SEPART(12)
C
C        TEMPØRARY STØRAGE
C
      DIMENSIØN U(12500),IU(12500),TEMP(512),TLAG(1)
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VALMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKC,MVMEAN,
     2TIMSAM,NWDS,IFREC,MSFC,NFILE,RMS(12),VMEAN(12),NØRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NBLK,NSTART,
     3CØMTIM
      LØGICAL CØVAR
      DIMENSIØN CØM(1)
      EQUIVALENCE (START(1),CØM(1))
      EQUIVALENCE (U,IU)
      EQUIVALENCE (TLAG,U)
      EQUIVALENCE (U,VLAG)
      EQUIVALENCE(TIMSAM,ESMPP)
C
 9000 FØRMAT (1H 12I6)
 9001 FØRMAT (1H 10F10.6)
      NUMCØM=175
      NBEAM=12
C        SYSTEM  PARAMETERS
C
C      NAME         DESCRIPTIØN                     TYPE  DIMENSIØN
C
C      MAXSTR - MAXIMUM STØRAGE ØF DATA PØØL      I
C      MAXCHN - MAXIMUM NUMBER  ØF CHANNELS       I
C
C      MAXCR  - MAXIMUM CØRRELATIØNS PER CHANNEL I
C
C
C
      MAXSTR=12500
      MAXCHN=12
      MAXCR = 6
C
C               INTERMEDIATE TAPE
      IRT=11
      IDAT=10
      NFLAG=0
      NBLK=30
      NWPR=NBEAMS+1
C
C          PRØBLEM PARAMETERS
```

```
C
C      NAME          DESCRIPTIØN                           TYPE     DIMENSIØN
C
C
C
       NAMELIST/CVARNC/CØVAR
       NAMELIST /TIMES/ START ,STØP,  DELTAT,IPRINT
       NAMELIST /DELAY/ TAUMIN,TAUMAX,DELTAU,VELLAC,SEPART
       READ (IDAT) (CØM(I),I=1,NUMCØM)
       ESMPP=ESMPP*FLØAT(IFREQ)
       STØP(NSTART)=SPØT
       READ (5,CVARNC)
       IF (CØVAR) GØ TØ 180
       GØ TØ 1
  180  NFLAG=1
     1 READ(5,TIMES)
        WRITE(6,TIMES)
       READ(5,DELAY)
       WRITE(6,DELAY)
       WRITE(IRT) (CØM(I),I=1,NUMCØM)
C
C      DETERMINE  TIME LAGS
C
       NLAGS=(TAUMAX-TAUMIN)/DELTAU +.5
       NBETA=DELTAU/ESMPP +.5
       NTLAGS=2*NLAGS+1
       NT=NLAGS+1
       IIT=NLAGS+1
       MMIT=NLAGS+1
       TLAG(IIT)=TAUMIN
       DØ 2 I=2,NT
       IT=IIT+I-1
       MIT=MMIT-I+1
       FI=I-1
       TLAG(IT)=TAUMIN+FI*DELTAU
  2    TLAG(MIT)=-TLAG(IT)
C
C          DETERMINE   CØNSTANTS FØR STØRAGE
C
       MAXINC=TAUMAX/ESMPP+.5
       MSUB=DELTAT/ESMPP+.5
C
C
C          DETERMINE  STØRAGE REQUIREMENTS
C        AND SET INDEX NUMBERS
       CALL ASSIGN(NBEAM ,MAXCR,TEMP,NCHID,NEWID,NCTBL,NCRPC,NACR
      1,NCH,ND,NU,NAUTØ,NCRT,NCD)
       CALL CHØLT(ND,NCHID,NCRPC,NCTBL,NBEAM ,MAXCR,NCD)
  94   IF (VELLAC) 92,91,92
  91   MISC1=1
       MISC2=1
       GØ TØ 3
  92   MISC1=NCRT+1
       MISC2=MISC1
  3    MISC=2*MISC1*NLAGS+MISC2
       KP=MISC+9*NCH+NCRT*(NTLAGS+1)
       NUMSP=MAXSTR-KP
C        CHECK STØRAGE
C
       MAXCIN=MAXINC*NCH
       NPT=(NUMSP-MAXINC*NCH)/(MSUB*NCH)
```

```
      IF(NPT.GE.1) GØ TØ 8
      CALL ERRØR( 1,24H STØRAGE EXCEEDED           KP,NUMSP)
      ND=NC-1
      IF(NC.LT.1) GØ TØ 7
      NCRT=NACR(ND+1)
      GØ TØ 94
    7 CALL ERRØR( 1,24H NØT SPECIFIED CØRRECTLY,NCRT,KP)
      CALL EXIT
    8 CØNTINUE
      CALL CHØLT(ND,NCHID,NCRPC,NCTBL,NBEAM,MAXCR,NCD)
C     WRITE(IRT) NCH,ND,NU,NAUT2,NCRT,NCHID,NEWIC,NCTBL,NCRPC,NACR
C
C     DETERMINE VELØCITY LAGS
C
      IF (VELLAG) 93,86,93
 93   CØNTINUE
      IIV=2*NLAGS
      DØ 85 JJ=1,NCRT
      IVV=IIV+2*(NLAGS)*(JJ-1)+JJ
      DØ 84 I=1,NTLAGS
      IV=IVV+I
      IF (I-NLAGS-1) 81,82,81
 82   VLAG(IV)=20.0
      GØ TØ 84
 81   VLAG(IV)=SEPART(JJ)/TLAG(I)
 84   CØNTINUE
 85   CØNTINUE
 86   CØNTINUE
C
      WRITE (IRT) NCH,NC,NU,NAUTØ,NCRT,NCHID,NEWIC,NCTBL,NCRPC,NACR,NCD
      WRITE (IRT) DELTAT,TAUMIN,TAUMAX,DELTAU,NLAGS,NTLAGS,VELLAG
      WRITE (IRT) (U(I),I=1,MISC)
C         INITIALIZE FØR LØØP
      IPR=I
      IP=1
      KS=KP
      KESM=MISC+1
      KEAM=KESM+NCH
      KEASM=KEAM+NCH
      KASM=KEASM+NCH
      KMA=KASM+NCH
      KRA=KMA+NCH
      KPSM=KRA+NCH
      KMP=KPSM+NCH
      KRP=KMP+NCH
      KTP=KRP+NCH
C       CLEAR AREA
      NST=MISC+1
      DØ 30 I=NST,KS
   30 U(I)=0.0
C
      KK=KS+1
C         MAIN LØØP
C
C         SET NUMBER ØF PIECES
C
 60   TP=STØP(IP)-START(IP)
      KNP=1
      NF =TP/DELTAT +.5
      NUMST=TP/ESMPP +.5
C
```

```
C          CHECK SPECIFICATIØNS
C
      NDIF =NUMST-NF*MSUB
      IF(NDIF) 10,11,12
   10 CALL ERRØR( 1,24H TIME SPAN AND PIECE ØFF ,NUMST,NDIF)
      NUMST=(NF-1)*MSUB
      GØ TØ 11
   12 CALL ERRØR( 1,24H TIME SPAN .GTR. PIECES  ,NUMST,NDIF)
      NUMST=NF*MSUB
   11 CØNTINUE
      NTØT=(STØP(IP)-START(IP))/ESMPP+.5
      KD=KK
      NPP=NPT
      NF=(NTØT-MAXINC)/MSUB
      IF(NF.LT.NPP) NPP=NF
      NUMS=NPP*MSUB+MAXINC
      IF (NF .GE. 1) GØ TØ 20
      WRITE (6,9002) NF,NUMS,SPØT
 9002 FØRMAT (36H INSUFFICENT DATA IN TIME INTERVAL.   ,2I6,F10.5)
      GØ TØ 25
 20   CALL READR(U(KD),NUMS,NCH,NCHID,INC,IDAT,NBLK,NWPR,TEMP,START(IP),
     1 TEND)
      KPP=1
   21 CØNTINUE
      CALL ACCPC(U(KMP),U(KRP),U(KPSM),U(KK),MSUB,NCH)
      IF (NFLAG) 181,181,182
 182  CALL REMØVE (U(KMP),U(KK),MSUB,NCH)
 181  CØNTINUE
      DØ 17 J=1,ND
      L=NCD(J)
      NT=NCRPC(J)
      DØ 170 K=1,NT
      KR=KTP+(K-1+NACR(J))*(NTLAGS+1)
      NCU=NCTBL(J,K)
      CALL CØRLAT(U(KK),U(KK),NLAGS,TLAG(NLAGS+1),ESMPP,L,NCU,NCH,MSUB,
     1U(KR))
      WRITE (6,9000) KP,MISC,KK,KR,NT,J,NCRPC(J)
      WRITE (6,9001) U(KR)
      IA=KR+NTLAGS
      DØ 50 I=1,NTLAGS
       II=KR+I-1
   50 U(IA)=U(IA)+U(II)
      U(IA)=U(IA)/FLØAT(NTLAGS)
      IF (L .NE. NCU) GØ TØ 185
      CALL XKRAUS (U(KMP),U(KRP),U(KPSM),U(IA),J,XASTRK,NCH)
 185  CØNTINUE
 170  CØNTINUE
   17 CØNTINUE
C          ACCUMULATE PIECES
      NT=3*NCH
      CALL PCRC1 (U(KASM),U(KFSM),NT,KNP)
      IF(KNP.EQ. 1) GØ TØ 71
      CALL STØER1 (U(KESM),U(KASM),U(KPSM),NT,KNP)
   71 CØNTINUE
C
C       TEST FØR ØUTPUT
C
       IF(IPRINT.EQ. 0) GØ TØ 40
      IF (IPR-IPRINT) 31,183,183
 183  IPR=0
      TIM=FLØAT(KNP*MSUB)*ESMPP
```

```
      PCELNG=FLØAT(MSUB)*ESMPF
      CALL ØUT1(6,EXPNØ,SC(2),SC(1),NØPAGE,SC(3),SC(4),NØRUN)
      CALL ØUT5  (6,NCH,KNP,KNP,START(1),TIM,PCELNG,NCHIC,U(KMP),
     1U(KRP),U(KMA),U(KEAM),U(KRA),U(KEASM))
      CALL ØUT5A (6,NCH,KNP,KNP,START(1),TIM,PCELNG,NCHIC,XASTRK,
     1U(KPSM),U(KMA),U(KEAM),U(KASM),U(KESM))
      CALL ØUT1(6,EXPNØ,SC(2),SC(1),NØPAGE,SC(3),SC(4),NØRUN)
      NNN=2*(NLAGS+1)
      DØ 32 J=1,ND
      NT=NCRPC(J)
      DØ 132 K=1,NT
      NCU=NCTBL(J,K)
      KM=(K-1+NACR(J))*(NTLAGS+1)
      KR=KTP+KM
      KAA=KR
      KLA=KR+NTLAGS
      AREA=U(KLA)
      NN=NCD(J)
      N=NCHID(NN)
      NUP=NCHIC(NCU)
      CALL ØU6A(6,NLAGS,KNP,KNP,AREA,AREA,START(1),TIM,N,NUP,PCELNG,TLAG
     1,VLAG(NNN),U(KR),VELLAG)
      NNN=NNN+2*NLAGS+1
C     WRITE (6,9000) J,NT,KM,KR,KLA
C     WRITE (6,9001) U(KR)
  132 CØNTINUE
   32 CØNTINUE
   31 IPR=IPR+1
   40 CØNTINUE
      WRITE (IRT) KNP,(U(NN),NN=KESM,KS)
C
C      TEST FØR END
C
      IF(KNP.EQ.NF) GØ TØ 25
      KNP=KNP+1
      IF(KPP.GE.NPP) GØ TØ 23
      KPP=KPP+1
      KK=KK+MSUB*NCH
      GØ TØ 21
   23 NR =NF-KNP+1
      IF(NR.LT.NPT) NPP=NR
      NXX1=MSUB*NCH
      DØ 24 I=1,MAXCIN
      KI=KK+NXX1+I-1
      KX=KS+I
   24 U(KX)=U(KI)
      KD=KS+1+MAXCIN
      NUMS=NPP*MSUB
      KK=KS+1
      GØ TØ 20
   25 CØNTINUE
      IF(IP.GE.NSTART) GØ TØ 100
      IP=IP+1
      GØ TØ 60
  100 REWIND ICAT
      END FILE IRT
      REWIND IRT
      RETURN
      END
```

