

Abstract

By using a digitiser in conjunction with programs for calculating and contouring the gravitational attraction of a three dimensional body gravity modelling is readily performed for a specific project.

INTRODUCTION

The programs were written for use on Interdata 7/16 and Burroughs B6700 computers at the University of Tasmania. With minor changes, the programs could be transferred to other systems provided the necessary tablet digitiser, bulk storage, and plotter are available.

THE PROGRAMS

(a) *CONTDIG (Appendix 1)*

The hardware required for this program is a tablet digitiser with sampling switch and two status sensing switches, a graphics output unit with X and Y co-ordinate ranges from -2048 to +2048, a 9-track tape drive, and a console device. The program is intended for digitising and displaying co-ordinates near Tasmania, but the area may be changed simply by changing the plotting scale and origin. If desired the map may be divided into four separate panels to allow digitising at a larger scale or of a larger area. Any rotation of the map relative to the digitising tablet is removed when the map scale is determined. The program output is used as input for program U2588/20.

Machine code routines called are:

PRIVLG	used to put the program in privileged state to allow I/O without supervisor intervention.
SYSCOM(I,7HAS 6EB*)	assign a pseudo-device to allow EBCDIC output in 80 character records on magnetic tape.
PLOTOM(3HTVS)	direct plotted output to the C.R.T. display.
SCREEN(0)	clear the C.R.T. screen.
CALL PLOT00(7)	gather the colour guns together.
PLOT(IX, IY, IPEN, ICOL)	move to IX, IY with the pen up (IPEN=1) or down (IPEN=0) and draw a line of colour ICOL. (ICOL=0 is erase).
EOF(6)	write a single tape mark.
ISENSE(249)	gets the status of the two switches on the digitiser.
I=KDIGIT(IX, IY)	returns the digitiser co-ordinates of the current cursor position and the status switch settings when the digitise switch is operated.

Input is similar to the control input for program U2588 (Richardson, 1981) and is:

- NCO, DENSITY NCO=0 end of run
 NCO=1 only acceptable value other than 0
 DENSITY the body density
- TITLE a title of 80 or less characters.
- Y or N answer Yes or No in reply to a prompt about data in that panel.
- XØ, YØ the map co-ordinates of a point near the left-hand side of the map.
- XC, YC the map co-ordinates of a point near the right-hand side of the map.

 N.B. YC=YØ
- NBODY the number of bodies in the panel.
- NCONT for each body the number of contours.
- DEPTH the depth of each contour (depth negative below datum).
- Y or N answer Yes if the contour as displayed is correct.

(b) U2588/20 (Appendix 2)

This program calculates the gravitational attraction of three-dimensional models digitised using CONTDIG. The attractions are calculated at points on a rectangular grid and output is in a form suitable for contouring. The co-ordinates of the observation points are determined between lines 10300 and 11800. The data maximum and minimum are output to the printer.

On a Burroughs B6700 the processor time for a program run is approximately 2.5 seconds for each line of the input file. In the current program version, the total number of vertices for a model (set by the DIMENSION of XA, YA) must be less than 2500.

(c) CONTOUR/20 (Appendix 3)

This program plots a map of Tasmania and contours of calculated gravitational attraction at a scale of 1:1 000 000. As the plotter width is only 10.5 inches (267 mm) the final map is formed by joining two plots.

Input is:

- File 7 the A.M.G. co-ordinates specifying Tasmania.
 A negative value for the X co-ordinate causes the plotter pen to be raised, the pen moved to the co-ordinate pair and the pen lowered. This allows islands and lakes to be drawn.
- File 4 the output of U2588/20.

Subroutines without listings are:

SETCORNER(IX, IY, LENGTH) initialise the plotter with the bottom left-hand corner of the paper having co-ordinates (IX, IY) and allow a paper length of LENGTH.

N.B. all plotter commands are given in co-ordinates consistent with (IX, IY) and are in units of 0.01 inches. The plotter axes are contrary to normal practice and have the X-axis across the paper and the Y-axis along the paper.

SETCHA(IHT, IDIRN) set the character size and direction for labelling contours. If IDIRN=0 text is written from left to right parallel to the X-axis.

CONTUR(VALUE, AMAP, NX, NY, NX*NY, IX1, IX2, IY1, IY2, X, Y) draws a contour at a given level (VALUE) through data (AMAP) on a rectangular grid using the method of Bengtsson and Nordbeck (1967). The grid is NX by NY but only the range IX1 to IX2 and IY1 to IY2 is contoured. Arrays X and Y are used for workspace. The subroutine makes use of calls to XFORM to convert from array element units to plotter co-ordinates.

MOVETO(IX, IY) the pen is moved to co-ordinates IX, IY without being raised or lowered.

PLTEND terminate the plot and move the pen up the Y-axis until it is beyond the furthest limit previously plotted.

REFERENCES

- BENGTSSON, B.; NORDBECK, S. 1967. Construction of isarithms and isarithmic maps by computers. *Bit* 4:87-105.
- RICHARDSON, R.G. 1981. Programs for the calculation of the gravitational and magnetic anomaly of 3-dimensional bodies. *Unpubl.Rep.Dep.Mines Tasm.* 1981/20.

