NAVAL BIODYNAMICS LABORATORY
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X-RAY ANTHROPOMETRY DIGITIZATION PROGRAM

FOR THE HEWLETT-PACKARD 9000/835 COMPUTER

DOROTHY FRANCIS

Software Documentation

May 1991

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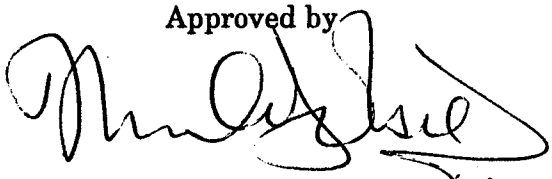

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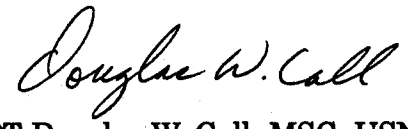

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This publication provides documentation of the X-ray anthropometry digitization program used on a Hewlett-Packard 9000/835 computer at the Naval Biodynamics Laboratory in New Orleans, LA.

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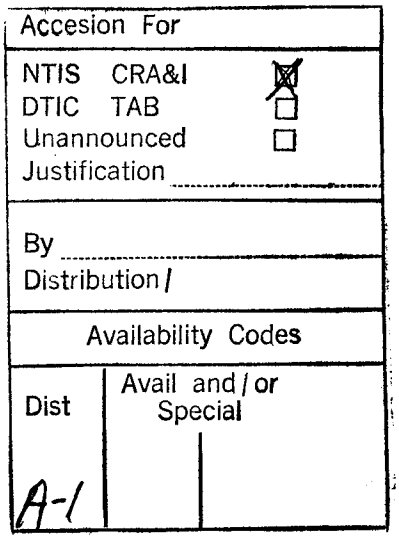

CONTENTS

X-RAY ANTHROPOMETRY DIGITIZATION PROGRAM FOR THE HEWLETT-PACKARD 9000/835 COMPUTER

1. INTRODUCTION

The Naval Biodynamics Laboratory (NAVBIODYNLAB), located in New Orleans, Louisiana, is a research facility under the cognizance of the Naval Medical Research and Development Command. The NAVBIODYNLAB is the principal Navy laboratory conducting biomedical research on the effects of mechanical forces (motion and impact) encountered by Navy personnel. Among its goals are the establishment of human tolerance limits and the development of appropriate methods of avoiding and treating the deleterious effects of such forces. Ongoing research programs at the laboratory acquire accelerometer and photographic impact data from NAVBIODYNLAB horizontal and vertical accelerators.

The proper analysis of data from NAVBIODYNLAB's impact experiments requires that two anatomical coordinate systems be defined, one on the head and one at the base of the neck on the first thoracic vertebra (T-1); these are depicted in Figures 1 and 2. The methodology for defining and obtaining these has been previously reported [1]. Motion data collected from inertial instrumentation packages on the head and T-1 are referenced to their own coordinate systems; thus knowledge of the transformation matrices from the instrument to the anatomical coordinate systems is also required.

This information is obtained from both anterior-posterior and lateral X-rays of the subject with instrument mounts in place. X-rays are taken for both T-1 and head mounts, and a set of calibration X-rays that utilize a plexiglass target containing an array of radio-opaque BBs located at known positions. When the X-rays are developed, tracings are made showing the locations of the BBs. Using BBs from the background plexiglass plate to determine the origin and reference axes for the X-rays, the locations of the other BBs on the X-ray are digitized. The digitized points are used to determine the instrumentation origin and the instrument-to-anatomy transformation matrices.

This report describes a computer program developed by NAVBIODYNLAB to calculate the required transformation matrices. Operational requirements for its use on the Hewlett-Packard 9000/835 computer interfaced with an HP9872T plotter/digitizer [2] are also described.

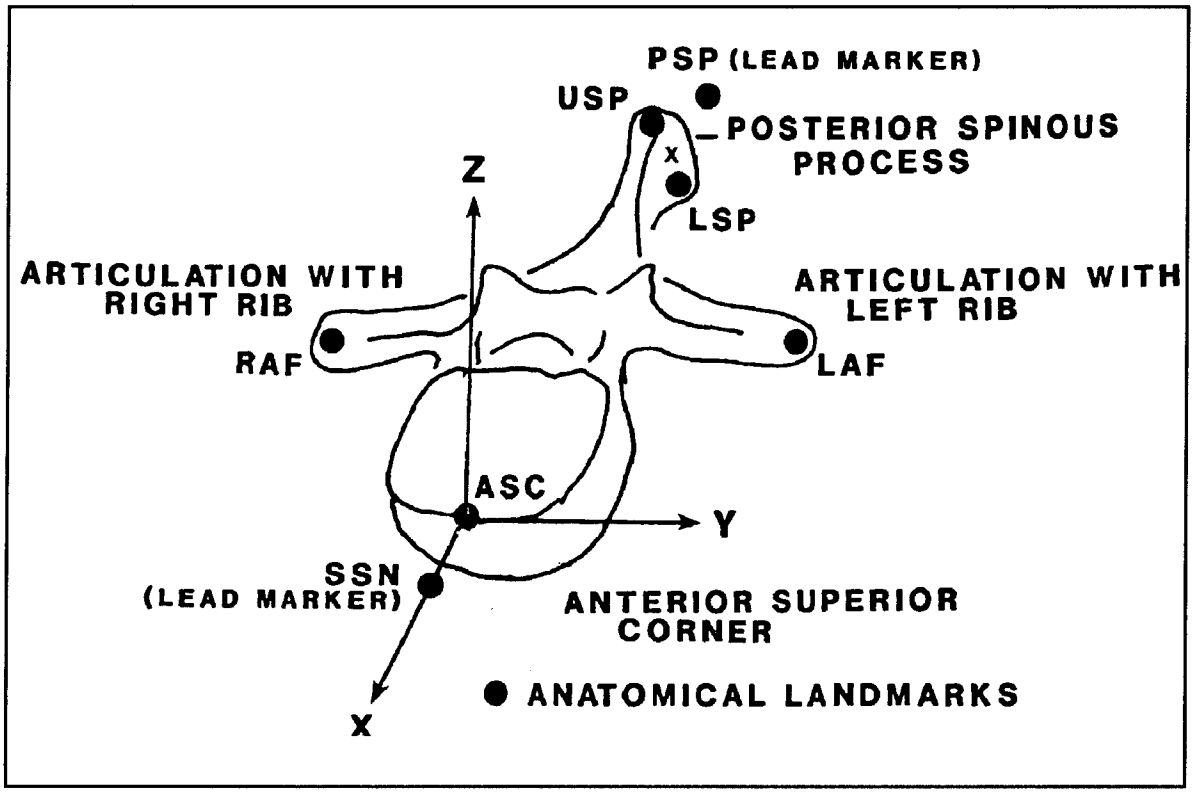

Figure 1. The T_1 Anatomical Coordinate System.

2. X-RAYS

There are six X-ray views that may be digitized:

1. Anterior-posterior X-ray of the head.
2. Lateral X-ray of the head.
3. Anterior-posterior X-ray of the neck.
4. Lateral X-ray of the neck.
5. Anterior-posterior calibration X-ray.
6. Lateral calibration X-ray.

The program allows the operator to select any of the six X-ray views for digitization, to print the results, and to plot the data back on the paper to confirm the results.

3. FUNCTION

The following program and subroutines are supplied:

XXRAY — Main program, which allows the operator to select major options.
XINIT — Allows the operator to define new subject identification.
APHED — Digitizes anterior-posterior X-rays of the head.
LTHED — Digitizes lateral X-rays of the head.
APNEC — Digitizes anterior-posterior X-rays of the neck.
LTNEC — Digitizes lateral X-rays of the neck.
APCAL — Digitizes anterior-posterior calibration X-rays.
LTCAL — Digitizes lateral calibration X-rays.

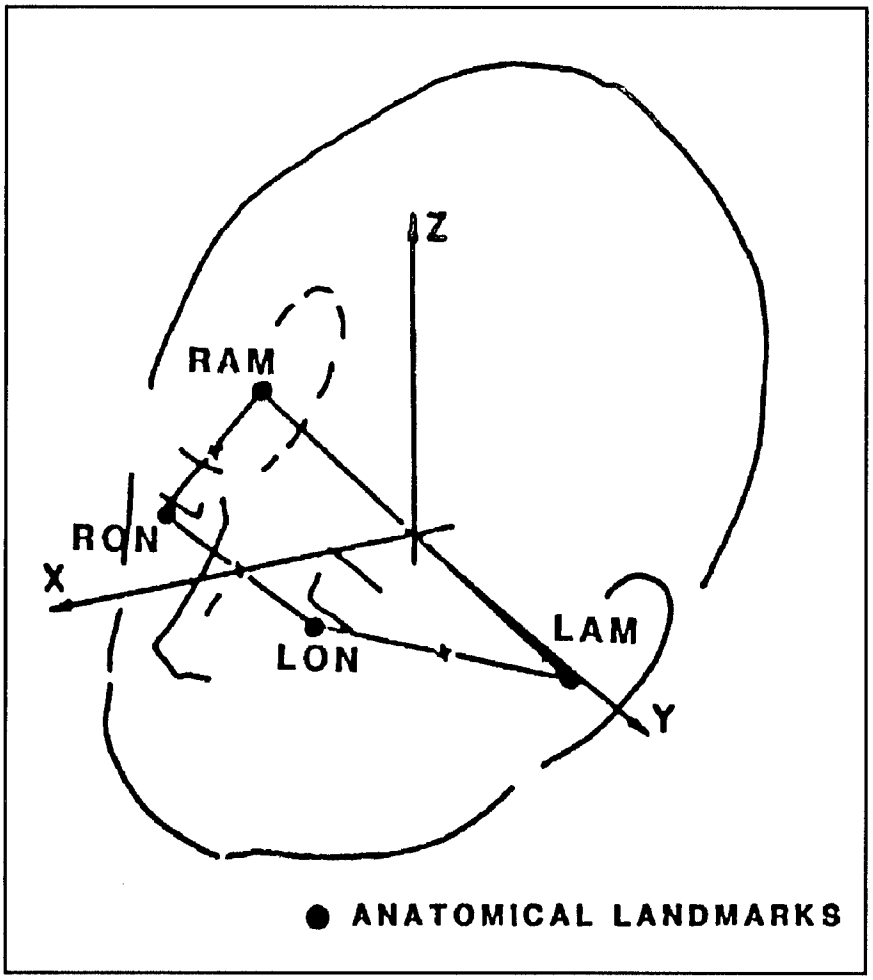

Figure 2. The Head Anatomical Coordinate System.

HPDIG — Digitizes a single point.
CAPPR — Writes to data files digitized data for the anterior-posterior calibration X-rays.
CLTPR — Writes to data files digitized data for the lateral calibration X-rays.
HEDPR — Writes to data files digitized data for the anterior-posterior and lateral X-rays of the head.
NECPR — Writes to data files digitized data of the anterior-posterior and lateral X-rays of the neck.
XRYCM — BLOCK DATA subroutine, which defines and initializes named common HDR.
XRYDG — Prompts operator during digitization of a series of points from X-ray.
XRYPL — Plots digitized results on HP9872T plotter.

The following utility subroutines are also supplied:

BELL — Sounds the bell on the terminal.
CONVERT — Converts a 20-byte character string to three integer variables.
DEC2I — Decodes 2-byte character string to integer variable.
ERASE — Clears the display screen on the terminal.
KWAIT — Waits for a response from the keyboard.
PLTIO — Input/Output subroutine package in the C programming language for the HP-9872T plotter.

4. MAIN PROGRAM

4.1 XXRAY

XXRAY is an interactive program for digitizing X-ray anthropometry data. The results may be written to a file for later printing or plotted for verification.

The operator may select the following options:

-1: Exit program.
0: Set up for new subject.
1: Digitize calibration A-P.
2: Digitize calibration lateral.
3: Digitize head A-P.
4: Digitize head lateral.
5: Digitize neck A-P.
6: Digitize neck lateral.

After an option has been selected, the appropriate subroutine is executed. For printed results, the print option of the specific subroutine must be executed.

4.2 COMPILATION

All the subroutines needed to execute the program are stored in the file 'libxrayant.a,' which is in the directory /7933/prod/source/anthropometry.

The program was compiled with the following command:

fc xxray.f libxrayant.a -o xxray

4.3 EXECUTION

The executable code is stored in a file named 'xxray.' To execute the program, type the file name and press the RETURN key. The program will instruct you to select one of the above options. To get printed results, execute the "lp" command using the file 'xrayprint.'

5. SUBROUTINE DESCRIPTIONS

5.1 XINIT

The XINIT routine allows the operator to define subject identification, mount identification, date, and general comments.

The call is:

CALL XINIT

5.2 APHED

The APHED routine digitizes anterior-posterior head X-rays. The operator may digitize points in standard sequence, redigitize selected points, print results, verify results by plotting the points, and exit from the subroutine.

The call is:

CALL APHED

The options are as follows:

-3: Exit subroutine.
-2: Plot results.
-1: Print results.
0: Digitize points in standard sequence.
1: Digitize only ORG: X,Y origin.
2: Digitize only Y AX: point on Y axis.
3: Digitize only RAM: right auditory meatus.
4: Digitize only LAM: left auditory meatus.
5: Digitize only RON: right orbital notch.
6: Digitize only LON: left orbital notch.
7: Digitize only CTP: center of T-plate.

8: Digitize only RTP: right T-plate.
9: Digitize only LTP: left T-plate.

5.3 LTHED

The LTHED routine digitizes lateral head X-rays. The operator may digitize points in standard sequence, redigitize selected points, print results, verify results by plotting the points, and exit from the subroutine as desired.

