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AUTHORITY

ESD ltr, 4 Dec 1973

Project Report

PA-229-6
(RSP)

Data Reduction Program Documentation
ALTFENCE

(Effective: April 1971)

C. R. Berndtson
R. H. French
D. E. Nessman

8 April 1971

Prepared for the Advanced Research Projects Agency,
the Department of the Army, and the Department of the Air Force
under Electronic Systems Division Contract F19628-70-C-0230 by

Lincoln Laboratory
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Lexington, Massachusetts

Unclassified

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

DATA REDUCTION PROGRAM DOCUMENTATION ALTFENCE (EFFECTIVE: APRIL 1971)

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Philco-Ford Corporation

Editors

29 p.

F19628-70-C-0230,

ARPA Order-600

PROJECT REPORT PA-229-6 (RSP)

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L. G. Hanscom Field

Bedford, Mass. 01730

LEXINGTON MASSACHUSETTS

Unclassified

207 650

The work reported in this document was performed at Lincoln Laboratory, a center for research operated by Massachusetts Institute of Technology. This work was sponsored by the Advanced Research Projects Agency of the Department of Defense (ARPA Order 600), the Department of the Army, and the Department of the Air Force under Air Force Contract F19628-70-C-0230.

FOREWORD

This is the sixth report in the Data Reduction Program Documentation series. It is dated according to the date of completion of the documentation. No implication is made that this program will not subsequently be modified, amended, or superseded; on the contrary, the history of radar data processing is one of continuous evolution of techniques, and it is unrealistic to assume that steady-state has been reached. The PA-229 series is being published for the convenience of interested parties, and Lincoln assumes no responsibility for the correctness of the information presented, nor for its currency.

The preparation of reports in this series is under the Editorship of Charles R. Berndtson of Lincoln, and of D. Nessman and R. French of Philco-Ford Corporation. Inquiries, suggestions, corrections, criticisms, and requests for additional copies should be directed to C. R. Berndtson.

The principal contributor to this report was J. R. Cornelius (Philco-Ford). Due to the intricate, evolutionary manner in which the programs came into being, the editors regret that it is in general impossible to give due credit to all -- mathematicians or radar analysts or programmers -- who contributed to the definition and writing of the programs.

Alan A. Grometstein

CONTENTS

COMMON SYMBOLS AND ABBREVIATIONS

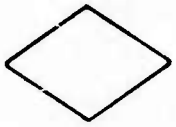
(The units given for certain quantities are the units commonly used for those quantities, unless otherwise noted.)

ADT	ALCOR Data Tape
Alt	Altitude (km)
APS	Average Pulse Shape
ARS	ALTAIR Recording System
Avg	Average, Averaging
Az	Azimuth (deg)
CADJ	Adjusted Calibration Constant (db)
C-band	ALCOR frequency, 5664 MHz (NB) and 5667 MHz (WB)
El	Elevation (deg)
EOF	End of File
GMT	Greenwich Mean Time
h	Hours
Hz	Hertz
in	Inches
LC	Left Circular Polarization
min	Minutes
NB	Narrow Band
NRTPOD	Non-real Time Precision Orbit Determination Program
POD	Project PRESS Operation and Data Summary Report
Phase	Presented in deg
PRF	Pulse Repetition Frequency (pps)
PRI	Pulse Repetition Interval (s)
pps	Pulses per second
pts	Points
R	Range (km)
$\dot{R}$	Range Rate (km/s)
rad	Radians
RC	Right Circular Polarization
RCS	Radar Cross Section (dbsm)
s	Seconds
SD_w	Standard Deviation of Wake Velocity

T	Time
TAL	Time After Launch (s)
UHF	ALTAIR Frequency; 415 MHz
V	Velocity
V_d	Doppler Velocity
V_w	Mean Wake Velocity
VHF	ALTAIR Frequency; 155.5 MHz
WB	Wide Band
θ	Total Off-axis Angle (deg)
λ	Wavelength
*	Denotes Multiplication

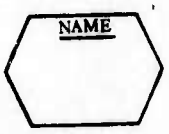
FLOW DIAGRAM SYMBOLS

PROCESS, ANNOTATION



DECISION

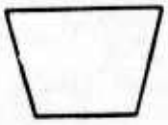
TERMINATOR



SUBROUTINE: where NAME is the entry call into the subroutine

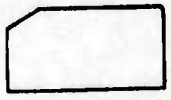
CONNECTOR: where P specifies a page in the flow diagram, and L designates a statement number in the program listing or a reference point in the flow diagram

CONNECTOR: where X implies a continuation of the diagram to the next page

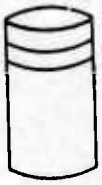


INPUT/OUTPUT OPERATION

MAGNETIC TAPE



PUNCHED CARD



DISK

ALTFENCE

I. PURPOSE AND UTILIZATION

A. Source of Data

ALTAIR[1]

B. Data Input

ALTAIR transcription tape

C. Description

ALTFENCE produces a chaff cloud profile, and computes the integrated RCS (m^2) of a chaff cloud.

D. Output

1. Listing of computed quantities.
2. Plots vs relative range of average RCS and integrated RCS (m^2).

II. DESCRIPTION

ALTFENCE computes the average RCS in each gate. The average RCS is then plotted vs relative range. The relative range is set equal to zero at the first gate in the request, and the range for subsequent gates is computed using the following relationship:

G (gate-to-gate width (m)) = 150 ($A \times 2^k$)

where A (gate width for contiguous samples) =

0.2 μs for VHF data

0.1 μs for UHF data

k = sample spacing

The integrated RCS* is computed by summing the RCS (m^2) in relative range segments equivalent to the width (W) of the return pulse at the 3-db points.** The equation for integrated RCS is then:

$$\text{Integrated RCS} = \frac{G}{W} \sum_{j=1}^{n} \text{RCS}(j)$$

where G = gate-to-gate spacing (m)

W = pulse width (m)

RCS (j) = RCS in j-th gate (m^2)

n = total no. of gates processed

If desired, it is possible to have the noise removed by selecting a gate (usually the first or last gate in the request) that contains only noise. The noise level (m^2) is computed for this gate and subtracted from the RCS (m^2) in each gate before summing. The integrated RCS (m^2) is then plotted vs relative range.

*Listed and plotted as a function of relative range.

**The return pulse shape is measured at periodic intervals. At present, W is 30 m at VHF and 15 m at UHF.

The data cards are not checked for validity. Subroutine ALREAD[2] makes a number of checks on transcription tape parameters. For some errors (missing format tables; end of file; target no., sampling pattern, or polarization not on tape) information is returned to main program for decision to terminate.