```
$IBFTC DECK2A                                                          DECK0000
      SUBROUTINE ASSIGN(NBEAMS,MAXCR,K,NCHID,NEWID,NCTBL,NCRPC,NACR,
     1 NCH,ND,NU,NAUTØ,NCRT,NCD)
C         SUBRØUTINE READS IN CØRRELATIØN SPECIFICATIØNS
C                   J,K1,K2,ETC
C         FØRMS  TABLES AND REASSIGNS CHANNEL NUMBERS
C         FØR INTERNAL USE.
C         WRITTEN BY  A. WACHØWSKI
C INPUT
C     NAME          DESCRIPTIØN                      TYPE  DIMENSIØN
C     NBEAMS= MAX. NØ. ØF CHANNELS                     I
C     MAXCR = MAX. NØ. ØF CØRRELATIØNS/CHANNEL         I
C     K     = TEMP STØRAGE                             I      (NBEAMS)
C ØUTPUT
C     NCHID = ØLD CHANNEL NUMBERS IN NEW ØRDER         I      (NBEAMS)
C     NEWID = NEW CHANNEL NUMBERS IN ØLD ØRDER         I      (NBEAMS)
C     NCTBL = CØRRELATIØN TABLE                        I      (NBEAMS,MAXCR)
C     NCRPC = NØ. CØRR. PER CHANNEL                    I      (NBEAMS)
C     NACR  = ACCUM. NØ. ØF CØRR.                      I      (NBEAMS)
C     NCH   = NØ. ØF CHANNELS USED                     I
C     ND    = NØ. ØF DELAYED CHANNELS                  I
C     NU    = NØ. ØF UNDELAYED CHANNELS                I
C     NAUTØ = NØ. ØF AUTØ CØRRELATIØNS                 I
C     NCRT  = TØTAL NØ ØF CØRRELATIØNS                 I
      DIMENSIØN  K(6)     ,NCTBL(NBEAMS,MAXCR),NCHID(NBEAMS)
     1,NEWID(NBEAMS),NCRPC(NBEAMS),NACR(NBEAMS),NCD(NBEAMS)
      NAMELIST/CØRR/ J,K
C     INITIALIZE
      NCH=0
      NAUTØ=0
      DØ 1 I=1,NBEAMS
      NCHID(I)=0
      NEWID(I)=0
      NCRPC(I)=0
      NACR (I)=0
      NCD(I)=0
      DØ 1 L=1,MAXCR
      NCTBL(I,L)=0
    1 CØNTINUE
    2 READ(5,CØRR)
      WRITE (6,CØRR)
      IF(J.EQ.0) GØ TØ 10
      IF(NCH.NE.0) GØ TØ 17
      NCHID(1)=J
      NCH=1
 17   DØ 6 I=1,NCH
      IF(NCHID(I).EQ.J) GØ TØ 7
    6 CØNTINUE
      NCH=NCH+1
      NCHID(NCH)=J
    7 CØNTINUE
      DØ 5 L=1,MAXCR
      IF(K(L).EQ.0) GØ TØ 15
    5 CØNTINUE
      LM=MAXCR
      GØ TØ 20
   15 LM=L-1
   20 CØNTINUE
      DØ 3 M=1,LM
      KT=K(M)
      IF(KT.EQ.J) NAUTØ=NAUTØ+1
```

```
      DØ 4 L=1,NCH
      IF(KT.EQ.NCHID(L)) GØ TØ 3
    4 CØNTINUE
      NCH=NCH+1
      NCHID(NCH)=KT
    3 CØNTINUE
      CALL SØRT(K,LM,1,1)
      II=1
      DØ 9 L=1,LM
      IF(K(L).NE.K(L+1)) GØ TØ 8
      CALL ERRØR(1,24H  DUPLICATE CHANNELS K,J,K(L))
      LM=LM-1
      GØ TØ 9
    8 NCTBL(J,II)=K(L)
      II=II+1
    9 CØNTINUE
      NCRPC(J)=LM
      GØ TØ 2
   10 CALL SØRT(NCHID,NCH,1,1)
      DØ 11 I=1,NCH
      KT=NCHID(I)
   11 NEWID(KT)=I
      N=1
      DØ 12 I=1,NBEAMS
      LM=NCRPC(I)
      IF(LM.EQ.0) GØ TØ 12
      NCD(N)=NEWID(I)
      DØ 13 L=1,LM
      NC=NCTBL(I,L)
   13 NCTBL(N,L)=NEWID(NC)
      NCRPC(N)=LM
      N=N+1
   12 CØNTINUE
      ND=N-1
      NU=NCH-ND
      DØ 14 I=1,ND
   14 NACR(I+1)=NACR(I)+NCRPC(I)
      NCRT=NACR(ND+1)
      RETURN
      END
```

```
$IBFTC DECK2B                                                              DECK0000
      SUBRØUTINE SØRT(IARRAY,N1,N2,N3)                                     SØRT0010
      DIMENSIØN IARRAY(1)                                                  SØRT0020
      LØGICAL CHECK                                                        SØRT0030
      M=(N1-1)*N2                                                          SØRT0040
      M1=2*N2                                                              SØRT0050
    1 CHECK=.FALSE.                                                        SØRT0060
      DØ 2 I=1,2                                                           SØRT0070
      I1=(I-1)*N2+N3                                                       SØRT0080
      IF(I1.GT.M) GØTØ 2                                                   SØRT0081
      DØ 4 J=I1,M,M1                                                       SØRT0090
      J1=J+N2                                                              SØRT0100
      IF(IARRAY(J).LE.IARRAY(J1)) GØ TØ 4                                  SØRT0110
      DØ 3 K=1,N2                                                          SØRT0120
      J2=J-N3+K                                                            SØRT0130
      J3=J2+N2                                                             SØRT0140
      ITEMP=IARRAY(J2)                                                     SØRT0150
      IARRAY(J2)=IARRAY(J3)                                                SØRT0160
    3 IARRAY(J3)=ITEMP                                                     SØRT0170
      CHECK=.TRUE.                                                         SØRT0180
    4 CØNTINUE                                                             SØRT0181
    2 CØNTINUE                                                             SØRT0190
      IF(CHECK) GØ TØ 1                                                    SØRT0200
      RETURN                                                               SØRT0210
      END                                                                  SØRT0220
```

```
$IBFTC DECK2C                                                             DECK0000
      SUBROUTINE ERROR(ITYPE,MESS,ID1,ID2)
C
C       PRINTS ALL ERROR MESSAGES
C
C         WRITTEN BY  A. WACHOWSKI
C     NAME         DESCRIPTION                         TYPE  DIMENSION
C
C     ITYPE  = PRINT OPTION                            I
C     MESS   = ERROR MESSAGE                           I      (NUM)
C
C     ID1    = INFORMATION  ON MESSAGE
C     ID2    =
C
C
      DIMENSION MESS(4)
      EQUIVALENCE (IDX,FD1),(IDY,FD2)
      NUM=4
      IDX=ID1
      IDY=ID2
      IF(ITYPE.NE.0) GO TO 1
C     INITIALIZE CONSTANT INFORMATION FOR SPECIAL
C     FORMATS
      RETURN
    1 IF(ITYPE.NE.1) GO TO 2
      WRITE(6,11)(MESS(I),I=1,NUM),ID1,ID2
   11 FORMAT(4A6,2I5)
      RETURN
    2 IF(ITYPE.NE.2) GO TO 3
      WRITE(6,12)(MESS(I),I=1,NUM),FD1,FD2
   12 FORMAT(4A6,2E14.7)
      RETURN
    3 IF(ITYPE.NE.3) GO TO 4
C
C     OPEN
C
      RETURN
    4 CONTINUE
      RETURN
      END
```

```
$IBFTC DECK2D
      SUBRØUTINE ACCPC(S,S2,S3,DATA,N,NC)
C
C     ACCUMULATE SUM AND SUM ØF SQUARES
C        WRITTEN BY  A. WACHØWSKI
C
      DIMENSIØN S(NC),S2(NC),DATA(NC,N)
      DIMENSIØN S3(NC)
      XN=N
      DØ 1 L=1,NC
      S(L)=0.0
    1 S2(L)=0.0
C
      DØ 3 J=1,NC
      DØ 2 I=1,N
      S(J)=S(J)+DATA(J,I)
    2 S2(J)=S2(J)+DATA(J,I)*DATA(J,I)
      S(J)=S(J)/XN
      S2(J)=(S2(J)/XN)
      S3(J)=S2(J)-S(J)**2
 3    CØNTINUE
C
 4    RETURN
      END
```

```
$IBFTC DECK2E                                                           DECK0000
      SUBRØUTINE CHØUT(ND,NCHID,NCRPC,NCTBL,NBEAMS,MAXCR,NCD)
C
C        ØUTPUT RØUTINE FØR INTERNAL CHANNEL
C      ASSIGNMENTS.
C        WRITTEN BY  A. WACHØWSKI
C
      DIMENSIØN NCHID(NC),NCRPC(ND),NCTBL(NBEAMS,MAXCR),NCD(NC)
      WRITE(6,1)
    1 FØRMAT(1H1,10X,20H CHANNEL ASSIGNMENTS / 11X,3HNEW,4X,3HØLD,4X,
     1 6HNØ. ØF,5X,9HUNDELAYED/12X,2HID,5X,2HID,4X,5HCØRR.,6X,8HCHANNELS
     2/)
      DØ 2 I=1,NC
      KN=NCRPC(I)
      N=NCD(I)
      KC=NCHID(N)
      WRITE(6,3) I,KC,KN,(NCTBL(I,J),J=1,KN)
    3 FØRMAT(12X,I2,5X,I2,6X,I2,5X,12(I2,2X))
    2 CØNTINUE
      RETURN
      END
```