[6 May 1981]

APPENDIX 1

Programme CONTDIG

(1)

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C PROGRAM CONTDIG
C TO DIGITISE CONTOURS FROM A MAP OF TAS - SCALE 1:1000000
C MAY USE UP TO FOUR PANELS WITH SCALE. TO USE MORE OR LESS
C PANELS CHANGE SCALE AND PANEL UPPER LIMIT.
  DIMENSION X(800),Y(800),TITLE(18)
  INTEGER*2 IXI(800),IYI(800)
  EQUIVALENCE (TITLE(1),X(1))
  DATA AOK/4HY /
C USED FOR OK CHECKS
  CALL PRIVLG
  CALL SYSCOM(I,7HAS 6EB*)
  CALL PLOTOM(3HTVS)
C PLOT ON TV
  CALL SCREEN (0)
  CALL PLOT00(7)
  SCALE=4000./475.
C WANT 475KM TO BE 4000 PLOTTING STEPS
  IX=235.0*SCALE
  IY=237.5*SCALE
  CALL PLOT(-IX,-IY,1,7)
  CALL PLOT(-IX,IY,0,7)
  CALL PLOT(IX,IY,0,7)
  CALL PLOT(IX,-IY,0,7)
  CALL PLOT(-IX,-IY,0,7)
C DRAW BOUNDARY
C
C NOW DRAW MAP OF TAS IF WANTED
C
  I=IGITA(X0,Y0)
C FORCE CALIBRATION
  197 WRITE(5,103)
  103 FORMAT('NCO,DENSITY(I2,F6.)')
  READ(5,104) NCO,DENSTY
  104 FORMAT(I2,F6.0)
  WRITE(6,200) NCO
  200 FORMAT(I2,70X)
  IF (NCO .LE. 0) GOTO 876
C END OF RUN
  WRITE(6,201) DENSTY
  201 FORMAT(F8.3,64X)
  WRITE(5,128)
  128 FORMAT('TITLE')
  READ(5,129) TITLE
  129 FORMAT(18A4)
  WRITE(6,129) TITLE
C TITLE FOR EACH BODY
  IBCONT=1
C USED TO CONTROL PARAMETERS PASSED TO MAIN PROGRAM
  DO 9990 III=1,4
C LOOP TO ALLOW PANELLING - SET FOR 4 ABOVE
  WRITE(5,118)
  118 FORMAT('ANY DATA?')
  READ(5,119) YES
  119 FORMAT(A4)

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IF (YES .NE. AOK) GOTO 9990
C DONT HAVE ANY DATA IN THIS PANEL
WRITE(5,50)
50 FORMAT(' TOUCH ORIGIN,CORNER,TYPE ' /
.' XO,YO,XC,YC (2F6./2F6.)')
I=IGITA(XO,YO)
C ORIGIN
I=IGITA(XC,YC)
C CORNER WITH SAME Y COORD AS CORNER - ALLOWS PANELLING
XD=XC-XO
YD=YC-YO
C DISTANCES ALONG AXES
DDIGIT=SQRT(XD*XD+YD*YD)
C DISTANCE AS MEASURED ON DIGITISER
THETA=ATAN(YD/XD)
C ANGLE BETWEEN DIGITISER GRID AND MAP GRID
C THETA=COS(THETA)
S THETA=SIN(THETA)
C NEEDED FOR COORDINATE TRANSFORMATION
READ(5,102) XOMAP,YOMAP,XCMAP,YCMAP
102 FORMAT(2F6.0/2F6.0)
XMAP=XCMAP-XOMAP
YMAP=YCMAP-YOMAP
DMAP=SQRT(XMAP*XMAP+YMAP*YMAP)
XSCALE=DMAP/DDIGIT
C ASSUME SCALE OF MAP IS THE SAME IN BOTH DIRECTIONS
C MAY NOW USE COORDINATE ROTATIONS FOR A GRID WITH A
C COMMON ORIGIN
C XMAP=XD*COS(THETA)+YD*SIN(THETA)
C YMAP=-XD*SIN(THETA)+YD*COS(THETA)
WRITE(5,66)
66 FORMAT(' NO. BODIES (I2)')
READ(5,67) NBODY
67 FORMAT(I2)
DO 68 IBODY=1,NBODY
C LOOP FOR NUMBER OF BODIES IN EACH PANEL
CALL CONTRL(-IBCONT)
C IF ALREADY HAVE A BODY WITH THESE CONSTANTS WRITE A SET
C OF 0 CONTROL PARAMETERS
IBCONT=1
37 WRITE(5,2)
2 FORMAT(' NO. CONTRS (I3)')
READ(5,3) NCONT
3 FORMAT(I3)
IF (NCONT .LE. 0) GOTO 9990
C NO CONTOURS IN THIS PANEL
IF (MOD(NCONT,2) .EQ. 0) GOTO 37
C NEED ODD NUMBER OF CONTOURS
WRITE(6,3) NCONT
ICON=1
10 WRITE(5,11) ICON
11 FORMAT(' DEPTH OF CONTOUR',I3,' ?')
READ(5,12) DEPTH
12 FORMAT(F8.0)

