HP-41CV/CX Surveying Field Solutions

REVISED 2nd EDITION

NOTICE

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REVISED 2nd EDITION

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This book is dedicated to my wife, Phyllis, with my heartfelt thanks for her continued support.

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About the book

This book was originally written as an attempt to make additional programming available to surveyors and engineers for solving the every-day problems encountered in the field. The programs do NOT include Traverse, Inverse, Intersections, etc. Everyone else has written and rewritten versions of those, some independent and some using the routines already contained in Hewlett-Packard's Surveying Pac.

Almost all software for the 41 series calculator which has been written to do anything else (EDM slope staking, topographic pickup, etc.) was put into modules for marketing. The price for the modules ranges from $150 for a 4K ROM to over $500 for one containing 8K of programming. Most of what these modules do is Traverse, Inverse, and intersections.

Here then, is an effort to make 41 software available at a price that everyone can afford. As programs which reside in the calculator in program step form, they have the added advantage that the user may customize them to his/her needs, add to them, or modify the type of output.

A printer is not a requirement, but a convenient option. If you have access to a card reader, having the programs on cards is the best way to assure error-free input of the program steps, and a mag card programming service is available through the publisher.

While, in some cases, the programs could have been made shorter (or faster), and 'fancier' output could have been obtained through use of Synthetic Programming, not all of the users would be able to program the routines into the calculator. Those of you with experience in synthetic programming may wish to modify the programs somewhat; please feel free to do so, since your use of these programs is what the book is all about.

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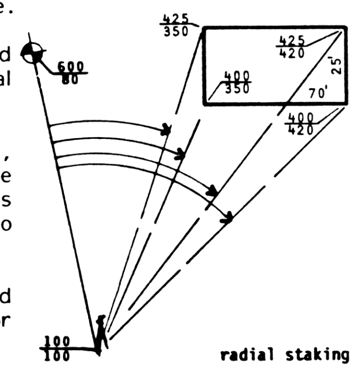
Radial Inverse

Radial inversing has become a standard procedure in the past few years, and is used for setting points on all types of surveys, from boundary corners to footing stakes. The advent of EDM has given us the capability to set accurate points at known distances without the necessity of chaining. Lower prices of instruments which have the EDM built-in, and can turn an accurate angle, has put them within "budget" reach for almost everyone.

This program calculates the horizontal distance and the angle right from any known backsight for radial stakeout from a central instrument setup.

If the instrument were set, as shown to the right, on a point with the coordinates of 100/100 and the backsight has the known coordinates of 600/80, it is easy to lay out the building corners by inversing to their coordinates.

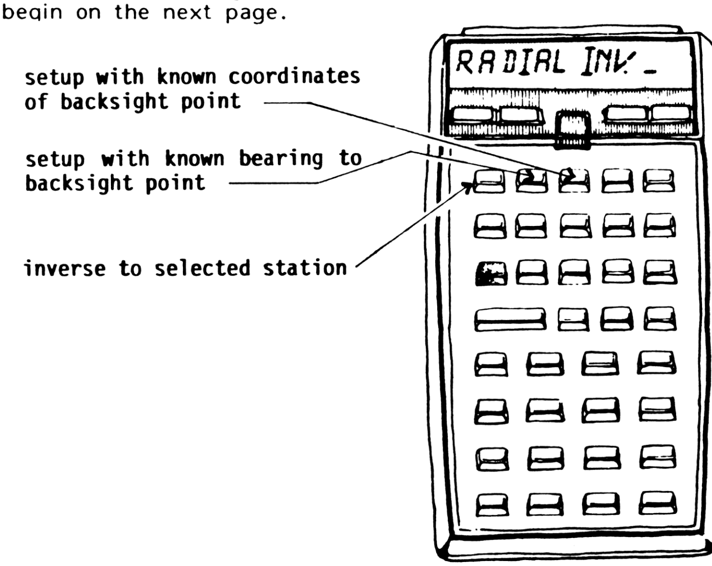
This routine gives outputs as shown below when used with a printer attached, but may be used with or without the printer.



radial staking

```
N= 425.0000
E= 350.0000

HD = 410.030
∠RT=
 39° 51' 33.1"

N= 400.0000
E= 350.0000

HD = 390.512
∠RT=
 42° 5' 46.3"

N= 425.0000
E= 420.0000

HD = 456.098
∠RT=
 46° 50' 47.3"

N= 400.0000
E= 420.0000

HD = 438.634
∠RT=
 49° 8' 17.6"
```

The keys used for this routine are shown in the sketch of the keyboard assignments, and step-by-step instructions begin on the next page.



KEYBOARD ASSIGNMENTS

There are two options for input with this program; one using **known coordinates** at the instrument and backsight stations, and the other for use when the coordinates of the setup station and the **bearing** to the backsight are known. With the exception of the initial input keystrokes (step #3), the operation is the same for either condition.

Before beginning, the calculator should be sized to at least 030, and the utility programs "**STA**" and "**AZ**", as well as the program "**LO**" should be in program memory. The utility program "**AZ**" may be omitted if the calculator contains either the HP Surveying Pac or the D'Zign **COGO 41** module. If the program is to be used with a printer attached, program memory must also contain the utility program "**DMS**".

1 **Initialize the program** by keystroking [XEQ] [ALPHA] [L] [O] [ALPHA]

For the condition where there are **known coordinates** for the instrument and backsight points:

2	Input the N-coordinate of the instrument point	[ENTER↑]
3	Input the E-coordinate of the instrument point	[C]
4 **BACKSIGHT?**	Input the N-coordinate of the backsight point	[ENTER↑]
5	Input the E-coordinate of the backsight point	[R/S]

or: For the condition with a **known backsight bearing**:

2	Input the N-coordinate of the instrument point	[ENTER↑]
3	Input the E-coordinate of the instrument point	[B]
4 **BRG=?**	Input the bearing to the backsight	[R/S]
5 **QD=?**	Input the quadrant code for the bearing	[R/S]

then:

6 **INV. ONLY?**	At this point we are only inversing to known coordinates, so answer "yes", by stroking	[Y] [R/S]
7 **N ↑ E**	Input the N-coordinate of the new point	[ENTER↑]
8	Input the E-coordinate of the new point	[A]

output will be the coordinates of the point being set, followed by the **horizontal distance** from the instrument and the **angle right** from the backsight to the point being set.* Repeat steps **7** and **8** for the next inverse.

As an example of the keystrokes used with this routine, and using the information from the illustration on page 1, we have the following:

keystrokes:

[XEQ] [ALPHA] [L] [0] [ALPHA]

display: 0.0000

keystrokes:

[1] [0] [0] [ENTER↑]
[1] [0] [0] [C]

prompt: BACKSITE?

keystrokes:

[6] [0] [0] [ENTER↑]
[8] [0] [R/S]

prompt: INV. ONLY?

keystrokes:

[Y] [R/S]

prompt: N↑E

keystrokes:

[4] [2] [5] [ENTER↑]
[3] [5] [0] [A]

output:
N= 425.0000
E= 350.0000

HD = 410.030
∠RT=
39° 51' 33.1"

prompt: N↑E

keystrokes:

[4] [0] [0] [ENTER↑]
[3] [5] [0] [A]

output:
N= 400.0000
E= 350.0000

HD = 390.512
∠RT=
42° 5' 46.3"

prompt: N↑E

keystrokes:

[4] [2] [5] [ENTER↑]
[4] [2] [0] [A]

output:
N= 425.0000
E= 420.0000

HD = 456.098
∠RT=
46° 50' 47.3"

prompt: N↑E

keystrokes:

[4] [0] [0] [ENTER↑]
[4] [2] [0] [A]

output:
N= 400.0000
E= 420.0000

HD = 438.634
∠RT=
49° 8' 17.6"

prompt: N↑E

Alternate input, with the bearing to the backsight instead of the backsight coordinates, uses the same keystrokes and will give the same output as shown after the initial input.

The keystrokes for the alternate input are:

keystrokes:

[1] [0] [0] [ENTER↑]
[1] [0] [0] [B]

prompt: BRG=?

keystrokes:

[2] [•] [1] [7] [2] [6] [R/S]

prompt: QD=?

keystrokes:

[4] [R/S]

prompt: INV. ONLY?

keystrokes:

[Y] [R/S]

prompt: N↑E

. . . . . . **etc.**

*If a printer is attached, the output is automatic. If there is no printer attached, continue stroking [R/S] until the prompt for input of the next point reappears.

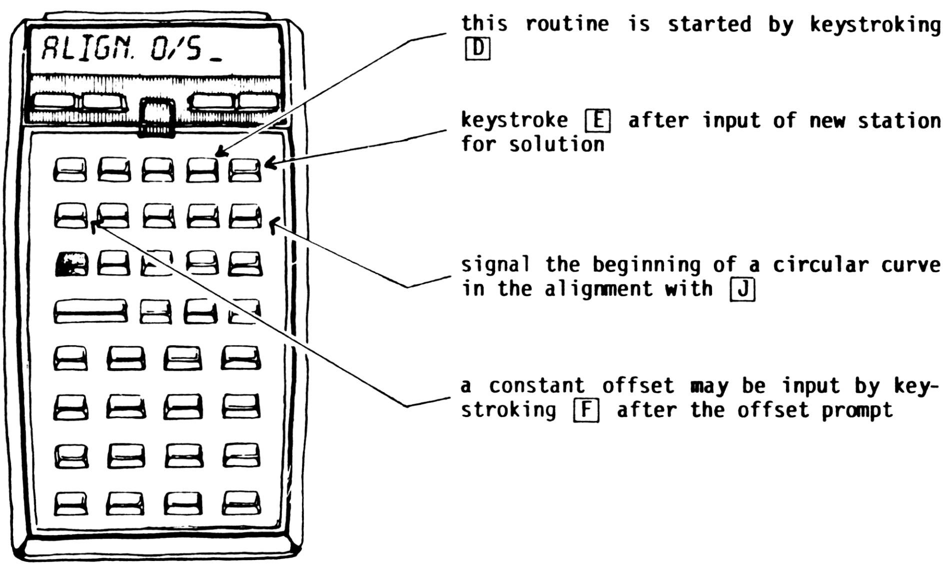
notes

Alignment & Offsets

This routine quickly calculates the coordinates of any station along a centerline, or any offset to the station. Input is simple and straightforward, and the output allows the option of calculating the offset coordinates with or without the output of the centerline coordinates.

The calculator should be sized at a minimum size of 030, and program memory should contain the programs "**LO**", "**STA**" and "**AZ**" ("**AZ**" is contained in both the HP Surveying Pac and D'Zign's **COGO 41** module, and need not be re-input as a utility program if either of these ROMs is plugged into the calculator). In addition, if a printer is attached to the calculator, the program "**DMS**" must also be in program memory.

The keyboard assignments used with this routine are shown below, followed by this routine's program instructions.



K E Y B O A R D   A S S I G N M E N T S

1 **Initialize the routine** by keystroking [XEQ] [ALPHA] [L] [O] [ALPHA]

2 Begin the station-coordinate routine [D]

3 BEG. STA? Input the beginning station as XXXXX.xxx; this can be any station with a known or assumed coordinate value [R/S]

4	COORD. N↑E	Input the N-coordinate of the beginning station	ENTER↑
5		Input the E-coordinate of the beginning station	R/S
6	BRG=?	Input the tangent bearing ahead as DD.mmss	R/S
7	QD=?	Input the quadrant code for the bearing	R/S
8	STA COORDS?	At this point you may choose which option you want. If you want coordinates for the offsets, but do not need the centerline coordinates, keystroke N; If both centerline and offset coordinates are required, keystroke Y	R/S

Note: If you select offset coordinates only, and later decide that you would like a particular centerline coordinate, such as an intersection point, B.C. or E.C., this coordinate may still be obtained by requesting an offset of "0".

9	STA?	Input the station at which the coordinates are wanted	E
		The station will be displayed in the form **XXX+XX.xxx** if a printer is not attached, keystroke	R/S
10		If the answer to step number 8 was NO, proceed at step number 12, if yes, the display will show N= XXXX.xxxx for the value of the N-coordinate if a printer is not attached, keystroke	R/S
11		If the answer to step number 8 was yes, the display will show E= XXXX.xxxx for the value of the E-coordinate if a printer is not attached, keystroke	R/S
12	O/S?	Input the offset distance (if left, CHS) if a printer is not attached, keystroke	R/S
13		The offset is displayed as O/S= XX.xxxx if a printer is not attached, keystroke	R/S
14		The N-coordinate is displayed as N= XXXX.xxxx if a printer is not attached, keystroke	R/S
15		The E-coordinate is displayed as E= XXXX.xxxx if a printer is not attached, keystroke	R/S

O/S? Repeat step 12 until all of the offsets for this station have been calculated. Then return to step number 9 for the next station.

Option: If a constant offset is required, you can set this constant at step #12 by input of the offset distance and keystroking [F]. From then on, the program will prompt **STA?** after each of the outputs instead of **O/S?** and will automatically use that offset distance at each station as the calculations continue. For a constant offset distance this is a faster form to use.

CURVE ROUTINE: To go around the curves, input the station at the beginning of the curve (B.C. station) at step number 9, and calculate any needed offsets as shown for steps 12 through 15.

16 When all of the required offsets at the B.C. station have been calculated [J]

17 DELTA? Input the central angle of the curve as DDD.mmss (if the curve is to the left, stroke [CHS]) [R/S]

18 R? Input the radius of the curve [R/S]

19 Output will show R = XXX.xxxx
if a printer is not attached, keystroke [R/S]

20 Output: N= XXXX.xxxx (radius point)
if a printer is not attached, keystroke [R/S]

21 Output: E= XXXX.xxxx (radius point)
if a printer is not attached, keystroke [R/S]

22 Output: DELTA = DD.mmss
if a printer is not attached, keystroke [R/S]

23 Output: EC=
if a printer is not attached, keystroke [R/S]

24 Output: XXX+XX.xxx
if a printer is not attached, keystroke [R/S]

STA? Return to step number 9 and continue as before. When the stationing exceeds the E.C. station the program automatically returns to the tangent ahead for additional stationing, until the next curve has been input.

This program routine has been designed in such a way that the station which is input after beginning a curve is compared to the station at the E.C. station, and when it has exceeded that point reverts to calculations based on the stored bearing of the next tangent.

As an example of the keystroke procedures, we can use the alignment shown in the illustration below. Assume that we need to know the coordinates of the even stations (every 100') along centerline, and the coordinates of the right-of-way points opposite the B.C. and E.C. stations.

keystrokes:

[XEQ] [ALPHA] [L] [0]
[ALPHA]

display: **0.0000**

keystroke: [D]

prompt: **BEG. STA?**

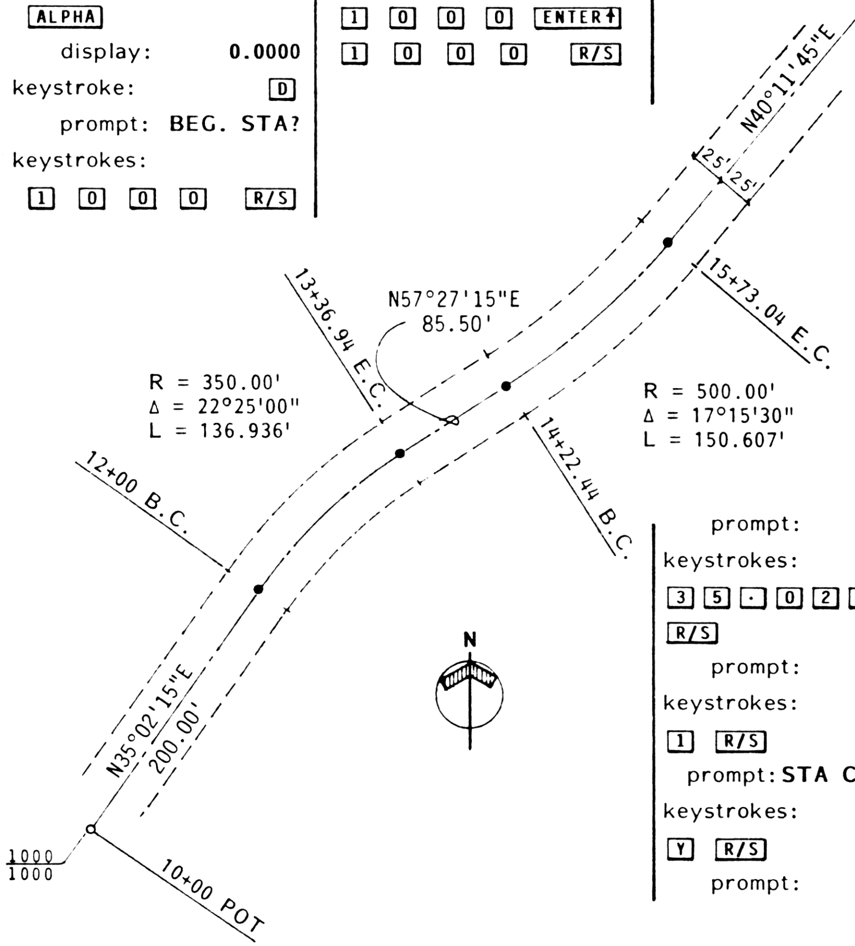
keystrokes:

[1] [0] [0] [0] [R/S]

prompt: **COORD N↑E**

keystrokes:

[1] [0] [0] [0] [ENTER↑]
[1] [0] [0] [0] [R/S]



prompt: **BRG=?**

keystrokes:

[3] [5] [.] [0] [2] [1] [5]
[R/S]

prompt: **QD=?**

keystrokes:

[1] [R/S]

prompt: **STA COORDS?**

keystrokes:

[Y] [R/S]

prompt: **STA?**

keystrokes:

[1] [1] [0] [0] [E]

output:
11+00.000
N= 1,081.8776
E= 1,057.4112

prompt: **O/S?**

keystrokes:

[1] [2] [0] [0] [E]

output:
12+00.000
N= 1,163.7553
E= 1,114.8225

prompt: **O/S?**

keystrokes:

[2] [5] [CHS] [R/S]

output:
O/S= -25.0000
N= 1,178.1081
E= 1,094.3531

prompt: **O/S?**

keystrokes:

[2] [5] [R/S]

output:
O/S= 25.0000
N= 1,149.4025
E= 1,135.2919

At this point, since 12+00 is the B.C. of the first curve, initiate the curve routine with

[J]

prompt: **DELTA?**

keystrokes:

[2] [2] [.] [2] [5] [R/S]

prompt: **R?**

keystrokes:

[3] [5] [0] [R/S]

output:
R = 350.0000
N= 962.8159
E= 1,401.3943

DELTA =
22° 25' 0.0"
EC =
13+36.936

prompt: **STA?**

keystrokes:

[1] [3] [0] [0] [E]

output:
13+00.000
N= 1,236.3775
E= 1,183.0733

prompt: **O/S?**

Note: It is not a requirement of the program that the E.C. station be input. For the present example, it is input in order to calculate the 25' offsets.

keystrokes:

[1] [3] [3] [6] [.] [9] [3] [6] [E]

output:
13+36.936
N= 1,257.8526
E= 1,213.1036

prompt: **O/S?**

keystrokes:

[2] [5] [CHS] [R/S]

output:
O/S= -25.0000
N= 1,278.9267
E= 1,199.6543

prompt: **O/S?**

keystrokes:

[2] [5] [R/S]

output:
O/S= 25.0000
N= 1,236.7786
E= 1,226.5530

prompt: **O/S?**

keystrokes:

[1] [4] [0] [0] [E]

output:
14+00.000
N= 1,291.7794
E= 1,266.2641

prompt: **O/S?**

keystrokes:

[1] [4] [2] [2] [.] [4] [3] [6] [E]

output:
14+22.436
N= 1,303.8494
E= 1,285.1768

prompt: **O/S?**

keystrokes:

[2] [5] [CHS] [R/S]

output:
O/S= -25.0000
N= 1,324.9234
E= 1,271.7275

prompt: **O/S?**

keystrokes:

[2] [5] [R/S]

output:
O/S= 25.0000
N= 1,282.7754
E= 1,298.6262

prompt: **O/S?**

keystroke:

[J]

prompt: **DELTA?**

keystrokes:

[1] [7] [.] [1] [5] [3] [CHS]
(this is a curve to the left)

[R/S]

prompt: **R?**

keystrokes:

[5] [0] [0] [R/S]

output:
R = 500.0000
N= 1,725.3301
E= 1,016.1898
DELTA =
-17° 15' 30.0"
EC =
15+73.043

prompt: **STA?**

keystrokes:

[1] [5] [0] [0] [E]

output:
15+00.000
N= 1,350.4709
E= 1,347.0683

prompt: **O/S?**

keystrokes:

[1] [5] [7] [3] [.] [0] [4] [3]
[E]

output:
15+73.043
N= 1,402.6287
E= 1,398.1110

prompt: **O/S?**

keystrokes:

[2] [5] [CHS] [R/S]

output:
O/S= -25.0000
N= 1,418.7638
E= 1,379.0150

prompt: **O/S?**

keystrokes:

[2] [5] [R/S]

output:
O/S= 25.0000
N= 1,386.4937
E= 1,417.2071

prompt: **O/S?**

keystrokes:

[1] [6] [0] [0] [E]

output:
16+00.000
N= 1,423.2196
E= 1,415.5091

prompt: **O/S?**

keystrokes:

[1] [7] [0] [0] [E]

output:
17+00.000
N= 1,499.6039
E= 1,480.0493

In this example the coordinates of the centerline points were output, and specific offsets were selected as the calculations were being done. Another option available with this routine is CONSTANT OFFSET.

As a second example, using the same alignment, assume that the requirement is the offset stakes, on the left side, for the curb and gutter layout. For this example, assume the offset is to be 18.50' left of centerline, which would be an offset of 3.00' to the back of the curb.

The coordinates of the offsets are wanted at 25' intervals from station 11+00 through the first curve, but the centerline coordinates are not needed this time.

Input of the information for the beginning station, coordinates, bearing and quadrant code are the same as in the previous example, until the prompt "**STA COORDS?**". This time the answer to this prompt will be "NO". Stroke [N] [R/S]

. . STA COORDS?

keystrokes:

[N] [R/S]

prompt: STA?

keystrokes:

[1] [1] [0] [0] [E]

output: 11+00.000

prompt: O/S?

keystrokes:

[1] [8] [.] [5] [CHS] [F]

output:
O/S= -18.5000
N= 1,092.4987
E= 1,042.2639

prompt: STA?

keystrokes:

[1] [1] [2] [5] [E]

output:
11+25.000
O/S= -18.5000
N= 1,112.9681
E= 1,056.6167

prompt: STA?

keystrokes:

[1] [1] [5] [0] [E]

output:
11+50.000
O/S= -18.5000
N= 1,133.4376
E= 1,070.9695

prompt: STA?

keystrokes:

[1] [1] [7] [5] [E]

output:
11+75.000
O/S= -18.5000
N= 1,153.9070
E= 1,085.3223

prompt: STA?

keystrokes:

[1] [2] [0] [0] [E]

output:
12+00.000
O/S= -18.5000
N= 1,174.3764
E= 1,099.6751

prompt: STA?

keystroke:

[J] (sets curve)

prompt: DELTA?

keystrokes:

[2] [2] [.] [2] [5] [R/S]

prompt: R?

keystrokes:

[3] [5] [0] [R/S]

output:
R = 350.0000
N= 962.8159
E= 1,401.3943

DELTA =
22° 25' 0.0"
EC =
13+36.936

prompt: STA?

keystrokes:

[1] [2] [2] [5] [E]

output: 12+25.000

O/S= -18.5000
N= 1,195.3700
E= 1,115.5431

prompt: STA?

keystrokes:

[1] [2] [5] [0] [E]

output: 12+50.000

O/S= -18.5000
N= 1,215.1775
E= 1,132.8689

prompt: STA?

keystrokes:

[1] [2] [7] [5] [E]

output: 12+75.000

O/S= -18.5000
N= 1,233.6981
E= 1,151.5641

prompt: STA?

keystrokes:

[1] [3] [0] [0] [E]

output: 13+00.000

O/S= -18.5000
N= 1,250.8372
E= 1,171.5334

prompt: STA?

keystrokes:

[1] [3] [2] [5] [E]

output: 13+25.000

O/S= -18.5000
N= 1,266.5075
E= 1,192.6750

prompt: STA?

. . . .

When this program is run with a printer attached, and centerline coordinates are not wanted, the offsets to stations along a curve are printed with a space between the station and the offset's distance and coordinates to differentiate the **radial** offsets from those at 90° to the centerline.

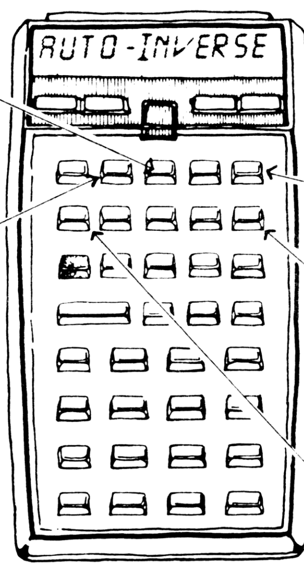
The **AUTO-INVERSE** routine is a combination of the previous two routines. When you are going to do a layout, such as the alignment in the example, from a known instrument setup and backsight location, the radial inverses for ties to set the points can be automatically generated as the alignment is calculated.

It is far less time-consuming than running the alignment and offset point coordinates and then calculating the ties by any method. It is much better than having to key in bearings and distances with curve data through a traverse and sideshot program, and then still having to calculate the ties.

The keyboard assignments below show all of the keys used for the combination routine. The initial entry for Auto-Inversing uses the Radial Inverse portion first, and automatically takes you on to the alignment input portion. The only difference in the use of this routine will be a "NO" answer to the **INV. ONLY?** prompt, instead of "yes" as in the radial inversing example.

use [C] for input of setup with known coordinates of the backsight point

[B] for setup with known bearing to backsight point



keystroke [E] after new station has been input

keystroke [J] to signal that the last station input was the B.C. station of a curve

a constant offset is set by stroking [F]

KEYBOARD ASSIGNMENTS

Auto-Inverse

For an example, let's assume that a basic traverse has been run and adjusted, and will be used for laying out our new roadway. We'll use traverse point **B** as the first instrument position and point **C** for the backsight.

Begin the routine as you did for the RADIAL INVERSE routine, following steps 1 through 5 (page 2). We'll use coordinate input for the example. Initialize, and input the coordinates of the instrument, as shown below:

keystrokes:

[1] [2] [1] [0] [ENTER↑]

[9] [3] [0] [C]

prompt: **BACKSITE?**

keystrokes:

[1] [5] [0] [5] [ENTER↑]

[1] [1] [9] [0] [R/S]

prompt: **INV ONLY?**

not just inversing this time

keystrokes:

[N] [R/S]

prompt: **STA INV?**

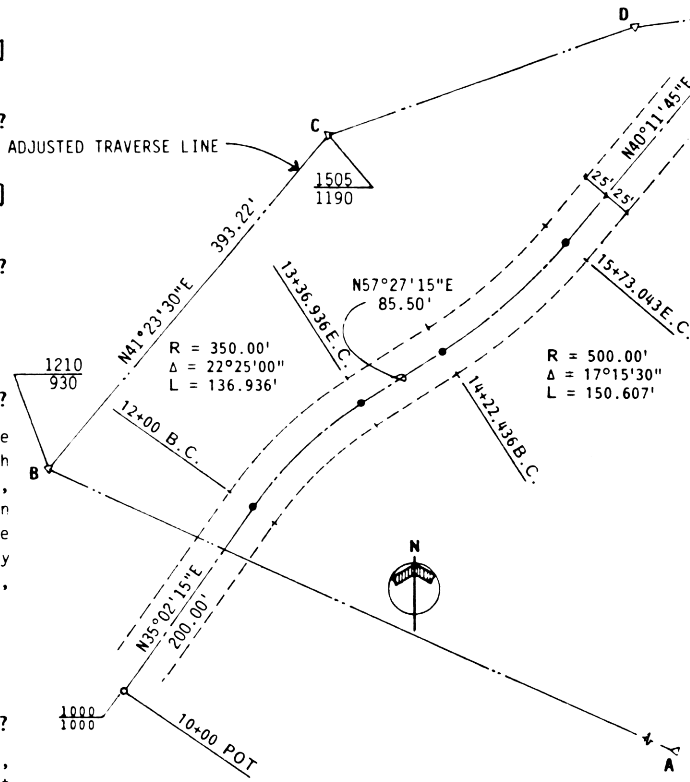
At this point, you have the option of inversing to both centerline and offset points, or just to the offsets. An answer of [Y] will give inverses to both, [N] only to the offsets. For our example, we will say "NO".

keystrokes:

[N] [R/S]

prompt: **BEG. STA?**

When this prompt is displayed, begin input of the alignment in the same way as for the ALIGNMENT & OFFSET routine. Follow the steps shown on pages 5 through 7.



With the instrument and backsight information already input, as shown on the previous page, we can re-do the example with the offset constant of 18.5' left.

keystrokes:

[1] [0] [0] [0] [R/S]

prompt: COORD N↑E

keystrokes:

[1] [0] [0] [0] [ENTER↑]

[1] [0] [0] [0] [R/S]

prompt: BRG=?

keystrokes:

[3] [5] [.] [0] [2] [1] [5]

[R/S]

prompt: QD=?

keystrokes:

[1] [R/S]

prompt: STA COORDS?

keystrokes:

[N] [R/S]

prompt: STA?

keystrokes:

[1] [1] [0] [0] [E]

output:

```
11+00.000
```

prompt: O/S?

keystrokes:

[1] [8] [.] [5] [CHS] [F]

output:

```
O/S= -18.5000
N= 1,092.4987
E= 1,042.2639

HD = 162.511
∡RT=
 94° 54' 51.4"
```

prompt: STA?

keystrokes:

[1] [1] [2] [5] [E]

output:

```
11+25.000
O/S= -18.5000
N= 1,112.9691
E= 1,056.6167

HD = 159.521
∡RT=
 86° 4' 22.7"
```

prompt: STA?

keystrokes:

[1] [1] [5] [0] [E]

output:

```
11+50.000
O/S= -18.5000
N= 1,133.4376
E= 1,070.9695

HD = 160.419
∡RT=
 77° 6' 55.6"
```

prompt: STA?

keystrokes:

[1] [1] [7] [5] [E]

output:

```
11+75.000
O/S= -18.5000
N= 1,153.9070
E= 1,085.3223

HD = 165.141
∡RT=
 68° 27' 54.5"
```

prompt: STA?

keystrokes:

[1] [2] [0] [0] [E]

output:

```
12+00.000
O/S= -18.5000
N= 1,174.3764
E= 1,099.6751

HD = 173.374
∡RT=
 60° 27' 56.2"
```

prompt: STA?

keystroke:

[J]

prompt: DELTA?

keystrokes:

[2] [2] [.] [2] [5] [R/S]

prompt: R?

keystrokes:

[3] [5] [0] [R/S]

output:

```
R = 350.0000
N= 962.8159
E= 1,401.3943

DELTA =
 22° 25' 0.0"
EC =
13+36.936
```

prompt: STA?

keystrokes:

[1] [2] [2] [5] [E]

output:

```
12+25.000

O/S= -18.5000
N= 1,195.3700
E= 1,115.5431

HD = 186.119
∡RT=
 53° 7' 0.9"
```

prompt: STA?

keystrokes:

[1] [2] [5] [0] [E]

output:

12+50.000

O/S= -18.5000
N= 1,215.1775
E= 1,132.8689

HD = 202.935
∠RT=
47° 8' 47.4"

prompt: STA?

keystrokes:

[1] [2] [7] [5] [E]

output:

12+75.000

O/S= -18.5000
N= 1,233.6981
E= 1,151.5641

HD = 222.828
∠RT=
42° 30' 12.3"

prompt: STA?

keystrokes:

[1] [3] [0] [0] [E]

output:

13+00.000

O/S= -18.5000
N= 1,250.8372
E= 1,171.5334

HD = 244.961
∠RT=
39° 0' 43.0"

prompt: STA?

keystrokes:

[1] [3] [2] [5] [E]

output:

13+25.000

O/S= -18.5000
N= 1,266.5075
E= 1,192.6750

HD = 268.684
∠RT=
36° 28' 4.3"

prompt: STA?

keystrokes:

[1] [3] [3] [6] [.] [9] [3] [6] [E]

output:

13+36.936
O/S= -18.5000
N= 1,273.4474
E= 1,203.1511

HD = 280.423
∠RT=
35° 31' 54.2"

. . . etc.

If we had answered [Y] to the prompt **STA INV?** the output would inverse to the centerline <u>and</u> the offset. Output at each station would be:

11+00.000
HD = 180.690
∠RT=
93° 46' 4.5"

O/S= -18.5000
N= 1,092.4987
E= 1,042.2639

HD = 162.511
∠RT=
94° 54' 51.4"

Multiple offsets at a station, with inverses to the offsets, and the centerline coordinates calculated, would result in output such as that below. For multiple offsets, input them individually, instead of as a constant.

11+25.000
N= 1,102.3471
E= 1,071.7641

HD = 178.006
∠RT=
85° 49' 14.9"

O/S= -25.0000
N= 1,116.6999
E= 1,051.2946

HD = 153.027
∠RT=
86° 10' 33.7"

O/S= 25.0000
N= 1,087.9942
E= 1,092.2335

HD = 202.990
∠RT=
85° 33' 10.9"

O/S= -18.5000
N= 1,112.9681
E= 1,056.6167

HD = 159.521
∠RT=
86° 4' 22.7"

Inverses only to centerline, without coordinate output would look like this:

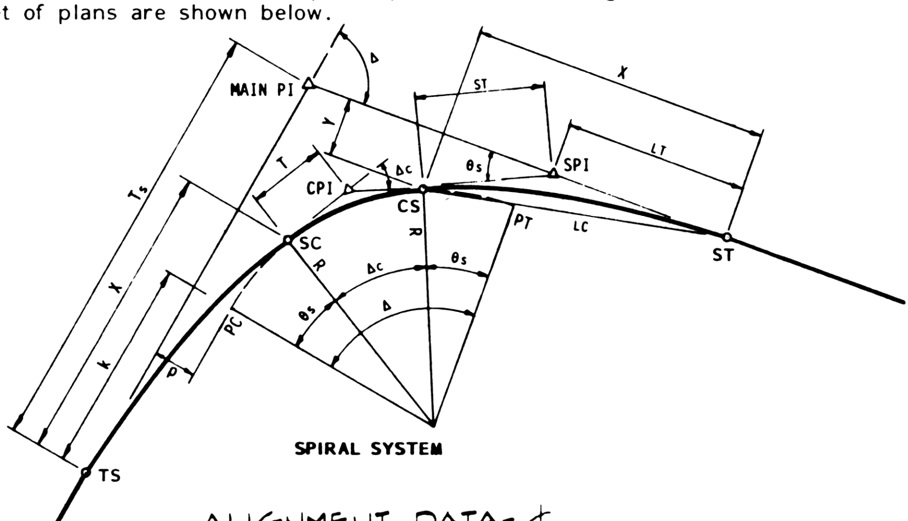
11+50.000
HD = 178.811
∠RT=
77° 47' 22.8"

notes

Spiral Curves

This group of **SPIRAL CURVE** programs is designed to calculate the data needed for field layout of a spiral curve. The type of spiral used is the BARNETT SPIRAL, (also known as the Talbot spiral). It uses arc definition, and is the type most frequently encountered.