```
$IBFTC DECK2F                                                                    DECK0000
      SUBRØUTINE CØRLAT(X,Y,NLAGS,TLAG,ESMPP,NCD,NCU,NCH,MSUB,R)
C   NAME      DESCRIPTIØN                                  TYPE DIMENSIØN
C         PIECEWISE CØRRELATIØN
C          WRITTEN BY   A. WACHØWSKI
C
C
C   X       -ARRAY FØR UNDELAYED CHANNELS                     R   X(NCH,MSUB)
C   Y       -ARRAY FØR DELAYED CHANNELS                       R   Y(NCH,MSUB)
C   NLAGS   -NUMBER ØF LAGS                                   I
C   TLAG    -TIME LAG ARRAY                                   R   TLAG(NLAGS+1)
C   ESMPP   -EFFECTIVE SAMPLING PERIØD                        R
C   NCD     -DELAYED CHANNEL                                  I
C   NCU     -UNDELAYED CHANNEL                                I
C   NCH     -NUMBER ØF CHANNELS                               I
C   MSUB    -NUMBER ØF SAMPLES                                I
C   R       -CØRRELATIØN ARRAY                                R
C
      DIMENSIØN   X(NCH,MSUB),Y(NCH,MSUB),TLAG(NLAGS),R(1)
      NTL=NLAGS+1
      XMSUB=MSUB
      DØ 2 L=1,NTL
      K1=NLAGS+L
      R(K1)=0.0
      K2=NLAGS-L+2
      R(K2)=0.0
      II=TLAG(L)/ESMPP+.5
      DØ 1 I=1,MSUB
      IM=II+I
      R(K1)=R(K1)+X(NCD,I)*Y(NCU,IM)
      IF(L .EQ. 1) GØ TØ 1
      R(K2)=R(K2)+X(NCD,IM)*Y(NCU,I)
    1 CØNTINUE
      R(K1)=R(K1)/XMSUB
      IF(L .EQ. 1) GØ TØ 2
      R(K2)=R(K2)/XMSUB
 2    CØNTINUE
      RETURN
      END
```

```
$IBFTC DECK2G                                                        DECK0000
      SUBRØUTINE READR(U,N,NCH,NCHID,IND,IDAT,NBLK,NWPR,TEMP,START
     1 TEND)
C
C           SUBRØUTINE TØ REAC A BLØCKED CATA TAPE ANC SUPPLY
C           SELECTED CHANNELS TØ A SCRIAL CATA ARRAY U.
C         WRITTEN BY   A. WACHØWSKI
C
C     NAME           DESCRIPTIØN                               TYPE  DIM.
C
C     U      - DATA ARRAY                                       R     (N)
C     N      - NUMBER ØF DATA SAMPLES REQUESTED                 I
C     NCH    - NUMBER ØF SELECTED CHANNELS                      I
C     NCHID  - ARRAY ØF CHANNEL NUMBERS                         -     (NCH)
C     IND    - INDEX ØF SAMPLE IN TEMP                          I
C     IDAT   - DATA TAPE NO.                                    I
C     NBLK   - NUMBER ØF RECØRCS PER BLØCK                      I
C     NWPR   - NUMBER ØF WØRDS PER RECØRD                       I
C     TEMP   - BUFFER TØ HØLD BLØCKED RECØRDS                   V     (1)
C
C
      DIMENSIØN TEMP(1),NCHIC(NCH),U(1)
      DATA INIT/1/
      IF(INIT.EQ.0) GØ TØ 1
      IND=0
      INIT=0
      NWPB=NBLK*NWPR
    1 KP=0
 11   IF(INC.NE.0) GØ TØ 8
      READ(ICAT) (TEMP(I),I=1,NWPB)
C
C     TEST FØR END ØF DATA
C
    8 KT=INC*NWPR
      IF(TEMP(KT+1).LT.START) GØ TØ 10
      DØ 7 I=1,NCH
      KC=NCHIC(I)
      KB=KT+KC+1
      KS=KP+I
      U(KS)=TEMP(KB)
    7 TENC=TEMP(KT+1)
      KP=KP+NCH
   10 IND=IND+1
      IF(INC.GE.NBLK) IND=0
      NI=KP/NCH
      IF (NI .LT. N) GØ TØ 11
      IF (IND .GE. NBLK) INIT=1
      RETURN
      END
```

```
$IBFTC DECK2K                                                         DECK0000
      SUBRØUTINE PCRC1(A,X,N,NP)
C
C        THIS SUBRØUTINE PERFØRMS THE PIECEWISE
C     RECURSIØN FØRMULA FØR ACCUMULATIVE AVERAGES
C         A(N+1)=(A(N)*N+X(N+1))/(N+1)
C
      DIMENSIØN A(1),X(1)
      XKNP=NP
      XKNP1=NP-1
      DØ 1 I=1,N
    1 A(I)=(A(I)*XKNP1+X(I))/XKNP
      RETURN
      END
```

```
$IBFTC DECK2L                                                         DECK0000
      SUBRØUTINE STDER1 (E,A,P,N,NP)
C
C        THIS SUBRØUTINE PERFØRMS THE RECURSIØN FØRMULA
C     FØR THE STANDARD ERRØR ØF THE ACCUMULATIVE AVERAGES
C
C        E(N+1)=E(N)*(N-1)/N+((A(N+1)-P(N+1)-P(N+1))**2)*(N+1)/N**2)
C
      DIMENSIØN E(1),A(1),P(1)
      IF(NP.EQ.1) GØ TØ 2
      XNP=NP-1
      XNPM1=NP-2
      XNPP1=NP
      DØ 1 I=1,N
    1 E(I)=E(I)*XNPM1/XNP+((A(I)-P(I))**2)*XNPP1/XNP**2
    2 RETURN
      END
```

```
$IBFTC DECK2M  LIST,NØDC,DECK
      SUBRØUTINE REMØVE (S,DATA,N,NC)
      DIMENSIØN S(NC),DATA(NC,N)
      DØ 4 J=1,NC
      DØ 5 I=1,N
 5    DATA(J,I)=DATA(J,I)-S(J)
 4    CØNTINUE
      RETURN
      END
```

```
$IBFTC DCTRNC   LIST,NØDD,DECK
      SUBRØUTINE XKRAUS (S,S2,S3,RXX,J,XASTRK,NC)
      DIMENSIØN S(NC),S2(NC),S3(NC),XASTRK(1)
      ASTRIC=RXX-S(J)**2
      XASTRK(J)=SQRT(ABS(ASTRIC))
      IF (ASTRIC .GE. 0.0) GØ TØ 9
      XASTRK(J)=-XASTRK(J)
    9 CØNTINUE
      S3(J)=ABS(S2(J)-RXX)
      RETURN
      END
```

```
$IBFTC DECK2H  LIST,NØDD,DECK                                                DECK0000
      SUBRØUTINE ØUT5(N,NCH,NØPCE,NØACC,ACCST,ACCTME,PCELNG,NØCHAN,
     1                PMNVAL,PRMS,AMNVAL,STERR1,ARMS,STERR2)
      DIMENSIØN NØCHAN(1),PMNVAL(1),PRMS(1),AMNVAL(1),STERR1(1),ARMS(1),
     1          STERR2(1)
      WRITE(N,1200) NØPCE,NØACC,ACCST,ACCTME,PCELAG
 1200 FØRMAT(1H ,43(1H+),29HAVERAGES WITH ZERØ TIME DELAY,44(1H+),/2H +, FM 12CC
     27X,13HPIECE NUMBER=,I5,4H   +,7X,6(1H+,12X),1H+,/22H +ACCUMULATIØN FM 1200
     3 NUMBER=,I5,4H   +,7X,40H+  PIECEWISE + PIECEWISE  +ACCUMULATIVE+, FM 1200
     412H    MEAN    ,26H+ACCUMULATIVE+MEAN-SQUARED, 1H+,/22H +ACCUMULAT
     4IØN  START=,F8.2,87H+CHANNEL+ MEAN VALUE + RØØT-MEAN  + MEAN VALUE
     5 +  STANDARD  + RØØT  MEAN +  STANDARD  +,/22H +ACCUMULATIØN   TIM
     6E=,F8.2,9H+ NUMBER+,12X,
     714H+SQUARE-VALUE+,12X,9H+   ERRØR,4X,22H+SQUARE VALUE+   ERRØR,
     84X,1H+,/2H +,7X,13HPIECE LENGTH=,F8.2,1H+,7X,6(1H+,12X),1H+,/1H ,1 FM 12CC
     916(1H+))                                                          FM 1200
      XKNP=NØPCE
      DØ 1 I=1,NCH
      DUM1=SQRT(PRMS(I))
      DUM2=SQRT(STERR1(I)/XKNP)
      DUM3=SQRT(ARMS(I))
      DUM4=SQRT(STERR2(I)/XKNP)
 1    WRITE(N,1220) NØCHAN(I),PMNVAL(I),DUM1,   AMNVAL(I),DUM2,
     1            DUM3,DUM4
 1220 FØRMAT(2H +,28X,3H+  ,I2,4H   +,6(F12.8,1H+))                      FM 1220
      WRITE(N,1230)
 1230 FØRMAT(1X,116(1H+))
      RETURN
      END
```

```
$IBFTC DECK2J . LIST,NØDC,DECK                                          DECK0000
      SUBRØUTINE ØUT5A(N,NCH,NØPCE,NØACC,ACCST,ACCTME,PCELNG,NØCHAN,
     1                 PMNVAL,PRMS,AMNVAL,STERR1,ARMS,STERR2)
      DIMENSIØN NØCHAN(1),PMNVAL(1),PRMS(1),AMNVAL(1),STERR1(1),ARMS(1),
     1          STERR2(1)
      WRITE(N,1200) NØPCE,NØACC,ACCST,ACCTME,PCELNG
 1200 FØRMAT(1H ,43(1H+),29HAVERAGES WITH ZERØ TIME DELAY,44(1H+),/2H +, FM 1200
     27X,13HPIECE NUMBER=,I5,4H    +,7X,6(1H+,12X),1H+,/22H +ACCUMULATIØN FM 1200
     3 NUMBER=,I5,4H    +,7X,40H+  PIECEWISE + PIECEWISE  +ACCUMULATIVE+, FM 1200
     412H    MEAN     ,26H+ACCUMULATIVE+    STANDARD   ,1H+,/22H +ACCUMULAT
     4IØN  START=,F8.2,87H+CHANNEL+ D C  TREND +  STANDARD  + MEAN VALUE
     5 +  STANDARD  +  STANDARD  +    ERRØR    +,/22H +ACCUMULATIØN   TIM
     6E=,F8.2,9H+ NUMBER+,12X,
     714H+  DEVIATIØN +,12X,9H+   ERRØR,4X,24H+  DEVIATIØN +  VARIANCE,
     82X,1H+,/2H +,7X,13HPIECE LENGTH=,F8.2,1H+,7X,6(1H+,12X),1H+,/1H ,1
     916(1H+))
      XKNP=NØPCE
      DØ 1 I=1,NCH
      DUM1=SQRT(PRMS(I))
      DUM2=SQRT(STERR1(I)/XKNP)
      DUM3=SQRT(ARMS(I))
      DUM4=SQRT(STERR2(I)/XKNP)
 1    WRITE(N,1220) NØCHAN(I),PMNVAL(I),DUM1,   AMNVAL(I),DUM2,
     1              DUM3,DUM4
 1220 FØRMAT(2H +,28X,3H+  ,I2,4H   +,6(F12.8,1H+))                    FM 1220
      WRITE(N,1230)
 1230 FØRMAT(1X,116(1H+))
      RETURN
      END