The call is:

CALL LTHED

The options are as follows:

-3: Exit subroutine.
-2: Plot results.
-1: Print results.
0: Digitize points in standard sequence.
1: Digitize only ORG: X,Y origin.
2: Digitize only Y AX: point on Y axis.
3: Digitize only RAM: right auditory meatus.
4: Digitize only LAM: left auditory meatus.
5: Digitize only RON: right orbital notch.
6: Digitize only LON: left orbital notch.
7: Digitize only CTP: center of T-plate.
8: Digitize only RTP: right T-plate.
9: Digitize only LTP: left T-plate.

5.4 APNEC

The APNEC routine digitizes anterior-posterior neck X-rays. The operator may digitize points in standard sequence, redigitize selected points, print results, verify results by plotting the points, and exit from the subroutine as desired.

The call is:

CALL APNEC

The options are as follows:

-3: Exit subroutine.
-2: Plot results.
-1: Print results.
0: Digitize points in standard sequence.
1: Digitize only ORG: X,Y origin.
2: Digitize only Y AX: point on Y axis.
3: Digitize only PSP: posterior spinous process.

4: Digitize only SSN: suprasternal notch.
5: Digitize only CTP: center of T-plate.
6: Digitize only RTP: right T-plate.
7: Digitize only LTP: left T-plate.
8: Digitize only RAF: right articular facet.
9: Digitize only LAF: left articular facet.

5.5 LTNEC

The LTNEC routine digitizes lateral neck X-rays. The operator may digitize points in standard sequence, redigitize selected points, print results, verify results by plotting the points, and exit from the subroutine as desired.

The call is:

CALL LTNEC

The options are as follows:

−3: Exit subroutine.
−2: Plot results.
−1: Print results.
0: Digitize points in standard sequence.
1: Digitize only ORG: X,Y origin.
2: Digitize only Y AX: point on Y axis.
3: Digitize only PSP: posterior spinous process.
4: Digitize only SSN: suprasternal notch.
5: Digitize only CTP: center of T-plate.
6: Digitize only RTP: right T-plate.
7: Digitize only LTP: left T-plate.
8: Digitize only ASC: anterior-superior corner.
9: Digitize only LSP: lower spinous process.
10: Digitize only USP: upper spinous process.

5.6 APCAL

The APCAL routine digitizes anterior-posterior calibration X-rays. The operator may digitize points in standard sequence, redigitize selected points, print results, verify results by plotting the points, and exit from the subroutine as desired.

The call is:

CALL APCAL

The options are as follows:

−3: Exit subroutine.

-2: Plot results.
-1: Print results.
0: Digitize points in standard sequence.
1: Digitize only ORG: X,Y origin.
2: Digitize only Y AX: point on Y axis.
3: Digitize only 3: 3.
4: Digitize only 13: 13.
5: Digitize only 4: 4.
6: Digitize only 11: 11.
7: Digitize only 10: 10.
8: Digitize only 9: 9.
9: Digitize only 2: 2.
10: Digitize only 12: 12.
11: Digitize only 1: 1.

5.7 LTCAL

The LTCAL routine digitizes lateral calibration X-rays. The operator may digitize points in standard sequence, redigitize selected points, print results, verify results by plotting the points, and exit from the subroutine as desired.

The call is:

CALL LTCAL

The options are as follows:

-3: Exit subroutine.
-2: Plot results.
-1: Print results.
0: Digitize points in standard sequence.
1: Digitize only ORG: X,Y origin.
2: Digitize only Y AX: point on Y axis.
3: Digitize only 5: 5.
4: Digitize only 13: 13.
5: Digitize only 8: 8.
6: Digitize only 11: 11.
7: Digitize only 10: 10.
8: Digitize only 9: 9.
9: Digitize only 6: 6.
10: Digitize only 12: 12.
11: Digitize only 7: 7.

5.8 HPDIG

The HPDIG routine digitizes a single point. This routine allows the operator to enter X,Y position of the digitizing sight.

The call is:

CALL HPDIG (X,Y)

where

X = X value of digitizing sight position.
Y = Y value of digitizing sight position.

5.9 CAPPR

The CAPPR routine documents the results of the digitizing operation. CAPPR is the anterior-posterior X-ray calibration write routine. The argument list defines the X-ray origin (first entry), a point on the +Y axis (second entry), and points of anatomical interest (third through ninth entries).

Each anatomical point is transformed from digitizer raster units to inches in the X-ray film coordinate system. The results are printed and identified using the 32 character label. The results are also written to data files.

The call is:

CALL CAPPR(X,Y,PNT,NPNT)

where

X = Array of X coordinates to be printed.
Y = Array of Y coordinates to be printed.
PNT = Array of 32 character labels to be printed.
NPNT = Number of entries in each of the above arrays (Entry 1 defines the origin of the X-ray coordinate system. Entry 2 defines the direction of the +Y axis).

5.10 CLTPR

The CLTPR routine documents the results of the digitizing operation. LTPR is the lateral X-ray calibration write routine. The argument list defines the X-ray origin (first entry), a point on the +Y axis (second entry), and points of anatomical interest (third through ninth entries).

Each anatomical point is transformed from digitizer raster units to inches in the X-ray film coordinate system. The results are printed and identified using the 32 character label. The results are also written to data files.

The call is:

CALL CLTPR(X,Y,PNT,NPNT)

where

X = Array of X coordinates to be printed.
Y = Array of Y coordinates to be printed.
PNT = Array of 32 character labels to be printed.
NPNT = Number of entries in each of the above arrays. (Entry 1 defines origin of the X-ray coordinate system. Entry 2 defines the direction of the +Y axis).

5.11 HEDPR

The HEDPR routine documents the results of the digitizing operation. HEDPR is the write routine for anterior-posterior and lateral X-rays of the head. The argument list defines the X-ray origin (first entry), a point on the +Y axis (second entry), and points of anatomical interest (third through ninth entries).

Each anatomical point is transformed from digitizer raster units to inches in the X-ray film coordinate system. The results are printed and identified using the 32 character label. The results are also written to data files.

The call is:

CALL HEDPR(X,Y,PNT,NPNT)

where

X = Array of X coordinates to be printed.
Y = Array of Y coordinates to be printed.
PNT = Array of 32 character labels to be printed.
NPNT = Number of entries in each of the above arrays. (Entry 1 defines origin of the X-ray coordinate system. Entry 2 defines the direction of the +Y axis).

5.12 NECPR

The NECPR routine documents the results of the digitizing operation. NECPR is the write routine for anterior-posterior (AP) and lateral X-rays of the neck. The argument list defines the X-ray origin (first entry), a point on the +Y axis (second entry), and points of anatomical interest (third through ninth entries).

Each anatomical point is transformed from digitizer raster units to inches in the X-ray film coordinate system. The results are printed and identified using the 32 character label. The results are also written to data files.

The call is:

CALL NECPR(X,Y,PNT,NPNT,ITYPE)

where

X = Array of X coordinates to be printed.
Y = Array of Y coordinates to be printed.
PNT = Array of 32 character labels to be printed.
NPNT = Number of entries in each of the above arrays. (Entry 1 defines origin of the X-ray coordinate system. Entry 2 defines the direction of the +Y axis).
ITYPE = Type of X-ray (AP or lateral).
1 — AP.
2 — lateral.

5.13 XRYCM

XRYCM is a block data subroutine that defines and initializes the named common HDR.

5.14 XRYDG

The XRYDG routine prompts the operator during digitization of a series of points from an X-ray. The operator is requested to enter specific points according to the type of X-ray being digitized.

The call is:

CALL XRYDG(X,Y,PNT,NPNT)

where

X = Array of X coordinates of points digitized.
Y = Array of Y coordinates of points digitized.
PNT = Array of 32 character labels for each point.
NPNT = Number of entries in each of the above arrays.

5.15 XRYPL

The XRYPL routine plots the digitized results. It is used to verify the X-ray digitization operation. Each X,Y coordinate specified in the argument list is circled and labelled on the plotter.

The call is:

CALL XRYPL(X,Y,PNT,NPNT)

where

X = Array of X coordinates to be plotted.
Y = Array of Y coordinates to be plotted.
PNT = Array of 32 character labels to be plotted. (Only the first four characters are drawn).
NPNT = Number of entries in each of the above arrays.

6. UTILITY SUBROUTINES

Several utility subroutines are used in the X-ray anthropometry program and are included in the program file. Therefore, a brief description of each is given in this section.

6.1 BELL

The routine BELL sounds the bell on the terminal.
The call is:

CALL BELL

6.2 CAPS

The routine CAPS enables the "caps" mode on the HP-2627A terminal.
The call is:

CALL CAPS

6.3 CAPOFF

The routine CAPOFF disables the "caps" mode on the HP-2627A terminal.
The call is:

CALL CAPOFF

6.4 CONVERT

The CONVERT routine converts a 20-byte character string to three integer variables. The input string is the character string read from the HP-9872T plotter after the execution of an output digitized point and pen status ("OD"). The X and Y coordinates and pen status (up or down) associated with the last digitized point is returned.
The call is:

CALL CONVERT(STR,IX,IY,IP)

where

STR	= 20-byte character string read from HP-9872T plotter.
IX	= X coordinate in absolute plotter units (returned integer).
IY	= Y coordinate in absolute plotter units (returned integer).
IP	= Pen status (0 = pen up, 1 = pen down).

6.5 DEC2I

The routine DEC2I decodes a 2-byte character string to an integer variable.
The call is:

CALL DEC2I (STR,I)

where

STR = 2-byte character string.
I = Returned integer.

6.6 ERASE

The ERASE routine clears the display screen on the terminal.
The call is:

CALL ERASE

6.7 KWAIT

The KWAIT routine waits for a response from the keyboard.
The call is:

CALL KWAIT

6.8 PLTIO

PLTIO is an input/output (I/O) subroutine package in the C programming language for the HP-9872T plotter. Most of HP-UX is written in C, and all the HP-UX system calls and subroutines are accessed as C functions. This is due mainly to the portability features of the C programming language. A feature of C is the "# include" file. Machine dependent code and declarations can be segregated in separate files, so that to port the code, you need only change some "# include" statements and supply the appropriate files to be included. HP-UX I/O operations seem to be based on this principle, since most I/O operations have to use the C language standard I/O package 'stdio.h'.

PLTIO is a machine-dependent code and the various C subroutines are as follows:

PLTIO — Writes out a status inquiry and sets status.
PLTOPEN — Opens the plotter.
PLTOUT — Writes a command out to the plotter.
PLTCLOSE — Closes the plotter.

6.9 USING PLTIO

PLTIO may be called from a FORTRAN program. Assuming there is a FORTRAN program in file 'main.f' that uses PLTIO, the commands to compile and link these two files are:

cc -c pltio.c

This creates the file 'pltio.o.'

fc main.f pltio.o

The resulting object file would be in 'a.out.'

6.10 PLTIO SUBROUTINE DESCRIPTIONS

6.10.1 PLTIO

The PLTIO routine requests and reads output status byte from the HP-9872T plotter. The call is:

CALL PLTIO (PLTID,OUTSTR,RESULT)

where

PLTID = Plotter device unit number.
OUTSTR = 4-byte character string containing the output status command "OS."
RESULT = 8-byte character string containing the status information read from the plotter.

6.10.2 PLTOPEN

The PLTOPEN routine opens the HP-9872T plotter by assigning it the logical unit number −1.

The call is:

CALL PLTOPEN (DEVICE,PLTID)

where

DEVICE = Device name on system.
PLTID = Plotter logical unit number.

6.10.3 PLTOUT

The PLTOUT routine writes a command out to the plotter.

The call is:

CALL PLTOUT (PLTID,OUTSTR)

where

PLTID = Plotter logical unit number.
OUTSTR = Four-byte character string containing the command to be written out.

6.10.4 PLTCLOSE

The PLTCLOSE routine closes the plotter down by disconnecting it from the logical unit assigned to it.

The call is:

CALL PLTCLOSE (PLTID)

where PLTID is the plotter logical unit number.

7. PROCEDURE FOR RUNNING THE HP-9000 DIGITIZING PROGRAM

Place the paper to be digitized on the HP9872 plotter bed and tape it to the surface. Place the digitizing sight in the pen holder.

To execute the program, type:

cd $anthropometry

and

xxray

7.1 SPECIFY SUBJECT IDENTIFICATION AND RELATED INFORMATION

The following messages will appear on the screen:

a. "aaaaaa(Subject ID)" Subject Identification.
   Key in the Subject ID.
b. "nnnn (mouth Mount ID)" Mouth Mount Number.
   Key in mouth mount number.
c. "nnnn (Neck Mount ID)" Neck Mount Number.
   Key in neck mount number.

d. "dddyy" (Julian date of X-ray).
"mmddyy" (Date of X-rays). Date X-ray was taken.
Key in dates.
e. "nnnnnnn (Start date) nnnnnnn (end date)" Start date and end date for the X-ray data.
Key in dates for animals. Key in 0 space 0 otherwise.
f. "aaaaaaaaaaaaaaaaaaaaaaaaaaaaaa" General Comments.

Key in any appropriate descriptive information.

7.2 SELECT TYPE OF X-RAYS

The following menu of options will be presented to the operator:

-1: Exit Program.
0: Set Up For New Subject.
1: Digitize Calibration A-P.
2: Digitize Calibration Lateral.
3: Digitize Head A-P.
4: Digitize Head Lateral.
5: Digitize Neck A-P.
6: Digitize Neck Lateral.

a. Key in a number from 1 through 6 to go to paragraph 3 and digitize the desired X-ray, or
b. Key in 0 to return to paragraph 1 for a new subject, or
c. Key in -1 to exit from the program when finished.