This is the form of spiral used on interstate highways, and adopted by most states which use spiral curves in their alignment design. It is also the form of spiral used for railroad alignment by agencies such as Washington D.C.'s METRO and the Bay Area Rapid Transit District (BART) in California. The nomenclature used for the spiral system, and the alignment data from a typical set of plans are shown below.



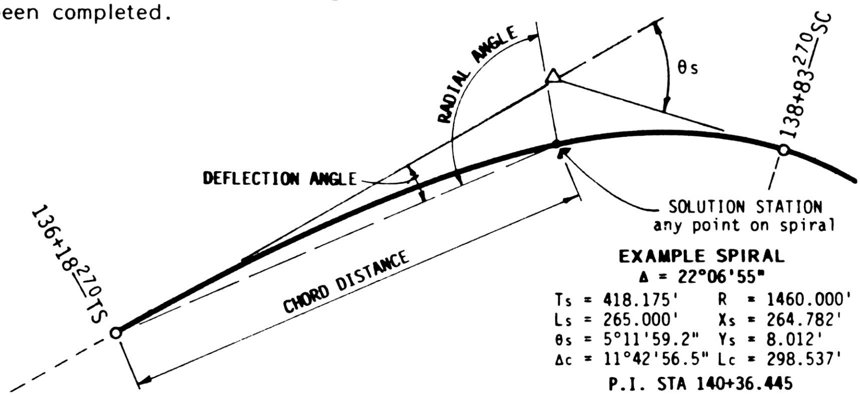
SPIRAL SYSTEM

ALIGNMENT DATA- ℄

	POINT	STATION	COORDINATES N	COORDINATES E	CURVE DATA	DESIGN SPEED
M2-LINE	POT	130+99.349	38,156.113	30,142.993	P.I. STA = 140+36.445	
	PI-4		39,026.499	30,394.100	Δ = 22° 06' 55" T_{S1} = 418.175' T_{S2} = 418.175'	
	T S	136+18.270	38,638.388	30,549.792	L_{S1} = 265.000' X_{S1} = 264.782	V = 50 MPH E = 5.250 U = 2.710
	SC	138+83.270	38,887.117	30,458.646	θ_{S1} = 5° 11' 59.2", Y_{S1} = 8.012'	
		CC-CURVE 4	39,305.651	31,857.310	Δc = 11° 42' 56.5' Lc = 298.537' Rc = 1460.000'	
	CS	141+81.807	39,179.855	30,402.800	L_{S2} = 265.000' X_{S2} = 264.782'	
	ST	144+46.807	39,444.670	30,395.915	θ_{S2} = 5° 11' 59.2" Y_{S2} = 8.012'	
	PI-70	151+27.015	40,124.871	30,399.025		

In the first routine using this program the **CHORD** and **DEFLECTION ANGLE** to any station on the spiral is calculated. The radial angle at the station is also calculated.

To illustrate this routine, the spiral data on the previous page will be used. The entrance spiral is shown below, and the curve data for the spiral portions is the same for both the entrance and exit spirals. Stationing at the **CS** and **ST** will be output by the program after calculations for the entrance spiral have been completed.

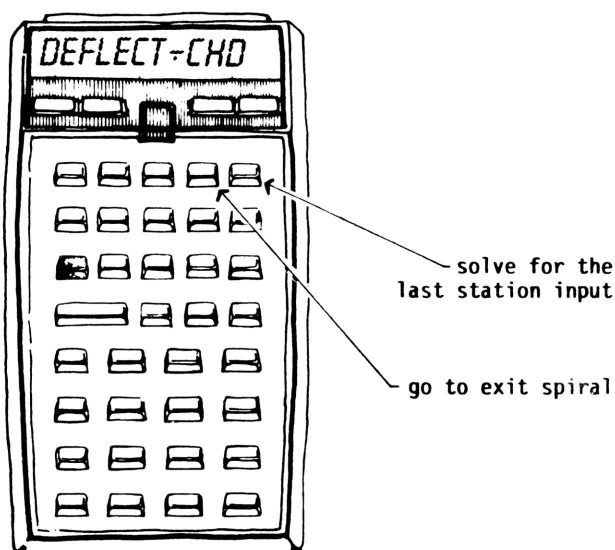


The keys used for this routine are shown in the sketch to the right.

The required input is prompted by the program as you proceed, and followed by stroking the [R/S] button, except after input of a new station for solution.

The program may be used without a printer, but for ease of illustration, the printer output will be shown.

Step-by-step instructions are shown on the next page.



Deflection & Chord

Program memory should contain the program "**SP**" and the utility programs "**STA**" and "**AZ**" before beginning. "**AZ**" may be omitted if the calculator contains either the HP Surveying Pac or the D'Zign COGO 41 ROM module. The utility program "**DMS**" must also be in memory if the calculator is being used with a printer attached. Size the calculator to a minimum size of 050.

1 **Initialize the program** by keystroking [XEQ] [ALPHA] [S] [P] [ALPHA]

The program will begin the prompts for type of solution wanted.

2 **COORD-O/S?** Answer this prompt no [N] [R/S]

3 **TAN O/S?** Answer this prompt no [N] [R/S]

4 **PI STATION?** Input the main P.I. station. If it is not shown on the curve data provided it can be calculated by inputting the TS station and adding the T_S distance to it. [R/S]

5 **DELTA?** Input the system delta. If curve left [CHS] [R/S]

6 **R?** Input the radius for the circular curve [R/S]

7 **L?** Input the spiral length [R/S]

Output will be a display of the length of spiral curve, the spiral angle (output is in the form D.MMSS), and the radius. If a printer is not attached, continue stroking [R/S]. Output continues with the P.I. station, the central angle, and the TS and SC stations, followed by the next prompt

8 **STA?** Input the station for which the deflection and chord solution is required [E]

Output will be the chord, deflection angle and radial angle. Continue stroking [R/S] each time if not using a printer until the prompt STA? appears

9 **STA?** Repeat step 8 until all of the required stations have been calculated for the entrance spiral. It is normal to also calculate the SC station last. When ready to calculate the exit spiral, keystroke [D]

Output will be the stations of the CS and ST, followed by the prompt

10 **STA?** Input the exit spiral stations for solution in the same manner as before, repeating step 8 until all of the required stations have been calculated. The exit spiral can be calculated in either direction, but the deflection angles and chords are from the ST, sighting toward the P.I.

As an example of the keystrokes used with this routine, and using the information in the example spiral (page 17) we will calculate the entrance and exit spirals at the 100' stations.

keystrokes:

[XEQ] [ALPHA] [S] [P] [ALPHA]

prompt: COORD-O/S?

keystrokes:

[N] [R/S]

prompt: TAN O/S?

keystrokes:

[N] [R/S]

prompt: PI STATION?

keystrokes:

[1] [4] [0] [3] [6] [.] [4] [4] [5] [R/S]

prompt: DELTA?

keystrokes:

[2] [2] [.] [0] [6] [5] [5] [R/S]

prompt: R?

keystrokes:

[1] [4] [6] [0] [R/S]

prompt: L?

keystrokes:

[2] [6] [5] [R/S]

output:

L = 265.0000
S∡ =
5° 11' 59.2"
R = 1,460.0000

PI =
140+36.445
CENTRAL ∡ =
22° 6' 55.0"

TS =
136+18.270
SC =
138+83.270

At this point we begin to calculate the even stations along the entrance spiral

prompt: STA?

keystrokes:

[1] [3] [7] [0] [0] [E]

output:

137+00.000
CD = 81.730
DEFLECTION ∡=
0° 9' 53.5"
RADIAL ∡ =
90° 19' 47.0"

keystrokes:

[1] [3] [8] [0] [0] [E]

output:

138+00.000
CD = 181.715
DEFLECTION ∡=
0° 48' 54.4"
RADIAL ∡ =
91° 37' 49.0"

keystrokes:

[1] [3] [8] [8] [3] [.] [2] [7] [E]

output:

138+83.270
CD = 264.903
DEFLECTION ∡=
1° 43' 59.3"
RADIAL ∡ =
93° 27' 59.9"

With the calculations for the entrance spiral completed, we can move to the exit spiral

keystroke:

[D]

output:

ST =
144+46.807
CS =
141+81.807

prompt: STA?

keystrokes:

[1] [4] [1] [8] [1] [.] [8] [0] [7] [E]

output:

141+81.807
CD = 264.903
DEFLECTION ∡=
1° 43' 59.3"
RADIAL ∡ =
93° 27' 60.0"

keystrokes:

[1] [4] [2] [0] [0] [E]

output:

142+00.000
CD = 246.739
DEFLECTION ∡=
1° 30' 12.1"
RADIAL ∡ =
93° 0' 25.1"

keystrokes:

[1] [4] [3] [0] [0] [E]

output:

143+00.000
CD = 146.802
DEFLECTION ∡=
0° 31' 55.0"
RADIAL ∡ =
91° 3' 50.0"

keystrokes:

[1] [4] [4] [0] [0] [E]

output:

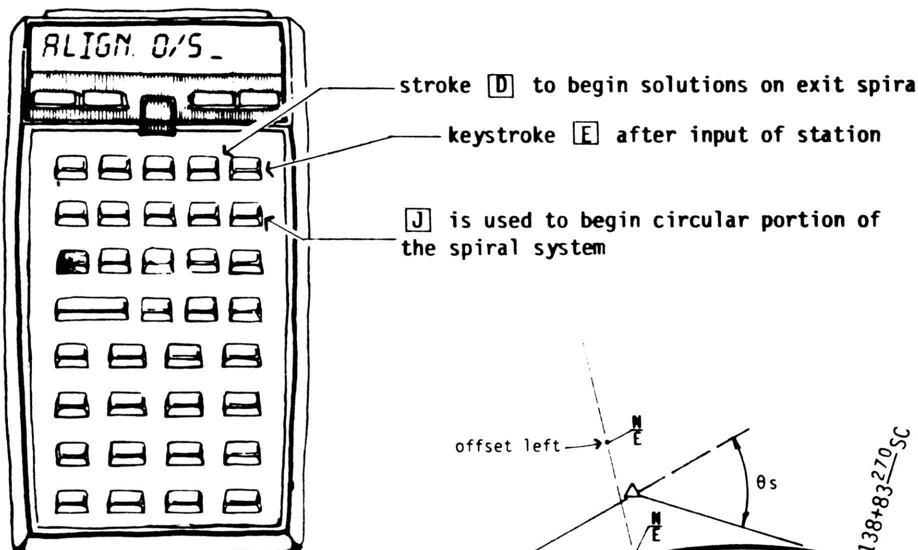
144+00.000
CD = 46.807
DEFLECTION ∡=
0° 3' 14.7"
RADIAL ∡ =
90° 6' 29.3"

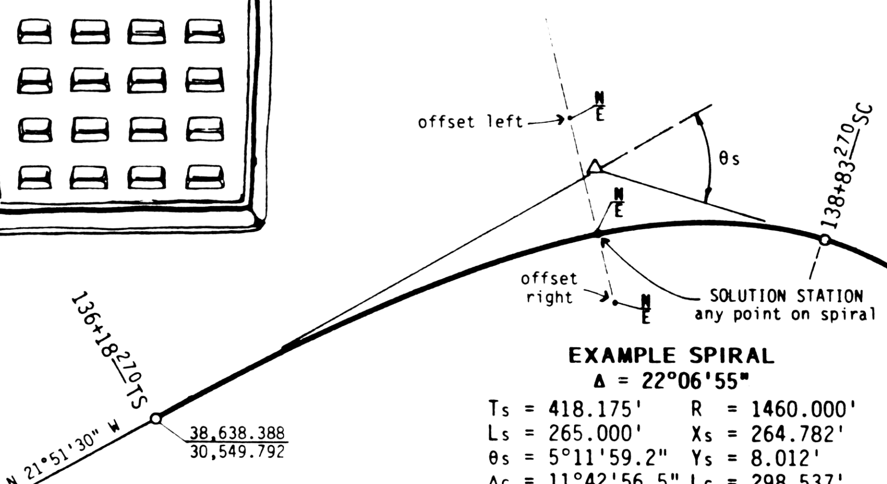
Alignment & Offsets

This routine outputs the coordinates along a spiral curve alignment at any station, including the circular portion. It not only provides direct output of the centerline coordinates, but the coordinates of any offsets to the curves may be calculated at the same time.

In addition to the information about the spiral system which was input in the last routine, you will need to know the coordinates of the **TS** and the **ST** stations, and the bearings of the entrance and exit tangents. If these are not given on the set of plans that you are working from, they can be easily calculated prior to beginning this routine.

The keys used in this routine are shown in the keyboard assignment sketch below.





EXAMPLE SPIRAL

Δ = 22°06'55"

T_s =	418.175'	R =	1460.000'
L_s =	265.000'	X_s =	264.782'
θ_s =	5°11'59.2"	Y_s =	8.012'
Δ_c =	11°42'56.5"	L_c =	298.537'

P.I. STA 140+36.445

Begin with the calculator sized at 050, and program memory containing the programs "**SP**", "**STA**" and "**AZ**" (the latter may be omitted if the calculator contains a ROM module for the HP Surveying Pac or the D'Zign COGO 41). If a printer is attached, program memory must also contain the utility program "**DMS**". After being initialized the program will begin with the prompts for type of solution wanted.

1	**Initialize the program** by keystroking		[XEQ] [ALPHA] [S] [P] [ALPHA]
2	**COORD-O/S?**	Answer this prompt yes	[Y] [R/S]
3	**BRG=?**	Input the entrance tangent bearing	[R/S]
4	**QD=?**	Input the quadrant code for the bearing **toward** the P.I. of the system	[R/S]
5	**TS N↑E**	Input the north coordinate of the TS	[ENTER↑]
		Input the east coordinate of the TS	[R/S]
6	**PI STATION?**	Input the main P.I. station.	[R/S]
7	**DELTA?**	Input the system delta. If curve left, [CHS]	[R/S]
8	**R?**	Input the radius for the circular curve	[R/S]
9	**L?**	Input the spiral length	[R/S]

Output will be a display of the length of spiral curve, the spiral angle (output is in the form D.MMSS), and the radius. If a printer is not attached, continue stroking [R/S]. Output continues with the P.I. station, the central angle, and the TS and SC stations, followed by the next prompt

10	**STA?**	Input the station for which coordinates are required	[E]

Output will be the station and its coordinates. Continue stroking [R/S] each time, if not using a printer, until the prompt **O/S DIST?** appears.

11	**O/S DIST?**	Any desired offsets to this station may be calculated at this time. Input the offset distance ([CHS] if the offset is to the left)

Output will be the offset and its coordinates. An offset to the left will be shown as a negative offset.

12 **O/S DIST?**

Repeat step 11 until all of the required offsets for the station have been calculated, or return to step 10 with input of a new station. When all of the required stations and offsets have been calculated for the entrance spiral, we can go to the circular portion, as follows:

13 **O/S DIST?**

Calculate the SC station last. When ready to calculate the circular portion, keystroke [J]

14 **O/S DIST?**

Input the circular radius distance. If the curve is to the left, [CHS] [R/S]

Output will be the coordinates of the radius point of the circular curve. **The circular portion has a slightly different input format than the spiral portion.** The station will be input each time, for each offset. For the centerline station coordinates, the offset is input as 0.

15 **STA?**

Input the next station NOTE: different stroke than for spiral [R/S]

16 **O/S DIST?**

Input 0 for the centerline coordinates, or the offset distance. If the offset is to the left of centerline, [CHS] [R/S]

Output will be the station and its coordinates (or the offset and its coordinates).

17 **STA?**

Repeat steps 15 and 16 until all of the stations and offsets have been calculated through the circular portion. Go to the exit spiral by keystroking [D]

18 **BRG=?**

Input the bearing of the **exit** tangent [R/S]

19 **QD=?**

Input the quadrant code for the exit tangent in the direction **toward** the P.I. [R/S]

20 **ST N↑E**

Input the north coordinate of the ST [ENTER↑]

Input the east coordinate of the ST [R/S]

Output will be the ST and CS stations.

21 **STA?**

Calculate the stations through the exit spiral, beginning with the CS station, by repeating steps 10 and 11 until all of the required stations and offsets have been calculated.

As an example of the keystrokes used with this routine, and using the information on page 17, in the example spiral, we will calculate the coordinates at even stations. In addition, to use the offset option, we will calculate the coordinates for an offset at 20 feet left and right at one of the stations in the entrance, circular and exit portions of the system.

keystrokes:

[XEQ] [ALPHA] [S] [P] [ALPHA]

prompt: COORD-O/S?

keystrokes:

[Y] [R/S]

prompt: BRG=?

keystrokes:

[2] [1] [.] [5] [1] [3] [R/S]

prompt: QD=?

keystrokes:

[4] [R/S]

prompt: TS N↑E

keystrokes:

[3] [8] [6] [3] [8] [.]
[3] [8] [8] [ENTER↑]
[3] [0] [5] [4] [9] [.]
[7] [9] [2] [R/S]

prompt: INVERSE?

keystrokes:

[N] [R/S]

prompt: PI STATION?

keystrokes:

[1] [4] [0] [3] [6] [.]
[4] [4] [5] [R/S]

prompt: DELTA?

keystrokes:

[2] [2] [.] [0] [6] [5] [5]
[R/S]

prompt: R?

keystrokes:

[1] [4] [6] [0] [R/S]

prompt: L?

keystrokes:

[2] [6] [5] [R/S]

output:

L = 265.0000
S∠ =
5° 11' 59.2"
R = 1,460.0000

PI =
140+36.445
CENTRAL ∠ =
22° 6' 55.0"

TS =
136+18.270
SC =
138+83.270

prompt: STA?

keystrokes:

[1] [3] [7] [0] [0] [E]

output: 137+00.000

N = 38,714.3292
E = 30,519.5814

prompt: O/S DIST?