$IBFTC DECK2I                                                           DECK0000
      SUBRØUTINE ØU6A(N,NLAG,NØPCE,NØACC,ARVCØR,ACACØR,ACCST,ACCTME,
     1                 ICHAN1,ICHAN2,PCELNG,TD,VELDLY,
     2                 PCECØR,LLAG)
      DIMENSIØN TD(1),VELDLY(1),PCECØR(1)
      WRITE(N,1260) NØPCE,NØACC,ARVCØR,ACCST,ACCTME,PCELNG,ICHAN1
     1,ICHAN2
 1260 FØRMAT(1H ,25(1H+),24HAVERAGES WITH TIME DELAY,25(1H+),/9X,1H+,7X, FM 1260
     213HPIECE NUMBER=,I5,14H    +AREA UNDER,14X,1H+,/9X,21H+ACCUMULATIØN FM 1260
     3 NUMBER=,I5,16H    +CØRRELATIØN=,F12.8,1H+,/9X,21H+ACCUMULATIØN  ST FM 1260
     4ART=,F8.2,11H+CØRRELATED,14X,1H+,/9X,21H+ACCUMULATIØN    TIME=,F8.2 FM 1260
     5,9H+CHANNELS,16X,1H+,/9X,1H+,7X,13HPIECE LENGTH=,F8.2,2H+ ,I2,5H A FM 1260
     6ND ,I2,14X,1H+,/9X,55(1H+),/13X,43H+  TIME DELAY++VELØCITY DELAY++ P FM 12
     7 PIECEWISE +,/13X,1H+,12X,2H++,14X,14H++CØRRELATIØN+,/13X,43(1H+))   FM 12
      NTLAGS=2*NLAG+1
      DØ 1 I=1,NTLAGS
      IF (LLAG .NE. 0) GØ TØ 4
      DUMMY=0.0
      GØ TØ 3
 4    DUMMY=VELDLY(I)
 3    WRITE (N,1300) TD(I),DUMMY,PCECØR(I)
 1300 FØRMAT(13X,1H+,F11.5,6H ++   ,F7.3,4X,2H++,F11.5,1H+)
    1 CØNTINUE
      WRITE(N,1310)
 1310 FØRMAT(1X,74(1H+))
      RETURN
      END
```

```
$ØRIGIN         ALPHA,SYSUT2,REW
$INCLUDE        SCLV,MXYV,MØDV,LNRV,NLAV,ØNBD,ØRID,LØLV
$INCLUDE        PLØT,CMRV,PRTV,STMV,GRAX,CXDY,LMNV,ERLV
$INCLUDE        ERNV,EMKV,HLDV,LINV,STCV,STPV,FLØG
$INCLUDE        MRGN,NBLK,PLTV,APLV,APRV,MØLV,CULP,QUKV
$INCLUDE        CLEN,FSCN,FATN
$IBFTC DECK1    LIST,NØDD,DECK
      SUBRØUTINE LINK3(KRUN)
C
C        ØUTPUT LINK ØF MLTCØR PRØGRAM
C
C        THIS LINK FØRMS MØDIFIED CØRRELATIØNS FRØM
C
C       SELECTED PIECEWISE STATISTICS
C
C
C        REGIØNS FØR  CHANNEL ASSIGNMENTS
C
      DIMENSIØN NCHID(12),NEWID(12),NCTBL(12, 6),NCRPC(12)
     1,NACR(13),NCD(12)
C
C        TEMPØRARY STØRAGE
C
      CØMMØN START(5),STØP(5),SC(53),VALMIN(12),VØLMAX(12)
     1,SLØPE(12),BIAS(12),LTN,NBEAMS,NFLSKC,NFLSKE,MVMEAN,
     2TIMSAM,NWDS,IFREQ,MSFC,NFILE,RMS(12),VMEAN(12),NCRUN,EXPNØ,NØPAGE,
     4AVGMIN(12),AVGMAX(12),NBLK,NSTART,
     3CØMTIM
      DIMENSIØN U( 8000),IU( 8000)
      DIMENSIØN CØM(1)
      DIMENSIØN NUMPCE(10),PRØCD(12)
      DIMENSIØN BEAC(5),ENAC(5)
      EQUIVALENCE (START(1),CØM(1))
      EQUIVALENCE (U,IU)
      EQUIVALENCE(TIMSAM,ESMPP)
      LØGICAL NØRM, DTREND,IEAD,       PREPLT,PLØT
      NAMELIST/DELETE/NUMPCE,NPRINT
      NAMELIST /MØDIFY/ NØRM,DTRENC,       PREPLT,PLØT
      NAMELIST/ACCUM/NØ,BEGIN,END
C
      NUMCØM=175
      NBEAM=12
C       SYSTEM  PARAMETERS
C
C     NAME          DESCRIPTIØN                          TYPE  DIMENSIØN
C
C     MAXSTR - MAXIMUM STØRAGE ØF DATA PØØL              I
C     MAXCHN - MAXIMUM NUMBER  ØF CHANNELS               I
C
C
C
      MAXSTR= 8000
      MAXCHN=12
      MAXCR = 6
      IRT=11
C
C               INTERMEDIATE TAPE
      REWIND IRT
      READ(IRT) (CØM(I),I=1,NUMCØM)
      READ (IRT) NCH,ND,NU,NAUTØ,NCRT,NCHID,NEWID,NCTBL,NCRPC,NACR,NCD
      NTP=C
```

```
      IEND=.FALSE.
    2 READ(5,DELETE)
      WRITE(6,DELETE)
         DØ 1 I=1,10
      IF(NUMPCE(I).EQ.0) GØ TØ 3
      NTP=NTP+1
      IU(NTP)=NUMPCE(I)
    1 CØNTINUE
      GØ TØ 2
    3 NST=NTP+1
C        SET TIME LAGS AND VELØCITY LAGS
      READ(IRT) DELTAT,TAUMIN,TAUMAX,DELTAU,NLAGS,NTLAGS,LLAG
      NTT=NST+NTLAGS+NCRT*(NTLAGS*LLAG)-1
      READ(IRT) (U(I),I=NST,NTT)
C        SET MØDIFICATIØNS
      READ(5,MØDIFY)
      WRITE(6,MØDIFY)
      INAC=0
   40 READ(5,ACCUM)
      WRITE(6,ACCUM)
      IF(NØ.EQ.0) GØ TØ 41
      INAC=INAC+1
      BEAC(INAC)=BEGIN
      ENAC(INAC)=END
      STØP(NSTART)=STØP(NSTART)-TAUMAX
      IF (ENAC(INAC) .LT. STØP(NSTART)) GØ TØ 42
      NNTEMP=STØP(NSTART)/DELTAT
      ENAC(INAC)=FLØAT(NNTEMP)*DELTAT
 42   CØNTINUE
      GØ TØ 40
   41 NAC=INAC
      READ(5,6) PRØCD
      WRITE(6,6)      PRØCD
    6 FØRMAT(12A6)
C
C        STØRAGE PØINTERS
C
      LTLAG=NST
      LVLAG=LTLAG+NTLAGS
      ICHA=LVLAG+NCRT*NTLAGS*LLAG
C          ERRØRS
      IESM=ICHA+ND
      IEAM=IESM+NCH
      IEASM=IEAM+NCH
      IEXP=IEASM+NCH
C
C
C          ACCUMULATIØN
      LASM=IEXP+NCRT*(NTLAGS+1)
      LMA=LASM+NCH
      LRA=LMA+NCH
      LXA=LRA+NCH
C          MØDIFIED CØRRELATIØNS
      MPSM=LXA+NCRT*(NTLAGS+1)
      MMP=MPSM+NCH
      MRP=MMP+NCH
      MTP=MRP+NCH
C
      KEXP=MTP+NCRT*(NTLAGS+1)
      KATP=KEXP+NCRT*(NTLAGS+1)
C          PIECE WISE CØRRELATIØNS  (FRØM LINK2)
```

```
C
      KESM=KATP+NCRT*(NTLAGS+1)
      KEAM=KESM+NCH
      KEASM=KEAM+NCH
      KASM=KEASM+NCH
      KMA=KASM+NCH
      KRA=KMA+NCH
      KPSM=KRA+NCH
      KMP=KPSM+NCH
      KRP=KMP+NCH
      KTP=KRP+NCH
C
      KD=KESM
      KDM=KTP+NCRT*(NTLAGS+1)-1
      INAC=1
C         SET NEW
C         ACCUMULATION
C
   29 ASTAR=BEAC(INAC)
      ASTØP=ENAC(INAC)
      ACCTIM=0.0
      KNPT=0
      IPR=0
      NTC=MAXSTR-ICHA
      CALL CLEAR(NTC,U(ICHA))
C       GET NEXT PIECE
C
   30 READ(IRT) KNP,(U(I),I=KD,KDM)
      DØ 31 I=1,NTP
      IF(KNP.EQ.IU(I)) GØ TØ 30
   31 CØNTINUE
      KNPT=KNPT+1
      IPR=IPR+1
      ACCTIM=ACCTIM+DELTAT
      CALL MØVE(U(KPSM),U(MPSM),3*NCH)
C
C         FØRM MØDIFIED CØRRELATIØNS
C
      DØ 10 J=1,ND
      L=NCD(J)
      NT=NCRPC(J)
      DØ 10 K=1,NT
      KRI=(K-1+NACR(J))*(NTLAGS+1)
      KR=KTP+KRI
      MT=MTP+KRI
      KRT=KR+NTLAGS
      MRT=MT+NTLAGS
      NCU=NCTBL(J,K)
   16 IF(NØRM) GØ TØ 11
      SX=1.0
      SY=1.0
      GØ TØ 14
   11 LX=MPSM-1+L
      LY=MPSM-1+NCU
      SX=SQRT(U(LX))
      SY=SQRT(U(LY))
      SXSY=SX*SY
   14 AVLAG=0.0
      SAVLAG=0.0
      DØ 15 I=1,NTLAGS
      LL=KR+I-1
```

