CIVIL ENGINEERS
POCKET COMPUTER MONTHLY

SURVEYING - PART III

This issue contains Part Three of the three-part series on the subject of Surveying. It provides two useful programs:

Closed Traverse
Angle Arithmetic

CLOSED TRAVERSE

The Closed Traverse program is somewhat similar to the Open Traverse program which was provided in the November issue. As before, the data is entered via data statements. However, there are important differences. Whereas the open traverse program should prove useful for office computations, the Closed Traverse program is intended to resolve field data. It will define the error of closure, including X and Y components; and will define the angular error. Then, using the "compass rule", all leg lengths and azimuths are recalculated so as to reduce the error of closure, and the angular error, to zero.

The program also calculates and prints out the ratio of the closure error to the total length of the survey. This ratio defines the accuracy of the survey. If this ratio is more than about 1 in 3000, the likelihood becomes strong that the problem does not stem from "error" (which pertains to the limitations inherent in the method), but rather to a mistake or blunder.

PROGRAM LISTING - CLOSED TRAVERSE/PC-2

```
10:"A"CLEAR :
   LPRINT "CLOSED
    TRAVERSE":
   LPRINT
20:LLIST 740,
30:N=100:DIM X(N)
   ,Y(N),X2(N),Y2
   (N),X3(N),Y3(N
   ),AL(N),BE(N):
   N=0
40:"W"READ TH,L:
   IF TH=999THEN
   "Q"
50:GOSUB "DMS":
   GOSUB "DEG-DEC
   ":TH=NH
60:N=N+1:NN=N
70:IF N=1LET SH=T
   H
80:TI=TI+TH
90:T2=TI:GOSUB "C
   HECK":TI=T2
100:X(N)=L*SIN TI
110:Y(N)=L*COS TI
120:M=M+L
130:X1=X1+X(N)
140:Y1=Y1+Y(N)
150:GOTO "W"
160:"Q"LPRINT "ERR
   OR AS SURVEYED
   :"
170:READ TJ
180:TH=TJ:GOSUB "D
   MS":GOSUB "DEG
   -DEC":TJ=NH
190:TI=TI+TJ-SH:LF
   2
200:T2=TI:GOSUB "C
   HECK":TI=T2
210:LPRINT "ANGLE
   ERROR=":PH=TI:
   GOSUB "DEGMNSC
   "
220:Z=√(X1^2+Y1^2)
230:LPRINT "ERROR
   CLOSURE,X=";
   LPRINT INT (X1
   *1000+.5)/1000
240:LPRINT "ERROR,
   CLOSURE,Y=";
   LPRINT INT (Y1
   *1000+.5)/1000
250:LPRINT "ERROR
   CLOSURE=";
   LPRINT INT (Z*
   1000+.5)/1000
260:IF Z=0THEN "R"
270:LPRINT "RATIO:
   ";LPRINT "TOTA
   L LENGTH/ERROR
   ":LPRINT "1 IN
   ";INT (M/Z)
280:"R"LF 1:LPRINT
   "**CORRECTED D
   ATA**":LF 1
290:RESTORE :X0=X1
   :Y0=Y1:FOR N=1
   TO NN
```

