ESD-TR-66-198
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ESD-TR-66-198

Technical Note 1966-1

Amplitude Analysis Program

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29 April 1966

Prepared for the Advanced Research Projects Agency
under Electronic Systems Division Contract AF 19(628)-5167 by

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Lexington, Massachusetts

The work reported in this document was performed at Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology. This research is a part of Project DEFENDER, which is sponsored by the U.S. Advanced Research Projects Agency of the Department of Defense; it is supported by ARPA under Air Force Contract AF 19(628)-5167 (ARPA Order 600).

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

AMPLITUDE ANALYSIS PROGRAM

FLORENCE WILSON

Group 21

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ABSTRACT

The Amplitude Analysis Programs have been written to produce an average pulse shape over a reasonable time interval for up to 200 range stations behind the tracked target leading edge and a frequency distribution of cross section at each station over the time period. The final output is presented as Stromberg-Carlson 4020 plots of average pulse and distributions. The input is obtained by digitizing A-Scope films on the Group 21 High Precision computer controlled film reader, filtering this data with a ramp filter to locate the position of the tracked target leading edge, and then writing a tape containing only that data behind the leading edge.

The Amplitude Frequency Distribution and Statistical Program uses this filtered output tape and computes an average pulse and the standard deviation from this pulse at each desired range station over a given time interval and also finds the distribution of cross section at each range station, if desired. A tape containing this information is then used as input to the Amplitude Plotting Program which produces the Stromberg-Carlson 4020 plots.

The present report contains a summary of the method of obtaining the input data, the mathematics involved, a description and listing of the two programs, and directions for running the programs.

Accepted for the Air Force
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Chief, Lincoln Laboratory Office

I. INTRODUCTION

The Amplitude Analysis Programs have been designed to produce an average pulse shape over any reasonable time interval for up to 200 range stations along a filmed trace. The frequency distribution of the radar backscattering cross section at each range station over the selected time period is also available. The input data is obtained from the digitization of filmed A-Scope data, obtained from the Wallops Island Trailblazer experiments, on the Group 21 High Precision computer controlled film reader. This data is subsequently filtered using a ramp filter to obtain positions behind the tracked target leading edge before being entered into the present program. The outputs are in the form of plots of average pulse shape and of frequency distributions of radar cross section at each range station.

II. FILM TRACE DIGITIZATION

The Amplitude Frequency Distribution and Statistical Program accepts a digital definition of points along a filmed trace. The Group 21 High Precision computer controlled automatic film reader is used to digitize, pulse-by-pulse, sets of simultaneous traces from A-scope films. Figure 1 shows a sample film to be digitized. The missing trace seen in the second channel corresponds to the moment of recording a time mark (see channel 3). Each trace will produce approximately 200 points. The Y axis of the film reader is visually aligned with the range direction of the traces so that points of common Y as read by the reader can be considered to be points of common range for each trace in the set. The traces consist of either quadrature pairs or independent amplitude recordings.

The output of the film reader program is first processed by the "Filter" program which serves to edit the data and to perform a range tracking function in identifying the position of the leading edge of the tracked target. This computer tracking by means of the pattern recognition of a pulse and the identification of the leading edge compensates for jitter present in the automatic range tracker servo system of the radar. The program must establish a zero deflection reference for each trace based only on the data describing that individual trace. The pulse return generally fills only a small fraction of the length of a trace. Therefore, the mode of the distribution of the amplitude values of each trace is separately calculated. This mode is used as the zero reference from which the amplitude and polarity for each point of that trace are computed. Thus the data are self-fiducialized.

The "Filter" program is used to obtain the leading edge of the tracked target. The amplitude is first computed either directly from amplitude data or by translating the bipolar quadrature data to a unipolar amplitude function by summing the squares of the deflection amplitudes of the common range points. The amplitudes are then smoothed using a ramp filter in order to emphasize the leading edge of a target pulse and to reduce the effect of erroneous readings caused by dirt and scratches on the film. The filtered function is then sliced with an experimentally determined amplitude level in order to locate the position of the tracked target leading edge. The program then outputs the corrected data for this leading edge position and all subsequent increments. In this way returns from identifiable range stations with respect to the leading edge of the tracked target may be correlated on a pulse-by-pulse basis.

The output from the Filter program is an 800 bit per inch packed binary tape, (Fig. 2). The first record in each file is the BCD title from the input (film reader) tape. Each succeeding record contains the data for one pair of traces. The first word in each record is a time code, the first 18 bits giving the time block number and the last 18 giving the number of the current trace set within that time block. Since a time trace occurs, in general, once every 48 traces (0.05 sec.) the time code will be interpreted as 0-0, 0-1, 0-2, ... 0-47, 1-0, 1-1, ... 1-47, etc. When running data it is usual to start on a time trace i.e. a trace whose second code word is 0 (for example, 0-0, 1-0, 2-0, 3-0, etc.). The second word of the record contains a count of the remaining words in the record (i.e. the number of recorded points behind the pulse leading edge). The third and fourth words are not used by this program. The remaining words in each record are each divided into two half-words (18 bits): the first half-word contains channel one information; the second half-word contains channel two information. In the case that only one channel was filtered, the second half-word in each case would be zero. The Amplitude Frequency Distribution and Statistical Program is equipped to unpack these words and assemble them in usable form.

III. RADAR CALIBRATION

The radar system is calibrated immediately before and after each test. The entire system is calibrated by injecting calibrated test signal amplitudes into the radar receiver and comparing these locally generated calibration signals with the signal amplitudes returned from a precision metallic sphere of known cross section located at known distances from the radar. The precision sphere is carried aloft by a balloon of negligible radar cross section.

This sphere and signal-generator calibration enables the use of a simplified radar equation:

$$P_R = K\ \sigma/R^4 \tag{1}$$

where

P_R	-	power received in milliwatts
R	-	range in nautical miles
σ	-	radar cross section in square meters
K	-	radar coefficient in (nautical miles)^4 milliwatts/meter^2

Enough information is obtained from this sphere and signal-generator combination to determine the radar system coefficient K relating radar backscattering cross section to slant range and signal-generator calibrations. The constant K can then be used to compute cross sections for other targets whose ranges and received signal amplitudes are known.

The calibrated signal is also recorded on the film at specified power increments between -50 and -115 dbm. These calibration pulses are read on the High Precision automatic film reader and the peak displacement from baseline at each power level is recorded. A calibration curve is obtained showing power in dbm as a function of displacement from baseline. A sample calibration curve is shown in Fig. 3. A table of values of power in dbm vs. amplitude displacement in film reader units is entered into the Amplitude Frequency Distribution and Statistical Program to be used in calibrating the data.

IV. MATHEMATICS

The Amplitude Frequency Distribution and Statistical Program is designed to produce an average cross section over a given time interval as a function of range station behind the leading edge of the tracked target and a frequency distribution of the cross section for each individual station.

The raw amplitude data (either entered directly as amplitude from the input tape or computed as the square root of the sum of the squares of the quadrature data) is first changed to cross section in db/m^2 by the formula:

$$\sigma(db) = 40 \log R - K(db) + DBM \tag{2}$$

where

$\sigma(db)$	-	radar backscattering cross section in db relative to one square meter, (db/m^2).
R	-	radar slant range in nautical miles.

K (db) - radar coefficient in db

DBM - received signal power as determined from the scaled calibration.

Then the cross section in square meters is found by:

$$\sigma \text{ (square meters)} = 10^{\sigma(\text{db})/10} \tag{3}$$

The statistical analysis is performed on the cross sections in square meters to give an average pulse and the standard deviation from that pulse at each station. The average pulse is computed by the equation

$$\bar{\sigma} \text{ (square meters)} = \frac{\sum_{i=1}^{N} \sigma_i \text{ (square meters)}}{N} \tag{4}$$

where N is number of points over which averaging is performed. The standard deviation is then calculated as

$$\text{s. d.} = \sqrt{\frac{\sum_{i=1}^{N} (\sigma^2)_i}{N} - \bar{\sigma}^2} \tag{5}$$

Any signal found to lie above the calibration curve is omitted from the statistical analysis since its true power value can not be determined; any signal lying below the calibration is considered as noise and is arbitrarily set equal to the value of the minimum discernible signal, (MDS).

After the average and standard deviations have been computed at each station on the cross section in square meters, they are converted back to db/m^2 for plotting.

A frequency distribution may also be taken for each range station and plotted if desired. This distribution is found by simply selecting boxes of suitable width for cross section in db/m^2 and counting the number of points at each station which fall into each box.

V. DESCRIPTION OF THE AMPLITUDE FREQUENCY DISTRIBUTION AND STATISTICAL PROGRAM

A. General

The Amplitude Frequency Distribution and Statistical Program is written in Fortran II for the IBM 7094 computer and is presented in Appendix A. The program uses as input the packed binary tape containing the digitized traces produced by the "Filter" program. The major output is a BCD 800 bit per inch tape containing a description of the average pulse cross sections, the average pulse ± one standard deviation, and a frequency distribution of cross section for each individual station, all in db/m^2. This tape is used as input to the Amplitude Plotting Program (see Section VI.). Numerical values for the average cross section and standard deviation in square meters and in db/m^2 at each station are also recorded on the monitor tape.

The program is designed to handle up to 200 range stations per trace and can take a distribution over up to 100 distribution boxes. The program is designed to make maximum use of the limited core storage area remaining. A generalized flow chart of the program appears in Fig. 4. The current record is first read from the input tape and converted to amplitude in film reader units by the proper subroutine depending on whether it is desired to process channel one alone, channel two alone, or both channels as quadrature data. A calibration is applied to convert the amplitude in film reader units to cross section in square meters. A running summation of cross section and of cross section squared at each station is computed up to the current record. The cross section is then converted back to db/m^2 and counted in the proper distribution box for that value of cross section at that station. The next record is then read in and the procedure repeated until all the traces to be processed in the current set have been read.

When all the traces to be processed in the present set have been read into the computer, the sum of the cross sections and the sum of the cross sections squared for each station have automatically been computed. At this time it remains only to compute average cross section at each station (Eq. 4) in square meters and standard deviation at each station (Eq. 5). The average and the average ± one standard deviation are then computed and converted to db/m^2; a form more suitable for plotting. Pertinent data is written on the monitor tape and the averages and averages ± one standard deviation at each station are written on the plotting tape. The frequency distribution for each station is also written on the plotting tape at this time.

After the tapes have been written for the current set of data, the program will cycle back and begin to process the next set as above. If this next set is to be independent of the previous set, the counters are cleared and the program re-run with all new data. If it should be desired to take the statistics over a longer time interval, the counters are not cleared at this time and the next set of data is simply added to the previous set. The total number of traces to be averaged is limited only by possible overflow of the summation counters.

B. Subroutines

The Amplitude Frequency Distribution Program contains 7 Fortran II subroutines. Subroutine AMPDA1 will unpack and compute amplitude in film reader units using channel one data only. Subroutine AMPDA2 will unpack and compute amplitude using channel two data only. Subroutine QUAD will compute amplitude using both channels as quadrature data from the formula

$$A = (A^2 \sin^2 \theta + A^2 \cos^2 \theta)^{1/2}$$

where channel one is assumed to contain A sin θ and channel two contains A cos θ (or their equivalent in polarized amplitude data).

Subroutine DBCOM calibrates the data i. e. substitutes cross section in square meters for the given amplitude in film reader units. If the given value lies above the calibration curve, it is omitted from the analysis since no exact measure of its power can be found. If it lies below the curve, the power is arbitrarily set to MDS for that point. A count of the points lying above and below the curve at each station is kept and printed out on the monitor tape. A linear interpolation is used to find power corresponding to amplitudes lying between given points in the table. The cross section in square meters is then computed by Eqs. (2) and (3). Note: since for ease in punching, the - DBM's of the calibration are read in as positive numbers, Eq. (2) must be rewritten as

$$\sigma\,(\mathrm{db}) = 40 \log R - K\,(\mathrm{db}) - (-\mathrm{DBM})$$

Subroutine ADSTAT simply computes the sums of the cross sections and cross sections squared up to the current pulse for each station ignoring any point lying above the calibration curve.

Subroutine FREQCT changes cross section back to db/m^2 and adds the proper additive factor to obtain a positive number. The program checks to make sure that the value lies within the limits of the boxes (i. e. between STBLOK and ENBLOK). If the value lies outside these limits, a special code counter is set. If the value lies within the limits, the count in the proper box is incremented by 1 so that when all traces of the set have been processed, each box will contain the frequency of values lying within that box.

Subroutine STAT computes the average and standard deviation at each station over the desired time interval. The number of points to use is first determined by subtracting out the number of values lying above the calibration curve at this station from the total number of traces used in this set. The program is ended here if any overflow has occurred in the counters. Averages and standard deviations at each range station are calculated by Eqs. (4) and (5).

The program also uses several FAP subroutines.

Subroutine SKIP will skip NSKIP records within one file on the input tape (A8) either forward if NSKIP is positive or backward if NSKIP is negative.

Subroutine READA will read the next binary record from the A8 tape and will unpack the time code and the number of data points in the record.

Subroutine UNPAK is used to unpack the data words which consist essentially of two 18 bit words packed as one 36 bit word. The first 18 bits are stored as a channel one reading into IX1 and the last 18 bits are stored as a channel two reading into IX2.

C. Outputs

The following computed outputs are written on the monitor tape (A3) for each range station.

1. Range station number.
2. Average cross section in square meters.
3. Standard deviation in square meters.
4. Average cross section in db/m^2.
5. Average cross section + 1 standard deviation in db/m^2.
6. Average cross section -1 standard deviation in db/m^2.
7. Number of points used in analysis.
8. Number of points lying above calibration curve.
9. Number of points lying below calibration curve.

The number of points lying outside the limits of the distribution boxes and the value of the lowest cross section in square meters, corresponding to MDS are also recorded on the A3 tape.

The other output tape (B7) is written at 800 bits/inch BCD and contains the average cross section at each range station and the average cross section ± 1 standard deviation all in db/m^2. If desired it will also contain the frequency distribution of cross section in db/m^2 at each station. The tape contains the following information:

I. Frequency distributions consisting of one group of data for each station as follows:

Record 1 and 2	Titles to print on plots.
Record 3	MDS for this time interval.
Record 4	Average cross section in db/m^2 for this station.
Records 5 - end	Value of cross section in middle of distribution box and frequency of points in that box for each of the EN boxes. Format (1 H - 12 F 10. 3). Each record thus contains values for 6 boxes.

Data for the next station follows directly in the same format until all stations have been recorded.