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NVERT=0
30 NVERT=NVERT+1
   IF (NVERT .GT. 800) GOTO 10
C TOO MANY VERTICES
   K=IGITA(X(NVERT),Y(NVERT))
   IF (LAND(K,64)) 33,30,33
C TERMINATE BY RAISING LEFT-HAND SWITCH
   33 NVERT=NVERT-1
C MAIN COMPUTATIONAL PROGRAM CLOSSES BODY
   DO 337 I=1,NVERT
   XD=(X(I)-X0)*XSCALE
   YD=(Y(I)-Y0)*XSCALE
   X(I)=(XD*CTHETA+YD*STHETA)+XOMAP
   Y(I)=(YD*CTHETA-XD*STHETA)+YOMAP
337 CONTINUE
C CONVERT FROM DIGITISER COORDS TO MAP COORDS
   IIX=(X(1)-430.0)*SCALE
   IIY=(Y(1)-362.5)*SCALE
   CALL PLOT(IIX,IIY,1,7)
   DO 38 I=2,NVERT
   IX=(X(I)-430.0)*SCALE
   IY=(Y(I)-362.5)*SCALE
   IXI(I)=IX
   IYI(I)=IY
   CALL PLOT(IX,IY,0,2)
38 CONTINUE
   CALL PLOT(IIX,IIY,0,2)
   WRITE(5,35)
35 FORMAT(' OK?')
   READ(5,119) YES
   IF (YES .NE. AOK) GOTO 83
   CALL PLOT(IIX,IIY,1,6)
   DO 39 I=2,NVERT
   IX=IXI(I)
   IY=IYI(I)
   CALL PLOT(IX,IY,0,6)
39 CONTINUE
   CALL PLOT(IIX,IIY,0,6)
   WRITE(6,34) DEPTH,NVERT
34 FORMAT(F8.3,I6,58X)
   WRITE(6,36) (X(K),Y(K),K=1,NVERT)
36 FORMAT(4(F10.2,F8.2))
   ICON=ICON+1
   IF (ICON .LE. NCONT) GOTO 10
   IF (IBODY .EQ. NBODY) IBCONT=-1
C LAST TIME THROUGH WAIT AND SEE IF HAVE MORE BODIES WITH THE
C SAME CONSTANTS
   CALL CONTRL(IBCONT)
   68 CONTINUE
C END OF BODY LOOP
9990 CONTINUE
C END OF PANEL LOOP
   WRITE(6,43)
43 FORMAT(' 0 0 0 1',64X)
```

C WRITE OUT CONTROL PARAMETERS

GOTO 197

876 CONTINUE

CALL EOF(6)

CALL EOF(6)

STOP

83 CALL PLOT(IIY,IIY,1,0)

DO 84 I=2,NVERT

84 CALL PLOT(IXI(I),IYI(I),0,0)

CALL PLOT(IIY,IIY,0,0)

GOTO 10

C ERASE UNWANTED CONTOUR

END

SUBROUTINE CONTRL(I)

IF (I .EQ. -1) RETURN

C DONT WRITE

WRITE(6,100)

100 FORMAT(' 0 0 0 0',64X)

RETURN

END

FUNCTION IGITA(X,Y)

C DIGITIZE X,Y COORDS WHEN FOOT SWITCH PRESSED.

C UNITS ARE CMS. WITH AN ARBITRARY ORIGIN

C CALIBRATION FACILITIES ARE INCLUDED

C ALLOWS SENSING OF THE TWO STATUS SWITCHES:

C LEFT HAND SWITCH VALUES 64

C BOTH LEFT AND RIGHT HAND SWITCHES - CHECK FOR BOTH 32 AND 64

C TO INVOKE A CALIBRATION BEFORE THE NEXT POINT IS DIGITISED

C SET ONLY THE RIGHT HAND SWITCH(32) UP.

C CALIBRATION CONSISTS OF DIGITISING THE COORDINATES OF A POINT

C IN THE FRONT LEFT HAND CORNER AND THE BACK RIGHT-HAND BACK CORNER

DATA IFIR/-1/,XFACT/0.0/,YFACT/0.0/

IF (IFIR) 1,2,2

2 J=ISENSE(249)

IF (LAND(J,32) .NE. 0 .AND. LAND(J,64) .EQ. 0) GOTO 1

GOTO 100

C FORCED CALIBRATION

1 WRITE(5,5)

5 FORMAT('CALIBRATION')

I=KDIGIT(IX0,IY0)

I=KDIGIT(IX1,IY1)

SLENGF=70.0

C 70.0 CM. CALIBRATION BASE

XFACT=ABS(SLENGF/FLOAT(IX1-IX0))

YFACT=ABS(SLENGF/FLOAT(IY1-IY0))

C DOESNT MATTER WHAT THE ORDER IS

IFIR=0

WRITE(5,9)

9 FORMAT('SET CAL SWITCH')

PAUSE

GOTO 2

100 IGITA=KDIGIT(IX1,IY1)

X=FLOAT(IX1)*XFACT

Y=FLOAT(IY1)*YFACT

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RETURN
END

23-A1/5

APPENDIX 2

Programme U2588/20

FILE: U2588/20 (12/06/79)

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100 $SET 2
200 $SET LINEINFO
300 $RESET FREE
400 $OPT=+1
500 $SET VECTORMODE
600 FILE 7(KIND=PACK,FILETYPE=7)
700 FILE 6(KIND=PRINTER)
800 FILE 5(TITLE="TASGRAV/MOD2",KIND=PACK,FILETYPE=7)
900 FILE 4(KIND=PACK,FILETYPE=0,UNITS=WORDS,MAXRECSIZE=14,MINRECSIZE=14,
1000 .BLOCKSIZE=420,FILEKIND=DATA,AREAS=300,AREASIZE=450)
1100 C U2588 SOLID 3-D GRAVITATIONAL ATTRACTION - SIMPLE VERSION
1200 C TRANSLATED FROM THE ALGOL VERSION D.S.I.R. GEOPHYSICS DIVISION.
1300 C GP030 SOLID.
1400 C TALWANI METHOD FOR CALCULATING THE GRAVITY AND MAGNETIC EFFECTS
1500 C OF A BODY OF ARBITRARY SHAPE APPROXIMATED BY POLYGONAL CONTOURS
1600 C VIDE TALWANI, EWING, 1959:
1700 C <RAPID COMPUTATION OF GRAVITATIONAL ATTRACTION OF THREE-DIMENSIONAL
1800 C BODIES OF ARBITRARY SHAPE>