We will use this station as an example for the offsets.

keystrokes:

[2] [0] [CHS] [R/S]

output:

O/S = -20.0000
N = 38,707.0434
E = 30,500.9556

prompt: O/S DIST?

keystrokes:

[2] [0] [R/S]

output:

O/S = 20.0000
N = 38,721.6149
E = 30,538.2071

prompt: O/S DIST?

keystrokes:

[1] [3] [8] [0] [0] [E]

output: 138+00.000

N = 38,807.9846
E = 30,484.5431

prompt: O/S DIST?

keystrokes:

[1] [3] [8] [8] [3] [.] [2] [7]
[E]

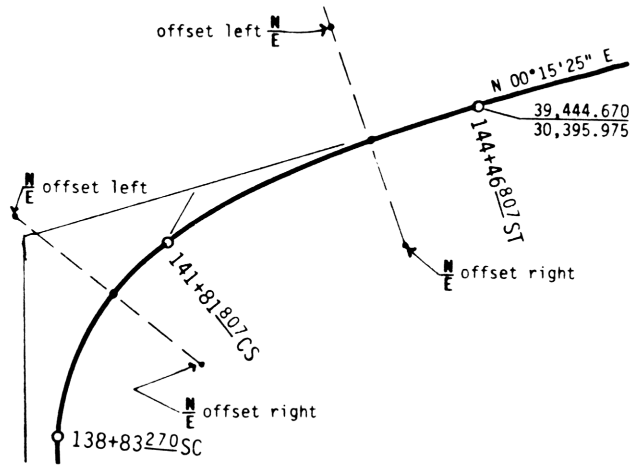
output: 138+83.270

N = 38,887.1168
E = 30,458.6462

prompt: O/S DIST?

After calculating any needed offsets at the **SC**, move to the circular portion of the system

keystroke: [J]



output: CIRCULAR:

prompt: **O/S DIST?**

keystrokes:

[1] [4] [6] [0] [R/S]

output:
RADIUS POINT:
N = 39,305.6513
E = 31,857.3702

prompt: **STA?**

keystrokes:

[1] [3] [9] [0] [0] [R/S]

prompt: **O/S =**

keystrokes:

[0] [R/S]

output:
139+00.000
N = 38,903.1717
E = 30,453.9422

prompt: **STA?**

keystrokes:

[1] [3] [9] [0] [0] [R/S]

prompt: **O/S =**

keystrokes:

[2] [0] [CHS] [R/S]

output:
139+00.000
O/S = -20.0000
N = 38,897.6583
E = 30,434.7171

prompt: **STA?**

keystrokes:

[1] [3] [9] [0] [0] [R/S]

prompt: **O/S =**

keystrokes:

[2] [0] [R/S]

output:
139+00.000
O/S = 20.0000
N = 38,908.6852
E = 30,473.1672

prompt: **STA?**

keystrokes:

[1] [4] [0] [0] [0] [R/S]

prompt: **O/S =**

keystrokes:

[0] [R/S]

output:
140+00.000
N = 39,000.1655
E = 30,429.6873

prompt: **STA?**

keystrokes:

[1] [4] [1] [0] [0] [R/S]

prompt: **O/S =**

keystrokes:

[0] [R/S]

output:
141+00.000
N = 39,098.5919
E = 30,412.1275

prompt: **STA?**

With the circular portion completed, go to the exit spiral

keystroke: [D]

prompt: **BRG=?**

keystrokes:

[.] [1] [5] [2] [5] [R/S]

prompt: QD=?

keystrokes:

[3] [R/S]

prompt: ST N↑E

keystrokes:

[3] [9] [4] [4] [4] [.]
[6] [7] [ENTER↑]
[3] [0] [3] [9] [5] [.]
[9] [7] [5] [R/S]

output: ST =
144+46.807
CS =
141+81.807

prompt: STA?

keystrokes:

[1] [4] [1] [8] [1] [.]
[8] [0] [7] [E]

output: 141+81.807

N = 39,179.8546
E = 30,402.7994

prompt: O/S DIST?

Since all of the offsets through the exit spiral work the same at any station, we can use the CS as the example station for the offset calculations

keystrokes:

[2] [0] [CHS] [R/S]

output: O/S = -20.0000
N = 39,178.1314
E = 30,382.8737

prompt: O/S DIST?

keystrokes:

[2] [0] [R/S]

output: O/S = 20.0000
N = 39,181.5779
E = 30,422.7250

prompt: O/S DIST?

keystrokes:

[1] [4] [2] [0] [0] [E]

output: 142+00.000

N = 39,197.9891
E = 30,401.3422

prompt: O/S DIST?

keystrokes:

[1] [4] [3] [0] [0] [E]

output: 143+00.000

N = 39,297.8695
E = 30,396.6796

prompt: O/S DIST?

keystrokes:

[1] [4] [4] [0] [0] [E]

output: 144+00.000

N = 39,397.8630
E = 30,395.8093

prompt: O/S DIST?

keystrokes:

[1] [4] [4] [4] [6] [.]
[8] [0] [7] [E]

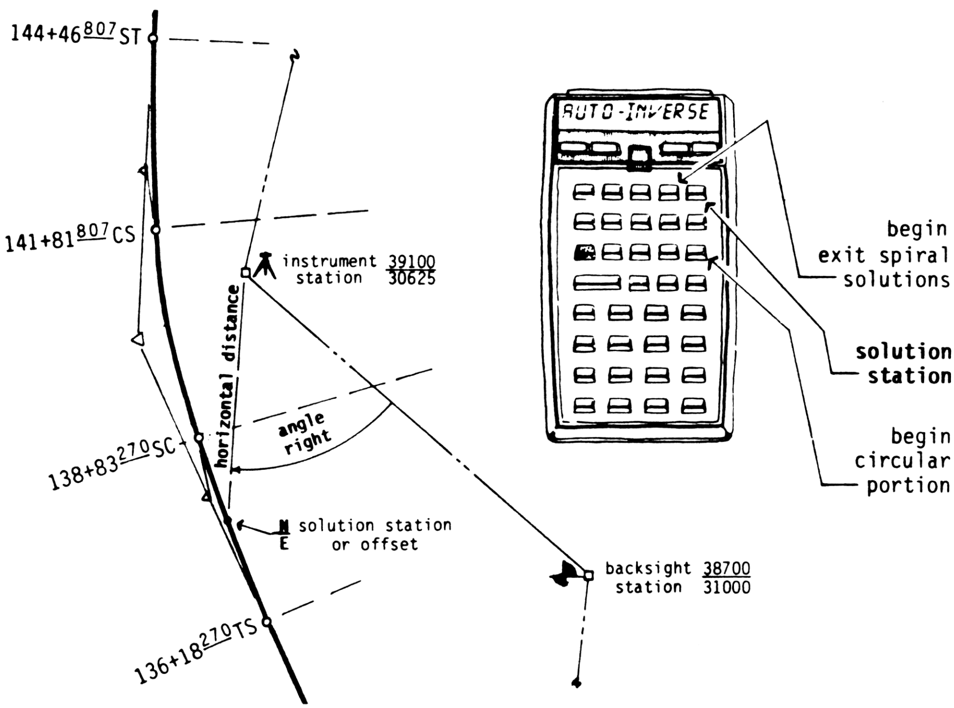
output: 144+46.807

N = 39,444.6697
E = 30,395.9750

Auto-Inverse

This routine is similar to the previous one, in that it calculates the coordinates to the solution station and offsets. In addition, it also calculates the angles and distances for radial stakeout in the field.

Working from one point on a control line and sighting another, all of the points which you calculate can be 'sprayed' directly using an EDM for the distances.



Program memory should contain the program "**SP**" and the same utility programs that are used for the ALIGNMENT & OFFSET routine (pages 21 - 26) and the DEFLECTION & CHORD routine (pages 18 - 20). As in the previous examples, the required input is fully prompted, with the response to the prompt followed by keystroking [R/S] except after the input of each new station. The calculator should be sized at 050 or more.

1 **Initialize** the routine by keystroking [XEQ] [ALPHA] [S] [P] [ALPHA]

2 COORD-O/S? Answer this prompt yes [Y] [R/S]

3 BRG=? Input the entrance tangent bearing [R/S]

4 QD=? Input the quadrant code for the bearing **toward** the P.I. of the system [R/S]

5 TS N↑E Input the north coordinate of the TS [ENTER↑]
Input the east coordinate of the TS [R/S]

6 INVERSE? Answer this prompt yes [Y] [R/S]

7 INST N↑E Input the north coordinate of the setup point [ENTER↑]
Input the east coordinate of the setup point [R/S]

8 BACKSITE? Input the north coordinate of the backsight station [ENTER↑]
Input the east coordinate of the backsight station [R/S]

9 PI STATION? Input the station of the system P.I. [R/S]

10 DELTA? Input the system delta. If curve left, [CHS] [R/S]

11 R? Input the radius for the circular curve [R/S]

12 L? Input the spiral length [R/S]

Output will be a display of the length of spiral curve, the spiral angle (output is in the form D.MMSS), and the radius. If a printer is not attached, continue stroking [R/S]. Output continues with the P.I. station, the central angle, and the TS and SC stations, followed by the next prompt

13 STA? Input the station for which the coordinates are required [E]

Output will be the station and its coordinates, followed by the horizontal distance from the instrument to the point and the angle from the backsight to the point. Continue stroking [R/S] each time if not using a printer until the prompt O/S DIST? appears.

14 **O/S DIST?** Any desired offsets may be calculated at this time. If the offset is to the left, [CHS] [R/S]

Output will be the offset and its coordinates, followed by the horizontal distance and angle to the point. Offsets to the left will be shown as negative

15 **O/S DIST?** Repeat step 14 until all of the required offsets for the station have been calculated and inversed, or return to step 13 with input of a new station. When all of the required stations and offsets have been calculated for the **entrance** spiral, go to the circular portion, as follows:

16 **O/S DIST?** Calculate the SC station last. When ready to calculate the circular portion, keystroke [J]

17 **O/S DIST?** Input the circular radius distance. If the curve is to the left, [CHS] [R/S]

Output will be the coordinates of the radius point of the circular curve. Remember, the circular portion has a different input format than the spirals. The station will be input each time, for each offset.

18 **STA?** Input the next station [R/S]

19 **O/S DIST?** Input 0 for centerline, or the offset distance. If the offset is to the left, [CHS] [R/S]

Output will be the station and its coordinates (or the offset and its coordinates) with the horizontal distance and angle.

20 **STA?** Repeat steps 18 and 19 until all of the stations and offsets have been calculated through the circular portion. **Go to the exit spiral** by keystroking [D]

21 **BRG=?** Input the bearing of the exit tangent [R/S]

22 **QD=?** Input the quadrant code for the exit tangent in the direction **toward** the P.I. [R/S]

23 **ST N↑E** Input the north coordinate of the ST [ENTER↑]

Input the east coordinate of the ST [R/S]

Output will be the ST and CS stations.

24 **STA?** Calculate the stations through the exit spiral, beginning with the CS station, by repeating steps 13 and 14 until all of the required stations and offsets have been calculated and inversed.

EXAMPLE SPIRAL
Δ = 22°06'55"

T_s = 418.175'	R = 1460.000'
L_s = 265.000'	X_s = 264.782'
θ_s = 5°11'59.2"	Y_s = 8.012'
Δ_c = 11°42'56.5"	L_c = 298.537'

P.I. STA 140+36.445

As an example, and to demonstrate the added keystrokes for this routine, we will calculate the ties to points 20 feet left and 20 feet right at one of the stations in the entrance spiral and circular portions of the system.

Keystrokes for the exit spiral are the same as for the entrance spiral, and the radial inversing is automatic. The curve data is shown to the left.

keystrokes: [XEQ]

[ALPHA] [S] [P] [ALPHA]

prompt: COORD-O/S?

keystrokes:

[Y] [R/S]

prompt: BRG=?

keystrokes:

[2] [1] [.] [5] [1] [3] [R/S]

prompt: QD=?

keystrokes:

[4] [R/S]

prompt: TS N↑E

keystrokes:

[3] [8] [6] [3] [8]

[.] [3] [8] [8] [ENTER↑]

[3] [0] [5] [4] [9]

[.] [7] [9] [2] [R/S]

prompt: INVERSE?

keystrokes:

[Y] [R/S]

prompt: INST N↑E?

keystrokes:

[3] [9] [1] [0] [0] [ENTER↑]

[3] [0] [6] [2] [5] [R/S]

prompt: BACKSITE?

keystrokes:

[3] [8] [7] [0] [0] [ENTER↑]

[3] [1] [0] [0] [0] [R/S]

prompt: PI STATION?

keystrokes:

[1] [4] [0] [3] [6] [.]

[4] [4] [5] [R/S]

prompt: DELTA?

keystrokes:

[2] [2] [.] [0] [6]

[5] [5] [R/S]

prompt: R?

keystrokes:

[1] [4] [6] [0] [R/S]

prompt: L?

keystrokes:

[2] [6] [5] [R/S]

output:
L = 265.0000
S∡ =
5° 11' 59.2"
R = 1,460.0000

PI =
140+36.445
CENTRAL ∡ =
22° 6' 55.0"

TS =
136+18.270
SC =
138+83.270

prompt: STA?

keystrokes:

[1] [3] [7] [0] [0] [E]

output:
137+00.000

N = 38,714.3292
E = 30,519.5814

HD = 399.819
∡RT=
58° 26' 24.3"

prompt: O/S DIST?

keystrokes:

[2] [0] [CHS] [R/S]

output:
O/S = -20.0000
N = 38,707.0434
E = 30,500.9556

HD = 412.070
∡RT=
60° 40' 18.1"

prompt: O/S DIST?

keystrokes:

[2] [0] [R/S]

output:
O/S = 20.0000
N = 38,721.6149
E = 30,538.2071

HD = 388.212
∡RT=
56° 4' 16.5"

prompt: O/S DIST?

keystrokes:

[1] [3] [8] [0] [0] [E]

output:
138+00.000

N = 38,807.9846
E = 30,484.5431

HD = 324.039
∡RT=
68° 50' 22.4"

prompt: O/S DIST?

keystrokes:

[1] [3] [8] [8] [3] [.] [2] [7] [E]

output:
138+83.270

N = 38,887.1168
E = 30,458.6462

HD = 270.172
∡RT=
81° 9' 27.4"

After calculating any needed offsets at the **SC**, move to the circular portion of the system

keystroke: [J]

output: CIRCULAR:

prompt: O/S DIST?

keystrokes:

[1] [4] [6] [0] [R/S]

output:
RADIUS POINT:
N = 39,305.6513
E = 31,857.3702

prompt: STA?

keystrokes:

[1] [3] [9] [0] [0] [R/S]

prompt: O/S DIST?

keystrokes:

[0] [R/S]

output:
139+00.000
N = 38,903.1717
E = 30,453.9422

HD = 260.772
∡RT=
84° 8' 43.3"

prompt: STA?

keystrokes:

[1] [3] [9] [0] [0] [R/S]

prompt: O/S DIST?

keystrokes:

[2] [0] [CHS] [R/S]

output:
139+00.000
O/S = -20.0000
N = 38,897.6583
E = 30,434.7171

HD = 277.758
∡RT=
86° 23' 35.5"

prompt: STA?

keystrokes:

[1] [3] [9] [0] [0] [R/S]

prompt: O/S DIST?

keystrokes:

[2] [0] [R/S]

output:

139+00.000
O/S = 20.0000
N = 38,908.6852
E = 30,473.1672

HD = 244.243
∡RT=
81° 35' 20.0"

prompt: **STA?**

keystrokes:

[1] [4] [0] [0] [0] [R/S]

prompt: **O/S DIST?**

keystrokes:

[0] [R/S]

output:

140+00.000
N = 39,000.1655
E = 30,429.6873

HD = 219.349
∡RT=
106° 4' 42.4"

prompt: **STA?**

. . . . . . **etc.**

After all of the required offsets have been calculated in the circular portion, go to the **exit** spiral by keystroking [D] and answering the prompts for input of the exit bearing, quadrant code and coordinates.

The keystrokes used for the AUTO-INVERSE routine are the same as for ALIGNMENT & OFFSET, on pages 25 and 26.

When the calculations are being done for radial stakeout with this routine,it is possible that the whole curve cannot be seen from one setup. In that event, the portion that is to be sprayed in from the first setup point should be completed, and then the program started over for the second setup.

If the first setup included the circular portion, and the second setup will be in the exit spiral only, it is not necessary to go through all of the steps for the entrance spiral and circular portions of the system.

Tangent Offset

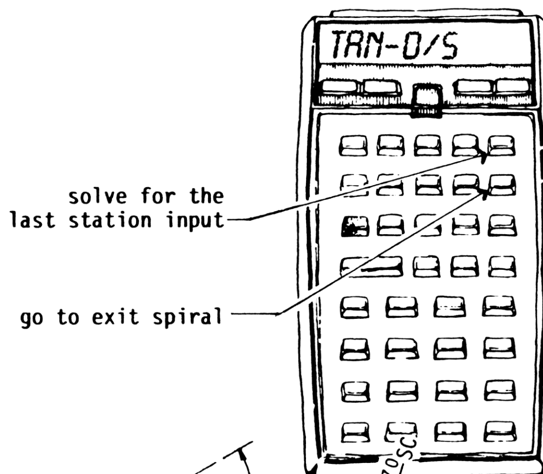
In this routine, the solution is in the form of the tangent distance and the offset from the tangent to any point on the spiral. The tangent distance is the distance along the entrance tangent from the **TS**, or back along the exit tangent from the **ST**. The tangent offset is measured at right angles to the tangent.