II. Average Pulse Cross Section

Each time interval will have one set of records giving the computed statistical data as follows:

Record 1 and 2	Titles to print on plots.
Records 3→. . . .	Each record will contain data for 1 station in the form: Station number. Average in square meters. Standard Deviation in square meters. Average in db/m^2.

Average + 1 standard deviation in db/m^2.

Average - 1 standard deviation in db/m^2.

Number of points used in analysis.

Number of points above calibration curve.

Number of points below calibration curve.

Format (1H - I5, 5F12.5, I5, 2I4)

After sets I and II have been written for the current time interval, the same data for the next time interval will immediately follow on the tape. If no frequency distribution was taken, only II (the average pulse cross section data) will appear on the tape. Figure 5 shows a sample diagram of the arrangement of data on the B7 tape.

VI. THE AMPLITUDE PLOTTING PROGRAM

The Amplitude Plotting Program is designed to produce plots of the frequency distributions and average pulses obtained from the Amplitude Frequency Distribution and Statistical Program. The Plotting Program has been written in the Fortran IV language and is run under the IBSYS monitor. The plots are produced on the Stromberg-Carlson 4020 plotter and are available either as hard copy or film. A flow chart of the program is shown in Fig. 6; a program listing is given in Appendix B.

Figures 7a and 7b are sample frequency distribution plots. It will be seen that the data from two stations are plotted in each frame and that the titles at the top of the frame identify the data. MDS level for the time interval is shown on each plot and the average signal for the given range station is indicated. The distributions are plotted showing number of cases in the box (or frequency) as ordinate as a function of cross section in db/m^2 at the middle of the box, as abscissa.

Figure 7a demonstrates the case where the cross section distribution ranges over a wide set of values corresponding to a large standard deviation whereas 7b demonstrates the case where the distribution is much more compact corresponding to a small standard deviation. The peak at MDS in each case is influenced by the arbitrary cut-off point at the lower end of the calibration curve below which all data is considered to be noise and set arbitrarily to MDS level.

Figure 8 is a typical plot of the average pulse cross section taken over a 0.1 sec. interval. The value of cross section in db/m^2 is plotted as ordinate against range station number as abscissa. The circles indicate the position of the average cross section taken over this time interval at the indicated station. The bars indicate the position of average ± one standard deviation. The standard deviation is not symmetric about the average when plotted on the db/m^2 scale since the original statistics were performed on cross section in square meters and were merely changed back to db/m^2 for ease in plotting. Thus, although one standard deviation is symmetric about the average in the original calculation, it is not symmetric on the logarithmic scale of the plots. The bottom of the standard deviation is arbitrarily cut-off at MDS if it extends below this level.

VII. OPERATING PROCEDURES FOR THE AMPLITUDE FREQUENCY DISTRIBUTION AND STATISTICAL PROGRAM

The Amplitude Frequency Distribution and Statistical Program is run under the FORTRAN monitor. The input tape is the 800 bit/inch binary output tape from "FILTER" and is mounted on A8. If a tape is to be made for plotting frequency distributions or average pulses, a blank tape must be mounted on B7 and set to 800 bit/inch. This tape will be kept and used as input to the Amplitude Plotting Program. The program and control data input is from A2 and the monitor tape is A3. Two versions of the Amplitude Frequency Distribution and Statistical Program have been written. Version I is the program described above. Version II is a simplified version of the program which may be used whenever all the variables in the program remain constant for all sets of data and where it is desired to process only sequentially in time, i.e. whenever it is desired to run one time interval and then run the next set by repeating the last time trace and processing the next sequential time interval immediately. The counters are cleared at this time so that each set must be independent of the previous set. The actual functioning of the program is identical for both versions; Version II is usually used for production work to save time in punching data cards.

The control cards for the two versions of the program are made out as follows:

Control Cards: Version I

I. The first card following the "*DATA" card will contain 6 fixed point numbers [Format (6I5)]

Name	Description	Columns
NSET	The number of sets of data to follow. Each set will give a complete analysis of any time interval desired. Up to 100 sets of data may be run at one time: however, each set must be in the same file on the input tape.	1-5
IFB7	A code telling if averages and deviations are to be written on B7 tape = 1 if averages and deviations are to be written = 0 if they are not to be written	6-10
NOFILE	Number of initial files on the A8 input tape to skip before beginning processing---NOFILE = 0 for first file; NOFILE = 1 for second file, etc. Usually only one file is on each tape so that NOFILE = 0.	11-15

Name	Description	Columns
IFPLOT	Code to tell if frequency distribution is to be computed and written on B7 = 1 if distribution to be written = 0 if distribution not to be written	16-20
IXIN	Granularity of original film reader data word---usually IXIN = 4---the film reader could digitize data to 4000 counts per inch but because of resolution considerations only 1000 counts per inch were usually utilized.	21-25
IFCAL	Number of points in calibration table = 0 if no calibration to be used. = number of points in table if calibration to be performed---$0 < \text{IFCAL} \leq 50$ if calibration desired.	26-30

The second data card will be a title card punched as follows:

Col. 1	must contain a blank.
Col. 2-5	contains the experiment identification number (ex. A223).
Col. 6-7	must be blank.
Col. 8-72	any title desired to follow the time on the output tape title---usually starting off as (in Col. 8): "sec. data---".

The third data card will contain 9 constants to be used throughout all sets [Format (10F7.5)] Decimal points will be punched.

Name	Description	Columns
XMULT	Multiplicative factor for channel two.	1-7
XADD	Additive factor for channel two.	8-14
YMULT	Multiplicative factor for channel one.	15-21
YADD	Additive factor for channel one.	22-28
AKLOG	Radar constant K, in db (N. M.^{4} mw/m^2)	29-35
STBLOK	Minimum value for distribution boxes ---STBLOK ≥ 0.	36-42
ENBLOK	Maximum value for distribution boxes.	43-49
EN	Number of distribution boxes. (EN $\leq$ 100)	50-56
CONTPL	Additive constant to make all cross section values in db/m^2 positive for the distribution determination.	57-63

The next set of cards will have ranges punched on them (one for each set to be analyzed). 10 to a card--[Format (10F7. 0). Decimal points will be punched. The ranges will be obtained from a graph of range vs. time or from the output of the Willmann - Wallops program. Ranges will be in kilofeet.

The next group of cards will contain the calibration, if one is to be used. They will be punched 10 numbers per card--[Format (10F7. 5)]. Starting with the first card of the group they would be punched

amplitude 1	1-7
-dbm 1	8-14
amplitude 2	15-21
-dbm 2	22-28
amplitude 3	29-35
-dbm 3	36-42

amplitude 4	43-49
-dbm 4	50-56
amplitude 5	57-63
-dbm 5	64-70

Decimal points must be punched. The first amplitude recorded will be the lowest (highest -dbm) and the last will be the highest amplitude (lowest -dbm).

II. Following these control cards which are fixed for the entire run, will follow NSET sets of data cards of 2 cards each as follows:

Card 1 of the set will contain 8 fixed point numbers---Format (14I5).

Name	Description	Columns
N	Number of pulses to process (as many as desired).	1-5
M	Last station per pulse to process ($1 \leq M \leq 200$)	6-10
NSKIP	Number of initial records to skip on the A8 input tape (forward or back). To start at the beginning of the file NSKIP = 0.	11-15
IFCLER	Code telling whether to clear the frequency counters and sums at start of current set = 1 if desired to clear counters = 0 if desired not to clear counters (in general, the counters will be cleared at the start of a set---however, it may be desired to continue averaging over a longer time interval in which case they would not be cleared. For example, to compute the series 390.0 - 390.1, and then 390.0 - 390.2 the counters would not be cleared for the second set).	16-20

Name	Description	Columns
NPT1	Number of first station to process.	21-25
INT	Interval between stations to process. i. e. INT = 1 if every station is to be processed; INT = 2 for every other station, etc.	26-30
IFSTAT	Code telling if averages and standard deviations to be computed. = 0 if they are not to be computed. = 1 if they are to be computed.	31-35
IFQUAD	Code telling what type input is to be used = - 1 if only channel one to be processed. = +1 if only channel two to be processed. = 0 if both channels to be processed as quadrature data.	36-40

The second card of the set will contain 2 numbers [Format (2F10. 5)] Punch decimal point.

Name	Description	Columns
TMI	Initial time in seconds for set.	1-10
DTM	Interval in time in seconds over which Distribution taken (usually DTM = 0. 1).	11-20

Version II has been written to make the program as simple as possible to run on a production basis. This version can be used whenever the constants do not change within a run and the data is to be run in sequential time order.

Version II requires the following data cards.

Card 1: Format (14I5)

Name	Description	Columns
NSET	Number of sets of data to process. Each will give a complete analysis of the time interval desired. Up to 100 sets of data may be run at one time but must be sequential in time as described above.	1-5
IFB7	Code telling if averages and deviations to be written on B7 tape. = 1 if averages and deviations to be written = 0 if they are not to be written	6-10
IFQUAD	Code telling what type input is to be used = -1 if only channel one to be processed. = +1 if only channel two to be processed. = 0 if both channels to be processed as quadrature data.	11-15
NOFILE	Number of initial files on the A8 input tape to skip before beginning processing---NOFILE = 0 for first file; NOFILE = 1 for second file, etc.	16-20
IFPLOT	Code to tell if frequency distribution to be computed and written on B7. = 1 if distribution to be written. = 0 if distribution not to be written.	21-25

Name	Description	Columns
IXIN	Granularity of original film reader data word---usually IXIN = 4---the film reader could digitize data to 4000 counts per inch but because of resolution considerations only 1000 counts per inch were usually utilized.	26-30
IFCAL	Number of points in calibration table. = 0 if no calibration to be used. = number of points in table if calibration to be performed ---$0 < IFCAL \leq 50$ if calibration to be used.	31-35
N	Number of pulses to process (as many as desired).	36-40
M	Last station to process per pulse ($1 \leq M \leq 200$)	41-45
NSKIP	Number of initial records to skip on input tape A8---can only skip records before the first set for this version.	46-50
IFCLER	Must be +1 in this version as counters must be cleared.	51-55
NPT1	Number of first station to process.	56-60
INT	Interval between stations to process, i. e. INT = 1 to process every station; INT = 2 for every other station, etc.	61-65

Name	Description	Columns
IFSTAT	Code telling if averages and standard deviations to be computed. = 0 if not to be computed. = 1 if they are to be computed.	66-70

Card 2 will be a title card punched as follows:

Col. 1	must contain a blank.
Col. 2-5	contain the experiment identification number (A223 for example).
Col. 6-7	are blank.
Col. 8-72	any title desired to follow the time on the output---usually starting off in Col. 8 with the words "sec. data---".

Card 3: [Format (2F10. 5)] Punch decimal points.

initial time of run, in seconds.	1-10
interval in time in seconds over which to take distribution (usually = 0. 1).	11-20

Card 4: [Format (10F7. 5)] Punch decimal points.

Name	Description	Columns
XMULT	Multiplication factor for channel two.	1-7
XADD	Addition factor for channel two.	8-14
YMULT	Multiplication factor for channel one.	15-21
YADD	Addition factor for channel one.	22-28
AKLOG	Radar constant K in db (N. M.^{4} mw/m^2)	29-35

Name	Description	Columns
STBLOK	Value of minimum distribution box ($0 \leq$ STBLOK).	36-42
ENBLOK	Maximum distribution box.	43-49
EN	Number of boxes (EN $\leq$ 100).	50-56
CONTPL	Additive constant to make all values of cross section in db/m^2 positive for the distribution determination.	57-63

The next group of cards will have ranges punched on them (one for each set computed). They will be punched 10 to a card in Format (10F7.0). Decimal points will be punched. The ranges will be obtained from a graph of range vs. time for each 0.1 sec. interval or from the output of the Willmann - Wallops Program. Ranges will be in kilofeet.

The last set of cards will contain the calibration used. They will be punched as follows 10 numbers per card in Format (10F7.5) starting with the first card.

amplitude 1	1-7
-dbm 1	8-15
amplitude 2	15-21
-dbm 2	22-28
amplitude 3	29-35
-dbm 3	36-42
amplitude 4	43-49
-dbm 4	50-56
amplitude 5	57-63
-dbm 5	64-70

The first amplitude recorded will be the lowest (highest -dbm) and the last will be the highest amplitude (lowest -dbm).

VIII. OPERATING PROCEDURE FOR AMPLITUDE PLOTTING PROGRAM

The Amplitude Plotting Program will plot the frequency distributions and the average pulses on the Stromberg-Carlson 4020. It uses as input the B7 tape obtained from the Amplitude Frequency Distribution and Statistical Program (which will be mounted on B7) and produces as output a 4020 tape on B6. The program is run under IBSYS.

Input consists of two cards for each set of data with common constants (usually the entire run may be made without changing constants).

Card 1: Format (5I5)

Name	Description	Columns
MM	Number of time intervals to process.	1-5
NBLOK	Number of boxes over which distribution was taken.	6-10
M	Number of stations per time interval to plot. ---if not every station is processed, M here is only the number of *actual* stations run and *not* the last station run.	11-15
IFFREQ	= 0 if frequency distribution to be plotted = 1 if distribution not to be plotted and does not exist on the input tape. = -1 if no distribution is to be plotted but the distribution *has* been written on the input tape.	16-20

Card 2: Format (14F5.0) Punch decimal points.

Name	Description	Columns
XMINFR	Minimum limit of distribution boxes (minimum abscissa) in db/m^2.	1-5
XMAXFR	Maximum limit of distribution boxes (maximum abscissa) in db/m^2.	6-10
DXFR	Increment for tic marks on x axis of distribution in db/m^2.	11-15
YMAXFR	Maximum frequency to plot (for 0.1 sec. intervals YMAXFR = 100) (maximum ordinate).	16-20
DYFR	Increment for tic marks on y axis of distribution.	21-25
XMINA	Minimum x scale value, minimum station number, for average pulse plot---usually XMINA = 0.	26-30
XMAXA	Maximum x scale value, maximum station number, for average pulse plot.	31-35
DXA	Increment in x axis tic marks for average pulse plot.	36-40
YMINA	Minimum y scale value in db/m^2 for average pulse plot.	41-45
YMAXA	Maximum y scale value in db/m^2 for average pulse plot.	46-50
DYA	Increment in y axis tic marks in db/m^2 for average pulse plot.	51-55

The program will produce the frequency distributions of two stations per frame. Hence, if the number of stations (M) is even, the frequency distributions will occupy M/2 frames per time interval. If M is odd, they will occupy M/2 + 1 frames (since the extra station must be plotted somewhere). Also, there is a title frame and an average pulse frame for each time interval. Thus, the total number of frames required should be (if frequency distributions are plotted):

For M even - number of frames = MM (M/2 + 2)

or

For M odd - number of frames = MM (M/2 + 3)

If only average plots are to be plotted, there will be only MM frames.