PROGRAM LISTING -
CLOSED TRAVERSE/PC-2
(continued)

```
300:READ TH,L
310:GOSUB "DMS":
    GOSUB "DEG-DEC
    ":TH=NH
320:X2(N)=X0*L/M:X
    3(N)=X(N)-X2(N
    )
330:Y2(N)=Y0*L/M:Y
    3(N)=Y(N)-Y2(N
    )
340:X1=X3(N):Y1=Y3
    (N):GOSUB "AZI
    MUTH":AL(N)=TK
    :IF N=1LET SK=
    TK
350:X2=X2+X3(N):Y2
    =Y2+Y3(N)
360:BE(N)=AL(N)-AL
    (N-1):T2=BE(N)
    :GOSUB "CHECK"
    :BE(N)=T2
370:Z=SQR(X1^2+Y1^2)
    :Z=INT (Z*1000
    +.5)/1000
380:LPRINT :USING
    :LPRINT "LEG#"
    ;N:LPRINT "LEG
     LENGTH=";Z:
    LPRINT "LEG AZ
    IMUTH="
390:PH=AL(N):GOSUB
    "DEGMNSC":IF N
    =1NEXT N
400:LF 1:LPRINT "A
    T";(N-1);"-";N
    :LF 1
410:LPRINT "DEFLEC
    T.ANGLE=":PH=B
    E(N):GOSUB "DE
    GMNSC"
420:LPRINT "INTERI
    OR ANGLE=":PH=
    180-BE(N):
    GOSUB "DEGMNSC
    "
430:X1=X2:Y1=Y2:
    NEXT N
440:LF 2:LPRINT "A
    T";N;"-1":RH=A
    L(N)-SK:RH=360
    -RH:T2=RH:
    GOSUB "CHECK":
    RH=T2
450:PH=RH:LPRINT "
    DEFLECT.ANGLE=
    ":GOSUB "DEGMN
    SC"
460:LPRINT "INTERI
    OR ANGLE=":PH=
    180-RH:GOSUB "
    DEGMNSC":LF 2
470:Z=SQR(X1^2+Y1^2)
    :Z=INT (Z*1000
    +.5)/1000
480:LF 2:LPRINT "A
    FTER CORRECTIO
    NS HAVE BEEN A
    PPLIED:":
    LPRINT
490:LPRINT "ERROR,
    CLOSURE,X=";
    LPRINT INT (X1
    *1000+.5)/1000
500:LPRINT "ERROR,
    CLOSURE,Y=";
    LPRINT INT (Y1
    *1000+.5)/1000
510:LPRINT "ERROR,
    CLOSURE=";
    LPRINT Z:LF 3
580:END
590:"AZIMUTH"IF X1
    <0AND Y1<0LET
    X3=ABS X1:Y3=
    ABS Y1:TJ=ATN
    (X3/Y3):TK=180
    +TJ:RETURN
600:IF X1<0LET X3=
    ABS X1:TJ=ATN
    (X3/Y1):TK=360
    -TJ:RETURN
610:IF Y1<0LET Y3=
    ABS Y1:TJ=ATN
    (X1/Y3):TK=180
    -TJ:RETURN
620:TJ=ATN (X1/Y1)
    :TK=TJ:RETURN
630:"DEGMNSC"PJ=(P
    H-INT PH)*60:P
    K=INT ((PJ-INT
    PJ)*60+.5)
640:PH=INT PH:PJ=
    INT PJ:IF PJ=5
    9AND PK=60LET
    PH=PH+1:PJ=0:P
    K=0
650:IF PK=60LET PJ
    =PJ+1:PK=0
660:IF PH=360AND P
    J=0AND PK=0LET
    PH=0
670:LPRINT PH;"DEG
    ";PJ;"M.";PK;"
    S.":RETURN
680:"CHECK"IF T2<0
    LET T2=T2+360:
    RETURN
690:IF T2>360LET T
    2=T2-360
700:RETURN
710:"DMS"PH=INT (T
    H/10000):PJ=(T
    H-PH*10000)/10
    0:PK=(PJ-INT P
    J)*100:PJ=INT
    PJ
720:RETURN
730:"DEG-DEC"NH=PH
    +(PJ+PK/60)/60
    :RETURN
740:DATA 450000,14
    14
750:DATA 900000,14
    14
760:DATA 450000,10
    00
770:DATA 300000,19
    98
780:DATA 1200000,1
    998
790:DATA 300000,99
    9
810:DATA 999,999
820:DATA 450000
```

WORKED OUT EXAMPLE

CLOSED TRAVERSE

All traverses are assumed to have been surveyed in the clockwise direction. Angles are "clockwise positive".

Each DATA statement is comprised of an angle and a length. In the first DATA statement, the angle is solely for the purpose of orienting the entire traverse to north within the X-Y coordinate system; it expresses the angle between the first leg and north. The accuracy of this first angle therefore does not affect the accuracy of the analysis for traverse closure; it merely affects the correctness of each azimuth relative to north. If the orientation of the traverse to north is not of importance, you may enter zero.

The program assumes that deflection angles were measured at all points of intersection, and that all legs were measured. The analysis finds the error of closure of the unadjusted data. The program reports the angle error, the X and Y components of error, and the total error. Then the accuracy of the survey is evaluated and reported as a ratio of total length of the survey, to the closure; the significance of this number, as above discussed, is to provide a gauge on the reasonableness of the adjustment. There obviously is no point in adjusting a survey which contains a significant blunder.

The "compass rule" is utilized in making the adjustment; corrections are applied in proportion to the lengths of the legs, as a fraction of the total length of the survey, as follows:

> X correction = (X component of total error)*(leg length)/(total length of survey)

The X and Y corrections are applied to each leg; the new leg length is found, the new X and Y coordinates of the ends of the legs (Points of intersection) are calculated, then the revised azimuths of the legs, the new deflection angles, and the interior angles.