III. OPERATION

A. Input

Start time (GMT)

Specified set of range gates

Target and sampling pattern numbers

Polarization

Noise removal gate

Averaging interval

A sample input is shown in Appendix A.

CARD 1 (15A4)

(Col.)	
1-16	Label for plots and listing
17-60	Additional labels for listing

CARD 2 (2I3, 2F7.3, 6I5)

2- 3	IH (I3)	Start time (GMT) in h, min, and s
5- 6	IM (I3)	
7-13	ZSEC (F7.3)	
14-20	TINC	Averaging interval (s) (F7.3)
21-25	NRG	Number of range gates (I5)
26-30	ITARG*	Target no. (I5)
31-35	IPAT**	Sampling pattern in which initial gate is located. (I5)
36-40	IPOL	Data channel: 1 = LC; 2 = RC; 3 = Az error †; 4 = El error† (I5)
41-45	NOIGAT	Location, relative to ING, of noise removal gate. If NOIGAT = 0, noise not subtracted. (I5)
46-50	ING††	Location within IPAT of initial gate (I5)

*Also called INTARG.
**Also called INPAT.
† VHF transcriptions only.
†† Also called ISG and ISTGAT.

B. Output

LISTING

First data card giving label

Start and stop times (GMT)

Averaging interval (s)

R

NRG

Frequency and polarization

Target no.

R (relative to initial gate requested)
Average RCS
Integrated RCS (m^2)
} For each gate

PLOTS

Average RCS vs relative range
(The ordinate ranges from +40 to -60 dbsm at 20 db/in. The abscissa is selected by the program.)

Integrated RCS (m^2) vs relative range
(Both scales are selected by the program.)

Sample outputs are shown in Appendix B.

IV. PROGRAM LIMITATIONS

The requested gates must be equally spaced for valid results. This is not checked by the program.

Start time	Must be on tape
NRG	≤ 120 gates
TAVG	If entire averaging interval is not on tape, program uses data to end of tape
ITARG	Must be on tape
NOIGAT	≤ NRG
Length of run	Limited only by length of tape

V. PROGRAMMING

A. CHAFEN (see Appendices C and D.)

CHAFEN is the control section of ALTFENCE. CHAFEN reads the input cards, calls ALREAD and TSPLIT, averages the data returned, and computes the integrated RCS. CHAFEN also calls the plot routines and prints the data.

B. ALREAD[2]

ALREAD is the Fortran driver for the machine language tape reading routines.

The call statement is ALREAD (TSTART, TSTOP, TLIFT, INTARG, INPAT, IPOL, NOPHA, NPTS, DFPG, NEWPAS, NRG, ISTGAT).

INPUT

TSTART	Start time of processing (GMT total seconds)
TSTOP	End time of processing (GMT total seconds)
INTARG	Target number to be processed
IPAT*	Sampling pattern in which initial gate is located
NRG	Number of range gates to be processed
ISTGAT**	Location within INPAT of initial gate wanted
NOPHA	1 (only RCS data wanted)
IPOL	Data channel: 1 = LC; 2 = RC; 3 = Az error; 4 = El error

*Also called INPAT.
**Also called ING or ISG.

INPUT AND OUTPUT PARAMETERS

NPTS*	Output: number of pulses of data returned
	Input: must be initialized by calling program before each call to ALREAD
NEWPAS**	Cycle and error pointer

OUTPUT

TLIFT	Lift-off time (GMT total seconds)
DFPG	Frequency and polarization (e.g. VHF LC)

C. TSPLIT (see Appendix E.)

TSPLIT is used to convert time from GMT total seconds to h, min, s, and decimal fractions of s.

The call statement is TSPLIT (AVGTM, IHM, TRUN).

INPUT

AVGTM	GMT total seconds

OUTPUT

IHM (1)	Hours
IHM (2)	Minutes
TRUN	Seconds and decimal fractions of seconds

D. REW

REW is an entry to subroutine BREADS[3] used to rewind the tape.

*Set to zero for first call. Set to number of saved points for subsequent calls.
**Also called IAGAIN.

E. CHFPLT

CHFPLT is the plotting routine.

F. Plotting System Subroutines

They are REREAD, STOIDV, and PLTND.