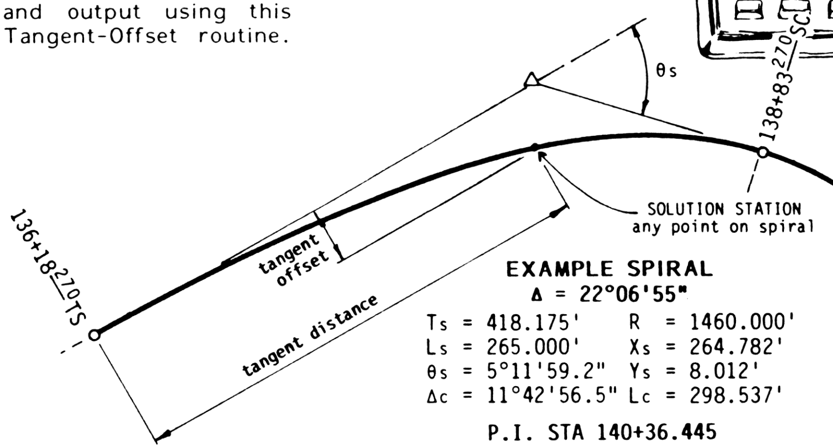
To illustrate this routine, the spiral data below will be used. The entrance spiral is shown below, and the curve data for the spiral portions is the same for both the entrance and exit spirals. Stationing at the **CS** and **ST** will be output by the program after calculations for the entrance spiral have been completed.

The keys used for this routine are shown in the sketch to the right.

The required input is prompted by the program as you proceed, and followed by stroking the [R/S] button except after input of a new station for solution.

The step-by-step keystroke instructions are shown on the next page and are followed by an example of the input and output using this Tangent-Offset routine.





EXAMPLE SPIRAL

Δ = 22°06'55"

Ts = 418.175'	R = 1460.000'
Ls = 265.000'	Xs = 264.782'
θs = 5°11'59.2"	Ys = 8.012'
Δc = 11°42'56.5"	Lc = 298.537'

P.I. STA 140+36.445

Begin with the calculator sized at 050, and program memory containing the programs "**SP**" and "**STA**". If the calculator is being used with a printer attached, the utility program "**DMS**" must also be in program memory, and unless the calculator contains the HP Surveying Pac or the D'Zign COGO 41 module, memory must also include "**AZ**".

1 **Initialize the program** by keystroking [XEQ] [ALPHA] [S] [P] [ALPHA]

2 **COORD-O/S?** Answer this prompt no [N] [R/S]

3 **TAN O/S?** Answer this prompt yes [Y] [R/S]

4 **PI STATION?** Input the main P.I. station. If it is not shown on the curve data provided it can be calculated by inputting the TS station and adding the T_S distance to it. [R/S]

5 **DELTA?** Input the system delta. If curve left, [CHS] [R/S]

6 **R?** Input the radius for the circular curve [R/S]

7 **L?** Input the spiral length [R/S]

Output will be a display of the length of spiral curve, the spiral angle (output is in the form D.MMSS), and the radius. If a printer is not attached, continue stroking [R/S]. Output continues with the P.I. station, the central angle, and the TS and SC stations, followed by the next prompt

8 **STA?** Input the station for which the the tangent distance and tangent offset are required [E]

Output will be the tangent distance and the tangent offset. Continue stroking [R/S] each time if not using a printer until the prompt STA? appears.

9 **STA?** Repeat step 8 until all of the required stations have been calculated for the entrance spiral. It is normal to also calculate the SC station last. When ready to calculate the exit spiral, keystroke [D]

Output will be the stations of the CS and ST, followed by the prompt

10 **STA?** Input the exit spiral stations for solution in the same manner as before, repeating step 8 until all of the required stations have been calculated. The exit spiral can be calculated in either direction, but the tangent distances and offsets are from the ST, sighting toward the P.I.

Tangent Offset

For the keystroke example, using the curve data shown on page 33, we will calculate the 100' stations for the entrance and exit spirals using the TANGENT-OFFSET method of stakeout.

keystrokes: [XEQ]

[ALPHA] [S] [P] [ALPHA]

prompt: **COORD-O/S?**

keystrokes:

[N] [R/S]

prompt: **TAN O/S?**

keystrokes:

[Y] [R/S]

prompt: **PI STATION?**

keystrokes:

[1] [4] [0] [3] [6] [.]
[4] [4] [5] [R/S]

prompt: **DELTA?**

keystrokes:

[2] [2] [.] [0] [6] [5] [5]
[R/S]

prompt: **R?**

keystrokes:

[1] [4] [6] [0] [R/S]

prompt: **L?**

keystrokes:

[2] [6] [5] [R/S]

output:
L = 265.0000
S∡ =
5° 11' 59.2"
. . . etc.

prompt: **STA?**

keystrokes:

[1] [3] [7] [0] [0] [E]

output:
137+00.000
TD = 81.7294
T O/S = 0.2352

prompt: **STA?**

keystrokes:

[1] [3] [8] [0] [0] [E]

output:
138+00.000
TD = 181.6969
T O/S = 2.5851

prompt: **STA?**

keystrokes:

[1] [3] [8] [8] [3] [.] [2] [7]
[E]

output:
138+83.270
TD = 264.7818
T O/S = 8.0118

This completes the calculation of the **entrance** spiral. This routine does not calculate the circular portion of the system, so we move to the **exit** spiral:

keystroke:

[D]

output:
ST =
144+46.807
CS =
141+81.807

prompt: **STA?**

keystrokes:

[1] [4] [1] [8] [1] [.]
[8] [0] [7] [E]

output:
141+81.807
TD = 264.7821
T O/S = -8.0119

prompt: **STA?**

keystrokes:

[1] [4] [2] [0] [0] [E]

output:
142+00.000
TD = 246.6544
T O/S = -6.4734

prompt: **STA?**

keystrokes:

[1] [4] [3] [0] [0] [E]

output:
143+00.000
TD = 146.7959
T O/S = -1.3629

prompt: **STA?**

keystrokes:

[1] [4] [4] [0] [0] [E]

output:
144+00.000
TD = 46.8072
T O/S = -0.0442

prompt: **STA?**

keystrokes:

[1] [4] [4] [4] [6] [.]
[8] [0] [7] [E]

output:
144+46.807
TD = 0.0003
T O/S = -9.4564E-18

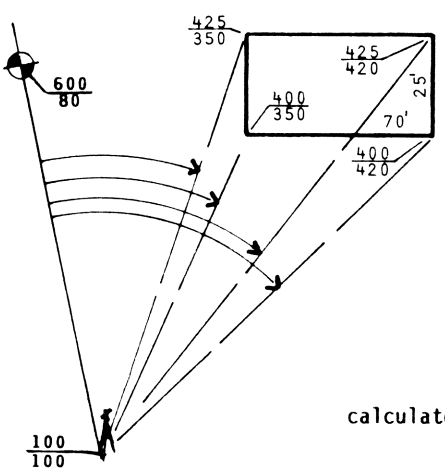
NOTE:
"zero" is sometimes output, as above, as a very small number in scientific notation.

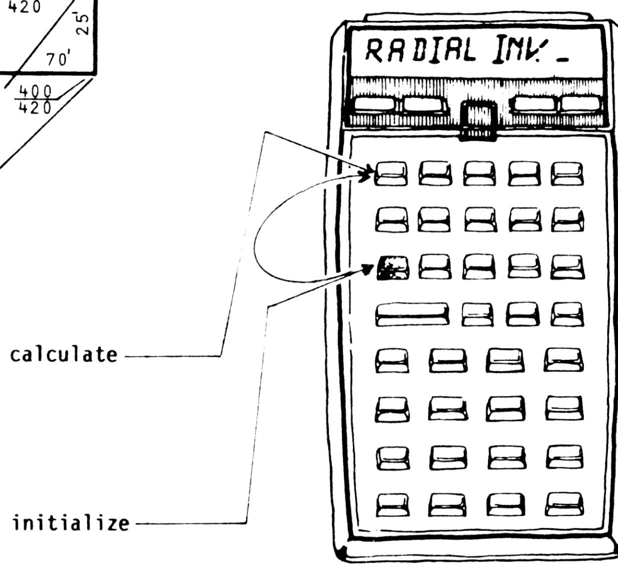
This routine may be used to calculate the angle right and horizontal distance to any point of known coordinates, from an instrument setup station and backsight station which have known coordinates, and is similar to the RADIAL INVERSE routine included with the program "**LO**".

It has been included in this section because the capability is already in the programming, and it is therefore available for use with other field problems when the program "**SP**" is in the program memory, instead of "**LO**".

The calculator should be sized at 050, and if used with a printer, memory should include the utility program "**DMS**". "**AZ**" should also be in the program memory, either as a subroutine program or by having the HP Surveying Pac or D'Zign's COGO 41 ROM in the calculator.

If the calculator has been off, and a printer is not attached, the numbers will 'flash' by. If this happens, reset flag 21 by keystroking [SF] [2] [1].





Radial Inverse

Unlike the other routines in this program group, the RADIAL INVERSE routine is accessed by using "**GTO**" (shift, RCL) instead of "**XEQ**" to bring the program to the top of program memory. It may also be accessed by "**XEQ**" if you then ignore the first prompt (note that the calculator is in ALPHA mode) and clear ALPHA by stroking [ALPHA].

then:

keystrokes:

[a] (key [shift] [A])

prompt: **INST N↑E**

keystrokes:

[1] [0] [0] [ENTER↑]

[1] [0] [0] [R/S]

prompt: **BACKSITE?**

keystrokes:

[6] [0] [0] [ENTER↑]

[8] [0] [R/S]

prompt: **N↑E?**

keystrokes:

[4] [2] [5] [ENTER↑]

[3] [5] [0] [A]

output:

425.0000
350.0000

HD = 410.030
∡RT=
39° 51' 33.1"

prompt: **N↑E?**

keystrokes:

[4] [0] [0] [ENTER↑]

[3] [5] [0] [A]

output:

400.0000
350.0000

HD = 390.512
∡RT=
42° 5' 46.3"

prompt: **N↑E?**

keystrokes:

[4] [2] [5] [ENTER↑]

[4] [2] [0] [A]

output:

425.0000
420.0000

HD = 456.098
∡RT=
46° 50' 47.3"

prompt: **N↑E?**

keystrokes:

[4] [0] [0] [ENTER↑]

[4] [2] [0] [A]

output:

400.0000
420.0000

HD = 438.634
∡RT=
49° 8' 17.6"

prompt: **N↑E?**

Continue with the input of any other coordinates which may be wanted. The north-coordinate is entered, the east-coordinate input, and followed by the keystroke [A].

This routine is useful if the coordinates for offsets were calculated prior to knowing where they would be set from.

notes

Topo

The easiest introduction to the use of this program group is the routine where it is used to do a topographic survey. After input of the information needed to establish the baseline, the input of the horizontal and vertical (zenith) angles, slope distance and rod for each shot gives output in terms of the station along the baseline, offset (left or right), at the shot, and the elevation of the shot.

If a printer is attached, the input can also be shown as part of the output by 'toggling' between the I and J keys. This establishes a flag status condition which prints out the stack after input, but before beginning the calculations for the solution.

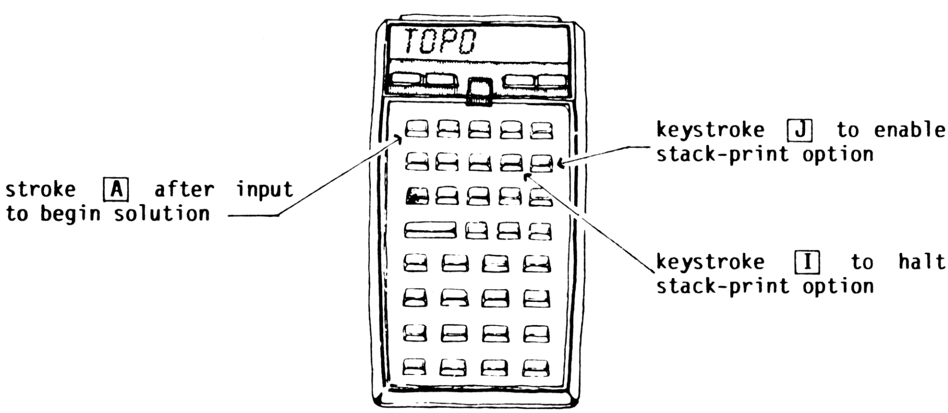
```
T=  127.1625
Z=  94.0235
Y=  206.5400
X= -5.0000
```

The stack-print option may only be used with a printer attached, or a "nonexistent" will be displayed when the program reaches the program step with the PRINT STACK command.

```
STA 8+75.23
AT 163.95 RT
ELEV = 80.44
```

The baseline for the topo may be two points along a traverse line, or along the existing alignment of any road or highway. The instrument and backsite **do not have to be on centerline** with this program. They can be at any convenient offset to the baseline or centerline, and they can be at different offsets, if that is more convenient. One or the other can even be at a station or offset in a curve (both can be if it is the same curve).

In the case of a simple baseline, assign the instrument point a station, such as 0+00, and the backsite the station equivalent to its distance from the instrument. The use of the station-offset output allows rapid plotting of the topo in the office.



K E Y B O A R D   A S S I G N M E N T S

Before beginning, the calculator should be sized to 045 (or larger). This program group uses the program "**TT**".

1 **Initialize the program** by keystroking [XEQ] [ALPHA] [T] [T] [ALPHA]

2 **INST. STA.?** Input the station which (or opposite which) the instrument occupys [R/S]

3 **OFFSET?** If the instrument is on the centerline or baseline, enter 0. If on an offset, enter the offset distance. If the offset is to the left, [CHS] [R/S]

4 **ON CURVE?** This prompt will be answered NO, [N] unless the instrument is on (or opposite) a station which is in the curve. If the setup station **is** within a curve, answer [Y], and answer the additional prompts for curve data (marked *) [R/S]

5 ***B.C. STA?** Enter the station at which the curve starts [R/S]

6 ***RADIUS?** Input the radius of the curve [R/S]

7 ***DELTA?** Input delta (DD.MMSS). If curve left, [CHS] [R/S]

8 **H.I.?** Input the elevation at the height of the instrument. This can be found by taking a shot at a benchmark, measuring up from the known elevation of the setup station, or may be an assumed height of instrument [R/S]

9 **BKSITE STA?** Input the station of the point that will be used as the backsight point [R/S]

10 **OFFSET?** Input 0 if on centerline, or the offset distance if not. If the offset is left, [CHS] [R/S]

11 **ON CURVE?** If the backsight station is on a curve, answer [Y]. If not, answer [N]. If both the instrument and the backsight are on the curve, the curve data has been input already and need not be repeated; if this is the case, answer NO. [R/S]

If the answer is yes, and the instrument was not on the curve, the prompts at steps 5 through 7 (*) will now appear. If neither the instrument nor the backsight were on a curve, but there is a curve in the alignment, it is included in the calculations by the response to the next prompt.

12 **CURVE AREA?** This prompt will appear if the neither the instrument nor backsight are on a curve. If there is a curve in the centerline alignment which will fall within the scope of the topo, answering [Y] will bring up the prompts shown at steps 5 through 7. Shots taken within the area of the curve will be shown as **radial** offsets to the curve stations when output. If there is no curve area involved, answer [N] [R/S]

13 **SHOW GRADE?** Answer this prompt NO, [N] [R/S]

14 **INPUT SHOT**** This is the prompt to begin input of the shots. Input the horizontal angle [ENTER↑]

Input the vertical (zenith) angle [ENTER↑]

Input the measured slope distance [ENTER↑]

Input the rod reading. With the EDM, it is the height of the rod at the prism, and it is a minus rod. Unless the rod is inverted, all rods are minus rods and the rod is input as a minus by [CHS] prior to keystroking [A]

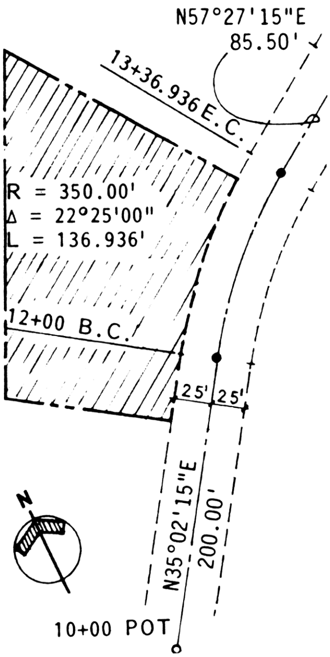
** If a printer is attached, and the print-stack option is wanted, to record the input data [J]

** You can halt the print-stack option by keystroking [I]

Output will be the station, offset and elevation at the shot. Return to step 14 for the next shot. If using the calculator without a printer attached, keystroke [R/S] for each part of the output each time until the INPUT SHOT prompt is shown.

NOTE: When there is a curve in the alignment the program executes a subroutine for solution, after first determining that the shot falls within the curve area. After the solution is calculated, it is then compared to the EC station, and if it it exceeds the curve area is recalculated as an offset to the exit tangent.

For this reason the program running time also becomes slightly longer when you have passed the curve area with the shots.



As an example of how the program works, and to practice the keystrokes and input used, we can do part of the little topograpic survey shown to the left.