```
      PAVLAG=PAVLAG+U(LL)
   15 CONTINUE
      U(KRT)=PAVLAG/FLOAT(NTLAGS)
      IF (DTREND) GO TO 13
      TR=0.0
      GO TO 650
 13   TR=U(KRT)
 650  CONTINUE
      DO 651 I=1,NTLAGS
      MM=MT+I-1
      LL=KR+I-1
      IF (PREMLT) GO TO 600
      XTAU=1.0
      GO TO 601
 600  NNN=LTLAG+I-1
      XTAU=U(NNN)
 601  CONTINUE
      U(MM)=(U(LL)-TR)/SXSY*XTAU
      AVLAG=AVLAG+U(MM)
 651  CONTINUE
      U(MRT)=AVLAG/FLOAT(NTLAGS)
   10 CONTINUE
C
C
C
C         ACCUMULATE PIECE
      NTA=NCRT*(NTLAGS+1)
      CALL PCRC(U(KATP),U(KTP),NTA,KNPT)
      CALL STDERR(U(KEXP),U(KATP),U(KTP),NTA,KNPT)
C
      NTT=3*NCH+NCRT*(NTLAGS+1)
      CALL PCRC(U(LASM),U(MPSM),NTT,KNPT)
C
C         DETERMINE ERRORS
C
      CALL STDERR(U(IESM),U(LASM),U(MPSM),NTT,KNPT)
C
C
C            FORM STATISTICAL AND CHANNEL AVERAGES
      DO 60 J=1,ND
      MIC=ICHA+J-1
      U(MIC)=0.0
      NT=NCRPC(J)
      DO 61 K=1,NT
      KRI=(K-1+NACR(J))*(NTLAGS+1)
      KK=IEXP+KRI
      KKK=KEXP+KRI
      MMM=KKK+NTLAGS
      MM=KK+NTLAGS
      CALL AVERGE (U(MMM),U(KKK),NTLAGS)
      CALL AVERGE(U(MM),U(KK),NTLAGS)
      U(MM)=SQRT(U(MM)/FLOAT(KNPT))
      U(MMM)=SQRT(U(MMM)/FLOAT(KNPT))
      U(MIC)=U(MIC)+U(MM)
   61 CONTINUE
      U(MIC)=U(MIC)/FLOAT(NT)
   60 CONTINUE
C
C
C           OUTPUT SELECTION
C
```

```
      IF (.NØT.IEND) GØ TØ 702
      GØ TØ 703
 702  IF (NPRINT-IPR) 704,703,704
 703  CØNTINUE
      IPR=0
      CALL ØUT1(6,EXPNØ,SC(2),SC(1),NØPAGE,SC(3),SC(4),NØRUN)
      DØ 32 J=1,ND
      NT=NCRPC(J)
      MIC=ICHA+J-1
      DØ 32 K=1,NT
      NCU=NCTBL(J,K)
      KRI=(K-1+NACR(J))*(NTLAGS+1)
C
C        SET CØRRELATIØN PØINTERS
C        PIECEWISE
      KR=KTP+KRI
      KAP=KATP+KRI
      KER=KEXP+KRI
C
C        MØDIFIED
      MR=MTP+KRI
      MAP=LXA+KRI
      MER=IEXP+KRI
C
C        AVERAGE LAG PØINTERS
      NI=NTLAGS
      KPAL=KR+NI
      KAPAL=KAP+NI
      MPAL=MR+NI
      MAPAL=MAP+NI
      KERP=KER+NI
      ARVCØR=U(KPAL)
      ACACØR=U(KAPAL)
      AMCCØR=U(MPAL)
      ACMCØR=U(MAPAL)
      MERP=MER+NI
      NN=NCC(J)
      N=NCHID(NN)
      NUP=NCHID(NCU)
      CALL ØUT6 (6,NLAGS,KNPT,INAC,ARVCØR,ACACØR,START(1),ACCTIM,
     1N, NUP,DELTAT,AMCCØR,ACMCØR,U(LTLAG),U(LVLAG),U(KR),U(MR),
     2U(KAP),  U(KER),U(MAP),U(MER),LLAG)
      IF (PLØT) GØ TØ 607
      GØ TØ 608
 607  CØNTINUE
      I1=KDM+1
      CALL PLØTA (U(LTLAG),U(KR),U(MR),U(KAP),  U(KER),U(MAP),U(MER),SC,
     1KNPT,INAC,ACCTIM,N,NUP,DELTAT,NTLAGS,TIMSAM,U(I1),U(KERP),U(MERP))
      CALL CLEAR (NTLAGS,U(I1))
 608  CØNTINUE
      NCA=NCAV+J
      AVTIM=ACCTIM-START(1)
   33 CALL ØUT7(6,N, NUP,INAC,PRØCC,ACCTIM,START(1),AVTIM,U(KERP),
     1U(MERP),U(MIC))
      IF(.NØT.IEND) GØ TØ 35
      MXM=LMA+NN-1
      MYM=LMA+NCU-1
      MXR=LASM+NN-1
      MYR=LASM+NCU-1
      CALL ØUT8(6,NLAGS,N, U(MXM),NUP,U(MXR),U(MYM),U(MYR),U(LTLAG),
     1U(LVLAG),U(KAP),U(MAP,,LLAG)
```

```
      IF (KRUN .NE. 4) GØ TØ 701
      CALL LINK4(NLAGS,NTLAGS,DELTAU,U(LTLAG),U(MAP),U(I1))
 701  CØNTINUE
   35 CØNTINUE
   32 CØNTINUE
 704  CØNTINUE
      A=ACCTIM-ASTAR
      B=ASTØP
      C=ACCTIM+DELTAT
      IF (C .GE. ASTØP) IEND=.TRUE.
      IF (A .GE. B) GØ TØ 101
      GØ TØ 30
 101  IF(INAC.EQ.NAC) GØ TØ 100
      IEND=.FALSE.
      INAC=INAC+1
      GØ TØ 29
 100  CØNTINUE
      IF (PLØT) GØ TØ 605
      GØ TØ 606
 605  CØNTINUE
      CALL CLEAN
 606  CØNTINUE
      REWIND IRT
      RETURN
      END
```

```
$IBFTC DECK2                                                            DECK0000
      SUBRØUTINE PCRC(A,X,N,NP)
C
C        THIS SUBRØUTINE PERFØRMS THE PIECEWISE
C     RECURSIØN FØRMULA FØR ACCUMULATIVE AVERAGES
C          A(N+1)=(A(N)*N+X(N+1))/(N+1)
C
      DIMENSIØN A(1),X(1)
      XKNP=NP
      XKNP1=NP-1
      DØ 1 I=1,N
    1 A(I)=(A(I)*XKNP1+X(I))/XKNP
      RETURN
      END
```

```
$IBFTC DECK3                                                            DECK0000
      SUBRØUTINE STDERR(E,A,P,N,NP)
C
C        THIS SUBROUTINE PERFØRMS THE RECURSIØN FØRMULA
C     FØR THE STANDARD ERRØR ØF THE ACCUMULATIVE AVERAGES
C
C        E(N+1)=E(N)*(N-1)/N+((A(N+1)-P(N+1)-P(N+1))**2)*(N+1)/N**2)
C
      DIMENSIØN E(1),A(1),P(1)
      IF(NP.EQ.1) GØ TØ 2
      XNP=NP-1
      XNPM1=NP-2
      XNPP1=NP
      DØ 1 I=1,N
    1 E(I)=E(I)*XNPM1/XNP+((A(I)-P(I))**2)*XNPP1/XNP**2
    2 RETURN
      END
```

```
$IBFTC DECK6                                                            DECK0000
      SUBRØUTINE AVERGE(A,U,N)
C        FØRMS  AVERAGE VALUE ØF N VALUES ØF U AND
C
C     STØRES AVERAGE IN A
C
C
C
      DIMENSIØN U(1)
      XN=N
      A=0.0
      DØ 1 I=1,N
    1 A=A+U(I)
      A=A/XN
      RETURN
      END
```

```
$IBFTC DECK5                                                            DECK0000
      SUBRØUTINE MØVE(X,Y,N)
C
C        MØVE N LØCATIØNS FRØM X TØ Y
C
      DIMENSIØN X(1),Y(1)
      DØ 1 I=1,N
    1 Y(I)=X(I)
      RETURN
      END
```

```
$IBFTC DECK4                                                                   DECK0000
      SUBRØUTINE CLEAR(N,X)
C
C     THIS SUBRØUTINE SETS N PØSITIØNS ØF X TØ ZERØ
C
      DIMENSIØN X(1)
      DØ 1 I=1,N
    1 X(I)=0.0
      RETURN
      END
```

```
$IBFTC DECK7                                                                   DECK0000
      SUBRØUTINE ØUT6(N,NLAG,NØPCE,NØACC,ARVCØR,ACACØR,ACCST,ACCTME,
     1                ICHAN1,ICHAN2,PCELNG,AMDCØR,ACMCØR,TD,VELDLY,
     2                PCECØR,PCMCØR,ACØR,STDER3,AMCØR,STDER4,LLAG)
      DIMENSIØN TD(1),VELDLY(1),PCECØR(1),PCMCØR(1),ACØR(1),STDER3(1),
     1          AMCØR(1),STDER4(1)
      WRITE(N,1260) NØPCE,NØACC,ARVCØR,ACACØR,ACCST,ACCTME,ICHAN1,ICHAN2
     1               ,PCELNG,AMDCØR,ACMCØR
 1260 FØRMAT(1H ,34(1H+),24HAVERAGES WITH TIME DELAY,44(1H+),/2H +,7X,13 FM 1260
     2HPIECE NUMBER=,I5,14H   +AREA UNDER,14X,35H+ACCUMULATIVE AREA UNDE FM 1260
     3R +CØRRELATED ++,8X,1H+,/22H +ACCUMULATIØN NUMBER=,I5,16H   +CØRRE FM 1260
     4LATIØN=,F12.8,13H+CØRRELATIØN=,F12.8,14H+ CHANNELS  ++,8X,1H+,/22H FM 1260
     5 +ACCUMULATIØN  START=,F8.2,11H+AREA UNDER,14X,26H+ACCUMULATIVE AR FM 1260
     6EA UNDER +,11X,2H++,8X,1H+,/22H +ACCUMULATIØN   TIME=,F8.2,2(9H+MØ FM 1260
     7DIFIED,16X),2H+ ,I2,5H AND ,I2,3H ++,9X,1H+,/2H +,7X,13HPIECE LENG FM 1260
     8TH=,F8.2,2(13H+CØRRELATIØN=,F12.8),1H+,11X,2H++,8X,1H+,/1H ,102(1H FM 1260
     9+),/103H +TIME DELAY++VELØCITY DELAY++ PIECEWISE ++ PIECEWISE ++AC FM 1260
     1CUMULATIVE++STANDARD++ACCUMULATIVE++STANDARD+,/2H +,10X,2H++,14X,7 FM 1260
     25H++CØRRELATIØN++  MØDIFIED ++CØRRELATIØN ++  ERRØR ++  MØDIFIED   FM 1260
     3++  ERRØR +,/2H +,10X,2H++,14X,2H++,11X,15H++CØRRELATIØN++,12X,2H+ FM 1260
     4+,8X,16H++CØRRELATIØN ++,8X,1H+,/1H ,102(1H+))                     FM 1260
      NTLAGS=2*NLAG+1
      DØ 1 I=1,NTLAGS
      DUMMY1=SQRT(STDER3(I)/FLØAT(NØPCE))
      DUMMY2=SQRT(STDER4(I)/FLØAT(NØPCE))
      IF (LLAG .NE. 0) GØ TØ 4
      DUMMY=0.0
      GØ TØ 3
    4 DUMMY=VELDLY(I)
    3 WRITE(N,1300) TD(I),DUMMY,    PCECØR(I),PCMCØR(I),ACØR(I),DUMMY1,
     1                AMCØR(I),DUMMY2
 1300 FØRMAT(2H +,F9.5,6H ++   ,F7.3,4X,2(2H++,F11.5),2(2H++,F12.5,2H++, FM 1300
     2F8.5),1H+)
    1 CØNTINUE
      WRITE(N,1310)
 1310 FØRMAT(1X,102(1H+))
      RETURN
      END
```