3-21-6790

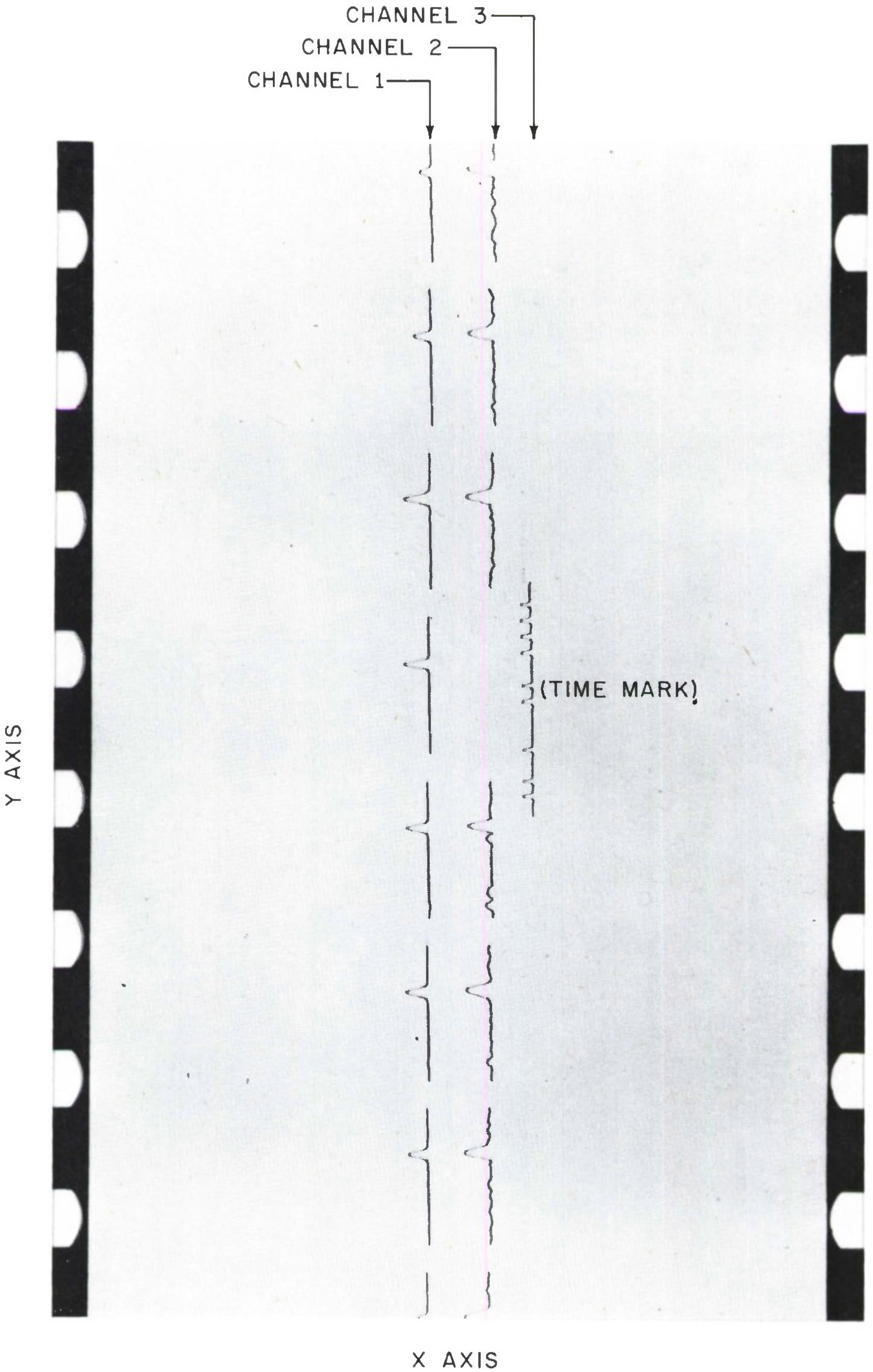

Fig. 1. Sample A-Scope Film.

3-21-6791

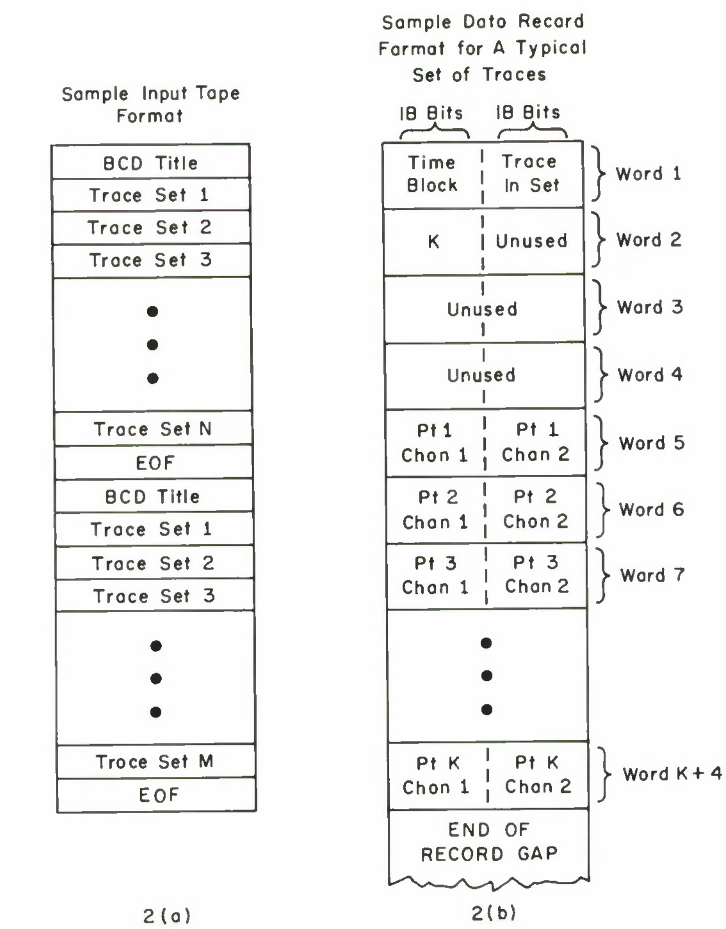

Fig. 2. Sample Input Tape Format.

3-21-6795

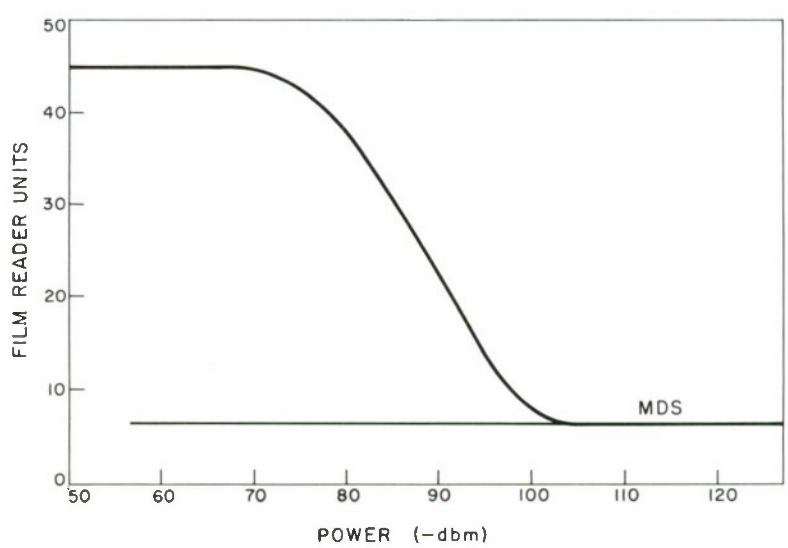

Fig. 3. Typical Calibration Curve Relating Power in -DBM to Amplitude in Film Reader Units.

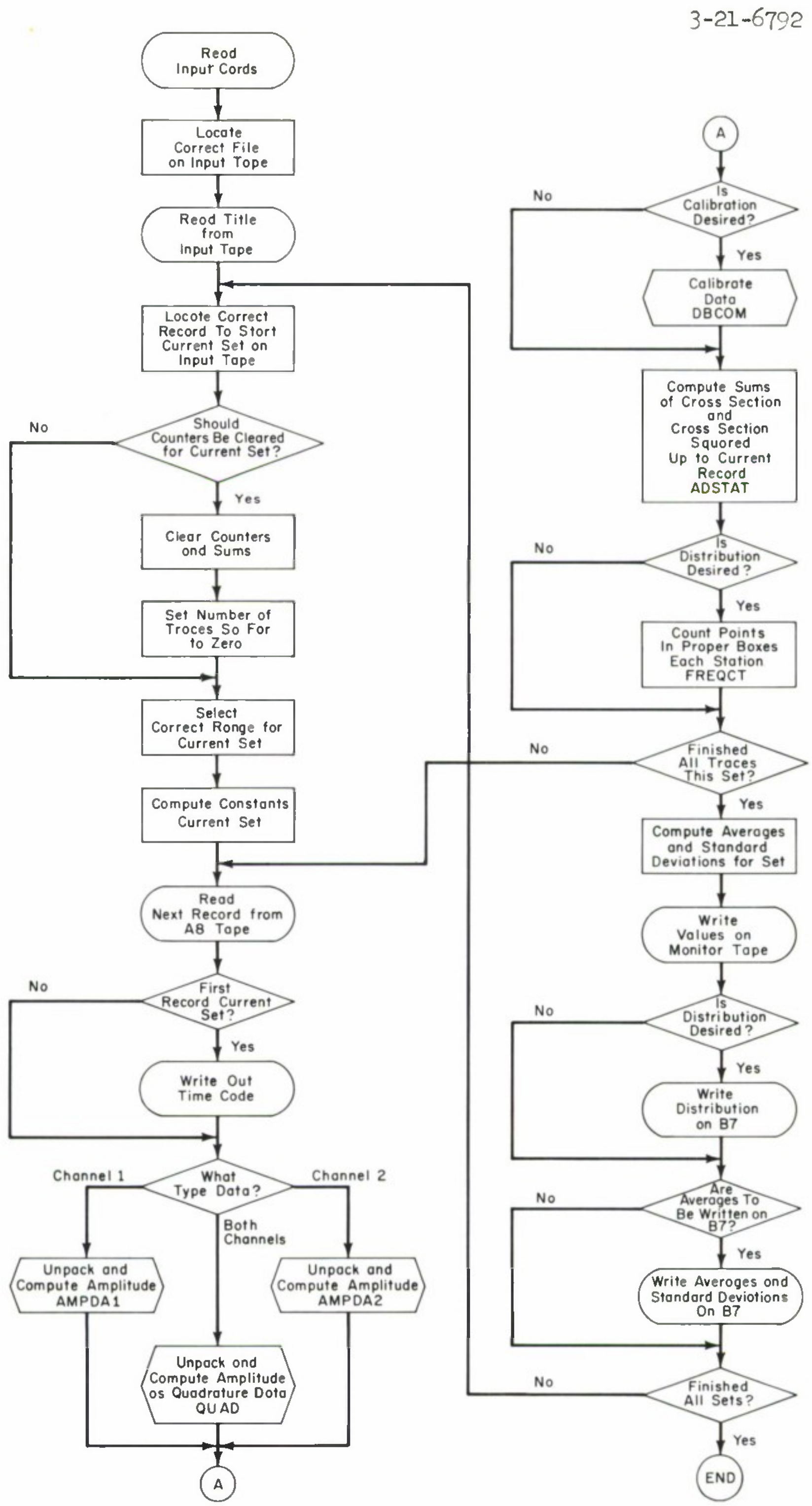

Fig. 4. Flow Chart of Amplitude Frequency Distribution and Statistical Program.

3-21-6794

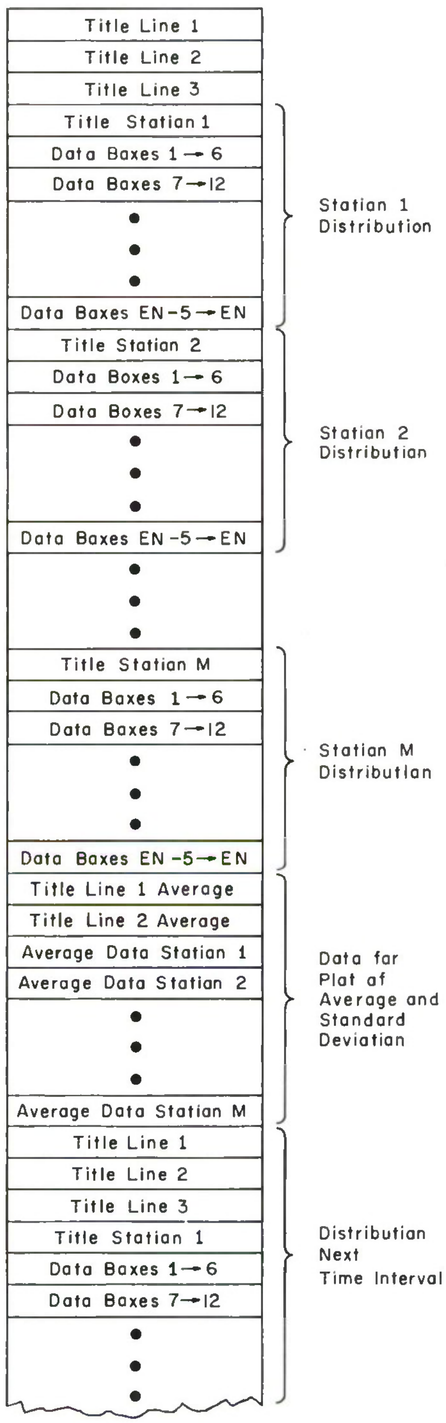

Fig. 5. Sample Output Tape Format.