7.3 DIGITIZE SELECTED X-RAY VIEW

After selecting the desired X-ray view by typing in a number from 1 through 6, a heading descriptive of the selected view will appear on the screen. The operator will be presented with the following menu of options:

-3: Exit Subroutine
-2: Plot Results
-1: Print Results
0: Digitize Points in Standard Sequence
1:
.
.
. Digitize only a specific point
.
n:

Select the desired option by keying in the corresponding number:

(–3)	X-ray complete, return to main routine. Continue with paragraph 2.
(–2)	Plot and label all points digitized for this X-ray. Proceed as specified in paragraph 6.
(–1)	Print archival copy of digitized values for this X-ray. Proceed as specified in paragraph 5.
(0)	Digitize all data points in this X-ray in a predefined sequence. Proceed as specified in paragraph 4.
(1,2...,or N)	Select a particular data point to be redigitized from the X-ray. Proceed as specified in paragraph 7.

7.4 DIGITIZE POINTS IN A STANDARD SEQUENCE (MENU OPTION 0)

The first point the program will ask for will be the "ORG." This is the point of origin on the x,y axis and is digitized as follows:

a. Move the digitizing sight to the point by means of four directional buttons (arrows indicate up, down, left, and right).
b. When the digitizing sight is over the desired point on the paper, press the DOWN button until the sight touches the paper.
c. Move the sight until the black dot is directly over the point, then press the ENTER button.
d. The program reads the x,y value and lifts the sight off the paper. Next, the program will ask to digitize the point "Y AX" on the y axis. Repeat steps a, b, c, and d above.

The program continues to ask for points to be entered until all the points on that X-ray have been digitized. Repeat steps a, b, c, and d above for all of the points. After the last point is digitized, the menu at the start of paragraph 3 is displayed.

7.5 PRINT THE RESULTS (MENU OPTION –1)

This option should be executed for each X-ray.

All data associated with this X-ray are printed in the file 'xrayprint.' The printed output should be requested a few minutes after exiting the main program and can be produced with the following command:

lp xrayprint

All data associated with this X-ray is stored in the text file 'digoutput' and used for input to the main X-ray anthropometry program. To print this file use the following command:

lp digoutput

Examine the output for errors and redigitize data if necessary. The printed output should be saved as a permanent record of the digitized results. The program returns to the menu in paragraph 3.

7.6 PLOT THE RESULTS (MENU OPTION -2)

a. The following message will appear on the screen:

MANUALLY REMOVE DIGITIZING SIGHT FROM HOLDER
PLACE PEN IN STABLE #1
ENTER <BLANK><RETURN> TO CONTINUE

b. When this is done and you are ready to continue, press the RETURN key.

The plot routine will verify the results by using the plotter to draw a circle around and label each digitized point. Examples are appended at the end of this document.

c. Examine the output for errors and redigitize data if necessary. The program returns to the menu in paragraph 3.

7.7 RE-DIGITIZE A SPECIFIC POINT

Select the data point to be redigitized by keying in the number to the left of the data point on the menu.

a. Move the digitizing sight to that point by means of four directional buttons. (Arrows indicate up, down, left, and right.)
b. When the digitizing sight is over the desired point on the paper, press the DOWN button, so that the sight touches the paper.
c. Move the sight until the black dot is directly over the point and press the ENTER button.
d. The program reads the x,y value and lifts the sight off the paper.
e. Program returns to the menu in paragraph 3.

8. DESCRIPTION OF OUTPUT FILES

The output file 'digoutput' is used as input to the main X-ray anthropometry program. The format of the file is as follows:

Record 1: Subject identification number (Subjid), Julian Date, Mouth Mount, Neck Mount, Start Day, Start Year, End Day, End Year.
Record 2: Anterior-posterior calibration X values (13 values).
Record 3: Anterior-posterior calibration Y values (13 values).
Record 4: Lateral (LAT) calibration X values (13 values).
Record 5: Lateral calibration Y values (13 values).
Record 6: AP Head X values (RAM, LAM, RON, LON, CTP, RTP, LTP).
Record 7: AP Head Y values (RAM, LAM, RON, LON, CTP, RTP, LTP).
Record 8: LAT Head X values (RAM, LAM, RON, LON, CTP, TRP, LTP).
Record 9: LAT Head Y values (RAM, LAM, RON, LON, CTP, RTP, LTP).
Record 10: AP Neck X values (PSP, SSN, CTP, RTP, LTP).
Record 11: AP Neck Y values (PSP, SSN, CTP, RTP, LTP).
Record 12: LAT Neck X values (PSP, SSN, CTP, RTP, LTP).
Record 13: LAT Neck Y values (PSP, SSN, CTP, RTP, LTP).
Record 14: RAF X value, RAF Y value , LAF X value , LAF Y value (All AP).
Record 15: ASC X value, ASC Y value, LSP X value, LSP Y value, USP X value, USP Y value.

The print file is 'xrayprint.' Listings of files 'digoutput' and 'xrayprint' follow.

REFERENCES

1. Becker, E., "Stereoradiographic Measurements for Anatomically Mounted Instruments," *Proceedings the Twenty-first STAPP Car Crash Conference*, Society of Automotive Engineers, Inc., Warrendale, PA, 1977.
2. Hewlett-Packard Company, "9872 C Graphic Plotter and 9872T Graphic Plotter Operating and Programming Manual Using HP-GL Instructions," No. 09872-90011, Microfiche No. 09872-90061, San Diego, CA, 1980.

APPENDIX A

PROGRAM LISTING OF FILE "XRAYPRINT"

--------results of xray digitization--------

----------a-p cal ----------

subject : H00227
xray date : 3/13/90
mount id : 1101
comments : DIGITIZED DATA

point:	3	x: 2.613	y: 7.040	inches	:	3
point:	13	x: 6.655	y: 7.348	inches	:	13
point:	4	x: 11.052	y: 7.028	inches	:	4
point:	11	x: 2.415	y: 2.763	inches	:	11
point:	10	x: 6.651	y: 2.705	inches	:	10
point:	9	x: 11.496	y: 2.655	inches	:	9
point:	2	x: 2.565	y: -1.438	inches	:	2
point:	12	x: 6.655	y: -1.933	inches	:	12
point:	1	x: 11.048	y: -1.454	inches	:	1

--------results of xray digitization--------

----------lat cal ----------

subject : H00227
xray date : 3/13/90
mount id : 1101
comments : DIGITIZED DATA

point:	5	x: 1.830	y: 7.224	inches	:	5
point:	13	x: 5.754	y: 8.211	inches	:	13
point:	8	x: 10.045	y: 7.231	inches	:	8
point:	11	x: .156	y: 3.306	inches	:	11
point:	10	x: 5.784	y: 3.095	inches	:	10
point:	9	x: 10.290	y: 2.979	inches	:	9
point:	6	x: 1.467	y: -1.470	inches	:	6
point:	12	x: 5.839	y: -1.979	inches	:	12
point:	7	x: 10.158	y: -1.442	inches	:	7

--------results of xray digitization--------

----------a-p head----------

subject : H00227
xray date : 3/13/90
mount id : 1101
comments : DIGITIZED DATA

point: ram	x: 3.200	y: 2.965	inches	:	right auditory meatuse
point: lam	x: 8.819	y: 3.173	inches	:	left auditory meatuse
point: ron	x: 4.221	y: 4.512	inches	:	right orbital notch
point: lon	x: 7.411	y: 4.474	inches	:	left orbital notch
point: ctp	x: 5.467	y: 5.416	inches	:	center of t-plate
point: rtp	x: 2.434	y: 2.409	inches	:	right t-plate
point: ltp	x: 8.601	y: 2.354	inches	:	left t-plate

```
--------results of xray digitization--------

  ----------lat head----------

  subject    :  H00227
  xray date  :   3/13/90
  mount id   :  1101
  comments   :  DIGITIZED DATA

point: ram    x:  5.724   y:  3.548 inches  : right auditory meatuse
point: lam    x:  5.889   y:  3.502 inches  : left auditory meatuse
point: ron    x:  9.621   y:  5.252 inches  : right orbital notch
point: lon    x:  9.428   y:  4.952 inches  : left orbital notch
point: ctp    x: 12.878   y:  6.000 inches  : center of t-plate
point: rtp    x: 11.843   y:  3.087 inches  : right


--------results of xray digitization--------

  ----------a-p neck----------

  subject    :  H00227
  xray date  :   3/13/90
  mount id   :  2101
  comments   :  DIGITIZED DATA

point: psp    x:  5.915   y:  3.427 inches  : posterior spinous process
point: ssn    x:  5.867   y:   .585 inches  : suprasternal notch
point: ctp    x:  6.015   y:  4.338 inches  : center of t-plate
point: rtp    x:  3.052   y:  4.740 inches  : right t-plate
point: ltp    x:  8.589   y:  4.922 inches  : left t-plate
point: raf    x:  3.922   y:  3.934 inches  : right articular facet
point: laf    x:  7.563   y:  4.082 inches  : left articular facet


--------results of xray digitization--------

  ----------lat neck----------

  subject    :  H00227
  xray date  :   3/13/90
  mount id   :  2101
  comments   :  DIGITIZED DATA

point: psp    x:  6.053   y:  3.952 inches  : posterior spinous process
point: ssn    x: 12.331   y:  1.058 inches  : suprasternal notch
point: ctp    x:   .380   y:  5.014 inches  : center of t-plate
point: rtp    x:  3.283   y:  5.779 inches  : right t-plate
point: ltp    x:  3.682   y:  5.411 inches  : left t-plate
point: asc    x: 10.605   y:  3.639 inches  : anterior superior corner
point: lsp    x:  7.004   y:  4.089 inches  : lower spinous process
point: usp    x:  7.098   y:  4.376 inches  : upper spinous process
```

APPENDIX B

LISTING OF FILE "DIGOUTPUT"

```
H00209 10888 1101 2201   0   0  0   0
 10.386   1.648   1.532  10.273 999.000 999.000 999.000 999.000   9.278   4.890
  1.144   4.973   4.818
 -1.914  -1.944   6.812   7.015 999.000 999.000 999.000 999.000   2.285   2.327
  2.359  -2.526   7.180
999.000 999.000 999.000 999.000   2.924   2.415  11.212  11.315  11.119   5.850
 -.286    5.800   5.935
999.000 999.000 999.000 999.000   6.814  -1.942  -2.286   6.697   2.051   1.813
  1.548  -3.216   6.883
   .712   6.362    .994   4.576   2.565   -.581   5.697
  3.036   3.823   4.461   4.814   5.660   2.627   2.389
  1.778   3.033   7.023   7.421  11.146  10.489  10.542
  2.356   3.491   3.935   4.366   5.072   1.787   1.945
  4.729   4.216   5.040   1.992   7.698
  1.597  -1.608   4.446   4.522   4.175
  6.308  11.900   -.370   2.328   3.053
  1.045  -1.989   4.237   4.010   3.804
  2.304   1.575   6.920   1.459
 10.223   -.059   6.750    .369   6.984    .860
```

APPENDIX C

PROGRAM LISTING

X-Ray Anthropometry Digitization Program

```
FORTRAN 77/UX HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:15:50 1990


 1        subroutine apcal
 2  c
 3  c     function:
 4  c     interactive subroutine to digitize anterior-posterior
 5  c     calibration x-ray film. Operator may digitize points in standard
 6  c     sequence, redigitize selected points, print results,
 7  c     verify results by plotting points, and exit from the
 8  c     subroutine as desired.
 9  c
10  c
11  c     By:
12  c     W. Campos
13  c     QEI Computer And Information System Inc.
14  c     New Orleans Division
15  c     21 Nov 83
16  c     For:
17  c     Naval Biodynamics Laboratory
18  c     New Orleans, Louisiana
19  c     Contract: N00014-83-C-0691
20  c
21  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
22
23  c.....named common for header info
24        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
25       *idate, isday, isyear, ieday, ieyear
26  c
27  c.....organize data storage
28        character*6 ksubj
29        real  x(11),y(11)
30        integer pnt(8,11)
31        data pnt/
32       1 'org ','': x,','y or','igin','    ','    ','    ','    ',
33       2 'y ax','': po','int ','on y','  axi','s ','    ','    ',
34       3 '  3 ','':  3','    ','    ','    ','    ','    ','    ',
35       4 ' 13 ','': 13','    ','    ','    ','    ','    ','    ',
36       5 '  4 ','':  4','    ','    ','    ','    ','    ','    ',
37       6 ' 11 ','': 11','    ','    ','    ','    ','    ','    ',
38       7 ' 10 ','': 10','    ','    ','    ','    ','    ','    ',
39       8 '  9 ','':  9','    ','    ','    ','    ','    ','    ',
40       9 '  2 ','':  2','    ','    ','    ','    ','    ','    ',
41       * ' 12 ','': 12','    ','    ','    ','    ','    ','    ',
42       * '  1 ','':  1','    ','    ','    ','    ','    ','    '/
43        data npnt/11/
44        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
45  c
46  c
47  c.....identify subroutine
48  100   call erase
49        call bell
50        write(idsp,900) (i,(pnt(j,i),j=1,8),i=1,npnt)
51  900   format(' ---digitize a-p calibration x-ray---'//
52       1  ' place digitizing sight in hp-9872 plotter'/
53       2  ' place pen in station #1'//
54       3  '  -3: exit subroutine'/
55       4  '  -2: plot results'/
```

```
56          5  '  -1: print results'/
57          6  '   0: digitize points in standard sequence'/
58          7     11(i4,': digitize only ',8a4/) /
59          8  ' select option')
60           read(ikey,*,err=100,end=100) iopt
61    c
62    c.....execute option requested
63          if(iopt.eq.-3) return
64    c
65    c.....plot results
66          if(iopt.eq.-2) then
67              call xrypl(x,y,pnt,npnt)
68    c
69    c.....print and save results
70          else if(iopt.eq.-1) then
71              call cappr(x,y,pnt,npnt)
72    c
73    c.....digitize points in standard sequence
74          else if(iopt.eq.0) then
75              call xrydg(x,y,pnt,npnt)
76    c
77    c.....digitize specific point
78          else if(iopt.ge.1 .and. iopt.le.npnt) then
79              call xrydg(x(iopt),y(iopt),pnt(1,iopt),1)
80    c
81    c.....out of options
82          endif
83          go to 100
84    c
85    950   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i1,1x),20(f7.3,1x))
86    955   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i7,1x),20(f7.3,1x))
87          end

NUMBER OF ERRORS = 0         NUMBER OF WARNINGS = 0
```