The survey is going to be used by an architect, who is designing a residence for the lot that is shown (shaded), and he needs to know enough about the topography to start designing his footings.

One of the advantages of this program is that there is no need to run a traverse just to do a topo. Any baseline can be used, as long as it can be related to the site for plotting. For the example we will assume that the instrument is set over a right-of-way pin at 25' left of 12+00 B.C., and the backsight is at 10+00 on centerline.

This has us already tied to the alignment for plotting of the topography, and we can use an assumed height of instrument of 200. The program will number the shots as they are taken so that the only field notes which will be required for plotting is a list of the shots' descriptions.*

Begin by initializing the program with

[XEQ] [ALPHA] [T] [T] [ALPHA]

prompt: **INST. STA.?**

keystrokes:

[1] [2] [0] [0] [R/S]

prompt: **OFFSET?**

keystrokes:

[2] [5] [CHS] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **H.I.?**

keystrokes:

[2] [0] [0] [R/S]

prompt: **BKSITE STA?**

keystrokes:

[1] [0] [0] [0] [R/S]

prompt: **OFFSET?**

keystrokes:

[0] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **CURVE AREA?**

keystrokes:

[Y] [R/S]

prompt: **B.C. STA?**

keystrokes:

[1] [2] [0] [0] [R/S]

prompt: **RADIUS?**

keystrokes:

[3] [5] [0] [R/S]

prompt: **DELTA?**

keystrokes:

[2] [2] [.] [2] [5] [R/S]

prompt: **SHOW GRADE?**

keystrokes:

[N] [R/S]

* With the printer attached.

prompt: **INPUT SHOT**

keystrokes:

[8] [5] [.] [1] [0] [2] [5] [ENTER↑]

[9] [1] [.] [1] [5] [1] [ENTER↑]

[5] [7] [.] [3] [ENTER↑]

[5] [CHS] [A]

output:

```
1

T=  85.1025
Z=  91.1510
Y=  57.3000
X= -5.0000
STA 11+88.14
AT 81.04 LT
ELEV = 193.75
```

prompt: **INPUT SHOT**

keystrokes:

[1] [0] [2] [.] [2] [5] [3] [5] [ENTER↑]

[9] [2] [.] [0] [7] [3] [ENTER↑]

[6] [3] [.] [7] [ENTER↑]

[5] [CHS] [A]

output:

```
2

T=  102.2535
Z=  92.0730
Y=  63.7000
X= -5.0000
STA 12+04.70
AT 88.42 LT
ELEV = 192.64
```

All of the required setup information has been input at this point, and we have the prompt for shot input, as shown to the left.

At this point you can keystroke [J] to have the angles and slope distances output, along with the solution of the shots, if your printer is attached. This output can be returned to the 'solution only' form at any time by keystroking [I]. Neither key disturbs the stack, but it is generally more convenient to switch just before or just after input, since it does erase the prompt.

When the **print-stack** option is selected, the stack is printed as follows:

The T register contains the horizontal angle, the Z register contains the zenith angle, the Y register has the slope distance and the X register the rod.

The keystrokes to the left are typical input, and additional shot solutions are shown with the print-stack input.

```
3

T=  135.1000
Z=  92.3500
Y=  25.0000
X= -5.0000
STA 12+13.64
AT 44.97 LT
ELEV = 193.87
```

```
4

T=  134.2630
Z=  93.2000
Y=  43.6000
X= -5.0000
STA 12+22.52
AT 60.47 LT
ELEV = 192.46
```

```
5

T=  132.5445
Z=  94.3630
Y=  92.4000
X= -5.0000
STA 12+41.72
AT 102.93 LT
ELEV = 187.58
```

```
6

T=  136.0250
Z=  95.0240
Y=  106.5000
X= -5.0000
STA 12+50.63
AT 112.37 LT
ELEV = 185.64
```

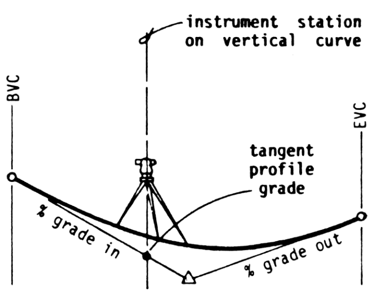
notes

As-builts

The program is used in essentially the same way for taking as-built shots, except that the shots are usually taken with more accuracy. It can be used, for instance, for determining the location of building slabs as they are poured on the lots in a subdivision, or as-built shots on curb and gutter.

This routine will also be useful for checking the forms prior to pouring concrete, and is generally quicker than elevation-offset shots on complex structures. In the case of a structure as-built, the shots should be taken with a butt chain, and slope chained directly to the instrument head from the point or corner being checked.

In the case of a curb and gutter as-built, the routine will carry the profile grade information and output finish grade at each shot in addition to the elevation of the shot for quick comparison. This means that the shots can be taken at convenient locations without having to be at an exact station where the grade is known.

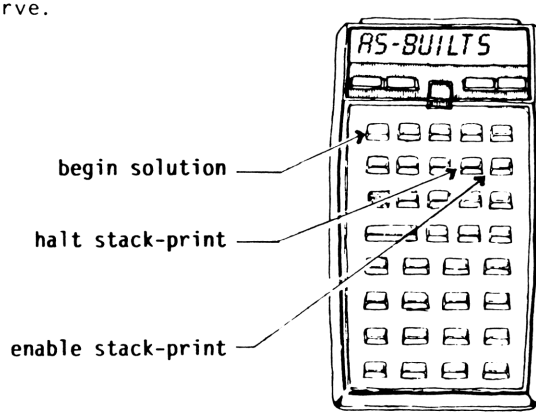


The routine can carry one grade break or vertical curve at a time, together with the entrance and exit grades.

As shown in the sketch to the left, the instrument may occupy a station that is within the area of the vertical curve, but the elevation which you input when prompted **PROFILE EL?** will be the elevation of the **vertical tangent** at the instrument station, rather than the elevation on the vertical curve.

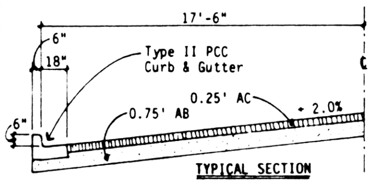
The keyboard assignments are the same for this routine as in the last (TOPO), as shown to the right.

The input information may be output as part of the solution as before, by switching the flag status with keystrokes of [I] (input not printed) and [J] (input printed), when using a printer.



This program routine is used in the same manner as TOPO, and areas including horizontal curves can be incorporated in the same way. The main difference is that we are also carrying the existing alignment information in the program memory.

For this example, we'll use a straight section of alignment, since the new keystrokes are those which deal with the **vertical** alignment.



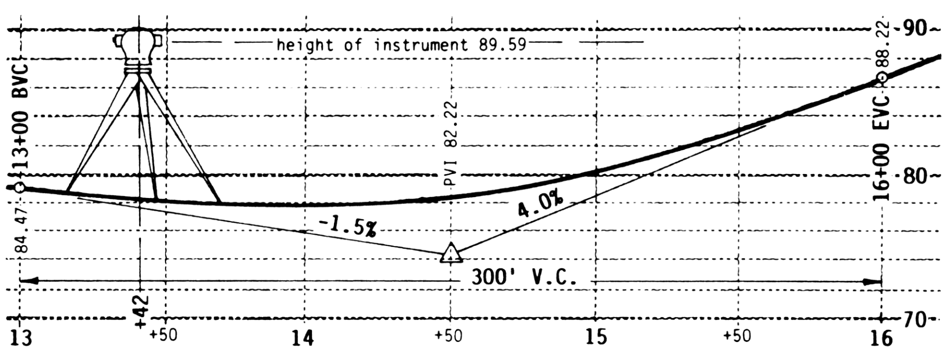
A typical section for a street is shown to the left, and we will 'as-built' the top of curb at the face of curb on the left side of the street for our example. The centerline profile for the street is shown below, and we will assume that the instrument is set up at station 13+42, backsighting station 11+00, both on centerline.

There are two things to do before beginning.

First, we will want to input the elevation of the profile grade for the curb, rather than the centerline, so, using the typical section,

top of curb = centerline grade - (17.5' x .02) + 0.5'
= **centerline profile + 0.15'**

Second, the grade on the vertical tangent at 13+42 needs to be calculated; we're going 42' at -1.5%, and -.015 x 42 = -0.63. Take centerline grade at the BVC -0.63 + 0.15, and we have an elevation of 83.99 for the vertical tangent at top of curb for station 13+42. We input this after the prompt PROFILE EL?.



CENTERLINE PROFILE

As-builts

To begin, the calculator should be sized at 045 and program "**TT**" must be in the program memory.

1 **Initialize the program**, keystroking [XEQ] [ALPHA] [T] [T] [ALPHA]

2 **INST. STA.?** Input the instrument station [R/S]

3 **OFFSET?** If the instrument is on the centerline or baseline, enter 0. If on an offset, enter the offset distance. If the offset is to the left, [CHS] [R/S]

4 **ON CURVE?** This prompt will be answered NO, [N] unless the instrument **is** on (or opposite) a curve station. If in a curve, answer [Y], and answer the additional prompts (marked*) for curve data. [R/S]

5 ***B.C. STA?** Enter the station at which the curve starts [R/S]

6 ***RADIUS?** Input the radius of the curve [R/S]

7 ***DELTA?** Input delta (DD.MMSS). If curve left, [CHS] [R/S]

8 **H.I.?** Input the elevation at the height of the instrument. [R/S]

9 **BKSITE STA?** Input the backsight station. [R/S]

10 **OFFSET?** Input 0 if on centerline, or the offset distance if not. If the offset is left, [CHS] [R/S]

11 **ON CURVE?** If the backsight station is on a curve, answer [Y]. If not, answer [N]. If both the instrument and the backsight are on the curve, the curve data has been input already and need not be repeated, and this prompt can now be answered NO. [R/S]

12 **CURVE AREA?** This prompt will appear when neither the instrument nor backsight are on a curve. If there is a curve in the centerline alignment which will fall within the scope of the work, answering [Y] will bring up the prompts at steps 5 through 7. If there is no curve area involved, answer [N] [R/S]

13 **SHOW GRADE?** Answer this prompt YES. Additional prompts for input of profile grade information (marked †) will follow [Y] [R/S]

14 **PROFILE EL?†** Input the finished grade elevation at the instrument station. If the instrument is at a station which is located within a vertical curve, input the elevation of the **tangent profile grade**. [R/S]

15 **GRADE? †** Input the % of grade. If negative, [CHS] [R/S]

16 **SPRINGLINE?†** Answer this prompt NO [N] [R/S]

17 **VERT CURVE?†** If the grade is a straight slope, answer [N]. If there is a vertical curve within the work area answer [Y] [R/S]

THE NEXT THREE PROMPTS APPEAR IF THE ANSWER (above) WAS YES

18 **BVC STA?** Input the beginning station of the vertical curve [R/S]

19 **LENGTH?** Input the length of the vertical curve [R/S]

20 **GRADE OUT?** Input the % of grade leaving the vertical curve. If the grade is negative, [CHS] [R/S]

21 **INPUT SHOT** This is the prompt to begin input of the shots. Input the horizontal angle [ENTER↑]

Input the vertical (zenith) angle [ENTER↑]

Input the measured slope distance [ENTER↑]

Input the rod reading. If you are sighting directly to a point, and slope chaining to it, input 0. An inverted rod is a 'plus' rod, and a normal rod is a 'minus' rod ([CHS] for minus rod) [A]

Output will be the station, offset, elevation and finished grade at the shot. Return to step 21 for the next shot. If using the calculator without a printer attached, keystroke [R/S] for each part of the output each time until the INPUT SHOT prompt is shown.

If the printer is attached, the input can be shown, when wanted, by using [I] (not shown) and [J] (shown) keystrokes.

For this example, we will try two shots. Assume an H.I. elevation of 89.59, and that the shots were:

	horizontal angle	vertical angle	slope distance	rod reading
1	168°24'55"	90°15'00"	87.34'	-5.00'
2	170°43'40"	90°05'20"	108.73'	-5.00'

keystrokes: [XEQ]

[ALPHA] [T] [T] [ALPHA]

prompt: **INST. STA.?**

keystrokes:

[1] [3] [4] [2] [R/S]

prompt: **OFFSET?**

keystrokes:

[0] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **H.I.?**

keystrokes:

[8] [9] [·] [5] [9] [R/S]

prompt: **BKSITE STA?**

keystrokes:

[1] [1] [0] [0] [R/S]

prompt: **OFFSET?**

keystrokes:

[0] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **CURVE AREA?**

keystrokes:

[N] [R/S]

prompt: **SHOW GRADE?**

keystrokes:

[Y] [R/S]

prompt: **PROFILE EL?**

keystrokes:

[8] [3] [·] [9] [9] [R/S]

prompt: **GRADE?**

keystrokes:

[1] [·] [5] [CHS] [R/S]

prompt: **SPRINGLINE?**

keystrokes:

[N] [R/S]

prompt: **VERT CURVE?**

keystrokes:

[Y] [R/S]

prompt: **BVC STA?**

keystrokes:

[1] [3] [0] [0] [R/S]

prompt: **LENGTH?**

keystrokes:

[3] [0] [0] [R/S]

prompt: **GRADE OUT?**

keystrokes:

[4] [R/S]

Now, with all of the required "setup" information input, we get the prompt for input of the shot data

prompt: **INPUT SHOT**

keystrokes:

[1] [6] [8] [·] [2] [4] [5] [5]

[ENTER↑]

[9] [0] [·] [1] [5]

[ENTER↑]

[8] [7] [·] [3] [4]

[ENTER↑]

[5] [CHS] [A]

output:

```
1
STA 14+27.56
AT 17.54 LT
ELEV = 84.21
GR = 84.20
```

prompt: **INPUT SHOT**

keystrokes:

[1] [7] [0] [·] [4] [3] [4]

[ENTER↑]

[9] [0] [·] [0] [5] [2]

[ENTER↑]

[1] [0] [8] [·] [7] [3]

[ENTER↑]

[5] [CHS] [A]

output:

```
2
STA 14+49.31
AT 17.52 LT
ELEV = 84.42
GR = 84.42
```

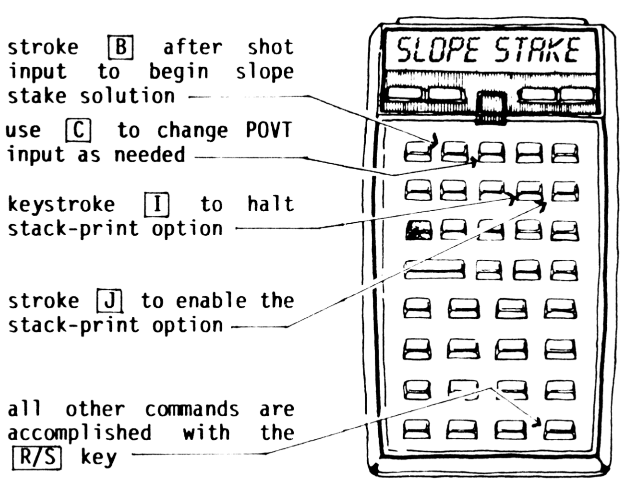
Setting slope stakes along an alignment prior to construction is one of the most time-consuming processes in construction surveying. This routine allows the staking of a large area to be accomplished from each instrument setup. It is still a 'trial and error' procedure, but it has some distinct advantages.

One advantage is that the catch points may be located at the high and low points of the existing terrain, as well as in-between. This is not usually done, even though it provides better control of the slopes, because it requires the additional calculations for the extra station grades in the field.

Both the instrument and backsight points may be at any offset to (or on) a known station on the alignment being staked. The input includes the profile of the finished grade, and calculates the station, offset and the cut or fill at any point shot.

Once input, the 'half-width' and slope ratio are carried as constants, but may be changed when desired. This feature is useful in cases such as a change from cut to fill at the station shot, or to 'flatten' the slope before and after reaching a daylight area.

After each trial shot, the program displays the distance needed (**at that same elevation**) to reach the actual catch point for the station being shot. When the distance is within acceptable (±0.2') accuracy, stroking [R/S] outputs the cut or fill information.



The illustration to the left shows the keyboard assignments used with the slope staking procedure.

Each time [B] is stroked, the ½-width is displayed. The display will show **W/2=0.00** the first time, and the correct distance is input, followed by [R/S]. In the same manner, the original slope ratio will be displayed as **SR=0:1** and the correct ratio is input. These may be changed at any time, by inputting a new value when they are displayed.

Remote Slope Staking

Begin with the program "TT" in the program memory, and the calculator sized to at least size 045.