3-21-6793

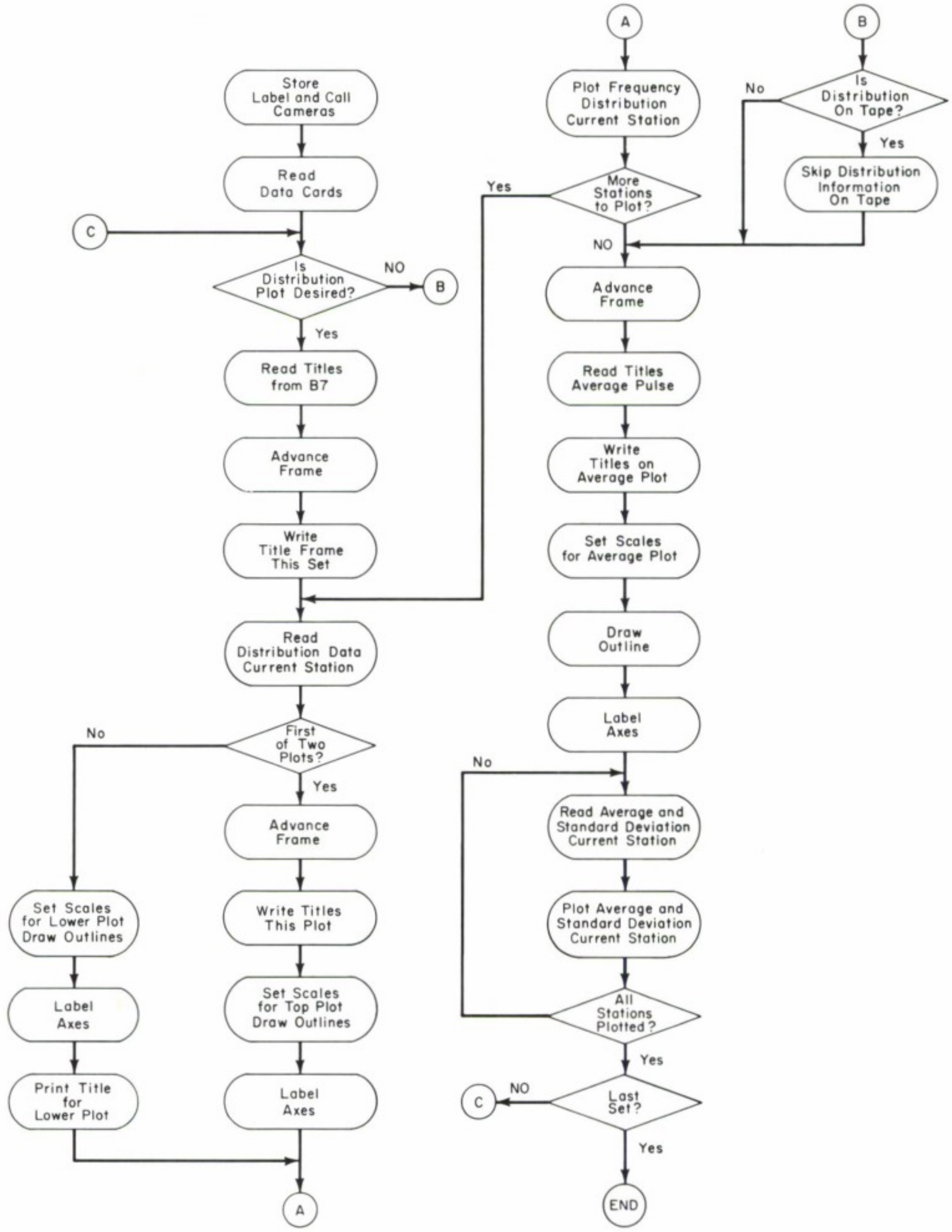

Fig. 6. Flow Chart of Amplitude Plotting Program.

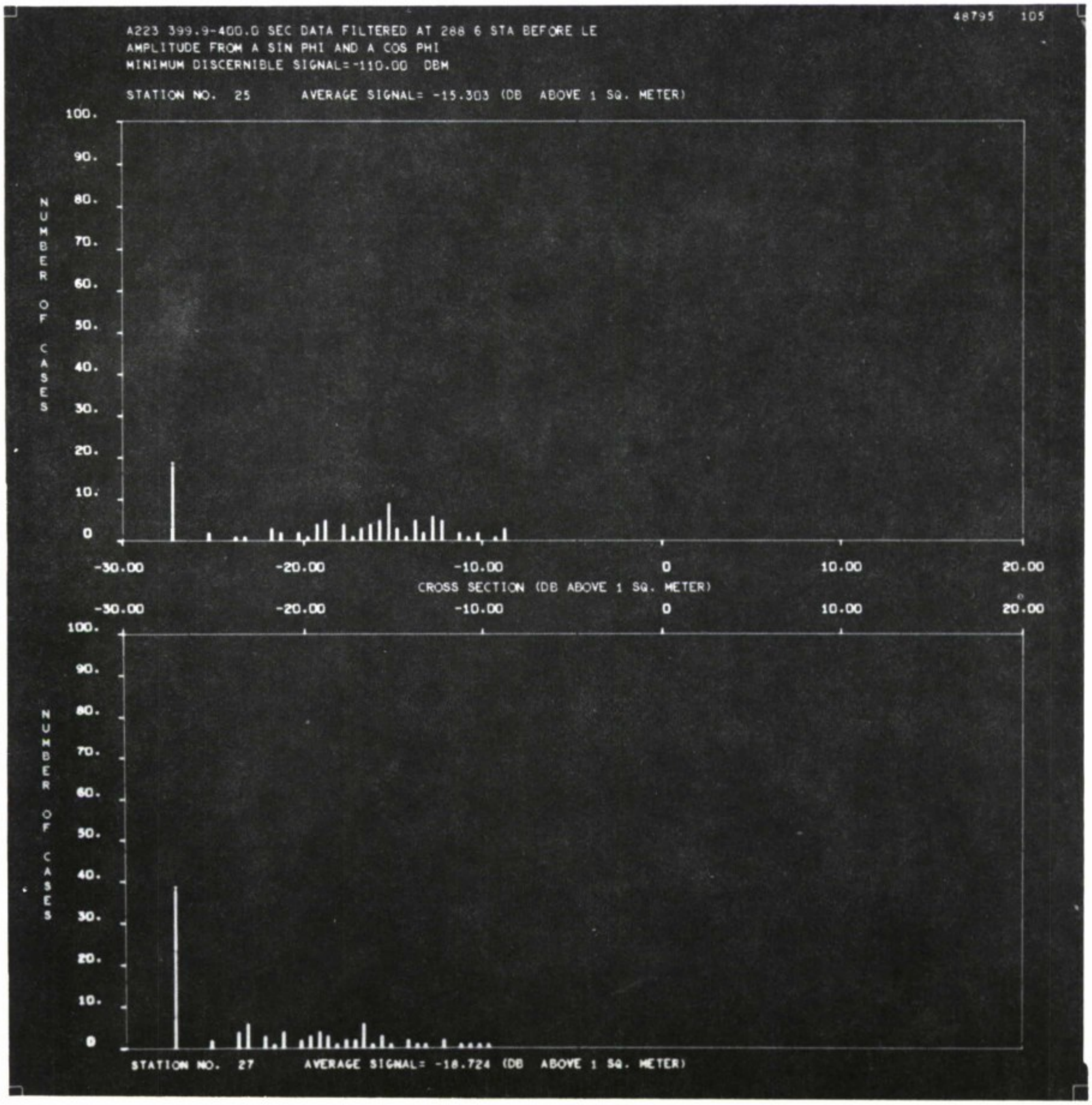

Fig. 7(a). Sample Frequency Distribution with Large Standard Deviation.

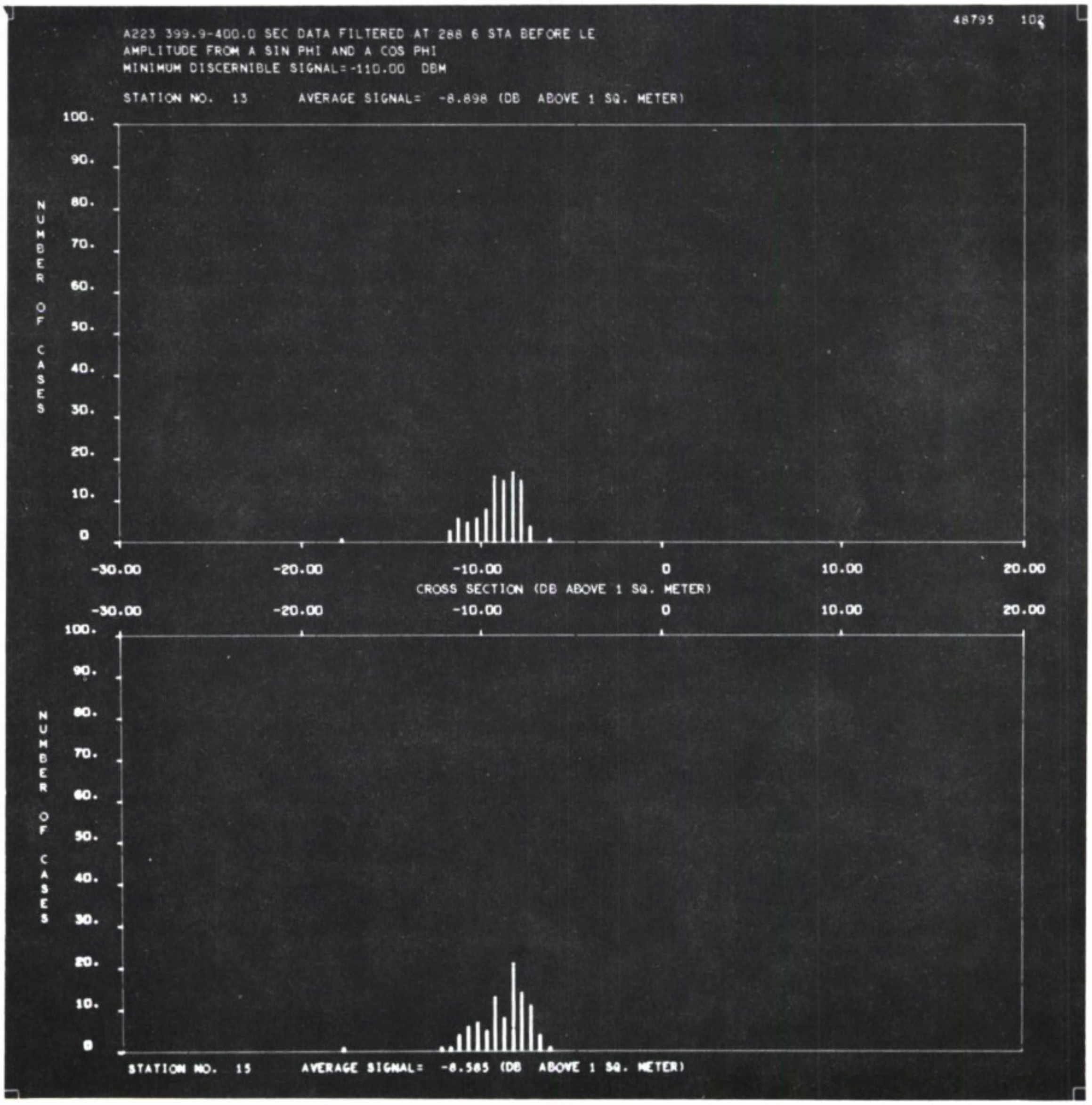

Fig. 7(b). Sample Frequency Distribution with Small Standard Deviation.

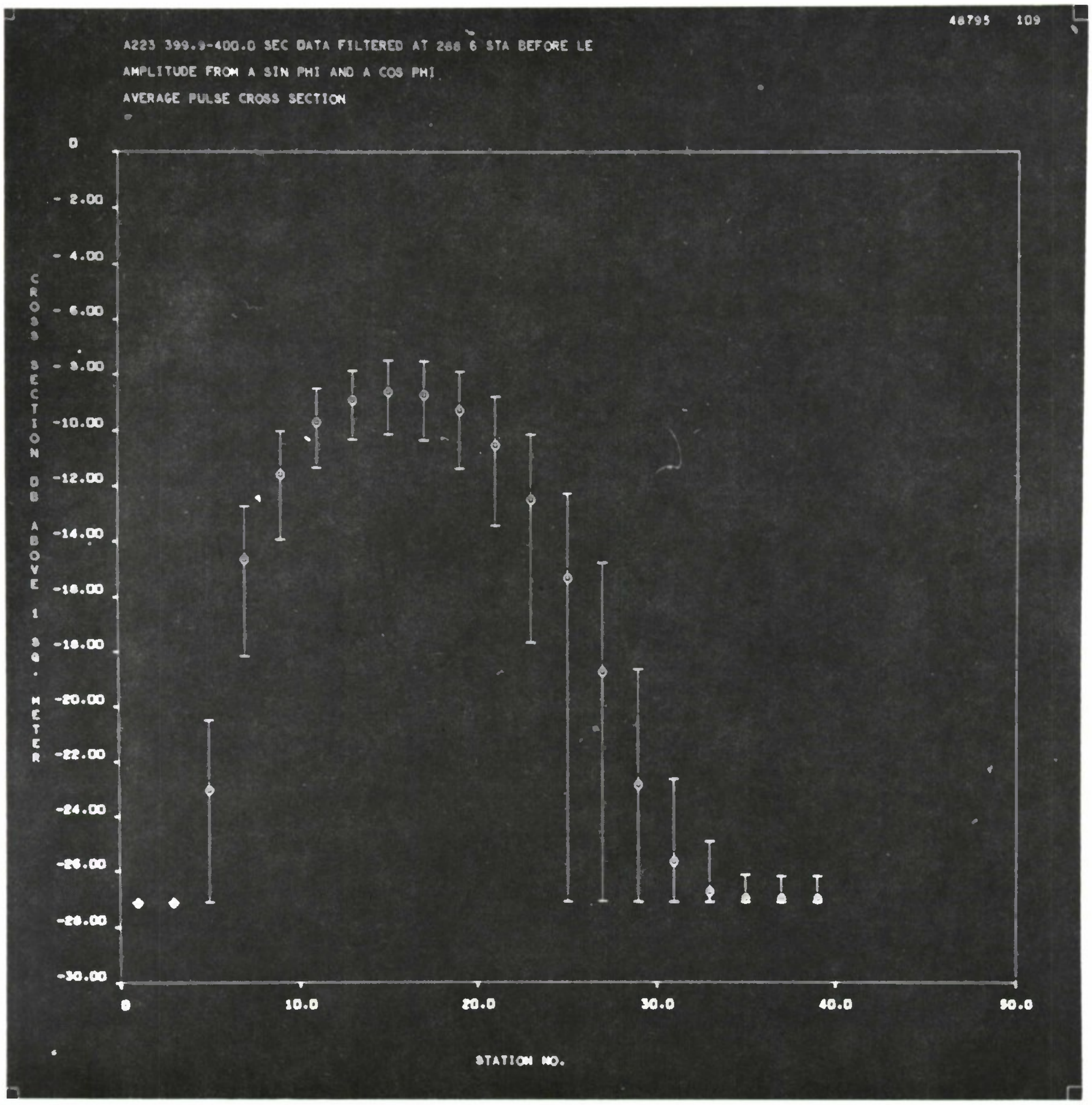

Fig. 8. Sample Plot of Average Pulse Cross Section Showing One Standard Deviation of Either Side of Average.