1900 C IN GEOPHYSICS, VOL. XXV, NO. 1 (FEBRUARY 1960).
2000 C TALWANI, M., 1964:
2100 C COMPUTATION WITH THE HELP OF A DIGITAL COMPUTER OF MAGNETIC
2200 C ANOMALIES CAUSED BY BODIES OF ARBITRARY SHAPE>
2300 C IN GEOPHYSICS, VOL. XXX, NO. 5 (OCTOBER 1965).
2400 C PROGRAMME WRITTEN BY M.A. SAUNDERS, D.S.I.R. APPLIED MATHEMATICS
2500 C DIVISION, SEPTEMBER 1966. . . . AND ALTERED FOR THE UNIVERSITY OF
2600 C TASMANIA B6700 BY R.G. PICHARDSON (1978 BOTH ALGOL AND FORTRAN).
2700 C GRAVITY ONLY
2800 LOGICAL NEWPRB,NEWPC,REPLAC,NJCNST,FIRST,NF,NR
2900 INTEGER I,IBUF,J,M1,N1,UH1,UV1,NP,NC,ND,
3000 . NCD,FM,M,AM,BH,AV,BV,NPROR,NCPT,
3100 . RPLAC,NCNST,CT,MO,DY1I,NCP,CPC
3200 REAL UH,UV,XX,YY,ZZ,X1,X2,Y1,Y2,PI,
3300 . PIBY2,K,NUMBER,H1,H2,H3,A,B,C
3400 REAL SCALE(7),X(576),Y(576),Z(576),
3500 . GC(576),GZZC(576),
3600 . DENS(10),XA(2500),YA(2500),ZA(30),Q1,Q2,Q3
3700 INTEGER A1(7),B1(7),PPC(577),TITLE(80),NV(15)
3800 REAL UZ(576),W,V1,Z3(576),UZI,
3900 . D3,TERM,SUM,Z1,Z2,RX1,RX2,R12,R1,R2,R1I,R2I,
4000 . EPSLNH,EPNLNV,SQ,CF,DX1,DY1,G1,P,ZPP,
4100 . COSG,COSB,BETA,GAMMA,DPSI,INTEGL,G,CZZ
4200 LOGICAL BA,BB,NDERIV,NANOM
4300 COMMON /INTGRL/ Q1(7),Q2(7),Q3(7),ND
4400 COMMON /WSP/W,P,PIBY2,DX1,DY1,PI,CF,SQ
4500 SCALE(5)=1.E5
4600 SCALE(4)=182.87984
4700 SCALE(6)=160934.3
4800 SCALE(1)=1.E2
4900 SCALE(2)=30.479973
5000 SCALE(3)=91.4399
5100 SCALE(7)=185318.2
5200 K=6.673E-8
5300 C
5400 C*****
5500 C*****
5600 C SET OPTIONS HERE
5700 C NDERIV=.FALSE. FOR VERTICAL DERIVATIVE
5800 C NANOM=.FALSE. FOR SIMPLE ANOMALY
5900 C NDERIV=.TRUE.
6000 C NANOM=.FALSE.
6100 C*****
6200 C*****
6300 C
6400 C
6500 A1(1)=6
6600 A1(2)=6
6700 A1(3)=6
6800 A1(4)=6
6900 A1(5)=3
7000 A1(6)=3
7100 A1(7)=3
7200 B1(1)=0
7300 B1(2)=0
7400 B1(3)=0
7500 B1(3)=0
7600 B1(4)=0
7700 B1(5)=3

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7800      B1(6)=3
7900      B1(7)=3
8000      PI=3.1415926536
8100      PI*Y2=PI/2.
8200      NUMBER=-57.2957795*3600./980.
8300      NEWPRB=.TRUE.
8400      NEWCP=.TRUE.
8500      NUCNST=.TRUE.
8600      FIRST=.TRUE.
8700      999 CONTINUE
8800      C OLD REPEAT LABEL
8900      IF (.NOT. NEWCP) GOTO 14
9000      C READ COMPUTING POINTS
9100      UH1=4
9200      UV1=4
9300      C SET FOR KILOMETRES
9400      UH1=UH1+1
9500      UV1=UV1+1
9600      AH=A1(UH1)
9700      BH=B1(UH1)
9800      AV=A1(UV1)
9900      BV=B1(UV1)
0000      UH=SCALE(UH1)
0100      UV=SCALE(UV1)
0200      II=0
0300      XNORTH=125.0
0400      C GO FROM 125 KM N TO 585 KM N
0500      DO 11 I=1,24
0600      XEAST=195.0
0700      C GO FROM 195 KM E TO 655 KM E
0800      DO 10 J=1,24
0900      II=II+1
1000      Z(II)=0.0
1100      PPC(II)=II
1200      C COMPUTING POINT NUMBER
1300      X(II)=(XEAST+1.E-6)*UH
1400      Y(II)=XNORTH*UH
1500      XEAST=XEAST+20.0
1600      10 CONTINUE
1700      XNORTH=XNORTH+20.0
1800      11 CONTINUE
1900      PPC(577)=-1
2000      I=576
2100      NP=1
2200      WRITE(6,1003)
2300      1003 FORMAT(1H1)
2400      C SET UP REGULAR GRID TO COVER STATE ON 49 POINTS
2500      C END READ COMPUTING POINTS
2600      14 CONTINUE
2700      IF (.NOT. NUCNST) GOTO 16
2800      C READ CONSTANTS
2900      READ(5,107) NCO
3000      107 FORMAT(I2)
3100      IF (NCO .LE. 0) GOTO 787
3200      C WRITE OUT RESULTS BEFORE STOP
3300      DO 15 N1=1,NCO
3400      READ(5,110) DENS(N1)
3500      110 FORMAT(F8.3)
3600      READ(5,101) TITLE
3700      101 FORMAT(80A1)
3800      WRITE(6,102) TITLE
3900      102 FORMAT(1X,80A1)
4000      C TITLE FOR EACH BODY
4100      15 CONTINUE
4200      C END READ CONSTANTS
4300      16 CONTINUE
4400      C
4500      C
4600      C NEW BODY
4700      READ(5,114) NC
4800      114 FORMAT(I3)
