Analysis of Ultrasonic Tracking Records of Adult Sockeye Salmon Migration in Babine Lake

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FISHERIES RESEARCH BOARD OF CANADA

TECHNICAL REPORT NO. 335

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ANALYSIS OF ULTRASONIC TRACKING RECORDS OF ADULT SOCKEYE SALMON MIGRATION IN BABINE LAKE

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Pacific Biological Station, Nanaimo, B.C.

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SECTION I

INTRODUCTION

Migratory pathways of adult sockeye salmon (Oncorhynchus nerka) on their way to the spawning grounds in Babine Lake were monitored by ultrasonic tracking techniques in 1969 and 1970. This report presents procedures and computer programs used for processing the tracking data. It also contains instructions for coding meteorological and other environmental data for further analysis.

Investigators employing ultrasonic tracking techniques to study movements of aquatic animals use a variety of methods to record and analyze their data (Johnson 1960, Hasler et al. 1969, McCleave and Horrall 1970, Yuen 1970, Leggett 1971, Madison et al. 1972, Evans 1972). Standardizing the collecting and processing methods of such data makes comparisons between different studies easier and more meaningful. We hope that the recording and analysis procedures discussed in this report can be a base for such standardization.

MATERIALS AND METHODS

Experimental animals

Sockeye salmon were obtained from fences in the main salmon rivers entering or draining Babine Lake. The fish were transported 15 to 60 km by boat to the release or holding sites. Holding times ranged from 0 to 6 days with an average of 2 days.

Tagging procedure

Sonic tags (56 mm × 14 mm, Smith-Root Electronics Ltd.) were inserted through the mouth into the fish's stomach with the transducer end facing the tail. The tags had frequencies of 65, 70 and 75 KHz and repetition rates of approximately 0.6, 1.2, 2.5 and 5 pulses per second. All experimental fish were marked with a Petersen disc tag bearing a number and return address for easy recognition at fences or on spawning grounds.

No anaesthetic was used during transportation or tagging. The complete operation of applying internal and external tags took less than a minute. The salmon were allowed to recover in a net alongside the boat for about 15 to 30 min until they regained equilibrium. This usually occurred after coming to the surface to gulp air a number of times. They were released by pulling a slipknot on the bottom of the net.

Tracking procedure

Sonic-tagged fish were followed with a barge equipped with hydrophones and receivers (models: Smith-Root S-70 and Lawson). Distance of the tracking barge from the fish was estimated to vary between 100 and 300 m with an average of 200 m.

Every 15 min[1] the position of the tracking barge was plotted on a map using radar (Decca 101) and/or a sextant (Plath). The barge was not moved closer to the fish for positioning for fear it would affect the fish's behaviour.

Since size of the maps equalled the radar display at the 2-mile range plots were quickly accomplished by tracing shore contours and center of radar picture on a circular piece of transparent plastic and aligning this on the map.

Weather and water observations were made every 3 to 4 hours[2] during a track following coding instructions given in section 4. Minimum and maximum temperatures for the day, barometric pressure, precipitation and hours of sunshine for the day were obtained from meteorological records taken by the Fisheries Service on Babine Lake. All observations were punched on computer cards for further analysis. Changes in environmental conditions occurring between regular observation times were noted on the maps.

ANALYSIS OF DATA

The objective of the following analysis was to obtain information on speed, direction and angular change of movement and to compare these parameters with changes in meteorological conditions during the time of observation.

Three types of cards, one Position Card (P) and two Header Cards (F1 and F2), containing the pertinent data for each track were prepared for computer analysis. Instructions for punching these cards are given in section 2.

Position plots of each track were digitized with a Trilateral Reader and punched on paper tape. The reader consists of a rectangular plate (40 × 50 cm) with a potentiometer mounted on each top corner. The potentiometers have a spring-loaded drum, around which a string is wrapped. Both strings are attached to a pointer which can be moved across the map. The pointer's position on the map and the two potentiometer drums are the apices of a triangle. The distance between the two drums (the base of the triangle) is a known constant and the string lengths are determined by the potentiometers and displayed on digital voltmeters. The voltmeters are interfaced with a Teletype to transform the data to paper tape. Accuracy of the Trilateral Reader is ±1 mm over a distance of 600 mm (diagonal of screen). This apparatus was also used to

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[1]Present practice is to take position plots every 30 min. Analysis and checking of data are enhanced by taking these plots exactly at the half and full hours.

[2]At present weather and water observations are made every 2 hours on the hour. These environmental conditions are then compared with information on speed, direction and angular change from 1 hour before to 1 hour after the weather and water observations.

digitize the map of Babine Lake.

A number of computer programs were written to plot tracks in appropriate lake areas and to extract information on speed, direction and angular changes of movements. All mainline programs are in Fortran 1130 (a subset of Fortran IV) and were used under Disk Monitor Version II of an IBM 1130 computer with 16 K core. The complete system includes a paper tape reader, disk, card reader, card punch, typewriter/keyboard, printer and plotter. A flow chart of analysis sequence is presented in Fig. 1. Source decks of the programs listed in the flow chart are available on request from the Computer Centre, Pacific Biological Station, Nanaimo, B. C., Canada.

Plotting of map and tracks and punching of new position cards

Program DVCC controls the following operations:

1. Reads pairs of string lengths from the paper tape, which were obtained with the Trilateral Reader. Subroutine GET2 converts the A1 format to an integer and checks for errors.

2. Converts these string lengths into x-y coordinates using subroutine CORD2.

3. Rotates points with respect to true north-south so that separate sections of map and/or track are properly lined up. Large maps and tracks had to be digitized in sections which are combined in this program.

4. Transforms the x-y coordinates in relation to a master reference point on the map and scales them in kilometers.

5. Sets up file record DVMF.

DVCC was written for a specific system (Trilateral Reader - paper tape) and will have to be modified if other digitizing techniques are used.

Program MTPLT plots either a map or a track or both in the desired scale. Sections where signal was lost are indicated by a dashed line. When a salmon went around a point of land, positions are interpolated for the plotting procedures. The interpolated points are not used in the analysis of speed, direction and an angular change of movement. MLPLT is a self-contained program and can be run separately from DVCC provided the proper input is supplied.

An example of actual map and track plots is presented in Fig. 2. A redrawn version is given in Fig. 3. Indicated are start and end of track and the path covered by the tracking barge while following a salmon. The crosses (Fig. 2) or dots (Fig. 3) are the position plots at approximately 15-min intervals.

Solid and dashed lines connecting the plots in Fig. 3 represent, respectively, night and day sections. Civil twilight was used for separating the day from the night observations. Stippled line sections show portions where signal was lost. Arrows alongside tracks indicate direction of movement.

Program PUNCH reads the x-y coordinates in kilometers from the DVMF file and combines these with data from the Position Cards (P) to punch New Position Cards.

Speed of movement

CREF uses information from the New Position Cards and the Header Cards F1 and F2 to create a file TEST (see Table 1 and 2), which is used by program MACH1 to calculate speeds of movement for day or night and for different days of the track. Program MACH1 requires subroutines HEAD and SWIM: MACH1 can also give speed of movement for different intervals of the day, but there must always be a dawn (-200) and a dusk (-100), which are inserted in their proper places on the time scale. See Table 3 for an example of the output of MACH1 for track 14-70.

MACH2 performs similar operations to MACH1, except that it separates the data in predetermined time intervals with no regard to twilight periods. This program is useful when regular time intervals are required, such as for regressions with environmental data. An output example for track 14-70 is presented in Table 4.

Direction of movement

Using information from the New Position Card (P) and the two Header Cards (F1 and F2), program ADNTP calculates the direction between successive positions. It then loads this information on disk file TSDN, together with track number, day number and time of day. For an example of output of ADNTP see Table 5.

Program CBMTP groups vector directions over certain time intervals. For this operation subroutine PUTI is required to convert integers to A1 format. CBMTP also calls links to programs DIRTP and PLTP. The programs for analysis of direction of movement are designed to handle a maximum of 31 tracks with a maximum of 310 positions per track. DIRTP and PLPT are not self-contained and have to be run as a package with CBMTP.

Program DIRTP calculates parameters of the circular normal distribution using the Rayleigh test (Batschelet 1965) and prints out vector directions, sum of sines (W), sum of cosines (V), total number of data points (N), direction of vector resultant (THETA), vector resultant (R), vector strength (A), Rayleigh statistic R^2/N (Z), coefficient of concentration (KAPPA) and the angular deviation (Table 6, 7 and 8). This program also checks for bimodality by doubling the angles of the vectors (Groot 1965, Batschelet 1965). A bimodal distribution can thus be generated to a unimodal one and when the vector strength (A_2) for this vector summation is almost as great or greater than

for the unmodified distribution, (i.e. $A_z > (A_1 - 0.10)$) the new statistics are printed in addition (for example see Table 7).

To determine the coefficient of concentration (KAPPA) information contained in Table B from Batschelet (1965) is loaded in file TABLB by TLOAD. Subroutine ANGLE converts angles from the arctangent function into compass directions in degrees True North.

DIRTP also performs a test of goodness of fit (X^2 test, Batschelet 1965, p. 25), compares the calculated mean direction with a theoretical direction (Batschelet 1965, p. 29) and compares mean directions with each other (Batschelet 1965, p. 33) (see Tables 7 and 8 for examples).

Program PLPT plots the vector distribution and the vector resultant on a compass diagram for each time interval (Fig. 4). For bimodal distributions a directional axis is presented in addition (Fig. 5). PLPT requires subroutine QSORT to sort directions in ascending order.

Angular change of movement

Disk file TSDN contains directions between successive positions. Program TATP calculates the degree of change between following vectors in both clockwise and counterclockwise directions and loads this in data file TSDT. An example of file TSDT as printed by program ADMTP is given in Table 9.

Program ATPLT plots clockwise and counterclockwise angular changes over time for the entire track (Fig. 6). A histogram of percent frequencies of left- and right-hand turns in 10° intervals is printed and plotted by program TAHIS (Table 10 and Fig. 7) and program TACUM gives a cumulative plot of left- and right-hand turns for each track (Fig. 8).

Environmental factors

Available library programs for linear multiple regression analysis [such as IBM (IBM Statistical System No. CA06X, Program REGR), Lindsey (Lindsey 1971) and Berkeley (Borkon and Boles 1971)] can be used to determine the effect of environmental factors on speed, directional tendencies and angular changes. To facilitate such analysis the weather and water observations are recorded in digital form following instructions given in section 4. A sample of the record sheets used is given in Fig. 9.

ACKNOWLEDGEMENTS

The assistance of Miss Louise Anderson in digitizing and plotting of map and tracks and in writing some of the programs used for analyzing speed of movement is gratefully acknowledged. DIRTP and PLPT are based on programs written by Dr. L. V. Pienaar. Thanks are due to Mr. J. A. C. Thomson and his

staff of the Computer Centre of the Pacific Biological Station at Nanaimo for their support.

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SECTION 2

PREPARATION OF POSITION AND HEADER CARDS

Position Card Code

Column number	Description
1	Track type 1 = Sonic track 2 = Float track 3 = Control (Identification tag only. No sonic tag.)
2-5	Track no. and year 01 to 99 69, 72 etc.
6	Blank
7-10	Track pos'n no. Sequential pos'n. nos. from start of track 0001 to 9999
11	Blank
12-25	Pos'n co-ordinates* N-S and E-W distances from master reference point in km
26-27	Blank
28-30	Date Day no. from Jan. 1 = 001 to Dec. 31 = 365
31	Blank
32-35	Time 24 hr clock 0001 to 2359 N.B. for midnight use 0001 (change date)
36	Blank

Position Card Code (cont'd)

Column number	Description
37-40	Water depth in feet
41	Blank
42	Pos'n - day or night 1 = Day 2 = Night
43	Blank
44	Pos'n fish lost or found 1 = Lost 2 = Found
80	Card P = Position card

*Field 12-26 is blank until filled by program PUNCH to make New Position Cards.

Header Card Code Card F1

Column number	Description
1	Track type 1 = Sonic track 2 = Float track 3 = Control (Identification tag only. No sonic tag.)
2-5	Track no. and year 01 to 99 69, 72 etc.
6	Agency 1 = FRBC (Nanaimo) 2 = FRBC (St. Andrews) 3 = D of F (Vancouver)
7	Transmitter type and size 1 = Smith-Root Cylindrical 9/16" × 2 1/4" 2 = Smith-Root Cylindrical 'B' type
8-11	Transmitter no.
12-13	Transmitter frequency Frequency in KHz
14-15	Transmitter pulse rate Pulse rate/sec Units and tenths
16	External tag type and size 1 = 1" dia. white disc prefix B 2 = 1/2" dia. red disc

Header Card Code (cont'd) Card F1

Column number	Description
17 18-21	External tag no. Letter prefix (Fish identifi- Number 1 to 9999 cation)
22	Species 1 = Sockeye 2 = Chum 3 = Pink 4 = Coho 5 = Chinook 6 = Steelhead Blank = Unknown
23-24	Scale no. 1 to 99
25-26	Freshwater age Number of freshwater checks Ocean age Number of ocean checks e.g. 22 = A 5_3 fish Columns left blank if age not known 99 = Scale regenerated
27	Condition of fish 1 = Good 2 = Fair 3 = Poor 4 = Sampled, not released
28	Maturity of fish 1 = Red 2 = Green
29	Sex 1 = Male 2 = Female Blank = Unknown
30	Anaesthetic used 1 = MS222 Blank = Not used

Header Card Code (cont'd) Card F1

Column number	Description	
31-33	Fork length	Tip of snout to fork of tail to nearest 0.5 cm beyond the fork of the tail. e.g. if tail falls on 49.6, 49.7, 49.8, 49.9 or 50.0 cm record 50.0 cm or 500
34-36	Weight	Weight recorded in decagrams (001 to 998, 999 = weights over 998)
37-39	Date of capture	Day no. from Jan. 1 = 001 to Dec. 31 = 365
	Location of capture	
40-44	Latitude	e.g. 55106 = 55°10.6'
45-49	Longitude	e.g. 26354 = 126°35.4'
50	Method of capture	1 = Fence 2 = Stream (Dipnet, etc.) 3 = Purse seine 4 = Gillnet
51-53	Holding period (including transport to release site)	In hours, 1 to 999
	Holding location	
54-58	Latitude	e.g. 55106 = 55°10.6'
59-63	Longitude	e.g. 26354 = 126°35.4'
64-78	Blank	
79	Card Identification	F 1

Header Card Code Card F2

Column number	Description	
1 2-5	External tag no. (Fish identification)	Letter prefix Number 1 to 9999
6-9	Track no. and year	01 to 99 69, 72 etc.
10-12	Release date	Day number from Jan. 1 = 001 to Dec. 31 = 365
13-16	Release time	24 hr clock, 0001 to 2359 N.B. for midnight use 0001 (change date)
	Release location	
17-21	Latitude	e.g. 55106 = 55°10.6'
22-26	Longitude	e.g. 26354 = 126°35.4'
27-29	Track termination date	Day no. from Jan. 1 = 001 to Dec. 31 = 365
30-33	Track termination time	24 hr clock 0001 to 2359. N.B. for midnight use 0001 (change date)
	Track termination Location	
34-38	Latitude	e.g. 55106 = 55°10.6'
39-43	Longitude	e.g. 26354 = 126°35.4'
44	Reason for termination of track	1 = Signal lost 2 = Track abandoned (weather, fatigue, etc.) 3 = Fish entered river or creek 4 = Fish taken in fishery

Header Card Code (cont'd) Card F2

Column number		Description
45-49	Recovery year and date	71, 72 etc. Day no. from Jan. 1 = 001 to Dec. 31 = 365
	Recovery location	
50-54	Latitude	e.g. 55106 = 55°10.6'
55-59	Longitude	e.g. 26354 = 126°35.4'
60	Recovery method	1 = Stream 2 = Gillnet 3 = Purse Seine 4 = Gillnet
61-78	Blank	
79	Card	F
80	Identification	2

SECTION 3

PROGRAMS

(WITH OUTPUT EXAMPLES)

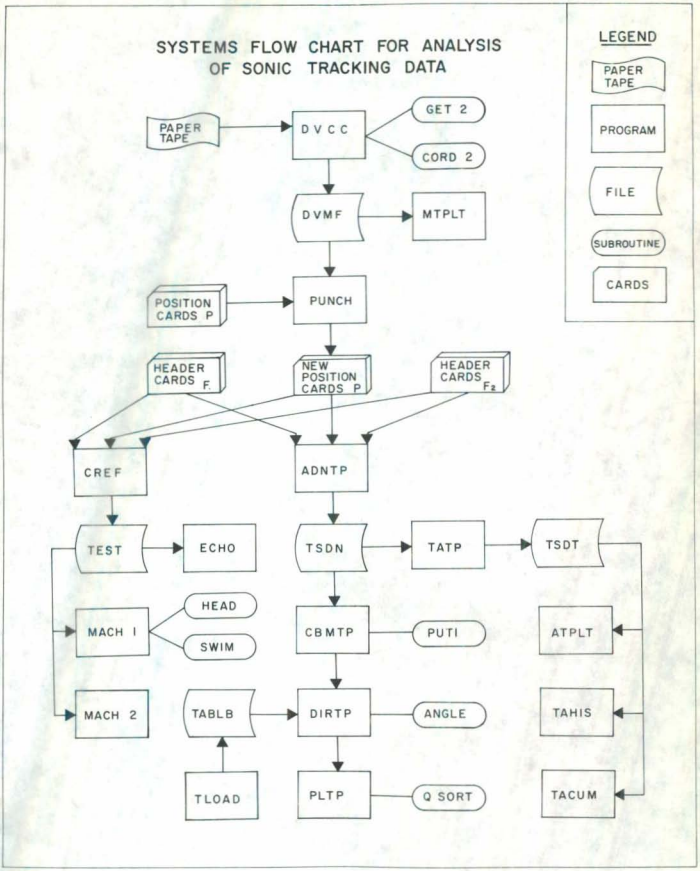

Fig. 1. Systems flow chart for analysis of sonic tracking data.

Job control cards for sonic tracking data.

```
// JOB
// XEQ DVCC     1
*FILES(1,DVMF)

// JOB
// XEQ CREF     1
*FILES(1,TEST)

// JOB
// XEQ ECHO     1
*FILES(1,TEST)


// JOB
// XEQ MACH1    1
*FILES(1,TEST)
27
1111111
76
0000-200080012001600-100


// JOB
// XEQ MACH2    1
*FILES(1,TEST)
1470120


// JOB
// XEQ ADNTP    1
*FILES(1,TSDN)


// JOB
// XEQ CBMTP    1
*FILES(1,TSDN),(5,TABLB)
TRACK NUMBER      , ANGLES FROM TRUE NORTH, DAY  ,       TO DAY  ,
147018211980240


// JOB
// XEQ TATP     1
*FILES(1,TSDN),(2,TSDT)
   12407


// JOB
// XEQ ATPLT    1
*FILES(2,TSDT)
17401896
```

```
// JOB
// XEQ TAHIS    1
*FILES(2,TSDT)
17401896

// JOB
// XEQ TACUM    1
*FILES(2,TSDT)
```