APPENDIX A

```
*      WILSON,FLORENCE  AMPLITUDE PROGRAM VERSION 1  11/5/65
*      LIST
*      LABEL
*      SYMBOL TABLE
C
C              DIMENSION STATEMENTS
       DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
      1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSO(200)
       DIMENSION AVDBM(200),AVDBP(200),AVDB(200),X1(200),X4(200)
       DIMENSION TITLE(12),RNG(100)
C              COMMON STATEMENTS
       COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
      1,ANUM,CONTPL,NCAL,CONLOG
       COMMON XMULT,XADD,YMULT,YADD  ,AMPLOW,DBLOW,AMPHI,DBHI
       COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C              FORMAT STATEMENTS
  197  FORMAT(12A6)
   98  FORMAT(6H TIME=I5,3X,I5)
   99  FORMAT(1H1)
  100  FORMAT(A6,F5.1,1H-F5.1,11A6)
  101  FORMAT(39H AMPLITUDE FROM A SIN PHI AND A COS PHI)
  102  FORMAT(14I5)
  103  FORMAT(72H
      1                    )
  104  FORMAT(3H N=I4,4X,2HM=I4,4X,6HNSKIP=I4,4X,7HIFCLER=I4,4X,6HIFCAL=I
      14,4X,7HIFOUAD=I4)
  105  FORMAT(7F10.5)
  106  FORMAT(1H04X,1HJ9X,8HAVER MSQ12X,6HSD MSO7X,5HAVDBM8X,4HDBHI8X,4HD
      1BLO5X,1HN2X,2HHI2X,2HLO)
  107  FORMAT(12H STATION NO.I4,6X,15HAVERAGE SIGNAL=F8.3,23H (DB ABOVE 1
      1 SQ. METER))
  108  FORMAT(1XI5,1P2E18.8,0P3F12.5,I5,2I4)
  109  FORMAT(39H AMPLITUDE FROM CHANNEL 1 ONLY          )
  110  FORMAT(8H STBLOK=F8.2,7X,7HENBLOK=F8.2,4X,2HN=F5.0,5X,6HWIDTH=F8.3
      1)
  111  FORMAT(1H 12F10.3)
  112  FORMAT(39H AMPLITUDE FROM CHANNEL 2 ONLY          )
  113  FORMAT(3H X=F10.4,2H +F10.4,6H    Y=F10.4,2H +F10.4)
  114  FORMAT(28H MINIMUM DISCERNIBLE SIGNAL=F8.2,4H DBM)
  115  FORMAT(1H I5,5F12.5,I5,2I4)
  116  FORMAT(10F7.5)
  120  FORMAT(7H0MAXIM=I5)
  122  FORMAT(7H RANGE=F10.4,5X,2HK=F10.4/19H CROSS SECTION=DBM+F10.5/22H
      1 LOWEST CROSS SECTION=F12.8,14H SOUARE METERS)
  123  FORMAT(1H 6F15.5)
  124  FORMAT(20H0CALIBRATION FOLLOWS)
  125  FORMAT(1H04X,1HJ6X,6HAVMESQ7X,5HSDMSQ6X,5HAVDBM8X,4HDBHI8X,4HDBLO5
      1X,1HN2X,2HHI2X,2HLO)
C              CONVERSION FROM KILOFEET TO NAUTICAL MILES
       AALOG=40.*LOG10F(6.0761033)
C              NSET=NUMBER OF TIME INTERVALS TO PROCESS
C              IFB7=1 IF AVERAGE AND DEVIATION TO BE WRITTEN ON B7
C              IFB7=0 IF NO AVERAGE AND DEVIATION TO BE WRITTEN ON B7
C              NOFILE=NUMBER OF INITIAL FILES TO SKIP ON INPUT TAPE
C              IFPLOT=1 IF FREOUENCY DISTRIBUTION TO BE WRITTEN ON B7
C              IFPLOT=0 IF NO FREOUENCY DISTRIBUTION TO BE WRITTEN ON B7
C              IXIN=GRANULARITY OF ORIGINAL READING
C              IFCAL=NUMBER OF CALIBRATION POINTS IN CURVE
```

```
C             IFCAL=0 IF NO CALIBRATION TO BE PERFORMED
      READ INPUT TAPE 2,102,NSET,IFB7,NOFILE,IFPLOT,IXIN,IFCAL
      READ INPUT TAPE 2,197,TITLE
C             XMULT=MULTIPLICATION FACTOR FOR CHANNEL 2
C             XADD=ADDITIVE CONSTANT FOR CHANNEL 2
C             YMULT=MULTIPLICATION FACTOR FOR CHANNEL 1
C             YADD=ADDITIVE CONSTANT FOR CHANNEL 1
C             AKLOG=RADAR K FACTOR
C             STBLOK=MINIMUM END OF FREQUENCY BLOCKS
C             ENBLOK=MAXIMUM END OF FREQUENCY BLOCKS
C             EN=NUMBER OF BLOCKS
C             CONTPL=ADDITIVE CONSTANT TO MAKE ALL VALUES POSITIVE
C             FOR DISTRIBUTION
      READ INPUT TAPE 2,116,XMULT,XADD,YMULT,YADD,AKLOG,STBLOK,ENBLOK,
     1EN,CONTPL
C             RNG=RANGE OF THIS SET IN KFT
      READ INPUT TAPE 2,116,(RNG(J),J=1,NSET)
      CALL DNSITY(1,8,2)
C             READ IN CALIBRATION TABLE IF CALIBRATION TO BE DONE
C             A=AMPLITUDES FOR CALIBRATION TABLE
C             DB=POWER IN -DBM FOR CALIBRATION TABLE
      IF(IFCAL)92,93,92
   92 NCAL=IFCAL
      READ INPUT TAPE 2,116,(A(JJ),DB(JJ),JJ=1,NCAL
C             AMPLOW=SMALLEST AMPLITUDE POSSIBLE
C             DBLOW=POWER CORRESPONDING TO MINIMUM AMPLITUDE READING
C             AMPHI=HIGHEST AMPLITUDE POSSIBLE
C             DBHI=POWER CORRESPONDING TO MAXIMUM AMPLITUDE READING
      AMPLOW=A(1)
      DBLOW=DB(1)
      AMPHI=A(NCAL)
      DBHI=DB(NCAL)
C             SKIP TO TOP OF NEXT A3 PAGE
      WRITE OUTPUT TAPE 3,99
C             WRITE OUT CALIBRATION TABLES ON A3
      WRITE OUTPUT TAPE 3,124
      WRITE OUTPUT TAPE 3,123,(A(JJ),DB(JJ),JJ=1,NCAL )
C             SET UP B7 TAPE IF IT IS TO BE USED
   93 IF(IFB7)4,5,4
    4 REWIND17
      CALL DNSITY(2,7,2)
    5 IF(IFPLOT)76,75,76
   76 CALL DNSITY(2,7,2)
      REWIND 17
C             SHUT OFF INDICATORS AT START TO CHECK LATER
   75 IF ACCUMULATOR OVERFLOW 6,6
    6 IF DIVIDE CHECK 7,7
C             FIND PROPER FILE ON A8 INPUT TAPE
    7 REWIND 8
      CALL AHEAD (8,NOFILE,0)
C             READ BCD TITLE FROM INPUT TAPE
      READ INPUT TAPE 8,103
C             PERFORM LOOP FOR EACH SET OF DATA
      DO 50 ISET=1,NSET
C             N=NUMBER OF TRACES TO PROCESS
C             M=NUMBER OF LAST STATION TO PROCESS
C             NSKIP=NUMBER OF INITIAL RECORDS TO SKIP
C             IFCLER=1 IF COUNTERS TO BE CLEARED FOR THIS SET OF DATA
```

```
C              IFCLER=0 IF COUNTERS NOT TO BE CLEARED AT THIS TIME
C              NPT1=NUMBER OF FIRST STATION TO PROCESS
C              INT=INTERVAL BETWEEN STATIONS TO PROCESS
C              IFSTAT=1 IF STATISTICAL ANALYSIS TO BE PERFORMED
C              IFSTAT=0 IF NO STATISTICAL ANALYSIS TO BE PERFORMED
C              IFQUAD=0 FOR QUADRATURE DATA
C              IFQUAD=NEGATIVE IF CHANNEL 1 ONLY TO BE USED
C              IFQUAD=POSITIVE IF CHANNEL 2 ONLY TO BE USED
      READ INPUT TAPE 2,102,N,M,NSKIP,IFCLER,NPT1,INT,IFSTAT ,IFQUAD
C              TM1=STARTING TIME FOR THIS SET
C              DTM=TIME INTERVAL OVER WHICH SET TO BE PROCESSED
      READ INPUT TAPE 2,105,TM1,DTM
  303 TM2=TM1+DTM
C              WRITE OUT TITLES AND CODE WORDS ON A3 TAPE FOR REFERENCE
      WRITE OUTPUT TAPE 3,99
      WRITE OUTPUT TAPE 3,100,TITLE(1),TM1,TM2,(TITLE(J),J=2,12)
      IF(IFQUAD)400,401,402
  400 WRITE OUTPUT TAPE 3,109
      GO TO 403
  402 WRITE OUTPUT TAPE 3,112
      GO TO 403
  401 WRITE OUTPUT TAPE 3,101
  403 WRITE OUTPUT TAPE 3,103
      WRITE OUTPUT TAPE 3,104,N,M,NSKIP,IFCLER,IFCAL,IFQUAD
C              FIND PROPER POINT ON INPUT TAPE TO BEGIN PROCESSING
      CALL SKIP(NSKIP)
C              CLEAR COUNTERS IF DESIRED
C              ALSO SET SUMS SO FAR TO ZERO
      IF(IFCLER)9,10,9
    9 DO 26 I=1,200
      DO 11 J=1,104
      ICT(I,J)=0
   11 CONTINUE
      SUMAMP(I)=0.
      SUMSQ(I)=0.
   26 CONTINUE
      ANUM=0.
C              GET CURRENT RANGE
   10 RANGE=RNG(ISET)
C              COMPUTE WIDTH OF COUNTING BLOCK
      WIDTH=(ENBLOK-STBLOK)/EN
      WRITE OUTPUT TAPE 3,110,STBLOK,ENBLOK,EN,WIDTH
      WRITE OUTPUT TAPE 3,113,XMULT,XADD,YMULT,YADD
C              CONLOG=40 LOG R - K
      RANLOG=LOG10F(RANGE)
      CCLOG=AKLOG+AALOG
      CONLOG=40.*RANLOG-CCLOG
C              CSLOW=MINIMUM DISCERNIBLE SIGNAL
      CSLOW=-DB(1)+CONLOG
      CSLOW=10.**(CSLOW/10.)
      WRITE OUTPUT TAPE 3,122,RANGE,AKLOG,CONLOG,CSLOW
C              NN=ANUM=NUMBER OF POINTS OVER WHICH STATISTICS TO BE TAKEN
      ANUM=ANUM+FLOATF(N)
      NN=ANUM
      NBLOK=EN
      DO 51 JK=1,N
C              READ NEXT RECORD FROM A8
      CALL READA
```

```
C             CHECK TIME CODE IF FIRST RECORD OF SET
      IF(JK-1)300,300,301
  300 WRITE OUTPUT TAPE 3,98,IT1,IT2
  301 NOP=NOP
C             REVERSE WORDS INTO FORTRAN ORDER IN MATRIX
      DO 13 J=1,NOP
      JJ=221-J
      ITEMP(J)=IX(JJ)
   13 CONTINUE
C             COMPUTE AMPLITUDE BY PROPER METHOD DEPENDING ON TYPE DATA
      IF(IFQUAD)14,15,16
   14 CALL AMPDA1
      GO TO 17
   16 CALL AMPDA2
      GO TO 17
   15 CALL QUAD
C             CALIBRATE DATA
   17 IF(IFCAL)90,18,90
   90 CALL DBCOM
C             PERFORM ADDITION FOR THIS RECORD
   18 CALL ADSTAT
C             DO FREQUENCY DISTRIBUTION IF DESIRED
      IF(IFPLOT)91,51,91
   91 CALL FREQCT
C             END OF LOOP---GO READ NEXT RECORD IF ANY REMAINS IN SET
   51 CONTINUE
C             END OF LOOP---READY TO DO STATISTICAL ANALYSIS OVER PERIOD
C             COMPUTE AVERAGE AND STANDARD DEVIATION EACH STATION
      IF(IFSTAT)19,20,19
   19 CALL STAT
      WRITE OUTPUT TAPE 3,106
C             COMPUTE AVERAGE,AVERAGE + ONE S.D. AND AVERAGE - ONE S.D.
C             CHANGE BACK TO DB OVER 1 SQUARE METER
      DO 52 J=NPT1,M,INT
      NNN=SANUM(J)
      AVDB(J)=10.*LOG10F(AVER(J))
      AVDBP(J)=AVER(J)+SD(J)
      AVDBP(J)=10.*LOG10F(AVDBP(J))
      AVDBM(J)=AVER(J)-SD(J)
C             IF BELOW MDS SET TO VALUE AT MDS
      IF(AVDBM(J)-CSLOW)220,220,221
  220 AVDBM(J)=CSLOW
  221 AVDBM(J)=10.*LOG10F(AVDBM(J))
C             WRITE VALUES ON MONITOR TAPE A3
C             ALSO SHOW IF ANY POINTS ABOVE OR BELOW CALIBRATION CURVE
  222 WRITE OUTPUT TAPE 3,108,J,AVER(J),SD(J),AVDB(J),AVDBP(J),AVDBM(J),
     1NNN,ICT(J,103),ICT(J,104)
   52 CONTINUE
C             COMPUTE MAXIMUM NUMBER IN ANY BLOCK AND PRINT VALUE
   20 IF(IFPLOT) 21,22,21
   21 MAXIM=0
      DO 70 J=NPT1,M,INT
      DO 70 JJJ=1,NBLOK
      IF(ICT(J,JJJ)-MAXIM)70,70,71
   71 MAXIM=ICT(J,JJJ)
   70 CONTINUE
      WRITE OUTPUT TAPE 3,120,MAXIM
C             WRITE 4 LINES OF TITLES ON PLOTTING TAPE
```

```
      WRITE OUTPUT TAPE 17,100,TITLE(1),TM1,TM2,(TITLE(J),J=2,12)
      IF(IFQUAD)404,405,406
  404 WRITE OUTPUT TAPE 17,109
      GO TO 407
  406 WRITE OUTPUT TAPE 17,112
      GO TO 407
  405 WRITE OUTPUT TAPE 17,101
  407 ALA=-DB(1)
      WRITE OUTPUT TAPE 17,114,ALA
      X1(1)=STBLOK+WIDTH/2.  -CONTPL
      NBLM1=NBLOK-1
C             STORE MID POINT EACH BLOCK IN X1
      DO 82 JKL=1,NBLM1
      L=JKL+1
      X1(L)=X1(JKL)+WIDTH
   82 CONTINUE
      DO 72 J=NPT1,M,INT
      WRITE OUTPUT TAPE17,107,J ,AVDB(J)
      DO 83 JKL=1,NBLOK
      X4(JKL)=ICT(J,JKL)
   83 CONTINUE
C             WRITE MID POINT OF BLOCK AND FREQUENCY IN THAT BLOCK
C             ON PLOTTING TAPE
  202 WRITE OUTPUT TAPE 17,111,(X1(JJ),X4(JJ),JJ=1,NBLOK)
   72 CONTINUE
C             WRITE VALUES FOR AVERAGE PULSE ON PLOTTING TAPE
   22 IF(IFB7)24,50,24
   24 WRITE OUTPUT TAPE17,100 ,TITLE(1),TM1,TM2,(TITLE(J),J=2,12)
      IF(IFQUAD)408,409,410
  408 WRITE OUTPUT TAPE 17,109
      GO TO 411
  410 WRITE OUTPUT TAPE 17,112
      GO TO 411
  409 WRITE OUTPUT TAPE17,101
  411 DO 53 J=NPT1,M,INT
      NNN=SANUM(J)
      WRITE OUTPUT TAPE 17,115,J,AVER(J),SD(J),AVDB(J),AVDBP(J),AVDBM(J)
     1,NNN,ICT(J,103),ICT(J,104)
   53 CONTINUE
C             GO DO NEXT SET
   50 CONTINUE
C             REWIND AND UNLOAD TAPES AT END
      IF(IFB7)28,29,28
   28 END FILE 17
      CALL RUN(2,7)
      GO TO 208
   29 IF(IFPLOT)30,208,30
   30 END FILE 17
      CALL RUN(2,7)
  208 CALL EXIT
      END
```

```
*     WILSON,FLORENCE  AMPLITUDE PROGRAM VERSION 2  FEB 1
*     LIST
*     LABEL
*     SYMBOL TABLE
C
C              DIMENSION STATEMENTS
      DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
     1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
      DIMENSION AVDBM(200),AVDBP(200),AVDB(200),X1(200),X4(200)
      DIMENSION TITLE(12),RNG(100)
C              COMMON STATEMENTS
      COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
     1,ANUM,CONTPL,NCAL,CONLOG
      COMMON XMULT,XADD,YMULT,YADD ,AMPLOW,DBLOW,AMPHI,DBHI
      COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C              FORMAT STATEMENTS
  197 FORMAT(12A6)
   98 FORMAT(6H TIME=I5,3X,I5)
   99 FORMAT(1H1)
  100 FORMAT(A6,F5.1,1H-F5.1,11A6)
  101 FORMAT(39H AMPLITUDE FROM A SIN PHI AND A COS PHI)
  102 FORMAT(16I5)
  103 FORMAT(72H
     1          )
  104 FORMAT(3H N=I4,4X,2HM=I4,4X,6HNSKIP=I4,4X,7HIFCLER=I4,4X,6HIFCAL=I
     14,4X,7HIFQUAD=I4)
  105 FORMAT(7F10.5)
  106 FORMAT(1H04X,1HJ9X,8HAVER MSQ12X,6HSD MSQ7X,5HAVDBM8X,4HDBHI8X,4HD
     1BLO5X,1HN2X,2HHI2X,2HLO)
  107 FORMAT(12H STATION NO.I4,6X,15HAVERAGE SIGNAL=F8.3,23H (DB ABOVE 1
     1 SQ. METER))
  108 FORMAT(1XI5,1P2E18.8,0P3F12.5,I5,2I4)
  109 FORMAT(39H AMPLITUDE FROM CHANNEL 1 ONLY          )
  110 FORMAT(8H STBLOK=F8.2,7X,7HENBLOK=F8.2,4X,2HN=F5.0,5X,6HWIDTH=F8.3
     1)
  111 FORMAT(1H 12F10.3)
  112 FORMAT(39H AMPLITUDE FROM CHANNEL 2 ONLY          )
  113 FORMAT(3H X=F10.4,2H +F10.4,6H    Y=F10.4,2H +F10.4)
  114 FORMAT(28H MINIMUM DISCERNIBLE SIGNAL=F8.2,4H DBM)
  115 FORMAT(1H I5,5F12.5,I5,2I4)
  116 FORMAT(10F7.5)
  120 FORMAT(7H0MAXIM=I5)
  122 FORMAT(7H RANGE=F10.4,5X,2HK=F10.4/19H CROSS SECTION=DBM+F10.5/22H
     1 LOWEST CROSS SECTION=F12.8,14H SQUARE METERS)
  123 FORMAT(1H 6F15.5)
  124 FORMAT(20H0CALIBRATION FOLLOWS)
  125 FORMAT(1H04X,1HJ6X,6HAVMESQ7X,5HSDMSQ6X,5HAVDBM8X,4HDBHI8X,4HDBLO5
     1X,1HN2X,2HHI2X,2HLO)
C              CONVERSION FROM KILOFEET TO NAUTICAL MILES
      AALOG=40.*LOG10F(6.0761033)
C              NSET=NUMBER OF TIME INTERVALS TO PROCESS
C              IFB7=1 IF AVERAGE AND DEVIATION TO BE WRITTEN ON B7
C              IFB7=0 IF NO AVERAGE AND DEVIATION TO BE WRITTEN ON B7
C              IFQUAD=0 FOR QUADRATURE DATA
C              IFQUAD=NEGATIVE IF CHANNEL 1 ONLY TO BE USED
C              IFQUAD=POSITIVE IF CHANNEL 2 ONLY TO BE USED
```

```
C             NOFILE=NUMBER OF INITIAL FILES TO SKIP ON INPUT TAPE
C             IFPLOT=1 IF FREQUENCY DISTRIBUTION TO BE WRITTEN ON B7
C             IFPLOT=0 IF NO FREQUENCY DISTRIBUTION TO BE WRITTEN ON B7
C             IXIN=GRANULARITY OF ORIGINAL READING
C             IFCAL=NUMBER OF CALIBRATION POINTS IN CURVE
C             IFCAL=0 IF NO CALIBRATION TO BE PERFORMED
C             N=NUMBER OF TRACES TO PROCESS
C             M=NUMBER OF LAST STATION TO PROCESS
C             NSKIP=NUMBER OF INITIAL RECORDS TO SKIP
C             IFCLER=1 IF COUNTERS TO BE CLEARED FOR THIS SET OF DATA
C             IFCLER=0 IF COUNTERS NOT TO BE CLEARED AT THIS TIME
C             NPT1=NUMBER OF FIRST STATION TO PROCESS
C             INT=INTERVAL BETWEEN STATIONS TO PROCESS
C             IFSTAT=1 IF STATISTICAL ANALYSIS TO BE PERFORMED
C             IFSTAT=0 IF NO STATISTICAL ANALYSIS TO BE PERFORMED
      READ INPUT TAPE 2,102,NSET,IFB7,IFQUAD,NOFILE,IFPLOT,IXIN,IFCAL
     1,N,M,NSKIP,IFCLER,NPT1,INT,IFSTAT
      READ INPUT TAPE 2,197,TITLE
C             TM1=STARTING TIME FOR THIS SET
C             DTM=TIME INTERVAL OVER WHICH SET TO BE PROCESSED
      READ INPUT TAPE 2,105,TM1,DTM
C             XMULT=MULTIPLICATION FACTOR FOR CHANNEL 2
C             XADD=ADDITIVE CONSTANT FOR CHANNEL 2
C             YMULT=MULTIPLICATION FACTOR FOR CHANNEL 1
C             YADD=ADDITIVE CONSTANT FOR CHANNEL 1
C             AKLOG=RADAR K FACTOR
C             STBLOK=MINIMUM END OF FREQUENCY BLOCKS
C             ENBLOK=MAXIMUM END OF FREQUENCY BLOCKS
C             EN=NUMBER OF BLOCKS
C             CONTPL=ADDITIVE CONSTANT TO MAKE ALL VALUES POSITIVE
C             FOR DISTRIBUTION
      READ INPUT TAPE 2,116,XMULT,XADD,YMULT,YADD,AKLOG,STBLOK,ENBLOK,
     1EN,CONTPL
C             RNG=RANGE OF THIS SET IN KFT
      READ INPUT TAPE 2,116,(RNG(J),J=1,NSET)
      CALL DNSITY(1,8,2)
C             READ IN CALIBRATION TABLE IF CALIBRATION TO BE DONE
C             A=AMPLITUDES FOR CALIBRATION TABLE
C             DB=POWER IN -DBM FOR CALIBRATION TABLE
      IF(IFCAL)92,93,92
   92 NCAL=IFCAL
      READ INPUT TAPE 2,116,(A(JJ),DB(JJ),JJ=1,NCAL   )
C             AMPLOW=SMALLEST AMPLITUDE POSSIBLE
C             DBLOW=POWER CORRESPONDING TO MINIMUM AMPLITUDE READING
C             AMPHI=HIGHEST AMPLITUDE POSSIBLE
C             DBHI=POWER CORRESPONDING TO MAXIMUM AMPLITUDE READING
      AMPLOW=A(1)
      DBLOW=DB(1)
      AMPHI=A(NCAL)
      DBHI=DB(NCAL)
C             SKIP TO TOP OF NEXT A3 PAGE
      WRITE OUTPUT TAPE 3,99