4900      I=NC-1
5000      ND=INT(I/2)
5100      IF (2*ND .EQ. I) GOTO 17
5200      WRITE(6,115)
5300      115 FORMAT(" SHOULD BE ODD NUMBER OF LAYERS")
5400      STOP
5500      17 CONTINUE
5600      CT=0
5700      IF2TEM=AV+BV+2

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5800      FM=AH+BH+2
5900      DO 23 I=1,NC
6000      READ(5,116) A,M
6100      116  FORMAT(F8.2,I6)
6200      ZA(I)=-A*UV
6300      NV(I)=M
6400      IF (M.EQ. 1) GOTO 22
6500      MO=CT+1
6600      CT=CT+M
6700      READ(5,118) (XA(J),YA(J),J=MO,CT)
6800      118  FORMAT(4(F10.2,F8.2))
6900      DO 20 J=MO,CT
7000      XA(J)=XA(J)*UH
7100      YA(J)=YA(J)*UH
7200      20  CONTINUE
7300      CT=CT+1
7400      YA(CT)=YA(MO)
7500      YA(CT)=YA(MO)
7600      22  CONTINUE
7700      C END READ CARDS FOR CONTOURS
7800      23  CONTINUE
7900      J=1
8000      DO 25 I=1,ND
8100      H3=ZA(J+1)
8200      H1=ZA(J)-H3
8300      H2=H3-ZA(J+2)
8400      H3=H1+H2
8500      IF (H1.LE. 0) GOTO 24
8600      H1=-H1
8700      H2=-H2
8800      H3=-H3
8900      24  CONTINUE
9000      Q1(I)=H3*(H2/H1-2)
9100      Q2(I)=-H3*H3*H3/(H1*H2)
9200      Q3(I)=H3*(H1/H2-2)
9300      J=J+2
9400      C END I LOOP
9500      25  CONTINUE
9600      C
9700      C
9800      C WHAT TO DO WITH NEXT BODY
9900      READ(5,121) NPROB,NCPT,RPLAC,NCONST
0000      121  FORMAT(4I2)
0100      NEWPRB=NPROB .NE. 0
0200      NEWCP=NCPT .NE. 0
0300      REPLAC=RPLAC .NE. 0
0400      NUCNST=NCONST .NE. 0
0500      NF=.NOT. FIRST
0600      NR=.NOT. REPLAC
0700      C
0800      C CALCULATE ANOMALIES
0900      EPSLNH=UH*1.E-6
1000      EPSLNV=UV*1.E-6
1100      XX=0
1200      YY=0
1300      ZZ=0
1400      DO 60 M1=1,NP
1500      XX=XX-X(M1)
1600      YY=YY-Y(M1)
1700      ZZ=ZZ-Z(M1)
1800      CT=0
1900      DO 63 I=1,NC
2000      ZA(I)=ZA(I)+ZZ
2100      M=NV(I)
2200      IF (M.EQ. 1) GOTO 62
2300      MO=CT+1
2400      CT=MO+M
2500      DO 61 J=MO,CT
2600      XA(J)=XA(J)+XX
2700      YA(J)=YA(J)+YY
2800      61  CONTINUE
2900      62  CONTINUE
3000      C END I LOOP
3100      63  CONTINUE
3200      XX=X(M1)
3300      YY=Y(M1)
3400      ZZ=Z(M1)
3500      CT=0
3600      DO 74 I=1,NC
3700      M=NV(I)

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23800      IF (M .NE. 1) GOTO 64
23900      UZ(I)=0
24000      Z3(I)=0
24100      GOTO 75
24200      C GOTO OLD NEWI LABEL
24300      64 CONTINUE
24400      Z1=ZA(I)
24500      Z2=Z1*Z1
24600      MD=CT+1
24700      CT=CT+M
24800      X1=XA(MD)
24900      Y1=YA(MD)
25000      SQ=X1*X1+Y1*Y1
25100      RX1=SQRT(SQ)
25200      R1=SQRT(SQ+Z2)
25300      R1I=1.0/R1
25400      UZ1=0
25500      D3=0
25600      DO 73 J=MD,CT
25700      X2=XA(J+1)
25800      Y2=YA(J+1)
25900      SQ=X2*X2+Y2*Y2
26000      RX2=SQRT(SQ)
26100      R2=SQRT(SQ+Z2)
26200      R2I=1.0/R2
26300      DX1=X1-X2
26400      DY1=Y1-Y2
26500      R12=SQRT(DX1*DX1+DY1*DY1)
26600      P=(X1*Y2-X2*Y1)/R12
26700      SQ=P*P
26800      ZPP=Z2+SQ
26900      COSG=(DX1*X2+DY1*Y2)/(R12*RX2)
27000      COSB=(DX1*X1+DY1*Y1)/(R12*RX1)
27100      BA=ABS(P) .GT. EPSLNH
27200      C BA=BIG(P)
27300      IF (.NOT. BA) GOTO 72
27400      IF (NANOM) GOTO 81
27500      CF=Z1/SQRT(ZPP)
27600      BETA=ANGLE(X1,Y1,RX1,BA)
27700      GAMMA=ANGLE(X2,Y2,RX2,BA)
27800      DPSI=GAMMA-BETA
27900      SUM=DPSI+ANGLEE(COSG)-ANGLEE(COSB)
28000      UZ1=UZ1+SUM*F SIGN(P)
28100      81 CONTINUE
28200      IF (NDERIV) GOTO 72
28300      C NOT DERITAVE
28400      TERM=RX2*COSG*R2I
28500      CF=RX1*COSB*R1I
28600      G1=(CF-TERM)*P/ZPP
28700      SUM=CF/(R1*R1)-TERM/(R2*R2)
28800      D3=D3+(2.0*G1+P*SUM)/ZPP
28900      C IF (.NOT. BA) GOTO HERE
29000      72 CONTINUE
29100      X1=X2
29200      Y1=Y2