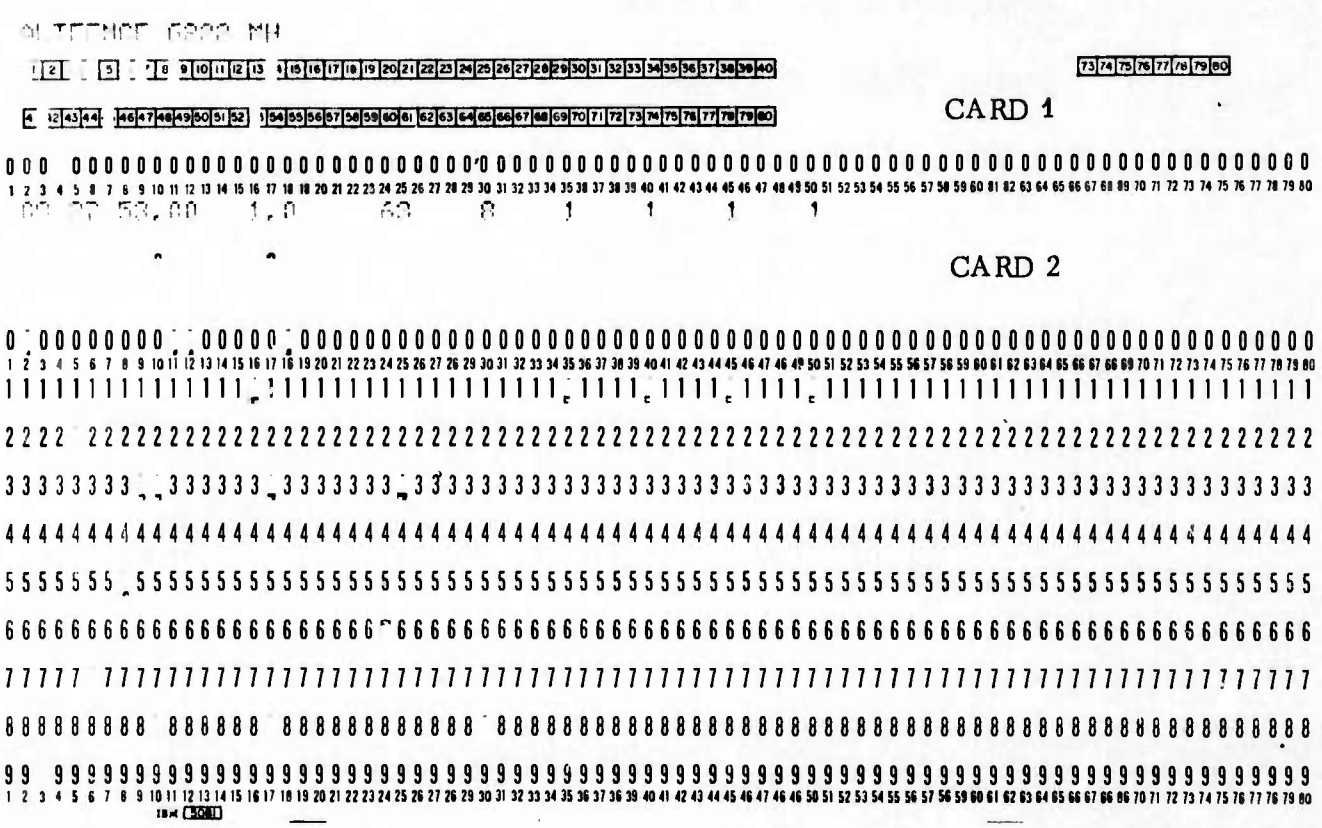
REFERENCES

1. "ALTAIR Data User's Manual", LM-97, Lincoln Laboratory, M.I.T. (to be published), UNCLASSIFIED.

2. "Data Reduction Program Documentation, ALREAD, (Effective: March 1971)", PA-229-3, Lincoln Laboratory, M.I.T. (17 March 1971), UNCLASSIFIED.

3. "Data Reduction Program Documentation, ALTAIR Tape Read Package, (Effective: April 1970)", PA-229-1, Lincoln Laboratory, M.I.T. (17 March 1971), UNCLASSIFIED.

APPENDIX A
ALTFENCE INPUT



APPENDIX B

ALTFENCE OUTPUTS

ALTAIR FENCE CHAFF VERSION DATE 20 OCTOBER 1970
ALTFENCE G222 MH

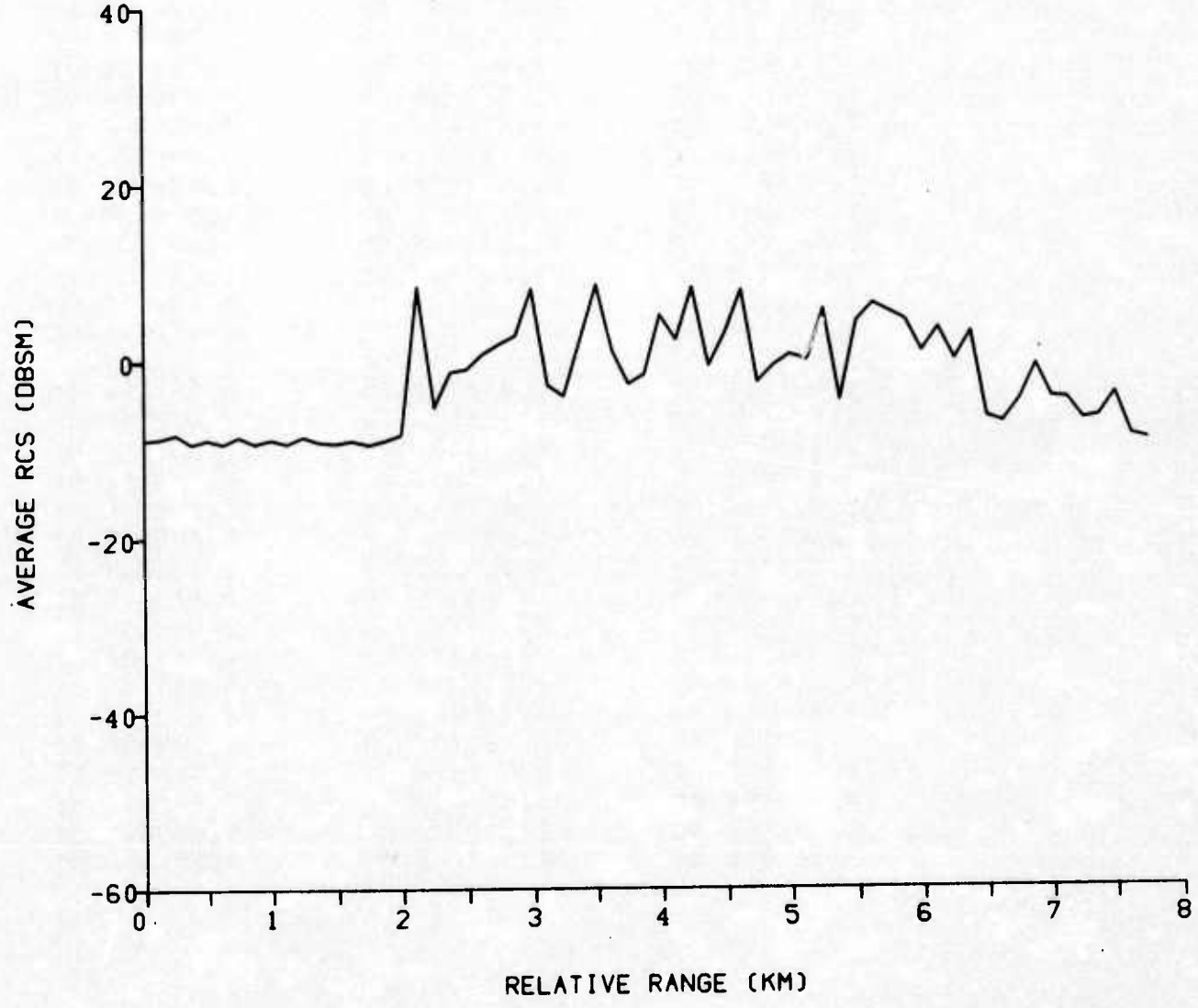
TIME 9 27 53.0000 TO 9 27 54.0000 AVG INT = 1.0000
RANGE = 124.800 63 GATES VHF-LC TARGET 8