```
$IBFTC DECK8                                                                 DECK0000
      SUBROUTINE ØUT7(N,ICHANA,ICHANB,NØACC,PRØCD ,ENACC,         ACCST,
     1                          AVETME,CSTERR,CMSTER,CHERR)
      DIMENSIØN AVETME(1),CSTERR(1),CMSTER(1),CHERR(1),PRØCD(1)
      WRITE(N,1320) ICHANA,ICHANB,NØACC,(PRØCD(I),I=1,5),ENACC,(PRØCD(I)
     1,I=6,10),ACCST,(PRØCD(I),I=11,12)
 1320 FØRMAT( //1H ,42(1H+),25HINTEGRATED ERRØR ANALYSIS,35(1H+),/24H +  FM 1320
     2 CØRRELATED CHANNELS=,I2,5H AND ,I2,1H+,11X,13H+  MØDIFIED +,11X,2 FM 1320
     39H+ACCUMULATIØN PRØCEDURE USED-,4X,1H+,/24H +  ACCUMULATIØN NUMBER FM 1320
     4=,I5,4X,37H+CØRRELATIØN+CØRRELATIØN+  CHANNEL  +,5(A6),2X,1H+,/24H FM 1320
     5 +  END ØF ACCUMULATIØN=,F8.2,38H +STATISTICAL+STATISTICAL+STATIST FM 1320
     6ICAL+,5(A6),2X,1H+,/24H +START ØF ACCUMULATIØN=,F8.2,38H +   ERRØR FM 1320
     7   +    ERRØR    +    ERRØR    +,2(A6),20X,1H+,/1H ,102(1H+),/1H ,17(1
     8H+),14HAVERAGING TIME,71(1H+))
      WRITE(N,1340)AVETME,CSTERR,CMSTER,CHERR
 1340 FØRMAT(2H +,15X,2H+ ,F9.3,5X,3(1H+,F11.7),1H+,32X,1H+)            FM 1340
      WRITE(N,1360)
 1360 FØRMAT(1H ,102(1H+))                                              FM 1360
      RETURN
      END
```

```
$IBFTC DECK9                                                                 DECK0000
      SUBRØUTINE ØUT8(N,NLAG,ICØRCH,XMNVAL,JCØRCH,XRMS,YMNVAL,YRMS,TD,
     1VELDLY,CØR,MCØR,LLAG)
      XRMS=SQRT(XRMS)
      YRMS=SQRT(YRMS)
      WRITE(N,1380)ICØRCH,XMNVAL,XRMS,JCØRCH,YMNVAL,YRMS
      DIMENSIØN TD(1),VELDLY(1),CØR(1),MCØR(1)
 1380 FØRMAT( //1H ,34(1H+),27HFINAL TABULATIØN ØF RESULTS,24(1H+),/39H  FM 1380
     2+CØRRELATED + MEAN VALUE+ RØØT MEAN  +,11X,1H+,10X,2(1H+,11X),1H+, FM 1380
     3/14H + CHANNELS  +,11X,14H+SQUARE VALUE+,11X,12H+ VELØCITY +,11X,1 FM 1380
     43H+  MØDIFIED +,/2H +,4X,I2,5X,2(1H+,F11.7)    , 49H + TIME DELAY+  FM 1380
     5 DELAY   +CØRRELATIØN+CØRRELATIØN+,/2H +,4X,I2,5X,1H+,F11.7,2H+ ,F FM 1380
     611.7,1H+,11X,1H+,10X,2(1H+,11X),1H+,/1H ,85(1H+))
      NTLAGS=2*NLAG+1
      DØ 1 I=1,NTLAGS
      IF (LLAG .NE. 0) GØ TØ 4
      DUMMY=0.0
      GØ TØ 3
 4    DUMMY=VELDLY(I)
    3 WRITE(N,1500) TD(I),DUMMY,    CØR(I),MCØR(I)
 1500 FØRMAT(2H +,36X,2H+ ,2(F10.6,1H+),2(F11.7,1H+))                   FM 1500
    1 CØNTINUE
      WRITE(N,1520)
 1520 FØRMAT(1H ,85(1H+))                                               FM 1520
      RETURN
      END
```

```
$IBFTC PLT1                                                          PLT10000
      SUBRØUTINE PLØTA (TD,PCECØR,PCMCØR,ACØR,STDER3,AMCØR,STDER4,SC,
     1KNPT,INAC,ACCTIM,N,NUP,PCELNG,NTLAGS,TIMSAM,TEMP,ERR1,ERR2)
      DIMENSIØN TD(1),PCECØR(1),PCMCØR(1),ACØR(1),STDER3(1),
     1AMCØR(1),STDER4(1),SC(1),TEMP(1)
      DIMENSIØN INFØR(6)
      DIMENSIØN TITLE1(9),TITLE2(9),TITLE3(9),TITLE4(9)
      DIMENSIØN ALAB1(12),ØLAB1(12),ØLAB2(12),ØLAB3(12),ØLAB4(12)
      DATA NFLAG/0/
      DATA TITLE1/54H                    PIECEWISE CØRRELATIØN
     1   /
      DATA TITLE2/54H               PIECEWISE MØDIFIED CØRRELATIØN
     1   /
      DATA TITLE3/54H     ACCUMULATIVE CØRRELATIØN AND STANDARD ERRØR
     1   /
      DATA TITLE4/54HACCUMULATIVE MØDIFIED CØRRELATIØN AND STANDARD ERRØ
     1R  /
      DATA ALAB1/72H
     1TIME DELAY          /
      DATA ØLAB1/72H                          CØRRELATIØNS
     1                    /
      DATA ØLAB2/72H                          MØDIFIED CØRRELATIØNS
     1                    /
      DATA ØLAB3/72H           CØRRELATIØN AND STANDARD ERRØR
     1                    /
      DATA ØLAB4/72H           MØDIFIED CØRRELATIØN AND STANDARD ERRØR
     1                    /
      DATA INFØR/36H470960  BIN 309 63  JAYRØE R. COCCOO/
      IF (NFLAG) 11,10,11
 10   CØNTINUE
      CALL SCLØCK (INFØR(6),TIME,ESEC,E60SEC)
      CALL CAMRAV(9)
      NFLAG=1
 11   CØNTINUE
      XKNPT=KNPT
      NX=-1
      CALL PLØTB1 (ALAB1,ØLAB1,TITLE1,TD,PCECØR,NTLAGS,INAC,N,NUP,
     1TIMSAM,ACCTIM,PCELNG,SC,NX,INFØR(6),KNPT,ERR1,ERR2)
      NX=-1
      CALL PLØTB1 (ALAB1,ØLAB2,TITLE2,TD,PCMCØR,     NTLAGS,INAC,N,NUP,
     1TIMSAM,ACCTIM,PCELNG,SC,NX,INFØR(6),KNPT,ERR1,ERR2)
      NX=-1
      CALL PLØTB1 (ALAB1,ØLAB3,TITLE3,TD,ACØR,        NTLAGS,INAC,N,NUP,
     1TIMSAM,ACCTIM,PCELNG,SC,NX,INFØR(6),KNPT,ERR1,ERR2)
      DØ 12 I1=1,NTLAGS
      TEMP(I1)=SQRT(STDER3(I1)/XKNPT)
 12   CØNTINUE
      NX=0
      CALL PLØTB2 (TD,TEMP,  NX)
      NX=-1
      CALL PLØTB1 (ALAB1,ØLAB4,TITLE4,TD,AMCØR,       NTLAGS,INAC,N,NUP,
     1TIMSAM,ACCTIM,PCELNG,SC,NX,INFØR(6),KNPT,ERR1,ERR2)
      DØ 13 I2=1,NTLAGS
      TEMP(I2)=SQRT(STDER4(I2)/XKNPT)
 13   CØNTINUE
      NX=0
      CALL PLØTB2 (TD,TEMP,  NX)
      RETURN
      END
```

```
$IBFTC PLT2                                                                     PLT20000
      SUBRØUTINE PLØTBI(AARRAY,ØARRAY,TITLE,XDATA,YDATA,NP,INAC,N,NUP,
     1TIMSAM,ACCTIM,PCELNG,SC,NXX,DATE,KNPT,ERR1,ERR2)
      DIMENSIØN SC(1),AARRAY(1),ØARRAY(1),TITLE(1),XDATA(1),YDATA(1)
      INTEGER TEMPX1,TEMPX2,TEMPY1,TEMPY2
      FINAC=INAC
      FKNPT=KNPT
      FNN=N
      FNUP=NUP
      N1=N+7
      N2=NUP+7
      NPP=-NP
      CALL FRAMEV
      CALL PRINTV (54,TITLE,345,1017)
      CALL PRINTV (15,15HUNMØD ERRØR   =,200,984)
      CALL LABLV (ERR1,328,984,-6,1,1)
      CALL PRINTV (8,8HRUN NØ.=,200, 1000)
      CALL PRINTV (6,SC(1),272,1000)
      CALL PRINTV (10,10HMØD ERRØR= ,200,968)
      CALL LABLV (ERR2,290,968,-6,1,1)
      CALL PRINTV (16,16HTØTAL PIECE NØ.=,200,952)
      CALL LABLV (FKNPT,336,952,6,1,5)
      CALL PRINTV (11,11HACCUM. NØ.=,200,936)
      CALL LABLV (FINAC,296,936,6,1,5)
      CALL PRINTV (21,21HCORRELATIØN CHANNELS=,200,920)
      CALL LABLV (FNN,344,920,6,1,5)
      CALL PRINTV (3,3HAND,400,920)
      CALL LABLV (FNUP,408,920,6,1,5)
      CALL PRINTV (5,5HDATE=,600,1000)
      CALL PRINTV (6,DATE,    648,1000)
      CALL PRINTV (18,18HFINAL SAMPLE RATE=,600, 984)
      CALL LABLV (TIMSAM,752, 984,-6,1,1)
      CALL PRINTV (11,11HACCUM TIME=,600, 968)
      CALL LABLV (ACCTIM,696, 968,-6,1,1)
      CALL PRINTV (13,13HPIECE LENGTH=,600,952)
      CALL LABLV (PCELNG,712,952,-6,1,5)
      CALL PRINTV (13,13HØRGANIZATIØN=,600,936)
      CALL PRINTV (6,SC(2),712,936)
      CALL PRINTV (18,18HCHANNEL VARIABLES=,600,920)
      CALL PRINTV (6,SC(N1), 752,920)
      CALL PRINTV (3,3HAND,800,920)
      CALL PRINTV (6,SC(N2),    832,920)
      CALL PRINTV (72,AARRAY,0,0)
      CALL APRNTV (0,-14,72,ØARRAY,0,1010)
C     *
C     SET MIN AND MAX LIMITS
C     *
      XR=XDATA(NP)
      XL=XDATA(1)
      TEMP1=YDATA(1)
      J=1
      DØ 10 I=2,NP
      IF (TEMP1 .LE. YDATA(I)) GØ TØ 10
      TEMP1=YDATA(I)
      J=I
 10   CØNTINUE
      YB=YDATA(J)
      TEMP1=YDATA(1)
      J=1
      DØ 11 I=2,NP
      IF (TEMP1 .GE. YDATA(I)) GØ TØ 11
```