PROGRAMS

FOR

MAP AND TRACK PLOTTING

```
// JOB                                                                  START001
// DUP                                                                  START002
*STOREDATA  WS  UA  DVMF   329                                          START003


// JOB                                                                  DVCC0001
// FOR                                                                  DVCC0002
*LIST ALL                                                               DVCC0003
*ONE WORD INTEGERS                                                      DVCC0004
*IOCS(1442 PUNCH,PAPER TAPE,TYPEWRITER,KEYBOARD,1403 PRINTER,DISK)      DVCC0005
* NAME DVCC                                                            DVCC0006
**DVCC - X,Y COORDINATE LOAD OF FILE DVMF.                              DVCC0007
C                                                                       DVCC0008
C ********************************************************************* DVCC0009
C                                                                       DVCC0010
C  PROGRAM FUNCTION ...                                                 DVCC0011
C  - TO READ DIGITIZED DATA OF MAPS OR FISH TRACKS, PRODUCED BY A TRI -  DVCC0012
C    LATERAL READER. (EACH DATA POINT IS REPRESENTED BY TWO STRING      DVCC0013
C    LENGTHS)                                                           DVCC0014
C  - TO CONVERT STRING LENGTHS TO X,Y COORDINATES, ROTATE AND SCALE WITH DVCC0015
C    RESPECT TO A MASTER REFERENCE POINT. (IN UNITS OF KILOMETERS)      DVCC0016
C  - TO SUPPLY A PRINTED AND PUNCHED (OPTIONAL) OUTPUT OF THE X,Y CO -   DVCC0017
C    ORDINATES.                                                         DVCC0018
C  - TO STORE ON DISK DATA FILE DVMF, THE FOLLOWING INFORMATION PER      DVCC0019
C    RECORD ...  WORD 1     - PLOTTER PEN COMMAND                       DVCC0020
C                     2 - 3 - X COORDINATE                              DVCC0021
C                     4 - 5 - Y COORDINATE                              DVCC0022
C                OF EACH DATA POINT.                                    DVCC0023
C                                                                       DVCC0024
C  FILE DVMF REQUIRES 329 SECTORS OF USER'S AREA FOR A MAXIMUM OF 21,000 DVCC0025
C    DATA POINT STORAGE.  USE *FILES(1,DVMF) TO EXECUTE THIS PROGRAM.   DVCC0026
C                                                                       DVCC0027
C  PAPER TAPE INPUT FORMAT ...                                          DVCC0028
C    1) CARRIAGE RETURN, LINE FEED CHARACTERS.                          DVCC0029
C    2) TITLE (MAXIMUM OF 70 CHARACTERS)                                DVCC0030
C    3) CARRIAGE RETURN LINE FEED CHARACTERS.                           DVCC0031
C    4) FIVE PAIRS OF TRILATERAL STRING LENGTHS.                        DVCC0032
C    5) CARRIAGE RETURN, LINE FEED CHARACTERS.                          DVCC0033
C    6) STEPS 4 AND 5 REPEATED AS NECESSARY , OR AN ASTERISK IN THE     DVCC0034
C       FIRST DIGIT OF WHAT WOULD NORMALLY BE A S1 STRING LENGTH, TO    DVCC0035
C       INDICATE END OF DATA INPUT.                                     DVCC0036
C  DISCUSSION OF INPUT 4                                                DVCC0037
C  THE FORMAT IS AS FOLLOWS ...                                         DVCC0038
C    , S1,S2 S1,S2 S1,S2 S1,S2 S1,S2.                                   DVCC0039
C    WHERE S1 AND S2 ARE FOUR DIGIT INTEGER NUMBERS, REPRESENTING       DVCC0040
C    LEFT AND RIGHT STRING LENGTHS RESPECTIVELY.  EACH S1 , S2 PAIR     DVCC0041
C    ARE CONVERTED TO A (X,Y) COORDINATE, PAIR.                         DVCC0042
C  FURTHER, FIVE COMMANDS MAY IMMEDIATELY PRECEED A S1,S2 PAIR ...      DVCC0043
C     000= - THE S1,S2 PAIR FOLLOWING ARE TO REPLACE THE PREVIOUS S1,S2 DVCC0044
C            PLEASE NOTE THIS IS A NUMBER SIGN CHARACTER - DECIMAL      DVCC0045
C            EQIVALENT OF 31552 OF EBCDIC CODE.                         DVCC0046
C     0001 - PEN LIFT COMMAND FOR PLOTTING - THIS COMMAND MUST ALWAYS    DVCC0047
C            PRECEED THE FIRST S1,S2 DATA POINT OF A FISH TRACK.        DVCC0048
C     0002 - PRECEEDS ANY EXTRAPOLATED S1,S2 DATA POINT.                 DVCC0049
C            THIS MAY BE NECESSARY TO GET A FISH AROUND A PENNINSULA ETC. DVCC0050
```

```
C    0003 - PRECEEDS ANY POINT AT WHICH A FISH IS LOST SUBSEQUENTLY.      DVCC0051
C    0004 - PRECEEDS THE FIRST POINT AT WHICH A FISH IS FOUND AFTER       DVCC0052
C           BECOMING LOST.  NOTE - ANY NUMBER OF INTERPOLATED POINTS MAY  DVCC0053
C           OCCUR BETWEEN A 0003 AND 0004 COMMAND, AND SHOULD NOT BE      DVCC0054
C           PRECEEDED BY A 0002 COMMAND.                                  DVCC0055
C FURTHER, THE FIRST THREE S1,S2 DATA ENTRIES ON TAPE MUST BE ...         DVCC0056
C   1) LOCAL REFERENCE POINT - THIS POINT IS SIMPLY A POINT WITHIN THE    DVCC0057
C      SECTION OF MAP OR TRACK DIGITIZED ON THIS RUN.  THE DISTANCE OF    DVCC0058
C      THIS POINT FROM A MASTER REFERENCE POINT ( A POINT WITHIN THE      DVCC0059
C      ENTIRE AREA BEING STUDIED) MUST BE KNOWN OR PREVOUSLY CALCULATED.DVCC0060
C   2) THE NORTH POINT OF A TRUE NORTH - SOUTH VECTOR FOR THIS SECTION.  DVCC0061
C   3) THE SOUTH POINT OF A TRUE NORTH - SOUTH VECTOR FOR THIS SECTION.  DVCC0062
C                                                                        DVCC0063
C KEYBOARD ENTRY INPUT                                                   DVCC0064
C   1) THE DISTANCE IN KILOMETERS THAT THE LOCAL REFERENCE POINT IS      DVCC0065
C      NORTH OF THE MASTER REFERENCE POINT.                              DVCC0066
C   2) THE DISTANCE IN KILOMETERS THAT THE LOCAL REFERENCE POINT IS EASTDVCC0067
C      OF THE MASTER REFERENCE POINT.                                    DVCC0068
C   3) FILE RECORD NUMBER AT WHICH STORAGE IS TO BEGIN ON FILE DVMF.     DVCC0069
C      THIS WILL FACILITATE SEQUENTAL DIGITIZATION FROM PREVIOUS SECTIONDVCC0070
C   4) THE SCALE OF MAP USED IN CENTIMETERS PER KILOMETER.  THIS WILL    DVCC0071
C      ENABLE ALL X,Y COORDINATES TO BE IN UNITS OF KILOMETERS .         DVCC0072
C PROGRAM AUTOMATICALLY CALLS LINK TO PLOTTING PROGRAM MTPLT TO PLOT     DVCC0073
C MAP OR TRACK SECTIONS OF FILE DVMF.                                    DVCC0074
C DATA SWITCH ONE ON WILL ENABLE A BYPASS OF COORDINATE CARD PUNCHING.   DVCC0075
C                                                                        DVCC0076
C PROGRAM REQUIRES SUBROUTINES                                           DVCC0077
C      CORD2 - STRING LENGTHS TO X,Y COORDINATE CONVERSION.              DVCC0078
C      GET2 AND BYTE - A1 TO INTEGER CONVERSION WITH ERROR CHECK.        DVCC0079
C                                                                        DVCC0080
C ********************************************************************** DVCC0081
C                                                                        DVCC0082
      INTEGER TAPE,PUNCH,TYPE,KEYBD,PRINT                                DVCC0083
      DIMENSION X(1000),Y(1000),IPC(1000),IDATA(73)                      DVCC0084
      DATA TAPE,PUNCH,TYPE,KEYBD,PRINT / 4,9,1,6,5 /                     DVCC0085
C THE ABOVE ARE LOGICAL UNIT NUMBERS.                                    DVCC0086
      DEFINE FILE 1(21000,5,U,KK1)                                       DVCC0087
C                                                                        DVCC0088
C FORMATS                                                                DVCC0089
800   FORMAT (73A1)                                                      DVCC0090
866   FORMAT(//'ENTER'/'- DISTANCE NORTH IN KILOMETERS OF LOCAL REFERENCDVCC0091
866  1E POINT FROM MASTER REFERENCE POINT - PRESS EOF'/' - THEN ENTER DIDVCC0092
866  2STANCE EAST OF MASTER REFERENCE POINT - PRESS EOF'/' MAXIMUM OF 10DVCC0093
866  3 DIGITS INCLUDING DECIMAL POINT')                                 DVCC0094
867   FORMAT (F10.0)                                                     DVCC0095
942   FORMAT    (I4,2F10.3,51X,I5)                                       DVCC0096
946   FORMAT(' ',I4,2F10.3,I6)                                           DVCC0097
1001  FORMAT('1',73A1/'OP.C.',4X,'X',9X,'Y',5X,'SEQ.NO.')               DVCC0098
8030  FORMAT (//'DATSW 1 ON TO BYPASS PUNCH')                            DVCC0099
8034  FORMAT (I5)                                                        DVCC0100
8036  FORMAT (//'ENTER FILE RECORD NUMBER AT WHICH STORAGE IS TO BEGIN -DVCC0101
8036 1'/'** RIGHT JUSTIFY NUMBER IN A FIVE COLUMN FIELD')               DVCC0102
9076  FORMAT(//'ENTER SCALE OF MAP USED IN CM. / KILOMETER'/'MAX OF 10 DDVCC0103
9076 1IGITS INCLUDING DECIMAL POINT')                                    DVCC0104
C                                                                        DVCC0105
      WRITE (TYPE,8030)                                                  DVCC0106
```

```
      WRITE (TYPE,866)                                                  DVCC0107
      READ (KEYBD,867) XMP                                              DVCC0108
      READ (KEYBD,867) YMP                                              DVCC0109
      WRITE (TYPE,8036)                                                 DVCC0110
      READ (KEYBD,8034) IFILE                                           DVCC0111
      WRITE (TYPE,9076)                                                 DVCC0112
      READ (KEYBD,867) SCMAP                                            DVCC0113
C                                                                       DVCC0114
      KK1 = IFILE                                                       DVCC0115
      CALL DATSW(1,M1)                                                  DVCC0116
      K = 1                                                             DVCC0117
C TO READ TITLE - ONE DUMMY READ TO FIRST CARRIAGE RETURN, LINE FEED.   DVCC0118
      READ (TAPE,800) IDATA                                             DVCC0119
      READ (TAPE,800) IDATA                                             DVCC0120
      WRITE (PRINT,1001) IDATA                                          DVCC0121
C                                                                       DVCC0122
C TO READ DATA INPUT RECORD.                                            DVCC0123
    1 READ (TAPE,800) IDATA                                             DVCC0124
    2 IDELT = 3                                                         DVCC0125
C OUTER LOOP - 100 - PROCESSES THE FIVE S1,S2 PAIRS PER INPUT RECORD.   DVCC0126
      DO 100 II = 1,5                                                   DVCC0127
      LPC = 0                                                           DVCC0128
      I = (II - 1) * 10 +IDELT                                          DVCC0129
      J = I + 3                                                         DVCC0130
C CONVERT A1 FIELD TO INTEGER FOR S1 VALUE                              DVCC0131
      CALL GET2(IDATA,I,J,IX,L)                                         DVCC0132
      IF (L - (J+1)) 101,200,101                                        DVCC0133
C ABOVE CHECKS FOR MISREAD I.E. BLANKS                                  DVCC0134
C BELOW CHECKS FOR NUMBER SIGN CHARACTER - ERROR IN PREVIOUSLY DIGITIZEDDVCC0135
C POINT, TO BE REPLACED BY THIS SET.                                    DVCC0136
  101 IF (IDATA(I) - 31552) 140,102,140                                 DVCC0137
  102 IDELT = IDELT + 1                                                 DVCC0138
      K = K - 1                                                         DVCC0139
      I = I + 1                                                         DVCC0140
      J = I + 3                                                         DVCC0141
      CALL GET2(IDATA,I,J,IX,L)                                         DVCC0142
      IF (L - (J+1)) 150,200,150                                        DVCC0143
C                                                                       DVCC0144
C TO GET Y VALUE                                                        DVCC0145
  200 I = I + 5                                                         DVCC0146
      J = I + 3                                                         DVCC0147
      CALL GET2(IDATA,I,J,IY,L)                                         DVCC0148
      IF (L-(J+1)) 201,199,201                                          DVCC0149
C                                                                       DVCC0150
C TO TEST FOR PEN CONTROL                                               DVCC0151
  201 IF (IDATA(J) - 27456) 150,202,150                                 DVCC0152
  202 I = I - 1                                                         DVCC0153
      LPC = IX                                                          DVCC0154
      J = J - 1                                                         DVCC0155
      IDELT = IDELT + 4                                                 DVCC0156
      CALL GET2(IDATA,I,J,IX,L)                                         DVCC0157
      IF (L - (J+1)) 150,200,150                                        DVCC0158
C                                                                       DVCC0159
C TO CHECK FOR ASTERISK CHARACTER - END OF DATA.                        DVCC0160
  140 IF (IDATA(I) - 23616) 150,2000,150                                DVCC0161
C                                                                       DVCC0162
```

```
C ERROR TRAP                                                          DVCC0163
  150 WRITE (1,802) IDATA                                             DVCC0164
  802 FORMAT(//'LINE OF ERROR - PUNCH COMPLETE LINE IN WITH CORRECTIONS'DVCC0165
  8021//73A1)                                                         DVCC0166
      PAUSE 1                                                         DVCC0167
      READ (6,800) IDATA                                              DVCC0168
      K = K - II + 1                                                  DVCC0169
      GO TO 2                                                         DVCC0170
C                                                                     DVCC0171
C TO ALLOCATE STRING PAIRS TO X AND Y VECTORS.                        DVCC0172
C NOTE THAT A ZERO S1 OR S2 IS NOT PROCESSED.                         DVCC0173
  199 IF (IX) 100,100,370                                             DVCC0174
  370 IF (IY) 100,100,371                                             DVCC0175
  371 X(K) = IX                                                       DVCC0176
      Y(K) = IY                                                       DVCC0177
      IPC(K) = LPC                                                    DVCC0178
      K = K + 1                                                       DVCC0179
C STORE 1000 POINTS AT A TIME                                         DVCC0180
      IF (K - 1000) 100,100,181                                       DVCC0181
C CONVERT STRING LENGTHS TO X,Y COORDINATES.                          DVCC0182
  181 CALL CORD2 (X,Y,1000)                                           DVCC0183
      DO 182 KK = 1,1000                                              DVCC0184
C STORE PEN COMMAND, X AND Y COORDINATE IN DISK FILE                  DVCC0185
  182 WRITE(1'KK1) IPC(KK),X(KK),Y(KK)                                DVCC0186
      K = 1                                                           DVCC0187
  100 CONTINUE                                                        DVCC0188
      GO TO 1                                                         DVCC0189
 2000 K = K - 1                                                       DVCC0190
C                                                                     DVCC0191
C TO CONVERT AND STORE LAST PAIRS OF STRING LENGTHS.                  DVCC0192
      CALL CORD2(X,Y,K)                                               DVCC0193
      DO 183 KK = 1,K                                                 DVCC0194
  183 WRITE(1'KK1) IPC(KK),X(KK),Y(KK)                                DVCC0195
C                                                                     DVCC0196
C TO CONVERT X AND Y INTO UNITS FROM REFERENCE POINT AND ROTATE WITH   DVCC0197
C RESPECT TO TRUE NORTH SOUTH                                         DVCC0198
      L = KK1 - IFILE                                                 DVCC0199
      IDELT = 0                                                       DVCC0200
      KKL = IFILE                                                     DVCC0201
C FIRST X,Y PAIR ARE THE COORDINATES OF THE LOCAL REFERENCE POINT.    DVCC0202
      READ (1'KKL) LPC,RX,RY                                          DVCC0203
      KKL = IFILE + 1                                                 DVCC0204
C SECOND X,Y PAIR ARE THE COORDINATES OF THE NORTH POINT OF THE TRUE   DVCC0205
C NORTH - SOUTH VECTOR.                                               DVCC0206
      READ (1'KKL) LPC,XN,YN                                          DVCC0207
      KKL = IFILE + 2                                                 DVCC0208
C THIRD PAIR OF X,Y ARE THE COORDINATES OF THE SOUTH POINT OF THE TRUE DVCC0209
C NORTH - SOUTH VECTOR.                                               DVCC0210
      READ (1'KKL) LPC,XS,YS                                          DVCC0211
      J = 1                                                           DVCC0212
      IF (XN- XS)  9004,930,9003                                      DVCC0213
 9003 THETA = ATAN(ABS(XS-XN)/ABS(YS-YN)) + (3.14159/2.0)             DVCC0214
      IF (YS - YN) 9002,9002,930                                      DVCC0215
 9002 THETA = - THETA                                                 DVCC0216
      GO TO 930                                                       DVCC0217
 9004 THETA = ATAN(ABS(YS -YN) / ABS(XS - XN))                        DVCC0218
```

```
      IF (YS - YN) 922,922,930                                          DVCC0219
  922 THETA = - THETA                                                   DVCC0220
  930 DO 300 I = 4,L                                                    DVCC0221
      IL = I + (IFILE - 1)                                              DVCC0222
      IF (J -1000) 301,301,310                                          DVCC0223
  301 READ (1'IL)IPC(J),X(J),Y(J)                                       DVCC0224
C                                                                       DVCC0225
C TO RELOCATE CO-ORDINATES WITH RESPECT TO LOCAL REFERENCE POINT.       DVCC0226
      X(J) = X(J) - RX                                                  DVCC0227
      Y(J) = Y(J) - RY                                                  DVCC0228
C                                                                       DVCC0229
C TO ROTATE AXIS WITH RESPECT TO TRUE NORTH - SOUTH VECTOR.             DVCC0230
      XX = X(J)*COS(THETA) + Y(J) * SIN(THETA)                          DVCC0231
      YY =-(X(J)*SIN(THETA))+ Y(J)*COS(THETA)                           DVCC0232
C                                                                       DVCC0233
C TO CONVERT MILLIMETER CO-ORDINATES TO KILOMETERS.                     DVCC0234
      X(J) = XX / (10.0*SCMAP)                                          DVCC0235
      Y(J) = YY / (10.0*SCMAP)                                          DVCC0236
C                                                                       DVCC0237
C TO RELOCATE WITH RESPECT TO MASTER REFERENCE POINT.                   DVCC0238
      X(J) = X(J) + XMP                                                 DVCC0239
      Y(J) = Y(J) + YMP                                                 DVCC0240
      J = J + 1                                                         DVCC0241
      GO TO 300                                                         DVCC0242
  310 DO 312 K = 1,1000                                                 DVCC0243
      KKL = IDELT + K + (IFILE-1)                                       DVCC0244
      WRITE (1'KKL) IPC(K),X(K),Y(K)                                    DVCC0245
C                                                                       DVCC0246
C TO PUNCH PEN COMMAND, X , Y COORDINATE AND SEQUENCE NUMBER IF DESIRED DVCC0247
      GO TO (945,940),M1                                                DVCC0248
  940 WRITE (PUNCH,942) IPC(K),X(K),Y(K),KKL                            DVCC0249
C                                                                       DVCC0250
C TO PRINT PEN COMMAND, X, Y COORDINATE AND SEQUENCE NUMBER             DVCC0251
  945 WRITE(PRINT,946) IPC(K),X(K),Y(K),KKL                             DVCC0252
  312 CONTINUE                                                          DVCC0253
      IDELT = IDELT + 1000                                              DVCC0254
      J = 1                                                             DVCC0255
      GO TO 301                                                         DVCC0256
  300 CONTINUE                                                          DVCC0257
      K = J - 1                                                         DVCC0258
      DO 961 I = 1,K                                                    DVCC0259
      KKL = IDELT + I + (IFILE -1)                                      DVCC0260
      WRITE (1'KKL) IPC(I),X(I),Y(I)                                    DVCC0261
      GO TO (955,951),M1                                                DVCC0262
  951 WRITE (PUNCH,942) IPC(I),X(I),Y(I),KKL                            DVCC0263
  955 WRITE (PRINT,946) IPC(I),X(I),Y(I),KKL                            DVCC0264
  961 CONTINUE                                                          DVCC0265
C FILE HAS BEEN COMPRESSED THREE RECORDS - TO ZERO THESE THREE          DVCC0266
      YY = 0.0                                                          DVCC0267
      XX = 0.0                                                          DVCC0268
      LPC = 0                                                           DVCC0269
      J = KKL + 1                                                       DVCC0270
      WRITE (1'J) LPC,XX,YY                                             DVCC0271
      J = KKL+2                                                         DVCC0272
      WRITE (1'J) LPC,XX,YY                                             DVCC0273
      J = KKL + 3                                                       DVCC0274
```

```
      WRITE (1'J) LPC,XX,YY                                    DVCC0275
C                                                              DVCC0276
      CALL LINK (MTPLT)                                        DVCC0277
      END                                                      DVCC0278
// DUP                                                         DVCC0279
*DELETE              DVCC                                      DVCC0280
*STORE       WS  UA  DVCC                                      DVCC0281
```

```
// JOB                                                                  CORD2001
// FOR                                                                  CORD2002
*ONE WORD INTEGERS                                                      CORD2003
*LIST ALL                                                               CORD2004
      SUBROUTINE CORD2 (X,Y,IB)                                         CORD2005
C                                                                       CORD2006
C ********************************************************************* CORD2007
C                                                                       CORD2008
C SUBROUTINE TO CONVERT S1,S2 STRING LENGTHS TO X,Y COORDINATES.        CORD2009
C                                                                       CORD2010
C ********************************************************************* CORD2011
C                                                                       CORD2012
      DIMENSION X(2),Y(2)                                               CORD2013
C AL = DISTANCE ACROSS TOP OF TRI - LATERAL READER.                     CORD2014
      AL = 457.0                                                        CORD2015
      DO 1 I = 1,IB                                                     CORD2016
      A = X(I) * 0.1                                                    CORD2017
      B = Y(I) * 0.1                                                    CORD2018
      YY = (-(B*B) + (A*A) + (AL*AL)) / (2.0*AL)                        CORD2019
      XX = SQRT((A*A) - (YY*YY))                                        CORD2020
      X(I) = XX                                                         CORD2021
      Y(I) = YY                                                         CORD2022
    1 CONTINUE                                                          CORD2023
      RETURN                                                            CORD2024
      END                                                               CORD2025
// DUP                                                                  CORD2026
*DELETE              CORD2                                              CORD2027
*STORE       WS  UA  CORD2                                              CORD2028
```

```
// JOB                                                                  GET20001
// FOR GET2                                                             GET20002
****   SUBROUTINE GET2   ****                                          GET20003
*ONE WORD INTEGERS                                                     GET20004
*LIST ALL                                                              GET20005
      SUBROUTINE GET2(IMAGE,L1,L2,I,L)                                 GET20006
C  PROGRAM WRITTEN BY BILL WEBB  UNIVERSITY OF BRITISH COLUMBIA         GET20007
      INTEGER BYTE,IMAGE(2)                                            GET20008
      DATA MINUS/'-'/                                                  GET20009
      I=0                                                              GET20010
      IF(IMAGE(L1)-MINUS)100,200,100                                   GET20011
200   J=-1                                                             GET20012
      L3=L1+1                                                          GET20013
      GO TO 300                                                        GET20014
100   J=1                                                              GET20015
      L3=L1                                                            GET20016
300   DO 10 L=L3,L2                                                    GET20017
      K=BYTE(IMAGE(L))-240                                             GET20018
      IF(K)20,10,10                                                    GET20019
10    I=I*10+K                                                         GET20020
20    I=I*J                                                            GET20021
      RETURN                                                           GET20022
      END                                                              GET20023
// DUP                                                                 GET20024
*DELETE             GET2                                             GET20025
*STORE      WS  UA  GET2                                             GET20026
```

```
// JOB                                                                  BYTE0001
// ASM                                                                  BYTE0002
*XREF                                                                   BYTE0003
                        ENT     BYTE                                    BYTE0004
                BYTE    DC      *-*                                     BYTE0005
                        LDX     I1 BYTE                                 BYTE0006
                        LD      I1 0                                    BYTE0007
                        SRA     8                                       BYTE0008
                        BSC     L1 1                                    BYTE0009
                        END                                             BYTE0010
// DUP                                                                  BYTE0011
*DELETE             BYTE                                               BYTE0012
*STORE      WS  UA  BYTE                                               BYTE0013
```

```
// JOB                                                                  MTPLT001
// FOR                                                                  MTPLT002
*IOCS(1403 PRINTER,PLOTTER,TYPEWRITER,KEYBOARD,DISK)                    MTPLT003
*LIST ALL                                                              MTPLT004
*ONE WORD INTEGERS                                                     MTPLT005
*NAME MTPLT                                                            MTPLT006
**MTPLT - MAP OR TRACK PLOTS FROM FILE DVMF.                           MTPLT007
C                                                                       MTPLT008
C ********************************************************************* MTPLT009
C                                                                       MTPLT010
C PROGRAM IS LINKED FROM PROGRAM DVCC, OR MAY BE EXECUTED BY NAME, TO   MTPLT011
C OBTAIN PLOTTED OUTPUT OF DIGITIZED MAP OR TRACK POINTS.               MTPLT012
C                                                                       MTPLT013
C KEYBOARD INPUT FOR PLOTTING ...                                       MTPLT014
C       PROGRAM WILL REQUEST FOLLOWING INFORMATION                      MTPLT015
C    1) MAP PLOTTING - ENTER A 1                                        MTPLT016
C       TRACK PLOTTING - ENTER A 2                                      MTPLT017
C    2) DVMF RECORD NUMBER OF FIRST DATA POINT TO BE PLOTTED.  THIS     MTPLT018
C       INFORMATION IS AVAILABLE FROM THE PRINTED OUTPUT OF DVCC.       MTPLT019
C    3) FILE RECORD NUMBER OF LAST DATA POINT TO BE PLOTTED.            MTPLT020
C    4) SCALE OF MAP OR TRACK IN CENTIMETERS PER KILOMETER - FOR A MAP  MTPLT021
C       OR TRACK TO BE THE SAME SIZE AS THE ONE DIGITIZED, ENTER AS FOR MTPLT022
C       KEYBOARD ENTRY INPUT 4 OF PROGRAM DVCC.                         MTPLT023
C    5) ONCE THE ABOVE PLOT IS COMPLETED, PROGRAM WILL REQUEST A        MTPLT024
C       RECYCLE OPTION - BY TURNING ON DATASWITCH 5, PROGRAM WILL RECYCLEMTPLT025
C       THE PLOTTING PROCEDURE.  BY THIS METHOD A MAP MAY BE DRAWN,     MTPLT026
C       THEN BY RECYCLING, A FISH TRACK WITHIN THAT MAP MAY BE PLOTTED. MTPLT027
C       IF THIS OPTION IS NOT DESIRED SIMPLY PRESS START, PROGRAM WILL  MTPLT028
C       THEN REQUEST FOLLOWING ...                                      MTPLT029
C    6) TITLE - 73 CHARACTERS FREE TEXT .  PLOTTER PEN MUST BE MANNUALLY MTPLT030
C       RELOCATED INTO POSITION FOR TITLE .                             MTPLT031
C    7) THE POSITIONING OF PLOTTER PEN FOR NORTH - SOUTH VECTOR.        MTPLT032
C       VECTOR IS FOUR UNITS LONG AND SHOULD BE PLACED SUCH THAT IT WILL MTPLT033
C       NOT CROSS INTO MAP BOUNDARIES.                                  MTPLT034
C                                                                       MTPLT035
C SOME EXPERIMENTATION OF ORIGINAL PLOTTER PEN POSITION MAY BE NECESSARYMTPLT036
C SINCE DESIRED POSITION WILL CHANGE ACCORDING TO SCALE AND SIZE USED.  MTPLT037
C                                                                       MTPLT038
C IF THIS PROGRAM IS EXECUTED ON A STAND ALONE BASIS, USE *FILES(1,DVMF)MTPLT039
C                                                                       MTPLT040
C ********************************************************************* MTPLT041
C                                                                       MTPLT042
      INTEGER PLOT,KEYBD,TYPE,PRINT                                     MTPLT043
      DIMENSION IDATA(73)                                               MTPLT044
      DATA PLOT,KEYBD,TYPE,PRINT / 7,6,1,5 /                            MTPLT045
      DEFINE FILE 1(21000,5,U,KK1)                                      MTPLT046
C                                                                       MTPLT047
C FORMATS                                                               MTPLT048
800    FORMAT (73A1)                                                    MTPLT049
830    FORMAT(//'TURN ON DATA SWITCH 15 TO RECEIVE A PRINT OUT OF DATA'/'MTPLT050
830   1POINTS AT ANY TIME DURING PLOT'//'ENTER FILE RECORD NUMBER OF FIRSMTPLT051
830   2T DATA POINT - PRESS EOF'/'THEN ENTER FILE NUMBER OF LAST DATA POIMTPLT052
830   3NT - PRESS EOF'/'** NUMBER MUST BE RIGHT ORIENTED IN A FIVE COLUMNMTPLT053
830   4 FIELD **')                                                      MTPLT054
835    FORMAT(//'ENTER SCALE OF PLOT IN CENTIMETERS PER KILOMETER'/'MAXIMMTPLT055
```

```
835  1UM OF 10 DIGITS INCLUDING DECIMAL POINT')                          MTPLT056
836   FORMAT (//'IF MAP IS INCOMPLETE TURN ON DATSW 5 TO RECYCLE --- OR MTPLT057
836  1EXIT BY PRESSING START')                                           MTPLT058
867   FORMAT (F10.0)                                                     MTPLT059
946   FORMAT(' ',I4,2F10.3,I6)                                           MTPLT060
7009  FORMAT (//'POSITION PEN FOR TITLE - LINE IS RIGHT ORIENTED, AND ENMTPLT061
7009 1TER DESIRED HEADING - 73A1')                                       MTPLT062
7012  FORMAT (//'POSITION PEN FOR NORTH-SOUTH VECTOR')                   MTPLT063
7013  FORMAT ('N')                                                       MTPLT064
7014  FORMAT ('S')                                                       MTPLT065
8034  FORMAT (I5)                                                        MTPLT066
9079  FORMAT (//' --- PLOTTING ROUTINE TO FOLLOW ---'/'SET PEN MANUALLY MTPLT067
9079 1TO DESIRED POSITION  ')                                            MTPLT068
9091  FORMAT (//'ENTER  1  FOR A MAP TO BE PLOTTED , OR A  2  FOR A PLOTMTPLT069
9091 1 OF A FISH TRACK - I1 FORMAT')                                     MTPLT070
9092  FORMAT (I1)                                                        MTPLT071
C                                                                        MTPLT072
C TO RECEIVE INPUT PARAMETERS VIA KEYBOARD.                              MTPLT073
  860 WRITE (TYPE,9079)                                                  MTPLT074
      WRITE (TYPE,9091)                                                  MTPLT075
      READ (KEYBD,9092) IMAP                                             MTPLT076
      WRITE (TYPE,830)                                                   MTPLT077
      READ (KEYBD,8034) ISTAR                                            MTPLT078
      READ (KEYBD,8034) IEND                                             MTPLT079
      J = ISTAR + 1                                                      MTPLT080
      WRITE (TYPE,835)                                                   MTPLT081
      READ (KEYBD,867) SC                                                MTPLT082
      THETA = 30.0 * 0.01745                                             MTPLT083
      S = SC / 2.54                                                      MTPLT084
      CALL SCALF (S,S,0.0,0.0)                                           MTPLT085
      CALL FCHAR (0.0,0.0,0.15,0.15,0.0)                                 MTPLT086
      READ (1'ISTAR) LPC,XX,YY                                           MTPLT087
      AX = XX                                                            MTPLT088
      AY = YY                                                            MTPLT089
      XX =AX * COS(THETA) +AY*SIN(THETA)                                 MTPLT090
      YY =-AX*SIN(THETA) +AY*COS(THETA)                                  MTPLT091
      CALL FPLOT (1,XX,YY)                                               MTPLT092
      DO 1010 I = J,IEND                                                 MTPLT093
      READ (1'I) LPC,XX,YY                                               MTPLT094
      CALL DATSW (15,M)                                                  MTPLT095
      GO TO(833,834), M                                                  MTPLT096
  833 WRITE (PRINT,946) LPC,XX,YY,I                                      MTPLT097
  834 AX = XX                                                            MTPLT098
      AY = YY                                                            MTPLT099
      XX =AX * COS(THETA) +AY*SIN(THETA)                                 MTPLT100
      YY =-AX*SIN(THETA) +AY*COS(THETA)                                  MTPLT101
      IF (LPC - 1) 1008,1009,2009                                        MTPLT102
 1008 CALL FPLOT (2,XX,YY)                                               MTPLT103
      GO TO (1010,9093), IMAP                                            MTPLT104
 9093 CALL POINT (1)                                                     MTPLT105
      GO TO 1010                                                         MTPLT106
 1009 CALL FPLOT (1,XX,YY)                                               MTPLT107
      GO TO (1010,9094), IMAP                                            MTPLT108
 9094 CALL FPLOT (2,XX,YY)                                               MTPLT109
      CALL POINT (1)                                                     MTPLT110
      GO TO 1010                                                         MTPLT111
```

```
C                                                                       MTPLT112
C TO PLOT LOST TRACKS                                                   MTPLT113
 2009 IF (LPC - 2) 9400,9500,9400                                       MTPLT114
 9500 CALL FPLOT (2,XX,YY)                                              MTPLT115
      J = I - 1                                                         MTPLT116
      READ (1'J) LPC,XXX,YYY                                            MTPLT117
      XA = XXX                                                          MTPLT118
      YA = YYY                                                          MTPLT119
      XXX = XA*COS(THETA) + YA*SIN(THETA)                               MTPLT120
      YYY = -XA*SIN(THETA) + YA*COS(THETA)                              MTPLT121
      IF (XXX-XX) 9501,9501,9502                                        MTPLT122
 9501 CALL  POINT (3)                                                   MTPLT123
      GO TO 1010                                                        MTPLT124
 9502 CALL POINT (5)                                                    MTPLT125
      GO TO 1010                                                        MTPLT126
 9400 IF (LPC - 3) 1010,2020,1010                                       MTPLT127
 2020 CALL FPLOT (2,XX,YY)                                              MTPLT128
      CALL POINT (1)                                                    MTPLT129
 2030 I = I + 1                                                         MTPLT130
      READ (1'I) LPC,XXX,YYY                                            MTPLT131
      XA = XXX                                                          MTPLT132
      YA = YYY                                                          MTPLT133
      XXX = XA*COS(THETA) + YA*SIN(THETA)                               MTPLT134
      YYY = -XA*SIN(THETA) + YA*COS(THETA)                              MTPLT135
      YINC = (YYY-YY) / 9.0                                             MTPLT136
      XINC = (XXX-XX) / 9.0                                             MTPLT137
      YSTAR = YY + YINC                                                 MTPLT138
      XSTAR = XX + XINC                                                 MTPLT139
      CALL FPLOT (1,XSTAR,YSTAR)                                        MTPLT140
      DO 2023 KJ = 1,4                                                  MTPLT141
      YSTAR = YSTAR + YINC                                              MTPLT142
      XSTAR = XSTAR + XINC                                              MTPLT143
      CALL FPLOT (2,XSTAR,YSTAR)                                        MTPLT144
      YSTAR = YSTAR + YINC                                              MTPLT145
      XSTAR = XSTAR + XINC                                              MTPLT146
      CALL FPLOT (1,XSTAR,YSTAR)                                        MTPLT147
 2023 CONTINUE                                                          MTPLT148
      XA = XX                                                           MTPLT149
      YA = YY                                                           MTPLT150
      XX = XXX                                                          MTPLT151
      YY = YYY                                                          MTPLT152
      IF (LPC - 4) 9098,9099,9098                                       MTPLT153
 9098 CALL FPLOT (2,XXX,YYY)                                            MTPLT154
      IF (XXX-XA) 9504,9504,9505                                        MTPLT155
 9504 CALL POINT (3)                                                    MTPLT156
      GO TO 2030                                                        MTPLT157
 9505 CALL POINT (5)                                                    MTPLT158
      GO TO 2030                                                        MTPLT159
 9099 CALL FPLOT (2,XXX,YYY)                                            MTPLT160
      CALL POINT (1)                                                    MTPLT161
 1010 CONTINUE                                                          MTPLT162
C                                                                       MTPLT163
C TO RETURN TO ORIGIN AND ASK IF PLOTTING IS COMPLETE.                  MTPLT164
      CALL FPLOT (1,0.0,0.0)                                            MTPLT165
      WRITE (TYPE,836)                                                  MTPLT166
      PAUSE 10                                                          MTPLT167
```

```
      CALL DATSW (5,M)                                                  MTPLT168
      GO TO (860,839), M                                                MTPLT169
C ROTATE AXIS OF PRINT -90 DEGREES FOR TITLE HEADINGS ETC.              MTPLT170
  839 CALL FCHAR (0.0,0.0,0.20,0.20,+1.57050)                           MTPLT171
      WRITE (TYPE,7009)                                                 MTPLT172
      READ (KEYBD,800) IDATA                                            MTPLT173
      WRITE (PLOT,800) IDATA                                            MTPLT174
      WRITE (TYPE,7012)                                                 MTPLT175
      PAUSE 12                                                          MTPLT176
      WRITE (PLOT,7013)                                                 MTPLT177
      CALL SCALF (5,5,0.0,0.0)                                          MTPLT178
      YY = 0.0                                                          MTPLT179
      XX = 4.0                                                          MTPLT180
      AX = XX*COS(THETA) + YY*SIN(THETA)                                MTPLT181
      AY = -XX*SIN(THETA) + YY*COS(THETA)                               MTPLT182
      CALL FPLOT(2,AX,AY)                                               MTPLT183
      WRITE (PLOT,7014)                                                 MTPLT184
      CALL EXIT                                                         MTPLT185
      END                                                               MTPLT186
// DUP                                                                  MTPLT187
*DELETE              MTPLT                                            MTPLT188
*STORE       WS  UA  MTPLT                                            MTPLT189
```

Fig. 2. Example output program MTPLT.

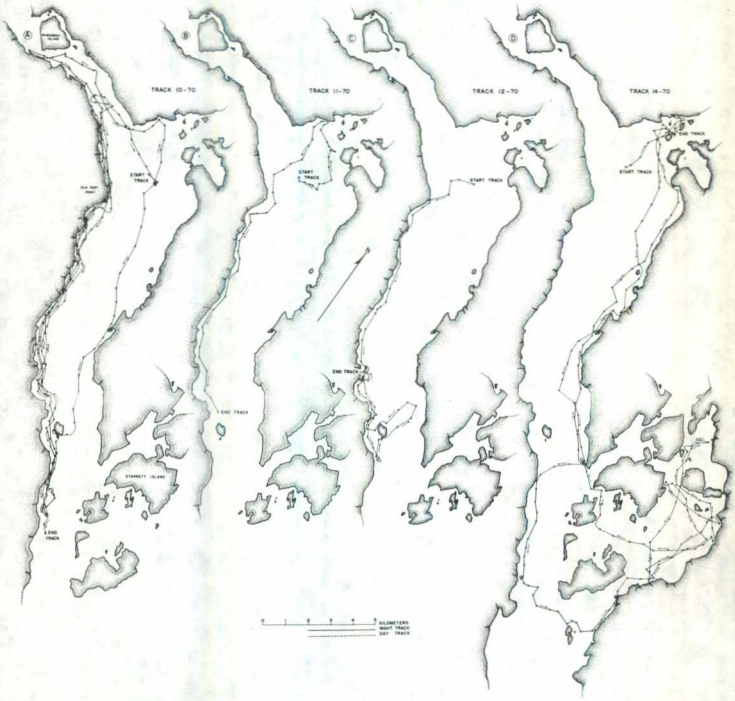

Fig. 3. A-D: Sonic tracks redrawn from output of program MTPLT. See text for explanations.

```
// JOB                                                                  PUNCH001
// FOR                                                                  PUNCH002
*ONE WORD INTEGERS                                                      PUNCH003
*IOCS(1442 PUNCH,DISK,2501 READER,TYPEWRITER)                           PUNCH004
*LIST ALL                                                              PUNCH005
*NAME PUNCH                                                            PUNCH006
** PUNCH - PROGRAM TO PUNCH X,Y COORDINATES ON TRACK POSITION CARDS.    PUNCH007
C                                                                       PUNCH008
C ********************************************************************* PUNCH009
C                                                                       PUNCH010
C USE *FILES(1,DVMF) TO EXECUTE THIS PROGRAM.                           PUNCH011
C                                                                       PUNCH012
C INPUT                                                                 PUNCH013
C     1) BLANK CARD                                                     PUNCH014
C     2) HEADER CARDS (CARD TYPES F1 AND F2)                            PUNCH015
C     3) KEYPUNCHED TRACK POSITION CARDS P.  THESE CARDS MUST BE IN THE PUNCH016
C        SAME SEQUENCE AS THE TRACK POSITION POINTS WERE DIGITIZED.     PUNCH017
C        COLS 1 - 5  TRACK NUMBER                                       PUNCH018
C             7 -10  POINT SEQUENCE NUMBER                              PUNCH019
C            28-30  DAY NUMBER                                          PUNCH020
C            32-33  HOUR                                                PUNCH021
C            34-35  MINUTE                                              PUNCH022
C            37-40  DEPTH                                               PUNCH023
C            42-42  DAWN/DUSK INDICATOR.                                PUNCH024
C            44-44  LOST/FOUND INDICATOR                                PUNCH025
C     4) INPUTS 1 TO 3 REPEATED FOR NEW TRACKS  (NOTE THAT THE SEQUENCE PUNCH026
C        OF TRACK NUMBERS READ MUST BE THE SAME AS THAT ON DATA FILE.   PUNCH027
C     -  OR A NEGATIVE ENTRY IN COLUMNS 1-5 OF A BLANK CARD TO SIGNIFY  PUNCH028
C        END OF DATA.                                                   PUNCH029
C OUTPUT.                                                               PUNCH030
C     OUTPUT CONSISTS OF CARDS TYPE 'P' (TO BE USED BY PROGRAM CREF)    PUNCH031
C        WHICH ARE ESSENTIALLY THE SAME AS THE KEYPUNCHED POSITION      PUNCH032
C        CARDS WITH THE ADDED INFORMATION OF X, Y COORDINATES           PUNCH033
C        OF POSITION POINTS SUPPLIED BY FILE DVMF.                      PUNCH034
C     NOTE THAT THE FIRST TRACK TO BE READ MUST HAVE ITS CORRESPONDING  PUNCH035
C        FILE RECORD NUMBER (OF DVMF) ENTERED AS THE VALUE FOR THE      PUNCH036
C        VARIABLE M.                                                    PUNCH037
C                                                                       PUNCH038
C ********************************************************************* PUNCH039
C                                                                       PUNCH040
      INTEGER CARD,PUNCH,TYPE                                           PUNCH041
      DEFINE FILE 1(21000,5,U,M)                                        PUNCH042
      DATA CARD,PUNCH,TYPE / 8,9,1 /                                    PUNCH043
C                                                                       PUNCH044
C FORMATS                                                               PUNCH045
  300 FORMAT (I5,1X,I4,17X,I3,1X,I4,1X,I4,1X,I1,1X,I1)                  PUNCH046
  301 FORMAT (' ')                                                      PUNCH047
  200 FORMAT (80X)                                                      PUNCH048
  302 FORMAT (' ','THE BEGINNINGS OF THE TRACKS DO NOT COINCIDE')       PUNCH049
  303 FORMAT (I5,1X,I4,1X,F7.3,1X,F7.3,1X,I3,1X,I4,1X,I4,1X,I1,1X,I1,   PUNCH050
     135X,A1)                                                           PUNCH051
C                                                                       PUNCH052
C THE VALUE OF M MUST CORRESPOND TO THE FIRST FILE RECORD NUMBER OF THE PUNCH053
C FIRST TRACK TO BE READ.                                               PUNCH054
      M=16550                                                           PUNCH055
```

```
      IP=-10432                                                          PUNCH056
C TO READ THE KEYPUNCHED TRACK POSITION CARDS.                           PUNCH057
C FIRST CARD READ MUST BE A BLANK FOLLOWED BY TWO HEADER CARDS.          PUNCH058
    1 READ(CARD,300) ITRK,ISEQ,IDATE,ITIME,IDEP,IDORN,ILOST              PUNCH059
      K=2                                                                PUNCH060
      IF (ITRK) 8,2,3                                                    PUNCH061
    2 WRITE (PUNCH,301)                                                  PUNCH062
      WRITE (PUNCH,301)                                                  PUNCH063
C TO READ THE TWO HEADER CARDS                                           PUNCH064
      READ (CARD,200)                                                    PUNCH065
      READ (CARD,200)                                                    PUNCH066
      READ(CARD,300) ITRK,ISEQ,IDATE,ITIME,IDEP,IDORN,ILOST              PUNCH067
      K=1                                                                PUNCH068
    3 READ (1'M) IPEN,XCO,YCO                                            PUNCH069
C THE BEGINNING OF ALL TRACKS START WITH A PEN UP INDICATOR (IPEN=1)     PUNCH070
      IF (IPEN-1) 6,4,6                                                  PUNCH071
    4 IF (K-1) 5,6,5                                                     PUNCH072
    5 WRITE (TYPE,302)                                                   PUNCH073
      GO TO 8                                                            PUNCH074
C EXTRAPOLATED POINTS (IPEN=2) ARE NOT PUNCHED                           PUNCH075
    6 IF (IPEN-2) 7,3,7                                                  PUNCH076
    7 WRITE(PUNCH,303) ITRK,ISEQ,XCO,YCO,IDATE,ITIME,IDEP,IDORN,ILOST,IPPUNCH077
C IPEN=3 IS THE FIRST POINT AT WHICH FISH IS SUBSEQUENTLY LOST           PUNCH078
      IF (IPEN-3) 1,77,1                                                 PUNCH079
   77 READ(CARD,300) ITRK,ISEQ,IDATE,ITIME,IDEP,IDORN,ILOST              PUNCH080
   78 READ (1'M) IPEN,XCO,YCO                                            PUNCH081
C IPEN=4 IS THE POINT AT WHICH A LOST FISH WAS FOUND                     PUNCH082
      IF (IPEN-4) 78,7,7                                                 PUNCH083
    8 CALL EXIT                                                          PUNCH084
      END                                                                PUNCH085
// DUP                                                                   PUNCH086
*DELETE              PUNCH                                               PUNCH087
*STORE       WS  UA  PUNCH                                               PUNCH088
```