X-Ray Anthropometry Digitization Program

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:15:57 1990


 1        subroutine aphed
 2  c
 3  c     function:
 4  c     interactive subroutine to digitize anterior-posterior
 5  c     head x-rays. Operator may digitize points in standard
 6  c     sequence, redigitize selected points, print results,
 7  c     verify results by plotting points, and exit from the
 8  c     subroutine as desired.
 9  c
10  c
11  c  By:
12  c     W. Anderson
13  c     Naval Biodynamics Laboratory
14  c     28 Oct 83
15  c
16  c  Revised by D. Francis for HP-9000 system 28 Aug 1986
17  c
18  c.....named common for header info
19        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
20       *idate,isday,isyear,ieday,ieyear
21  c
22  c.....organize data storage
23        character*6 ksubj
24        real  x(9),y(9)
25        integer pnt(8,9)
26        data pnt/
27       1 'org ',': x,',',y or','igin',',    ',',    ',',    ',' ',
28       2 'y ax',': po','int ','on y',',' axi','s',',    ',',    ',
29       3 'ram ',': ri','ght ','audi','tory',',' mea','tuse',',' ',
30       4 'lam ',': le','ft a','udit','ory ','meat','use ',',  ',
31       5 'ron ',': ri','ght ','orbi','tal ','notc','h  ',',   ',
32       6 'lon ',': le','ft o','rbit','al n','otch',',    ',',' ',
33       7 'ctp ',': ce','nter',',' of ',',t-pl','ate ',',    ',',' ',
34       8 'rtp ',': ri','ght ',',t-pl','ate ',',    ',',    ',',' ',
35       9 'ltp ',': le','ft t',',-pla','te  ',',    ',',    ',',' '/
36        data npnt/9/
37        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
38  c
39  c
40  c.....identify subroutine
41  100   call erase
42        call bell
43        write(idsp,900) (i,(pnt(j,i),j=1,8),i=1,npnt)
44  900   format(' ---digitize a-p head x-ray---'//
45       1  ' place digitizing sight in hp-9872 plotter'/
46       2  ' place pen in station #1'//
47       3  '  -3: exit subroutine'/
48       4  '  -2: plot results'/
49       5  '  -1: print and save results'/
50       6  '   0: digitize points in standard sequence'/
51       7     9(i4,': digitize only ',8a4)/)
52       8  'select option')
53        read(ikey,*,err=100,end=100) iopt
54  c
55  c.....execute option requested
```

```
56          if(iopt.eq.-3) return
57    c
58    c.....plot results
59          if(iopt.eq.-2) then
60              call xrypl(x,y,pnt,npnt)
61    c
62    c.....print and save results
63          else if(iopt.eq.-1) then
64              call hedpr(x,y,pnt,npnt)
65    c
66    c.....digitize points in standard sequence
67          else if(iopt.eq.0) then
68              call xrydg(x,y,pnt,npnt)
69    c
70    c.....digitize specific point
71          else if(iopt.ge.1 .and. iopt.le.npnt) then
72              call xrydg(x(iopt),y(iopt),pnt(1,iopt),1)
73    c
74    c.....out of options
75          endif
76          go to 100
77    c
78          950  format(a6,1x,i5,1x,a5,1x,i1,1x,2(i1,1x),20(f7.3,1x))
79          955  format(a6,1x,i5,1x,a5,1x,i1,1x,2(i7,1x),20(f7.3,1x))
80          end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:15:58 1990


 1        subroutine apnec
 2  c
 3  c     function:
 4  c     interactive subroutine to digitize anterior-posterior
 5  c     neck x-rays. Operator may digitize points in standard
 6  c     sequence, redigitize selected points, print results,
 7  c     verify results by plotting points, and exit from the
 8  c     subroutine as desired.
 9  c
10  c
11  c  By:
12  c     W. Campos
13  c     QEI Computer And Information System Inc.
14  c     New Orleans Division
15  c     21 Nov 83
16  c     For:
17  c     Naval Biodynamics Laboratory
18  c     New Orleans, Louisiana
19  c     Contract: N00014-83-C-0691
20  c
21  c  Revised by D. Francis for HP-9000 system 28 Aug 1986
22  c
23  c.....named common for header info
24        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
25       *idate,isday,isyear,ieday,ieyear
26  c
27  c.....organize data storage
28        character*6 ksubj
29        real  x(9),y(9)
30        integer pnt(8,9)
31        data pnt/
32       1 'org ','': x,',','y or','igin',','    ',','    ',','    ',','  ',
33       2 'y ax',': po','int ','on y',' axi','s  ',','    ',','  ',
34       3 'psp ',': po','ster','ior ','spin','ous ','proc','ess ',
35       4 'ssn ',': su','pras','tern','al n','otch',' ',',' ',
36       5 'ctp ',': ce','nter',' of ','t-pl','ate ',' ',',' ',
37       6 'rtp ',': ri','ght ','t-pl','ate ',','    ',',' ',',
38       7 'ltp ',': le','ft t','-pla','te  ',','    ',',' ',',
39       8 'raf ',': ri','ght ','arti','cula','r fa','cet ',' ',
40       9 'laf ',': le','ft a','rtic','ular',' fac','et  ',' '/
41       data npnt/9/
42       data idsp/6/,ikey/5/,iprt/1/,iplt/2/
43  c
44  c
45  c.....identify subroutine
46  100   call erase
47        call bell
48        write(idsp,900) (i,(pnt(j,i),j=1,8),i=1,npnt)
49  900   format(' ---digitize a-p neck x-ray---'//
50       1  ' place digitizing sight in hp-9872 plotter'/
51       2  ' place pen in station #1'//
52       3  '  -3: exit subroutine'/
53       4  '  -2: plot results'/
54       5  '  -1: print results'/
55       6  '   0: digitize points in standard sequence'/
```

```
56       7     9(i4,': digitize only ',8a4/) /
57       8  'select option')
58        read(ikey,*,err=100,end=100) iopt
59  c
60  c.....execute option requested
61        if(iopt.eq.-3) return
62  c
63  c.....plot results
64        if(iopt.eq.-2) then
65            call xrypl(x,y,pnt,npnt)
66  c
67  c.....print and save results
68        else if(iopt.eq.-1) then
69            call necpr(x,y,pnt,npnt,1)
70  c
71  c.....digitize points in standard sequence
72        else if(iopt.eq.0) then
73            call xrydg(x,y,pnt,npnt)
74  c
75  c.....digitize specific point
76        else if(iopt.ge.1 .and. iopt.le.npnt) then
77            call xrydg(x(iopt),y(iopt),pnt(1,iopt),1)
78  c
79  c.....out of options
80        endif
81        go to 100
82  c
83  950   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i1,1x),20(f7.3,1x))
84  955   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i7,1x),20(f5.3,1x))
85  c
86        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:01 1990


 1          subroutine bell
 2    c
 3    c     FUNCTION:
 4    c     sounds the bell
 5    c
 6    c     BY:
 7    c     D. Francis
 8    c     Naval Biodynamics Laboratory
 9    c     New Orleans, Louisiana
10    c     4 May 1987
11    c
12          equivalence (BEL,IB)
13    c
14          character*2 BEL
15    c
16          data IBELL/o'007'/
17    c
18          call mvbits(IBELL,0,16,IB,16)
19    c
20          write(6,10) BEL
21    10    format(a2)
22    c
23          return
24          end
NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:03 1990


 1        subroutine capoff
 2  c
 3  c     FUNCTION:
 4  c     Disables the 'caps' mode on the HP-2627A terminal.
 5  c
 6  c     BY:
 7  c     D. Francis
 8  c     Naval Biodynamics Laboratory
 9  c     New Orleans, Louisiana
10  c     28 June 1988
11  c
12        equivalence (ESCA,IEA),(AK0,IK0),(PP,IPP)
13  c
14        character*2 ESCA,AK0,PP
15  c
16        data IESCA/o'015446'/,K0/o'065460'/,IPSP/o'050040'/
17  c
18        call mvbits(IESCA,0,16,IEA,16)
19        call mvbits(K0,0,16,IK0,16)
20        call mvbits(IPSP,0,16,IPP,16)
21  c
22        write(6,10) ESCA,AK0,PP
23  10    format(6a2)
24  c
25        return
26        end
NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:05 1990


 1        subroutine cappr(x,y,pnt,npnt)
 2  c
 3        real x(npnt),y(npnt),pnt(8,npnt),xx(13),yy(13)
 4        integer index(9)
 5  c
 6  c     WHERE:
 7  c     x    : array of x coordinates to be printed
 8  c     y    : array of y coordinates to be printed
 9  c     pnt : array of 32 character labels to be printed
10  c     npnt: no. of entries in each of the above arrays
11  c     (entry 1 defines origin of the x-ray coord sys)
12  c     (entry 2 defines the direction of the +y axis)
13  c
14  c     FUNCTION:
15  c     This subroutine documents the results of the digitizing
16  c     operation. The argument list defines the x-ray origin
17  c     (first entry), a point on the +y axis (second entry), and
18  c     points of anatomical interest (third - npntth entries).
19  c     Each anatomical point is transformed from digitizer raster
20  c     units to inches in the x-ray film coordinate system. The
21  c     results are printed and identified using the 32 character label.
22  c
23  c     BY:
24  c     W. Anderson
25  c     Naval Biodynamics Laboratory
26  c     31 Oct 83
27  c
28  c
29  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
30  c
31  c
32  c.....named common for header info
33        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
34       *idate,isday,isyear,ieday,ieyear
35  c
36  c.....organize data storage
37        character*8 filmid(6)
38        character*6 ksubj
39        character*14 mtloc
40        data filmid/'a-p cal ','lat cal ','a-p head','lat head',
41       1  'a-p neck','lat neck'/
42  c
43        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
44        data index/3,13,4,11,10,9,2,12,1/
45  c
46  c
47  c     assign a unit number to the printer
48        open(1,file='xrayprint')
49        open(4,file='digoutput')
50  c
51  c.....initialize data arrays
52        do 10 i=1,13
53        xx(i)=999.000
54  10    yy(i)=999.000
55  c
```

```
56  c.....print heading information
57        write(iprt,920) filmid(kfilm),ksubj,
58       1  (kdate(i),i=1,3),kmount,(koment(i),i=1,20)
59  920   format(//////' --------results of xray digitization--------'//
60       1  '  ----------',a8,'----------'//
61       2  '  subject     :  ',a6/
62       3  '  xray date :  ',i2,'/',i2,'/',i2/
63       4  '  mount id  :  ',i4/
64       5  '  comments  :  ',20a2/)
65  c
66  c...calculate sin, cos terms for rotation from digitizer to film
67        sang=sin(atan2(x(2)-x(1),y(2)-y(1)))
68        cang=cos(atan2(x(2)-x(1),y(2)-y(1)))
69  c
70  c.....transform each anatomical point to x-ray coordinates& print
71        ii=1
72        do 210 i=3,npnt
73        xxform=((x(i)-x(1))*cang-(y(i)-y(1))*sang)/400./2.54
74        yxform=((x(i)-x(1))*sang+(y(i)-y(1))*cang)/400./2.54
75        j=index(ii)
76        xx(j)=xxform
77        yy(j)=yxform
78        ii=ii+1
79        write(iprt,922) pnt(1,i),xxform,yxform,(pnt(j,i),j=2,8)
80  922   format('point: ',a4,'x:',f7.3,'y:',f7.3,
81       1 ' inches  ',7a4)
82  210   continue
83  c
84  c.....write data to output file
85        write(4,220) (xx(k),k=1,13)
86        write(4,220) (yy(k),k=1,13)
87  220   format( 13(f7.3,1x) )
88  c
89        return
90  c
91        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:11 1990


 1          subroutine caps
 2    c
 3    c     FUNCTION:
 4    c     Enables the 'caps' mode on the HP-2627A terminal.
 5    c
 6    c     BY:
 7    c     D. Francis
 8    c     Naval Biodynamics Laboratory
 9    c     New Orleans, Louisiana
10    c     28 June 1988
11    c
12          equivalence (ESCA,IEA),(AK1,IK1),(PP,IPP)
13    c
14          character*2 ESCA,AK1,PP
15    c
16          data IESCA/o'015446'/,K1/o'065461'/,IPSP/o'050040'/
17    c
18          call mvbits(IESCA,0,16,IEA,16)
19          call mvbits(K1,0,16,IK1,16)
20          call mvbits(IPSP,0,16,IPP,16)
21    c
22          write(6,10) ESCA,AK1,PP
23    10    format(6a2)
24    c
25          return
26          end
NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