1	**Initialize the program**, keystroking		[XEQ] [ALPHA] [T] [T] [ALPHA]
2	**INST. STA.?**	Input the instrument station	[R/S]
3	**OFFSET?**	If the instrument is on the centerline or baseline, enter 0. If on an offset, enter the offset distance. If the offset is to the left, [CHS]	[R/S]
4	**ON CURVE?**	This prompt will be answered NO, [N] unless the instrument **is** on (or opposite) a curve station. If in a curve, answer [Y], and answer the additional prompts (marked*) for curve data.	[R/S]
5	***B.C. STA?**	Enter the station at which the curve starts	[R/S]
6	***RADIUS?**	Input the radius of the curve	[R/S]
7	***DELTA?**	Input delta (DD.MMSS). If curve left, [CHS]	[R/S]
8	**H.I.?**	Input the elevation at the height of the instrument.	[R/S]
9	**BKSITE STA?**	Input the backsight station.	[R/S]
10	**OFFSET?**	Input 0 if on centerline, or the offset distance if not. If the offset is left, [CHS]	[R/S]
11	**ON CURVE?**	If the backsight station is on a curve, answer [Y]. If not, answer [N]. If both the instrument and the backsight are on the curve, the curve data has been input already and need not be repeated, and this prompt can now be answered NO.	[R/S]
12	**CURVE AREA?**	This prompt will appear when neither the instrument nor backsight are on a curve. If there is a curve in the centerline alignment which will fall within the scope of the work, answering [Y] will bring up the prompts at steps 5 through 7. If there is no curve area involved, answer [N]	[R/S]

13 **SHOW GRADE?** Answer this prompt YES. Additional prompts for input of profile grade information (marked †) will follow [R/S]

14 **†PROFILE EL?** Input the finished grade elevation at the instrument station. If the instrument is at a station which is located within a vertical curve, input the elevation of the **tangent profile grade.** [R/S]

15 **†GRADE?** Input the % of grade. If negative, [CHS] [R/S]

16 **†SPRINGLINE?** Answer this prompt NO [N] [R/S]

17 **†VERT CURVE?** If the grade is a straight slope, answer [N]. If there is a vertical curve within the work area answer [Y] [R/S]

THE NEXT THREE PROMPTS APPEAR IF THE ANSWER (above) WAS YES

18 **BVC STA?** Input the beginning station of the vertical curve [R/S]

19 **LENGTH?** Input the length of the vertical curve [R/S]

20 **GRADE OUT?** Input the % of grade leaving the vertical curve. If the grade is negative, [CHS] [R/S]

21 **INPUT SHOT** This is the prompt to begin input of the shots. Input the horizontal angle [ENTER↑]

Input the vertical (zenith) angle [ENTER↑]

Input the measured slope distance [ENTER↑]

Input the rod reading. A normal rod is a 'minus' rod, so [CHS] [B]

22 **W/2= 0.00** Input the correct half-width value, if different from the value which is displayed [R/S]

23 **SR=0:1** Input the correct slope ratio value, if different from the value displayed [R/S]

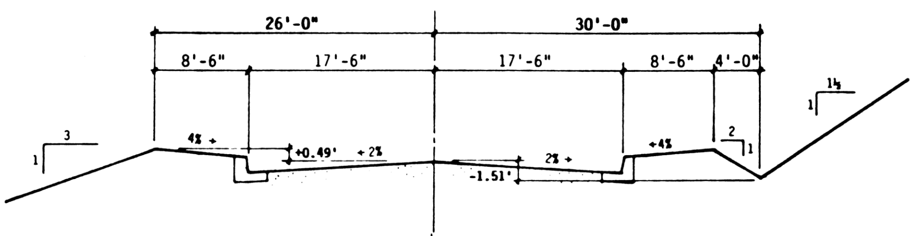
NOTE:
If the printer is attached, the input can be shown, when wanted, by using [I] (not shown) and [J] (shown) keystrokes.

The **DISPLAY** will now show the distance from the shot to the actual catch point. If the distance is considered to be within acceptable tolerance, [R/S], or if it is not, return to step 21 and input the data for the next trial shot.

When the decision has been reached to hold the current shot, and you stroke [R/S], the **output** will be the CUT (or FILL) and the horizontal width ("run") of the slope, followed by the STATION, OFFSET, ELEVATION of the shot, and FINISHED GRADE for the top or toe.

24 To change the POVT value, as when changing from a cut section to a fill section, or a different shoulder condition, input the **new POVT elevation** [C]

For the keystroke procedure example, we can assume the same setup and vertical alignment conditions as we had on page 46, where we did the as-built on the curb, but use the additional information in the section shown below for slope staking.



For a fill condition we have a centerline grade (on the vertical tangent) at the instrument of 83.84 (BVC - 42' @ -1.5%). To adjust this to the shoulder profile for slope staking, we have to go 17.5' @ -2%, +0.5' for the curb, and 8.5' at +4%. This gives us a total of +0.49. The grade for input then, will be centerline POVT at the instrument +0.49 = **84.33.**

In the 'cut' condition we have the same adjustment figures, but a ditch has been added at the toe of the slope, and we must go an additional 4' at 2:1 (-), or -2'. This gives a total correction in cut of -1.51' to be applied to our instrument POVT, so our grade input in a cut will be **82.33.**

When you are staking a fill area and come to a daylight section where the slope of the existing terrain causes the fill to become a cut, or the reverse, you can change from the fill POVT to the cut POVT by inputting the other number and keystroking [C]. The half-width and the slope ratio also change, and these can be changed be inputting the new number when they are displayed.

keystrokes: [XEQ] [ALPHA] [T] [T] [ALPHA]

prompt: **INST. STA.?**

keystrokes:

[1] [3] [4] [2] [R/S]

prompt: **OFFSET?**

keystrokes:

[0] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **H.I.?**

keystrokes:

[8] [9] [.] [5] [9] [R/S]

prompt: **BKSITE STA?**

keystrokes:

[1] [1] [0] [0] [R/S]

prompt: **OFFSET?**

keystrokes:

[0] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **CURVE AREA?**

keystrokes:

[N] [R/S]

prompt: **SHOW GRADE?**

keystrokes:

[Y] [R/S]

prompt: **PROFILE EL?**

Assume that we will be in a fill section for the first shots, and input the POVT for the top of the fill:

keystrokes:

[8] [4] [.] [3] [3] [R/S]

prompt: **GRADE?**

keystrokes:

[1] [.] [5] [CHS] [R/S]

prompt: **SPRINGLINE?**

keystrokes:

[N] [R/S]

prompt: **VERT CURVE?**

keystrokes:

[Y] [R/S]

prompt: **BVC STA?**

keystrokes:

[1] [3] [0] [0] [R/S]

prompt: **LENGTH?**

keystrokes:

[3] [0] [0] [R/S]

prompt: **GRADE OUT?**

keystrokes:

[4] [R/S]

The required input information has been completed, and we take a shot. We will use the following data for the keystroke example:

horizontal angle = 158°22'55"
vertical angle = 92°49'05"
slope distance = 115.74'
the prism is at 5.00'

prompt: **INPUT SHOT**

keystrokes:

[1] [5] [8] [.] [2] [2] [5] [5] [ENTER↑]

[9] [2] [.] [4] [9] [0] [5] [ENTER↑]

[1] [1] [5] [.] [7] [4] [ENTER↑]

[5] [CHS] [B]

display: **W/2= 0.00**

keystrokes:

[2] [6] [R/S]

display: **SR= 0:1**

keystrokes:

[3] [R/S]

display: **-1.01**

The minus sign indicates that you are **short** of a catch point at the elevation of the ground (amount of fill) this shot.

Just as in any other method of slope staking, the 'lay of the land' determines where you try your next shot. If the slope is 'up' toward centerline, move in and up. Assume the following data:

horizontal angle = 160°11'30"
vertical angle = 92°02'15"
slope distance = 113.87'
the rod, again is at 5.00'

This information will be used for the second try, and input as shown on the next page.

keystrokes:

[1] [6] [0] [.] [1] [1] [3]
[ENTER↑]
[9] [2] [.] [0] [2] [1] [5]
[ENTER↑]
[1] [1] [3] [.] [8] [7]
[ENTER↑]
[5] [CHS] [B]

display: W/2= 26.00

keystroke:

[R/S]

display: SR= 3:1

keystroke:

[R/S]

display: -0.10

This is close enough for slope staking, so we accept this as the catch point. Instead of input for a new shot, keystroke [R/S]

output:

```
FILL 4.2
  AT 12.7
STA 14+49.06
AT 38.56 LT
ELEV = 80.54
GR = 84.76
```

The next example will be in a 'cut' portion of the alignment, and we'll use this data:

horizontal angle = 192°20'40"
vertical angle = 87°23'40"
slope distance = 188.24'
rod reading = 5.00'

Before input of the shot data we have to change the POVC to the 'cut' toe elevation.

keystrokes:

[8] [2] [.] [3] [3] [C]

prompt: **INPUT SHOT**

keystrokes:

[1] [9] [2] [.] [2] [0] [4]
[ENTER↑]
[8] [7] [.] [2] [3] [4]
[ENTER↑]
[1] [8] [8] [.] [2] [4]
[ENTER↑]
[5] [CHS] [B]

display: W/2= 26.00

keystrokes:

[3] [0] [R/S]

display: SR= 3:1

keystrokes:

[1] [.] [5] [R/S]

display: -3.15

Again the indication that the shot is short of being the right distance from centerline for a catch point at the elevation of the shot. You have to go a greater distance out, go to a lower (less cut) elevation, or a combination of both.

This aspect of slope staking is always confusing, but is a little easier to understand if we assume that the existing ground is level, and take the next shot about 3.15 feet further from centerline. This would give your second shot the following data:

horizontal angle = 193°19'30"
zenith angle = 87°24'00"
slope distance = 188.24'
the rod is still at 5.00'

keystrokes:

[1] [9] [3] [.] [1] [9] [3]
[ENTER↑]
[8] [7] [.] [2] [4]
[ENTER↑]
[1] [8] [8] [.] [2] [4]
[ENTER↑]
[5] [CHS] [B]

display: W/2= 30.00

keystrokes:

[R/S]

display: SR= 1.50:1

keystrokes:

[R/S]

display: -0.02

This is the catch point. If we had printed out the first shot, it would have shown the same cut information (CUT 8.9 AT 13.4), but it was only at 40.20 feet from centerline.

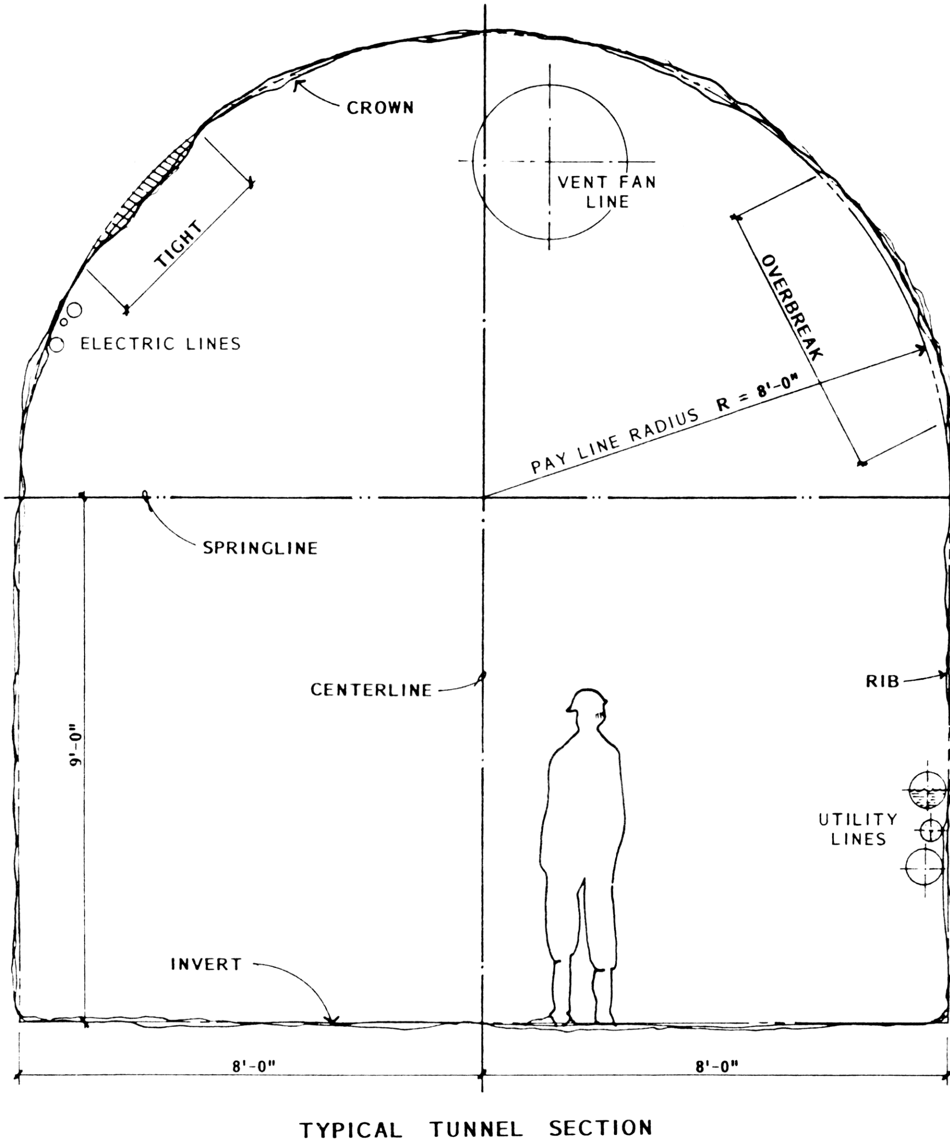
13.4 + 30.00 is 43.4, and that is the distance needed to have a catch point at this shot's elevation. The new shot should be at that distance if the cut is the same.

Instead of input for a new shot, keystroke

[R/S]

output:

```
CUT 8.9
  AT 13.4
STA 15+24.98
AT 43.34 RT
ELEV = 93.13
GR = 84.23
```



TYPICAL TUNNEL SECTION

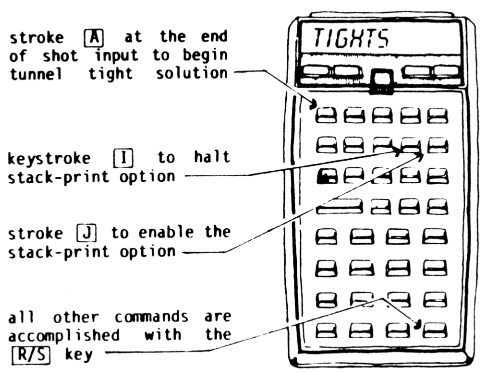
Tunnel Tights

This is the program routine that is responsible for the "**TT**" designation as a label. The program originated as a program for tight-checking in tunnels, and to make it the most effective routine possible for that work, is capable of carrying both a horizontal curve and a vertical curve (or grade break) alignment at the same time.

A "**tight**" is any portion of the excavated tunnel which still projects into the excavated area payline, and the basic technique for checking tights is to measure the distances with a rag-tape, from the head of the instrument.

In order to reach the crown (the arch portion above springline) and upper rib area, the zero end of the tape is fastened to a rod, or a powder pole, which is held in place by the rodman while the instrument is sighted onto the end where it touches the side of the tunnel.

Tights in tunnel excavation must be removed as the tunnel progresses, or going back later to remove them becomes very costly. This program allows complete breakdown of the shots at the time they are taken, and lets the field crew paint the tights as they do the check.



The typical section shown on the opposite page gives some of the basic nomenclature used to describe the parts of a tunnel. Note some of the things which are in the way when you are trying to do the shots.

The dimensions shown for the height, width, and crown radius are those which will be used for the keystroke example.

The keystrokes used for this routine are shown in the illustration to the left, and input will be the same as in the previous routines using this program, with the exception that we now input the springline.

A response of YES to the SPRINGLINE? prompt brings up additional prompts that are needed for reduction of the field data. Another difference when using this routine is that the **springline** elevation is used as profile grade, but the finished grade which is output will be the grade at the tunnel invert.

To begin, the calculator should be sized at 045 and have program "TT" in the program memory.

1 **Initialize the program**, keystroking [XEQ] [ALPHA] [T] [T] [ALPHA]

2 **INST. STA.?** Input the instrument station [R/S]

3 **OFFSET?** If the instrument is on centerline, enter 0. If on an offset, enter the offset distance. If the offset is left of centerline, [CHS] [R/S]

4 **ON CURVE?** This prompt will be answered NO, [N] unless the instrument is on (or opposite) a curve station. If on a curve, answer yes [Y], and answer the additional prompts (marked *) for curve data. [R/S]

5 ***B.C. STA?** Enter the station at which the curve starts [R/S]

6 ***RADIUS?** Input the radius of the curve [R/S]

7 ***DELTA?** Input delta (DD.MMSS). If curve left, [CHS] [R/S]

8 **H.I.?** Input the elevation at the height of the instrument. [R/S]

9 **BKSITE STA?** Input the backsight station. [R/S]

10 **OFFSET?** Input 0 if on centerline, or the offset distance if not. If the offset is left, [CHS] [R/S]

11 **ON CURVE?** If the backsight station is on a curve, answer [Y]. If not, answer [N]. If both the instrument and the backsight are on the curve, the curve data has been input already and need not be repeated, and this prompt can be answered NO. [R/S]

12 **CURVE AREA?** This prompt will appear when neither the instrument nor backsight are on a curve. If there is a curve in the centerline alignment which will fall within the scope of the work, answering [Y] will bring up the prompts at steps 5 through 7. If there is no curve area involved, answer [N] [R/S]

13 **SHOW GRADE?** Answer this prompt yes [Y] [R/S]

14 **PROFILE EL?** Input the SPRINGLINE elevation at the instrument station. If the instrument is at a station which is located within a vertical curve, input the elevation of the **SPRINGLINE tangent profile grade**. [R/S]

15 **GRADE?** Input the percent of grade. If negative, [CHS] [R/S]

16 **SPRINGLINE?** Answer this prompt YES [Y] [R/S]

17 **HEIGHT?** Input the height of the springline of the tunnel above the invert. This is the same as the difference in elevation between the springline and the invert [R/S]

18 **VERT CURVE?** If the grade is a straight slope, answer [N]. If there is a vertical curve OR grade break within the work area answer [Y]. [R/S]

THE NEXT THREE PROMPTS APPEAR IF THE ANSWER (above) WAS YES:

19 **BVC STA?** Input the beginning station of the vertical curve [R/S]

20 **LENGTH?** Input the length of the vertical curve. In the case of a grade-break instead of a vertical curve, input 0 [R/S]

21 **GRADE OUT?** Input the percent of grade leaving the vertical curve. If negative, [CHS] [R/S]

22 **INPUT SHOT** This is the prompt to begin input of the shot information. Input the horizontal angle [ENTER↑]

Input the vertical (zenith) angle [ENTER↑]

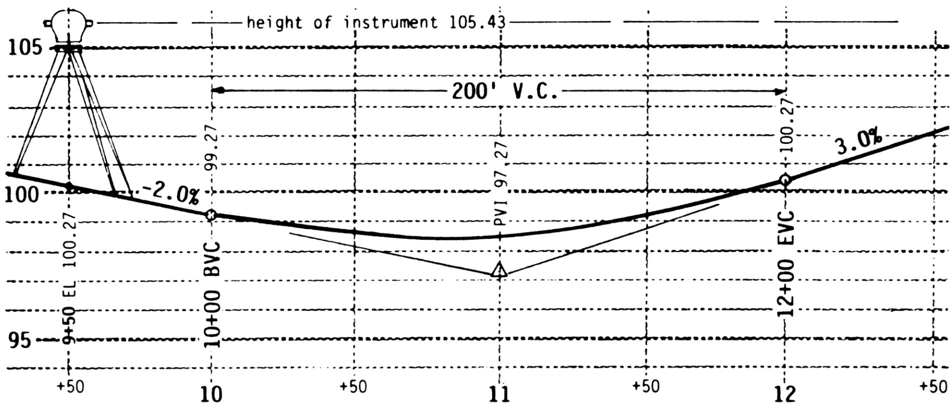
Input the measured slope distance [ENTER↑]

Input 0, since you are sighting directly to the zero end of the tape and there is no rod correction [A]

output will be the station, offset and elevation of the shot, followed by the invert grade at the station. If the shot is above springline, the radius at the shot will also be output, so that it may be compared to the design radius to determine whether the shot is 'tight' or not. Return to step 22 for the next shot.