PROGRAMS

SPEED OF MOVEMENT

```
// JOB                                                                  CREF0001
// DUP                                                                  CREF0002
*DELETE            TEST                                               CREF0003
*STOREDATA  WS  UA  TEST  0075                                         CREF0004
                                                                       CREF0005
// FOR                                                                 CREF0006
*LIST ALL                                                              CREF0007
*ONE WORD INTEGERS                                                     CREF0008
*IOCS(2501 READER,DISK)                                                CREF0009
*NAME CREF                                                             CREF0010
** CREF - LOADING OF DATA FILE TEST FOR MACH1.                         CREF0011
C                                                                      CREF0012
C ********************************************************************** CREF0013
C                                                                      CREF0014
C RESTRICTIONS ...                                                     CREF0015
C  1) MAXIMUM OF 32 TRACKS (VARIABLE K MINUS ONE )                     CREF0016
C  2) A MAXIMUM OF 312  POSITION CARDS PER TRACK.                      CREF0017
C  3) ALL TRACKS TO BE PROCESSED BY MACH1 SHOULD BE LOADED IN ONE RUN  CREF0018
C        OF THIS PROGRAM.                                              CREF0019
C        MODIFICATION OF K AND J WOULD HOWEVER FACILITATE ADDITIONS    CREF0020
C     OF TRACKS TO FILE TEST.                                          CREF0021
C  4) POSITION CARDS MUST BE SORTED IN ORDER OF ASCENDING HOURS AND    CREF0022
C     MINUTES WITHIN ASCENDING DAY NUMBER INTO TRACK.                  CREF0023
C                                                                      CREF0024
C INPUT ...                                                            CREF0025
C  1) CARD TYPE F1- CONTAINING                                         CREF0026
C        COLS 29    SEX                                              CREF0027
C             31-33 LENGTH OF FISH.                                    CREF0028
C  2) CARD TYPE F2- CONTAINING                                         CREF0029
C        10-12 BEGINNING DAY NUMBER OF TRACK                           CREF0030
C        13-14           HOUR                                          CREF0031
C        15-16           MINUTE                                        CREF0032
C        27-29 ENDING DATE (DAY NUMBER) OF TRACK                       CREF0033
C        30-31           HOUR                                          CREF0034
C        32-33           MINUTE                                        CREF0035
C  3) TRACK POSITION CARDS, CARD TYPE 'P', PUNCHED BY PROGRAM PUNCH    CREF0036
C         2- 5 TRACK NUMBER                                            CREF0037
C        12-18 X COORDINATE ( KILOMETERS )                             CREF0038
C        20-26 Y COORDINATE ( KILOMETERS )                             CREF0039
C        32-33 HOUR                                                    CREF0040
C        34-35 MINUTE                                                  CREF0041
C        42-42 1 = DAWN                                                CREF0042
C              2 = DUSK                                                CREF0043
C  4) BLANK CARD FOLLOWED BY INPUTS 1, 2, AND 3 OF NEW TRACK .         CREF0044
C     OR INSTEAD OF A BLANK CARD AND NEW DATA, A MINUS ENTRY IN COLUMNS CREF0045
C        2-5 OF AN OTHERWISE BLANK CARD TO SIGNIFY END OF DATA.        CREF0046
C                                                                      CREF0047
C OUTPUT ...                                                           CREF0048
C  OUTPUT IS THE CREATION OF DISK DATA FILE TEST, WHICH OCCUPIES 75    CREF0049
C     SECTORS OF USER'S AREA ON DISK.  TEST IS STRUCTURED AS FOLLOWS ...CREF0050
C        THE FIRST WORD OF THE FIRST 32 RECORDS (MAXIMUM) CONTAINS THE CREF0051
C        RECORD NUMBER WITH WHICH THAT TRACK BEGINS.  THUS THE FIRST   CREF0052
C        TRACK READ RECEIVES A FLAG (WORD ONE OF THE FIRST RECORD) WITHCREF0053
C        A VALUE OF 33, SINCE THE PROGRAM IS GEARED FOR A MAXIMUM OF   CREF0054
C        32 TRACKS.  THE BEGINNING RECORD NUMBER OF THE SECOND TRACK   CREF0055
```

```
C          IS THE VALUE LOCATED IN WORD ONE OF THE SECOND RECORD, AND      CREF0056
C          SO ON.                                                          CREF0057
C          THE FIRST RECORD OF A TRACK CONTAINS COMBINED INFORMATION       CREF0058
C          OF CARD TYPES F1 AND F2.  THE FOLLOWING RECORDS CONTAIN         CREF0059
C          INFORMATION OF TRACK POSITION CARDS (TYPE P),  A BLANK RECORD   CREF0060
C          BEING PLACED BETWEEN TRACKS.                                    CREF0061
C                                                                          CREF0062
C  SEE LISTING OF PROGRAM ECHO TO OBTAIN A PRINT OUT OF THE CONTENTS OF    CREF0063
C  DATA FILE TEST.                                                         CREF0064
C                                                                          CREF0065
C EXECUTE THIS PROGRAM (CREF) WITH *FILES(1,TEST)                          CREF0066
C                                                                          CREF0067
C ************************************************************************ CREF0068
C                                                                          CREF0069
      INTEGER SEX,RDATE,RHRS,RMIN,TDATE,THRS,TMIN,TRK,HRS,DORN             CREF0070
      INTEGER  CARD                                                        CREF0071
      DATA CARD / 8 /                                                      CREF0072
      DEFINE FILE 1(3000,8,U,M)                                            CREF0073
C                                                                          CREF0074
  300 FORMAT (28X,I1,1X,I3)                                                CREF0075
  301 FORMAT (9X,I3,2I2,10X,I3,2I2)                                        CREF0076
  302 FORMAT (1X,I4,6X,F7.3,1X,F7.3,5X,2I2,6X,I1)                          CREF0077
C                                                                          CREF0078
      K=33                                                                 CREF0079
C                                                                          CREF0080
C TO INITIALIZE FILE                                                       CREF0081
      J = K - 1                                                            CREF0082
      SEX = 0                                                              CREF0083
      DO 10 TRK = 1,J                                                      CREF0084
   10 WRITE (1'TRK) SEX                                                    CREF0085
      J=1                                                                  CREF0086
    1 M=J                                                                  CREF0087
      WRITE (1'M) K                                                        CREF0088
      READ (CARD,300) SEX,LENG                                             CREF0089
      READ (CARD,301) RDATE,RHRS,RMIN,TDATE,THRS,TMIN                      CREF0090
      M=K                                                                  CREF0091
      WRITE (1'M) SEX,LENG,RDATE,RHRS,RMIN,TDATE,THRS,TMIN                 CREF0092
      K=K+1                                                                CREF0093
    2 READ (CARD,302) TRK,XCO,YCO,HRS,MIN,DORN                             CREF0094
      WRITE (1'M) TRK,XCO,YCO,HRS,MIN,DORN                                 CREF0095
      K=K+1                                                                CREF0096
      IF (TRK) 5,4,2                                                       CREF0097
    4 J=J+1                                                                CREF0098
      GO TO 1                                                              CREF0099
    5 CALL EXIT                                                            CREF0100
      END                                                                  CREF0101
// DUP                                                                     CREF0102
*DELETE            CREF                                                   CREF0103
*STORE      WS  UA  CREF                                                   CREF0104
```

```
// JOB                                                                  ECH00001
// FOR                                                                  ECH00002
*IOCS(TYPEWRITER,DISK,1403 PRINTER,KEYBOARD)                            ECH00003
*ONE WORD INTEGERS                                                      ECH00004
*LIST ALL                                                               ECH00005
*NAME ECHO                                                              ECH00006
** ECHO - LISTING OF DISK DATA FILE TEST.                               ECH00007
C                                                                       ECH00008
C ********************************************************************* ECH00009
C                                                                       ECH00010
C EXECUTE THIS PROGRAM USING *FILES(1,TEST)                             ECH00011
C                                                                       ECH00012
C PROGRAM WILL LIST ALL TRACK NUMBERS WITH CORRESPONDING BEGINNING FILE ECH00013
C    RECORD NUMBERS, STORED ON DISK DATA FILE TEST.                     ECH00014
C THE USER HAS THE OPTION OF SPECIFYING THE FILE RECORD NUMBER AT        ECH00015
C    WHICH THE LISTING IS TO BEGIN BY ENTERING THIS NUMBER ON THE TYPE-  ECH00016
C    WRITER CONSOLE                                                     ECH00017
C                                                                       ECH00018
C ********************************************************************* ECH00019
C                                                                       ECH00020
      INTEGER PRINT,TYPE,KEYBD                                          ECH00021
      DIMENSION IN(8)                                                   ECH00022
      DATA PRINT,TYPE,KEYBD / 5,1,6 /                                   ECH00023
      DEFINE FILE 1(3000,8,U,KI)                                        ECH00024
C                                                                       ECH00025
100   FORMAT (///'ECHO LISTING OF FILE TEST'/'** SAVE THIS LIST FOR REFERECH00026
100   1ENCE TO TRACK NUMBER CODE FOR PROGRAM MACH1  **'//'CODE  TRACK NO.ECH00027
100   2  BEGINNING FILE RECORD NO.'/)                                   ECH00028
105   FORMAT (I3,4X,I5,10X,I6)                                          ECH00029
110   FORMAT (//'ENTER FILE RECORD NUMBER (RIGHT JUSTIFIED IN FIVE COLUMECH00030
110   1N FIELD)' /'WHICH LISTING IS TO BEGIN'/)                         ECH00031
112   FORMAT (I5)                                                       ECH00032
120   FORMAT ('1DATA FILE TEST LISTING'/)                               ECH00033
125   FORMAT('1',15X,'BEGINNING',6X,'ENDING'/' SEX  LENGTH  DAY  HR  MINECH00034
125   1  DAY  HR  MIN')                                                ECH00035
130   FORMAT (' ',I7,4X,I4,3X,I3,2X,I2,3X,I2,2X,I3,2X,I2,3X,I2)        ECH00036
140   FORMAT ('0TRACK',5X,'X',9X,'Y',6X,'HOUR  MIN  DUSK/DAWN'/)       ECH00037
145   FORMAT (' ',I5,2(1X,F9.3),3X,I3,3X,I2,6X,I1)                     ECH00038
C                                                                       ECH00039
C TO LIST ON CONSOLE PRINTER ALL TRACKS AVAILABLE.                      ECH00040
      WRITE (TYPE,100)                                                  ECH00041
      INC = 1                                                           ECH00042
      READ (1'1) K                                                      ECH00043
      KI= K + 1                                                         ECH00044
    5 READ (1'KI)ITRK                                                   ECH00045
      J = KI- 2                                                         ECH00046
      WRITE (TYPE,105) INC,ITRK,J                                       ECH00047
      INC = INC + 1                                                     ECH00048
   10 READ (1'KI) ITRK                                                  ECH00049
      IF (ITRK) 20,15,10                                                ECH00050
   15 KI = KI + 1                                                       ECH00051
      GO TO 5                                                           ECH00052
C                                                                       ECH00053
C TO ASK WHICH RECORD LISTING IS TO BEGIN.                              ECH00054
   20 WRITE (TYPE,110)                                                  ECH00055
```

```
      READ (KEYBD,112) KI                                          ECHO0056
C                                                                  ECHO0057
      WRITE (PRINT,120)                                            ECHO0058
   30 READ (1'KI) IN                                               ECHO0059
      WRITE (PRINT,125)                                            ECHO0060
      WRITE (PRINT,130) IN                                         ECHO0061
C                                                                  ECHO0062
      WRITE (PRINT,140)                                            ECHO0063
C                                                                  ECHO0064
   40 READ (1'KI) ITRK,X,Y,IHR,MIN,ID                              ECHO0065
      IF (ITRK) 50,30,45                                           ECHO0066
   45 WRITE (PRINT,145) ITRK,X,Y,IHR,MIN,ID                        ECHO0067
      GO TO 40                                                     ECHO0068
   50 CALL EXIT                                                    ECHO0069
      END                                                          ECHO0070
// DUP                                                             ECHO0071
*DELETE              ECHO                                         ECHO0072
*STORE       WS  UA  ECHO                                         ECHO0073
```

Table 1. Echo listing of file TEST. Save this list for reference to track number code for program MACH1.

CODE	TRACK NO.	BEGINNING FILE RECORD NO.
1	169	33
2	269	82
3	369	219
4	469	274
5	569	375
6	669	423
7	769	518
8	869	524
9	969	636
10	1069	670
11	1169	675
12	1269	842
13	1369	976
14	170	1028
15	270	1054
16	370	1080
17	470	1090
18	570	1125
19	670	1239
20	770	1258
21	870	1300
22	970	1326
23	1070	1331
24	1170	1521
25	1270	1571
26	1370	1628
27	1470	1922
28	1570	2087
29	1670	2198
30	1770	2399
31	1870	2454
32	1970	2515

ENTER FILE RECORD NUMBER (RIGHT JUSTIFIED IN FIVE COLUMN FIELD) WHICH LISTING IS TO BEGIN

-> 01922

Table 2. Example of data file listing of file TEST by program ECHO.

		BEGINNING			ENDING		
SEX	LENGTH	DAY	HR	MIN	DAY	HR	MIN
2	620	216	10	21	218	6	30

TRACK	X	Y	HOUR	MIN	DUSK/DAWN
1470	3.690	12.419	10	21	1
1470	3.472	12.539	10	30	1
1470	2.943	12.667	10	45	1
1470	2.225	12.584	11	0	1
1470	1.608	12.947	11	15	1
1470	1.367	12.979	11	30	1
1470	1.199	13.333	11	45	1
1470	0.567	13.211	12	0	1
1470	0.579	12.800	12	15	1
1470	0.841	13.094	12	31	1
1470	1.224	12.867	12	45	1
1470	1.625	12.476	13	40	1
1470	1.965	13.084	13	53	1
1470	2.326	13.243	14	0	1
1470	2.975	13.741	14	15	1
1470	3.551	14.173	14	30	1
1470	4.367	14.331	14	45	1
1470	5.213	14.410	15	0	1
1470	5.756	14.432	15	15	1
1470	6.222	14.869	15	30	1
1470	6.877	15.414	15	45	1
1470	7.415	15.804	16	0	1
1470	8.124	15.628	16	15	1
1470	8.806	16.038	16	30	1
1470	9.201	15.686	16	45	1
1470	9.714	15.575	17	0	1
1470	10.453	15.541	17	15	1
1470	11.187	15.228	17	30	1
1470	11.731	15.218	17	45	1
1470	12.303	15.419	18	0	1
1470	13.026	15.641	18	15	1
1470	13.501	15.804	18	30	1
1470	13.545	16.680	18	45	1
1470	13.891	17.161	19	0	1
1470	14.467	17.564	19	15	1
1470	14.966	18.111	19	30	1
1470	15.381	18.599	19	45	1
1470	15.522	18.645	20	0	1
1470	15.895	18.129	20	15	1
1470	16.384	17.635	20	30	1
1470	17.025	17.345	20	45	1
1470	17.332	17.376	21	0	1
1470	17.645	17.570	21	15	2
1470	18.160	17.876	21	30	2
1470	18.482	18.224	21	45	2
1470	18.835	18.427	22	0	2
1470	19.705	18.601	22	30	2
1470	20.063	18.774	22	45	2
1470	20.445	18.944	23	0	2
1470	20.730	19.136	23	15	2

```
// JOB                                                                  MACH1001
// FOR                                                                  MACH1002
*IOCS(2501 READER,DISK,1442 PUNCH,1403 PRINTER)                         MACH1003
*ONE WORD INTEGERS                                                      MACH1004
*LIST ALL                                                               MACH1005
*NAME MACH1                                                             MACH1006
**PROGRAM MACH1 - SPEED VS TIME DATA ANALYSIS                           MACH1007
C                                                                       MACH1008
C ********************************************************************* MACH1009
C                                                                       MACH1010
C USE *FILES(1,TEST) TO EXECUTE THIS PROGRAM                            MACH1011
C                                                                       MACH1012
C INPUT ....                                                            MACH1013
C     1) TRACK NUMBERS DESIRED, IN SEQUENCE CODE ... I.E. THE SEQUENCE  MACH1014
C        NUMBER OBTAINED BY THE ORDER IN WHICH THE TRACKS WERE LOADED   MACH1015
C        BY PROGRAM CREF.  TRACK NUMBER CODES ARE RIGHT ORIENTED, TWO   MACH1016
C        COLUMNS EACH,  STARTING FROM COLUMN ONE.                       MACH1017
C     2) OPTION CARD FOR PRINT - OUT CONTROL.                           MACH1018
C        COLS. 1 - 1 PUNCH FOR A DAWN TO DUSK BREAKDOWN                 MACH1019
C              2 - 1 PUNCH FOR DAWN TO DUSK BY DAY BREAKDOWN            MACH1020
C              3 - 1 PUNCH FOR THE FOLLOWING TIME BREAKDOWN ...         MACH1021
C                          000 - DAWN                                   MACH1022
C                          DAWN - 11.9 HOURS                            MACH1023
C                          12.0 - DUSK                                  MACH1024
C                          DUSK - 23.9 HOURS                            MACH1025
C              4 - 1 PUNCH FOR OPTION 3 BY DAY                          MACH1026
C              5 - 1 PUNCH TO SPECIFY A VARIABLE INTERVAL WILL BE GIVENMACH1027
C              6 - 1 PUNCH TO SPECIFY OPTION FIVE BY DAY.               MACH1028
C              7 - 1 PUNCH TO SPECIFY THAT SWIMMING SPEEDS ARE TO BE    MACH1029
C                    PUNCHED OUT.  FORMAT FOR CARD OUTPUT IS...         MACH1030
C                    COLS.  1 -  6  AVERAGE KILOMETERS PER HOUR.        MACH1031
C                          17 - 20  TRACK NUMBER.                       MACH1032
C                               22  DAY NUMBER INTO TRACK.             MACH1033
C                          24 - 26  BEGINNING HOUR OF INTERVAL.         MACH1034
C                    COLUMNS 5 OR 6 MUST CONTAIN A 1 PUNCH FOR          MACH1035
C                    THIS OPTION TO BE VALID.                           MACH1036
C           ONE OR ALL OPTIONS ABOVE MAY BE SPECIFIED.                  MACH1037
C     3) THIS CARD IS NEEDED ONLY IF VARIABLE TIME INTERVALS HAVE BEEN  MACH1038
C        SPECIFIED IN THE OPTION CARD ... IF SO, THIS CARD CONTAINS THEMACH1039
C        NUMBER OF TIMES (HOURS) THAT WILL BE READ IN ON THE NEXT CARD.MACH1040
C        THIS NUMBER WILL APPEAR AS TWO DIGITS IN COLUMNS 1 AND 2.      MACH1041
C     4) THIS CARD IS ONLY NEEDED IF VARIABLE INTERVALS WERE SPECIFIED  MACH1042
C        ON THE OPTION CARD ... IF SO, THIS CARD CONTAINS THE ACTUAL    MACH1043
C        HOURS THAT WILL REPRESENT THE STARTING HOUR OF THE VARIABLE    MACH1044
C        INTERVALS DESIRED.                                             MACH1045
C        EACH TIME WILL BE RIGHT JUSTIFIED IN 4 COLUMNS EACH. - MAX OF  MACH1046
C        TWENTY TIMES.                                                  MACH1047
C        E.G.   00000300-2000700100013001600-1002200                    MACH1048
C        WILL YIELD THE FOLLOWING TIME INTERVALS ...                    MACH1049
C                          00.0 - 03.0 HOURS                            MACH1050
C                          03.0 - DAWN                                  MACH1051
C                          DAWN - 07.0 HOURS                            MACH1052
C                          ...                                          MACH1053
C                          22.0 - 00.0                                  MACH1054
C        NOTE THAT THE TIMES ARE IN HOURS AND IN ASCENDING ORDER.       MACH1055
C        THE FIRST TIME GIVEN IS 0000, AND THE LAST TIME (0000) IS      MACH1056
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C         ASSUMED BY THE PROGRAM AND SHOULD NOT BE SPECIFIED ON THE      MACH1057
C         CARD.  THE TIME OF DAWN (-200 ENTRY) AND THE TIME OF DUSK      MACH1058
C         (-100 ENTRY) MUST BOTH APPEAR.                                 MACH1059
C         N.B. THE ENTRY IN COLUMNS 1 AND 2 OF INPUT NUMBER 3 WOULD      MACH1060
C         HAVE BEEN 09 FOR THE ABOVE EXAMPLE.                            MACH1061
C      5) INPUT ITEMS 1 - 4 (AS NECESSARY) REPEATED FOR DIFFERENT TIME   MACH1062
C         BREAKDOWNS OR A BLANK CARD TO SIGNIFY END OF DATA.             MACH1063
C                                                                        MACH1064
C SUBROUTINES HEAD AND SWIM ARE REQUIRED .                               MACH1065
C                                                                        MACH1066
C ********************************************************************** MACH1067
C                                                                        MACH1068
      INTEGER TRKNO(32),TEST(6),SLOTS(20),ALPHA(11,4),DAWN(4),DUSK(4),   MACH1069
     1NBDAW,NBDUS,DAY,DISTS(42),TIMES(42),SEX,RDATE,RHRS,RMIN,TDATE,     MACH1070
     2THRS,TMIN,TTIME,RTIME,DUR,TRK,HRS(2),DORN(2),DN,AMPM,DIST,TIME,    MACH1071
     3C1,C2,PUNCH,PRINT,CARD                                             MACH1072
      DIMENSION ISLOT(10),XCO(2),YCO(2),MIN(2),NAME(3),IVECD(4),         MACH1073
     1IVECN(4),ISEQ(10)                                                  MACH1074
      COMMON C1,C2,LENG,XLENG,XKMHR,YLSEC,KPAGE,TRK,RDATE,NAME,SEX,X,Y   MACH1075
      DATA DAWN/'D','A','W','N'/,DUSK/'D','U','S','K'/,IVECD/1,3,4,2/,   MACH1076
     1IVECN/4,2,1,3/                                                     MACH1077
      DATA PRINT,PUNCH,CARD / 5,9,8 /                                    MACH1078
      DEFINE FILE 1(3000,8,U,M)                                          MACH1079
C                                                                        MACH1080
C FORMATS                                                                MACH1081
  300 FORMAT (32I2)                                                      MACH1082
  301 FORMAT (7I1)                                                       MACH1083
  302 FORMAT (I2)                                                        MACH1084
  303 FORMAT (20I2)                                                      MACH1085
  304 FORMAT ('0',I4,3X,I3,4X,A1,4X,F4.1,9X,F4.1,1X,F4.1,4X,F4.1,4X,     MACH1086
     1F6.2,4X,F4.2,12X,F4.2)                                             MACH1087
  305 FORMAT (' ',32X,I3,2X,I3)                                          MACH1088
  306 FORMAT (' ',32X,'DAWN-DUSK',4X,F4.1,4X,F6.2,4X,F4.2,12X,F4.2)      MACH1089
  307 FORMAT (' ',32X,'DUSK-DAWN',4X,F4.1,4X,F6.2,11X,F4.2,11X,F4.2)     MACH1090
  308 FORMAT (' ',26X,'DAY ',I1,' DAWN-DUSK',4X,F4.1,4X,F6.2,4X,F4.2,    MACH1091
     112X,F4.2)                                                          MACH1092
  309 FORMAT (' ',26X,'DAY ',I1,' DUSK-DAWN',4X,F4.1,4X,F6.2,11X,F4.2,   MACH1093
     111X,F4.2)                                                          MACH1094
  310 FORMAT (' ',32X,'00.0-DAWN',4X,F4.1,4X,F6.2,11X,F4.2,11X,F4.2)     MACH1095
  311 FORMAT (' ',32X,'DAWN-11.9',4X,F4.1,4X,F6.2,4X,F4.2,12X,F4.2)      MACH1096
  312 FORMAT (' ',32X,'12.0-DUSK',4X,F4.1,4X,F6.2,4X,F4.2,12X,F4.2)      MACH1097
  313 FORMAT (' ',32X,'DUSK-23.9',4X,F4.1,4X,F6.2,11X,F4.2,11X,F4.2)     MACH1098
  314 FORMAT (' ',26X,'DAY ',I1,' 00.0-DAWN',4X,F4.1,4X,F6.2,11X,F4.2,   MACH1099
     111X,F4.2)                                                          MACH1100
  315 FORMAT (' ',26X,'DAY ',I1,' DAWN-11.9',4X,F4.1,4X,F6.2,4X,F4.2,    MACH1101
     112X,F4.2)                                                          MACH1102
  316 FORMAT (' ',26X,'DAY ',I1,' 12.0-DUSK',4X,F4.1,4X,F6.2,4X,F4.2,    MACH1103
     112X,F4.2)                                                          MACH1104
  317 FORMAT (' ',26X,'DAY ',I1,' DUSK-23.9',4X,F4.1,4X,F6.2,11X,F4.2,   MACH1105
     111X,F4.2)                                                          MACH1106
  318 FORMAT (' ',32X,4A1,'-',4A1,4X,F4.1,4X,F6.2,11X,F4.2,11X,F4.2)     MACH1107
  319 FORMAT (' ',32X,4A1,'-',4A1,4X,F4.1,4X,F6.2,4X,F4.2,12X,F4.2)      MACH1108
  320 FORMAT (' ',26X,'DAY ',I1,1X,4A1,'-',4A1,4X,F4.1,4X,F6.2,11X,F4.2,MACH1109
     111X,F4.2)                                                          MACH1110
  321 FORMAT (' ',26X,'DAY ',I1,1X,4A1,'-',4A1,4X,F4.1,4X,F6.2,4X,F4.2,  MACH1111
     112X,F4.2)                                                          MACH1112
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  400 FORMAT (' ')                                                    MACH1113
  900 FORMAT (F6.3,10X,I4,1X,I1,1X,I3)                                MACH1114
C                                                                     MACH1115
      NAME(1)=-11200                                                  MACH1116
      NAME(2)=-14784                                                  MACH1117
      NAME(3)=16448                                                   MACH1118
  600 READ (CARD,300) (TRKNO(I),I=1,32)                               MACH1119
      IF (TRKNO(1)) 601,700,601                                       MACH1120
  601 READ (CARD,301) (TEST(I),I=1,6),NPUN                            MACH1121
      LK=1                                                            MACH1122
      IF (TEST(5)+TEST(6)) 1,11,1                                     MACH1123
    1 READ (CARD,302) N                                               MACH1124
      READ (CARD,303) (SLOTS(I),I=1,20)                               MACH1125
      DO 3 I=1,N                                                      MACH1126
      ISLOT(I)=(SLOTS(2*I-1)+SLOTS(2*I)/60.0)*10.0+0.499              MACH1127
      IF (ISLOT(I)-240) 3,2,3                                         MACH1128
    2 ISLOT(I)=0                                                      MACH1129
    3 CONTINUE                                                        MACH1130
      DO 9 I=1,N                                                      MACH1131
      IF (SLOTS(2*I-1)+1) 5,7,4                                       MACH1132
    4 IT2=ISLOT(I)/100                                                MACH1133
      IT1=ISLOT(I)/10                                                 MACH1134
      IT=ISLOT(I)                                                     MACH1135
      ALPHA(I,1)=IT2*256-4032                                         MACH1136
      ALPHA(I,2)=(IT1-10*IT2)*256-4032                                MACH1137
      ALPHA(I,3)=19264                                                MACH1138
      ALPHA(I,4)=(IT-10*(IT/10))*256-4032                             MACH1139
      GO TO 9                                                         MACH1140
    5 DO 6 J=1,4                                                      MACH1141
    6 ALPHA(I,J)=DAWN(J)                                              MACH1142
      NBDAW=I                                                         MACH1143
      GO TO 9                                                         MACH1144
    7 DO 8 J=1,4                                                      MACH1145
    8 ALPHA(I,J)=DUSK(J)                                              MACH1146
      NBDUS=I                                                         MACH1147
    9 CONTINUE                                                        MACH1148
      DO 10 J=1,4                                                     MACH1149
   10 ALPHA(N+1,J)=ALPHA(1,J)                                         MACH1150
      LK=1                                                            MACH1151
   11 K=0                                                             MACH1152
      DAY=0                                                           MACH1153
      KPAGE=0                                                         MACH1154
      DO 12 J=1,42                                                    MACH1155
      DISTS(J)=0                                                      MACH1156
      TIMES(J)=0                                                      MACH1157
   12 CONTINUE                                                        MACH1158
      M=TRKNO(LK)                                                     MACH1159
      IF (M) 13,150,13                                                MACH1160
   13 READ (1'M) M                                                    MACH1161
      READ (1'M) SEX,LENG,RDATE,RHRS,RMIN,TDATE,THRS,TMIN             MACH1162
      IF (SEX) 15,14,15                                               MACH1163
   14 SEX=3                                                           MACH1164
   15 XLENG=LENG/10.0                                                 MACH1165
      TTIME=(THRS+TMIN/60.0)*10.0+0.499                               MACH1166
      IF (TTIME-240) 17,16,17                                         MACH1167
   16 TTIME=0                                                         MACH1168
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17 RTIME=(RHRS+RMIN/60.0)*10.0+0.499                                    MACH1169
   IF (RTIME-240) 19,18,19                                              MACH1170
18 RTIME=0                                                              MACH1171
19 IF (TTIME-RTIME) 21,20,20                                            MACH1172
20 DUR=(TDATE-RDATE)*240+(TTIME-RTIME)                                  MACH1173
   GO TO 22                                                             MACH1174
21 DUR=(TDATE-RDATE)*240-(RTIME-TTIME)                                  MACH1175
22 I=1                                                                  MACH1176
   READ (1'M) TRK,XCO(I),YCO(I),HRS(I),MIN(I),DORN(I)                   MACH1177
   ISAV=TRK                                                             MACH1178
   IF (DORN(I)-1) 25,23,24                                              MACH1179
23 DN=1                                                                 MACH1180
   GO TO 25                                                             MACH1181
24 DN=2                                                                 MACH1182
25 J=2                                                                  MACH1183
   IVEC=DN                                                              MACH1184
26 READ (1'M) TRK,XCO(J),YCO(J),HRS(J),MIN(J),DORN(J)                   MACH1185
   IF (TRK) 56,56,27                                                    MACH1186
27 IF (DORN(I)-DORN(J)) 28,33,28                                        MACH1187
28 IF (DN-1) 33,29,30                                                   MACH1188
29 DN=2                                                                 MACH1189
   GO TO 31                                                             MACH1190
30 DN=1                                                                 MACH1191
31 K=K+1                                                                MACH1192
   IF (K-2) 33,32,33                                                    MACH1193
32 DAY=DAY+1                                                            MACH1194
   K=0                                                                  MACH1195
33 IF (HRS(J)-12) 34,35,35                                              MACH1196
34 AMPM=0                                                               MACH1197
   GO TO 36                                                             MACH1198
35 AMPM=2                                                               MACH1199
36 XDIFF=XCO(J)-XCO(I)                                                  MACH1200
   YDIFF=YCO(J)-YCO(I)                                                  MACH1201
   DIST=(SQRT(XDIFF*XDIFF+YDIFF*YDIFF))*100.0+0.501                     MACH1202
   K1=(HRS(I)+MIN(I)/60.0)*10.0+0.499                                   MACH1203
   IF (K1-240) 38,37,38                                                 MACH1204
37 K1=0                                                                 MACH1205
38 K2=(HRS(J)+MIN(J)/60.0)*10.0+0.499                                   MACH1206
   IF (K2-240) 40,39,40                                                 MACH1207
39 K2=0                                                                 MACH1208
40 IF (K2-K1) 41,43,42                                                  MACH1209
41 TIME=K2+(240-K1)                                                     MACH1210
   GO TO 43                                                             MACH1211
42 TIME=K2-K1                                                           MACH1212
43 K3=DAY*4+DN+AMPM                                                     MACH1213
   DISTS(K3)=DISTS(K3)+DIST                                             MACH1214
   TIMES(K3)=TIMES(K3)+TIME                                             MACH1215
   IF (TEST(5)+TEST(6)) 53,53,44                                        MACH1216
44 L=1                                                                  MACH1217
45 IF (K2-ISLOT(L)) 47,46,46                                            MACH1218
46 L=L+1                                                                MACH1219
   IF (L-N-1) 45,47,45                                                  MACH1220
47 L=L-1                                                                MACH1221
   IF (ISLOT(L)+9) 48,50,52                                             MACH1222
48 IF (DN-1) 49,52,49                                                   MACH1223
49 L=L-1                                                                MACH1224
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      GO TO 52                                                          MACH1225
   50 IF (DN-1) 52,51,52                                                MACH1226
   51 L=L-1                                                             MACH1227
   52 K3=DAY*10+L+12                                                    MACH1228
      DISTS(K3)=DISTS(K3)+DIST                                          MACH1229
      TIMES(K3)=TIMES(K3)+TIME                                          MACH1230
   53 IF (I-1) 56,54,55                                                 MACH1231
   54 I=2                                                               MACH1232
      J=1                                                               MACH1233
      GO TO 26                                                          MACH1234
   55 I=1                                                               MACH1235
      J=2                                                               MACH1236
      GO TO 26                                                          MACH1237
   56 C1=0                                                              MACH1238
      DO 57 I=1,12                                                      MACH1239
   57 C1=DISTS(I)+C1                                                    MACH1240
      C2=DUR                                                            MACH1241
      CALL SWIM                                                         MACH1242
      CALL HEAD                                                         MACH1243
      S1=RTIME/10.0                                                     MACH1244
      S2=TTIME/10.0                                                     MACH1245
      S3=DUR/10.0                                                       MACH1246
      WRITE(PRINT,304) ISAV,RDATE,NAME(SEX),XLENG,S1,S2,S3,X,XKMHR,     MACH1247
     1YLSEC                                                             MACH1248
      WRITE (PRINT,305) RDATE,TDATE                                     MACH1249
      IF (TEST(1)) 65,65,59                                             MACH1250
   59 C1=0                                                              MACH1251
      C2=0                                                              MACH1252
      WRITE (PRINT,400)                                                 MACH1253
      DO 60 I=1,12,2                                                    MACH1254
      C1=C1+DISTS(I)                                                    MACH1255
   60 C2=C2+TIMES(I)                                                    MACH1256
      IF (C1) 62,62,61                                                  MACH1257
   61 CALL SWIM                                                         MACH1258
      CALL HEAD                                                         MACH1259
      WRITE (PRINT,306) Y,X,XKMHR,YLSEC                                 MACH1260
   62 C1=0                                                              MACH1261
      C2=0                                                              MACH1262
      DO 63 I=2,13,2                                                    MACH1263
      C1=C1+DISTS(I)                                                    MACH1264
   63 C2=C2+TIMES(I)                                                    MACH1265
      IF (C1) 65,65,64                                                  MACH1266
   64 CALL SWIM                                                         MACH1267
      CALL HEAD                                                         MACH1268
      WRITE (PRINT,307) Y,X,XKMHR,YLSEC                                 MACH1269
   65 IF (TEST(2)) 66,74,66                                             MACH1270
   66 WRITE (PRINT,400)                                                 MACH1271
      KK=IVEC                                                           MACH1272
      DO 73 I=1,3                                                       MACH1273
      DO 72 J=1,2                                                       MACH1274
      L=(I-1)*4+KK                                                      MACH1275
      C1=DISTS(L)+DISTS(L+2)                                            MACH1276
      C2=TIMES(L)+TIMES(L+2)                                            MACH1277
      IF (C1) 70,70,67                                                  MACH1278
   67 CALL SWIM                                                         MACH1279
      CALL HEAD                                                         MACH1280
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      IF (KK-1) 69,68,69                                          MACH1281
   68 WRITE (PRINT,308) I,Y,X,XKMHR,YLSEC                         MACH1282
      GO TO 70                                                    MACH1283
   69 WRITE (PRINT,309) I,Y,X,XKMHR,YLSEC                         MACH1284
   70 KK=KK+1                                                     MACH1285
      IF (KK-3) 72,71,72                                          MACH1286
   71 KK=1                                                        MACH1287
   72 CONTINUE                                                    MACH1288
   73 CONTINUE                                                    MACH1289
   74 IF (TEST(3)) 87,87,75                                       MACH1290
   75 C1=0                                                        MACH1291
      C2=0                                                        MACH1292
      WRITE (PRINT,400)                                           MACH1293
      DO 76 I=2,12,4                                              MACH1294
      C1=C1+DISTS(I)                                              MACH1295
   76 C2=C2+TIMES(I)                                              MACH1296
      IF (C1) 78,78,77                                            MACH1297
   77 CALL SWIM                                                   MACH1298
      CALL HEAD                                                   MACH1299
      WRITE (PRINT,310) Y,X,XKMHR,YLSEC                           MACH1300
   78 C1=0                                                        MACH1301
      C2=0                                                        MACH1302
      DO 79 I=1,11,4                                              MACH1303
      C1=C1+DISTS(I)                                              MACH1304
   79 C2=C2+TIMES(I)                                              MACH1305
      IF (C1) 81,81,80                                            MACH1306
   80 CALL SWIM                                                   MACH1307
      CALL HEAD                                                   MACH1308
      WRITE (PRINT,311) Y,X,XKMHR,YLSEC                           MACH1309
   81 C1=0                                                        MACH1310
      C2=0                                                        MACH1311
      DO 82 I=3,12,4                                              MACH1312
      C1=C1+DISTS(I)                                              MACH1313
   82 C2=C2+TIMES(I)                                              MACH1314
      IF (C1) 84,84,83                                            MACH1315
   83 CALL SWIM                                                   MACH1316
      CALL HEAD                                                   MACH1317
      WRITE (PRINT,312) Y,X,XKMHR,YLSEC                           MACH1318
   84 C1=0                                                        MACH1319
      C2=0                                                        MACH1320
      DO 85 I=4,13,4                                              MACH1321
      C1=C1+DISTS(I)                                              MACH1322
   85 C2=C2+TIMES(I)                                              MACH1323
      IF (C1) 87,87,86                                            MACH1324
   86 CALL SWIM                                                   MACH1325
      CALL HEAD                                                   MACH1326
      WRITE (PRINT,313) Y,X,XKMHR,YLSEC                           MACH1327
   87 IF (TEST(4)) 102,102,88                                     MACH1328
   88 WRITE (PRINT,400)                                           MACH1329
      IF (IVEC-1) 91,89,91                                        MACH1330
   89 DO 90 I=1,4                                                 MACH1331
   90 ISEQ(I)=IVECD(I)                                            MACH1332
      GO TO 93                                                    MACH1333
   91 DO 92 I=1,4                                                 MACH1334
   92 ISEQ(I)=IVECN(I)                                            MACH1335
   93 DO 101 I=1,3                                                MACH1336
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      DO 100 J=1,4                                                      MACH1337
      L=(I-1)*4+ISEQ(J)                                                 MACH1338
      C1=DISTS(L)                                                       MACH1339
      C2=TIMES(L)                                                       MACH1340
      IF (C1) 100,100,94                                                MACH1341
   94 CALL SWIM                                                         MACH1342
      CALL HEAD                                                         MACH1343
      IF (L-(I-1)*4-2) 95,96,97                                         MACH1344
   95 WRITE (PRINT,315) I,Y,X,XKMHR,YLSEC                               MACH1345
      GO TO 100                                                         MACH1346
   96 WRITE (PRINT,314) I,Y,X,XKMHR,YLSEC                               MACH1347
      GO TO 100                                                         MACH1348
   97 IF (L-(I-1)*4-4) 98,99,100                                        MACH1349
   98 WRITE (PRINT,316) I,Y,X,XKMHR,YLSEC                               MACH1350
      GO TO 100                                                         MACH1351
   99 WRITE (PRINT,317) I,Y,X,XKMHR,YLSEC                               MACH1352
  100 CONTINUE                                                          MACH1353
  101 CONTINUE                                                          MACH1354
  102 IF (TEST(5)) 110,110,103                                          MACH1355
  103 WRITE (PRINT,400)                                                 MACH1356
      DO 109 I=1,N                                                      MACH1357
      C1=0                                                              MACH1358
      C2=0                                                              MACH1359
      DO 104 J=1,3                                                      MACH1360
      L=I+(J-1)*10+12                                                   MACH1361
      C1=C1+DISTS(L)                                                    MACH1362
  104 C2=C2+TIMES(L)                                                    MACH1363
      IF (C1) 109,109,105                                               MACH1364
  105 CALL SWIM                                                         MACH1365
      CALL HEAD                                                         MACH1366
      IF (I-NBDAW) 107,106,106                                          MACH1367
  106 IF (NBDUS-I) 107,107,108                                          MACH1368
  107 WRITE(PRINT,318) (ALPHA(I,J),J=1,4),(ALPHA(I+1,J),J=1,4),Y,X,XKMHRMACH1369
     1,YLSEC                                                            MACH1370
      GO TO 109                                                         MACH1371
  108 WRITE(PRINT,319)(ALPHA(I,J),J=1,4),(ALPHA(I+1,J),J=1,4),Y,X,XKMHR,MACH1372
     1YLSEC                                                             MACH1373
  109 CONTINUE                                                          MACH1374
  110 IF (TEST(6)) 111,125,111                                          MACH1375
  111 WRITE (PRINT,400)                                                 MACH1376
      IF (IVEC-1) 115,112,115                                           MACH1377
  112 I=1                                                               MACH1378
      DO 113 J=NBDAW,N                                                  MACH1379
      ISEQ(I)=J                                                         MACH1380
      I=I+1                                                             MACH1381
  113 CONTINUE                                                          MACH1382
      KK=NBDAW-1                                                        MACH1383
      DO 114 J=1,KK                                                     MACH1384
      ISEQ(I)=J                                                         MACH1385
      I=I+1                                                             MACH1386
  114 CONTINUE                                                          MACH1387
      GO TO 118                                                         MACH1388
  115 I=1                                                               MACH1389
      DO 116 J=NBDUS,N                                                  MACH1390
      ISEQ(I)=J                                                         MACH1391
      I=I+1                                                             MACH1392
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  116 CONTINUE                                                          MACH1393
      KK=NBDUS-1                                                        MACH1394
      DO 117 J=1,KK                                                     MACH1395
      ISEQ(I)=J                                                         MACH1396
      I=I+1                                                             MACH1397
  117 CONTINUE                                                          MACH1398
  118 DO 124 I=1,3                                                      MACH1399
      DO 123 J=1,N                                                      MACH1400
      L=(I-1)*10+12+ISEQ(J)                                             MACH1401
      C1=DISTS(L)                                                       MACH1402
      C2=TIMES(L)                                                       MACH1403
      IF (C1) 123,123,119                                               MACH1404
  119 CALL SWIM                                                         MACH1405
      CALL HEAD                                                         MACH1406
      LL=ISEQ(J)                                                        MACH1407
      IF (NPUN) 603,603,602                                             MACH1408
  602 WRITE (PUNCH,900) XKMHR,ISAV,I,ISLOT(LL)                          MACH1409
  603 IF (LL-NBDAW) 121,120,120                                         MACH1410
  120 IF (NBDUS-LL) 121,121,122                                         MACH1411
  121 WRITE(PRINT,320) I,(ALPHA(LL,K),K=1,4),(ALPHA(LL+1,K),K=1,4),Y,X, MACH1412
     1XKMHR,YLSEC                                                       MACH1413
      GO TO 123                                                         MACH1414
  122 WRITE(PRINT,321) I,(ALPHA(LL,K),K=1,4),(ALPHA(LL+1,K),K=1,4),Y,X, MACH1415
     1XKMHR,YLSEC                                                       MACH1416
  123 CONTINUE                                                          MACH1417
  124 CONTINUE                                                          MACH1418
  125 IF (TRK) 150,126,150                                              MACH1419
  126 LK=LK+1                                                           MACH1420
      GO TO 11                                                          MACH1421
  150 GO TO 600                                                         MACH1422
  700 CALL EXIT                                                         MACH1423
      END                                                               MACH1424
// DUP                                                                  MACH1425
*DELETE              MACH1                                             MACH1426
*STORE       WS  UA  MACH1                                             MACH1427
```