29300      RX1=RX2
29400      R1=R2
29500      R1I=R2I
29600      73 CONTINUE
29700      C END J LOOP
29800      CT=CT+1
29900      UZ(I)=UZ1
30000      IF (NDERIV) GOTO 75
30100      Z3(I)=D3*Z1
30200      75 CONTINUE
30300      C OLD NEWI LABEL
30400      74 CONTINUE
30500      C END OF I LOOP
30600      IF (.NOT. NANOM) UZ1=-INTEGL(UZ)
30700      IF (.NOT. NDERIV) D3=-INTEGL(Z3)
30800      DO 78 NI=1,NCU
30900      A=K*DENS(N1)
31000      G=-UZ1*A*1.E3
31100      GZZ=-D3*A*1.E15
31200      C END N1 LOOP
31300      78 CONTINUE
31400      IF (.NOT. FIRST) GOTO 79
31500      GC(M1)=G
31600      GZC(M1)=GZZ
31700      GOTO 80

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31800      79 CONTINUE
31900      IF (.NOT. NR) GOTO 80
32000      GC(M1)=GC(M1)+G
32100      GZZC(M1)=GZZC(M1)+GZZ
32200      80 CONTINUE
32300      C END M1 LOOP
32400      C END ANOMALIES
32500      FIRST=NEWPRB .OR. NEWCP .OR. (FIRST .AND. REPLAC)
32600      GOTO 999
32700      CGOTO OLD REPEAT LABEL
32800      C NOW WRITE CUMULATIVE VALUES
32900      787 CONTINUE
33000      GCMAX=-99999.9
33100      GCMIN=99999.9
33200      GZZCMX=-99999.9
33300      GZZCMN=99999.9
33400      DO 87 M1=1,NP
33500      GCMAX=AMAX1(GC(M1),GCMAX)
33600      GCMIN=AMIN1(GC(M1),GCMIN)
33700      GZZCMX=AMAX1(GZZC(M1),GZZCMX)
33800      GZZCMN=AMIN1(GZZC(M1),GZZCMN)
33900      C FIND AND STORE MIN AND MAX VALUES TO PRINT OUT LATER
34000      87 CONTINUE
34100      WRITE(6,835) GCMIN,GCMAX,GZZCMN,GZZCMX
34200      835 FORMAT(///,' GCMIN=',F10.3,' GCMAX=',F10.3/
34300      . ' GZZCMIN=',F10.3,' GZZCMAX=',F10.3)
34400      C NEEDED FOR CONTOURING
34500      IF (.NANOM) GOTO 89
34600      C NO ANOMALY
34700      II=1
34800      DO 88 I=1,24
34900      WRITE(4,131) I
35000      131 FORMAT(I3)
35100      JUP=II+23
35200      WRITE(4,132) (GC(J),J=II,JUP)
35300      132 FORMAT(9F9.1)
35400      II=II+24
35500      88 CONTINUE
35600      C WRITTEN OUT ANOMALY
35700      89 CONTINUE
35800      IF (.NDERIV) GOTO 90
35900      II=1
36000      DO 91 I=1,24
36100      WRITE(4,131) I
36200      JUP=II+23
36300      WRITE(4,132) (GZZC(J),J=II,JUP)
36400      II=II+24
36500      91 CONTINUE
36600      90 CONTINUE
36700      CLOSE(4,DISP=CRUNCH)
36800      STOP
36900      END
37000      C END MAIN PROGRAM
37100      C
37200      REAL FUNCTION INTEGL(A)
37300      DIMENSION A(2)
37400      INTEGER K,J
37500      REAL I,W
37600      COMMON /INTGRL/ Q1(7),Q2(7),Q3(7),ND
37700      I=0
37800      K=1
37900      J=1
38000      10 CONTINUE
38100      W=Q1(K)*A(J)
38200      J=J+1
38300      W=W+Q2(K)*A(J)
38400      J=J+1
38500      I=I+W+Q3(K)*A(J)
38600      K=K+1
38700      IF (K-ND .LT. 1) GOTO 10
38800      INTEGL=I/6.
38900      RETURN
39000      END
39100      REAL FUNCTION ANGLE(XA,YA,R,B)
39200      LOGICAL B
39300      COMMON /WSP/W,P,PIBY2,DX1,DY1,PI,CF,SO
39400      W=ABS(P)/R
39500      IF (W .GE. 1.) GOTO 10
39600      W=ARSIN(W)
39700      GOTO 20

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39800      10 W=PIBY2
39900      20 CONTINUE
40000      B=(XA*DX1+YA*DY1) .LT. 0.0
40100      IF(B) W=PI-W
40200      ANGLE=W
40300      RETURN
40400      END
40500      REAL FUNCTION ANGLEF(CCOS)
40600      COMMON/WKSP/W,P,PIBY2,DX1,DY1,PI,CF,SQ
40700      W=CF*CCOS
40800      IF (ABS(W) .LT. 1.) GOTO 10
40900      ANGLE=FSIGN(W)*PIBY2
41000      RETURN
41100      10 ANGLE=ARSIN(W)
41200      RETURN
41300      END
41400      REAL FUNCTION FSIGN(A)
41500      IF (A .EQ. 0.) GOTO 10
41600      IF (A .GT. 0.0) GOTO 20
41700      FSIGN=-1.
41800      RETURN
41900      10 FSIGN=0.
42000      RETURN
42100      20 FSIGN=1.
42200      RETURN
42300      END
```