RG	REL RANGE (KM)	AVG RCS (DBSM)	INT RCS (M**2)
1	0.0	-8.94442E 00	0.0
5	1.24800E-01	-8.81619E 00	5.96087E-03
9	2.49600E-01	-8.33819E 00	4.17205E-02
13	3.74400E-01	-9.44241E 00	4.99690E-02
17	4.99200E-01	-8.96278E 00	4.99690E-02
21	6.24000E-01	-9.30261E 00	4.99690E-02
25	7.48800E-01	-8.65647E 00	4.99690E-02
29	8.73600E-01	-9.43989E 00	4.99690E-02
33	9.98400E-01	-8.95628E 00	4.99690E-02
37	1.12320E 00	-9.35881E 00	4.99690E-02
41	1.24800E 00	-8.57108E 00	4.99690E-02
45	1.37280E 00	-9.20307E 00	5.63245E-02
49	1.49760E 00	-9.42772E 00	5.63245E-02
53	1.62240E 00	-9.10733E 00	5.63245E-02
57	1.74720E 00	-9.48244E 00	5.63245E-02
61	1.87200E 00	-9.09871E 00	5.63245E-02
65	1.99680E 00	-8.43511E 00	7.41318E-02
69	2.12160E 00	8.36773E 00	1.06126E 01
73	2.24640E 00	-5.32529E 00	2.13851E 01
77	2.37120E 00	-1.31761E 00	2.25968E 01
81	2.49600E 00	-9.60721E-01	2.46011E 01
85	2.62080E 00	7.72228E-01	2.73172E 01
89	2.74560E 00	1.77832E 00	3.11324E 01
93	2.87040E 00	2.76323E 00	3.60314E 01
97	2.99520E 00	7.93567E 00	4.82792E 01
101	3.12000E 00	-2.92328E 00	5.83753E 01
105	3.24479E 00	-4.11998E 00	5.93773E 01
109	3.36959E 00	2.46535E 00	6.23357E 01
113	3.49439E 00	8.40262E 00	7.54890E 01
117	3.61919E 00	1.06748E 00	8.78849E 01
121	3.74399E 00	-2.76017E 00	9.03080E 01
125	3.86879E 00	-1.56406E 00	9.18246E 01

ALTFENCE G222 M

9 27 53.0000 TO 9 27 54.0000

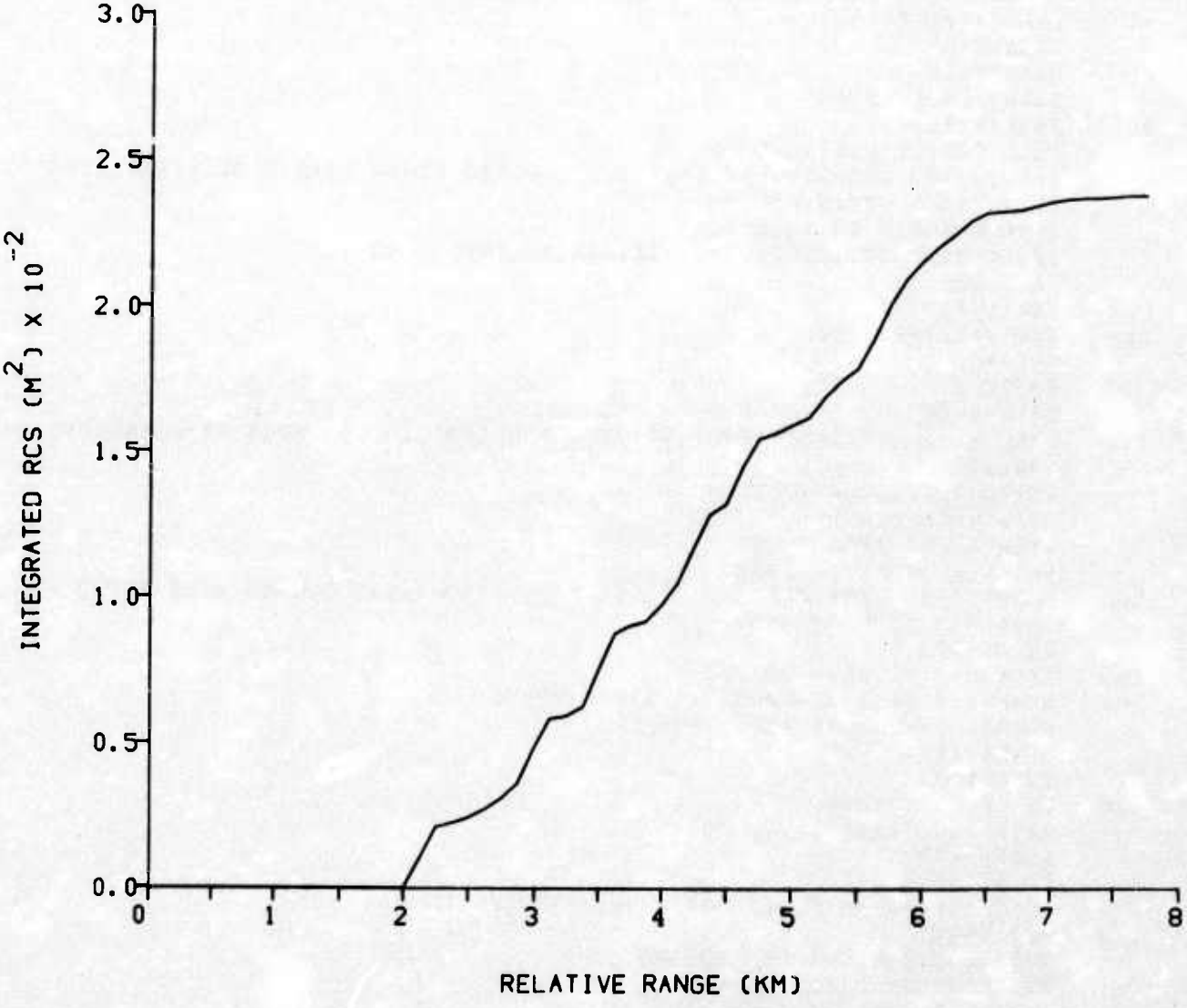
AVG INTERVAL = 1.0000 TARGET 8 63 GATES VHF-LC