Table 3. Sample output of program MACH1 of speed of movement for all possible options for track 14-70.

TRACK NO.	DATE	SEX	LENGTH	TIME START END	DURATION OF TRACK (HRS)	DISTANCE OF TRACK (KMS)	AVERAGE SPEED KM/HR DAY	AVERAGE SPEED KM/HR NIGHT	AVERAGE SPEED LENGTHS/SEC DAY	AVERAGE SPEED LENGTHS/SEC NIGHT
1470	216	F	62.0	10.3 5.5 216 218	43.2	94.31	2.18		0.97	
				DAWN-DUSK	29.8	66.39	2.22		0.99	
				DUSK-DAWN	13.4	27.92		2.08		0.93
				DAY 1 DAWN-DUSK	10.7	24.91	2.32		1.04	
				DAY 1 DUSK-DAWN	6.7	10.88		1.62		0.72
				DAY 2 DAWN-DUSK	17.3	36.43	2.10		0.94	
				DAY 2 DUSK-DAWN	6.7	17.04		2.54		1.13
				DAY 3 DAWN-DUSK	1.8	5.05	2.80		1.25	
				00.0-DAWN	8.0	17.12		2.14		0.95
				DAWN-11.9	11.2	21.82	1.94		0.87	
				12.0-DUSK	18.6	44.57	2.39		1.07	
				DUSK-23.9	5.4	10.80		2.00		0.89
				DAY 1 DAWN-11.9	1.4	2.88	2.05		0.92	
				DAY 1 12.0-DUSK	9.3	22.03	2.36		1.06	
				DAY 1 DUSK-23.9	2.7	4.56		1.68		0.75
				DAY 1 00.0-DAWN	4.0	6.32		1.58		0.70
				DAY 2 DAWN-11.9	8.0	13.89	1.73		0.77	
				DAY 2 12.0-DUSK	9.3	22.54	2.42		1.08	
				DAY 2 DUSK-23.9	2.7	6.24		2.31		1.03
				DAY 2 00.0-DAWN	4.0	10.80		2.70		1.20
				DAY 3 DAWN-11.9	1.8	5.05	2.80		1.25	
				00.0-DAWN	8.0	17.12		2.14		0.95
				DAWN-08.0	5.8	12.35	2.12		0.95	
				08.0-12.0	5.4	9.47	1.75		0.78	
				12.0-16.0	8.0	19.11	2.38		1.07	
				16.0-DUSK	10.6	25.46	2.40		1.07	
				DUSK-00.0	5.4	10.80		2.00		0.89
				DAY 1 08.0-12.0	1.4	2.88	2.05		0.92	
				DAY 1 12.0-16.0	4.0	8.79	2.19		0.98	
				DAY 1 16.0-DUSK	5.3	13.24	2.49		1.11	
				DAY 1 DUSK-00.0	2.7	4.56		1.68		0.75
				DAY 1 00.0-DAWN	4.0	6.32		1.58		0.70
				DAY 2 DAWN-08.0	4.0	7.30	1.82		0.81	
				DAY 2 08.0-12.0	4.0	6.59	1.64		0.73	
				DAY 2 12.0-16.0	4.0	10.32	2.58		1.15	
				DAY 2 16.0-DUSK	5.3	12.22	2.30		1.03	
				DAY 2 DUSK-00.0	2.7	6.24		2.31		1.03
				DAY 2 00.0-DAWN	4.0	10.80		2.70		1.20
				DAY 3 DAWN-08.0	1.8	5.05	2.80		1.25	

```
// JOB                                                                  HEAD0001
// FOR                                                                  HEAD0002
*NAME HEAD                                                              HEAD0003
*ONE WORD INTEGERS                                                      HEAD0004
*LIST ALL                                                               HEAD0005
      SUBROUTINE HEAD                                                   HEAD0006
      INTEGER TRK,RDATE,SEX,PRINT                                       HEAD0007
      DIMENSION NAME(3)                                                 HEAD0008
      DATA PRINT / 5 /                                                  HEAD0009
      COMMON I,J,LENG,XLENG,XKMHR,YLSEC,KPAGE,TRK,RDATE,NAME,SEX,X,Y    HEAD0010
C                                                                       HEAD0011
C *************************************************************       HEAD0012
C                                                                       HEAD0013
C SUBROUTINE HEAD YIELDS PRINTED OUTPUT FOR MAINLINE MACH1.             HEAD0014
C                                                                       HEAD0015
C *************************************************************       HEAD0016
C                                                                       HEAD0017
500   FORMAT ('1',43X,'DURATION  DISTANCE  AVERAGE SPEED  AVERAGE',     HEAD0018
500  11X,'SPEED')                                                       HEAD0019
501   FORMAT (' ','TRACK',30X,'TIME    OF TRACK  OF TRACK  KM/HR',     HEAD0020
501  12X,'KM/HR    LENGTHS/SEC')                                       HEAD0021
502   FORMAT (' ',1X,'NO.   DATE  SEX  LENGTH        START END',4X,     HEAD0022
502  1'(HRS)    (KMS)    DAY   NIGHT    DAY   NIGHT')                  HEAD0023
503   FORMAT ('0',I4,3X,I3,4X,A1,4X,F4.1)                               HEAD0024
C                                                                       HEAD0025
      IF (KPAGE/55*55-KPAGE) 20,5,15                                    HEAD0026
    5 WRITE (PRINT,500)                                                 HEAD0027
      WRITE (PRINT,501)                                                 HEAD0028
      WRITE (PRINT,502)                                                 HEAD0029
      KPAGE=KPAGE+3                                                     HEAD0030
      IF (KPAGE-3) 10,15,10                                             HEAD0031
   10 WRITE (PRINT,503) TRK,RDATE,NAME(SEX),XLENG                       HEAD0032
      KPAGE=KPAGE+2                                                     HEAD0033
   15 KPAGE=KPAGE+1                                                     HEAD0034
   20 RETURN                                                            HEAD0035
      END                                                               HEAD0036
// DUP                                                                  HEAD0037
*DELETE              HEAD                                               HEAD0038
*STORE      WS  UA  HEAD                                                HEAD0039
```

```
// JOB                                                                  SWIM0001
// FOR                                                                  SWIM0002
*NAME SWIM                                                              SWIM0003
*ONE WORD INTEGERS                                                      SWIM0004
*LIST ALL                                                               SWIM0005
      SUBROUTINE SWIM                                                   SWIM0006
      INTEGER TRK,RDATE,SEX                                             SWIM0007
      DIMENSION NAME(3)                                                 SWIM0008
      COMMON I,J,LENG,XLENG,XKMHR,YLSEC,KPAGE,TRK,RDATE,NAME,SEX,X,Y    SWIM0009
C                                                                       SWIM0010
C ***************************************************************     SWIM0011
C                                                                       SWIM0012
C SUBROUTINE TO CALCULATE SWIMMING SPEED FOR MAINLINE MACH1.            SWIM0013
C                                                                       SWIM0014
C ***************************************************************     SWIM0015
C                                                                       SWIM0016
      X=I/100.0                                                         SWIM0017
      Y=J/10.0                                                          SWIM0018
      IF (Y) 25,5,10                                                    SWIM0019
    5 XKMHR=0.0                                                         SWIM0020
      YLSEC=0.0                                                         SWIM0021
      GO TO 25                                                          SWIM0022
   10 XKMHR=X/Y                                                         SWIM0023
      IF (LENG) 25,15,20                                                SWIM0024
   15 YLSEC=0.0                                                         SWIM0025
      GO TO 25                                                          SWIM0026
   20 YLSEC=(100000.0*XKMHR)/(3600*XLENG)                               SWIM0027
   25 RETURN                                                            SWIM0028
      END                                                               SWIM0029
// DUP                                                                  SWIM0030
*DELETE              SWIM                                               SWIM0031
*STORE      WS  UA   SWIM                                               SWIM0032
```

```
// JOB                                                                  MACH2001
// FOR                                                                  MACH2002
*IOCS(1403 PRINTER,2501 READER,TYPEWRITER,DISK,1442 PUNCH)              MACH2003
*ONE WORD INTEGERS                                                      MACH2004
*LIST ALL                                                               MACH2005
*NAME MACH2                                                            MACH2006
C                                                                       MACH2007
C ********************************************************************* MACH2008
C                                                                       MACH2009
C PROGRAM TO CALCULATE TOTAL DISTANCE, AVERAGE SWIMMING SPEEDS IN KILO- MACH2010
C METERS PER HOUR AND FISH LENGTHS PER SECOND BY FIXED INTERVAL OF      MACH2011
C GIVEN TRACK.                                                          MACH2012
C                                                                       MACH2013
C INPUT - CONTROL CARD.                                                 MACH2014
C   COLS. 1 - 4  TRACK NUMBER DESIRED.                                  MACH2015
C         5 - 7  INTERVAL OF TIME, IN MINUTES, IN WHICH THE TRACK       MACH2016
C                DURATION IS TO BE BROKEN.                              MACH2017
C         8 - 11  HOURS (AND MINUTES - SEE BELOW) INTO TRACK WHICH      MACH2018
C                 INTERVALS ARE TO BEGIN - LEAVE BLANK IF INTERVAL      MACH2019
C                 START IS TO BE THE TIME OF THE FIRST DATA POINT.      MACH2020
C        12 - 13  MINUTES OF ABOVE.                                     MACH2021
C   NEW CONTROL CARDS FOR DIFFERENT TRACKS MAY FOLLOW, OR A BLANK CARD  MACH2022
C   TO CALL EXIT.                                                       MACH2023
C   ALL DATA IS READ FROM FILE TEST (AS FOR MACH1) - USE *FILES(1,TEST) MACH2024
C   TO EXECUTE THIS PROGRAM.                                            MACH2025
C                                                                       MACH2026
C OUTPUT.                                                               MACH2027
C - OUTPUT HEADINGS ARE ANALOGOUS TO PROGRAM MACH1.  I.E.               MACH2028
C                  DISTANCE TRAVELLED WITHIN INTERVAL (KILOMETERS)      MACH2029
C                  AVERAGE SPEED WITHIN INTERVAL (KILOMETERS / HOUR)    MACH2030
C                  AVERAGE SPEED WITHIN INTERVAL (FISH LENGTHS / SEC.)  MACH2031
C                        NOTE - FISH LENGTH UNITS OF MILLIMETERS ASSUMED MACH2032
C   MACH2 HOWEVER, CALCULATES THE ABOVE BY STEPPING THROUGH THE TRACK   MACH2033
C   DURATION IN FIXED INTERVALS OF TIME ( AS DEFINED IN MINUTES ON THE  MACH2034
C   CONTROL CARD.                                                       MACH2035
C - PUNCH OUTPUT IS ALSO AVAILABLE ( IT MAY BE BYPASSED BY TURNING ON   MACH2036
C   DATA SWITCH ONE ).  THE CARD OUTPUT FORMAT IS ...                   MACH2037
C   COLS. 1 - 4  TRACK NUMBER                                           MACH2038
C         5 - 14 AVERAGE SPEED IN KILOMETERS PER HOUR.                  MACH2039
C        15 - 24 AVERAGE SPEED IN FISH LENGTHS PER SECOND.              MACH2040
C        25 - 34 DISTANCE TRAVELLED IN KILOMETERS.                      MACH2041
C        35 - 36 DAY NUMBER INTO TRACK OF INTERVAL START                MACH2042
C        37 - 38 HOURS                                                  MACH2043
C        39 - 40 MINUTES                                                MACH2044
C        41 - 42 DAY NUMBER INTO TRACK OF INTERVAL END.                 MACH2045
C        43 - 44 HOURS                                                  MACH2046
C        45 - 46 MINUTES                                                MACH2047
C                                                                       MACH2048
C PROGRAM USES LINEAR INTERPOLATION BETWEEN POINTS WHICH CROSS INTERVAL MACH2049
C BOUNDARIES TO DETERMINE DISTANCE WITHIN THE INTERVAL.                 MACH2050
C                                                                       MACH2051
C ********************************************************************* MACH2052
C                                                                       MACH2053
      INTEGER CARD,PRINT,TYPE,PUNCH,SEX                                 MACH2054
      DIMENSION MT(312),X(312),Y(312)                                   MACH2055
```

```
      DATA CARD,PRINT,PUNCH,TYPE / 8,5,9,1 /                            MACH2056
      DEFINE FILE 1 ( 3000,8,U,KI)                                      MACH2057
C                                                                       MACH2058
C FORMATS                                                               MACH2059
100   FORMAT (I4,I3,I4,I2)                                              MACH2060
105   FORMAT (//'TRACK NUMBER ',I5,', CANNOT BE LOCATED ON FILE TEST')   MACH2061
110   FORMAT ('1TRACK    FISH',8X,'DURATION',5X,'INTERVAL  INTERVAL'/'   MACH2062
110  1NO.  SEX  LENGTH  DAYS HRS MINS (MINUTES)  DISTANCE',5X,'AVERAGE SMACH2063
110  2PEED'/' ',45X,'(KMS)',4X,'KMS/HR  LENGTHS/SEC'/' ',I4,3X,I1,3X,F5.MACH2064
110  31,3X,I3,2X,I2,3X,I2,4X,I4/'0',16X,'DAY HR MIN  TO  DAY HR MIN'/)  MACH2065
112   FORMAT (//'ERROR IN SUBMITTED CONTROL CARD'/'HOURS INTO TRACK TO BMACH2066
112  1GIN INTERVAL ARE',I3,', MINUTES ',I3/'- NO DATA DATA POINTS WERE FMACH2067
112  2OUND AFTER ABOVE TIME')                                          MACH2068
114   FORMAT (' ',16X,3I3,7X,3I3,F10.2,2F9.2)                           MACH2069
116   FORMAT (I4,3F10.2,6I2)                                            MACH2070
118   FORMAT (//'CAUTION - MAXIMUM NUMBER OF DATA POINTS , 312 , HAS BEEMACH2071
118  1N REACHED AND WILL BE PROCESSED'/'CHECK TO DETERMINE IF DATA EXCEEMACH2072
118  2DS THIS AMOUNT, TRACK ',I4)                                      MACH2073
120   FORMAT (//'TOTAL NUMBER OF MINUTES INTO TRACK HAS REACHED INTEGER MACH2074
120  1OVERFLOW,  TRACK ',I4)                                           MACH2075
C                                                                       MACH2076
C TO READ CONTROL CARD                                                  MACH2077
    1 READ (CARD,100) ITRK,INT,IHS,IMS                                  MACH2078
C CHECK FOR END OF CONTROL CARDS                                        MACH2079
      IF (ITRK) 999,999,2                                               MACH2080
C                                                                       MACH2081
C TO SEARCH FILE FOR DESIRED TRACK                                      MACH2082
    2 IEND = 32                                                         MACH2083
      DO 5 I = 1,IEND                                                   MACH2084
      READ (1'I) K                                                      MACH2085
      IF (K) 6,6,3                                                      MACH2086
    3 K = K + 1                                                         MACH2087
      READ (1'K) JTRK                                                   MACH2088
      IF (JTRK - ITRK) 5,8,5                                            MACH2089
    5 CONTINUE                                                          MACH2090
    6 WRITE (TYPE,105) ITRK                                             MACH2091
      GO TO 1                                                           MACH2092
C                                                                       MACH2093
    8 K = K - 1                                                         MACH2094
      CALL DATSW (1,I)                                                  MACH2095
C                                                                       MACH2096
C TO READ HEADER CARD INFORMATION FOR TRACK                             MACH2097
      READ (1'K) SEX,LENG,JDS,JHS,JMS,JDE,JHE,JME                       MACH2098
C                                                                       MACH2099
C TO CALCULATE DURATION OF TRACK                                        MACH2100
      ALENG = LENG                                                      MACH2101
      ALENG = ALENG / 10.0                                              MACH2102
      ITS = JHS * 60 + JMS                                              MACH2103
      ITE = JHE * 60 + JME                                              MACH2104
      KD = (JDE - JDS ) * 1440                                          MACH2105
      ITS = KD + (ITE - ITS)                                            MACH2106
      KD1= ITS / 1440                                                   MACH2107
      KH1= (ITS - (KD1* 1440)) / 60                                     MACH2108
      KM1= ITS - (KD1* 1440 + KH1* 60)                                  MACH2109
C                                                                       MACH2110
C WRITE HEADING AND HEADER INFORMATION ON PRINTER.                      MACH2111
```

```
      WRITE (PRINT,110) ITRK,SEX,ALENG,KD1,KH1,KM1,INT                  MACH2112
      LINE = 7                                                          MACH2113
      K = K + 1                                                         MACH2114
C                                                                       MACH2115
C TO READ DATA FROM FILE INTO ARRAY OF TOTAL MINUTES INTO TRACK.        MACH2116
      KI = K                                                            MACH2117
      READ (1'KI) JTRK,X(1),Y(1),KH,KM                                  MACH2118
      MT(1) = KH * 60 + KM                                              MACH2119
      KD = 1                                                            MACH2120
      DO 78 J = 2,312                                                   MACH2121
      READ (1'KI) JTRK,X(J),Y(J),JH,KM                                  MACH2122
      IF (JTRK) 80,80,70                                                MACH2123
   70 IF (JH - KH) 71,72,72                                             MACH2124
   71 KD = KD + 1                                                       MACH2125
   72 KM = ((KD - 1) * 24 + JH) * 60 + KM                               MACH2126
      IF (KM - 32766) 74,74,73                                          MACH2127
   73 WRITE (TYPE,120) ITRK                                             MACH2128
      GO TO 1                                                           MACH2129
   74 MT(J) = KM                                                        MACH2130
      KH = JH                                                           MACH2131
   78 CONTINUE                                                          MACH2132
      WRITE (TYPE,118) ITRK                                             MACH2133
   80 JMAX = J - 1                                                      MACH2134
      K = 1                                                             MACH2135
C                                                                       MACH2136
C TO TEST FOR WHICH TIME TO START INTERVAL                              MACH2137
      IF (IHS) 9,9,12                                                   MACH2138
    9 IF (IMS) 10,10,12                                                 MACH2139
   10 ITS = MT(K)                                                       MACH2140
      ITE=ITS+INT                                                       MACH2141
      K = K + 1                                                         MACH2142
      GO TO 30                                                          MACH2143
C                                                                       MACH2144
   12 ITS = IHS * 60 + IMS                                              MACH2145
      ITE = ITS + (INT - 1)                                             MACH2146
   14 IF (K - JMAX) 16,16,15                                            MACH2147
   15 WRITE (TYPE,112) IHS,IMS                                          MACH2148
      GO TO 1                                                           MACH2149
C                                                                       MACH2150
   16 IF (MT(K) - ITS) 14,17,30                                         MACH2151
   17 K = K + 1                                                         MACH2152
      GO TO 30                                                          MACH2153
C                                                                       MACH2154
C INTERVAL START HAS BEEN DETERMINED, TO BEGIN PROCESSING               MACH2155
C                                                                       MACH2156
   30 D = 0.0                                                           MACH2157
      S1 = 0.0                                                          MACH2158
      S2 = 0.0                                                          MACH2159
      LTOT=0                                                            MACH2160
      N = 0                                                             MACH2161
C                                                                       MACH2162
C TEST FOR END OF TRACK                                                 MACH2163
   32 IF (K - JMAX) 34,34,900                                           MACH2164
C                                                                       MACH2165
C READ DATA POINT PREVIOUS IN TIME                                      MACH2166
   34 J = K - 1                                                         MACH2167
```

```
C TEST IF PREVIOUS POINT EXISTS                                          MACH2168
      IF ( J - 1) 36,38,38                                               MACH2169
   36 K = K + 1                                                          MACH2170
      GO TO 32                                                           MACH2171
   38 JTOT = MT(J)                                                       MACH2172
      ITOT = MT(K)                                                       MACH2173
      XX = X(K) - X(J)                                                   MACH2174
      YY = Y(K) - Y(J)                                                   MACH2175
      IF (JTOT - ITS) 40,46,46                                           MACH2176
C                                                                        MACH2177
C PREVIOUS POINT IS BEFORE INTERVAL START                                MACH2178
   40 IF (ITOT - ITE ) 44,42,42                                          MACH2179
C PRESENT POINT IS AFTER INTERVAL END                                    MACH2180
   42 IDIF = ITE - ITS                                                   MACH2181
      GO TO 52                                                           MACH2182
C OR IS WITHIN INTERVAL                                                  MACH2183
   44 IDIF = ITOT - ITS                                                  MACH2184
      GO TO 52                                                           MACH2185
C                                                                        MACH2186
C PREVIOUS POINT IS WITHIN INTERVAL                                      MACH2187
   46 IF (ITOT - ITE ) 50,50,48                                          MACH2188
C PRESENT POINT IS BEYOND INTERVAL END                                   MACH2189
   48 IDIF = ITE - JTOT                                                  MACH2190
      GO TO 52                                                           MACH2191
C PRESENT POINT IS ALSO WITHIN INTERVAL                                  MACH2192
   50 IDIF = ITOT - JTOT                                                 MACH2193
      DIF = IDIF                                                         MACH2194
      DD = SQRT (XX*XX + YY*YY)                                          MACH2195
      GO TO 54                                                           MACH2196
C                                                                        MACH2197
C LINEAR INTERPOLATION                                                   MACH2198
C                                                                        MACH2199
   52 DIF = IDIF                                                         MACH2200
      KTOT = ITOT - JTOT                                                 MACH2201
      TOT = KTOT                                                         MACH2202
      DD = DIF / TOT * SQRT (XX*XX + YY*YY)                              MACH2203
C ABOVE CALCULATES AND ACCUMULATES DISTANCE IN D BELOW                   MACH2204
   54 D = D + DD                                                         MACH2205
      LTOT=LTOT+IDIF                                                     MACH2206
C     LTOT IS THE NUMBER OF ELAPSED MINUTES                              MACH2207
C     IN NORMAL CASES IT SHOULD EQUAL INT                                MACH2208
C     EXCEPT ON LAST SECTION WHEN TRACK ENDS                             MACH2209
      N = N + 1                                                          MACH2210
C                                                                        MACH2211
C CHECK FOR PRESENT POINT BEYOND INTERVAL END                            MACH2212
      IF (ITOT - ITE) 56,900,900                                         MACH2213
C                                                                        MACH2214
C IF NOT, INCREMENT RECORD NUMBER AND PROCESS NEXT POINT                 MACH2215
   56 K = K + 1                                                          MACH2216
      GO TO 32                                                           MACH2217
C IF SO, PRINT AND PUNCH (OPTIONAL) INTERVAL INFORMATION                 MACH2218
  900 IF (N) 902,902,901                                                 MACH2219
  901 AN = N                                                             MACH2220
  902 KD = ITS / 1440                                                    MACH2221
      TOT=FLOAT(LTOT)/60.00                                              MACH2222
C     TOT=INTERVAL IN HOURS                                              MACH2223
```

```
      S1=D/TOT +0.00501                                                  MACH2224
C     S1=TOTAL KMS TRAVELED IN TOT HOURS DIVIDED BY TIME IN HOURS.       MACH2225
      TOT=FLOAT(LTOT) *60.00                                             MACH2226
C     TOT=INTERVAL IN SECONDS                                            MACH2227
      S2=(D*100000.0)/ALENG                                              MACH2228
C     S2=FISH LENGTHS TRAVELED IN TOT SECONDS                            MACH2229
      S2=S2/TOT +0.00501                                                 MACH2230
      D = D + 0.00501                                                    MACH2231
      KH = (ITS - KD * 1440) / 60                                        MACH2232
      KM = ITS - ( KD * 1440 + KH * 60)                                  MACH2233
      IF(LTOT-INT)1112,1113,1113                                         MACH2234
 1112 ITE=ITS+LTOT                                                       MACH2235
 1113 CONTINUE                                                           MACH2236
      LD = ITE / 1440                                                    MACH2237
      LH = (ITE - LD * 1440) / 60                                        MACH2238
      LM = ITE - (LD * 1440 + LH * 60)                                   MACH2239
      IF ( LINE - 50) 910,910,908                                        MACH2240
  908 WRITE ( PRINT,110) ITRK,SEX,ALENG,KD1,KH1,KM1,INT                  MACH2241
      LINE = 7                                                           MACH2242
  910 WRITE (PRINT,114) KD,KH,KM,LD,LH,LM,D,S1,S2                        MACH2243
      LINE = LINE + 1                                                    MACH2244
      GO TO (904,903), I                                                 MACH2245
  903 WRITE (PUNCH,116) ITRK,S1,S2,D,KD,KH,KM,LD,LH,LM                   MACH2246
C                                                                        MACH2247
C CHECK FOR LAST RECORD OF TRACK                                         MACH2248
  904 IF ( K - JMAX) 905,1,1                                             MACH2249
C                                                                        MACH2250
C TO INITIALIZE FOR NEW INTERVAL                                         MACH2251
  905 S1 = 0.0                                                           MACH2252
      S2 = 0.0                                                           MACH2253
      D = 0.0                                                            MACH2254
      N = 0                                                              MACH2255
      LTOT=0                                                             MACH2256
      IDIF = ITOT - ITE                                                  MACH2257
      ITS=ITE                                                            MACH2258
      ITE = ITE + INT                                                    MACH2259
      IF (IDIF) 922,922,52                                               MACH2260
  922 K = K + 1                                                          MACH2261
      GO TO 32                                                           MACH2262
C                                                                        MACH2263
  999 CALL EXIT                                                          MACH2264
      END                                                                MACH2265
// DUP
*DELETE              MACH2
*STORE       WS  UA  MACH2
```

Table 4. Output example of MACH2 of speed of movement in 2-hr intervals for track 14-70.