APPENDIX 3

Programme CONTOUR/20

OUR/20 (04/23/80)

3:2

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100 $SET $
200 $SET LINEINFO
300 $RESET FREE
400 FILE 6(KIND=PRINTER)
500 FILE 4(TITLE="TAS/ GRAVITY/RAW",KIND=PACK,FILETYPE=7)
600 FILE 7(TITLE="(USGLO121)TAS MAPPER",KIND=PACK,FILETYPE=7)
700 $INCLUDE "(USGLO043)FORTRAN/PLOTPAK"
800 $OPT=1
900 $SET VECTORMODE
1000 C A PROGRAM TO CONTOUR DATA ON TWO SIDE BY SIDE SHEETS FOR TAS GRAVITY
1100 C DATA, SET UP FOR 20 KM. DATA GRID
1200 DIMENSION AMAP(24,24),X(576),Y(576)
1300 REAL MAPX(2301),MAPY(2301)
1400 COMMON /TFORM/ XFACT,YFACT,XBASE,YBASE
1500 C FOR PASSING VALUES TO XFORM
1600 READ(7) MAPX
1700 READ(7) MAPY
1800 DO 10 I=1,24
1900 READ(4,100) LINE
2000 100 FORMAT(I3)
2100 READ(4,200) (AMAP(J,LINE),J=1,24)
2200 200 FORMAT(9F8.1)
2300 10 CONTINUE
2400 C READ DATA INTO ARAY WITH X VALUE IN LEFT HAND SUBSCRIPT
2500 DO 11 I=1,24
2600 DO 11 J=1,24
2700 AMAPJI=-AMAP(J,I)
2702 AMAP(J,I)=AMAPJI
2704 C CORRECT FOR UPSIDE DOWN ANOMLY VALUES
2800 IF (AMOD(AMAPJI,10.0) .EQ. 0.0) AMAP(J,I)=AMAPJI+0.05
2900 11 CONTINUE
3000 C OFFSET VALUES ON CONTOURS SLIGHTLY
3100 CALL SETCOR(0,-10,2000)
3200 C INIT. PLOTTING ROUTINES
3300 CALL SETCHA(4,0)
3400 C EAST-WEST CHARS
3500 ABOT=-530.0
3501 C REMEMBER TO INVERT BECAUSE OF UPSIDE DOWN DATA
3600 ATOP=-10.0
3601 C REMEMBER TO INVERT BECAUSE OF UPSIDE DOWN DATA
3700 AINT=10.0
3800 C LOWEST LEVEL,HIGHEST LEVEL,INTERVAL (IN THIS CASE UNITS ARE MILLIGALS)
3900 VALUE=ABOT
4000 C STARTING VALUE
4100 NUMCON=((ATOP-ABOT)/AINT)+1.0
4200 C NUMBER OF CONTOUR LEVELS
4300 XFACT=100.0/(10.0*2.5400)
4400 C WANT SCALE OF 1 CM=10 KM)
4500 YFACT=XFACT
4600 C SQUARE GRID
4700 IX235=235.0*XFACT
4800 IY475=475.0*YFACT
4900 IX260=260.0*XFACT
5000 C NEEDED FOR BORDER ROUTINE
5100 XFACT=XFACT*20.0
5200 YFACT=YFACT*20.0
5300 C DATA ON 20 KM GRID
5400 XBASE=XFACT*1.0
5500 YBASE=YFACT*1.0
5600 C MOVE DOWN AND TO LEFT BY ONE UNIT
5700 XMBASE=195.0
5800 C MAP XBASE=195 KM E
5900 YMBASE=125.0
6000 C MAP YBASE=125 KM N
6100 DO 20 I=1,NUMCON
6200 CALL CONTUR(VALUE,AMAP,24,24,576,1,14,1,24,X,Y)
6300 WRITE(6,101) VALUE
6400 101 FORMAT(' LEVEL (LHS)',F8.3)
6500 C LEFT HAND SIDE OF MAP
6600 20 VALUE=VALUE+AINT
6700 C DRAWN FIRST HALF
6800 CALL TASMPP(MAPX,MAPY,XMBASE,YMBASE)
6900 C DRAW MAP OF TAS
7000 CALL BORDER(IX235,IY475,IX260)
7100 C DRAW BORDER WITH REFERENCE POINTS
7200 CALL PENUP
7300 CALL MOVETO(0,1990)