FORTRAN 77/UX HP92430A.07.04 COPYRIGHT HEWLETT-PACKARD CO. 1983 Thu Jul 26 14:16:12 1990

```
 1        subroutine cltpr(x,y,pnt,npnt)
 2  c
 3        real x(npnt),y(npnt),pnt(8,npnt),xx(13),yy(13)
 4        integer index(9)
 5  c
 6  c     WHERE:
 7  c     x    : array of x coordinates to be printed
 8  c     y    : array of y coordinates to be printed
 9  c     pnt : array of 32 character labels to be printed
10  c     npnt: no. of entries in each of the above arrays
11  c     (entry 1 defines origin of the x-ray coord sys)
12  c     (entry 2 defines the direction of the +y axis)
13  c
14  c     FUNCTION:
15  c     This subroutine documents the results of the digitizing
16  c     operation. The argument list defines the x-ray origin
17  c     (first entry), a point on the +y axis (second entry), and
18  c     points of anatomical interest (third - npntth entries).
19  c     Each anatomical point is transformed from digitizer raster
20  c     units to inches in the x-ray film coordinate system. The
21  c     results are printed and identified using the 32 character label.
22  c
23  c     BY:
24  c     W. Anderson
25  c     Naval Biodynamics Laboratory
26  c     31 Oct 83
27  c
28  c
29  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
30  c
31  c
32  c.....named common for header info
33        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
34       *idate,isday,isyear,ieday,ieyear
35  c
36  c.....organize data storage
37        character*8 filmid(6)
38        character*6 ksubj
39        character*14 mtloc
40        data filmid/'a-p cal ','lat cal ','a-p head','lat head',
41       1  'a-p neck','lat neck'/
42  c
43        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
44        data index/5,13,8,11,10,9,6,12,7/
45  c
46  c
47  c     assign a unit number to the printer
48        open(1,file='xrayprint')
49        open(4,file='digoutput')
50  c
51  c.....initialize data arrays
52        do 10 i=1,13
53        xx(i)=999.000
54  10    yy(i)=999.000
55  c
```

```
56  c.....print heading information
57        write(iprt,920) filmid(kfilm),ksubj,
58       1  (kdate(i),i=1,3),kmount,(koment(i),i=1,20)
59  920   format(//////' --------results of xray digitization--------'//
60       1  '  ----------',a8,'----------'//
61       2  '  subject     :  ',a6/
62       3  '  xray date :  ',i2,'/',i2,'/',i2/
63       4  '  mount id  :  ',i4/
64       5  '  comments  :  ',20a2/)
65  c
66  c...calculate sin, cos terms for rotation from digitizer to film
67        sang=sin(atan2(x(2)-x(1),y(2)-y(1)))
68        cang=cos(atan2(x(2)-x(1),y(2)-y(1)))
69  c
70  c.....transform each anatomical point to x-ray coordinates & print
71        ii=1
72        do 210 i=3,npnt
73        xxform=((x(i)-x(1))*cang-(y(i)-y(1))*sang)/400./2.54
74        yxform=((x(i)-x(1))*sang+(y(i)-y(1))*cang)/400./2.54
75        j=index(ii)
76        xx(j)=xxform
77        yy(j)=yxform
78        ii=ii+1
79        write(iprt,922) pnt(1,i),xxform,yxform,(pnt(j,i),j=2,8)
80  922   format('point: ',a4,'x:',f7.3,'y:',f7.3,
81       1 ' inches  ',7a4)
82  210   continue
83  c
84  c.....write data to output file
85        write(4,220) (xx(k),k=1,13)
86        write(4,220) (yy(k),k=1,13)
87  220   format( 13(f7.3,1x) )
88  c
89        return
90  c
91        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:19 1990


 1  c
 2        subroutine convert(str,ix,iy,ip)
 3  c
 4  c     function:
 5  c     This routine converts a 20-byte character string to three integer
 6  c     variables. The input string is the character string read from the
 7  c     HP-9872T plotter after the execution of an output digitized point
 8  c     and pen status instruction "OD". The X and Y coordinates and pen
 9  c     status (up or down) associated with the last digitized point is
10  c     returned.
11  c
12  c     argument definitions:
13  c     str  -- 20-byte character string read from HP-9872T plotter
14  c     ix   -- returned integer - X-coordinate in absolute plotter units
15  c     iy   -- returned integer - Y-coordinate in absolute plotter units
16  c     ip   -- returned integer - pen status (0=pen up, 1=pen down)
17  c
18  c
19  c
20  c     By:
21  c     D. Francis
22  c     Naval Biodynamics Laboratory
23  c     New Orleans, Louisiana
24  c     15 Dec 1986
25  c
26        character*20 str
27  c
28        read(str,10) ix,iy,ip
29  c
30  10    format(2i6,i1)
31  c
32        return
33        end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:21 1990


 1  c
 2        subroutine dec2i(str,i)
 3  c
 4  c     purpose:
 5  c     decode 2-byte character string to integer variable
 6  c
 7  c     argument definitions:
 8  c     str -- 2-byte char string
 9  c     i -- returned integer
10  c
11  c     programmer:  j lambert  23 jul 86
12  c
13        character*2 str
14  c
15        read(str,10)i
16  c
17  10    format(i2)
18  c
19        return
20        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:22 1990


 1        subroutine erase
 2  c
 3  c     FUNCTION:
 4  c     clears display screen
 5  c
 6  c     By:
 7  c     D. Francis
 8  c     Naval Biodynamcis Laboratory
 9  c     New Orleans, Louisiana
10  c     4 May 1987
11  c
12        equivalence  (ESCH,IH), (ESCJ,IJ)
13  c
14        character*2 ESCH,ESCJ
15  c
16        data IESCH/o'015510'/, IESCJ/o'015512'/
17  c
18        call mvbits(IESCH,0,16,IH,16)
19        call mvbits(IESCJ,0,16,IJ,16)
20  c
21        write(6,10)  ESCH,ESCJ
22  10    format(3a2)
23  c
24        return
25        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:23 1990


 1        subroutine hedpr(x,y,pnt,npnt)
 2  c
 3        real x(npnt),y(npnt),pnt(8,npnt),xx(7),yy(7)
 4  c
 5  c     WHERE:
 6  c     x    : array of x coordinates to be printed
 7  c     y    : array of y coordinates to be printed
 8  c     pnt : array of 32 character labels to be printed
 9  c     npnt: no. of entries in each of the above arrays
10  c     (entry 1 defines origin of the x-ray coord sys)
11  c     (entry 2 defines the direction of the +y axis)
12  c
13  c     FUNCTION:
14  c     This subroutine documents the results of the digitizing
15  c     operation. The argument list defines the x-ray origin
16  c     (first entry), a point on the +y axis (second entry), and
17  c     points of anatomical interest (third - npntth entries).
18  c     Each anatomical point is transformed from digitizer raster
19  c     units to inches in the x-ray film coordinate system. The
20  c     results are printed and identified using the 32 character label.
21  c
22  c     BY:
23  c     W. Anderson
24  c     Naval Biodynamics Laboratory
25  c     31 Oct 83
26  c
27  c
28  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
29  c
30  c
31  c.....named common for header info
32        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
33       *idate,isday,isyear,ieday,ieyear
34  c
35  c.....organize data storage
36        character*8 filmid(6)
37        character*6 ksubj
38        character*14 mtloc
39        data filmid/'a-p cal ','lat cal ','a-p head','lat head',
40       1  'a-p neck','lat neck'/
41  c
42        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
43  c
44  c
45  c     assign a unit number to the printer
46        open(1,file='xrayprint')
47        open(4,file='digoutput')
48  c
49  c.....print heading information
50        write(iprt,920) filmid(kfilm),ksubj,
51       1  (kdate(i),i=1,3),kmount,(koment(i),i=1,20)
52  920   format(//////' --------results of xray digitization--------'//
53       1  '  ----------',a8,'----------'//
54       2  '  subject   :  ',a6/
55       3  '  xray date :  ',i2,'/',i2,'/',i2/
```

```
56        4  '  mount id  :  ',i4/
57        5  '  comments  :  ',20a2/)
58    c
59    c...calculate sin, cos terms for rotation from digitizer to film
60          sang=sin(atan2(x(2)-x(1),y(2)-y(1)))
61          cang=cos(atan2(x(2)-x(1),y(2)-y(1)))
62    c
63    c.....transform each anatomical point to x-ray coordinates & print
64          ii=1
65          do 210 i=3,npnt
66          xxform=((x(i)-x(1))*cang-(y(i)-y(1))*sang)/400./2.54
67          yxform=((x(i)-x(1))*sang+(y(i)-y(1))*cang)/400./2.54
68          xx(ii)=xxform
69          yy(ii)=yxform
70          ii=ii+1
71          write(iprt,922) pnt(1,i),xxform,yxform,(pnt(j,i), j=2,8)
72    922   format('point: ',a4,'x:',f7.3,'y:',f7.3,
73          1 ' inches  ',7a4)
74    210   continue
75    c
76    c.....write data to output file
77          write(4,220) (xx(k),k=1,7)
78          write(4,220) (yy(k),k=1,7)
79    220   format( 7(f7.3,1x) )
80    c
81          return
82    c
83          end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

```
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14:16:28 1990


 1        subroutine hpdig(x,y)
 2  c
 3  c     WHERE:
 4  c     x  : x value of digitizing sight position
 5  c     y  : y value of digitizing sight position
 6  c
 7  c     FUNCTION:
 8  c     Allows operator to move and enter x,y position of
 9  c     digitizing sight.
10  c
11  c     BY:
12  c     W. Anderson
13  c     Naval Biodynamics Laboratory
14  c     26 Oct 83
15  c
16  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
17  c
18  c
19  $ALIAS CPLTIN = 'pltio'(%ref,%ref,%ref)
20  $ALIAS CPLTOPEN = 'pltopen'(%ref,%ref)
21  $ALIAS CPLTOUT = 'pltout'(%ref,%ref)
22  $ALIAS CPLTCLOSE = 'pltclose'(%ref)
23  c
24        CHARACTER*14 DEVICE
25        CHARACTER*4 OUTSTR,OUTSTR2,OUTSTR3,OUTSTR4
26        CHARACTER*20 DIGTZPT
27        CHARACTER*8 RESULT
28        INTEGER PLTID
29  c
30        integer ibuf(40)
31  c
32        DEVICE = '/dev/hpib/0a1'//char(0)
33        OUTSTR = 'DP;'//char(0)
34        OUTSTR2= 'OS;'//char(0)
35        OUTSTR3= 'OD;'//char(0)
36        OUTSTR4= 'PU;'//char(0)
37  c
38  c
39  c     assign a unit number to the plotter
40  c
41  c
42        CALL CPLTOPEN(DEVICE,PLTID)
43  c
44  c
45  c.....send 'digitize point' command
46  c     -turns plotter 'enter' light on, indicating that a point
47  c         may be digitized.
48  c     -the operator may position the digitizer to any desired
49  c         x,y location.
50  c     -when the operator presses the 'enter' button, the x,y
51  c         location of the pen and the pen up/down status are
52  c         stored by the plotter for retrieval by the 'od' command.
53  c     -pressing the 'enter' button also turns off the 'enter'
54  c         button light, and sets bit position 2 in the output
55  c         status word.
```

```
56  c
57        CALL CPLTOUT(PLTID,OUTSTR)
58  c
59  c......request and read output status byte
60  c
61  100   CALL CPLTIN(PLTID,OUTSTR2,RESULT)
62  c
63  c.....convert character string to integer
64  c
65        call dec2i(RESULT,istat)
66  c
67  c.....check for response from operator
68  c
69        if(iand(istat,4).eq.0) go to 100
70  c
71  c.....request and read 'digitized point'
72  c     -'od' command queues x,y and pen status info
73  c     ix: 0-16000
74  c     iy: 0-11400
75  c     ip: 0 (pen up)
76  c         1 (pen down)
77  c
78        CALL CPLTIN(PLTID,OUTSTR3,DIGTZPT)
79  c
80  c.....convert plotter output
81  c
82        call convert(DIGTZPT,ix,iy,ip)
83  c
84  c.....raise digitizing sight
85  c
86        CALL CPLTOUT(PLTID,OUTSTR4)
87  c
88  c.....convert coordinates to real format
89  c
90        x=ix
91        y=iy
92  c
93  c.....close the plotter down
94  c
95        CALL CPLTCLOSE(PLTID)
96  c
97        return
98        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:45 1990


 1          subroutine kwait
 2    c
 3    c     FUNCTION:
 4    c     Wait for response from keyboard
 5    c
 6    c
 7    c     BY:
 8    c     W. Anderson
 9    c     Naval Biodynamics Laboratory
10    c     27 Feb 84
11    c
12    c     Revised by D. Francis 4 May 1987
13    c
14    c.....cue operator and wait
15          call bell
16          write(6,900)
17    900   format('...enter <blank><return> to continue')
18          read(5,910,err=100,end=100) ia
19    910   format(a1)
20    100   return
21          end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:45 1990


 1        subroutine ltcal
 2  c
 3  c     function:
 4  c     interactive subroutine to digitize lateral
 5  c     calibration x-ray film. Operator may digitize points in standard
 6  c     sequence, redigitize selected points, print results,
 7  c     verify results by plotting points, and exit from the
 8  c     subroutine as desired.
 9  c
10  c
11  c  By:
12  c     W. Campos
13  c     QEI Computer And Information System Inc.
14  c     New Orleans Division
15  c     21 Nov 83
16  c     For:
17  c     Naval Biodynamics Laboratory
18  c     New Orleans, Louisiana
19  c     Contract: N00014-83-C-0691
20  c
21  c  Revised by D. Francis for HP-9000 system 28 Aug 1986
22  c
23  c.....named common for header info
24        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
25       *idate,isday,isyear,ieday,ieyear
26  c
27  c.....organize data storage
28        character*6 ksubj
29        real  x(11),y(11)
30        integer pnt(8,11)
31        data pnt/
32       1 'org ','': x,','y or','igin','    ','    ','    ','  ',
33       2 'y ax','': po','int ','on y',' axi','s','    ','  ',
34       3 '  5 ','':  5','    ','    ','    ','    ','    ','  ',
35       4 ' 13 ','': 13','    ','    ','    ','    ','    ','  ',
36       5 '  8 ','':  8','    ','    ','    ','    ','    ','  ',
37       6 ' 11 ','': 11','    ','    ','    ','    ','    ','  ',
38       7 ' 10 ','': 10','    ','    ','    ','    ','    ','  ',
39       8 '  9 ','':  9','    ','    ','    ','    ','    ','  ',
40       9 '  6 ','':  6','    ','    ','    ','    ','    ','  ',
41       * ' 12 ','': 12','    ','    ','    ','    ','    ','  ',
42       * '  7 ','':  7','    ','    ','    ','    ','    ','  '/
43        data npnt/11/
44        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
45  c
46  c
47  c.....identify subroutine
48  100   call erase
49        call bell
50        write(idsp,900) (i,(pnt(j,i),j=1,8),i=1,npnt)
51  900   format(' ---digitize lat calibration x-ray---'//
52       1  ' place digitizing sight in hp-9872 plotter'/
53       2  ' place pen in station #1'//
54       3  '  -3: exit subroutine'/
55       4  '  -2: plot results'/
```