C             WRITE OUT CALIBRATION TABLES ON A3
      WRITE OUTPUT TAPE 3,124
      WRITE OUTPUT TAPE 3,123,(A(JJ),DB(JJ),JJ=1,NCAL )
C             SET UP B7 TAPE IF IT IS TO BE USED
   93 IF(IFB7)4,5,4
    4 REWIND17
```

```
      CALL DNSITY(2,7,2)
    5 IF(IFPLOT)76,75,76
   76 CALL DNSITY(2,7,2)
      REWIND 17
C              SHUT OFF INDICATORS AT START TO CHECK LATER
   75 IF ACCUMULATOR OVERFLOW 6,6
    6 IF DIVIDE CHECK 7,7
C              FIND PROPER FILE ON A8 INPUT TAPE
    7 REWIND 8
      CALL AHEAD (8,NOFILE,0)
C              READ BCD TITLE FROM INPUT TAPE
      READ INPUT TAPE 8,103
C              PERFORM LOOP FOR EACH SET OF DATA
      DO 50 ISET=1,NSET
C              BACKSPACE ONE RECORD AFTER FIRST SET
      IF(ISET-1)302,303,302
  302 NSKIP=-1
C              GET TIME AT END OF INTERVAL
  303 TM2=TM1+DTM
C              WRITE OUT TITLES AND CODE WORDS ON A3 TAPE FOR REFERENCE
      WRITE OUTPUT TAPE 3,99
      WRITE OUTPUT TAPE 3,100,TITLE(1),TM1,TM2,(TITLE(J),J=2,12)
      IF(IFQUAD)420,421,422
  420 WRITE OUTPUT TAPE 3,109
      GO TO 423
  422 WRITE OUTPUT TAPE 3,112
      GO TO 423
  421 WRITE OUTPUT TAPE 3,101
  423 WRITE OUTPUT TAPE 3,103
      WRITE OUTPUT TAPE 3,104,N,M,NSKIP,IFCLER,IFCAL,IFQUAD
C              FIND PROPER POINT ON INPUT TAPE TO BEGIN PROCESSING
      CALL SKIP(NSKIP)
C              CLEAR COUNTERS
C              ALSO SET SUMS SO FAR TO ZERO
    9 DO 26 I=1,200
      DO 11 J=1,104
      ICT(I,J)=0
   11 CONTINUE
      SUMAMP(I)=0.
      SUMSQ(I)=0.
   26 CONTINUE
      ANUM=0.
C              GET CURRENT RANGE
   10 RANGE=RNG(ISET)
C              COMPUTE WIDTH OF COUNTING BLOCK
      WIDTH=(ENBLOK-STBLOK)/EN
      WRITE OUTPUT TAPE 3,110,STBLOK,ENBLOK,EN,WIDTH
      WRITE OUTPUT TAPE 3,113,XMULT,XADD,YMULT,YADD
C              CONLOG=40 LOG R - K
      RANLOG=LOG10F(RANGE)
      CCLOG=AKLOG+AALOG
      CONLOG=40.*RANLOG-CCLOG
C              CSLOW=MINIMUM DISCERNIBLE SIGNAL
      CSLOW=-DB(1)+CONLOG
      CSLOW=10.**(CSLOW/10.)
      WRITE OUTPUT TAPE 3,122,RANGE,AKLOG,CONLOG,CSLOW
C              NN=ANUM=NUMBER OF POINTS OVER WHICH STATISTICS TO BE TAKEN
      ANUM=ANUM+FLOATF(N)
```

```
      NN=ANUM
      NBLOK=EN
      DO 51 JK=1,N
C              READ NEXT RECORD FROM A8
      CALL READA
C              CHECK TIME CODE IF FIRST RECORD OF SET
      IF(JK-1)300,300,301
  300 WRITE OUTPUT TAPE 3,98,IT1,IT2
C              REVERSE WORDS INTO FORTRAN ORDER IN MATRIX
  301 NOP=NOP
      DO 13 J=1,NOP
      JJ=221-J
      ITEMP(J)=IX(JJ)
   13 CONTINUE
C              COMPUTE AMPLITUDE BY PROPER METHOD DEPENDING ON TYPE DATA
      IF(IFQUAD)14,15,16
   14 CALL AMPDA1
      GO TO 17
   16 CALL AMPDA2
      GO TO 17
   15 CALL QUAD
C              CALIBRATE DATA
   17 IF(IFCAL)90,18,90
   90 CALL DBCOM
C              PERFORM ADDITION FOR THIS RECORD
   18 CALL ADSTAT
C              DO FREQUENCY DISTRIBUTION IF DESIRED
      IF(IFPLOT)91,51,91
   91 CALL FREQCT
C              END OF LOOP---GO READ NEXT RECORD IF ANY REMAINS IN SET
   51 CONTINUE
C              END OF LOOP---READY TO DO STATISTICAL ANALYSIS OVER PERIOD
C              COMPUTE AVERAGE AND STANDARD DEVIATION EACH STATION
      IF(IFSTAT)19,20,19
   19 CALL STAT
      WRITE OUTPUT TAPE 3,106
C              COMPUTE AVERAGE,AVERAGE + ONE S.D. AND AVERAGE - ONE S.D.
C              CHANGE BACK TO DB OVER 1 SQUARE METER
      DO 52 J=NPT1,M,INT
      NNN=SANUM(J)
      AVDB(J)=10.*LOG10F(AVER(J))
      AVDBP(J)=AVER(J)+SD(J)
      AVDBP(J)=10.*LOG10F(AVDBP(J))
      AVDBM(J)=AVER(J)-SD(J)
C              IF BELOW MDS SET TO VALUE AT MDS
      IF(AVDBM(J)-CSLOW)220,220,221
  220 AVDBM(J)=CSLOW
  221 AVDBM(J)=10.*LOG10F(AVDBM(J))
C              WRITE VALUES ON MONITOR TAPE A3
C              ALSO SHOW IF ANY POINTS ABOVE OR BELOW CALIBRATION CURVE
  222 WRITE OUTPUT TAPE 3,108,J,AVER(J),SD(J),AVDB(J),AVDBP(J),AVDBM(J),
     1NNN,ICT(J,103),ICT(J,104)
   52 CONTINUE
C              COMPUTE MAXIMUM NUMBER IN ANY BLOCK AND PRINT VALUE
   20 IF(IFPLOT) 21,22,21
   21 MAXIM=0
      DO 70 J=NPT1,M,INT
      DO 70 JJJ=1,NBLOK
```

```
      IF(ICT(J,JJJ)-MAXIM)70,70,71
   71 MAXIM=ICT(J,JJJ)
   70 CONTINUE
      WRITE OUTPUT TAPE 3,120,MAXIM
C              WRITE 4 LINES OF TITLES ON PLOTTING TAPE
      WRITE OUTPUT TAPE 17,100,TITLE(1),TM1,TM2,(TITLE(J),J=2,12)
      IF(IFQUAD)400,401,402
  400 WRITE OUTPUT TAPE 17,109
      GO TO 403
  402 WRITE OUTPUT TAPE 17,112
      GO TO 403
  401 WRITE OUTPUT TAPE 17,101
  403 ALA=-DB(1)
      WRITE OUTPUT TAPE 17,114,ALA
      X1(1)=STBLOK+WIDTH/2.   -CONTPL
      NBLM1=NBLOK-1
C              STORE MID POINT EACH BLOCK IN X1
      DO 82 JKL=1,NBLM1
      L=JKL+1
      X1(L)=X1(JKL)+WIDTH
   82 CONTINUE
      DO 72 J=NPT1,M,INT
      WRITE OUTPUT TAPE17,107,J  ,AVDB(J)
      DO 83 JKL=1,NBLOK
      X4(JKL)=ICT(J,JKL)
   83 CONTINUE
C              WRITE MID POINT OF BLOCK AND FREQUENCY IN THAT BLOCK
C              ON PLOTTING TAPE
  202 WRITE OUTPUT TAPE 17,111,(X1(JJ),X4(JJ),JJ=1,NBLOK)
   72 CONTINUE
C              WRITE VALUES FOR AVERAGE PULSE ON PLOTTING TAPE
   22 IF(IFB7)24,350,24
   24 WRITE OUTPUT TAPE17,100  ,TITLE(1),TM1,TM2,(TITLE(J),J=2,12)
      IF(IFQUAD)404,405,406
  404 WRITE OUTPUT TAPE 17,109
      GO TO 407
  406 WRITE OUTPUT TAPE 17,112
      GO TO 407
  405 WRITE OUTPUT TAPE17,101
  407 DO 53 J=NPT1,M,INT
      NNN=SANUM(J)
      WRITE OUTPUT TAPE 17,115,J,AVER(J),SD(J),AVDB(J),AVDBP(J),AVDBM(J)
     1,NNN,ICT(J,103),ICT(J,104)
   53 CONTINUE
C              COMPUTE STARTING TIME FOR NEXT INTERVAL
  350 TM1=TM1+DTM
C              GO DO NEXT SET IF ANY
   50 CONTINUE
C              REWIND AND UNLOAD TAPES AT END
  550 IF(IFB7)28,29,28
   28 END FILE 17
      CALL RUN(2,7)
      GO TO 208
   29 IF(IFPLOT)30,208,30
   30 END FILE 17
      CALL RUN(2,7)
  208 CALL EXIT
      END
```

```
*      LIST
*      LABEL
*      SYMBOL TABLE
       SUBROUTINE AMPDA1
CAMP1 AMPLITUDE USING CHANNEL 1 ONLY
C               DIMENSION STATEMENTS
       DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
      1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
C               COMMON STATEMENTS
       COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
      1,ANUM,CONTPL,NCAL,CONLOG
       COMMON XMULT,XADD,YMULT,YADD  ,AMPLOW,DBLOW,AMPHI,DBHI
       COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C               UNPACK AND COMPUTE AMPLITUDE FOR CHANNEL 1 ONLY
       DO 1 J=NPT1,M,INT
       CALL UNPAK(ITEMP(J),IX1,IX2)
       AMP(J)=IX1/IXIN
     1 AMP(J)=AMP(J)*YMULT+YADD
       RETURN
       END
```

```
*      LIST
*      LABEL
*      SYMBOL TABLE
       SUBROUTINE AMPDA2
CAMP2 AMPLITUDE USING CHANNEL 2 ONLY
C               DIMENSION STATEMENTS
       DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
      1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
C               COMMON STATEMENTS
       COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
      1,ANUM,CONTPL,NCAL,CONLOG
       COMMON XMULT,XADD,YMULT,YADD  ,AMPLOW,DBLOW,AMPHI,DBHI
       COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C               UNPACK AND COMPUTE AMPLITUDE FOR CHANNEL 2 ONLY
       DO 1 J=NPT1,M,INT
       CALL UNPAK(ITEMP(J),IX1,IX2)
       AMP(J)=IX2/IXIN
     1 AMP(J)=AMP(J)*XMULT+XADD
       RETURN
       END
```

```
*      LIST
*      LABEL
*      SYMBOL TABLE
       SUBROUTINE QUAD
CQUAD AMPLITUDE FROM QUADRATURE DATA   USING BOTH CHANNELS
C               DIMENSION STATEMENTS
       DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
      1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
C               COMMON STATEMENTS
       COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
```

```
     1,ANUM,CONTPL,NCAL,CONLOG
      COMMON XMULT,XADD,YMULT,YADD  ,AMPLOW,DBLOW,AMPHI,DBHI
      COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C               UNPACK AND COMPUTE AMPLITUDE FROM BOTH CHANNELS
      DO 1 J=NPT1,M,INT
      CALL UNPAK(ITEMP(J),IX1,IX2)
    3 AM1=IX1 /IXIN
      AM2=IX2/IXIN
      AM1=AM1*YMULT+YADD
      AM2=AM2*XMULT+XADD
    5 AMP(J)=SQRTF(AM1*AM1+AM2*AM2)
    1 CONTINUE
      RETURN
      END
```

```
*     LIST
*     LABEL
*     SYMBOL TABLE
      SUBROUTINE DBCOM
CDBCOM   ROUTINE TO CALIBRATE THE DATA
C              DIMENSION STATEMENTS
      DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
     1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
C              COMMON STATEMENTS
      COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
     1,ANUM,CONTPL,NCAL,CONLOG
      COMMON XMULT,XADD,YMULT,YADD ,AMPLOW,DBLOW,AMPHI,DBHI
      COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C              PERFORM LOOP FOR EACH STATION
      DO 1 J=NPT1,M,INT
C              IF VALUE ABOVE CURVE COUNT IT AS BAD POINT
      IF(AMP(J)-AMPHI)2,2,3
    3 ICT(J,103)=ICT(J,103)+1
C              ALSO SET AMP=77777    (CODE)
      AMP(J)=77777.
      GO TO 1
C              IF BELOW CURVE SET VALUE EQUAL TO LOWEST POWER
    2 IF(AMP(J)-AMPLOW)4,5,5
    4 AMP(J)=DBLOW
C              AND COUNT AS POINT BELOW CURVE
      ICT(J,104)=ICT(J,104)+1
      GO TO 8
    5 DO 12 I=1,NCAL
C              INTERPOLATE TO FIND POWER CORRESPONDING TO GIVEN AMPLITUDE
C              BY LINEAR INTERPOLATION BETWEEN TABULATED POINTS
      IF(AMP(J)-A(I))10,11,12
   11 AMP(J)=DB(I)
      GO TO 8
   10 AAB=(AMP(J)-A(I-1))/(A(I)-A(I-1))
      DDB=(DB(I)-DB(I-1))*AAB
   14 AMP(J)=DB(I-1)+DDB
      GO TO 8
   12 CONTINUE
C              DBM READ IN AS POSITIVE NUMBER  THUS MUST TAKE -DBM READ
C              CROSS SECTION(DB)=-DBM+40 LOG R -K
    8 AMP(J)=-AMP(J)+CONLOG
C              CROSS SECTION IN SQUARE METERS
      AMP(J)=10.**(AMP(J)/10.)
    1 CONTINUE
      RETURN
      END
```

```
*      LIST
*      LABEL
*      SYMBOL TABLE
       SUBROUTINE ADSTAT
CADST  SUBROUTINE TO ADD AND STORE FOR AVERAGES
C                DIMENSION STATEMENTS
       DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
      1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
C                COMMON STATEMENTS
       COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
      1,ANUM,CONTPL,NCAL,CONLOG
       COMMON XMULT,XADD,YMULT,YADD ,AMPLOW,DBLOW,AMPHI,DBHI
       COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C                IF ABOVE CURVE DO NOT USE IN STATISTICS
       DO 1 J=NPT1,M,INT
       IF(AMP(J)-77777.)10,1,1
C                FIND SUM OF CROSS SECTION AND CROSS SECTION SQUARED
C                UP TO CURRENT POINT
   10  SUMAMP(J)=SUMAMP(J)+AMP(J)
       SUMSQ(J)=SUMSQ(J)+AMP(J)*AMP(J)
    1  CONTINUE
       RETURN
       END
```

```
*      LIST
*      LABEL
*      SYMBOL TABLE
CFREQ FREQUENCY DISTRIBUTION
      SUBROUTINE FREQCT
C             DIMENSION STATEMENTS
      DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
     1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
C             COMMON STATEMENTS
      COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
     1,ANUM,CONTPL,NCAL,CONLOG
      COMMON XMULT,XADD,YMULT,YADD ,AMPLOW,DBLOW,AMPHI,DBHI
      COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C             PERFORM LOOP FOR EACH STATION
      DO 1 J=NPT1,M,INT
C             IF ABOVE CURVE DO NOT USE
      IF(AMP(J)-77777.)10,1,1
C             CHANGE CROSS SECTION BACK TO DB/SQUARE METER
C             FOR DISTRIBUTION
   10 AMP(J)=10.*LOG10F(AMP(J))
C             ADD CONSTANT TO GET POSITIVE NUMBER
   12 AMP(J)=AMP(J)+CONTPL
C             IF BELOW MINIMUM BOX EDGE COUNT AS SPECIAL CASE
      IF(AMP(J)-STBLOK)2,3,4
    2 ICT(J,101)=ICT(J,101)+1
      GO TO 1
    3 ICT(J,1)=ICT(J,1)+1
      GO TO 1
C             IF  ABOVE MAXIMUM BLOCK EDGE COUNT AS SPECIAL CASE
    4 IF(AMP(J)-ENBLOK)5,6,7
    7 ICT(J,102)=ICT(J,102)+1
      GO TO 1
    6 ICT(J,NBLOK)=ICT(J,NBLOK)+1
      GO TO 1
C             OTHERWISE LOCATE IN PROPER BOX AND ADD ONE TO CURRENT
C             VALUE OF THAT BOX
    5 ANOB=AMP(J)/WIDTH+1.
   14 NOB=ANOB
   13 ICT(J,NOB)=ICT(J,NOB)+1
    1 CONTINUE
      RETURN
      END
```

```
*     LIST
*     LABEL
*     SYMBOL TABLE
      SUBROUTINE STAT
CSTAT STATISTICAL ANALYSIS FOR AMPLITUDE DATA
C             DIMENSION STATEMENTS
      DIMENSION  A(50),AMP(220),AVER(200),DB(50),ICT(200,104),ITEMP(220)
     1,IX(220),SANUM(200),SD(200),SUMAMP(200),SUMSQ(200)
C             COMMON STATEMENTS
      COMMON IT1,IT2,NOP,EN,ENBLOK,INT,M,NBLOK,NPT1,STBLOK,WIDTH,IXIN,EM
     1,ANUM,CONTPL,NCAL,CONLOG
      COMMON XMULT,XADD,YMULT,YADD ,AMPLOW,DBLOW,AMPHI,DBHI
      COMMON IX,ITEMP,AMP,AVER,ICT,SD,SUMAMP,SANUM,DB,A,SUMSQ
C             FORMAT STATEMENTS
  100 FORMAT(21H ACCUMULATOR OVERFLOW)
  101 FORMAT(3H0J=I5,18H   POINTS TOO LOW=I5)
  102 FORMAT(3H0J=I5,19H   POINTS TOO HIGH=I5)
C             PERFORM LOOP FOR EACH STATION
      DO 50 J=NPT1,M,INT
C             SET SUMS EQUAL TO ZERO AT START
      AVER(J)=0.
      SD(J)=0.
C             SANUM=NUMBER OF POINTS TO USE IN ANALYSIS
C             POINTS ABOVE CURVE HAVE BEEN ELIMINATED
      SANUM(J)=ANUM-FLOATF(ICT(J,103))
   50 CONTINUE
C              IF ANY OVERFLOW HAS OCCURRED IN ADDING--EXIT HERE
    1 IF ACCUMULATOR OVERFLOW 3,4
    3 WRITE OUTPUT TAPE 3,100
      CALL EXIT
    4 DO 5 J=NPT1,M,INT
C             COMPUTE AVERAGE EACH STATION
      AVER(J)=SUMAMP(J)/SANUM(J)
      IF(ICT(J,101))17,18,17
   17 WRITE OUTPUT TAPE 3,101,J,ICT(J,101)
   18 IF(ICT(J,102))19,5,19
   19 WRITE OUTPUT TAPE 3,102,J,ICT(J,102)
    5 CONTINUE
C             COMPUTE STANDARD DEVIATION
    6 DO 14 J=NPT1,M,INT
      SD(J)=SQRTF(SUMSQ(J)/SANUM(J)-AVER(J)*AVER(J))
   14 CONTINUE
      RETURN
      END
```

```
*       FAP
        COUNT    51
        ENTRY    READA
        ENTRY    UNPAK
        ENTRY    SKIP
*               STORE INDEX REGISTER 1
 SKIP   SXD      TEMP1,1
*               PLACE NUMBER OF RECORDS TO SKIP INTO ACCUMULATOR
*               AND INTO INDEX REGISTER 1
        CLA*     1,4
        PDX      ,1
*               GO BACK TO MAIN PROGRAM IF NSKIP=0
        TZE      RETURN
        TMI      LOOP3
*               SKIP NSKIP RECORDS IN FORWARD DIRECTION IF NSKIP +
LOOP2   TCOA     *
        RTBA     8
        TIX      LOOP2,1,1
RETURN  LXD      TEMP1,1
        TRA      2,4
*               BACSPACE NSKIP RECORDS IF NSKIP -
LOOP3   TCOA     *
        BSRA     8
        TIX      LOOP3,1,1
        TRA      RETURN
*               READ BINARY RECORD FROM A8 INTO CORE
 READA  RTBA     8
        RCHA     C1
        TCOA     *
*               UNPACK TIME CODE WORDS FROM WORD 1 INTO IT1 AND IT2
        LDQ      =0
        CLA      IT1
        LGR      18
        ALS      18
        STO      IT1
        STQ      IT2
*               UNPACK NUMBER OF POINTS ON TRACE FROM WORD 2
        CLA      K
        LRS      18
        ALS      18
        STO      K
*               RETURN TO MAIN PROGRAM
  RET   TRA      1,4
*               PLACE NEXT WORD TO UNPACK INTO ACCUMULATOR
 UNPAK  CLA*     1,4
        LGR      18
        ALS      18
*               STORE FIRST 18 BITS INTO IX1
        STO*     2,4
*               STORE LAST 18 BITS INTO IX2
        SLQ*     3,4
*               RETURN TO CALLING PROGRAM
        TRA      4,4
*               STORAGE FOR RECORD READ IN FROM A8
   C1   IOCP     IT1,,1
        IOCP     K,,1
        IOCPN    C,,2
```

```
        IORP     IX-219,,220
        IOCD     0,0,0
   C    BSS      1
TEMP1   BSS      1
TEMP2   BSS      1
  IT1   COMMON   1
  IT2   COMMON   1
   K    COMMON   1
AAAA    COMMON   22
   IX   COMMON   220
        END
```