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7400 CALL PLTEND
7500 C END OF FIRST PLOT
7600 CALL SETCOR(0,-10,2000)
7700 CALL SETCHA(4,0)
7800 VALUE=ABOT
7900 XBASE=XFACT*11.5
8000 C MOVE TO THE LEFT AND USE PREVIOUS VERTICAL POSN.
8100 DO 30 I=1,NUMCON
8200 CALL CONTUR(VALUE,AMAP,24,24,576,12,24,1,24,X,Y)
8300 WRITE(6,102) VALUE
8400 102 FORMAT('LEVEL (RHS)',F8.3)
8500 30 VALUE=VALUE+A*INT
8600 C SECOND HALF DRAWN
8700 IX25=(25.0*XFACT)/20.0
8800 XMBASE=405.0
8900 C MAP XBASE=405 KM E
9000 CALL TASMAR(MAPX,MAPY,XMBASE,YMBASE)
9100 CALL BORDER(IX25,IY475,IX260)
9200 C DRAW BORDER WITH MARKER ON LHS
9300 CALL PENUP
9400 CALL MOVETO(0,1990)
9500 CALL PLTEND
9600 STOP
9700 END
9800 SUBROUTINE XFORM(A,B)
9900 COMMON /TRFORM/ XFACT,YFACT,XBASE,YBASE
0000 A=(A*XFACT)-XBASE
0100 B=(B*YFACT)-YBASE
0200 RETURN
0300 END
0400 SUBROUTINE BORDER(IX235,IY475,IX260)
0500 CALL PENUP
0600 CALL MOVETO(0,IY475)
0700 CALL PENDWN
0800 CALL MOVETO(IX235,IY475)
0900 CALL MOVETO(IX235,IY475+10)
1000 CALL MOVETO(IX235,IY475)
1100 CALL MOVETO(IX260,IY475)
1200 CALL MOVETO(IX260,0)
1300 CALL MOVETO(IX235,0)
1400 CALL MOVETO(IX235,-10)
1500 CALL MOVETO(IX235,0)
1600 CALL MOVETO(0,0)
1700 CALL MOVETO(0,IY475)
1800 C DRAWN BORDER
1900 RETURN
2000 END
2100 $INCLUDE "(GMGL0030)SUB/CONTOUR"
2200 SUBROUTINE TASMAR(MAPX,MAPY,XBASE,YBASE)
2300 REAL MAPX(2),MAPY(2)
2400 FACT=100.0/(10.0*2.5400)
2500 C WANT 1 CM = 10 KM
2600 CALL PENUP
2700 IX=(MAPX(1)-XBASE)*FACT
2800 IY=(MAPY(1)-YBASE)*FACT
2900 CALL MOVETO(IX,IY)
3000 CALL PENDWN
3100 DO 10 I=2,2301
3200 IY=(MAPY(I)-YBASE)*FACT
3300 IF (MAPX(I) .GE. 0.0) GOTO 20
3400 CALL PENUP
3500 IX=(ABS(MAPX(I))-XBASE)*FACT
3600 CALL MOVETO(IX,IY)
3700 CALL PENDWN
3800 C FOR DRAWING ISLANDS OR LAKES
3900 GOTO 10
4000 20 IX=(MAPX(I)-XBASE)*FACT
4100 CALL MOVETO(IX,IY)
4200 10 CONTINUE
4300 RETURN
4400 END

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