```
56        5  '  -1: print results'/
57        6  '   0: digitize points in standard sequence'/
58        7     11(i4,': digitize only ',8a4/) /
59        8  'select option')
60         read(ikey,*,err=100,end=100) iopt
61  c
62  c.....execute option requested
63         if(iopt.eq.-3) return
64  c
65  c.....plot results
66         if(iopt.eq.-2) then
67         call xrypl(x,y,pnt,npnt)
68  c
69  c.....print and save results
70         else if(iopt.eq.-1) then
71         call cltpr(x,y,pnt,npnt)
72  c
73  c.....digitize points in standard sequence
74         else if(iopt.eq.0) then
75         call xrydg(x,y,pnt,npnt)
76  c
77  c.....digitize specific point
78         else if(iopt.ge.1 .and. iopt.le.npnt) then
79         call xrydg(x(iopt),y(iopt),pnt(1,iopt),1)
80  c
81  c.....out of options
82         endif
83         go to 100
84  c
85  950    format(a6,1x,i5,1x,a5,1x,i1,1x,2(i1,1x),20(f7.3,1x))
86  955    format(a6,1x,i5,1x,a5,1x,i1,1x,2(i7,1x),20(f7.3,1x))
87  c
88         end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:46 1990


 1        subroutine lthed
 2  c
 3  c     function:
 4  c     interactive subroutine to digitize lateral
 5  c     head x-rays. Operator may digitize points in standard
 6  c     sequence, redigitize selected points, print results,
 7  c     verify results by plotting points, and exit from the
 8  c     subroutine as desired.
 9  c
10  c
11  c  By:
12  c     W. Campos
13  c     QEI Computer And Information System Inc.
14  c     New Orleans Division
15  c     21 Nov 83
16  c     For:
17  c     Naval Biodynamics Laboratory
18  c     New Orleans, Louisiana
19  c     Contract: N00014-83-C-0691
20  c     21 Nov 83
21  c
22  c  Revised by D. Francis for HP-9000 system 28 Aug 1986
23  c
24  c.....named common for header info
25        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
26       *idate,isday,isyear,ieday,ieyear
27  c
28  c.....organize data storage
29        character*6 ksubj
30        real x(9),y(9)
31        integer pnt(8,9)
32        data pnt/
33       1 'org ','': x,','y or','igin','    ','    ','    ','  ',
34       2 'y ax','': po','int ','on y',' axi','s  ','    ','  ',
35       3 'ram ','': ri','ght ','audi','tory',' mea','tuse','  ',
36       4 'lam ','': le','ft a','udit','ory ','meat','use ','  ',
37       5 'ron ','': ri','ght ','orbi','tal ','notc','h  ','  ',
38       6 'lon ','': le','ft o','rbit','al n','otch','    ','  ',
39       7 'ctp ','': ce','nter',' of ','t-pl','ate ','    ','  ',
40       8 'rtp ','': ri','ght ','t-pl','ate ','    ','    ','  ',
41       9 'ltp ','': le','ft t','-pla','te  ','    ','    ','  '/
42        data npnt/9/
43        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
44  c
45  c
46  c.....identify subroutine
47  100   call erase
48        call bell
49        write(idsp,900) (i,(pnt(j,i),j=1,8),i=1,npnt)
50  900   format(' ---digitize lateral head x-ray---'//
51       1  ' place digitizing sight in hp-9872 plotter'/
52       2  ' place pen in station #1'//
53       3  '  -3: exit subroutine'/
54       4  '  -2: plot results'/
55       5  '  -1: print results'/
```

```
56        6  '   0: digitize points in standard sequence'/
57        7     9(i4,': digitize only ',8a4/) /
58        8  'select option')
59         read(ikey,*,err=100,end=100) iopt
60  c
61  c.....execute option requested
62        if(iopt.eq.-3) return
63  c
64  c.....plot results
65        if(iopt.eq.-2) then
66            call xrypl(x,y,pnt,npnt)
67  c
68  c.....print and save results
69        else if(iopt.eq.-1) then
70            call hedpr(x,y,pnt,npnt,xy)
71  c
72  c.....digitize points in standard sequence
73        else if(iopt.eq.0) then
74            call xrydg(x,y,pnt,npnt)
75  c
76  c.....digitize specific point
77        else if(iopt.ge.1 .and. iopt.le.npnt) then
78            call xrydg(x(iopt),y(iopt),pnt(1,iopt),1)
79  c
80  c.....out of options
81        endif
82        go to 100
83  c
84  950   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i1,1x),20(f7.3,1x))
85  955   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i7,1x),20(f7.3,1x))
86  c
87        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
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14:16:58 1990


 1        subroutine ltnec
 2  c
 3  c     function:
 4  c     interactive subroutine to digitize lateral
 5  c     neck x-rays. Operator may digitize points in standard
 6  c     sequence, redigitize selected points, print results,
 7  c     verify results by plotting points, and exit from the
 8  c     subroutine as desired.
 9  c
10  c
11  c  By:
12  c     W. Campos
13  c     QEI Computer And Information System Inc.
14  c     New Orleans Division
15  c     21 Nov 83
16  c     For:
17  c     Naval Biodynamics Laboratory
18  c     New Orleans, Louisiana
19  c     Contract: N00014-83-C-0691
20  c
21  c  Revised by D. Francis for HP-9000 system 28 Aug 1986
22  c
23  c.....named common for header info
24        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
25       *idate,isday,isyear,ieday,ieyear
26  c
27  c.....organize data storage
28        character*6 ksubj
29        real x(10),y(10)
30        integer pnt(8,10)
31        data pnt/
32       1 'org ','': x,','y or','igin','    ','    ','    ','  ',
33       2 'y ax','': po','int ','on y',' axi','s   ','    ','  ',
34       3 'psp ','': po','ster','ior ','spin','ous ','proc','ess ',
35       4 'ssn ','': su','pras','tern','al n','otch','    ','  ',
36       5 'ctp ','': ce','nter',' of ','t-pl','ate ','    ','  ',
37       6 'rtp ','': ri','ght ','t-pl','ate ','    ','    ','  ',
38       7 'ltp ','': le','ft t','-pla','te  ','    ','    ','  ',
39       8 'asc ','': an','teri','or s','uper','ior ','corn','er  ',
40       9 'lsp ','': lo','wer ','spin','ous ','proc','ess ','  ',
41       * 'usp ','': up','per ','spin','ous ','proc','ess ','  '/
42        data npnt/10/
43        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
44  c
45  c
46  c.....identify subroutine
47  100   call erase
48        call bell
49        write(idsp,900) (i,(pnt(j,i),j=1,8),i=1,npnt)
50  900   format(' ---digitize lateral neck x-ray---'//
51       1  ' place digitizing sight in hp-9872 plotter'/
52       2  ' place pen in station #1'//
53       3  '  -3: exit subroutine'/
54       4  '  -2: plot results'/
55       5  '  -1: print results'/
```

```
56          6  '   0: digitize points in standard sequence'/
57          7     10(i4,': digitize only ',8a4/) /
58          8  'select option')
59           read(ikey,*,err=100,end=100) iopt
60    c
61    c.....execute option requested
62          if(iopt.eq.-3) return
63    c
64    c.....plot results
65          if(iopt.eq.-2) then
66              call xrypl(x,y,pnt,npnt)
67    c
68    c.....print and save results
69          else if(iopt.eq.-1) then
70              call necpr(x,y,pnt,npnt,2)
71    c
72    c.....digitize points in standard sequence
73          else if(iopt.eq.0) then
74              call xrydg(x,y,pnt,npnt)
75    c
76    c.....digitize specific point
77          else if(iopt.ge.1 .and. iopt.le.npnt) then
78              call xrydg(x(iopt),y(iopt),pnt(1,iopt),1)
79    c
80    c.....out of options
81          endif
82          go to 100
83    c
84    950   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i1,1x),20(f7.3,1x))
85    955   format(a6,1x,i5,1x,a5,1x,i1,1x,2(i7,1x),20(f7.5,1x))
86    c
87          end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:16:58 1990


 1        subroutine necpr(x,y,pnt,npnt,itype)
 2  c
 3        real x(npnt),y(npnt),pnt(8,npnt),xx(8),yy(8)
 4  c
 5  c     WHERE:
 6  c     x    : array of x coordinates to be printed
 7  c     y    : array of y coordinates to be printed
 8  c     pnt  : array of 32 character labels to be printed
 9  c     npnt : no. of entries in each of the above arrays
10  c            (entry 1 defines origin of the x-ray coord sys)
11  c            (entry 2 defines the direction of the +y axis)
12  c     itype: type of x-ray (ap or lateral).
13  c            1 - ap
14  c            2 - lateral
15  c
16  c     FUNCTION:
17  c     This subroutine documents the results of the digitizing
18  c     operation. The argument list defines the x-ray origin
19  c     (first entry), a point on the +y axis (second entry), and
20  c     points of anatomical interest (third - npntth entries).
21  c     Each anatomical point is transformed from digitizer raster
22  c     units to inches in the x-ray film coordinate system. The
23  c     results are printed and identified using the 32 character label.
24  c
25  c     BY:
26  c     W. Anderson
27  c     Naval Biodynamics Laboratory
28  c     31 Oct 83
29  c
30  c
31  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
32  c
33  c
34  c.....named common for header info
35        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
36       *idate,isday,isyear,ieday,ieyear,artfac(4)
37  c
38        common nmount
39  c
40  c.....organize data storage
41        character*8 filmid(6)
42        character*6 ksubj
43        character*14 mtloc
44        data filmid/'a-p cal ','lat cal ','a-p head','lat head',
45       1  'a-p neck','lat neck'/
46  c
47        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
48  c
49  c
50  c     assign a unit number to the printer
51        open(1,file='xrayprint')
52        open(4,file='digoutput')
53  c
54  c.....print heading information
55        write(iprt,920) filmid(kfilm),ksubj,
```

```
56        1  (kdate(i),i=1,3),nmount,(koment(i),i=1,20)
57  920    format(//////' --------results of xray digitization--------'//
58        1  '  ----------',a8,'----------'//
59        2  '  subject    :  ',a6/
60        3  '  xray date  :  ',i2,'/',i2,'/',i2/
61        4  '  mount id   :  ',i4/
62        5  '  comments   :  ',20a2/)
63  c
64  c...calculate sin, cos terms for rotation from digitizer to film
65         sang=sin(atan2(x(2)-x(1),y(2)-y(1)))
66         cang=cos(atan2(x(2)-x(1),y(2)-y(1)))
67  c
68  c.....transform each anatomical point to x-ray coordinates & print
69         ii=1
70         do 210 i=3,npnt
71         xxform=((x(i)-x(1))*cang-(y(i)-y(1))*sang)/400./2.54
72         yxform=((x(i)-x(1))*sang+(y(i)-y(1))*cang)/400./2.54
73         xx(ii)=xxform
74         yy(ii)=yxform
75         ii=ii+1
76         write(iprt,922) pnt(1,i),xxform,yxform,(pnt(j,i),j=2,8)
77  922    format('point: ',a4,'x:',f7.3,'y:',f7.3,
78        1 ' inches  ',7a4)
79  210    continue
80  c
81  c.....write data to output file
82         write(4,220) (xx(k),k=1,5)
83         write(4,220) (yy(k),k=1,5)
84  220    format( 7(f7.3,1x) )
85  c
86  c.....save ap data
87         if(itype.eq.2) go to 240
88         artfac(1)=xx(6)
89         artfac(2)=yy(6)
90         artfac(3)=xx(7)
91         artfac(4)=yy(7)
92         return
93  c
94  240    write(4,220) (artfac(i),i=1,4)
95         write(4,220) xx(6),yy(6),xx(7),yy(7),xx(8),yy(8)
96  c
97         return
98  c
99         end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

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```
 1        subroutine xinit
 2  c
 3  c  function:
 4  c     allow operator to define subject id, mount id, date, and
 5  c     general comment
 6  c
 7  c by:
 8  c     W. Anderson
 9  c     naval biodynamics laboratory
10  c     26 oct 83
11  c
12  c
13  c  Revised by D. Francis for HP-9000 system 28 Aug 1986
14  c
15  c
16        character*6 ksubj
17  c
18  c......named common for header info
19        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
20       *idate,isday,isyear,ieday,ieyear
21  c
22        common nmount
23  c
24  c.....organize data storage
25        data ikey/5/,idsp/6/,iprt/1/,iplt/2/
26  c
27  c.....assign output file
28        open(4,file='digoutput')
29  c
30  c.....identify function
31        call erase
32        write(idsp,900)
33  900   format(' ---identification info for new subject---'//
34       1  'please enter the following data'/)
35  c
36  c.....put terminal in 'caps' mode
37        call caps
38  c
39  c.....subject id
40  100   call bell
41        write(idsp,910)
42  910   format(/'aaaaaa (subject id)')
43        read(ikey,912,err=100,end=100) ksubj
44  912   format(a6)
45  c
46  c.....mount id
47  110   call bell
48        write(idsp,920)
49  920   format(/'nnnn ( mouth mount id)')
50        read(ikey,*,err=110,end=110) kmount
51  c
52  115   call bell
53        write(idsp,925)
54  925   format(/'nnnn (neck mount id)')
55        read(ikey,*,err=115,end=115) nmount
```