ALTFENCE G222 M

9 27 53.0000 TO 9 27 54.0000

AVG INTERVAL = 1.0000 TARGET 8 63 GATES VHF-LC



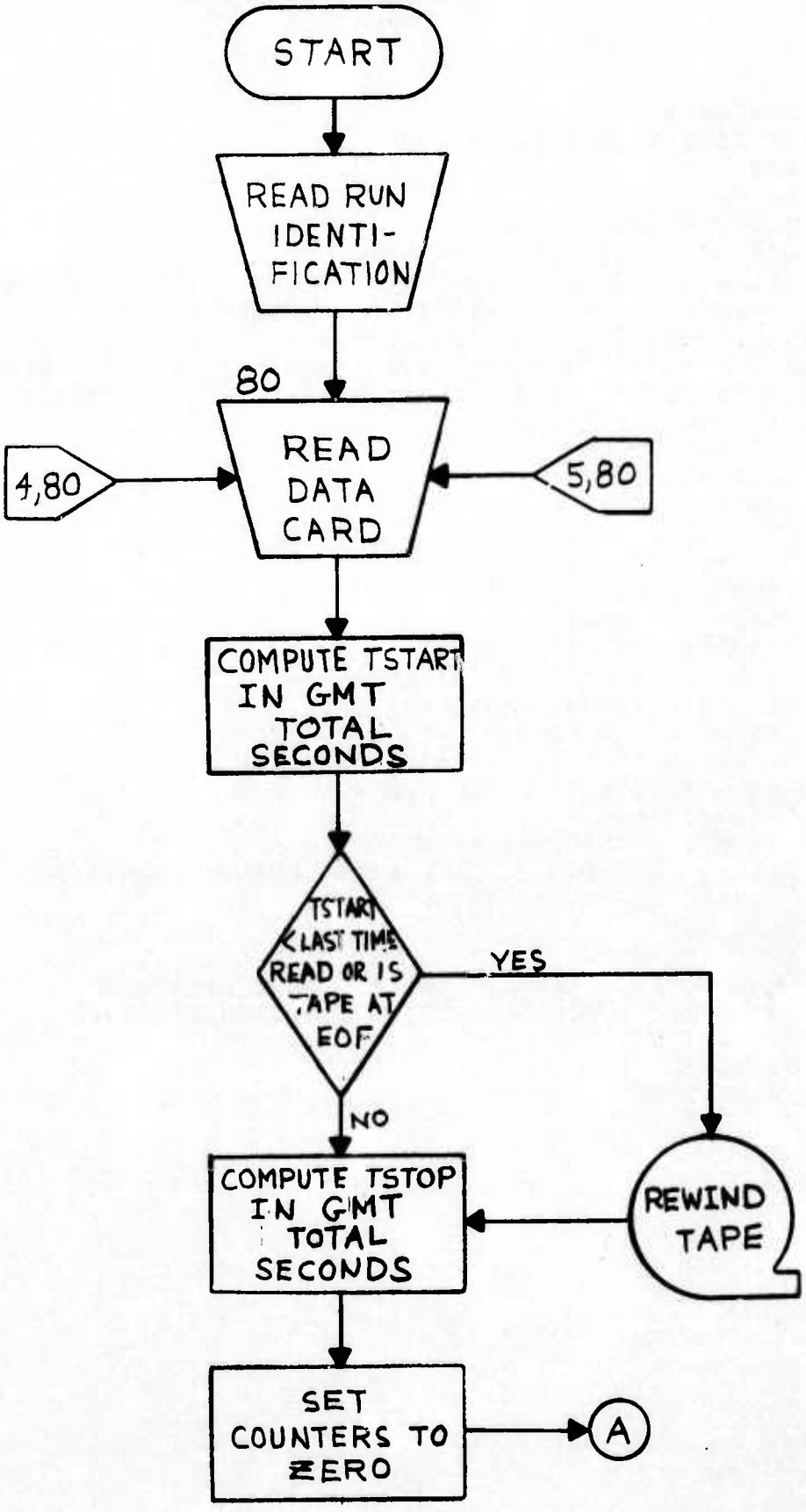
APPENDIX C
CHAFEN PROGRAM LISTING

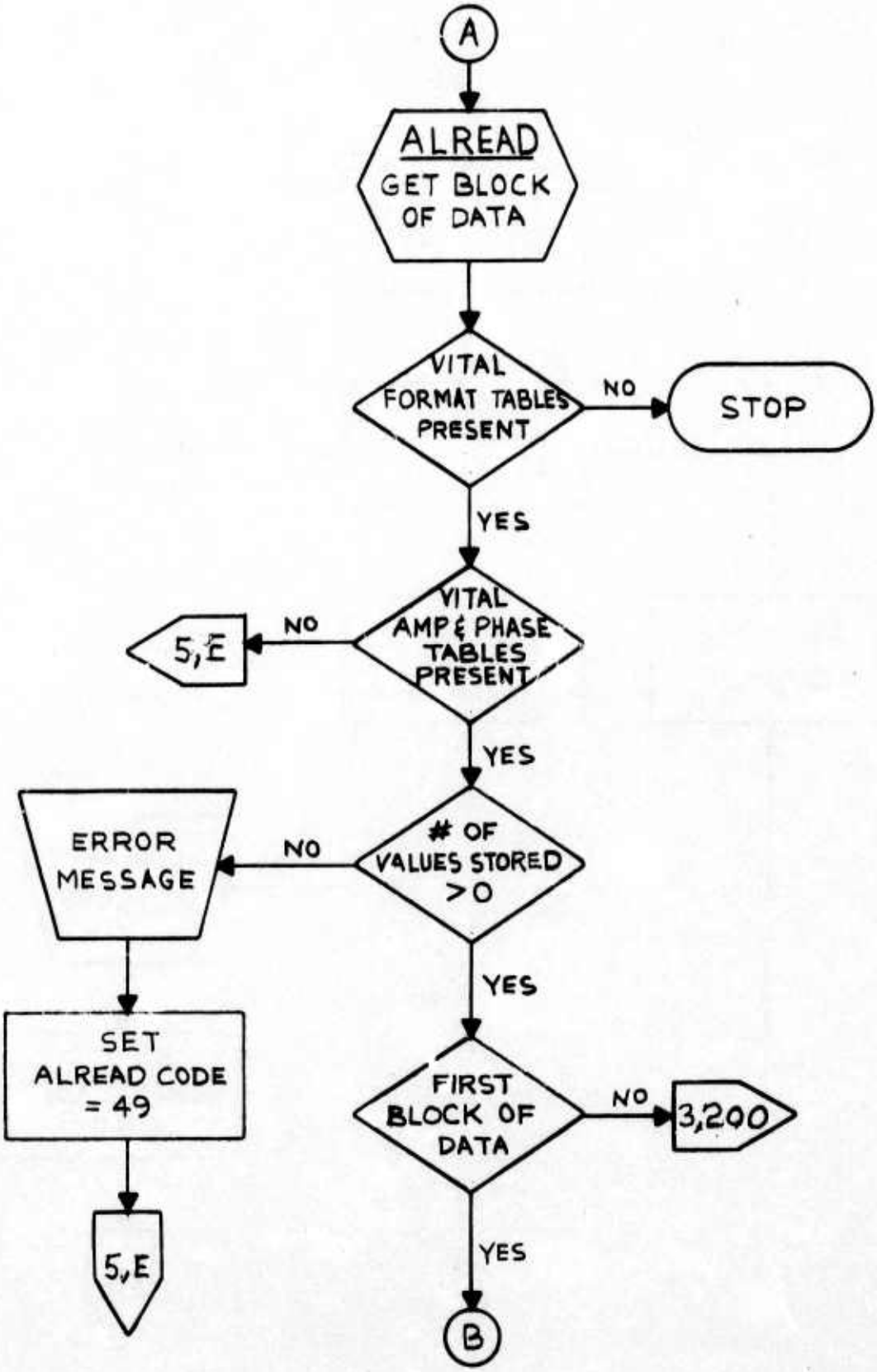
```
      DIMENSION AVSQM(120),AVXS(120),FPGCON(2),IT1(2),IT2(2),SPFAC(2),
     1SUMXS(120),RELRNG(120)
      COMMON/RDCOMT/TIMES(300),XS(120,300),RANGE(300),ALT(300),IRGA(120)
     1,NFPG
      COMMON/PLOTT/ZSTP,IHM(2),NRG,PLOTAG(15),DFPG(2),TINC
      EQUIVALENCE (XS(1,1),RELRNG(1)),(XS(1,101),SUMXS(1))
      DOUBLE PRECISION SEC,T1,T2,TIMES,TLIFT,TOTIM,TSTART,TSTOP,ZDUM1,
     1ZDUM2,ZSEC,ZSTP
      DATA SPFAC,FPGCON/30.0,15.0,30.0,15.0/
      DATA AVSQM/120*0.0/
      TOTIM(NH,NM,SEC)=DFLOAT(60*(60*NH+NM))+SEC
      CALL REREAD(99,540)
      IAGAIN=0
      TSTOP=0.0
      READ(5,40)PLOTAG
40    FORMAT(15A4)
      CALL STOIDV(PLOTAG,59,0)
80    READ(5,100,END=1000)IH,IM,ZSEC,TINC,NRG,ITARG,IPAT,IPOL,NOIGAT,ING
100   FORMAT(2I3,2F7.3,6I5)
      TSTART=TOTIM(IH,IM,ZSEC)
      IF((TSTART.GT.TSTOP).AND.(IAGAIN.NE.44))GO TO 120