APPENDIX B

```
$JOB            WILSON,FLORENCE  AMPLITUDE PLOTS        1/7/66
$EXECUTE        IBJOB
$IBJOB          GO,SOURCE
$IBFTC PLOAC    LIST,DECK,SDD
CA1/3 4020 PLOT FOR AMPLITUDE PROGRAM  1/3/66
C               DIMENSION STATEMENTS
      DIMENSION TITLE1(12),TITLE2(7),TITLE3(10),TITLE4(12),X1(100),X4(10
     10),STA(200),AVDB(200),AVDBP(200),AVDBM(200)
C               FORMAT STATEMENTS
   21 FORMAT(14I5)
   22 FORMAT(12A6)
   23 FORMAT(14F5.0)
  115 FORMAT(1X,I5,24X,3F12.5)
  111 FORMAT(1H,12F10.3)
C               STORE LABEL FOR ID FRAME
      CALL STOIDV(15HAMPLITUDE PLOTS,3)
C               SELECT CAMERAS
      CALL CAMRAV(2)
C               MM=NUMBER OF TIME INTERVALS TO PLOT
C               NBLOK=NUMBER OF BLOCKS IN FREQUENCY DISTRIBUTION
C               M=NUMBER OF STATIONS PER TIME INTERVAL
C               IFFREQ=-1 IF DISTRIBUTION IS ON TAPE BUT NOT TO BE PLOTTED
C               IFFREQ=0 IF DISTRIBUTION TO BE PLOTTED
C               IFFREQ=+1 IF DISTRIBUTION IS NOT WRITTEN ON INPUT TAPE
   70 READ(5,21)MM,NBLOK,M,IFFREQ
      WRITE (6,21)MM,NBLOK,M,IFFREQ
C               XMINFR=MINIMUM LIMIT OF DISTRIBUTION BOXES
C               XMAXFR=MAXIMUM LIMIT OF DISTRIBUTION BOXES
C               DXFR=INCREMENT FOR TIC MARKS FOR X AXIS OF DISTRIBUTION
C               YMAXFR=MAXIMUM FREQUENCY OF PLOT
C               DYFR=INCREMENT FOR TIC MARKS FOR Y AXIS OF DISTRIBUTION
C               XMINA=MINIMUM STATION NUMBER FOR AVERAGE PLOT
C               XMAXA=MAXIMUM STATION NUMBER FOR AVERAGE PLOT
C               DXA=INCREMENT FOR TIC MARKS FOR X AXIS OF AVERAGE
C               YMINA=MINIMUM Y SCALE VALUE FOR AVERAGE PLOT
C               YMAXA=MAXIMUM Y SCALE VALUE FOR AVERAGE PLOT
C               DYA=INCREMENT FOR TIC MARKS FOR Y AXIS OF AVERAGE
      READ (5,23)XMINFR,XMAXFR,DXFR,YMAXFR,DYFR,XMINA,XMAXA,DXA,YMINA,
     1YMAXA,DYA
      WRITE(6,23)XMINFR,XMAXFR,DXFR,YMAXFR,DYFR,XMINA,XMAXA,DXA,YMINA,
     1YMAXA,DYA
      DO 100 LM=1,MM
      IF(IFFREQ)203,201,200
C               IF DISTRIBUTION IS ON TAPE BUT NOT TO BE PLOTTED
C               SKIP OVER THIS SECTION OF INPUT TAPE
  203 READ(17,22)(TITLE1(J),J=1,12)
      READ(17,22)(TITLE2(J),J=1,7)
      READ(17,22)(TITLE3(J),J=1,10)
      DO 204 J=1,M
      READ(17,22)(TITLE4(JJ),JJ=1,12)
      READ(17,111)(X1(JJ),X4(JJ),JJ=1,NBLOK)
  204 CONTINUE
C               GO PLOT AVERAGES
      GO TO 200
C               READ TITLES FOR DISTRIBUTION FROM INPUT TAPE
  201 READ (17,22)(TITLE1(J),J=1,12)
      WRITE (6,22)(TITLE1(J),J=1,12)
```

```
      READ (17,22)(TITLE2(J),J=1,7)
      WRITE (6,22)(TITLE2(J),J=1,7)
      READ (17,22)(TITLE3(J),J=1,10)
      WRITE (6,22)(TITLE3(J),J=1,10)
C               ADVANCE FRAME
  352 CALL FRAMEV
C               PRINT OUT TITLE FRAME FOR TIME INTERVAL
      CALL PRINTV(72,TITLE1,100,500)
      CALL PRINTV(39,TITLE2,100,450)
C               L=0 FOR FIRST PLOT THIS FRAME
      L=0
C               READ DATA FOR NEXT STATION TO PLOT
      DO 354 J=1,M
      READ (17,22)(TITLE4(JJ),JJ=1,12)
      WRITE (6,22)(TITLE4(JJ),JJ=1,12)
      READ (17,111)(X1(JJ),X4(JJ),JJ=1,NBLOK)
C               IS THIS FIRST PLOT THIS FRAME
  401 IF(L)355,356,355
C               YES---SET CODE FOR NEXT STATION
  356 L=1
C               ADVANCE FRAME
  357 CALL FRAMEV
C               PRINT OUT IDENTIFYING TITLES AT TOP OF FRAME
      CALL PRINTV(72,TITLE1,100,1010)
      CALL PRINTV(39,TITLE2,100,994)
      CALL PRINTV(40,TITLE3,100,978)
      CALL PRINTV(68,TITLE4,100,950)
C               GET SCALE FACTORS FOR TOP PLOT
      CALL XSCALV(XMINFR,XMAXFR,100,50)
      CALL YSCALV(0.,YMAXFR,525,98)
C               OUTLINE TOP PLOT
      CALL LINEV(100,525,100,925)
      CALL LINEV(100,525,973,525)
      CALL LINEV(973,525,973,925)
      CALL LINEV(100,925,973,925)
C               LABEL AXES TOP PLOT
      CALL LINRV(1,500,520,525,XMINFR,XMAXFR,DXFR,1,1,5,8)
      CALL LINRV(2,50,95,100,0.,YMAXFR,DYFR,1,1,4,10)
      CALL PRINTV( 36,36HCROSS SECTION (DB ABOVE 1 SQ. METER),390,480)
      CALL APRNTV(0,-14, 15,15HNUMBER OF CASES,25,850)
C               SET LOWER Y LIMIT OF PLOT
      IY2=525
C               GO TO PLOTTING ROUTINE
      GO TO 360
C               NO---SET CODE FOR ADVANCING FRAME NEXT TIME
  355 L=0
C               GET SCALE FACTORS FOR LOWER PLOT
      CALL YSCALV(0.,YMAXFR,35,588)
C               OUTLINE LOWER PLOT
      CALL LINEV(100,35,973,35)
      CALL LINEV(100,35,100,435)
      CALL LINEV(100,435,973,435)
      CALL LINEV(973,35,973,435)
C               LABEL AXES LOWER PLOT
      CALL LINRV(1,460,435,440,XMINFR,XMAXFR,DXFR,1,1,5,8)
      CALL LINRV(2,50,95,100,0.,YMAXFR,DYFR,1,1,4,10)
      CALL APRNTV(0,-14, 15,15HNUMBER OF CASES,25,360)
      CALL PRINTV(68,TITLE4,100,20)
```

```
C             SET LOWER Y LIMIT OF PLOT
      IY2=35
C             PLOT FREQUENCY DISTRIBUTION FOR EACH BLOCK THIS STATION
  360 DO 367 II=1,NBLOK
      IF(X4(II))367,367,340
  340 AAA=X1(II)
      IX1=NXV(AAA)
      AAB=X4(II)
      IY1=NYV(AAB)
      CALL LINEV(IX1,IY1,IX1,IY2)
      IX1=IX1+1
      CALL LINEV(IX1,IY1,IX1,IY2)
      IX1=IX1-2
      CALL LINEV(IX1,IY1,IX1,IY2)
  367 CONTINUE
C             GO PLOT DISTRIBUTION OF NEXT STATION IF ANY
  354 CONTINUE
C             BEGIN AVERAGE PLOT
C             ADVANCE FRAME
  200 CALL FRAMEV
C             READ TITLES FROM INPUT TAPE
      READ (17,22)(TITLE1(JJ),JJ=1,12)
      WRITE(6,22)(TITLE1(JJ),JJ=1,12)
      READ (17,22)(TITLE2(JJ),JJ=1,7)
      WRITE(6,22)(TITLE2(JJ),JJ=1,7)
C             PRINT TITLES FOR AVERAGE PLOT
      CALL PRINTV(72,TITLE1,100,1000)
      CALL PRINTV(42,TITLE2,100,975)
      CALL PRINTV( 28,28H AVERAGE PULSE CROSS SECTION,100,950)
C             SET SCALE FACTORS FOR AVERAGE PLOT
      CALL XSCALV(XMINA,XMAXA,100,50)
      CALL YSCALV(YMINA,YMAXA,100,123)
C             OUTLINE PLOTTING AREA
      CALL LINEV(100,100,973,100)
      CALL LINEV(100,100,100,900)
      CALL LINEV(100,900,973,900)
      CALL LINEV(973,100,973,900)
C             LABEL AXES
      CALL LINRV(1,80,95,100,XMINA,XMAXA,DXA,1,1,4,8)
      CALL LINRV(2,50,95,100,YMINA,YMAXA,DYA,1,1,5,10)
      CALL PRINTV( 11,11HSTATION NO.,450,25)
      CALL APRNTV(0,-14, 34,34HCROSS SECTION DB ABOVE 1 SQ. METER,20,780
     1)
C             PLOT AVERAGES AND STANDARD DEVIATIONS EACH STATION
      DO 135 JJ=1,M
      READ (17,115)JK,AVDB(JJ),AVDBP(JJ),AVDBM(JJ)
  135 STA(JJ)=JK
      DO 361 J=1,M
      XAA=STA(J)
      YAA=AVDB(J)
      CALL POINTV(XAA,YAA,1)
      AAA=AVDBP(J)
      IY1=NYV(AAA)
      IX1=NXV(XAA)
      IX2=IX1+5
      IX3=IX1-5
      CALL LINEV(IX3,IY1,IX2,IY1)
      AAA=AVDBM(J)
```

```
      IY2=NYV(AAA)
      CALL LINEV(IX3,IY2,IX2,IY2)
      IY4=NYV(YAA)
      IY5=IY4+5
      IY6=IY4-5
      CALL LINEV(IX1,IY5,IX1,IY1)
      CALL LINEV(IX1,IY2,IX1,IY6)
C               GO DO NEXT STATION
  361 CONTINUE
C               PLOT NEXT TIME INTERVAL IF ANY
  100 CONTINUE
      GO TO 70
      END


*               SUBROUTINE TO DEFINE INPUT TAPE
$IBMAP UN17     6
       ENTRY    .UN17.
.UN17. PZE      UNIT17
UNIT17 FILE     ,B(2),HOLD,BLOCK=22
       END
```