Note that a DATA statement must be entered containing 999, 999. This is for the purpose of signalling the computer that all legs have been entered; however, it is necessary, at this point, to enter a final DATA statement which provides the deflection angle at the point of beginning.

Entry of angles is as follows: 7Ø degrees is entered as 7ØØØØØ; 15 deg. 7 min. 12 sec. is entered as 15Ø712.

The program is illustrated by the following Worked Out Example.

```
      CLOSED TRAVERSE


      740:DATA 450000,14
          14
      750:DATA 900000,14
          14
      760:DATA 450000,10
          00
      770:DATA 300000,19
          98
      780:DATA 1200000,1
          998
      790:DATA 300000,99
          9
      810:DATA 999,999
      820:DATA 450000



      ERROR AS SURVEYED:


      ANGLE ERROR=
       ØDEG ØM. ØS.
      ERROR CLOSURE, X=
                    1.698
      ERROR, CLOSURE, Y=
                      -1
      ERROR CLOSURE=
                    1.971
      RATIO:
      TOTAL LENGTH/ERROR
      1 IN 4477

      **CORRECTED DATA**


      LEG# 1
      LEG LENGTH= 1413.9
      21
      LEG AZIMUTH=
       44DEG 59M. 15S.
```

LEG# 2
LEG LENGTH= 1413.6
94
LEG AZIMUTH=
135DEG 0M. 12S.

AT 1- 2

DEFLECT.ANGLE=
90DEG 0M. 56S.
INTERIOR ANGLE=
89DEG 59M. 4S.

LEG# 3
LEG LENGTH= 999.88
7
LEG AZIMUTH=
180DEG 0M. 40S.

AT 2- 3

DEFLECT.ANGLE=
45DEG 0M. 28S.
INTERIOR ANGLE=
134DEG 59M. 32S.

LEG# 4
LEG LENGTH= 1997.9
96
LEG AZIMUTH=
210DEG 0M. 46S.

AT 3- 4

DEFLECT.ANGLE=
30DEG 0M. 6S.
INTERIOR ANGLE=
149DEG 59M. 54S.

LEG# 5
LEG LENGTH= 1998.3
88
LEG AZIMUTH=
329DEG 59M. 37S.

AT 4- 5

DEFLECT.ANGLE=
119DEG 58M. 51S.
INTERIOR ANGLE=
60DEG 1M. 9S.

LEG# 6
LEG LENGTH= 999.11
3
LEG AZIMUTH=
359DEG 59M. 20S.

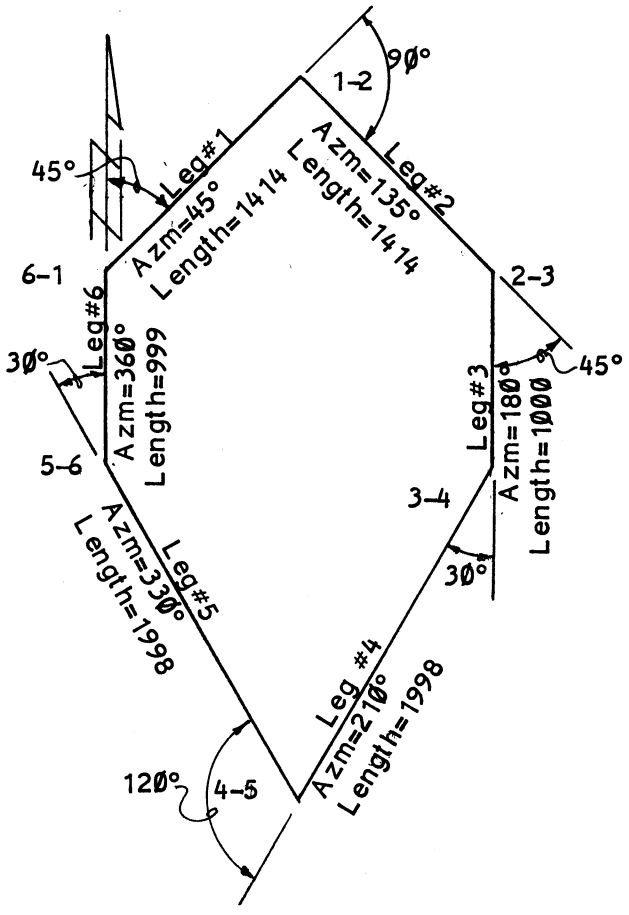
AT 5- 6

DEFLECT.ANGLE=
29DEG 59M. 43S.
INTERIOR ANGLE=
150DEG 0M. 17S.