```
56  c
57  c
58  c.....date of x-ray
59  120    call bell
60         write(idsp,930)
61  930    format(/'dddyy ( Julian date of x-ray)  mmddyy ( Date of x-ray)')
62         read(ikey,932,err=120,end=120) idate, (kdate(i),i=1,3)
63  932    format(i5,3i2)
64  c
65  c.....start date and end date
66  125    call bell
67         write(idsp,935)
68  935    format(/'nnnnnnn (start date) nnnnnnn (end date) ')
69         read(ikey,937,err=125,end=125) isday,isyear,ieday,ieyear
70  937    format(2(i3,i4))
71  c
72  c.....general comment
73  130    call bell
74         write(idsp,940)
75  940    format(/'aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa'
76         1 ' (general comment)')
77         read(ikey,942,err=130,end=130) (koment(i),i=1,20)
78  942    format(20a2)
79  c
80  c.....write subject data to output file
81         write(4,945) ksubj,idate,kmount,nmount,isday,isyear,ieday,ieyear
82  945    format(a6,1x,i5,1x,2(i4,1x),2(i3,i4))
83  c
84         return
85         end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
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14:17:06 1990


 1        block data xrycm
 2  c
 3  c     FUNCTION:
 4  c     Define common blocks for x-ray digitizing program.
 5  c
 6  c     BY:
 7  c     W. Anderson
 8  c     Naval Biodynamics Laboratory
 9  c     27 Oct 83
10  c
11  c
12  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
13  c
14        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
15       *idate,isday,isyear,ieday,ieyear,artfac(4)
16  c
17  c.....set hdr to initial values
18        data ksubj/6h /
19        data kmount/0/
20        data kdate/3*0/
21        data artfac/4*0/
22        data koment/20*2h  /
23        data idate/0/
24        data isyear/0/
25        data ieyear/0/
26        data ieday/0/
27        data isday/0/
28  c
29        end

NUMBER OF ERRORS = 0       NUMBER OF WARNINGS = 0
```

```
FORTRAN 77/UX  HP92430A.07.04  COPYRIGHT HEWLETT-PACKARD CO. 1983  Thu Jul 26
14:17:17 1990

 1        subroutine xrydg(x,y,pnt,npnt)
 2  c
 3        real x(npnt),y(npnt),pnt(8,npnt)
 4  c
 5  c     WHERE:
 6  c     x    : array of x coordinates of points digitized
 7  c     y    : array of y coordinates of points digitized
 8  c     pnt  : array of 32 characters labels for each point
 9  c     npnt : no. of entries in each of the above arrays
10  c
11  c     FUNCTION:
12  c     This subroutine is used to prompt the operator and digitize
13  c     points from the x-ray film.
14  c
15  c
16  c     BY:
17  c     W. Anderson
18  c     Naval Biodynamics Laboratory
19  c     New Orleans, Louisiana
20  c     28 Oct 83
21  c
22  c
23  c     Revised by D. Francis for HP-9000 system 28 Aug 1986
24  c
25  c
26  c.....named common for header info
27        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
28       *idate,isday,isyear,ieday,ieyear
29  c
30  c.....organize data storage
31        data idsp/6/,ikey/5/,iplt/2/
32  c
33  c
34  c.....instructions to operator
35        call erase
36        write(idsp,900)
37  900   format('---digitize x-ray data from the plotter---'//
38       1  ' carefully place digitized sight in hp 9872 plotter'/
39       2  ' position sight to request point'/
40       3  ' press enter when enter lamp is lit'/
41       4  '  terminal will beep, and'/
42       5  '  lamp will go out when computer accepts value'/)
43  c
44  c.....digitize point by point
45        do 220 i=1,npnt
46        call bell
47        write(idsp,932) (pnt(j,i),j=1,8)
48  932   format('enter ',8a4)
49        call hpdig(x(i),y(i))
50  220   continue
51  c
52        return
53  c
54        end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

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```
      subroutine xrypl(x,y,pnt,npnt)
c
      real x(npnt),y(npnt),pnt(8,npnt)
c
c     WHERE:
c     x    : array of x coordinates to be plotted
c     y    : array of y coordinates to be plotted
c     pnt  : array of 32 character labels to be plotted
c              (only the first 4 characters are drawn)
c     npnt: no. of entries in each of the above arrays
c
c     FUNCTION:
c     This subroutine is used to verify the x-ray digitizing
c     operation. Each x,y coordinate specified in the
c     argument list is circled and labelled on the plotter.
c
c
c     BY:
c     W. Anderson
c     Naval Biodynamics Laboratory
c     28 Oct 83
c
c
c     Revised by D. Francis for HP-9000 system 28 Aug 1986
c
c
      INTEGER ETX
c.....named common for header info
      common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
     *idate,isday,isyear,ieday,ieyear
c
c.....organize data storage
      data idsp/6/,ikey/5/,iplt/2/
c
      ETX=3
c     assign a unit number to the plotter
      open(2,file='/dev/hpib/0a1')
c
c.....prompt operator to make plotter ready
      call erase
      write(idsp,910)
910   format('---prepare to plot, label digitized points---'//
     1  '  manually remove digitized sight from holder'/
     2  '  place pen in stable #1'/)
c.....wait for return key from operator
      call kwait
c
c.....set default parameters, select pen, set char size
      write(iplt,912)
912   format("DF;SP1;SI.2,.2;")
c
c.....plot & label each point
      do 200 i=1,npnt
      ix=x(i)
      iy=y(i)
```

```
56          write(iplt,914) ix,iy,pnt(1,i),ETX
57    914   format('SMO;PU;PA'i5,','i5,';SM;CP1.5,0;LB',a4,'',1R1)
58    200   continue
59    c
60    c.....close the plotter
61    c
62          close(2)
63    c
64          return
65    c
66          end

NUMBER OF ERRORS = 0        NUMBER OF WARNINGS = 0
```

```
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14:17:21 1990


 1        program xxray
 2  c
 3  c     main ..... x-ray digitization program
 4  c
 5  c  function
 6  c     interactive program to digitize x-ray anthropometry
 7  c     data. Results may be output to the printer and verified
 8  c     by plotting on plotter.
 9  c
10  c by:
11  c     W. Anderson
12  c     Naval Biodynamcis Laboratory
13  c     28 Oct 83
14  c
15  c     Revised by D. Francis for HP-9000 system  28 Aug 1986
16  c
17  c
18  c
19  c
20        character*6 ksubj
21  c
22  c.....named common for header info
23        common /hdr/ksubj,kmount,kdate(3),koment(20),kfilm,
24       *idate,isday,isyear,ieday,ieyear,artfac(4)
25  c
26  c.....organize data storage
27        data idsp/6/,ikey/5/,iprt/1/,iplt/2/
28  c
29  c     assign unit number to the plotter
30        open(2,file='/dev/hpib/0a1')
31  c
32  c.....initialize program
33        call xinit
34  c
35  c.....display options menu
36  100   call erase
37        call bell
38        write(idsp,900)
39  900   format('---x ray digitization program---'//
40       1  '  main options menu  '//
41       2  '  -1: exit program'/
42       3  '  0: set up for new subject'/
43       4  '  1: digitize calibration a-p'/
44       5  '  2: digitize calibration lateral'/
45       6  '  3: digitize head a-p'/
46       7  '  4: digitize head lateral'/
47       8  '  5: digitize neck a-p'/
48       9  '  6: digitize neck lateral'//
49       z  '  select option number'/)
50        read(ikey,*,err=100) iopt
51  c
52  c....make the film id available to the subroutines
53        if(iopt.ge.1 .and. iopt.le.6) kfilm=iopt
54  c
55  c....execute option requested
```

```
56          if(iopt.eq.-1) then
57              call capoff
58              close(1)
59              close(4)
60              write(idsp,920)
61    920   format(/' ---exit from x-ray digitization program---'/)
62    c
63          call exit
64          else if(iopt.eq.0) then
65              call xinit
66          else if(iopt.eq.1) then
67              call apcal
68          else if(iopt.eq.2) then
69              call ltcal
70          else if(iopt.eq.3) then
71              call aphed
72          else if(iopt.eq.4) then
73              call lthed
74          else if(iopt.eq.5) then
75              call apnec
76          else if(iopt.eq.6) then
77              call ltnec
78          endif
79    c
80    c.....select a new option
81          go to 100
82    c
83          end

NUMBER OF ERRORS =  0  NUMBER OF WARNINGS = 0
```

LISTING OF PLTIO SUBROUTINE PACKAGE

```
#include <stdio.h>
#include <string.h>
#define CR '\015'
#define O_RDWR 2

/*
**  write out a status inquiry and get status
*/

int pltio(pltid,outstr,result)
int *pltid;
char *outstr, *result;
{
        FILE *fp;
    int i;
    char c,buf[80];

    write(*pltid,outstr ,strlen(outstr ));
    for (i=0; c != CR; i++ )
          {
               read(*pltid,&c,1);
               buf[i] = c;
          }
    buf[i] = '\0';
    strcpy(result,buf);
}



/*
**  write command out to plotter
*/

int pltout(pltid,outstr)
int *pltid;
char *outstr;
{
    write(*pltid,outstr ,strlen(outstr ));
}



/*
**  open plotter device
*/

int pltopen(device,pltid)
char *device;
int *pltid;
{
        char *errbuf = "ERROR device file not found \n";

    if ((*pltid = open(device ,O_RDWR)) == -1 )
```

```
            {
            write(6,errbuf,strlen(errbuf));
            exit(1);
            }
}