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DOCUMENT CONTROL DATA – R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Lincoln Laboratory, M.I.T.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP None

3. REPORT TITLE

Amplitude Analysis Program

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Technical Note

5. AUTHOR(S) *(Last name, first name, initial)*

Wilson, Florence

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
29 April 1966	64	None

8a. CONTRACT OR GRANT NO. AF 19(628)-5167 b. PROJECT NO. ARPA Order 600 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Note 1966-1 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* ESD-TR-66-198

10. AVAILABILITY/LIMITATION NOTICES

Distribution of this document is unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
None	Advanced Research Projects Agency, Department of Defense

13. ABSTRACT

The Amplitude Analysis Programs have been written to produce an average pulse shape over a reasonable time interval for up to 200 range stations behind the tracked target leading edge and a frequency distribution of cross section at each station over the time period. The final output is presented as Stromberg-Carlson 4020 plots of average pulse and distributions. The input is obtained by digitizing A-Scope films on the Group 21 High Precision computer controlled film reader, filtering this data with a ramp filter to locate the position of the tracked target leading edge, and then writing a tape containing only that data behind the leading edge.

The Amplitude Frequency Distribution and Statistical Program uses this filtered output tape and computes an average pulse and the standard deviation from this pulse at each desired range station over a given time interval and also finds the distribution of cross section at each range station, if desired. A tape containing this information is then used as input to the Amplitude Plotting Program which produces the Stromberg-Carlson 4020 plots.

The present report contains a summary of the method of obtaining the input data, the mathematics involved, a description and listing of the two programs, and directions for running the programs.

14. KEY WORDS

amplitude analysis	film readers	IBM 7094
trace	Fortran	

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Security Classification