AT 6-1
DEFLECT.ANGLE=
44DEG 59M. 55S.
INTERIOR ANGLE=
135DEG 0M. 5S.

AFTER CORRECTIONS
HAVE BEEN APPLIED:

ERROR, CLOSURE, X=
0
ERROR, CLOSURE, Y=
0
ERROR, CLOSURE=
0



PLAN-CLOSED TRAVERSE
Showing Data "as surveyed"

ANGLE ARITHMETIC

This program allows entry of angles in degrees, minutes, and seconds. It then either adds or subtracts, and reports the sum or remainder.

In subtraction, the first angle entered is the angle from which all other angles are subtracted.

The program assumes that angles greater than 360 degrees, and less than Ø degrees, are not desired; therefore the program provides answers only within the range of Ø to 360 degrees. This is accomplished in subroutine "CHECK", which adds 360 to any remainder less than Ø, and subtracts 360 from any sum greater than 360 degrees.

As in the CLOSED TRAVERSE program provided in this issue, all angles are entered in DEGMNSC; for example, 34Ødeg. 8 min. 2 sec. is entered as 34Ø8Ø2.

PROGRAM LISTING - ANGLE ARITHMETIC/ PC-2

```
10:"A"GOSUB "=";
   LPRINT "**ANGL
   E ADDITION**";
   LF 1
20:"B"CLEAR :
   INPUT "NO.OF A
   NGLES=";M
30:GOSUB "PRT"
40:FOR I=1TO M:
   LPRINT "ENTER
   ANGLE#";I
50:INPUT OH:GOSUB
   "ANGLE-DMS":
   GOSUB "DEG-DEC
   ":PH=NH:GOSUB
   "DEGMNSC"
60:SM=SM+NH
70:P2=SM:GOSUB "C
   HECK":SM=P2
80:NEXT I
90:PH=SM:LF 1:
   LPRINT "RESULT
    ANGLE=":GOSUB
   "DEGMNSC":LF 3
   :END
100:"ANGLE-DMS"PH=
    INT (OH/10000)
    :PJ=(OH-PH*100
    00)/100:PK=(PJ
    -INT PJ)*100:P
    J=INT PJ
110:RETURN
120:"DEG-DEC"NH=PH
    +(PJ+PK/60)/60
    :RETURN
130:"DEGMNSC"PJ=(P
    H-INT PH)*60:P
    K=INT ((PJ-INT
    PJ)*60+.5):PH=
    INT PH:PJ=INT
    PJ
140:IF PJ=59AND PK
    =60LET PH=PH+1
    :PJ=Ø:PK=Ø
150:IF PK=60LET PJ
    =PJ+1:PK=Ø
160:LPRINT PH;"DEG
    ";PJ;"M";PK;"S
    ":RETURN
170:"S"GOSUB "="
180:LPRINT "ANGLE
    SUBTRACTION";
    LF 1:GOSUB "PR
    T"
190:"C"CLEAR :
    INPUT "NO.OF A
    NGLES=";M
200:FOR I=1TO M:
    LPRINT "ENTER
    ANGLE#";I
210:INPUT OH:GOSUB
    "ANGLE-DMS":
    GOSUB "DEG-DEC
    ":PH=NH:GOSUB
    "DEGMNSC"
220:IF I=1LET SM=N
    H:NEXT I
230:SM=SM+NH
240:P2=SM:GOSUB "C
    HECK":SM=P2
250:NEXT I:GOTO 90
260:"CHECK"IF P2<Ø
    LET P2=P2+360:
    RETURN
270:IF P2>360LET P
    2=P2-360
280:RETURN
290:"PRT"LPRINT "E
    NTER ANGLES IN
     DEGMNSC":LF 1
    :RETURN
300:"="LPRINT "*AN
    GLE ARITHMETIC
    *":LF 1:RETURN
```

WORKED OUT EXAMPLES - ANGLE ARITHMETIC

```
*ANGLE ARITHMETIC*

**ANGLE ADDITION**

ENTER ANGLES IN DE
GMNSC

ENTER ANGLE# 1
 25DEG 14M 35S
ENTER ANGLE# 2
 94DEG 38M 54S
ENTER ANGLE# 3
 84DEG 51M 21S
ENTER ANGLE# 4
 125DEG 41M 2S
ENTER ANGLE# 5
 65DEG 53M 24S

RESULT ANGLE=
 36DEG 19M 16S

*ANGLE ARITHMETIC*

ANGLE SUBTRACTION

ENTER ANGLES IN DE
GMNSC

ENTER ANGLE# 1
 36DEG 19M 16S
ENTER ANGLE# 2
 65DEG 53M 24S
ENTER ANGLE# 3
 125DEG 41M 2S
ENTER ANGLE# 4
 84DEG 51M 21S
ENTER ANGLE# 5
 94DEG 38M 54S

RESULT ANGLE=
 25DEG 14M 35S
```