TRACK NO.	FISH SEX	FISH LENGTH	DURATION DAYS	DURATION HRS	DURATION MINS	INTERVAL (MINUTES)	INTERVAL DISTANCE (KMS)	AVERAGE SPEED KMS/HR	AVERAGE SPEED LENGTHS/SEC
1470	2	62.0	1	19	9	120			
			DAY	HR	MIN	TO DAY HR MIN			
			0	10	21	0 12 21	4.08	2.04	0.91
			0	12	21	0 14 21	3.45	1.73	0.77
			0	14	21	0 16 21	5.86	2.93	1.31
			0	16	21	0 18 21	5.18	2.59	1.16
			0	18	21	0 20 21	4.92	2.46	1.10
			0	20	21	0 22 21	3.90	1.95	0.87
			0	22	21	1 0 21	2.64	1.32	0.59
			1	0	21	1 2 21	2.68	1.34	0.60
			1	2	21	1 4 21	3.71	1.86	0.83
			1	4	21	1 6 21	3.34	1.67	0.75
			1	6	21	1 8 21	4.65	2.33	1.04
			1	8	21	1 10 21	4.10	2.05	0.92
			1	10	21	1 12 21	2.13	1.07	0.48
			1	12	21	1 14 21	5.31	2.66	1.19
			1	14	21	1 16 21	4.81	2.41	1.08
			1	16	21	1 18 21	4.27	2.14	0.96
			1	18	21	1 20 21	5.44	2.72	1.22
			1	20	21	1 22 21	4.36	2.18	0.98
			1	22	21	2 0 21	5.06	2.53	1.13
			2	0	21	2 2 21	5.25	2.63	1.18
			2	2	21	2 4 21	5.59	2.80	1.25
			2	4	21	2 5 30	3.55	3.09	1.38

PROGRAMS

DIRECTION OF MOVEMENT

```
// JOB                                                                  ADNTP001
// DUP                                                                  ADNTP002
*STORE DATA  WS  UA  TSDN    48                                         ADNTP003
                                                                        ADNTP004
// JOB                                                                  ADNTP005
// FOR                                                                  ADNTP006
*IOCS(1403 PRINTER,2501 READER,DISK,TYPEWRITER)                         ADNTP007
*LIST ALL                                                              ADNTP008
*ONE WORD INTEGERS                                                     ADNTP009
*NAME ADNTP                                                            ADNTP010
** ADNTP - COMPASS DIRECTIONS OF TRACK POSITION VECTORS                 ADNTP011
C                                                                       ADNTP012
C ********************************************************************* ADNTP013
C                                                                       ADNTP014
C PROGRAM IS DESIGNED TO CALCULATE THE ANGULAR DEVIATION FROM TRUE      ADNTP015
C NORTH OF THE VECTOR FORMED BY LINEARLY JOINING TWO SUCCESSIVE TRACK   ADNTP016
C POSITION X,Y COORDINATES.                                             ADNTP017
C                                                                       ADNTP018
C INPUT                                                                 ADNTP019
C   - SAME DATA INPUT AS FOR PROGRAM CREF.                              ADNTP020
C       I.E. TWO HEADER CARDS PER TRACK                                 ADNTP021
C            FOLLOWED BY POSITION CARDS FOR TRACK                       ADNTP022
C            BLANK CARD TO SIGNIFY END OF TRACK, OR A NEGATIVE TRACK    ADNTP023
C            NUMBER TO SIGNIFY END OF DATA                              ADNTP024
C            NEW HEADER CARDS ETC. IF CARD ABOVE WAS BLANK.             ADNTP025
C   - POSITION CARDS MUST BE IN CHRONOLOGICAL SEQUENCE.                 ADNTP026
C                                                                       ADNTP027
C OUTPUT                                                                ADNTP028
C   - ALTHOUGH A PRINTED OUTPUT IS GIVEN, THE PURPOSE OF THIS PROGRAM ISADNTP029
C     TO LOAD DISK FILE TSDN AS FOLLOWS.                                ADNTP030
C     PER RECORD - WORD 1 - TRACK NUMBER                                ADNTP031
C                       2 - DAY NUMBER                                  ADNTP032
C                       3 - HOUR                                        ADNTP033
C                       4 - MINUTES                                     ADNTP034
C                     5-6 - COMPASS DIRECTION OF SWIMMING DIRECTION     ADNTP035
C     A BLANK RECORD OCCURS BETWEEN TRACKS.                             ADNTP036
C                                                                       ADNTP037
C EXECUTE THIS PROGRAM WITH *FILES(1,TSDN)                              ADNTP038
C TSDN OCCUPIES 48 SECTORS OF USERS AREA ON DISK.                       ADNTP039
C                                                                       ADNTP040
C ********************************************************************* ADNTP041
C                                                                       ADNTP042
      INTEGER PRINT,CARD,TYPE,TRK                                       ADNTP043
      DIMENSION ANG(310),IDN(310),IHR(310),IMIN(310)                    ADNTP044
      DATA PRINT,CARD,TYPE /5,8,1 /                                     ADNTP045
C                                                                       ADNTP046
      DEFINE FILE 1(2520,6,U,KI)                                        ADNTP047
C                                                                       ADNTP048
C FORMATS                                                               ADNTP049
100   FORMAT (1X/1X)                                                    ADNTP050
105   FORMAT(1X,I4,1X,I4,2F8.0,I4,1X,2I2,8X,I1)                         ADNTP051
112   FORMAT('1TRACK NUMBER ',I4,18X,'PAGE ',I3/'OREC.NO.  DAY  HOUR  MIADNTP052
112  1N. DEGREES FROM NORTH'/)                                          ADNTP053
114   FORMAT(' ',1X,I4,4X,I3,3X,I2,4X,I2,7X,F6.2)                       ADNTP054
120   FORMAT(/'TRACK NUMBER INCORRECT - RESTART JOB')                    ADNTP055
```

```
  122   FORMAT(/'SEQUENCE IS OUT OF ORDER - RESTART JOB')                  ADNTP056
  124   FORMAT(/'NUMBER OF POSITION CARDS HAS EXCEEDED 310')               ADNTP057
C                                                                         ADNTP058
      KI= 1                                                               ADNTP059
      TRK = 0                                                             ADNTP060
C READ TWO HEADER CARDS                                                   ADNTP061
    1 READ (CARD,100)                                                     ADNTP062
C                                                                         ADNTP063
C READ FIRST POSITION CARD                                                ADNTP064
      READ (CARD,105)ITRK,ISEQ,X1,Y1,JDT,JHR,JMIN                         ADNTP065
C                                                                         ADNTP066
C READ SECOND PT. TO MAKE DIRECTION VECTOR.                               ADNTP067
      N = 1                                                               ADNTP068
      IGO = 1                                                             ADNTP069
    5 READ(CARD,105) JTRK,JSEQ,X2,Y2,KDT,KHR,KMIN,ILOST                   ADNTP070
      IF (JTRK) 6,6,20                                                    ADNTP071
C                                                                         ADNTP072
C TO WRITE OUT AND STORE TRACK ANGLES.                                    ADNTP073
    6 LINE = 55                                                           ADNTP074
      IPAGE= 1                                                            ADNTP075
      N = N - 1                                                           ADNTP076
      DO 10 I = 1,N                                                       ADNTP077
      IF (LINE - 50) 8,8,7                                                ADNTP078
    7 WRITE (PRINT,112) ITRK,IPAGE                                        ADNTP079
      LINE = 1                                                            ADNTP080
      IPAGE = IPAGE + 1                                                   ADNTP081
    8 THETA = ANG(I) + 0.00501                                            ADNTP082
      WRITE (PRINT,114)KI, IDN(I),IHR(I),IMIN(I),THETA                    ADNTP083
      LINE = LINE + 1                                                     ADNTP084
      WRITE (1'KI) ITRK,IDN(I),IHR(I),IMIN(I),ANG(I)                      ADNTP085
   10 CONTINUE                                                            ADNTP086
      WRITE (1'KI) TRK                                                    ADNTP087
      IF (JTRK) 999,1,1                                                   ADNTP088
C                                                                         ADNTP089
C TO CHECK FOR POINTS WHERE TRACK WAS LOST .                              ADNTP090
   20 GO TO (410,400), IGO                                                ADNTP091
  400 IF ( ILOST - 2) 5,401,5                                             ADNTP092
  401  X1 = X2                                                            ADNTP093
      Y1 = Y2                                                             ADNTP094
      JDT = KDT                                                           ADNTP095
      JHR = KHR                                                           ADNTP096
      JMIN = KMIN                                                         ADNTP097
      ISEQ = JSEQ                                                         ADNTP098
      IGO = 1                                                             ADNTP099
      GO TO 5                                                             ADNTP100
  410 IF (JTRK - ITRK) 21,22,21                                           ADNTP101
   21 WRITE(TYPE,120)                                                     ADNTP102
      PAUSE 666                                                           ADNTP103
      GO TO 999                                                           ADNTP104
   22 IF (ISEQ - JSEQ) 24,23,23                                           ADNTP105
   23 WRITE (TYPE,122)                                                    ADNTP106
      PAUSE 777                                                           ADNTP107
  999 CALL EXIT                                                           ADNTP108
C                                                                         ADNTP109
C NUMBER OF POSITION CARDS PER TRACK MUST BE LESS THAN 311.               ADNTP110
   24 IF (N - 310) 26,26,25                                               ADNTP111
```

```
   25 WRITE(TYPE,124)                                                ADNTP112
      PAUSE 888                                                      ADNTP113
      GO TO 999                                                      ADNTP114
C                                                                    ADNTP115
C NEGATIVE X DIRECTION IS NORTH.                                     ADNTP116
C POSITIVE X DIRECTION IS SOUTH.                                     ADNTP117
   26 IF (X1 * X2) 40,27,30                                          ADNTP118
   27 IDIRX = 3                                                      ADNTP119
      GO TO 60                                                       ADNTP120
   30 IF (X1) 31,27,37                                               ADNTP121
   31 X = ABS(X1) - ABS(X2)                                          ADNTP122
   32 IF (X) 33,34,35                                                ADNTP123
   33 IDIRX = 2                                                      ADNTP124
      X = ABS(X)                                                     ADNTP125
      GO TO 60                                                       ADNTP126
   34 IDIRX = 3                                                      ADNTP127
      GO TO 60                                                       ADNTP128
   35 IDIRX = 1                                                      ADNTP129
      GO TO 60                                                       ADNTP130
C                                                                    ADNTP131
   37 X = X2 - X1                                                    ADNTP132
      GO TO 32                                                       ADNTP133
C                                                                    ADNTP134
   40 IF (X1) 41,44,44                                               ADNTP135
   41 X = X2 - X1                                                    ADNTP136
      IDIRX = 1                                                      ADNTP137
      GO TO 60                                                       ADNTP138
   44 X = X1 - X2                                                    ADNTP139
      IDIRX = 2                                                      ADNTP140
C                                                                    ADNTP141
C NEGATIVE Y DIRECTION IS WEST.                                      ADNTP142
C POSITIVE Y DIRECTION IS EAST.                                      ADNTP143
   60 IF (Y1 * Y2) 70,61,62                                          ADNTP144
   61 IDIRY = 3                                                      ADNTP145
      GO TO 80                                                       ADNTP146
   62 IF (Y1) 63,61,69                                               ADNTP147
   63 Y = ABS(Y1) - ABS(Y2)                                          ADNTP148
   64 IF (Y) 65,66,67                                                ADNTP149
   65 IDIRY = 2                                                      ADNTP150
      Y = ABS(Y)                                                     ADNTP151
      GO TO 80                                                       ADNTP152
   66 IDIRY = 3                                                      ADNTP153
      GO TO 80                                                       ADNTP154
   67 IDIRY = 1                                                      ADNTP155
      GO TO 80                                                       ADNTP156
C                                                                    ADNTP157
   69 Y = Y2 - Y1                                                    ADNTP158
      GO TO 64                                                       ADNTP159
C                                                                    ADNTP160
   70 IF (Y1) 71,74,74                                               ADNTP161
   71 Y = Y2 - Y1                                                    ADNTP162
      IDIRY = 1                                                      ADNTP163
      GO TO 80                                                       ADNTP164
   74 Y = Y1 - Y2                                                    ADNTP165
      IDIRY = 2                                                      ADNTP166
C                                                                    ADNTP167
```

```
C FIND THETA OF FIRST QUADRANT AND ADJUST FOR FULL 360 DEGREES.          ADNTP168
C THETA INCREASES ANTICLOCKWISE.                                         ADNTP169
   80 GO TO (81,85,89),IDIRX                                             ADNTP170
   81 GO TO (82,83,84),IDIRY                                             ADNTP171
   82 T = 180.0 -(ATAN(Y/X) * 180. / 3.14159)                            ADNTP172
      GO TO 95                                                           ADNTP173
   83 T = 180.0 + ATAN(Y/X)  * 180. / 3.14159                            ADNTP174
      GO TO 95                                                           ADNTP175
   84 T = 180.0                                                          ADNTP176
      GO TO 95                                                           ADNTP177
   85 GO TO (86,87,88),IDIRY                                             ADNTP178
   86 T = ATAN(Y/X) * 180. / 3.14159                                     ADNTP179
      GO TO 95                                                           ADNTP180
   87 T = 360.0 - ATAN(Y/X)  * 180. / 3.14159                            ADNTP181
      GO TO 95                                                           ADNTP182
   88 T = 0.0                                                            ADNTP183
      GO TO 95                                                           ADNTP184
   89 GO TO (90,91,92),IDIRY                                             ADNTP185
   90 T = 90.0                                                           ADNTP186
      GO TO 95                                                           ADNTP187
   91 T = 270.0                                                          ADNTP188
      GO TO 95                                                           ADNTP189
   92 T = 0.0                                                            ADNTP190
C                                                                        ADNTP191
C RESET VARIABLES TO READ NEW X,Y COORDINATES.                           ADNTP192
   95 ANG(N) = T                                                         ADNTP193
      IDN(N) = JDT                                                       ADNTP194
      JDT = KDT                                                          ADNTP195
      IHR(N) = JHR                                                       ADNTP196
      JHR = KHR                                                          ADNTP197
      IMIN(N) = JMIN                                                     ADNTP198
      JMIN = KMIN                                                        ADNTP199
      ISEQ = JSEQ                                                        ADNTP200
      X1 = X2                                                            ADNTP201
      Y1 = Y2                                                            ADNTP202
      N = N + 1                                                          ADNTP203
      IF (ILOST - 1) 5,412,5                                             ADNTP204
  412 IGO = 2                                                            ADNTP205
      GO TO 5                                                            ADNTP206
      END                                                                ADNTP207
// DUP                                                                   ADNTP208
*DELETE              ADNTP                                               ADNTP209
*STORE       WS  UA  ADNTP                                               ADNTP210
```

Table 5. Output example of program ADNTP as it is entered into file TSDN.

TRACK NUMBER 1473 PAGE 1

REC.NO.	DAY	HOUR	MIN.	DEGREES FROM NORTH
1821	216	10	21	28.83
1822	216	10	30	15.63
1823	216	10	45	351.84
1824	216	11	0	30.47
1825	216	11	15	7.56
1826	216	11	30	64.61
1827	216	11	45	349.07
1828	216	12	0	268.33
1829	216	12	15	131.71
1830	216	12	31	210.65
1831	216	13	40	119.21
1832	216	13	53	156.23
1833	216	14	0	142.50
1834	216	14	15	143.13
1835	216	14	30	169.04
1836	216	14	45	174.67
1837	216	15	0	177.68
1838	216	15	15	136.84
1839	216	15	30	140.24
1840	216	15	45	144.06
1841	216	16	0	193.94
1842	216	16	15	148.99
1843	216	16	30	221.71
1844	216	16	45	192.21
1845	216	17	0	182.63
1846	216	17	15	203.09
1847	216	17	30	181.05
1848	216	17	45	160.64
1849	216	18	0	162.93
1850	216	18	15	161.06
1851	216	18	30	92.88
1852	216	18	45	125.73
1853	216	19	0	145.02
1854	216	19	15	132.37
1855	216	19	30	130.38
1856	216	19	45	161.93
1857	216	20	0	234.14
1858	216	20	15	225.29
1859	216	20	30	204.34
1860	216	20	45	174.23
1861	216	21	0	148.21
..	..	..	..	..
..	..	..	..	..
..	..	..	..	..
..	..	..	..	..
..	..	..	..	..
1972	218	3	15	356.41
1973	218	3	30	359.25
1974	218	3	45	353.60
1975	218	4	0	319.58
1976	218	4	15	279.71
1977	218	4	30	307.13
1978	218	4	45	317.52
1979	218	5	0	344.69
1980	218	5	15	100.87

```
// JOB                                                                  CBMTP001
// FOR                                                                  CBMTP002
*IOCS(1403 PRINTER,2501 READER,TYPEWRITER,DISK)                         CBMTP003
*LIST ALL                                                              CBMTP004
*ONE WORD INTEGERS                                                     CBMTP005
*NAME CBMTP                                                            CBMTP006
** CBMTP- TRACK POSITION ANGLES FROM NORTH, GROUPED BY TIME INTERVAL.   CBMTP007
C                                                                       CBMTP008
C ********************************************************************* CBMTP009
C                                                                       CBMTP010
C  INPUT                                                                CBMTP011
C   1) HEADER CARD OF THE FOLLOWING FORM                                CBMTP012
C        COLS. 1-12  -'TRACK NUMBER'                                    CBMTP013
C              13-17  - BLANK SPACES                                    CBMTP014
C              18-42  -', ANGLES FROM TRUE NORTH,'                      CBMTP015
C              43-46 - ' DAY'                                           CBMTP016
C              47-48 - BLANK                                            CBMTP017
C              49    - ','                                              CBMTP018
C              50-54 - BLANKS                                           CBMTP019
C              55-61 - ' TO DAY'                                        CBMTP020
C              62-63 - BLANK                                            CBMTP021
C              64    - ','                                              CBMTP022
C              65-70 - BLANK                                            CBMTP023
C   2) CONTROL CARD                                                     CBMTP024
C        COLS. 1-4  - TRACK NUMBER TO BE PROCESSED                      CBMTP025
C               5-8  - BEGINNING RECORD OF FILE TSDN FOR TRACK          CBMTP026
C               9-12 - LAST FILE RECORD                                 CBMTP027
C              13-15 - INTERVAL OF TIME, IN MINUTES, WHICH IS USED TO GROUPCBMTP028
C                      ANGLES                                           CBMTP029
C                                                                       CBMTP030
C  CBMTP AUTOMATICALLY CALLS LINK TO PROGRAMS DIRTP AND PLTP FOR        CBMTP031
C  ANALYSIS AND PLOTS OF GROUPED DATA.                                  CBMTP032
C                                                                       CBMTP033
C  EXECUTE THIS PROGRAM WITH *FILES(1,TSDN),(5,TABLB)                   CBMTP034
C                                                                       CBMTP035
C  RESTRICTION OF 25 GROUPS (INTERVALS) , 50 OBSERVATIONS PER GROUP.    CBMTP036
C                                                                       CBMTP037
C  SUBROUTINE PUTI REQUIRED TO CONVERT INTEGER TO A1.                   CBMTP038
C                                                                       CBMTP039
C ********************************************************************* CBMTP040
C                                                                       CBMTP041
      INTEGER TITLE(25,70),CARD,PRINT,TYPE                              CBMTP042
      DIMENSION V(25),W(25),K1(25),K2(25),IHEAD(70)                     CBMTP043
      COMMON TITLE,K,LO(25),N(25),IALFA(25,50),V,W,ILFA(25),A(25),ILFA2(CBMTP044
     125),NZ(25),K1,K2                                                  CBMTP045
      DATA CARD,PRINT,TYPE / 8,5,1 /                                    CBMTP046
      DEFINE FILE 1(2520,6,U,KI)                                        CBMTP047
C                                                                       CBMTP048
C FORMATS.                                                              CBMTP049
100   FORMAT (70A1)                                                     CBMTP050
102   FORMAT(3I4,I3)                                                    CBMTP051
110   FORMAT(/'CHECK CONTROL CARDS - TRACK ',I4,' WAS FOUND AT RECORDS  CBMTP052
110  1REQUESTED')                                                       CBMTP053
112   FORMAT (/'CHECK CONTROL CARD AND ADNTP OUTPUT'/'BLANK RECORD FOUNDCBMTP054
112  1 AT',I5,' AS OPPOSED TO THE REQUESTED RECORD OF',I5)             CBMTP055
```

```
  120    FORMAT ('1TRACK NUMBER ',I4,', ANGLES FROM TRUE NORTH OF POSITION CBMTP056
  120   1VECTORS'/' TIME INTERVAL = ',I3,' MINUTES')                      CBMTP057
  130    FORMAT ('0',70A1)                                                CBMTP058
  131    FORMAT (' SUM OF COSINES = ',F10.4)                              CBMTP059
  132    FORMAT (' SUM OF SINES =',F12.4)                                 CBMTP060
  134    FORMAT (' ',10I5)                                                CBMTP061
  160    FORMAT (/'NUMBER OF ANGLES HAS EXCEEDED 50')                     CBMTP062
  165    FORMAT (/'NUMBER OF GROUPS HAS EXCEEDED 25')                     CBMTP063
  170    FORMAT (/'NUMBER OF MINUTES HAS EXCEEDED 32766')                 CBMTP064
C                                                                         CBMTP065
       K1 = 1                                                             CBMTP066
C TO READ HEADER CARD                                                     CBMTP067
       READ (CARD,100) IHEAD                                              CBMTP068
C                                                                         CBMTP069
C READ CONTROL CARD                                                       CBMTP070
       READ (CARD,102) LTRK,IFB,IFE,INT                                   CBMTP071
C                                                                         CBMTP072
C SET FIRST DATA POINT AS THE BEGINNING OF ALL INTERVALS.                 CBMTP073
       IREC = IFB                                                         CBMTP074
       READ (1'IREC) JTRK,JDN,JHR,JMIN,ANG                                CBMTP075
       IF (JTRK - LTRK ) 7,3,7                                            CBMTP076
     3 IST = JHR * 60 + JMIN                                              CBMTP077
       KD = 1                                                             CBMTP078
       ID = 1                                                             CBMTP079
       IH = JHR                                                           CBMTP080
       IM = JMIN                                                          CBMTP081
       IET = IST + INT  - 1                                               CBMTP082
       IH1 = IET / 60                                                     CBMTP083
       IM1 = IET - IH1 * 60                                               CBMTP084
       IF (IH1 - 24) 801,800,800                                          CBMTP085
   800 ID1 = KD + (IH1 / 24 )                                             CBMTP086
       IH1 = IH1 - IH1 / 24 * 24                                          CBMTP087
       GO TO 804                                                          CBMTP088
   801 ID1 = ID                                                           CBMTP089
   804 INC = 1                                                            CBMTP090
       NN = 0                                                             CBMTP091
       SUMS = 0.0                                                         CBMTP092
       SUMC = 0.0                                                         CBMTP093
       IDN = JDN                                                          CBMTP094
       GO TO 12                                                           CBMTP095
     5 READ(1'IREC) JTRK,JDN,JHR,JMIN,ANG                                 CBMTP096
       IF (JTRK) 20,20,6                                                  CBMTP097
     6 IF (JTRK - LTRK) 7,10,7                                            CBMTP098
     7 WRITE (TYPE,110) JTRK                                              CBMTP099
       CALL EXIT                                                          CBMTP100
C                                                                         CBMTP101
    10 JTM = JHR * 60 + JMIN + 1440 * ( JDN - IDN)                        CBMTP102
       IF (JTM - 32766) 11,11,9                                           CBMTP103
     9 WRITE (TYPE,170)                                                   CBMTP104
       CALL EXIT                                                          CBMTP105
    11 IF ( JTM - IET ) 12,12,14                                          CBMTP106
    14 IF ( NN ) 15,15,20                                                 CBMTP107
C                                                                         CBMTP108
C RESET DAY, HOUR, MINUTE OF INTERVAL START.                              CBMTP109
    15 IST = IET + 1                                                      CBMTP110
       IET = IET + INT                                                    CBMTP111
```

```
      IH = IST / 60                                                     CBMTP112
      IM = IST - IH * 60                                                CBMTP113
      IF ( IH - 24 ) 701,700,700                                        CBMTP114
  700 ID = KD + IH / 24                                                 CBMTP115
      IH = IH - IH / 24 * 24                                            CBMTP116
C                                                                       CBMTP117
C RESET DAY, HOUR, MINUTE OF INTERVAL END.                              CBMTP118
  701 IH1 = IET / 60                                                    CBMTP119
      IM1 = IET - IH1 * 60                                              CBMTP120
      IF ( IH1 - 24 ) 11,702,702                                        CBMTP121
  702 ID1 = KD + IH1 / 24                                               CBMTP122
      IH1 = IH1 - IH1 / 24 * 24                                         CBMTP123
      GO TO 11                                                          CBMTP124
   12 NN = NN + 1                                                       CBMTP125
      IF ( NN - 50 ) 18,18,16                                           CBMTP126
   16 WRITE (TYPE,160)                                                  CBMTP127
      CALL EXIT                                                         CBMTP128
C                                                                       CBMTP129
C ACCUMULATE SINES AND COSINES OF ANGLES WITHIN AN INTERVAL.            CBMTP130
   18 IALFA(INC,NN)= ANG + 0.501                                        CBMTP131
      SUMC = SUMC + COS(ANG * 3.14159 / 180.0)                          CBMTP132
      SUMS = SUMS + SIN(ANG * 3.14159 / 180.0)                          CBMTP133
      IREC = IREC + 1                                                   CBMTP134
      GO TO 5                                                           CBMTP135
C                                                                       CBMTP136
C STORE DATA OF ONE INTERVAL.                                           CBMTP137
   20 N(INC) = NN                                                       CBMTP138
      V(INC) = SUMC                                                     CBMTP139
      W(INC) = SUMS                                                     CBMTP140
      CALL PUTI (IHEAD,14,17,LTRK,0)                                    CBMTP141
      CALL PUTI ( IHEAD,48,48,ID,0)                                     CBMTP142
      CALL PUTI(IHEAD,51,52,IH,0)                                       CBMTP143
      CALL PUTI (IHEAD,53,54,IM,0)                                      CBMTP144
      CALL PUTI (IHEAD,63,63,ID1,0)                                     CBMTP145
      CALL PUTI (IHEAD,66,67,IH1,0)                                     CBMTP146
      CALL PUTI (IHEAD,68,69,IM1,0)                                     CBMTP147
      DO 24 I = 1,70                                                    CBMTP148
   24 TITLE(INC,I) = IHEAD(I)                                           CBMTP149
      LO(INC) = 70                                                      CBMTP150
      IF (JTRK) 30,30,26                                                CBMTP151
   26 INC = INC + 1                                                     CBMTP152
      IF ( INC - 25 ) 28,28,27                                          CBMTP153
   27 WRITE ( TYPE,165 )                                                CBMTP154
      CALL EXIT                                                         CBMTP155
   28 NN = 0                                                            CBMTP156
      SUMS = 0.0                                                        CBMTP157
      SUMC = 0.0                                                        CBMTP158
      GO TO 15                                                          CBMTP159
C                                                                       CBMTP160
C TO PRINT OUT TRACK DATA                                               CBMTP161
   30 IF (IREC - 1 - IFE) 32,40,32                                      CBMTP162
   32 WRITE (TYPE,112) IREC,IFE                                         CBMTP163
   40 KK= INC                                                           CBMTP164
      WRITE (PRINT,120) LTRK,INT                                        CBMTP165
      DO 60 I = 1,KK                                                    CBMTP166
      K1(I) = I                                                         CBMTP167
```

```
      K2(I) = I + 1                                                    CBMTP168
      K = LO(I)                                                        CBMTP169
      WRITE (PRINT,130)(TITLE(I,J),J=1,K)                              CBMTP170
      WRITE (PRINT,131) V(I)                                           CBMTP171
      WRITE (PRINT,132) W(I)                                           CBMTP172
      K = N(I)                                                         CBMTP173
      WRITE (PRINT,134) (IALFA(I,J), J = 1,K)                          CBMTP174
   60 CONTINUE                                                         CBMTP175
      K1(INC) = -1                                                     CBMTP176
      K2(INC) = -1                                                     CBMTP177
      K = KK                                                           CBMTP178
      CALL LINK(DIRTP)                                                 CBMTP179
      END                                                              CBMTP180
// DUP                                                                 CBMTP181
*DELETE              CBMTP                                           CBMTP182
*STORE       WS  UA  CBMTP                                           CBMTP183
```

```
// JOB
// ASM PUTI
*LIST
                                                                    PUTI   1
                                                                    PUTI   2
         HDNG    INTEGER TO A1 CONVERSION                  PUTI   PUTI   3
         ENT     PUTI (KARD, I, J, INT, IEDIT)                    PUTI   4
         ENT     PUTZ (KARD, I, J, INT, IEDIT)                    PUTI   5
*INT IS CONVERTED TO A1 AND PUT IN KARD(I) THRU                    PUTI   6
*KARD(J).  IEDIT INDICATES THE NUMBER OF IMPLIED                   PUTI   7
*DECIMAL PLACES - ZERO OR NEGATIVE FOR NO DECIMAL                  PUTI   8
*POINT, POSITIVE FOR NUMBER OF PLACES.  LEADING                   PUTI   9
*ZEROS REPLACED BY BLANKS - USE IEDIT GREATER THAN                PUTI  10
*FIELD WIDTH FOR NO ZERO SUPPRESSION.  LEADING                    PUTI  11
*MINUS SIGN IF INT IS NEGATIVE.                                   PUTI  12
*                                                                 PUTI  13
*DAVE DILLARD, BARTON-ASCHMAN ASSOCIATES, INC.                    PUTI  14
*1771 W. HOWARD ST., CHICAGO, IL   60626                          PUTI  15
*                                                                 PUTI  17
NARG   EQU     5                                                  PUTI  18
KARD   EQU     0-NARG                                             PUTI  19
I      EQU     1-NARG                                             PUTI  20
J      EQU     2-NARG                                             PUTI  21
INT    EQU     3-NARG                                             PUTI  22
IEDIT  EQU     4-NARG                                             PUTI  23
*                                                                 PUTI  24
PUTI   EQU     *                                                  PUTI  25
PUTZ   EQU     *                                                  PUTI  26
ARGAD  DC      *-*                                                PUTI  27
       STX   1 XR1                                                PUTI  28
       LDX   I1 ARGAD                                             PUTI  29
       MDX   1 NARG                                               PUTI  30
       STX   1 RETRN                                              PUTI  31
       LD    I1 I                                                 PUTI  32
       BNP   L  DONE                                              PUTI  33
       S     I1 J                                                 PUTI  34
       A        MINUS                                             PUTI  35
       BNN   L  DONE                                              PUTI  36
       STO      NCHAR                                             PUTI  37
       LD    1 KARD                                               PUTI  38
       S     I1 I                                                 PUTI  39
       S        M2                                                PUTI  40
       STO      A1                                                PUTI  41
       LD    I1 IEDIT                                             PUTI  42
MINUS  EQU      *-1                                               PUTI  43
       STO      NDEC                                              PUTI  44
       LD    I1 INT                                               PUTI  45
M2     EQU      *-1                                               PUTI  46
       STO      INTGR                                             PUTI  47
       STO      SIGN                                              PUTI  48
       LDX   L1 *-*                                               PUTI  49
NCHAR  EQU      *-1                                               PUTI  50
*                                                                 PUTI  51
DIV10  EQU      *                                                 PUTI  52
       LD       INTGR                                             PUTI  53
       SRT      16                                                PUTI  54
       D        TEN                                               PUTI  55
```

```
                    STO       INTGR                                  PUTI  56
                    XCH                                              PUTI  57
                    BP    L   POS                                    PUTI  58
                    EOR       MINUS                                  PUTI  59
                    S         MINUS                                  PUTI  60
               POS  EQU       *                                      PUTI  61
                    SLA       8                                      PUTI  62
                    OR        ZERO                                   PUTI  63
               *                                                      PUTI  64
               PUT  EQU       *                                      PUTI  65
                    STO   L1  *-*                                    PUTI  66
               A1   EQU       *-1                                    PUTI  67
                    MDX   1   1                                      PUTI  68
                    B         DECNT                                  PUTI  69
               *                                                      PUTI  70
               DONE EQU       *                                      PUTI  71
                    LDX   L1  *-*                                    PUTI  72
               XR1  EQU       *-1                                    PUTI  73
                    B     L   *-*                                    PUTI  74
               RETRN EQU      *-1                                    PUTI  75
               *                                                      PUTI  76
               DECNT EQU      *                                      PUTI  77
                    LD        NDEC                                   PUTI  78
                    BNP   L   CHECK                                  PUTI  79
                    A         MINUS                                  PUTI  80
                    STO       NDEC                                   PUTI  81
                    BNZ   L   DIV10                                  PUTI  82
                    LD        POINT                                  PUTI  83
                    B         PUT                                    PUTI  84
               *                                                      PUTI  85
               CHECK EQU      *                                      PUTI  86
                    MDM   L   INTGR,0                                PUTI  87
                    B         DIV10                                  PUTI  88
                    LD        SIGN                                   PUTI  89
                    SKP       -                                      PUTI  90
                    B         PAD                                    PUTI  91
                    LD        DASH                                   PUTI  92
                    STO       SIGN                                   PUTI  93
                    B         PUT                                    PUTI  94
               *                                                      PUTI  95
               PAD  EQU       *                                      PUTI  96
                    LD        BLANK                                  PUTI  97
                    B         PUT                                    PUTI  98
               *                                                      PUTI  99
               SIGN DC        *-*                                    PUTI 100
               NDEC DC        *-*                                    PUTI 101
               INTGR DC       *-*                                    PUTI 102
               TEN  DC        10                                     PUTI 103
               ZERO EBC       .0 .                                   PUTI 104
               DASH EBC       .- .                                   PUTI 105
               BLANK EBC      .  .                                   PUTI 106
               POINT EBC      .. .                                   PUTI 107
                    END                                              PUTI 108
// DUP PUTI                                                          PUTI 109
*DELETE        PUTI                                                  PUTI 110
*STORE     WS  UA PUTI                                               PUTI 111
```

```
// JOB                                                                  DIRTP001
// FOR                                                                  DIRTP002
*ONE WORD INTEGERS                                                      DIRTP003
*IOCS(1403 PRINTER,DISK,TYPEWRITER,KEYBOARD)                            DIRTP004
*LIST ALL                                                              DIRTP005
*NAME DIRTP                                                            DIRTP006
C                                                                       DIRTP007
C*************************************************************************DIRTP008
C                                                                       DIRTP009
C     THIS PROGRAM CALCULATES SEVERAL STATISTICS DESCRIBING THE CIRCULAR DIRTP010
C     DISTRIBUTION OF INDEPENDENT DIRECTIONS IN EACH TEST. THE          DIRTP011
C     DISTRIBUTION IS THEN COMPARED TO A UNIFORM DISTRIBUTION TO SEE IF DIRTP012
C     IT DIFFERS SIGNIFICANTLY. THE DISTRIBUTION IS ALSO CHECKED TO SEE DIRTP013
C     IF IT HAS TWO OPPOSITE MODES.                                     DIRTP014
C     THE MEANS MAY BE COMPARED TO A SPECIFIED DIRECTION BY ENTERING VIA DIRTP015
C     THE KEYBOARD THE THEORETICAL DIRECTION ( THIS OPTION MAY BE BY-   DIRTP016
C     PASSED BY TURNING ON DATA SWITCH ONE ), AND FINALLY, THE MEANS ARE DIRTP017
C     COMPARED WITH EACH OTHER.                                         DIRTP018
C     FOR A COMPLETE DISCUSSION OF CIRCULAR DISTRIBUTION                DIRTP019
C     STATISTICS SEE THE AM. INST. BIOL. SCI. MONOGRAPH (1965) BY E.    DIRTP020
C     BATSCHELET, 'STATISTICAL METHODS FOR THE ANALYSIS OF PROBLEMS IN   DIRTP021
C     ANIMAL ORIENTATION AND CERTAIN BIOLOGICAL RHYTHMS'.               DIRTP022
C                                                                       DIRTP023
C     DIRTP IS ONLY SLIGHTLY MODIFIED FROM PROGRAM DIREC (SIMPSON AND   DIRTP024
C     GROOT, 1972) TO ANALYZE TRACK POSITION VECTORS.                   DIRTP025
C                                                                       DIRTP026
C     SUBROUTINE ANGLE AND DATA FILE TABLB ARE REQUIRED.                DIRTP027
C                                                                       DIRTP028
C*************************************************************************DIRTP029
C                                                                       DIRTP030
      INTEGER TITLE(25,70),TYPE,KEYBD,PRINT                             DIRTP031
      DIMENSION V(25),W(25),ALFA(25),R(25),IA(25),B(25),NSECT(25)       DIRTP032
      DIMENSION N1(25,50),XHISQ(25),NDF(25),X(25),IS(25),AAK(99)        DIRTP033
      DIMENSION AKAP(25),A2(25),K1(25),K2(25)                           DIRTP034
      COMMON TITLE,K,LO(25),N(25),IALFA(25,50),V,W,ILFA(25),A(25),ILFA2(DIRTP035
     125),NZ(25),K1,K2                                                 DIRTP036
      DATA TYPE,KEYBD,PRINT,XHISQ / 1,6,5,25*0.0 /                      DIRTP037
      DEFINE FILE 5(1,297,U,KK1)                                        DIRTP038
C                                                                       DIRTP039
C FORMATS                                                               DIRTP040
21    FORMAT(//,15X,'FREQUENCIES PER SECTOR',26I3,/,37X,1^I3)           DIRTP041
33    FORMAT(//,15X,'THETA =',I4,',  KAPPA =',F7.4)                     DIRTP042
48    FORMAT(///,1X,'BIMODAL DISTRIBUTION STATISTICS',///,5X,'V =',F8.4,DIRTP043
48   1',  W =',F8.4,',  R =',F8.4,',  DIRECTIONAL AXIS =',I4,' -',I4/'0'DIRTP044
48   2,4X,'A =',I2,',  Z =',F5.2,',  KAPPA =',F7.4)                    DIRTP045
105   FORMAT(/,15X,'N =',I4,',  V =',F8.4,',  W =',F8.4,',  R =',F8.4,',DIRTP046
105  1  MEAN VECTOR =',I4/'0',14X,'A =',I2,',  Z =',F5.2,',  ANGULAR DIRTP047
105  2DEV =',I3)                                                       DIRTP048
106   FORMAT(//,15X,'CHI-SQUARE =',F8.3,',  DF =',I3)                  DIRTP049
107   FORMAT(//,15X,'THETA(O) =',I4,',  TEST STATISTIC X =',F7.3,',  R =DIRTP050
107  1',F8.4)                                                          DIRTP051
108   FORMAT(//,10X,'ANGLE FOR TEST NO',I3,'  =  ANGLE FOR TEST NO',I3,'DIRTP052
108  1  F =',F8.3,'   DF =',I2,' ,',I3)                                DIRTP053
130   FORMAT(///,1X,'COMPARISON OF MEAN VECTOR WITH THETA(O)')          DIRTP054
133   FORMAT(1H1,1X,'COMPARISON OF MEAN VECTORS')                       DIRTP055
```

```
301    FORMAT ('1TEST NO.',I3,5X,70A1)                                  DIRTP056
302    FORMAT(///,1X,'TEST NO.',I2,2X,'HAS A BIMODAL DISTRIBUTION')     DIRTP057
370    FORMAT(/,15X,'PROBABILITY OF RANDOMNESS (FROM Z STATISTIC)  =',F6.DIRTP058
370  14)                                                                DIRTP059
453    FORMAT(////,1X,'ESTIMATES OF PARAMETERS OF THE CIRCULAR NORMAL DISDIRTP060
453  1TRIBUTION')                                                       DIRTP061
735    FORMAT(//,15X,'THETA(0) =',I4,',  TEST STATISTIC X =',F7.3,',  R =DIRTP062
735  1',F8.4,',  R(0) =',F8.4,'  (P=.05)')                             DIRTP063
6001   FORMAT(//'ENTER THEORETICAL DIRECTION TO COMPARE WITH MEAN'/'INTEGDIRTP064
6001 1ER NUMBER RIGHT JUSTIFIED IN A THREE COLUMN FIELD')               DIRTP065
6002   FORMAT (I3)                                                      DIRTP066
C                                                                       DIRTP067
       DO 20 KK=1,K                                                     DIRTP068
       NZ(KK)=0                                                         DIRTP069
       DO 20 J = 1,50                                                   DIRTP070
    20 N1(KK,J)=0                                                       DIRTP071
C      AAK IS A TABLE OF KAPPA VALUES (CONCENTRATION COEFFICIENTS OF    DIRTP072
C      DIRECTIONS AROUND THE MEAN, BATSCHELET, 1965)                    DIRTP073
       READ (5'1) AAK                                                   DIRTP074
       DO 205 KK=1,K                                                    DIRTP075
       ALFA(KK)=ATAN(W(KK)/V(KK))                                       DIRTP076
       CALL ANGLE(V(KK),W(KK),ALFA(KK))                                 DIRTP077
C      ILFA IS THE MEAN COMPASS DIRECTION                               DIRTP078
C      R IS THE LENGTH OF THE MEAN VECTOR, DETERMINED BY VECTOR ADDITION DIRTP079
C        OF DIRECTIONS (IE. UNIT VECTORS)                               DIRTP080
C      A IS THE VECTOR MEAN (VECTOR SUM (R) DIVIDED BY NO. OF DIRECTIONS) DIRTP081
C      IS REFERS TO THE ANGULAR DEVIATION AROUND THE MEAN               DIRTP082
C      B IS THE RAYLEIGH STATISTIC FOR TESTING UNIFORMITY OF THE        DIRTP083
C        DISTRIBUTION                                                   DIRTP084
       ILFA(KK)=ALFA(KK)                                                DIRTP085
       R(KK)=SQRT(W(KK)*W(KK)+V(KK)*V(KK))                              DIRTP086
       A(KK)=R(KK)/N(KK)                                                DIRTP087
       IS(KK)=SQRT(2.0*(1.0-A(KK)))*180.0/3.1416+0.501                  DIRTP088
       B(KK)=R(KK)*R(KK)/N(KK)+0.00501                                  DIRTP089
       A(KK)=A(KK)*100.0+0.501                                          DIRTP090
       IA(KK)=A(KK)                                                     DIRTP091
       LI=LO(KK)                                                        DIRTP092
       WRITE(PRINT,301)KK,(TITLE(KK,I),I=1,LI)                          DIRTP093
       WRITE (PRINT,453)                                                DIRTP094
C      FIND THE KAPPA VALUE CORRESPONDING TO THE STRENGTH OF THE MEAN (A) DIRTP095
       J=IA(KK)                                                         DIRTP096
       AKAP(KK)=AAK(J)                                                  DIRTP097
       WRITE(PRINT,33)ILFA(KK),AAK(J)                                   DIRTP098
       WRITE(PRINT,105)N(KK),V(KK),W(KK),R(KK),ILFA(KK),IA(KK),B(KK),IS(KDIRTP099
     1K)                                                                DIRTP100
       PX=(B(KK)*B(KK)*B(KK)*B(KK))/(90.0+N(KK))                        DIRTP101
C      P IS THE PROBABILITY OF RANDOMNESS (FROM RAYLEIGH STATISTIC,     DIRTP102
C WALCOTT AND MICHEMER, 1971)                                           DIRTP103
       P=1.0/(EXP(B(KK))*(1.0+PX))                                      DIRTP104
       WRITE(PRINT,370)P                                                DIRTP105
C      DIVIDE THE COMPASS INTO SECTORS SO THERE ARE FIVE OR MORE        DIRTP106
C INDEPENDENT DIRECTIONS IN MOST SECTORS.                               DIRTP107
       IF(N(KK)-5)791,792,792                                           DIRTP108
   791 NSECT(KK)=1                                                      DIRTP109
       GO TO 13                                                         DIRTP110
   792 NSECT(KK)=N(KK)/5                                                DIRTP111
```

```
   15 AK=360.0/FLOAT(NSECT(KK))+0.00001                                  DIRTP112
      NK=AK                                                              DIRTP113
      IF(360-NK*NSECT(KK))14,13,14                                       DIRTP114
   14 NSECT(KK)=NSECT(KK)-1                                              DIRTP115
      GO TO 15                                                           DIRTP116
   13 NN=N(KK)                                                           DIRTP117
      NSEC=NSECT(KK)                                                     DIRTP118
C     DETERMINE THE FREQUENCY IN EACH SECTOR                            DIRTP119
      DO 8 I=1,NN                                                        DIRTP120
      DO 7 J=1,NSEC                                                      DIRTP121
      IF(IALFA(KK,I)-NK*J)9,9,7                                          DIRTP122
    9 N1(KK,J)=N1(KK,J)+1                                                DIRTP123
      GO TO 8                                                            DIRTP124
    7 CONTINUE                                                           DIRTP125
    8 CONTINUE                                                           DIRTP126
      KK2=KK                                                             DIRTP127
      WRITE(PRINT,21)(N1(KK,J),J=1,NSEC)                                 DIRTP128
C     DETERMINE CHI SQUARED VALUE TO TEST UNIFORMITY OF DISTRIBUTION    DIRTP129
C (RATSCHELET, 1965)                                                     DIRTP130
      ASECT=FLOAT(N(KK))/FLOAT(NSEC)                                     DIRTP131
      DO 11 J=1,NSEC                                                     DIRTP132
      XHISQ(KK)=(N1(KK,J)-ASECT)**2/ASECT+XHISQ(KK)                      DIRTP133
      NDF(KK)=NSECT(KK)-1                                                DIRTP134
   11 CONTINUE                                                           DIRTP135
      WRITE(PRINT,106)XHISQ(KK),NDF(KK)                                  DIRTP136
C     CHECK FOR BIMODALITY IN DISTRIBUTION BY DOUBLING THE DIRECTIONS    DIRTP137
C (GROOT, 1965)                                                          DIRTP138
      V2=0                                                               DIRTP139
      W2=0                                                               DIRTP140
      DO 40 J=1,NN                                                       DIRTP141
      IALF2=IALFA(KK,J)*2                                                DIRTP142
      IF(IALF2-360)42,42,41                                              DIRTP143
   41 IALF2=IALF2-360                                                    DIRTP144
   42 V2=V2+COS(IALF2*3.1416/180.0)                                      DIRTP145
   40 W2=W2+SIN(IALF2*3.1416/180.0)                                      DIRTP146
      ALFA(KK)=ATAN(W2/V2)                                               DIRTP147
      CALL ANGLE(V2,W2,ALFA(KK))                                         DIRTP148
      ALFA(KK)=ALFA(KK)/2.0                                              DIRTP149
      ILFA2(KK)=ALFA(KK)                                                 DIRTP150
      IAXIS=ILFA2(KK)+180                                                DIRTP151
      IF(IAXIS-360)46,46,47                                              DIRTP152
   47 IAXIS=IAXIS-360                                                    DIRTP153
   46 R2=SQRT(W2*W2+V2*V2)                                               DIRTP154
      A2(KK)=R2/N(KK)                                                    DIRTP155
      A2(KK)=A2(KK)*100.0+0.501                                          DIRTP156
C     PRINT BIMODAL DISTRIBUTION STATISTICS IF NEW MEAN IS ALMOST AS     DIRTP157
C     STRONG                                                             DIRTP158
      IF(A2(KK)-(A(KK)-10.0))43,44,44                                    DIRTP159
   44 B2=R2*R2/N(KK)                                                     DIRTP160
      IA(KK)=A2(KK)                                                      DIRTP161
      J=IA(KK)                                                           DIRTP162
      AKAP(KK)=AAK(J)                                                    DIRTP163
      WRITE(PRINT,48)V2,W2,R2,ILFA2(KK),IAXIS,IA(KK),B2,AKAP(KK)         DIRTP164
C     CALL IT BIMODAL IF NEW MEAN IS STRONGER                            DIRTP165
      IF(A2(KK)-A(KK))43,43,303                                          DIRTP166
  303 NZ(KK)=1                                                           DIRTP167
```

```
      WRITE(PRINT,302)KK                                                DIRTP168
C     COMPARE MEAN WITH THEORETICAL DIRECTION  (BATSCHELET, 1965)       DIRTP169
   43 CALL DATSW(1,M1)                                                  DIRTP170
      GO TO (205,6000), M1                                              DIRTP171
 6000 WRITE (TYPE,6001)                                                 DIRTP172
      READ (KEYBD,6002) ILFAO                                           DIRTP173
      IF(ILFAO)205,114,114                                              DIRTP174
  114 JD=IABS(ILFA(KK)-ILFAO)                                           DIRTP175
      IF(JD-180)250,250,251                                             DIRTP176
  251 JD=360-JD                                                         DIRTP177
  250 X(KK)=R(KK)*COS(FLOAT(JD)*3.1416/180.0)                           DIRTP178
      WRITE(PRINT,130)                                                  DIRTP179
      IF(N(KK)-15)734,734,732                                           DIRTP180
  732 IF(X(KK)-N(KK)/3)733,734,734                                      DIRTP181
  733 RO=SQRT(X(KK)*X(KK)+3.841*N(KK)/2)                                DIRTP182
      WRITE(PRINT,735)ILFAO,X(KK),R(KK),RO                              DIRTP183
      GO TO 205                                                         DIRTP184
  734 WRITE(PRINT,107)ILFAO,X(KK),R(KK)                                 DIRTP185
  205 CONTINUE                                                          DIRTP186
      IF(K-1)117,117,342                                                DIRTP187
  342 ID=0                                                              DIRTP188
C     COMPARE TEST MEANS  (BATSCHELET, 1965)                            DIRTP189
      DO 710 KK=1,K                                                     DIRTP190
      KP=K1(KK)                                                         DIRTP191
      KQ=K2(KK)                                                         DIRTP192
      IF(KP)117,117,118                                                 DIRTP193
  118 ID=ID+1                                                           DIRTP194
      IF(ID-1)131,131,132                                               DIRTP195
  131 WRITE(PRINT,133)                                                  DIRTP196
  132 NT=N(KP)+N(KQ)                                                    DIRTP197
      VT=V(KP)+V(KQ)                                                    DIRTP198
      TW=W(KP)+W(KQ)                                                    DIRTP199
      TR=SQRT(VT*VT+TW*TW)                                              DIRTP200
      F=FLOAT(NT-2)*(R(KP)+R(KQ)-TR)/(FLOAT(NT)-R(KP)-R(KQ))            DIRTP201
      NDF1=1                                                            DIRTP202
      NDF2=NT-2                                                         DIRTP203
      WRITE(PRINT,108)KP,KQ,F,NDF1,NDF2                                 DIRTP204
  710 CONTINUE                                                          DIRTP205
  117 CALL LINK (PLTP)                                                  DIRTP206
      END                                                               DIRTP207
// DUP                                                                  DIRTP208
*DELETE            DIRTP                                              DIRTP209
*STORE       WS. UA  DIRTP                                            DIRTP210
```