      CALL REW
      IAGAIN=1
120   TSTOP=TSTART+TINC
      NPTS=0
      KOUNT=0
      T1=TSTART
160   CALL ALREAD(TSTART,TSTOP,TLIFT,ITARG,IPAT,IPOL,1,NPTS,DFPG,IAGAIN,
     1NRG,ING)
      IF(IAGAIN.EQ.55)GO TO 1000
      IF(IAGAIN.EQ.66)GO TO 80
      IF(NPTS.NE.0)GO TO 190
      WRITE(6,180)IH,IM,ZSEC
180   FORMAT('1   FOR TIME = ',I2,I3,F8.4,' NO VALID POINTS WERE FOUND -
     1 RUN HAS BEEN ABORTED.')
      GO TO 700
190   IF(KOUNT.NE.0)GO TO 200
      RA=FLOAT(IRGA(2)-IRGA(1))*SPFAC(NFPG)
      CONMUL=RA/(2.0*FPGCON(NFPG))
      FPKKM=RA/1000.0
      T2=TSTOP
200   DO 500 J=1,NPTS
      IF(T1.GT.TIMES(J))GO TO 500
      KOUNT=KOUNT+1
      DO 300 I=1,NRG
      AVSQM(I)=AVSQM(I)+10.0**(XS(I,J)/10.0)
300   CONTINUE
      IF(T2.GT.TIMES(J))GO TO 500
      IF(KOUNT.GT.0)GO TO 600
      CALL TSPLIT(T1,IT1,ZDUM1)
      CALL TSPLIT(T2,IT2,ZDUM2)
      WRITE(6,320)IT1,ZDUM1,IT2,ZDUM2
320   FORMAT('  BETWEEN TIMES ',2I3,F8.4,' AND ',2I3,F8.4,'  THERE IS A
     1TIME GAP.')
      GO TO 700
```