MASS STORAGE

Mass storage is probably the major area where the PC-2/PC-1500 is deficient. Perhaps a mini-floppy disk drive will eventually become available. However, it is our impression that disk drive units are touchy and sensitive-not likely to tolerate the shocks a portable computer must withstand in normal use. We have had no experience with a "stringy floppy" drive, but we are under the impression they are reasonably durable, comparable with a cassette tape drive. (Correct us if you think we are wrong). What we are leading up to is that a stringy floppy is reported available for the PC-2/PC-1500. You may inquire to Usonics, 7901 Oak Hill Drive, Cheltenham, PA 19012. The unit, costing about $400, will transfer 16K in about 30 seconds, about 50 times faster than an ordinary cassette drive.

As reported last month, you may now purchase a PC-1500A with a 16K RAM module for a total of at least 22K of user-available RAM. This is fine; however, the larger the memory capacity, the larger the program which may be written, the longer it would take to load such a program, perhaps as long as 40 minutes. For this problem, the stringy-floppy could be a solution. Check with Usonics.

Usonics will also sell you a BROTHER EP-22 portable electronic memory typewriter containing 2K internal memory. The EP-22 has a built in RS-232C interface; thus you may connect your PC-2 through the CE-158 RS-232C interface to this typewriter and use it as an external printer. Price: about $250.

We think it is possible that the PC-1500A will eventually become popular as a dedicated computer for such purposes as soil mechanics analysis, steel design, concrete design, surveying computations (office and field), and laboratory computations. Non-engineering applications could include navigation during flight, stock market analysis, and real estate/mortgage analysis. For such applications, portability and hard copy could be very significant advantages. These programs would be "burned" into EPROM modules.

Should you wish to purchase listings (no documentation) of any of our programs for the Commodore C-64 we will be happy to sell these at $7 each. Also, we offer these C-64 programs on 5¼" minidisk (single sided/double density/soft sectored) for an additional $7 each (minimum $35 charge per disk). In other words we will

provide up to five programs on a single disk for $35. For orders to be sent outside the US, we must add $2 per order. The above offer pertains to our programs we have provided this past year in our publication.

This is the last issue of our publication. We wish each of you a prosperous 1984. Please write us with comments, questions and errata.

Note This publication is solely for educational and experimental purposes. CECOM makes no representation or warranty of any kind, expressed or implied, concerning the accuracy, completeness, suitability or utility of any program, information, or process provided in this publication. We do not assume any liability for any direct, indirect, incidental or consequential damages relating to the use or application of the programs or information contained herein. We suggest that the user prove each program by making a trial run on a test problem for which answers are known.

ERRATA - February Issue

Lines 5ØØ, 51Ø and 52Ø, Steel Beam Column Program/PC-2, GOTO 535 should be GOTO 54Ø.

CIVIL ENGINEERS
POCKET COMPUTER MONTHLY
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December 28, 1983

Dear Subscriber:

Enclosed please find the October, November and December, 1983 issues of our publication. All these issues deal with the subject of Surveying. They constitute a set which we trust you will find useful.

We have decided to discontinue publication of Civil Engineers Pocket Computer Monthly because of the relatively poor response to our advertising campaign. This approach to marketing of software apparently does not have sufficient appeal to civil engineers.

Also enclosed is an updated index to software and to errata. Should any additional errata be found we will inform you.

If you have Commodore VIC-20 or C-64 equipment you may wish to purchase listings/ disks of our software written in BASIC 2.0. See the note in the December issue pertaining to this offer.

Note our offer of a free listing of Mr. Michael Sampl's software, Continuous Beam Analysis, written for TI99/4A. Send a self-addressed stamped envelope.

Please write us with any comments or errata.

Best wishes for the new year.

Sincerely,

H. C. Hall, PE
Editor

HCH:gd

December 28, 1983

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CIVIL ENGINEERS POCKET COMPUTER MONTHLY

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*All programs were authored by H. C. Hall, PE, except as otherwise designated.