Table 6. Example output program CBMTP for track 14-70.

```
TRACK NUMBER 1470, ANGLES FROM TRUE NORTH OF POSITION VECTORS
TIME INTERVAL = 240 MINUTES

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 1, 1021 TO DAY 1, 1420
SUM OF COSINES =      1.5414
SUM OF SINES =        3.6840
   29   16  352   30    8   65  349  268  132  211
  119  156  143  143

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 1, 1421 TO DAY 1, 1820
SUM OF COSINES =    -14.5998
SUM OF SINES =        2.1247
  169  175  178  137  140  144  194  149  222  192
  183  203  181  161  163  161

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 1, 1821 TO DAY 1, 2220
SUM OF COSINES =    -11.1575
SUM OF SINES =        4.8279
   93  126  145  132  130  162  234  225  204  174
  148  149  133  150  169

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 1, 2221 TO DAY 2,  220
SUM OF COSINES =     -4.7432
SUM OF SINES =        7.6946
  154  156  146  150  188  112   86   63  175  325
  127   70   68  110

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 2,  221 TO DAY 2,  620
SUM OF COSINES =      8.7985
SUM OF SINES =        3.7682
   17   75  119   50    5    2    4  346  207   75
  322  359   59   51  284   22

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 2,  621 TO DAY 2, 1020
SUM OF COSINES =      7.4755
SUM OF SINES =       -2.9665
   37   26   41   10  135  321  322  319  252  266
  272  325    8  346

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 2, 1021 TO DAY 2, 1420
SUM OF COSINES =     -9.9130
SUM OF SINES =        2.2235
   51  247  201  184  171  140  156  160  166  184
  184  141  150

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 2, 1421 TO DAY 2, 1820
SUM OF COSINES =      4.6885
SUM OF SINES =       -0.8998
  149  356   25  358   25  354   61  253  257  271
  279  296   67  103

TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 2, 1821 TO DAY 2, 2220
SUM OF COSINES =     -2.2599
SUM OF SINES =       -6.9344
  137  119  104  194  229  233  232  271  242  256
  260  324  323  331  332  242
```

Table 7. Example output program DIRTP listing statistics of the circular distribution of vector directions for track 14-70.

```
TEST NO.  1      TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 1, 1021 TO DAY 1, 1420

ESTIMATES OF PARAMETERS OF THE CIRCULAR NORMAL DISTRIBUTION

              THETA =  67,  KAPPA = 0.6063

              N =  14,  V =  1.5414,  W =  3.6840,  R =  3.9934,  MEAN VECTOR =  67

              A = 0.29,  Z = 1.14,  ANGULAR DEV = 69

              PROBABILITY OF RANDOMNESS (FROM Z STATISTIC)  =0.3133

              FREQUENCIES PER SECTOR 10  4

              CHI-SQUARE =   2.571,  DF =  1

BIMODAL DISTRIBUTION STATISTICS

    V =  4.1427,  W = -0.9200,  R =  4.2437,  DIRECTIONAL AXIS = 173 - 353

    A = 0.30,  Z = 1.28,  KAPPA = 0.6292

TEST NO. 1  HAS A BIMODAL DISTRIBUTION

COMPARISON OF MEAN VECTOR WITH THETA(0)

              THETA(0) =  45,  TEST STATISTIC X =  3.702,  R =  3.9934


TEST NO.  2      TRACK NUMBER 1470, ANGLES FROM TRUE NORTH, DAY 1, 1421 TO DAY 1, 1820

ESTIMATES OF PARAMETERS OF THE CIRCULAR NORMAL DISTRIBUTION

              THETA = 172,  KAPPA = 6.5394

              N =  16,  V =-14.5998,  W =  2.1247,  R = 14.7536,  MEAN VECTOR = 172

              A = 0.92,  Z =13.60,  ANGULAR DEV = 23

              PROBABILITY OF RANDOMNESS (FROM Z STATISTIC)  =0.0000

              FREQUENCIES PER SECTOR  0 16  0

              CHI-SQUARE =  31.999,  DF =  2
```

Table 8. Comparison of mean direction of subsequent tests for track 14-70 by program DIRTP.

OMPARISON OF MEAN VECTORS

ANGLE FOR TEST NO 1 = ANGLE FOR TEST NO 2 F = 11.085 DF = 1 , 28

ANGLE FOR TEST NO 2 = ANGLE FOR TEST NO 3 F = 1.643 DF = 1 , 29

ANGLE FOR TEST NO 3 = ANGLE FOR TEST NO 4 F = 3.309 DF = 1 , 27

ANGLE FOR TEST NO 4 = ANGLE FOR TEST NO 5 F = 15.860 DF = 1 , 28

ANGLE FOR TEST NO 5 = ANGLE FOR TEST NO 6 F = 2.984 DF = 1 , 28

ANGLE FOR TEST NO 6 = ANGLE FOR TEST NO 7 F = 44.481 DF = 1 , 25

ANGLE FOR TEST NO 7 = ANGLE FOR TEST NO 8 F = 19.773 DF = 1 , 25

ANGLE FOR TEST NO 8 = ANGLE FOR TEST NO 9 F = 6.035 DF = 1 , 28

ANGLE FOR TEST NO 9 = ANGLE FOR TEST NO 10 F = 13.120 DF = 1 , 30

ANGLE FOR TEST NO 10 = ANGLE FOR TEST NO 11 F = 1.061 DF = 1 , 26

```
// JOB                                                                  ANGLE001
// FOR                                                                  ANGLE002
*ONE WORD INTEGERS                                                      ANGLE003
*LIST ALL                                                               ANGLE004
C                                                                       ANGLE005
C*********************************************************************ANGLE006
C                                                                       ANGLE007
C     THIS SUBROUTINE CONVERTS ANGLES OBTAINED FROM THE ARCTANGENT (ATAN)ANGLE008
C     FUNCTION INTO COMPASS DIRECTIONS (DEGREES CLOCKWISE FROM THE      ANGLE009
C     POSITIVE Y DIRECTION).                                            ANGLE010
C                                                                       ANGLE011
C*********************************************************************ANGLE012
C                                                                       ANGLE013
      SUBROUTINE ANGLE(X,Y,THETA)                                       ANGLE014
C     X = COSINE OF THE DIRECTION                                       ANGLE015
C     Y = SINE OF THE DIRECTION                                         ANGLE016
      IF(X)13,14,15                                                     ANGLE017
   13 IF(Y)16,17,16                                                     ANGLE018
   14 IF(Y)18,18,19                                                     ANGLE019
   15 IF(Y)23,21,22                                                     ANGLE020
   16 THETA=THETA*180.0/3.1416+180.501                                  ANGLE021
      GO TO 30                                                          ANGLE022
   17 THETA=180.0                                                       ANGLE023
      GO TO 30                                                          ANGLE024
   18 THETA=270.0                                                       ANGLE025
      GO TO 30                                                          ANGLE026
   19 THETA=90.0                                                        ANGLE027
      GO TO 30                                                          ANGLE028
   23 THETA=360.0+THETA*180.0/3.1416+0.501                              ANGLE029
      GO TO 30                                                          ANGLE030
   21 THETA=0.0                                                         ANGLE031
      GO TO 30                                                          ANGLE032
   22 THETA=THETA*180.0/3.1416+0.501                                    ANGLE033
   30 RETURN                                                            ANGLE034
      END                                                               ANGLE035
// DUP                                                                  ANGLE036
*DELETE              ANGLE                                              ANGLE037
*STORE       WS  UA  ANGLE                                              ANGLE038
```

```
// JOB                                                                  TLOAD001
// DUP                                                                  TLOAD002
*DELETE              TABLB                                             TLOAD003
*STOREDATA  WS  UA  TABLB    1                                         TLOAD004


// JOB                                                                  TLOAD007
// FOR                                                                  TLOAD008
*IOCS(2501 READER,DISK)                                                 TLOAD009
*ONE WORD INTEGERS                                                      TLOAD010
*LIST ALL                                                               TLOAD011
*NAME TLOAD                                                             TLOAD012
**TLOAD - PROGRAM TO LOAD DISK DATA FILE TABLB.                         TLOAD013
C                                                                       TLOAD014
C ********************************************************************* TLOAD015
C                                                                       TLOAD016
C THIS PROGRAM LOADS DATA FILE TABLB , USED BY PROGRAM DIRTP IN         TLOAD017
C CONVERTING MEAN VECTOR LENGTHS INTO A MEASURE OF CONCENTRATION OF     TLOAD018
C DIRECTIONS AROUND THE MEAN (KAPPA) VALUE. (BATSCHELET, 1965)          TLOAD019
C                                                                       TLOAD020
C USE *FILES(5,TABLB) TO EXECUTE THIS PROGRAM.                          TLOAD021
C                                                                       TLOAD022
C ********************************************************************* TLOAD023
C                                                                       TLOAD024
      INTEGER CARD                                                      TLOAD025
      DIMENSION AAK(99)                                                 TLOAD026
      DATA CARD / 8 /                                                   TLOAD027
      DEFINE FILE 5(1,297,U,KI)                                         TLOAD028
C                                                                       TLOAD029
300   FORMAT (10F8.4)                                                   TLOAD030
C                                                                       TLOAD031
      READ (CARD,300) AAK                                               TLOAD032
      WRITE (5*1) AAK                                                   TLOAD033
      CALL EXIT                                                         TLOAD034
      END                                                               TLOAD035
// XEQ          1                                                       TLOAD036
*FILES(5,TABLB)                                                         TLOAD037
  0.0200  0.0400  0.0600  0.0801  0.1001  0.1202  0.1403  0.1605  0.1807  0.2010
  0.2213  0.2418  0.2622  0.2828  0.3034  0.3242  0.3450  0.3660  0.3871  0.4083
  0.4296  0.4511  0.4727  0.4945  0.5165  0.5386  0.5610  0.5835  0.6063  0.6292
  0.6524  0.6759  0.6996  0.7236  0.7478  0.7724  0.7973  0.8225  0.8481  0.8741
  0.9004  0.9272  0.9544  0.9821  1.0102  1.0389  1.0681  1.0979  1.1283  1.1593
  1.1911  1.2235  1.2567  1.2908  1.3257  1.3616  1.3984  1.4364  1.4754  1.5157
  1.5574  1.6004  1.6451  1.6913  1.7395  1.7895  1.8418  1.8964  1.9536  2.0136
  2.0769  2.1436  2.2143  2.2893  2.3693  2.4549  2.5469  2.6461  2.7538  2.8713
  3.0002  3.1426  3.3011  3.4790  3.6804  3.9107  4.1770  4.4888  4.8587  5.3047
  5.8522  6.5394  7.4257  8.6104 10.2716 12.7661 16.9266 25.2522 50.2421
```

```
// JOB                                                                    PLPT0001
// FOR                                                                    PLPT0002
*ONE WORD INTEGERS                                                        PLPT0003
*IOCS(PLOTTER)                                                            PLPT0004
*LIST ALL                                                                 PLPT0005
*NAME PLTP                                                               PLPT0006
C*************************************************************************PLPT0007
C                                                                         PLPT0008
C     THIS PROGRAM PLOTS THE VECTOR DIRECTIONS AND MEAN VECTOR ON A       PLPT0009
C   COMPASS DIAGRAM.  THE DIRECTIONS ARE PLOTTED AS CROSSES AROUND THE    PLPT0010
C   CIRCUMFERENCE OF THE COMPASS,  THE MEAN IS REPRESENTED AS A VECTOR    PLPT0011
C   FROM THE CENTER.                                                      PLPT0012
C     A DIRECTIONAL AXIS IS PLOTTED IF THE DISTRIBUTION IS BIMODAL.       PLPT0013
C                                                                         PLPT0014
C     12 INCH WIDE PAPER IS USED AND THE PEN SHOULD BE COMPLETELY TO THE  PLPT0015
C     RIGHT (-Y DIRECTION) AT THE START.                                  PLPT0016
C                                                                         PLPT0017
C     PROGRAM REQUIRES SUBROUTINE QSORT,  INTEGER SORT IN ASCENDING       PLPT0018
C   ORDER.                                                                PLPT0019
C                                                                         PLPT0020
C     PROGRAM IS SLIGHTLY MODIFIED FROM CPLOT  (SIMPSON AND GROOT, 1972). PLPT0021
C                                                                         PLPT0022
C*************************************************************************PLPT0023
C                                                                         PLPT0024
      INTEGER TITLE(25,70),PLOT                                           PLPT0025
      DIMENSION V(25),W(25),IHOLD(50)                                     PLPT0026
      COMMON TITLE,K,LO(25),N(25),IALFA(25,50),V,W,ILFA(25),A(25),ILFA2(PLPT0027
     125),NZ(25)                                                          PLPT0028
      DATA PLOT / 7 /                                                     PLPT0029
   20 FORMAT(70A1)                                                        PLPT0030
      DO 200 KK=1,K                                                       PLPT0031
      L=N(KK)                                                             PLPT0032
      CALL SCALF(4.0,4.0,0.0,-1.25)                                       PLPT0033
      CALL FCHAR(-1.0,1.25,0.12,0.12,0.0)                                 PLPT0034
      LI=LO(KK)                                                           PLPT0035
      WRITE (PLOT,20) (TITLE(KK,I),I=1,LI)                               PLPT0036
C     MARK THE EAST DIRECTION                                             PLPT0037
      CALL FPLOT(-2,1.025,0.0)                                            PLPT0038
      CALL POINT(2)                                                       PLPT0039
C     DRAW 4 INCH RADIUS CIRCLE                                           PLPT0040
      CALL FPLOT(1,1.0,0.0)                                               PLPT0041
      CALL FPLOT(2,1.0,0.0)                                               PLPT0042
      THETA=0.0                                                           PLPT0043
      DO 10 J=1,315                                                       PLPT0044
      THETA=THETA+0.02                                                    PLPT0045
      X=COS(THETA)                                                        PLPT0046
      Y=SIN(THETA)                                                        PLPT0047
   10 CALL FPLOT(0,X,Y)                                                   PLPT0048
      CALL FPLOT(1,X,Y)                                                   PLPT0049
C     MARK NORTH, WEST, AND SOUTH DIRECTIONS                              PLPT0050
      CALL FPLOT(-2,0.0,1.025)                                            PLPT0051
      CALL POINT(5)                                                       PLPT0052
      CALL FPLOT(1,0.0,1.025)                                             PLPT0053
      CALL FPLOT(-2,-1.025,0.0)                                           PLPT0054
      CALL POINT(4)                                                       PLPT0055
```

```
      CALL FPLOT(1,-1.025,0.0)                                          PLPT0056
      CALL FPLOT(-2,0.0,-1.025)                                         PLPT0057
      CALL POINT(3)                                                     PLPT0058
      CALL FPLOT(1,0.0,-1.025)                                          PLPT0059
C     MARK CENTER OF CIRCLE                                             PLPT0060
      CALL FPLOT(-2,0.0,0.0)                                            PLPT0061
      CALL POINT(0)                                                     PLPT0062
      CALL POINT(1)                                                     PLPT0063
      CALL FPLOT(1,0.0,0.0)                                             PLPT0064
C SORT DIRECTIONS IN ASCENDING ORDER.                                   PLPT0065
      DO 28 I = 1,L                                                     PLPT0066
   28 IHOLD(I) = IALFA(KK,I)                                            PLPT0067
      CALL QSORT (IHOLD,1,L)                                            PLPT0068
      DO 11 J=1,L                                                       PLPT0069
C     PLOT DIRECTIONS ON CIRCUMFERENCE AS CROSSES (PROJECTING INWARD IF PLPT0070
C     THERE ARE SEVERAL IN ONE DIRECTION)                               PLPT0071
      X = COS(FLOAT(IHOLD(J)) * 3.14159 / 180.0)                        PLPT0072
      Y = SIN(FLOAT(IHOLD(J)) * 3.14159 / 180.0)                        PLPT0073
      IF (J-1)51,51,52                                                  PLPT0074
   52 IF (IHOLD(J) - IHOLD(J - 1)) 51,50,51                             PLPT0075
   50 KNTR=KNTR+1                                                       PLPT0076
      GO TO 150                                                         PLPT0077
   51 KNTR=1                                                            PLPT0078
  150 X=X-0.025*KNTR*X                                                  PLPT0079
      Y=Y-0.025*KNTR*Y                                                  PLPT0080
      CALL FPLOT(-2,Y,X)                                                PLPT0081
      CALL POINT(1)                                                     PLPT0082
      CALL FPLOT(1,Y,X)                                                 PLPT0083
   11 CONTINUE                                                          PLPT0084
      IF(NZ(KK)-1)310,300,300                                           PLPT0085
  300 XX=COS(FLOAT(ILFA2(KK))*3.1416/180.0)                             PLPT0086
      YY=SIN(FLOAT(ILFA2(KK))*3.1416/180.0)                             PLPT0087
      CALL FPLOT(1,YY,XX)                                               PLPT0088
      X=XX+0.15*XX                                                      PLPT0089
      Y=YY+0.15*YY                                                      PLPT0090
      CALL FPLOT(2,Y,X)                                                 PLPT0091
      X=-XX                                                             PLPT0092
      Y=-YY                                                             PLPT0093
      CALL FPLOT(1,Y,X)                                                 PLPT0094
      X=X+0.15*X                                                        PLPT0095
      Y=Y+0.15*Y                                                        PLPT0096
      CALL FPLOT(2,Y,X)                                                 PLPT0097
      CALL FPLOT(1,Y,X)                                                 PLPT0098
C     PLOT THE MEAN VECTOR AND MARK WITH A CROSS AT ITS TIP             PLPT0099
  310 CALL FPLOT(-2,0.0,0.0)                                            PLPT0100
      X=(A(KK)/100.0)*COS(FLOAT(ILFA(KK))*3.1416/180.0)                 PLPT0101
      Y=(A(KK)/100.0)*SIN(FLOAT(ILFA(KK))*3.1416/180.0)                 PLPT0102
      CALL FPLOT(0,Y,X)                                                 PLPT0103
      CALL POINT(1)                                                     PLPT0104
      CALL FPLOT(1,2.5,-1.25)                                           PLPT0105
  200 CONTINUE                                                          PLPT0106
      CALL EXIT                                                         PLPT0107
      END                                                               PLPT0108
// DUP                                                                  PLPT0109
*DELETE            PLTP                                               PLPT0110
*STORE      WS  UA  PLTP                                               PLPT0111
```

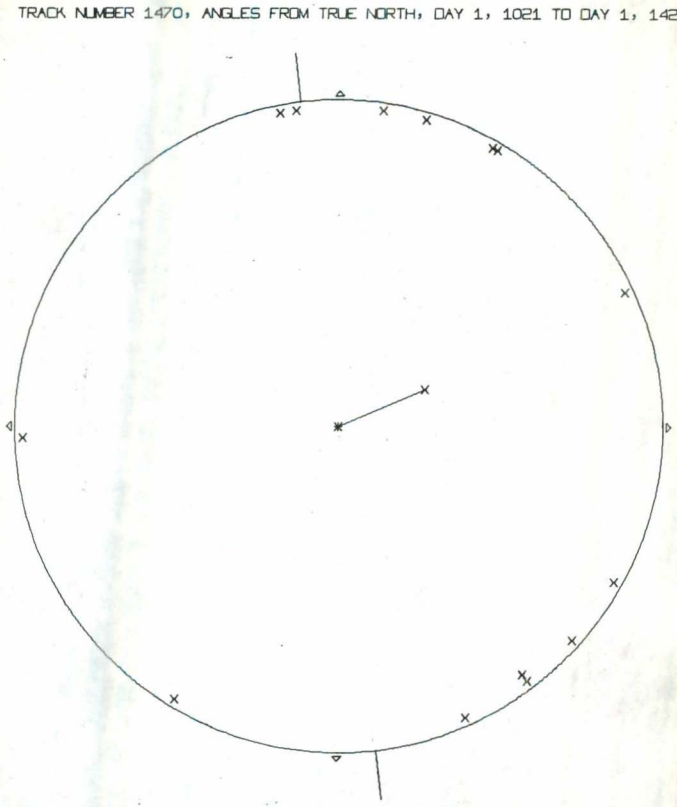

Fig. 4. Output example of program PLPT of vector directions, mean vector, length and direction, and bimodal directional axis for first 4-hr interval of track 14-70.