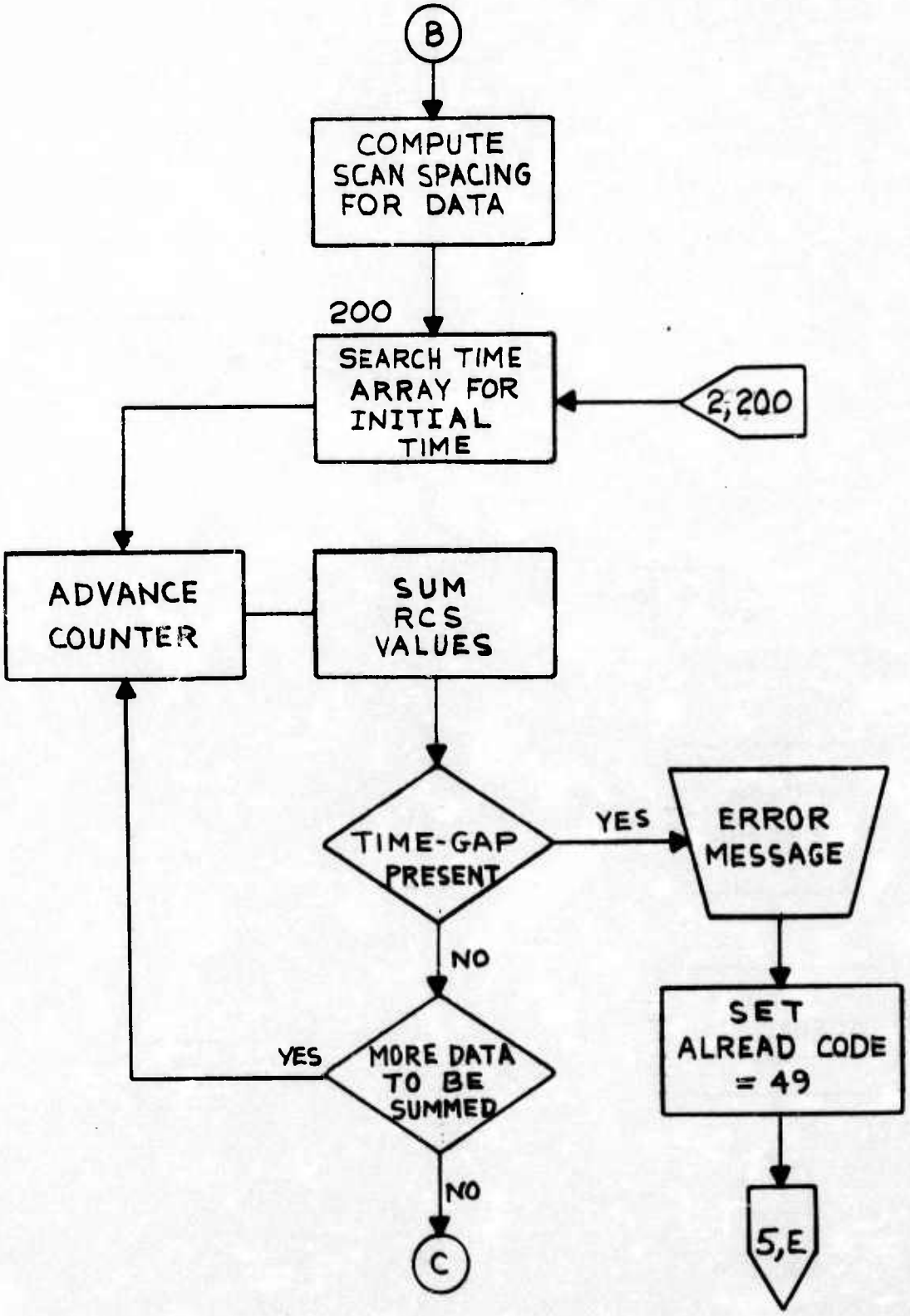
```
500   CONTINUE
      IF(IAGAIN.EQ.0)GO TO 600
      NPTS=0
      GO TO 160
600   COUNT=KOUNT
      CALL TSPLIT(TSTOP,IHM,ZSTP)
      WRITE(6,620)PLOTAG,IH,IM,ZSEC,IHM,ZSTP,TINC,RA,NRG,DFPG,ITARG
620   FORMAT('1'//14X,'ALTAIR FENCE CHAFF VERSION DATE 19 MARCH 1971'/
     114X,15A4//7X,'TIME ',2I3,F8.4,' TO ',2I3,F8.4,'   AVG INT = ',
     2F7.4/9X,'RANGE = ',F9.3,I6,' GATES',3X,2A4,' TARGET ',I2//3X,
     3'RG',15X,'REL RANGE (KM)',5X,'AVG RCS (DBSM)',4X,
     4'INT RCS (M**2)'/)
      RNGRUN=-FPKKM
      SUMXS(1)=0.0
      AVNOIS=0.0
      IF(NOIGAT.GT.0)AVNOIS=AVSQM(NOIGAT)/COUNT
      DO 680 I=1,NRG
      RNGRUN=RNGRUN+FPKKM
      RELRNG(I)=RNGRUN
      AVSQM(I)=AVSQM(I)/COUNT
      AVXS(I)=10.0*ALOG10(AVSQM(I))
      AVSQM(I)=AVSQM(I)-AVNOIS
      IF(I.EQ.1)GO TO 640
      SUMAD=CONMUL*(AVSQM(I-1)+AVSQM(I))
      IF(SUMAD.LT.0.0)SUMAD=0.0
      AVSQM(I-1)=0.0
      SUMXS(I)=SUMXS(I-1)+SUMAD
640   WRITE(6,660)IRGA(I),RELRNG(I),AVXS(I),SUMXS(I)
660   FORMAT(I5,11X,1P3E18.5)
680   CONTINUE
      AVSQM(NRG)=0.0
      CALL CHFPLT(RELRNG,AVXS,IH,IM,ZSEC,ITARG,1)
      CALL CHFPLT(RELRNG,SUMXS,IH,IM,ZSEC,ITARG,2)
700   IAGAIN=49
      GO TO 80
1000  CALL PLTND
      RETURN
      END
```