/*
**    close the plotter down
*/

int pltclose(pltid)
int *pltid;
{
    close(*pltid);
}
```

APPENDIX D

SAMPLES OF PLOTTED OUTPUT

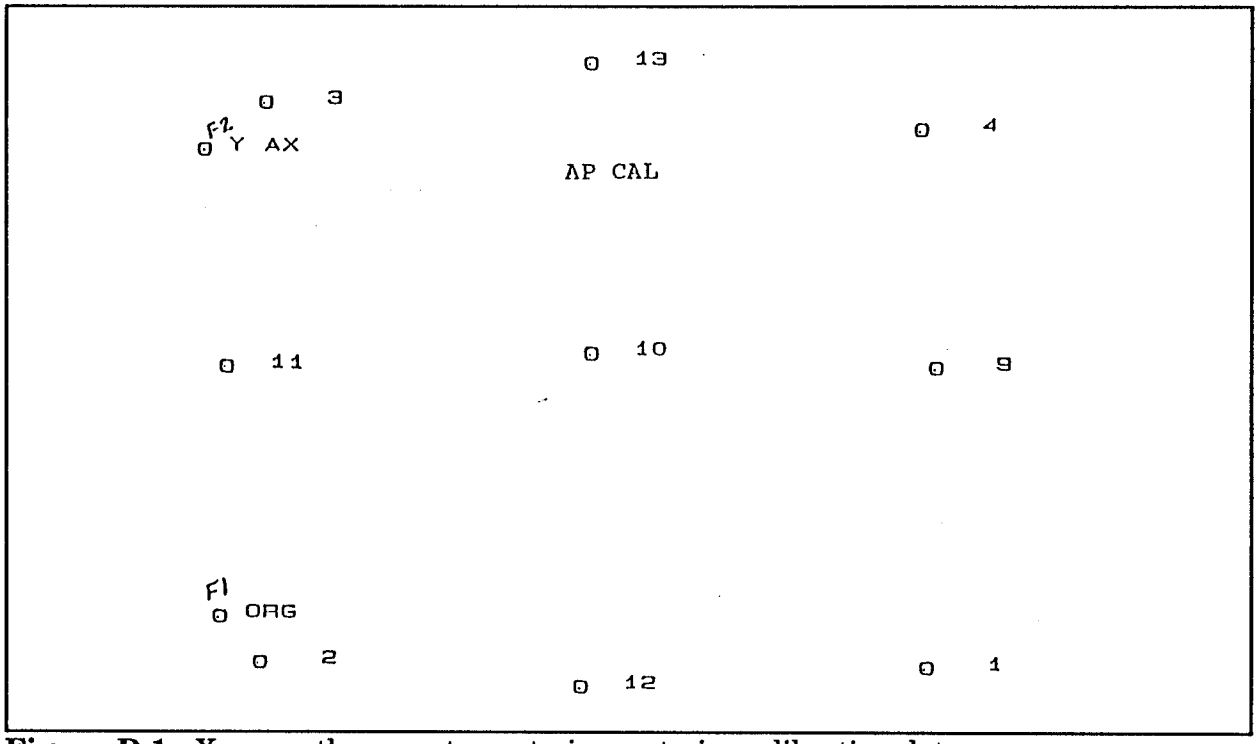

Figure D-1. X-ray anthropometry anterior-posterior calibration data.

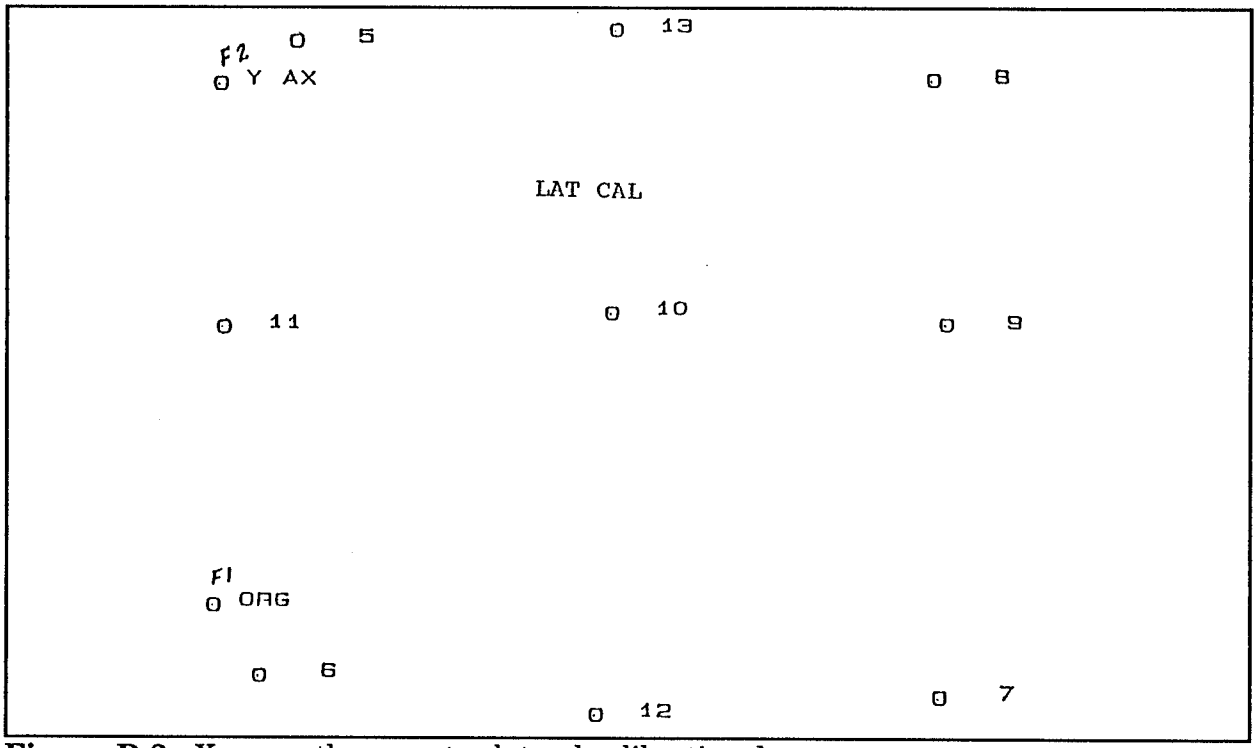

Figure D-2. X-ray anthropometry lateral calibration data.

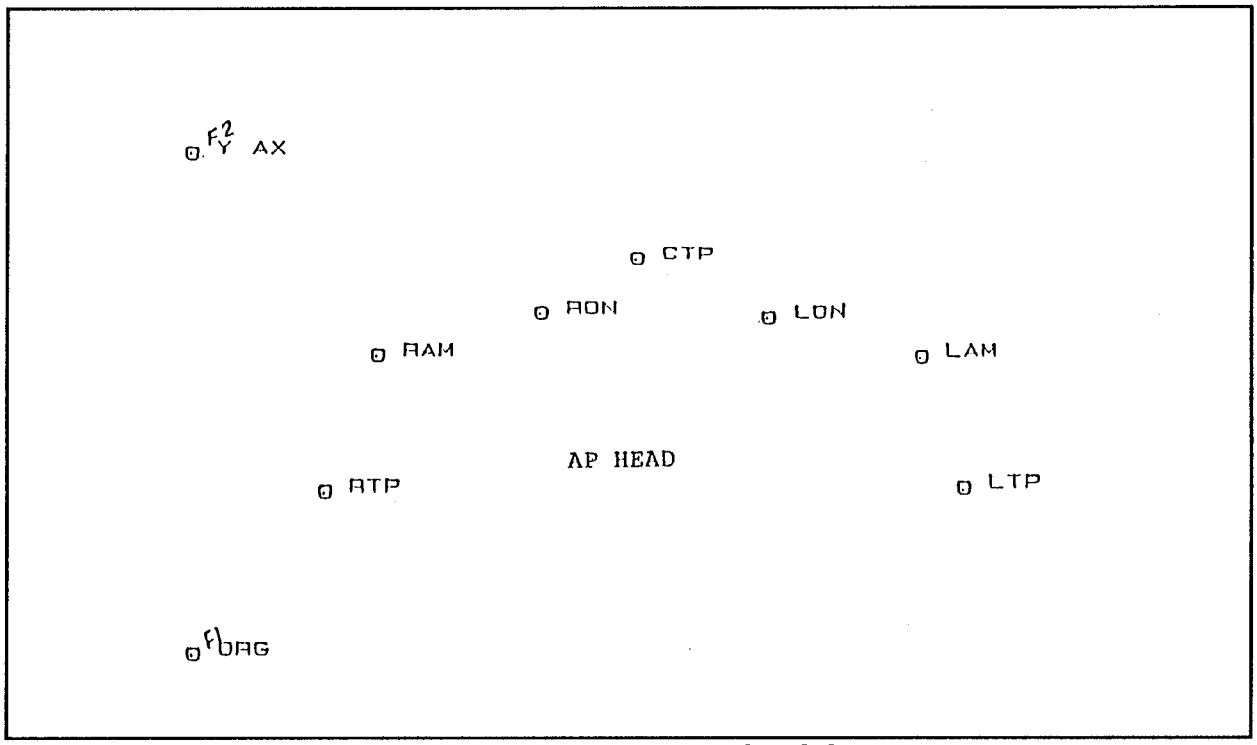

Figure D-3. X-ray anthropometry anterior-posterior head data.

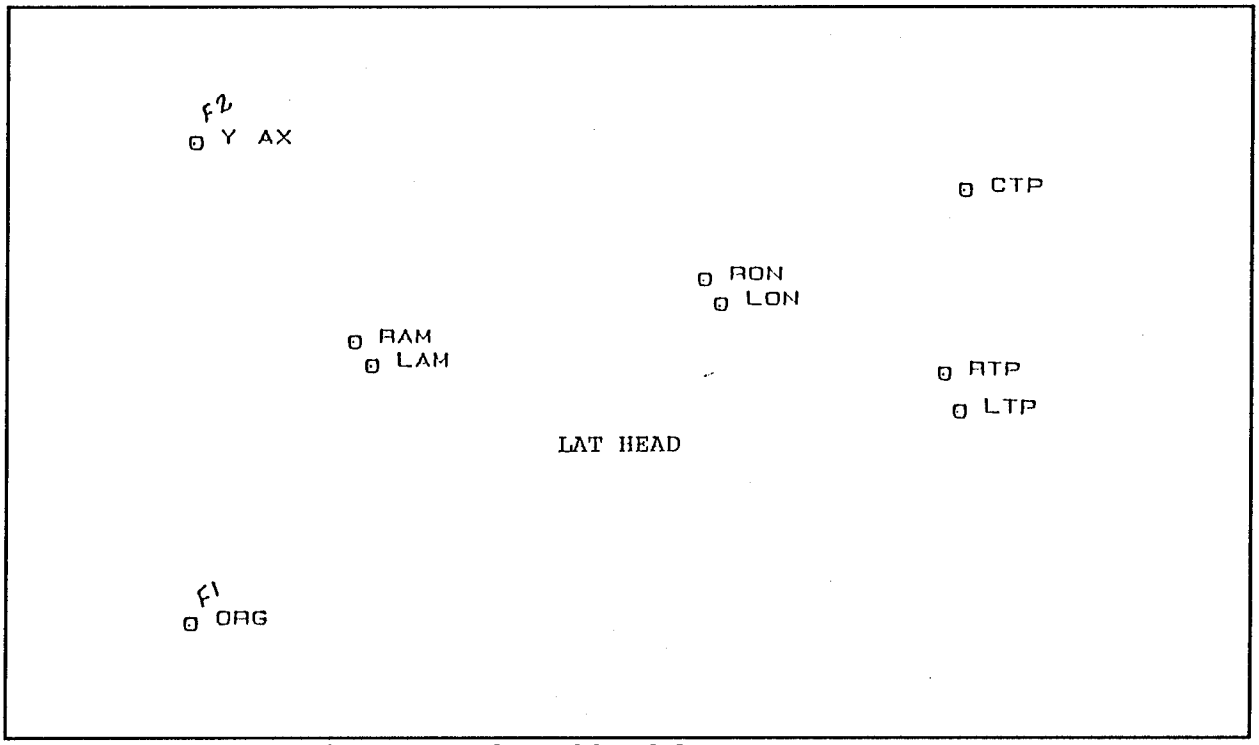

Figure D-4. X-ray anthropometry lateral head data.

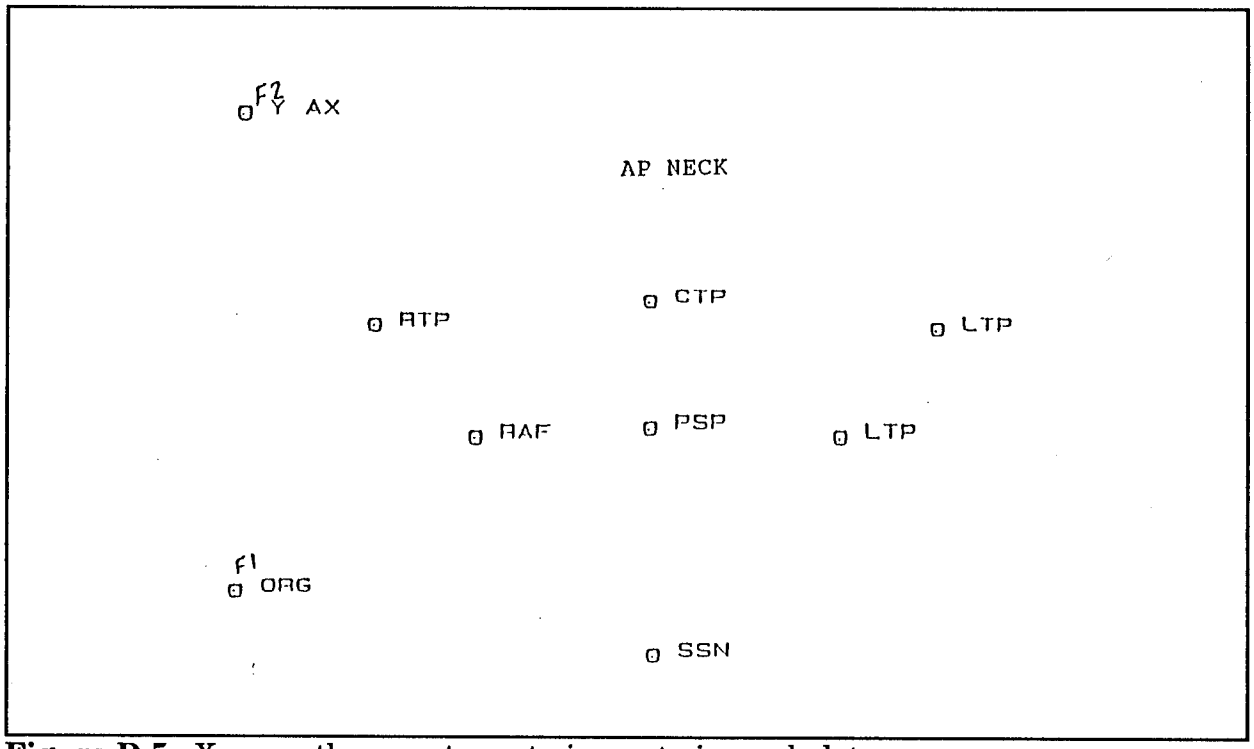

Figure D-5. X-ray anthropometry anterior-posterior neck data.

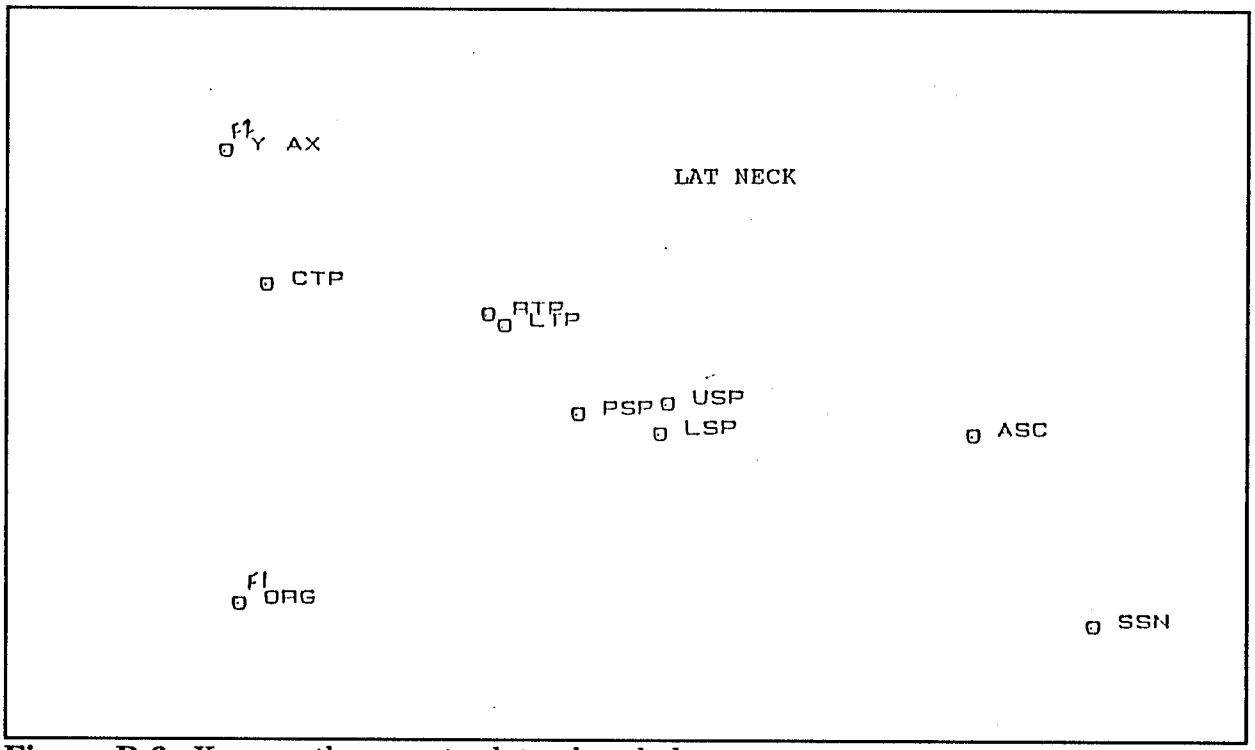

Figure D-6. X-ray anthropometry lateral neck data.