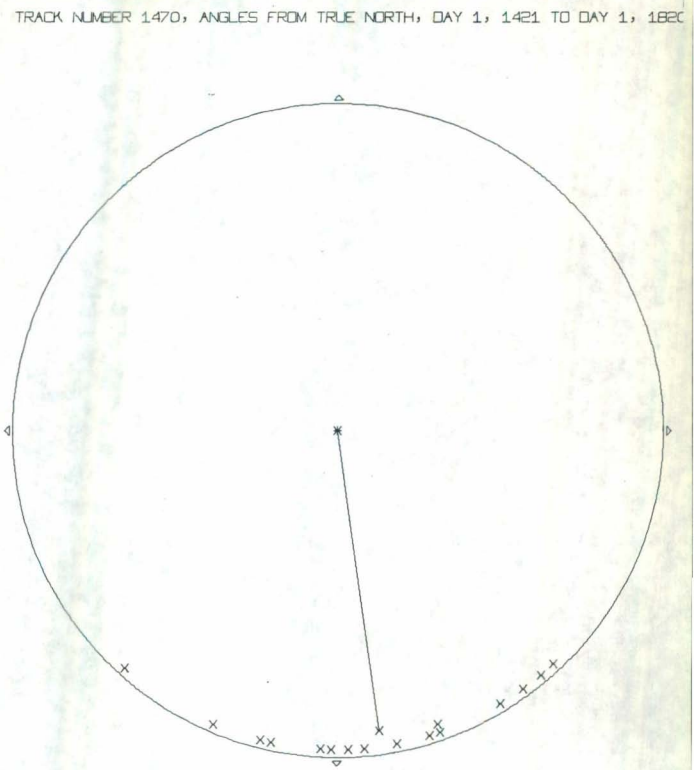

Fig. 5. Output example of program PLPT of vector directions and mean vector, length and direction of second 4-hr interval of track 14-70.

```
// JOB
// ASM
*LIST
* SUBROUTINE QSORT(IA,K,L)                                    QSORT003
*   SORTS A ONE WORD INTEGER ARRAY CALLED IA IN               QSORT004
*   ASCENDING ORDER FROM IA(K) TO IA(L).                      QSORT005
* 1130 ASSEMBLER,  DR. J. H. AHRENS,                          QSORT006
* NOVA SCOTIA TECHNICAL COLLEGE.                             QSORT007
       ENT     QSORT                                         QSORT008
IRONE  LDX  L1  *-*                                         QSORT009
IRTWO  LDX  L2  *-*                                         QSORT010
IRTRE  LDX  L3  *-*                                         QSORT011
STAT   LDS      *-*                                         QSORT012
       MDX  L   QSORT,+3                                    QSORT013
       BSC  I   QSORT                                       QSORT014
QSORT  DC       0                                           QSORT015
       STX   1  IRONE+1                                     QSORT016
       STX   2  IRTWO+1                                     QSORT017
       STX   3  IRTRE+1                                     QSORT018
       STS      STAT                                        QSORT019
       LDX  I1  QSORT                                       QSORT020
       LD    1  +0                                          QSORT021
       A        ONE                                         QSORT022
       S    I1  +1                                          QSORT023
       STO      L1                                          QSORT024
       A    I1  +1                                          QSORT025
       S    I1  +2                                          QSORT026
       STO      U1                                          QSORT027
       S        L1                                          QSORT028
       BSC  L   IRONE,-                                     QSORT029
       LD       ONE                                         QSORT030
       STO      INDEX                                       QSORT031
SORT   LD       L1                                          QSORT032
       STO      L                                           QSORT033
       LD       U1                                          QSORT034
       STO      U                                           QSORT035
PART   LDX  I1  L                                           QSORT036
       LDX  I2  U                                           QSORT037
       LD       L                                           QSORT038
       S        U                                           QSORT039
       STO  L   /0003                                       QSORT040
       LD    1  +0                                          QSORT041
       STO      X                                           QSORT042
       LD    2  +0                                          QSORT043
       STO      Z                                           QSORT044
       S        X                                           QSORT045
       BSC      0                                           QSORT046
       EOR      MONE                                        QSORT047
       BSC  L   NOXYZ,-                                     QSORT048
       LD       X                                           QSORT049
       RTE      +16                                         QSORT050
       LD       Z                                           QSORT051
       STO      X                                           QSORT052
       STO   1  +0                                          QSORT053
       RTE      +16                                         QSORT054
```

```
        STO     Z                                   QSORT050
        STO   2 +0                                  QSORT051
NOXYZ   LD      U                                   QSORT052
        S       L                                   QSORT053
        A       ONE                                 QSORT054
        BSC   L XSORT,-                             QSORT055
        LD      X                                   QSORT056
        STO     XX                                  QSORT057
        STX   1 IX                                  QSORT058
        LD      Z                                   QSORT059
        STO     ZZ                                  QSORT060
        STX   2 IZ                                  QSORT061
LEFT    MDX   1 -1                                  QSORT062
        MDX   3 -1                                  QSORT063
        BSC     Z+-                                 QSORT064
        MDX     NONX                                QSORT065
        LD    1 +0                                  QSORT066
        STO     X                                   QSORT067
        S       XX                                  QSORT068
        BSC     0                                   QSORT069
        EOR     MONE                                QSORT070
        BSC   L RIGHT,-                             QSORT071
        MDX     LEFT                                QSORT072
NONX    MDX   1 +1                                  QSORT073
        LDX   3 +1                                  QSORT074
        MDX     OUT                                 QSORT075
RIGHT   MDX   2 +1                                  QSORT076
        MDX   3 -1                                  QSORT077
        BSC     Z+-                                 QSORT078
        MDX     NONZ                                QSORT079
        LD    2 +0                                  QSORT080
        STO     Z                                   QSORT081
        S       ZZ                                  QSORT082
        BSC     0                                   QSORT083
        EOR     MONE                                QSORT084
        BSC   L DIST,+                              QSORT085
        MDX     RIGHT                               QSORT086
NONZ    MDX   1 +1                                  QSORT087
        LDX   3 +1                                  QSORT088
        LD      X                                   QSORT089
        STO     Z                                   QSORT090
        LD    1 +0                                  QSORT091
        STO     X                                   QSORT092
DIST    LD      X                                   QSORT093
        S       Z                                   QSORT094
        BSC     0                                   QSORT095
        EOR     MONE                                QSORT096
        BSC   L NOEXC,+                             QSORT097
        LD      X                                   QSORT098
        RTE     +16                                 QSORT099
        LD      Z                                   QSORT100
        STO     X                                   QSORT101
        STO   1 +0                                  QSORT102
        RTE     +16                                 QSORT103
        STO     Z                                   QSORT104
        STO   2 +0                                  QSORT105
```

```
NOEXC LD      X                                  QSORT106
      S       XX                                 QSORT107
      BSC     0                                  QSORT108
      EOR     MONE                               QSORT109
      BSC  L  SKIP,+                             QSORT110
      LD      X                                  QSORT111
      STO     XX                                 QSORT112
      STX   1 IX                                 QSORT113
SKIP  LD      Z                                  QSORT114
      S       ZZ                                 QSORT115
      BSC     0                                  QSORT116
      EOR     MONE                               QSORT117
      BSC  L  LEFT,-                             QSORT118
      LD      Z                                  QSORT119
      STO     ZZ                                 QSORT120
      STX   2 IZ                                 QSORT121
      MDX     LEFT                               QSORT122
ONE   DC      /0001                              QSORT123
INDEX DC      0                                  QSORT124
L1    DC      0                                  QSORT125
U1    DC      0                                  QSORT126
L     DC      0                                  QSORT127
U     DC      0                                  QSORT128
X     DC      0                                  QSORT129
Z     DC      0                                  QSORT130
XX    DC      0                                  QSORT131
ZZ    DC      0                                  QSORT132
IX    DC      0                                  QSORT133
IZ    DC      0                                  QSORT134
MONE  DC      /FFFF                              QSORT135
STACK BSS     28                                 QSORT136
OUT   LD   L  /0001                              QSORT137
      S       IX                                 QSORT138
      BSC  L  OUTA,+-                            QSORT139
      LD      XX                                 QSORT140
      STO   1 +0                                 QSORT141
      LD      X                                  QSORT142
      STO   I IX                                 QSORT143
OUTA  LD   L  /0002                              QSORT144
      S       IZ                                 QSORT145
      BSC  L  OUTB,+-                            QSORT146
      LD      ZZ                                 QSORT147
      STO   2 +0                                 QSORT148
      LD      Z                                  QSORT149
      STO   I IZ                                 QSORT150
OUTB  LD      U                                  QSORT151
      S    L  /0002                              QSORT152
      S    L  /0001                              QSORT153
      A       L                                  QSORT154
      MDX   1 +1                                 QSORT155
      MDX   2 -1                                 QSORT156
      BSC  L  OUTC,-                             QSORT157
      LD      L                                  QSORT158
      STO     L1                                 QSORT159
      STX   1 U1                                 QSORT160
      STX   2 L                                  QSORT161
```

```
                MDX      OUTD                                  QSORT162
        OUTC    LD       U                                     QSORT163
                STO      U1                                    QSORT164
                STX    2 L1                                    QSORT165
                STX    1 U                                     QSORT166
        OUTD    LD       U1                                    QSORT167
                S        L1                                    QSORT168
                BSC    L NOSRT,-                               QSORT169
                LDX    I3 INDEX                                QSORT170
                LD       L                                     QSORT171
                STO    L3 STACK-1                              QSORT172
                LD       U                                     QSORT173
                STO    L3 STACK+13                             QSORT174
                MDX    L  INDEX,+1                             QSORT175
                BSC    L  SORT                                 QSORT176
        XSORT   MDX    L  INDEX,-1                             QSORT177
                MDX       GOON                                 QSORT178
                BSC    L  IRONE                                QSORT179
        GOON    LDX    I3 INDEX                                QSORT180
                LD     L3 STACK+13                             QSORT181
                STO       U                                    QSORT182
                LD     L3 STACK-1                              QSORT183
                STO       L                                    QSORT184
        NOSRT   LD        L                                    QSORT185
                S         U                                    QSORT186
                BSC    L  PART,Z-                              QSORT187
                MDX       XSORT                                QSORT188
                END                                            QSORT189
// DUP
*DELETE         QSORT
*STORE      WS  UA QSORT
```

PROGRAMS

ANGULAR CHANGE OF MOVEMENT

```
// JOB                                                                  TATP0001
// DUP                                                                  TATP0002
*DELETE              TSDT                                              TATP0003
*STOREDATA  WS  UA  TSDT    40                                         TATP0004


// JOB                                                                  TATP0006
// FOR                                                                  TATP0007
*IOCS(1403 PRINTER,2501 READER,DISK)                                    TATP0008
*ONE WORD INTEGERS                                                      TATP0009
*LIST ALL                                                               TATP0010
*NAME TATP                                                              TATP0011
** TATP - PROGRAM TO CALCULATE TURNING ANGLES OF TRACK POSITION DATA.   TATP0012
C                                                                       TATP0013
C ********************************************************************* TATP0014
C                                                                       TATP0015
C TURNING ANGLES ARE CALCULATED FROM DATA STORED ON DISK FILE TSDN.     TATP0016
C  I.E.      FROM ANGLES FROM TRUE NORTH,  SEE PROGRAM LISTING OF ANDTP. TATP0017
C                                                                       TATP0018
C INPUT.                                                                TATP0019
C    CONTROL CARD                                                       TATP0020
C      COLS 1-4  BEGINNNNG RECORD OF FILE TSDN.                         TATP0021
C           5-8  LAST RECORD OF FILE TSDN.                              TATP0022
C                                                                       TATP0023
C OUTPUT                                                                TATP0024
C    ALTHOUGH PRINTED OUTPUT IS AVAILABLE, THE PURPOSE OF THIS PROGRAM  TATP0025
C  IS TO LOAD DISK DATA FILE TSDT,  A FILE ANALOGOUS TO TSDN.           TATP0026
C        PER RECORD - WORD 1 - TRACK NUMBER                             TATP0027
C                         2 - DAY NUMBER                                TATP0028
C                         3 - HOUR                                      TATP0029
C                         4 - MINUTE                                    TATP0030
C                         5 - ANGLE OF TURN (INTEGER VALUE)             TATP0031
C                                                                       TATP0032
C TURNING ANGLES RANGE FROM CLOCKWISE, 0 TO 180   DEGREES.              TATP0033
C                       ANTI-CLOCKWISE, 0  TO -180 DEGREES.             TATP0034
C                                                                       TATP0035
C EXECUTE THIS PROGRAM WITH *FILES(1,TSDN),(2,TSDT)                     TATP0036
C   WHERE TSDT OCCUPIES 40 SECTORS OF USERS AREA ON DISK.               TATP0037
C                                                                       TATP0038
C ********************************************************************* TATP0039
C                                                                       TATP0040
      INTEGER CARD,PRINT,DAY(310),HOUR(310),ANGLE(310)                  TATP0041
      DIMENSION MINUT(310)                                              TATP0042
      DATA CARD,PRINT /8,5 /                                            TATP0043
      DEFINE FILE 1 ( 2520,6,U,K1)                                      TATP0044
      DEFINE FILE 2 (2520,5,U,K2)                                       TATP0045
C                                                                       TATP0051
C FORMATS                                                               TATP0046
100   FORMAT (2I4)                                                      TATP0047
105   FORMAT ('1TRACK NUMBER ',I4,' ANGLES OF TURN')                    TATP0048
108   FORMAT ('OREC NO  DAY  HOUR  MINUTE  ANGLE'/)                     TATP0049
110   FORMAT ( ' ',I5,3X,I3,3X,I2,4X,I3,4X,I4)                          TATP0050
      K2 = 1                                                            TATP0052
C READ CONTROL CARD                                                     TATP0053
      READ (CARD,100) ISF,IEF                                           TATP0054
```

```
      IREC = ISF                                                        TATP0055
    1 READ (1'IREC) ITRK,IDY,IHR,IMN,ANG1                               TATP0056
      IREC = IREC + 1                                                   TATP0057
      K = 1                                                             TATP0058
    5 READ (1'IREC) JTRK,JDY,JHR,JMN,ANG2                               TATP0059
      IF (JTRK) 20,20,6                                                 TATP0060
C                                                                       TATP0061
C IF TIME LAPSE IS GREATER THAN 45 MINUTES, OMIT FIRST POINT.           TATP0062
    6 IF ((((JHR - IHR) * 60 + JMN) - IMN) - 45) 10,7,7                 TATP0063
C TO COMPUTE TURNING ANGLE                                              TATP0065
   10 IANG = IFIX ( ANG2 + 0.501)  -  IFIX (ANG1 + 0.501)               TATP0066
      IF (IANG) 16,30,12                                                TATP0067
   12 IF (IANG - 180) 30,14,14                                          TATP0068
   14 IANG = - (360 - IANG)                                             TATP0069
      GO TO 30                                                          TATP0070
   16 IF (IABS(IANG) - 180 ) 30,18,18                                   TATP0071
   18 IANG = 360 - IABS(IANG)                                           TATP0072
C TO TEMP STORE ANGLE OF TURN                                           TATP0074
   30 DAY(K) = JDY                                                      TATP0075
      HOUR(K) = JHR                                                     TATP0076
      MINUT(K) = JMN                                                    TATP0077
      ANGLE(K) = IANG                                                   TATP0078
      K = K + 1                                                         TATP0079
    7 IREC = IREC + 1                                                   TATP0080
      IMN = JMN                                                         TATP0081
      IHR = JHR                                                         TATP0082
      ANG1 = ANG2                                                       TATP0083
      GO TO 5                                                           TATP0084
C TO WRITE OUT TRACK DATA                                               TATP0086
   20 K = K - 1                                                         TATP0087
      J = K2                                                            TATP0088
      WRITE (PRINT,105) ITRK                                            TATP0089
      WRITE (PRINT,108)                                                 TATP0090
      DO 25 I = 1,K                                                     TATP0091
      WRITE (PRINT,110) J,DAY(I),HOUR(I),MINUT(I),ANGLE(I)              TATP0092
      J = J + 1                                                         TATP0093
   25 CONTINUE                                                          TATP0094
C                                                                       TATP0095
C TO LOAD FILE TSDT WITH TRACK DATA                                     TATP0096
      DO 28 I = 1,K                                                     TATP0097
   28 WRITE (2'K2) ITRK,DAY(I),HOUR(I),MINUT(I),ANGLE(I)                TATP0098
C                                                                       TATP0099
      I = 0                                                             TATP0100
      WRITE (2'K2) I                                                    TATP0101
C                                                                       TATP0102
      IF (IREC - 1 - IEF) 40,999,999                                    TATP0103
   40 IREC = IREC + 1                                                   TATP0104
      GO TO 1                                                           TATP0105
C                                                                       TATP0106
  999 CALL EXIT                                                         TATP0107
      END                                                               TATP0108
// DUP                                                                  TATP0109
*DELETE              TATP                                               TATP0110
*STORE       WS  UA  TATP                                               TATP0111
```

Table 9. Example of output of file TSDT as printed by program TATP.

TRACK NUMBER 1470, ANGLES OF TURN

REC NO	DAY	HOUR	MINUTE	ANGLE
1740	216	10	30	-13
1741	216	10	45	-24
1742	216	11	0	36
1743	216	11	15	-22
1744	216	11	30	57
1745	216	11	45	-76
1746	216	12	0	-81
1747	216	12	15	-136
1748	216	12	31	79
1749	216	13	53	37
1750	216	14	0	-13
1751	216	14	15	0
1752	216	14	30	26
1753	216	14	45	6
1754	216	15	0	3
1755	216	15	15	-41
1756	216	15	30	3
1757	216	15	45	4
1758	216	16	0	50
1759	216	16	15	-45
1760	216	16	30	73
1761	216	16	45	-30
1762	216	17	0	-9
1763	216	17	15	20
1764	216	17	30	-22
1765	216	17	45	-20
1766	216	18	0	2
1767	216	18	15	-2
1768	216	18	30	-68
1769	216	18	45	33
1770	216	19	0	19
1771	216	19	15	-13
1772	216	19	30	-2
1773	216	19	45	32
1774	216	20	0	72
1775	216	20	15	-9
1776	216	20	30	-21
1777	216	20	45	-30
1778	216	21	0	-26
1779	216	21	15	1
1780	216	21	30	-16
1781	216	21	45	17
1782	216	22	0	19
1783	216	22	30	-15
1784	216	22	45	2
1785	216	23	0	-10
1786	216	23	15	4
1787	216	23	30	38
1788	216	23	45	-76
1789	217	0	1	-26
1790	217	0	15	-23
1791	217	0	45	112

```
// JOB                                                                  ATPLT001
// FOR                                                                  ATPLT002
*IOCS(2501 READER,PLOTTER,DISK)                                         ATPLT003
*ONE WORD INTEGERS                                                      ATPLT004
*LIST ALL                                                               ATPLT005
*NAME ATPLT                                                             ATPLT006
**ATPLT - PROGRAM TO PLOT TURNING ANGLES FOR ENTIRE TRACK.              ATPLT007
C                                                                       ATPLT008
C ********************************************************************* ATPLT009
C                                                                       ATPLT010
C BOTH CLOCKWISE AND ANTI - CLOCKWISE DIRECTIONS ARE PLOTTED.           ATPLT011
C                                                                       ATPLT012
C INPUT                                                                 ATPLT013
C   - ALL DATA IS READ FROM FILE TSDT.                                  ATPLT014
C   CONTROL CARD.                                                       ATPLT015
C       COLS. 1-4  FIRST FILE RECORD DESIRED OF TSDT                    ATPLT016
C             5-8  LAST FILE RECORD OF TSDT DESIRED.                    ATPLT017
C       ALL TRACKS WITHIN ABOVE BOUNDS WILL BE PLOTTED SEPARATELY.      ATPLT018
C                                                                       ATPLT019
C USE *FILES(2,TSDT) TO EXECUTE THIS PROGRAM.                           ATPLT020
C                                                                       ATPLT021
C POSITION PLOTTER PEN ANYWHERE ON SMALL GRAPH PAPER.                   ATPLT022
C                                                                       ATPLT023
C ********************************************************************* ATPLT024
C                                                                       ATPLT025
      INTEGER CARD,PLOT,DAY(310),HOUR(310),ANGLE(310)                   ATPLT026
      DIMENSION MINUT(310)                                              ATPLT027
      DATA CARD,PLOT / 8,7 /                                            ATPLT028
      DEFINE FILE 2(2520,5,U,KI)                                        ATPLT029
C                                                                       ATPLT030
C FORMATS.                                                              ATPLT031
100   FORMAT (2I4)                                                      ATPLT032
102   FORMAT (I4)                                                       ATPLT033
104   FORMAT ('TRACK NUMBER ',I4)                                       ATPLT034
106   FORMAT ('1 HR = 0.2 INCHES')                                      ATPLT035
108   FORMAT ('TIME')                                                   ATPLT036
C                                                                       ATPLT037
C TO POSITION PLOTTER PEN.                                              ATPLT038
      CALL SCALF (1.0,1.0,0.0,0.0)                                      ATPLT039
      CALL FPLOT (1,0.0,-11.0)                                          ATPLT040
      CALL SCALF (1.0,1.0,0.0,0.0)                                      ATPLT041
      CALL FPLOT (1,0.0,5.0)                                            ATPLT042
C                                                                       ATPLT043
C READ CONTROL CARD                                                     ATPLT044
      READ (CARD,100) ISF,IEF                                           ATPLT045
      IREC = ISF                                                        ATPLT046
C                                                                       ATPLT047
    1 K = 1                                                             ATPLT048
C                                                                       ATPLT049
C TO READ DATA FOR ENTIRE TRACK.                                        ATPLT050
      READ (2'IREC) ITRK,DAY(K),HOUR(K),MINUT(K),ANGLE(K)               ATPLT051
    6 K = K + 1                                                         ATPLT052
      IREC = IREC + 1                                                   ATPLT053
    5 READ (2'IREC) JTRK,DAY(K),HOUR(K),MINUT(K),ANGLE(K)               ATPLT054
      IF (JTRK) 20,20,6                                                 ATPLT055
```

```
C                                                                       ATPLT056
C TO SET UP Y AXIS GRID.                                                ATPLT057
   20 CALL SCALF (0.2,0.02,0.0,0.0)                                     ATPLT058
      CALL FGRID (1,0.0,0.0,30.0,6)                                     ATPLT059
      X = -2.5                                                          ATPLT060
      Y = 180.0                                                         ATPLT061
      INC = 30                                                          ATPLT062
      IY = 180                                                          ATPLT063
      DO 22 I = 1,7                                                     ATPLT064
      CALL FPLOT (1,X,Y)                                                ATPLT065
      WRITE (PLOT,102) IY                                               ATPLT066
      IY = IY - INC                                                     ATPLT067
      Y = Y - INC                                                       ATPLT068
   22 CONTINUE                                                          ATPLT069
      CALL FGRID (3,0.0,0.0,30.0,6)                                     ATPLT070
      Y = -180.0                                                        ATPLT071
      IY = -180                                                         ATPLT072
      DO 24 I = 1,6                                                     ATPLT073
      CALL FPLOT (1,X,Y)                                                ATPLT074
      WRITE (PLOT,102) IY                                               ATPLT075
      IY = IY + INC                                                     ATPLT076
      Y = Y + INC                                                       ATPLT077
   24 CONTINUE                                                          ATPLT078
C                                                                       ATPLT079
C WRITE OUT TITLE                                                       ATPLT080
      X = - 5.0                                                         ATPLT081
      Y = -40.0                                                         ATPLT082
      CALL FCHAR (X,Y,0.1,0.1,1.5705)                                   ATPLT083
      WRITE (PLOT,104) ITRK                                             ATPLT084
      X = - 4.0                                                         ATPLT085
      CALL FCHAR (X,Y,0.10,0.07,1.5705)                                 ATPLT086
      WRITE (PLOT,106)                                                  ATPLT087
C                                                                       ATPLT088
C TO SET UP X AXIS GRID                                                 ATPLT089
      K = K -1                                                          ATPLT090
      H1 = HOUR(1)                                                      ATPLT091
      D1 = DAY(1)                                                       ATPLT092
      D2 = DAY(K)                                                       ATPLT093
      H = HOUR(K)                                                       ATPLT094
      AM = MINUT(K)                                                     ATPLT095
      X = (D2 - D1) * 24.0 + H + AM / 60.0 + 1.0    - H1                ATPLT096
      CALL FPLOT (1,0.0,0.0)                                            ATPLT097
      CALL FPLOT(2,X,0.0)                                               ATPLT098
      X = X + 0.5                                                       ATPLT099
      Y = -2.0                                                          ATPLT100
      CALL FCHAR (X,Y,0.1,0.1,0.0)                                      ATPLT101
      WRITE (PLOT,108)                                                  ATPLT102
C                                                                       ATPLT103
C TO PLOT DATA POINTS.                                                  ATPLT104
      DO 30 I = 1,K                                                     ATPLT105
      D2 = DAY(I)                                                       ATPLT106
      H = HOUR(I)                                                       ATPLT107
      AM = MINUT(I)                                                     ATPLT108
      X = (D2 - D1) * 24.0 + H + AM / 60.0  - H1                        ATPLT109
      Y = ANGLE(I)                                                      ATPLT110
      CALL FPLOT (1,X,0.0)                                              ATPLT111
```

```
      CALL FPLOT (2,X,Y)                                        ATPLT112
   30 CONTINUE                                                  ATPLT113
      X = X + 25.0                                              ATPLT114
      CALL FPLOT (1,X,0.0)                                      ATPLT115
C                                                               ATPLT116
C TO CHECK IF DESIRED RECORD HAS BEEN REACHED.                  ATPLT117
      IF (IREC - 1 - IEF) 32,999,999                            ATPLT118
   32 IREC = IREC + 1                                           ATPLT119
      GO TO 1                                                   ATPLT120
C                                                               ATPLT121
  999 CALL EXIT                                                 ATPLT122
      END                                                       ATPLT123
// DUP                                                          ATPLT124
*DELETE              ATPLT                                      ATPLT125
*STORE      WS  UA   ATPLT                                      ATPLT126
```

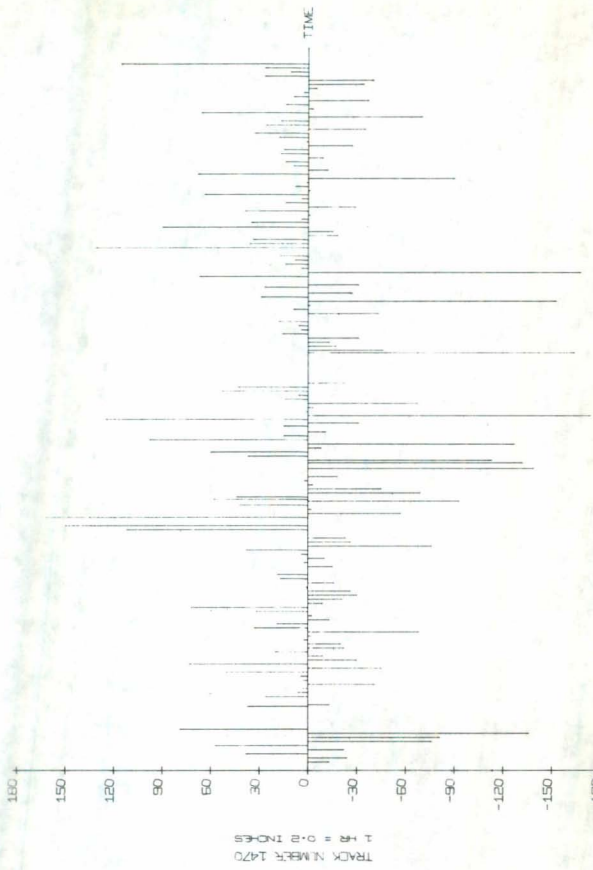

Fig. 6. Output program ATPLT for track 14-70 of clockwise and counterclockwise angular changes with time.

```
// JOB                                                                  TAHIS001
// FOR                                                                  TAHIS002
*IOCS(1403 PRINTER,2501 READER,PLOTTER,DISK)                            TAHIS003
*ONE WORD INTEGERS                                                      TAHIS004
*LIST ALL                                                               TAHIS005
*NAME TAHIS                                                             TAHIS006
** TAHIS - HISTOGRAM PLOT OF PERCENT FREQ. VS. TURNING ANGLE BY TRACK.  TAHIS007
C                                                                       TAHIS008
C ********************************************************************* TAHIS009
C                                                                       TAHIS010
C POSITION PLOTTER PEN ANYWHERE ON SMALL GRAPH PAPER.                   TAHIS011
C                                                                       TAHIS012
C DATA ( TURNING ANGLES ) ARE READ FROM DISK DATA FILE TSDT.            TAHIS013
C                                                                       TAHIS014
C USE *FILES (2,TSDT) TO EXECUTE THIS PROGRAM.                          TAHIS015
C                                                                       TAHIS016
C INPUT                                                                 TAHIS017
C   CONTROL CARD                                                        TAHIS018
C     COLS 1-4  FIRST FILE RECORD OF TSDT DESIRED.                      TAHIS019
C          5-8  LAST FILE RECORD OF TSDT DESIRED.                       TAHIS020
C     ALL TRACKS WITHIN ABOVE BOUNDS WILL BE PLOTTED SEPARATELY.        TAHIS021
C                                                                       TAHIS022
C ********************************************************************* TAHIS023
C                                                                       TAHIS024
      INTEGER PRINT,CARD,PLOT,ANGLE(310),TEST(18,2)                     TAHIS025
      DIMENSION HIST(36)                                                TAHIS026
      DATA PRINT,CARD,PLOT / 5,8,7 /                                    TAHIS027
      DEFINE FILE 2 (2520,5,U,KI)                                       TAHIS028
C                                                                       TAHIS029
C FORMATS                                                               TAHIS030
100   FORMAT (2I4)                                                      TAHIS031
102   FORMAT ('1TRACK NUMBER ',I4,', UNABLE TO FIND INTERVAL')          TAHIS032
110   FORMAT('1TRACK NUMBER ',I4,'.'/'0 DEGREES   PERCENT FREQUENCY'/)  TAHIS033
112   FORMAT (' ',I4,' TO ',I4,4X,F7.3)                                 TAHIS034
140   FORMAT (I3)                                                       TAHIS035
142   FORMAT ('FREQUENCY IN PERCENT')                                   TAHIS036
144   FORMAT ('TRACK NUMBER ',I4)                                       TAHIS037
146   FORMAT ('COUNTER CLOCKWISE')                                      TAHIS038
148   FORMAT ('CLOCKWISE')                                              TAHIS039
150   FORMAT (I4)                                                       TAHIS040
C                                                                       TAHIS041
      KI = 1                                                            TAHIS042
C                                                                       TAHIS043
C TEST CONTAINS 10 DEGREE INTERVAL BOUNDARIES FOR TURNING ANGLES        TAHIS044
      I = 0                                                             TAHIS045
      J = 10                                                            TAHIS046
      DO 2 K = 1,18                                                     TAHIS047
      TEST(K,1) = I                                                     TAHIS048
      TEST(K,2) = J                                                     TAHIS049
      I = J + 1                                                         TAHIS050
      J = J + 10                                                        TAHIS051
    2 CONTINUE                                                          TAHIS052
C                                                                       TAHIS053
C TO READ CONTROL CARD                                                  TAHIS054
      READ (CARD,100) ISF,IEF                                           TAHIS055
C                                                                       TAHIS056
```

```
C TO POSITION PLOTTER PEN                                              TAHIS057
      CALL SCALF (1.0,1.0,0.0,0.0)                                     TAHIS058
      CALL FPLOT (1,0.0,-11.0)                                         TAHIS059
      CALL SCALF (1.0,1.0,0.0,0.0)                                     TAHIS060
      CALL FPLOT (1,0.0,2.0)                                           TAHIS061
C                                                                      TAHIS062
C TO READ DATA OF ONE TRACK                                            TAHIS063
      IREC = ISF                                                       TAHIS064
    1 K = 1                                                            TAHIS065
      READ (2'IREC) ITRK,IY,IY,IY,ANGLE(K)                            TAHIS066
    5 K = K + 1                                                        TAHIS067
      IREC = IREC + 1                                                  TAHIS068
      READ (2'IREC) JTRK,IY,IY,IY,ANGLE(K)                            TAHIS069
      IF (JTRK) 10,10,5                                                TAHIS070
C                                                                      TAHIS071
C TO CALCULATE FREQUENCY BY INTERVAL                                   TAHIS072
   10 DO 12 I = 1,36                                                   TAHIS073
   12 HIST(I) = 0.0                                                    TAHIS074
      K = K - 1                                                        TAHIS075
      DO 20 I = 1,K                                                    TAHIS076
      IX = IABS(ANGLE(I))                                              TAHIS077
      DO 15 J = 1,18                                                   TAHIS078
      IF ((TEST(J,1)-IX)*0.1*(IX-TEST(J,2))) 15,16,16                  TAHIS079
   15 CONTINUE                                                         TAHIS080
      WRITE (PRINT,102) ITRK                                           TAHIS081
      GO TO 999                                                        TAHIS082
   16 IF (ANGLE(I)) 17,18,18                                           TAHIS083
   17 IX = 19 - J                                                      TAHIS084
   19 HIST(IX) = HIST(IX) + 1.0                                        TAHIS085
      GO TO 20                                                         TAHIS086
   18 IX = 18 + J                                                      TAHIS087
      GO TO 19                                                         TAHIS088
   20 CONTINUE                                                         TAHIS089
C                                                                      TAHIS090
C TO CALCULATE PERCENT FREQUENCY BY INTERVAL                           TAHIS091
      X = K                                                            TAHIS092
      DO 22 I = 1,36                                                   TAHIS093
   22 HIST(I) = HIST(I) / X * 100.0                                    TAHIS094
C                                                                      TAHIS095
C TO PRINT PERCENT FREQUENCY BY INTERVAL                               TAHIS096
      WRITE (PRINT,110) ITRK                                           TAHIS097
      I = -171                                                         TAHIS098
      J = -180                                                         TAHIS099
      DO 24 K = 1,18                                                   TAHIS100
      X = HIST(K) + 0.000501                                           TAHIS101
      WRITE (PRINT,112) I,J,X                                          TAHIS102
      I = I + 10                                                       TAHIS103
      J = J + 10                                                       TAHIS104
   24 CONTINUE                                                         TAHIS105
C                                                                      TAHIS106
      I = 0                                                            TAHIS107
      J = 10                                                           TAHIS108
      DO 26 K = 19,36                                                  TAHIS109
      X = HIST(K) + 0.000501                                           TAHIS110
      WRITE (PRINT,112) I,J,X                                          TAHIS111
      I = J + 1                                                        TAHIS112
```

```
      J = J + 10                                                        TAHIS113
   26 CONTINUE                                                          TAHIS114
C                                                                       TAHIS115
C TO PLOT                                                               TAHIS116
C                                                                       TAHIS117
C Y AXIS CONSTRUCTION                                                   TAHIS118
      CALL SCALF (0.25,0.07,0.0,0.0)                                    TAHIS119
      CALL FGRID (1,0.0,0.0,2.0,30)                                     TAHIS120
      IY = 60                                                           TAHIS121
      Y = IY                                                            TAHIS122
      INC = 10                                                          TAHIS123
      X = -1.9                                                          TAHIS124
      DO 28 I = 1,6                                                     TAHIS125
      YY = Y - 0.9                                                      TAHIS126
      CALL FPLOT (1,X,YY)                                               TAHIS127
      WRITE (PLOT,140) IY                                               TAHIS128
      IY = IY - INC                                                     TAHIS129
      Y = Y - INC                                                       TAHIS130
   28 CONTINUE                                                          TAHIS131
C                                                                       TAHIS132
C TO WRITE HEADING                                                      TAHIS133
      Y = 20.0                                                          TAHIS134
      X = -3.0                                                          TAHIS135
      CALL FCHAR (X,Y,0.10,0.10,1.5705)                                 TAHIS136
      WRITE (PLOT,142)                                                  TAHIS137
C                                                                       TAHIS138
C X AXIS CONSTRUCTION                                                   TAHIS139
      X = 14.0                                                          TAHIS140
      Y = -10.0                                                         TAHIS141
      CALL FCHAR (X,Y,0.10,0.13,0.0)                                    TAHIS142
      WRITE (PLOT,144) ITRK                                             TAHIS143
      X = 5.6                                                           TAHIS144
      Y = -5.0                                                          TAHIS145
      CALL FCHAR (X,Y,0.10,0.07,0.0)                                    TAHIS146
      WRITE (PLOT,146)                                                  TAHIS147
      X = 25.2                                                          TAHIS148
      CALL FPLOT (1,X,Y)                                                TAHIS149
      WRITE (PLOT,148)                                                  TAHIS150
C                                                                       TAHIS151
      CALL FCHAR (0.0,0.0,0.10,0.10,0.0)                                TAHIS152
      CALL FGRID (0,0.0,0.0,1.0,36)                                     TAHIS153
      X = 36.0 - 0.92                                                   TAHIS154
      IY = 180                                                          TAHIS155
      INC = 20                                                          TAHIS156
      Y = -2.2                                                          TAHIS157
      DO 30 I = 1,19                                                    TAHIS158
      CALL FPLOT (1,X,Y)                                                TAHIS159
      WRITE (PLOT,150) IY                                               TAHIS160
      X = X - 2.0                                                       TAHIS161
      IY = IY - INC                                                     TAHIS162
   30 CONTINUE                                                          TAHIS163
C                                                                       TAHIS164
C TO PLOT DATA                                                          TAHIS165
      DO 40 I = 1,36                                                    TAHIS166
      Y = HIST(I)                                                       TAHIS167
      IF (Y - 0.00501) 40,40,50                                         TAHIS168
```

```
C                                                                       TAHIS169
C  TO CHECK FOR POINTS OUT OF SCALE                                     TAHIS170
   50 IF ( Y - 60.0 ) 55,55,52                                          TAHIS171
   52 Y = 60.0                                                          TAHIS172
   55 X = I                                                             TAHIS173
      XX = I - 1                                                        TAHIS174
      CALL FPLOT (1,XX,0.0)                                             TAHIS175
      CALL FPLOT (2,XX,Y)                                               TAHIS176
      CALL FPLOT (2,X,Y)                                                TAHIS177
      CALL FPLOT (2,X,0.0)                                              TAHIS178
   40 CONTINUE                                                          TAHIS179
C                                                                       TAHIS180
      CALL FPLOT (1,55.0,0.0)                                           TAHIS181
C                                                                       TAHIS182
C  TO TEST IF LAST DESIRED RECORD HAS BEEN REACHED                      TAHIS183
      IF (IREC - 1 - IEF) 42,999,999                                    TAHIS184
   42 IREC = IREC +1                                                    TAHIS185
      GO TO 1                                                           TAHIS186
  999 CALL EXIT                                                         TAHIS187
      END                                                               TAHIS188
// DUP                                                                  TAHIS189
*DELETE            TAHIS                                              TAHIS190
*STORE       WS  UA  TAHIS                                             TAHIS191
```

Table 10. Example of output of program TAHIS of frequency in percent of clockwise and counterclockwise changes in 10^{o} intervals of track 14-70.