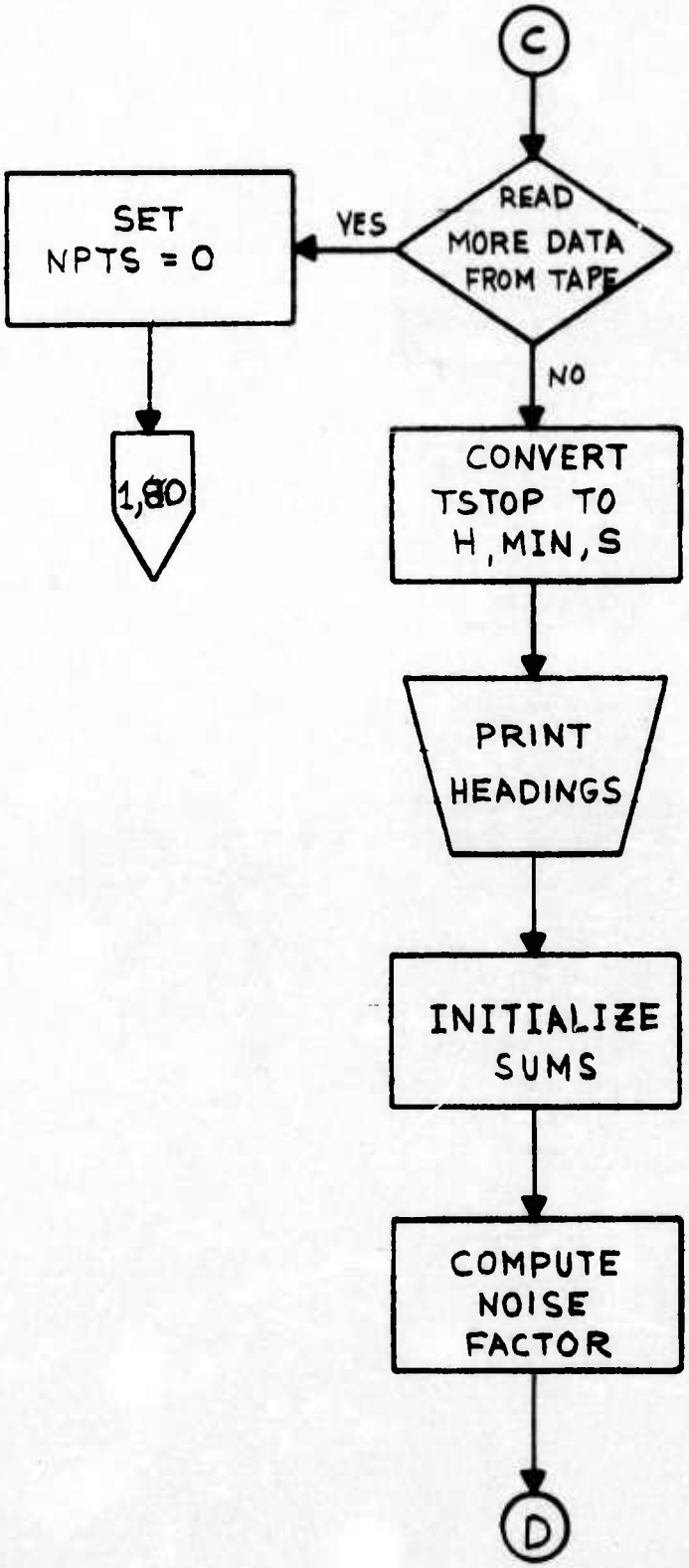
APPENDIX D

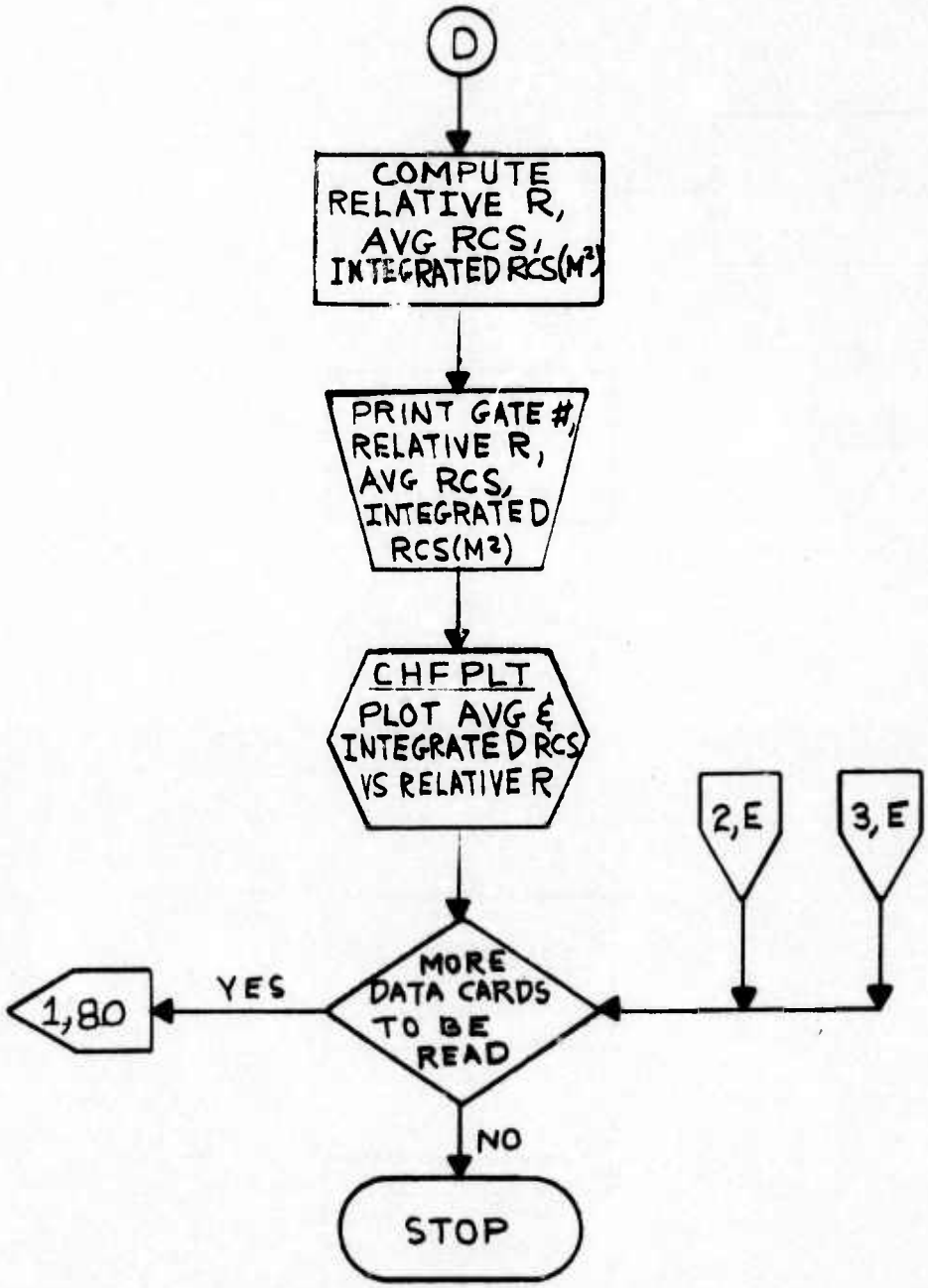
CHAFEN FLOW DIAGRAM




A
ALREAD
GET BLOCK OF DATA
VITAL FORMAT TABLES PRESENT
NO
STOP
YES
VITAL AMP & PHASE TABLES PRESENT
NO
5,E
YES
OF VALUES STORED >0
NO
ERROR MESSAGE
YES
SET ALREAD CODE = 49
5,E
FIRST BLOCK OF DATA
NO
3,200
YES
B


B
COMPUTE SCAN SPACING FOR DATA
200
SEARCH TIME ARRAY FOR INITIAL TIME
2,200
ADVANCE COUNTER
SUM RCS VALUES
TIME-GAP PRESENT
YES
ERROR MESSAGE
NO
SET ALREAD CODE = 49
YES
MORE DATA TO BE SUMMED
NO
C
5,E


C
READ MORE DATA FROM TAPE
YES
SET NPTS = 0
1,80
NO
CONVERT TSTOP TO H, MIN, S
PRINT HEADINGS
INITIALIZE SUMS
COMPUTE NOISE FACTOR
D


D
COMPUTE RELATIVE R, AVG RCS, INTEGRATED RCS(M²)
PRINT GATE #, RELATIVE R, AVG RCS, INTEGRATED RCS(M²)
CHFPLT
PLOT AVG & INTEGRATED RCS VS RELATIVE R
2,E
3,E
MORE DATA CARDS TO BE READ
YES
1,80
NO
STOP

APPENDIX E

TSPLIT PROGRAM LISTING

```
      SUBROUTINE TSPLIT(AVGTM,IHM,TRUN)
      DIMENSION IHM(2),DIVIDE(2)
      DOUBLE PRECISION AVGTM,TRUN
      DATA DIVIDE/3600.,60./
      TRUN=AVGTM
      DO 20 I=1,2
      IHM(I)=TRUN/DIVIDE(I)
      TRUN=TRUN-FLOAT(IHM(I))*DIVIDE(I)
20    CONTINUE
      RETURN
      END
```