```
      TEMP1=YDATA(I)
      J=I
 11   CØNTINUE
      YT=YDATA(J)
      CALL SETMIV(24,0,24,124)
      CALL DXDYV (1,XL,XR,DX,NX,IX,NNX,IC.,IERR,24,124)
      CALL DXDYV (2,YB,YT,DY,NY,IY,NNY,IC.0,IERR,24,124)
      CALL GRIDIV(2,XL,XR,YB,YT,DX,DY,NX,NY,IX,IY,NNX,NNY,24,124)
      TEMPX1=NXV(XDATA(1))
      TEMPY1=NYV(YDATA(1))
      DØ 12 J=2,NP
      TEMPX2=NXV(XDATA(J))
      TEMPY2=NYV(YDATA(J))
      CALL LINEV (TEMPX1,TEMPY1,TEMPX2,TEMPY2)
      TEMPX1=TEMPX2
      TEMPY1=TEMPY2
 12   CØNTINUE
      RETURN
      ENTRY PLØTB2 (XDATA,YDATA,NXX)
      TEMPX1=NXV(XDATA(1))
      TEMPY1=NYV(YDATA(1))
      DØ 13 J=2,NP
      TEMPX2=NXV(XDATA(J))
      TEMPY2=NYV(YDATA(J))
      CALL LINEV (TEMPX1,TEMPY1,TEMPX2,TEMPY2)
      TEMPX1=TEMPX2
      TEMPY1=TEMPY2
 13   CØNTINUE
      RETURN
      END
```

APPENDIX C

DETRENDING AND NORMALIZATION OF CORRELATION FUNCTIONS

Correlation analysis is strictly valid only for stationary data, i.e., experiments, where the test environment is time invariant. In the piecewise correlation techniques the condition of stationarity is approximated by integrating only over a short piece of a record of length ΔT since it is hoped, that in this short integration time the environment does not change. However, corrections for DC shifts and trends as well as drifting gains can not be avoided, if more accurate averages have to be obtained by averaging over many pieces.

Detrending procedures and normalization are thus necessary for each piece, to correct for the change of environment, prior to averaging over more than one piece.

Detrending procedures are developed by assuming, that DC shifts and trends may be linearly approximated, over a record piece of length ΔT. The recorded two signal time histories, x and y, may then be expressed by their stationary components $x_1(t)$ and $x_2(t)$ and the associated trends in the following way:

$$\left.\begin{aligned} x(t) &= x_1(t) + a_1 t + b_1 \\ y(t) &= x_2(t) + a_2 t + b_2 \end{aligned}\right\} \quad \text{for } (i-1)\,\Delta T \leq t \leq i\Delta T \qquad (1)$$

The condition of stationarity means, that the mean values of the stationary components should vanish.

$$\bar{x}_{1_i} = \frac{1}{\Delta T} \int_{(i-1)\,\Delta T}^{i\Delta T} x_1(t)\, dt = 0$$

$$\bar{x}_{2_i} = \frac{1}{\Delta T} \int_{(i-1)\,\Delta T}^{i\Delta T} x_2(t)\, dt = 0 \tag{2}$$

Furthermore the correlation function of the stationary components

$$R_{12}(\tau)_i = \frac{1}{\Delta T} \int_{(i-1)\,\Delta T}^{i\Delta T} x_1(t)\, x_2\,(t + \tau)\, dt \tag{3}$$

should give zero area, when averaged over the time lag range of interest, ($|\tau| \leq \tau_m$), otherwise the stationary components could not be expressed by superposition of harmonic waves. This condition leads to

$$_{\tau}R_{12} = \frac{1}{2\,\tau_m} \int_{-\tau_m}^{+\tau_m} R_{12}\,(\tau)\, d\tau = 0 \tag{4}$$

The detrending problem may now be defined by determining, what the corrections of the actual correlation:

$$(R_{xy}(\tau))_i = \frac{1}{\Delta T} \int_{(i-1)\,\Delta T}^{i\Delta T} x(t)\, y(t+\tau)\, dt \tag{5}$$

are necessary to retrieve the correlation ($R_{12}(\tau)_i$) of the stationary components. These corrections will now be derived. All over bars and the subscripts, are dropped from the correlation function, as a matter of convenience.

The relation between the accessible correlation, $R_{xy}(\tau)$ and the desired correlation, $R_{12}(\tau)$, may be expressed as

$$R_{xy}(\tau) = \overline{(x_1(t) + a_1 t + b_1)(x_2(t+\tau) + a_2 t + a_2 \tau + b_2)} = \overline{x_1(t)\, x_2(t+\tau)}$$

$$+ (b_2 + a_2\tau)\, \overline{x_1(t)} + b_1 \overline{x_2(t+\tau)} + a_2 \overline{t x_1(t)} + a_1 \overline{t x_2(t+\tau)}$$

$$+ \frac{1}{\Delta T} \int_{(i-1)\Delta T}^{i\Delta T} (a_1 t + b_1)\,(a_2 t + b_2 + a_2\tau)\, dt \qquad (6)$$

The first average on the right hand side is the desired correlation, $R_{12}(\tau)$ for positive values of τ. The second and third averages vanish according to equation (2). The fourth and fifth averages may also be neglected, as may be shown, through an integration by parts. To illustrate, we take the fourth average:

$$\overline{(t\, x_1(t))} = \Delta T\, \overline{(x_1(\tau))} - \frac{1}{\Delta T} \int_{t=(i-1)\Delta T}^{t=i\Delta T} \int_{t'=0}^{t'=t} (x_1(t)\ dt')\, dt \qquad (7)$$

In this equation the first term vanishes because of equation (2). The inner integrand of the second integral is an accumulative mean, which approaches zero in an oscillatory manner. This term might, therefore, also be neglected as stated above. The sixth term in equation (6) is an integral that may be given in closed form:

$$\frac{1}{\Delta T} \int_{t=(i-1)\Delta T}^{t=i\Delta T} (a_1 t + b_1)\,(a_2 t + b_2 + a_2\tau)\, dt \qquad (8)$$

$$= b_1(b_2 + a_2\tau) + \left[a_1 b_2 + a_2(a_1\tau + b_1)\right] \frac{\Delta T}{2} + a_1 a_2 \frac{\Delta T^2}{3}$$

Substituting all these averages into equation (6) one obtains

$$R_{xy}(\tau) = R_{12}(\tau) + a_1 a_2 \frac{\Delta T^2}{3} + (a_1 b_2 + a_2 b_1) \frac{\Delta T}{2} + b_1 b_2 + a_2 \left(\frac{a_1 \Delta T}{2} + b_1\right) |\tau| \quad \text{for } \tau \geq 0 \tag{9}$$

Negative values of τ are introduced in the correlation programs by switching channels

$$R_{xy}(-\tau) = \overline{(x(t+\tau)\ y(t))_i} = R_{12}(-\tau) + a_1 a_2 \frac{\Delta T^2}{3} + (a_1 b_2 + a_2 b_1) \frac{\Delta T}{2} + b_1 b_2 + a_1 \left(\frac{a_2 \Delta T}{2} + b_2\right) |\tau| \quad \text{for } \tau > 0 \tag{10}$$

The equations (9) and (10) are now reduced to experimentally accessible terms in two steps. The first step is to eliminate the constant b_1 and b_2. This is accomplished by employing the piecewise averages.

$$\overline{x(t)} = \overline{x_1(t) + a_1 t + b_1} = \frac{a_1 \Delta T}{2} + b_1 \tag{11}$$

and

$$\overline{y(t)} = \overline{x_2(t) + a_2 t + b_2} = \frac{a_2 \Delta T}{2} + b_2 \tag{12}$$

The constant in equation (9) and (10) may then be transformed as

$$(a_1 b_2 + a_2 b_1) \frac{\Delta T}{2} + b_1 b_2 = \frac{a_1 \Delta T}{2} \left(\bar{y} - \frac{a_2 \Delta T}{2}\right) + \frac{a_2 \Delta T}{2} \left(\bar{x} - \frac{a_1 \Delta T}{2}\right) + \left(\bar{x} - \frac{a_1 \Delta T}{2}\right) \left(\bar{y} - \frac{a_2 \Delta T}{2}\right) = \bar{x}\,\bar{y} - a_1 a_2 \frac{\Delta T^2}{4} \tag{13}$$

Substitution of equation (11) through (13) into equations (9) and (10) gives

$$R_{12}(\tau) = R_{xy}(\tau) - \bar{x}\,\bar{y} - \frac{1}{12} a_1 a_2 \Delta T^2 - a_2 \bar{x} \,|\tau| \quad \text{for } \tau > 0 \tag{14}$$

and

$$R_{12}(\tau) = R_{xy}(\tau) - \bar{x}\,\bar{y} - \frac{1}{12} a_1 a_2 \Delta T^2 - a_1 \bar{y} \,|\tau| \quad \text{for } \tau < 0 \tag{15}$$

Both expressions differ only with respect to the last term. The second step, the elimination of a_1 and a_2, is accomplished by expressing the left hand side of equations (14) and (15) in terms of the covariance function.

$$C_{xy}(\tau) = \overline{(x(t) - \bar{x})(y(t+\tau) - \bar{y})} = \overline{x(t)\, y(t+\tau)} - \bar{x}\,\overline{y(t+\tau)} \tag{16}$$

substituting

$$\overline{y(t+\tau)} = \overline{x_2(t) + a_2(t+\tau) + b_2} = a_2\left(\frac{\Delta T}{2} + \tau\right) + b_2 = \bar{y} + a_2\tau \tag{17}$$

gives

$$C_{xy}(\tau) = R_{xy}(\tau) - \bar{x}\,\bar{y} - a_2\,\bar{x}\tau \qquad \text{for } \tau > 0 \tag{18}$$

Comparing equation (18) with equation (14) gives an expression

$$R_{12}(\tau) = \overline{(x(t) - \bar{x})(y(t+\tau) - \bar{y})} - \frac{a_1 a_2}{12} \Delta T^2 \tag{19}$$

that is valid for positive and negative time delays. The last term may be calculated by integrating equation (19) over the time delay range and by applying equation (4).

$$\frac{1}{2\tau_m}\int_{-\tau_m}^{+\tau_m} R_{12}(\tau)\, d\tau = {}_{\tau}C_{xy} - \frac{a_1 a_2}{12}\ \Delta T^2 = 0 \tag{20}$$

This gives the final result:

$$\overline{R_{12}(\tau)_i} = \overline{\left[(x(t) - \overline{x_i})(y(t+\tau) - \overline{y_i})\right]_i} - {}_{\tau}(\overline{C_{xy}})_i \tag{21}$$

DC shifts and trends are thus eliminated from piecewise correlation functions by the following procedure:

(a) Subtract the piecewise means $\overline{x}_i$ and $\overline{y}_i$ prior to the product integration.

(b) Shift the resulting correlation curve by the amount ${}_{\tau}(\overline{C_{xy}})_i$ until the area under the shifted covariance curve vanishes.

Several important conclusions follow:

(1) The usual transformation between correlation and covariance functions

$$C_{xy} = R_{xy} - \overline{x}\ \overline{y} \tag{22}$$