TRACK NUMBER 1470.

DEGREES	PERCENT FREQUENCY
-171 TO -180	0.637
-161 TO -170	1.274
-151 TO -160	0.637
-141 TO -150	0.000
-131 TO -140	1.911
-121 TO -130	0.637
-111 TO -120	0.637
-101 TO -110	0.000
-91 TO -100	0.637
-81 TO -90	1.274
-71 TO -80	1.274
-61 TO -70	2.548
-51 TO -60	0.637
-41 TO -50	3.185
-31 TO -40	4.459
-21 TO -30	8.280
-11 TO -20	8.280
-1 TO -10	9.554
0 TO 10	16.561
11 TO 20	12.102
21 TO 30	3.822
31 TO 40	7.006
41 TO 50	2.548
51 TO 60	2.548
61 TO 70	2.548
71 TO 80	1.911
81 TO 90	0.637
91 TO 100	0.637
101 TO 110	0.000
111 TO 120	1.274
121 TO 130	0.637
131 TO 140	0.637
141 TO 150	0.637
151 TO 160	0.000
161 TO 170	0.637
171 TO 180	0.000

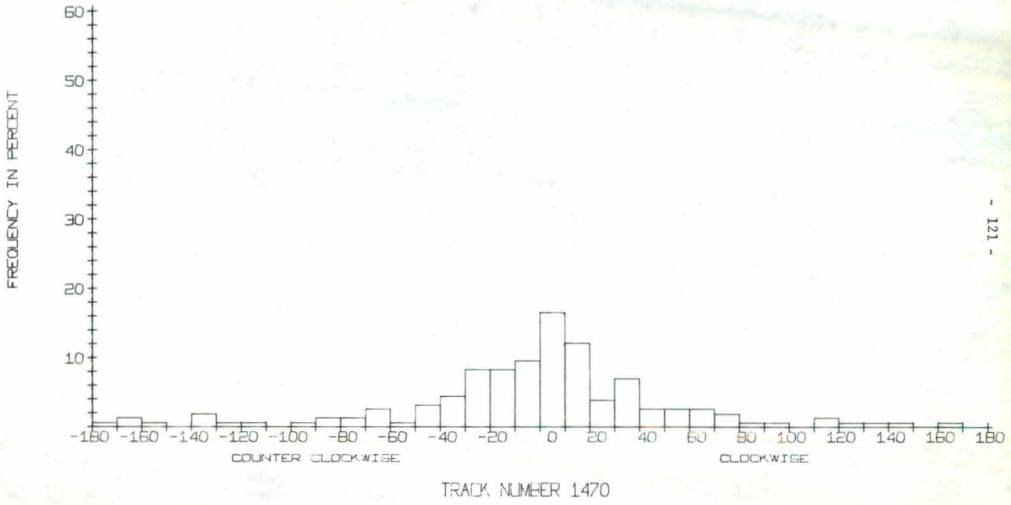

Fig. 7. Example of output program TAHIS of frequency in percent of clockwise and counterclockwise angular changes in 10° intervals of track 14-70.

```
// JOB                                                                  TACUM001
// FOR                                                                  TACUM002
*IOCS(2501 READER,DISK,PLOTTER)                                         TACUM003
*ONE WORD INTEGERS                                                      TACUM004
*LIST ALL                                                               TACUM005
*NAME TACUM                                                             TACUM006
** TACUM - CUMULATIVE PLOT LEFT AND RIGHT TURNS BY TRACK.               TACUM007
C                                                                       TACUM008
C ********************************************************************* TACUM009
C                                                                       TACUM010
C DATA (TURNING ANGLES) ARE READ FROM DISK DATA FILE TSDT.              TACUM011
C   USE *FILES(2,TSDT) TO EXECUTE THIS PROGRAM                          TACUM012
C                                                                       TACUM013
C POSITION PLOTTER PEN ANYWHERE ON SMALL PAPER.                         TACUM014
C                                                                       TACUM015
C INPUT                                                                 TACUM016
C   CONTROL CARD                                                        TACUM017
C       COLS 1-4  FIRST DESIRED RECORD OF TSDT                          TACUM018
C            5-8  LAST RECORD DESIRED OF TSDT.                          TACUM019
C       ALL TRACKS WITHIN ABOVE BOUNDS WILL BE PLOTTED SEPARATELY.      TACUM020
C                                                                       TACUM021
C ********************************************************************* TACUM022
C                                                                       TACUM023
      INTEGER CARD,PLOT                                                 TACUM024
      DIMENSION CUML(310),CUMR(310),IN(3)                               TACUM025
      DATA CARD,PLOT / 8,7 /                                            TACUM026
      DEFINE FILE 2(2520,5,U,KI)                                        TACUM027
C                                                                       TACUM028
C FORMATS                                                               TACUM029
100   FORMAT (2I4)                                                      TACUM030
102   FORMAT (F6.0)                                                     TACUM031
104   FORMAT ('CUMULATIVE ANGLE')                                       TACUM032
106   FORMAT ('TRACK NUMBER ',I4)                                       TACUM033
108   FORMAT ('* - CLOCKWISE TURNS')                                    TACUM034
110   FORMAT ('+ - COUNTER CLOCKWISE')                                  TACUM035
C                                                                       TACUM036
      KI = 1                                                            TACUM037
C                                                                       TACUM038
C TO READ CONTROL CARD                                                  TACUM039
      READ (CARD,100) ISF,IEF                                           TACUM040
C                                                                       TACUM041
C TO POSITION PLOTTER PEN                                               TACUM042
      CALL SCALF (1.0,1.0,0.0,0.0)                                      TACUM043
      CALL FPLOT (1,0.0,-11.0)                                          TACUM044
      CALL SCALF (1.0,1.0,0.0,0.0)                                      TACUM045
      CALL FPLOT (1,0.0,1.0)                                            TACUM046
C                                                                       TACUM047
C TO READ AND ACUMULATE ALL DATA OF ONE TRACK                           TACUM048
      IREC = ISF                                                        TACUM049
    1 READ (2'IREC) ITRK,IN,IANG                                        TACUM050
      K = 1                                                             TACUM051
      IF (IANG) 2,3,4                                                   TACUM052
    2 CUML(K) = IABS(IANG)                                              TACUM053
      CUMR(K) = 0.0                                                     TACUM054
      GO TO 5                                                           TACUM055
```

```
    3 CUML(K) = 0.0                                                    TACUM056
      CUMR(K) = 0.0                                                    TACUM057
      GO TO 5                                                          TACUM058
    4 CUMR(K) = IANG                                                   TACUM059
      CUML(K) = 0.0                                                    TACUM060
    5 K = K + 1                                                        TACUM061
      IREC = IREC + 1                                                  TACUM062
      READ (2'IREC) JTRK,IN,IANG                                       TACUM063
      IF (JTRK) 12,12,6                                                TACUM064
    6 IF (IANG) 7,8,9                                                  TACUM065
    7 CUML(K) = CUML(K-1) + IABS(IANG)                                 TACUM066
      CUMR(K) = CUMR(K-1)                                              TACUM067
      GO TO 5                                                          TACUM068
    8 CUML(K) = CUML(K-1)                                              TACUM069
      CUMR(K) = CUMR(K-1)                                              TACUM070
      GO TO 5                                                          TACUM071
    9 CUML(K) = CUML(K-1)                                              TACUM072
      CUMR(K) = CUMR(K-1) + IANG                                       TACUM073
      GO TO 5                                                          TACUM074
C                                                                      TACUM075
C TO FIND SCALE FOR Y AXIS                                             TACUM076
   12 K = K - 1                                                        TACUM077
      IF (CUML(K) - CUMR(K)) 14,14,15                                  TACUM078
   14 SM= CUMR(K)                                                      TACUM079
      GO TO 16                                                         TACUM080
   15 SM= CUML(K)                                                      TACUM081
   16 S =  7.0 / (SM * 0.1)                                            TACUM082
C                                                                      TACUM083
      DO 20 I = 1,K                                                    TACUM084
      CUML(I) = CUML(I) * S                                            TACUM085
      CUMR(I) = CUMR(I) * S                                            TACUM086
   20 CONTINUE                                                         TACUM087
C                                                                      TACUM088
      CALL SCALF (0.05,0.10,0.0,0.0)                                   TACUM089
      CALL FCHAR (0.0,0.0,0.1,0.1,0.0)                                 TACUM090
      X = -1                                                           TACUM091
      XX= +1                                                           TACUM092
      SM= SM/ 10.0 * S                                                 TACUM093
      DO 25 I = 1,10                                                   TACUM094
      Y = SM * I                                                       TACUM095
      CALL FPLOT (1,XX,Y)                                              TACUM096
      CALL FPLOT (2,X,Y)                                               TACUM097
      CALL FPLOT (1,-14.0,Y)                                           TACUM098
      YY = Y / S + 0.501                                               TACUM099
   25 WRITE (PLOT,102) YY                                              TACUM100
      CALL FPLOT(1,0.0,Y)                                              TACUM101
      CALL FPLOT(2,0.0,0.0)                                            TACUM102
C                                                                      TACUM103
      CALL FCHAR (-16.0,27.0,0.1,0.1,1.5705)                           TACUM104
      WRITE (PLOT,104)                                                 TACUM105
C                                                                      TACUM106
      X = K                                                            TACUM107
      CALL FPLOT (1,0.0,0.0)                                           TACUM108
      CALL FPLOT (2,X,0.0)                                             TACUM109
      CALL FCHAR (0.0,-4.5,0.1,0.1,0.0)                                TACUM110
      WRITE (PLOT,106) ITRK                                            TACUM111
```

```
      CALL FCHAR (0.0,-2.5,0.07,0.07,0.0)                              TACUM112
      WRITE (PLOT,1^^)                                                 TACUM113
      CALL FPLOT (1,0.0,-1.5)                                          TACUM114
      WRITE (PLOT,110)                                                 TACUM115
                                                                       TACUM116
C TO PLOT CLOCKWISE ANGLES                                             TACUM117
      CALL FPLOT (1,0.0,0.0)                                           TACUM118
      DO 40 I = 1,K                                                    TACUM119
      Y = CUMR(I)                                                      TACUM120
      X = I                                                            TACUM121
      CALL FPLOT (2,X,Y)                                               TACUM122
      IF (I/10 * 10-I) 40,38,40                                        TACUM123
   38 CALL POINT(3)                                                    TACUM124
      CALL POINT(1)                                                    TACUM125
   40 CONTINUE                                                         TACUM126
C                                                                      TACUM127
C TO PLOT COUNTER CLOCKWISE TURNS                                      TACUM128
      CALL FPLOT (1,0.0,0.0)                                           TACUM129
      DO 50 I = 1,K                                                    TACUM130
      Y = CUML(I)                                                      TACUM131
      X = I                                                            TACUM132
      CALL FPLOT (2,X,Y)                                               TACUM133
      IF (I/10 * 10 - I)  50,48,50                                     TACUM134
   48 CALL POINT(3)                                                    TACUM135
   50 CONTINUE                                                         TACUM136
C                                                                      TACUM137
      X = K + 90                                                       TACUM138
      CALL FPLOT (1,X,0.0)                                             TACUM139
C                                                                      TACUM140
      IF (IREC - 1 - IEF) 60,999,999                                   TACUM141
   60 IREC = IREC + 1                                                  TACUM142
      GO TO 1                                                          TACUM143
C                                                                      TACUM144
  999 CALL EXIT                                                        TACUM145
      END                                                              TACUM146
// DUP                                                                 TACUM147
*DELETE             TACUM                                             TACUM148
*STORE      WS  UA  TACUM                                             TACUM149
```

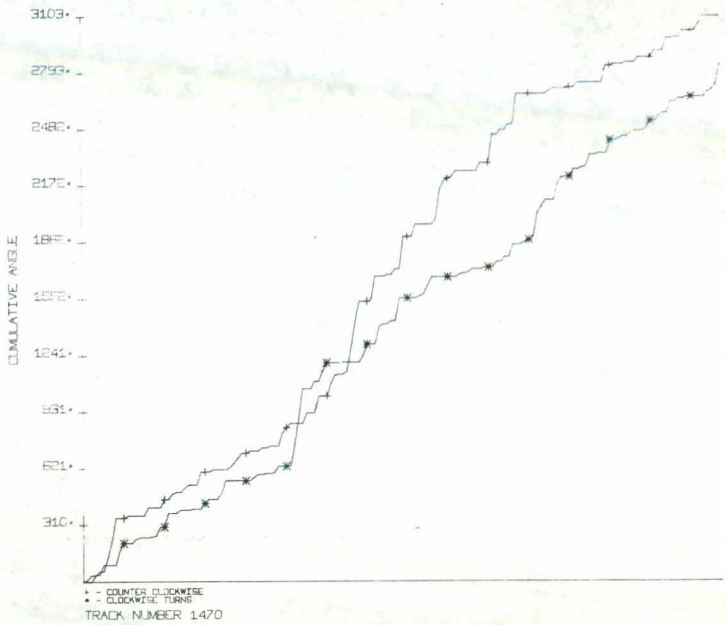

Fig. 8. Example of output program TACUM of cumulative angular changes of clockwise and counterclockwise turns for track 14-70. Marks on graph at 10 data point intervals.

SECTION 4

ENVIRONMENTAL DATA CODE

ENVIRONMENTAL CODING INSTRUCTIONS

General instructions

1. Columns on the code sheet (Fig. 9) should have numbers only. Do not leave any pertinent columns blank unless their value is zero.

2. Values not measured should be interpolated or extrapolated and entered between brackets in the records. There are special codes for this situation for directions only (00 = calm; 99 = unknown).

3. A regular recording schedule at 2-hr intervals should be kept with observations starting on the hour.

Code sheet explanation (Fig. 9)

FIELD 1: IDENTIFICATION CODE
Columns 1-4

FIELD 2: DATE
Columns 5-6 Day of month (01-31)
" 7-8 Month, January = 01 etc.
" 9-10 Year, last two digits only, e.g. 1962 = 62

FIELD 3: TIME
Columns 11-12 Hours (00-23)
" 13 Tenths of hours
Range = 00.0-23.9 TABLE 1

Table 1. Conversion Code

Minutes to 1/10 hours

Minutes	Tenths hours
00-03	0
04-09	1
10-15	2
16-21	3
22-27	4
28-33	5
34-39	6
40-45	7
46-51	8
52-57	9
58-59	0 (next hour)

FIELD 4: LIGHT INTENSITY
Columns 14-17
Enter as foot-candles in whole numbers

FIELD 5: WEATHER
Columns 18-19 Present weather TABLE 2

Table 2. Present Weather Code

Code	No precipitation on Station At time of Observation		Code	Precipitation on Station At time of Observation	
	No meteors except photometeors				
00	Cloud development not observed or not observable.	characteristic change of the state of sky during the past hour	50-59	Drizzle.	
			50	Drizzle, not freezing, intermittent	slight at time of observation
01	Clouds generally dissolving or becoming less developed.		51	Drizzle, not freezing, continuous	
			52	Drizzle, not freezing, intermittent	moderate at time of observation
02	State of sky on the whole unchanged.		53	Drizzle, not freezing, continuous	
			54	Drizzle, not freezing, intermittent	heavy (dense) at time of observation
03	Clouds generally forming or developing		55	Drizzle, not freezing, continuous	
	Haze, dust, sand or smoke		56	Drizzle, freezing, slight	
04	Visibility reduced by smoke, e.g. veldt or forest fires, industrial smoke or volcanic ashes.		57	Drizzle, freezing, moderate or heavy (dense)	
05	Haze.		58	Drizzle and rain, slight	
06	Widespread dust in suspension in the air, not raised by wind at or near the station at the time of observation.		59	Drizzle and rain, moderate or heavy	
			60-69	Rain	
07	Dust or sand raised by wind at or near the station at the time of observation, but no well developed dust whirl(s) or sand whirl(s), and no duststorm or sandstorm seen.		60	Rain, not freezing, intermittent	slight at time of observation
			61	Rain, not freezing, continuous	
			62	Rain, not freezing, intermittent	moderate at time of observation
08	Well developed dust whirl(s) or sand whirl(s) seen at or near the station during the preceding hour or at the time of observation, but no duststorm or sandstorm.		63	Rain, not freezing, continuous	
			64	Rain, not freezing, intermittent	heavy at time of observation
			65	Rain, not freezing, continuous	
09	Duststorm or sandstorm within sight at the time of observation, or at the station during the preceding hour.		66	Rain, freezing, slight	
			67	Rain, freezing, moderate or heavy	
			68	Rain or drizzle and snow, slight	
10	Mist.		69	Rain or drizzle and snow, moderate or heavy	
11	Patches of	shallow fog or ice fog at the station, whether on land or sea, not deeper than about 2 metres on land or 10 metres at sea	70-79	Solid precipitation not in showers	
12	More or less continuous		70	Intermittent fall of snow flakes	slight at time of observation
			71	Continuous fall of snow flakes	

Table 2 (cont'd)

Code	No precipitation on Station At time of Observation
13	Lightning visible, no thunder heard
14	Precipitation within sight, not reaching the ground or the surface of the sea
15	Precipitation within sight, reaching the ground or the surface of the sea, but distant (i.e., estimated to be more than 5 km) from the station
16	Precipitation within sight, reaching the ground or the surface of the sea, near to but not at the station
17	Thunderstorm, but no precipitation at the time of observation.
18	Squalls — at or within sight of the station during the preceding hour or at the time of observation
19	Funnel clouds — at or within sight of the station during the preceding hour or at the time of observation
20-29	Precipitation, fog, ice fog or thunderstorm at the station during the preceding hour but not at the time of observation
20	Drizzle (not freezing) or snow grains — not falling as shower(s)
21	Rain (not freezing) — not falling as shower(s)
22	Snow — not falling as shower(s)
23	Rain and snow or ice pellets, type (a) — not falling as shower(s)
24	Freezing drizzle or freezing rain — not falling as shower(s)
25	Shower(s) of rain
26	Shower(s) of snow, or of rain and snow
27	Shower(s) of hail, or of rain and hail

Code	Precipitation on Station At time of Observation
72	Intermittent fall of snow flakes — moderate at time of observation
73	Continuous fall of snow flakes — moderate at time of observation
74	Intermittent fall of snow flakes — heavy at time of observation
75	Continuous fall of snow flakes — heavy at time of observation
76	Ice prisms (with or without fog)
77	Snow grains (with or without fog)
78	Isolated star-like snow crystals (with or without fog)
79	Ice pellets, type (a)
80-99	Showery precipitation, or precipitation with current or recent thunderstorm
80	Rain shower(s), slight
81	Rain shower(s), moderate or heavy
82	Rain shower(s), violent
83	Shower(s) of rain and snow mixed, slight
84	Shower(s) of rain and snow mixed, moderate or heavy
85	Snow shower(s), slight
86	Snow shower(s), moderate or heavy
87	Shower(s) of snow pellets or ice pellets, type (b), with or without rain or rain and snow mixed — slight
88	Shower(s) of snow pellets or ice pellets, type (b), with or without rain or rain and snow mixed — moderate or heavy
89	Shower(s) of hail, with or without rain or rain and snow mixed, not associated with thunder — slight
90	Shower(s) of hail, with or without rain or rain and snow mixed, not associated with thunder — moderate or heavy
91	Slight rain at time of observation — thunderstorm

Table 2 (cont'd)

Code	No precipitation on Station At time of Observation		Code	Precipitation on Station At time of Observation	
28	Fog or ice fog		92	Moderate or heavy rain at time of observation	during the preceding hour but not at time of observation
29	Thunderstorm (with or without precipitation)		93	Slight snow, or rain and snow mixed or hail at time of observation	
30-39	Duststorm, sandstorm, drifting or blowing snow		94	Moderate or heavy snow, or rain and snow mixed or hail at time of observation	
30	Slight or moderate duststorm or sandstorm	-has decreased during the preceding hour	95	Thunderstorm, slight or moderate, without hail, but with rain and/or snow at time of observation	thunderstorm at time of observation
31		-no appreciable change during the preceding hour	96	Thunderstorm, slight or moderate, with hail at time of observation	
32		-has begun or has increased during the preceding hour	97	Thunderstorm, heavy, without hail, but with rain and/or snow at time of observation	
33	Severe duststorm or sandstorm	-has decreased during the preceding hour	98	Thunderstorm, combined with duststorm or sandstorm at time of observation	
34		-no appreciable change during the preceding hour	99	Thunderstorm, heavy with hail at time of observation	
35		-has begun or has increased during the preceding hour			
36	Slight or moderate blowing snow	generally low (below eye level)			
37	Heavy drifting snow				
38	Slight or moderate blowing snow	generally high (above eye level)			
39	Heavy blowing snow				
40-49	Fog or ice fog at the time of observation				
40	Fog or ice fog at a distance at the time of observation, but not at the station during the preceding hour, the fog or ice fog extending to a level above that of the observer				
41	Fog or ice fog in patches				
42	Fog or ice fog, sky visible	has become thinner			

Table 2 (cont'd)

Code	No precipitation on Station At time of observation	
43	Fog or ice fog, sky invisible	during the preceding hour
44	Fog or ice fog, sky visible	no appreciable change during the preceding hour
45	Fog or ice fog, sky invisible	
46	Fog or ice fog, sky visible	has begun or has become thicker during the preceding hour
47	Fog or ice fog, sky invisible	
48	Fog depositing rime, sky visible	
49	Fog, depositing rime, sky invisible	

Column 20 Past weather TABLE 3

Table 3. Past Weather Code

Code	
0	Cloud cover 1/2 or less throughout period
1	Changing cloud cover - from more than 1/2 to less than 1/2, or vice versa, during period
2	Cloud cover more than 1/2 throughout period
3	Sandstorm, duststorm, or blowing snow
4	Fog or thick haze (visibility less than1100 yards)
5	Drizzle
6	Rain
7	Snow, or rain and snow mixed
8	Shower(s)
9	Thunderstorm(s) with or without percipitation

NOTE: Describe weather prevailing between previous and present observations using the highest code figure.

FIELD 6: CLOUD

Column 21 Cloud type; code from TABLE 4
" 22 Cloud height; code from TABLE 5
" 23 Cloud cover
Enter as oktas (eighths), e.g. 1 = 1/8 cloud cover. 8 is recorded when the sky is obscured

Table 4. Cloud Type Code

Code	Cloud Type	Code	Cloud Type
0	Clear sky	5	Cumulus
1	Cirrus	6	Cumulonimbus
2	Cirrostratus	7	Altostratus
3	Cirrocumulus	8	Stratocumulus
4	Altocumulus	9	Stratus/Nimbostratus

Table 5. Cloud Height Code

Code	Cloud Height
0	Clear sky
1	Over 3,000 m (10,000 ft) Cirrus Cirrocumulus Cirrostratus
2	1,200-3,000 m (4,000-10,000 ft) Altocumulus Altostratus Stratocumulus
3	400-1,200 m (1,300-4,000 ft) Stratocumulus Cumulus
4	Below 400 m (1,300 ft) Stratocumulus Stratus/Nimbostratus
5	Fog

FIELD 7: VISIBILITY

Column 24 Horizontal visibility TABLE 6

Table 6. Horizontal Visibility Code

Code	Estimate of hor. Visibility	
0	Less than 50 metres	(less than 55 yards)
1	50-200 metres	(Approx. 55-220 yards)
2	200-500 metres	(Approx. 220-550 yards)
3	500-1,000 metres	(Approx. 550 yards - 5/8 n.m.)
4	1-2 km	(Approx. 5/8 - 1 n.m.)
5	2-4 km	(Approx. 1-2 n.m.)
6	4-10 km	(Approx. 2-6 n.m.)
7	10-20 km	(Approx. 6-12 n.m.)
8	20-50 km	(Approx. 12-30 n.m.)
9	50 km or more	(30 n.m. or more)

Note: n.m. = nautical mile

Day: Choose dark objects against the horizon. They should be away from the sun and subtend a visual angle of 0.5 to 5 degrees.

Night: Choose low candle power, noncollimated lights at shorter distances. Avoid using beacons except for long ranges and pick a light where other lights are not in the background.

Column 25 Sun visibility

Bright = 4
3
Half = 2
1
Invisible = 0

Column 26 Moon visibility

Multiply Brightness by Phase

Bright = 3 Full moon = 3
Moderate = 2 50-80% = 2
Vague = 1 10-40% = 1
Invisible = 0 0-10% = 0

Column 27 Star visibility

Bright	= 4
	3
Half	= 2
	1
Invisible	= 0

FIELD 8: WIND

Columns 28-29 True direction from which wind is blowing to nearest ten degrees TABLE 7

Table 7. Direction Code

Code	Direction	Code	Direction
00	Calm	19	185° to 194°
01	5° to 14°	20	195° to 204° - SSW
02	15° to 24° - NNE	21	205° to 214°
03	25° to 34°	22	215° to 224°
04	35° to 44°	23	225° to 234° - SW
05	45° to 54° - NE	24	235° to 244°
06	55° to 64°	25	245° to 254° - WSW
07	65° to 74° - ENE	26	255° to 264°
08	75° to 84°	27	265° to 274° - W
09	85° to 94° - E	28	275° to 284°
10	95° to 104°	29	285° to 294° - WNW
11	105° to 114° - ESE	30	295° to 304°
12	115° to 124°	31	305° to 314°
13	125° to 134°	32	315° to 324° - NW
14	135° to 144° - SE	33	325° to 334°
15	145° to 154°	34	335° to 344° - NNW
16	155° to 164° - SSE	35	345° to 354°
17	165° to 174°	36	355° to 4° - N
18	175° to 184° - S	99	wind direction variable or unknown

Column 30 Beaufort force of wind estimated or measured TABLE 8

Table 8. Wind Force Code

Code	Speed km/hr	Speed Knots	Appearance of sea if fetch and duration of the blow have been sufficient to develop the sea fully	Description
0	<2	<1	Sea like a mirror.	Calm
1	2-6	1-3	Ripples with the appearance of scales are formed but without foam crests.	Light air
2	7-11	4-6	Small wavelets; crests have a glassy appearance and do not break.	Light breeze
3	12-18	7-10	Large wavelets; crests begin to break; perhaps scattered white horses.	Gentle breeze
4	19-29	11-16	Small waves, becoming longer; fairly frequent white horses.	Moderate breeze
5	30-38	17-21	Moderate waves; many white horses are formed (chance of some spray).	Fresh breeze
6	39-49	22-27	Large waves; white foam crests everywhere (probably some spray).	Strong breeze
7	50-60	28-33	Sea heaps up and white foam from breaking waves begins to be blown in streaks along direction of wind.	Near gale
8	61-73	34-40	Moderately high waves; edges of crests begin to break into spindrift; well-marked foam streaks.	Gale
9	74-85	41-47	High waves; dense streaks of foam along wind; crests begin to topple, tumble and roll over; spray may affect visibility.	Strong gale

FIELD 9: ATMOSPHERIC PRESSURE

Columns 31-34 Sea level barometric pressure in millibars to one decimal. Subtract 900.0 mb, e.g. 1009.6 mb = 109.6. If the station is not at sea level, add a correction term. i.e. Code = measurement - (900.0 - altitude correction).

FIELD 10: AIR TEMPERATURE

Columns 35-37 Present air temperature in tenths of °C. If temperature is below 0°C, add 50 to value.

" 38-40 Maximum air temperature for the day or since the last observation. Coded as above.

" 41-43 Minimum air temperature for the day or since the last observation. Coded as above.

FIELD 11: HUMIDITY
Columns 44-46 Several parameters could be entered:

(a) Wet bulb temperature of a psychometer (in tenths of °C).

(b) Relative humidity calculated from wet bulb temperature or measured by an hygrometer (in percent).

(c) Vapor pressure calculated from wet bulb temperature or relative humidity (in tenths of millibars).

FIELD 12: PRECIPITATION
Columns 47-49 Precipitation (in 0.01 inches) for the day or as cumulated readings taken at each observation time during the day.

FIELD 13: HOURS OF SUNSHINE
Columns 50-52 Hours of bright sunshine to one decimal place for the day or since the last observation.

FIELD 14: WAVES*

Columns	53-54	Direction from which waves come	TABLE 7
"	55	Wave height	TABLE 9
"	56-57	Period of waves	TABLE 10
"	58	Description of crests	TABLE 11

*Record the major wave system if there is a cross-sea.

Table 9. Wave Height Code

Code	Height	Code	Height
0	Flat calm	5	90-150 cm (3-5 ft)
1	<15 cm (6 in)	6	150-210 cm (5-7 ft)
2	15-30 cm (6-12 in)	7	210-300 cm (7-10 ft)
3	30-60 cm (1-2 ft)	8	300-450 cm (10-15 ft)
4	60-90 cm (2-3 ft)	9	>450 cm (15 ft)

Table 10. Wave Period Code

Code	Period
00	Flat calm
01	<30 cm (1 ft)
02	<60 cm (2 ft)
03	<90 cm (3 ft)

etc.

Table 11. Code for Description of Crests

Code	Crests
0	Flat calm
1	Smooth, convex crests
2	Sharp crests
3	A few whitecaps
4	Waves usually breaking

FIELD 15: TURBULENCE
Column 59 Code from TABLE 12

Table 12. Turbulence Code

Code	Turbulence	Code	Turbulence
0	Calm	5	Tide-rip
1	Simple waves	6	Tidal race
2	Ripple on wave surface	7	Eddies
3	Cross-sea	8	Boils
4	Standing waves	9	Rapids

FIELD 16: SECCHI DISC VISIBILITY
Columns 60-62 Values in meters to one decimal place.

FIELD 17: WATER TEMPERATURE
Columns 63-65 Water temperature at surface in °C.
" 66-68 Water temperature at depth of fish being tracked in °C.

FIELD 18: TIDE
Columns 69-71 Approximate difference between the tidal level at observation time and the level at nearest slack tide (in ft).
" 72 Ebb or flood indication

0 = Slack tide
1 = Ebb
2 = Flood

FIELD 19: CURRENT
Columns 73-74 Direction that water is flowing towards. TABLE 7
" 75-76 Speed of current in kilometers per hour (to one decimal place).

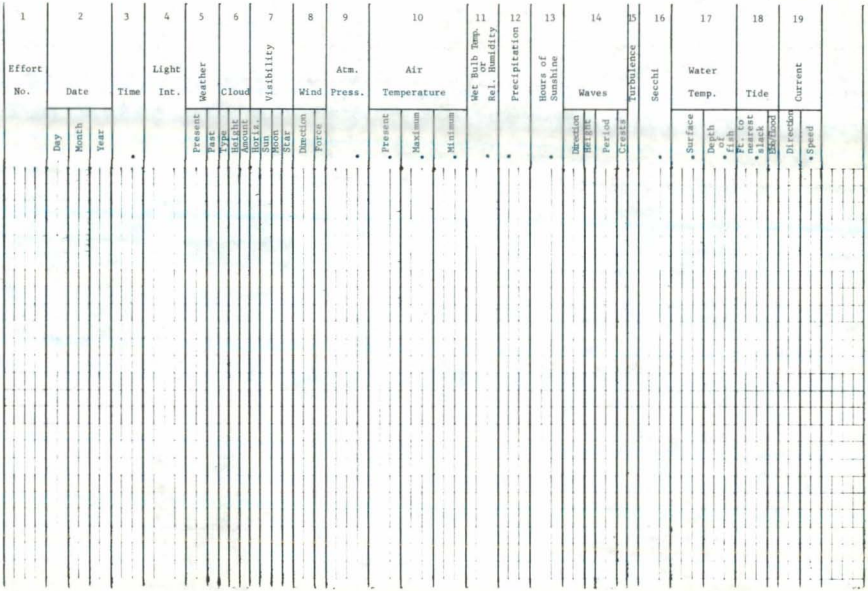

Fig. 9. Environmental record sheet.