is not valid in the presence of DC shifts and trends. The translation $\overline{x}\ \overline{y}$ must be replaced with the area shift ${}_{\tau}C_{xy}$ and the shape of C_{xy} and R_{xy} may be quite different, as indicated by the shape corrections $a_2\ \overline{x}(\tau)$ in equation (18).

(2) The area shift of the autocovariance curves

$$ {}_{\tau}(C_{xx})_i = \frac{1}{2\tau_m}\int_{-\tau_m}^{+\tau_m} \left[\overline{(x(t) - \overline{x}_i)\ (x(t+\tau) - \overline{x}_i)}\right]_i d\tau \tag{23}$$

gives a direct estimate of the DC trends.

$$\frac{a_1 \Delta T}{2} = \sqrt{3_\tau \overline{(C_{xx})}_i}$$

$$\frac{a_2 \Delta T}{2} = \sqrt{3_\tau \overline{(C_{yy})}_i} \tag{24}$$

which, in turn, may be used to calculate the DC shifts

$$b_1 = \bar{x}_i - \sqrt{3_\tau \overline{(C_{xx})}_i}$$

$$b_2 = \bar{y}_i - \sqrt{3_\tau \overline{(C_{yy})}_i} \tag{25}$$

(3) The amplitudes of the stationary components are given by the shifted covariance at zero time lag. The usual practice of normalizing with the unshifted covariance curve is incorrect.

$$\sigma_{x_i} = \overline{R_{11}(0)_i}^{1/2} = \sqrt{\left[(C_{xx}(\tau)) \right]_i (\tau=0) - {}_\tau(C_{xx})_i} \tag{26}$$

and

$$\sigma_{y_i} = \overline{R_{22}(0)_i}^{1/2} = \sqrt{\left[(C_{yy}(\tau)) \right]_i (\tau=0) - {}_\tau(C_{yy})_i} \tag{27}$$

(4) The accumulation over many pieces can correct for environmental variations of the gain factors as well as for DC shifts and trends, by normalizing with the amplitudes of the stationary components. This gives the accumulative normalized covariance function

$$C_{12}(\tau) = \frac{1}{m} \sum_{i=1}^{m} \frac{\overline{C_{xy}(\tau)}_i - {}_{\tau}(\overline{C_{xy}})_i}{\overline{\sigma_{x_i}}\ \overline{\sigma_{y_i}}} . \tag{28}$$

(5) The assumption of linear trends may be checked by calculating the ratio

$$\sqrt{\frac{{}_{\tau}(\overline{R_{xx}})_i \quad {}_{\tau}(\overline{R_{yy}})_i}{{}_{\tau}(\overline{R_{xy}})_i}} = \alpha . \tag{29}$$

Within the assumptions made in equations (1) through (4), this ratio should be equal to one.

(6) Additional checks are offered by the accumulative statistical error of the RMS amplitudes. The curves $\Delta(\overline{\overline{\sigma_x}})_m\ (T^{-1/2})$ and $\Delta(\overline{\overline{\sigma_y}})_m\ (T^{-1/2})$ should be more stationary, after removing the DC trends through equations (26) and (27).

APPENDIX D

EXPECTED ERROR CURVES

Let ( ) denote a statistic, i.e., a first or second order two channel product mean value between signals X and Y. The piecewise average of this statistic is defined as

$$\overline{(\ )}_i = \frac{1}{\Delta T}\int_{(i-1)\Delta T}^{i\Delta T} (\ )\, dt. \tag{1}$$

The expected error curves of these piecewise averages are derived from the hypothesis that all pieces of a long record belong to the same population of experiments, i.e., that they have been recorded in the same environment. In this case, the accumulative mean

$$\overline{\overline{(\ )}}_m = \frac{1}{m}\sum_{i=1}^{m} \overline{(\ )}_i \tag{2}$$

should asymptotically approach a limiting or true value, $E\left[\overline{(\ )}\right]$, with increasing record length $T = m\Delta T$. This true mean deviates from the sample mean $\overline{\overline{(\ )}}_m$, by the amount $\overline{\overline{(\ )}}_m - E\left[\overline{(\ )}\right]$. If the experiment could be repeated many times, each repeated run would give a different deviation of the accumulative mean, $\overline{\overline{(\ )}}_m$, from the true mean, $E\left[\overline{(\ )}\right]$. Then the deviation should furthermore follow the χ^2 distribution. Knowing this distribution, one can express the expected statistical error of the accumulative mean by

$$E\left[\overline{\overline{(\ )}}_m - E\left[\overline{(\ )}\right]\right] = \sqrt{\frac{m-1}{m}}\ \frac{A}{\sqrt{T}}\ . \tag{3}$$

The calculation of the constant A will be treated later. The actual error might deviate from this expected error within a confidence interval, which is also given by the χ^2 distribution.

Only 10 percent of all repeated runs will show an error, which is smaller than the lower confidence level, subscript 0.1

$$\left|\overline{\overline{(\ )}}_m - E\left[\overline{(\ )}\right]\right| \leq \frac{\chi_{0.1}(m)}{\sqrt{m}} \frac{A}{\sqrt{T}} \tag{4}$$

for 10 percent of all runs. However, 90 percent of all repeated runs will show errors, which are exceeded by the upper confidence level, subscript 0.9

$$\left|\overline{\overline{(\ )}}_m - E\left[\overline{(\ )}\right]\right| \leq \frac{\chi_{0.9}(m)}{\sqrt{m}} \frac{A}{\sqrt{T}} \tag{5}$$

for 90 percent of all runs. The expected error curves might thus be summarized as:

$\frac{\chi_{0.1}(m)}{\sqrt{m}} \frac{A}{\sqrt{T}}$ lower confidence level.

$\sqrt{\frac{m-1}{m}} \frac{A}{\sqrt{T}}$ expected error of accumulative mean.

$\frac{\chi_{0.9}(m)}{\sqrt{m}} \frac{A}{\sqrt{T}}$ upper confidence level.

The functions $\chi_{0.1}(m)$ and $\chi_{0.9}(m)$ are available in statistical handbooks and are given in Table VII. The constant A has to be calculated from the actual error curves.

The present estimate of A is based on the observations that the relative deviation of the statistical error,

$$\frac{\left|\overline{\overline{(\ )}}_m - E\left[\overline{(\ )}\right]\right| - E\left[\overline{\overline{(\ )}}_m - E\left[\overline{(\ )}\right]\right]}{E\left[\overline{\overline{(\ )}}_m - E\left[\overline{(\ )}\right]\right]}$$

is practically independent of the number of pieces, m, that was used in the accumulation process. For a group of i pieces, one sample of the accumulative statistical error may be calculated directly from the deviations between the piecewise averages $\overline{(\ )}_k$ around their accumulative average $\overline{\overline{(\ )}}_i$

$$\Delta\overline{\overline{(\ )}}_i = \frac{1}{i(i-1)} \sum_{k=1}^{i} \left(\overline{(\ )}_k - \overline{\overline{(\ )}}_i \right)^2 \qquad (6)$$

where i = 2,3, ... m.

The expected value of this error is given by $\sqrt{(i-1)/i}\ A/\sqrt{i\Delta T}$, and the relative deviation between the sample $\Delta\overline{\overline{(\ )}}_i$ and this most probable error should be practically independent of the accumulation number i. The constant A, is now chosen such, that this relative deviation becomes a minimum. Choosing only the one combination of i pieces, that is available to a completely sequential data processing logic, i.e., the samples given by equation (6). The above variation principle may be expressed as:

$$\frac{\partial}{\partial A} \sum_{i=2}^{m} \left\{ \frac{\Delta\overline{\overline{(\ )}}_i - \sqrt{\frac{i-1}{i}}\ \frac{A}{\sqrt{i\Delta T}}}{\sqrt{\frac{i-1}{i}}\ \frac{A}{\sqrt{i\Delta T}}} \right\}^2 = 0 \qquad (7)$$

Carrying out the partial differentiation of equation (7) gives an algebraic equation for A. The solution of this equation gives the desired computer estimate of A:

$$A = \sqrt{\Delta T}\ \frac{\sum_{i=2}^{m} \frac{i^2\ \Delta\overline{\overline{(\ )}}_i^2}{(i-1)}}{\sum_{i=2}^{m} \frac{i\ \Delta\overline{\overline{(\ )}}_i}{\sqrt{i-1}}} \qquad (8)$$

TABLE VII

EXPECTED ERROR AND CONFIDENCE LEVELS*

(a) Expected error of accumulative mean

$$E\left|\overline{\overline{(\quad)}}_m - E\left[(\quad)\right]\right| = \sqrt{\frac{m-1}{m}}\,\frac{A}{\sqrt{T}}$$

(b) Associated confidence levels

$$\frac{\chi_{0.1}}{\sqrt{m}}\,\frac{A}{\sqrt{T}} \le \left|\overline{(\quad)}_m - E\left[(\quad)\right]\right| \le \frac{\chi_{0.9}}{\sqrt{m}}\,\frac{A}{\sqrt{T}}$$

(c) Confidence factors of χ^2 distribution

m	$\chi^2_{0.1}$	$\chi^2_{0.9}$	$\sqrt{\frac{m-1}{m}}$	$\chi_{0.1}/\sqrt{m}$	$\chi_{0.9}/\sqrt{m}$
2	0.0158	2.71	0.707	0.09	1.16
3	0.211	4.61	0.817	0.27	1.24
4	0.584	6.25	0.866	0.382	1.25
5	1.06	7.78	0.894	0.46	1.25
6	1.61	9.24	0.913	0.52	1.24
7	2.20	10.6	0.926	0.56	1.23
8	2.83	12.0	0.935	0.59	1.22
9	3.49	13.4	0.942	0.62	1.22
10	4.17	14.7	0.949	0.65	1.21
11	4.87	16.0	0.953	0.67	1.21
12	5.58	17.3	0.958	0.682	1.20
14	7.04	19.8	0.964	0.709	1.19
16	8.55	22.3	0.968	0.730	1.18
18	10.1	24.8	0.972	0.750	1.17
20	11.7	27.2	0.976	0.765	1.17
25	15.7	33.2	0.980	0.792	1.15
30	19.8	39.1	0.983	0.812	1.14
61	46.5	74.4	0.992	0.873	1.10
∞	m	m	1.0	1.0	1.0

*Computer estimate of A given by equation (8) Appendix C.

Table VII and equation (7) are being added to the programs CORFUN and MLTCOR such that the expected error curves

$$\frac{\chi_{0.1}}{\sqrt{m}} \frac{A}{\sqrt{T}} ; \sqrt{\frac{m-1}{m}} \frac{A}{\sqrt{T}} \text{ and } \frac{\chi_{0.9}}{\sqrt{m}} \frac{A}{\sqrt{T}}$$

may be added by the computer, to any accumulative error curve

$$\Delta(\overline{\overline{\quad}})_m = f(T^{-1/2}).$$