For the keystroke example, we will use the dimensions of the tunnel shown in the section on page 56, and the profile information shown below. For the horizontal alignment, we'll use a centerline that has a curve to the right beginning at station 10+02.17, with the following curve data:

RADIUS = 1000.00', DELTA = 42°16'22", LENGTH = 737.80'



CENTERLINE PROFILE

Assume that the instrument is set up at station 9+50, backsighting 8+00, and that a rod shot at a nearby benchmark gives us an H.I. of 105.43. We want to do a tight-check in the vicinity between stations 9+50 and 10+50.

With the calculator sized at 045, program 'TT' in program memory, and the setup and backsight points known, begin the prompt sequence by stroking [XEQ] [ALPHA] [T] [T] [ALPHA]

prompt: **INST. STA.?**

keystrokes:

[9] [5] [0] [R/S]

prompt: **OFFSET?**

keystrokes:

[0] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **H.I. = ?**

keystrokes:

[1] [0] [5] [.] [4] [3] [R/S]

prompt: **BKSITE STA?**

keystrokes:

[8] [0] [0] [R/S]

prompt: **OFFSET?**

keystrokes:

[0] [R/S]

prompt: **ON CURVE?**

keystrokes:

[N] [R/S]

prompt: **CURVE AREA?**

keystrokes:

[Y] [R/S]

prompt: **B.C. STA?**

keystrokes:

[1] [0] [0] [2] [.] [1] [7] [R/S]

prompt: **RADIUS?**

keystrokes:

[1] [0] [0] [0] [R/S]

prompt: **DELTA?**

keystrokes:

[4] [2] [.] [1] [6] [2] [2] [R/S]

prompt: **SHOW GRADE?**

keystrokes:

[Y] [R/S]

prompt: **PROFILE EL?**

For tight-checking you will always use the SPRINGLINE elevation for input at this point. The invert profile grade at 9+50 is 100.27, and springline is 9' higher, so the grade to input is 109.27

keystrokes:

[1] [0] [9] [.] [2] [7] [R/S]

prompt: **GRADE?**

keystrokes:

[2] [CHS] [R/S]

prompt: **SPRINGLINE?**

keystrokes:

[Y] [R/S]

prompt: **HEIGHT?**

keystrokes:

[9] [R/S]

prompt: **VERT CURVE?**

keystrokes:

[Y] [R/S]

prompt: **BVC STA?**

keystrokes:

[1] [0] [0] [0] [R/S]

prompt: **LENGTH?**

keystrokes:

[2] [0] [0] [R/S]

prompt: **GRADE OUT?**

keystrokes:

[3] [R/S]

prompt: **INPUT SHOT**

We have the instrument set, backsighted and ready, and we have the calculator primed with the necessary information about the tunnel. The next step in a tight-check is to take shots at anything that looks like it sticks out more than the material around it. If it isn't tight, the area isn't.

Checking one spot, we get the following data:

Horizontal Angle = 168°34'15", Zenith Angle = 78°09'35",
Slope Distance = 33.5', Rod = 0

After input of these, following the 0 with [A] we get the output shown to the right, indicating that the point is tight by half a foot, since the radius should be 8'. The spot is marked with a dot of paint, and we begin taking shots around it, looking for the outline of "0" tight, so that we can paint it.

```
STA 9+82.14
AT 6.50 LT
ELEV = 112.30
GR = 99.63
  RAD. = 7.47
```

A second shot yields a radius of 8.17', so it is outside of the tight area, and the "0" point lies somewhere between the two shots. Since the difference is ±0.7', and our second shot is ±0.2' too far, the next shot is taken at about 2/7ths of the way back to the first shot. We get:

Horizontal Angle = 166°11'40", Zenith Angle = 77°29'30"
Slope Distance = 30.9' and the Rod = 0

keystrokes:

[1] [6] [6] [.] [1] [1] [4] [ENTER↑]

[7] [7] [.] [2] [9] [3] [ENTER↑]

[3] [0] [.] [9] [ENTER↑]

[0] [A]

output:

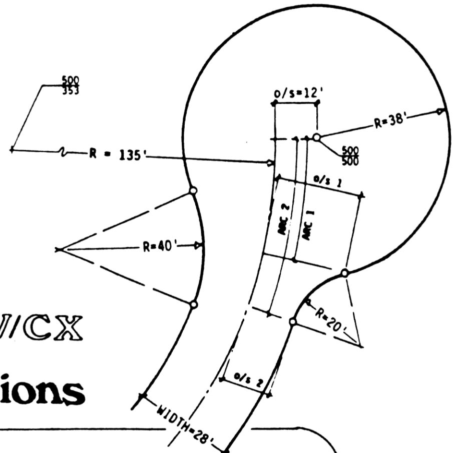
```
STA 9+79.30
AT 7.20 LT
ELEV = 112.12
GR = 99.68
   RAD. = 7.98
```

The keystrokes to the left are typical for input of any of the shots which are taken for locating tights.

Additional shots, with their stack-print input, which are relative to this particular area are shown below. When the shots are taken on the rib, the distance left or right of the centerline (the offset distance) is used to determine whether or not the area is tight.

In common practice the whole perimeter of the tight area is painted, like a contour line of "0" tight, and at least one or two spots on the tight are painted to show the depth of material to be removed. It is generally better to paint a little "loose", that is, a little more than necessary, to insure that the whole tight is removed in one shot.

T= 170.2910	T= 166.2115	T= 167.3740	T= 163.5210	T= 162.2645
Z= 75.1820	Z= 87.4015	Z= 80.3155	Z= 90.2710	Z= 79.2500
Y= 35.5000	Y= 34.2000	Y= 35.9000	Y= 28.9000	Y= 26.8000
X= 0.0000	X= 0.0000	X= 0.0000	X= 0.0000	X= 0.0000
STA 9+83.87	STA 9+83.21	STA 9+84.59	STA 9+77.76	STA 9+75.12
AT 5.68 LT	AT 8.06 LT	AT 7.59 LT	AT 8.03 LT	AT 7.95 LT
ELEV = 114.44	ELEV = 106.82	ELEV = 111.34	ELEV = 105.20	ELEV = 110.35
GR = 99.59	GR = 99.61	GR = 99.58	GR = 99.71	GR = 99.77
RAD. = 8.15		RAD. = 8.08		RAD. = 8.11



HP-41CV/CX

Geometrics Solutions

prompts — keystrokes — output

prompts	keystrokes
	[XEQ] [ALPHA] [C] [D] [C] [ALPHA]
LAYOUT?	[N] [R/S]
SHOW COORDS?	[Y] [R/S]
INTER-X N↑E	[5] [0] [0] [ENTER↑]
	[5] [0] [0] [R/S]
RADIUS N↑E	[5] [0] [0] [ENTER↑]
	[3] [5] [3] [R/S]
RADII?	[1] [3] [5] [CHS] [ENTER↑]
	[2] [0] [ENTER↑]
	[3] [8] [ENTER↑]
	[4] [0] [R/S]
WIDTH?	[2] [8] [R/S]
OFFSET?	[1] [2] [R/S]

output	output
R = 20.000	R = 40.000
DELTA =	DELTA =
58° 14' 58.7"	44° 48' 49.5"
L = 20.333	L = 31.286
T = 11.143	T = 16.492
CH = 19.469	CH = 30.495
ARC 1= 31.758	ARC 1= 17.689
O/S 1= 24.386	O/S 1= 22.049
N= 462.8507	N= 485.2423
E= 507.9958	E= 464.9827
RADIUS POINT:	RADIUS POINT:
N= 443.2985	N= 469.7078
E= 512.2041	E= 428.1224
N= 450.0087	N= 454.7487
E= 493.3634	E= 465.2200
ARC 2= 46.190	ARC 2= 51.745
O/S 2= 14.000	O/S 2= 14.000
R = 38.0000	
DELTA =	
280° 42' 21.3"	
L = 186.171	

EXAMPLE ONE
solving for coordinates and curve data

Software by D'Zign

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[415] 355·8942

prompts — **keystrokes** — **output**

prompts	keystrokes
	[XEQ] [ALPHA] [C] [D] [C] [ALPHA]
LAYOUT?	[Y] [R/S]
HUB OFFSET?	[3] [R/S]
MAX SPG?	[1] [2] [R/S]
SHOW COORDS?	[N] [R/S]
INTER-X N↑E	[5] [0] [0] [ENTER↑]
	[5] [0] [0] [R/S]
BACKSITE N↑E	[1] [0] [0] [ENTER↑]
	[2] [0] [0] [R/S]
RADIUS N↑E	[5] [0] [0] [ENTER↑]
	[3] [5] [3] [R/S]
RADII?	[1] [3] [5] [CHS] [ENTER↑]
	[2] [0] [ENTER↑]
	[3] [8] [ENTER↑]
	[4] [0] [R/S]
WIDTH?	[2] [8] [R/S]
OFFSET?	[1] [2] [R/S]

output

```
R = 20.0000              R = 40.00
DELTA =                  DELTA =
 58° 14' 58.7"            44° 48' 49.5"
L = 20.333               L = 31.286
T = 11.143               T = 16.492
CH = 19.469              CH = 30.495

ARC 1= 31.758            ARC 1= 17.689
O/S 1= 24.386            O/S 1= 22.049

HD = 41.000              HD = 41.000
∠RT=                     ∠RT=
 310° 59' 0.3"            30° 16' 39.0"

RADIUS POINT:            RADIUS POINT:
HD = 50.000              HD = 70.000
∠RT=                     ∠RT=
 310° 59' 0.3"            30° 16' 39.0"

1/2                      1/3
HD = 69.486              HD = 49.934
∠RT=                     ∠RT=
 322° 18' 48.3"           8° 0' 9.7"

HD = 51.140              2/3
∠RT=                     HD = 43.588
 327° 24' 11.8"          ∠RT=
                          16° 53' 21.6"
ARC 2= 46.190
O/S 2= 14.000            HD = 57.951
                         ∠RT=
                          3° 32' 2.8"
R = 38.0000
DELTA =                  ARC 2= 51.745
 280° 42' 21.3"          O/S 2= 14.000
L = 186.171
   (16.75)
```

EXAMPLE TWO
solution for radial field layout

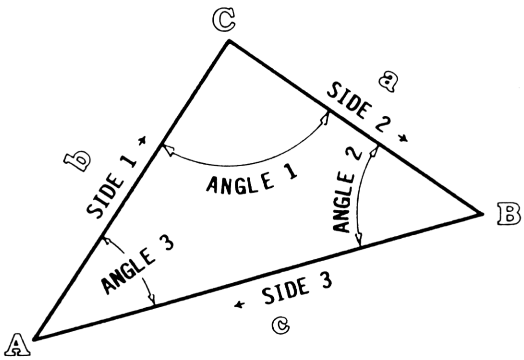
notes

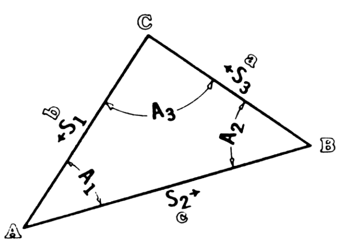
Triangle Solutions

This program solves triangles when three parts are known, including two solution routines where one of the known parts is the area. When the printer is attached the output is designed to indicate which parts of the triangle were input as known, and which are calculated.

The program does not use a standard 'textbook' notation for the angles and sides (**a** opposite **A**, **b** opposite **B** and **c** opposite **C**), but instead starts with any side being called "**side 1**" and goes around the triangle.

The next part is **angle 1**, then **side 2**, followed by **angle 2**, **side 3** and **angle 3**.





Side 1 may be assigned to any side that is convenient to use, depending upon the available information about the triangle. It should be located at a side where the known information then falls into position for solution by one of the routines.

The example triangle (above) shows this style of labeling, compared to the standard notation for sides and angles. In the example, the assigned designations go clockwise. If it better fits the information available, it can go counter-clockwise instead, as shown to the left.

There are seven types of solution available within the program, and each is identified in terms of which parts are already known. For example, the solution for a triangle with three known sides is identified as **S-1, S-2, S-3**. This is also the order in which the parts are input.

The calculator should be sized at 030, and the program "**TR**" must be in the program memory. If used with a printer attached, the program memory must also contain the utility program "**DMS**". Initialize the program by keystroking

[XEQ] [ALPHA] [T] [R] [ALPHA]

Follow the keystrokes shown with each solution type. It is not necessary to restart the program each time, for solution of additional triangles; simply begin the keystrokes for the next problem.

S-1, S-2, S-3

THREE SIDES KNOWN

1 Input side one

[ENTER↑]

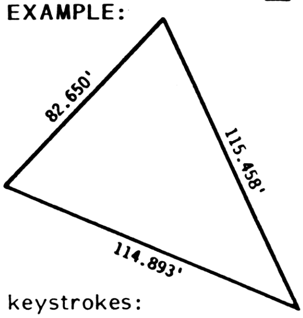
2 Input side two

[ENTER↑]

3 Input side three

[A]

EXAMPLE:



keystrokes:

[8] [2] [.] [6] [5]

[ENTER↑]

[1] [1] [5] [.] [4] [5] [8]

[ENTER↑]

[1] [1] [4] [.] [8] [9] [3]

[A]

output:

```
S-1 = 82.650
a-1 =
 68° 36' 29.9"

S-2 = 115.458
a-2 =
 42° 3' 7.8"

S-3 = 114.893
a-3 =
 69° 20' 22.3"

area = 4,442.601
```

A-3, S-1, A-1

TWO ANGLES AND THE INCLUDED SIDE

1 Input angle three

[ENTER↑]

2 Input side one

[ENTER↑]

3 Input angle one

[B]

EXAMPLE:

keystrokes:

[6] [9] [.] [2] [0] [2] [2]

[ENTER↑]

[8] [2] [.] [6] [5]

[ENTER↑]

[6] [8] [.] [3] [6] [3]

[B]

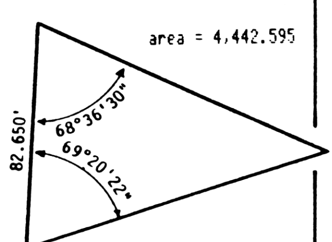
output:

```
S-1 = 82.650
A-1 =
 68° 36' 30.0"

s-2 = 115.458
a-2 =
 42° 3' 8.0"

s-3 = 114.893
A-3 =
 69° 20' 22.0"

area = 4,442.595
```



S-1, A-1, A-2

ONE SIDE AND THE TWO FOLLOWING ANGLES

1 Input side one

[ENTER↑]

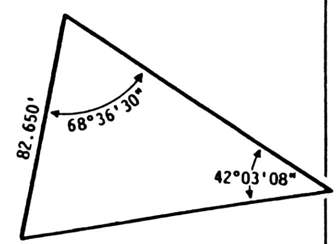
2 Input angle one

[ENTER↑]

3 input angle two

[C]

EXAMPLE:



keystrokes:

[8] [2] [.] [6] [5]

[ENTER↑]

[6] [8] [.] [3] [6] [3]

[ENTER↑]

[4] [2] [.] [0] [3] [0] [8]

[C]

output:

```
S-1 = 82.650
A-1 =
 68° 36' 30.0"

s-2 = 115.458
A-2 =
 42° 3' 8.0"

s-3 = 114.893
a-3 =
 69° 20' 22.0"

area = 4,442.595
```

Triangle Solutions

S-1, A-1, S-2

TWO SIDES AND
THE INCLUDED ANGLE

1 Input side one

ENTER↑

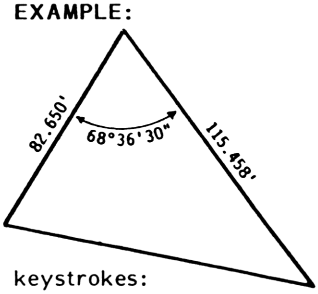
2 input angle one

ENTER↑

3 input side two

D

EXAMPLE:



keystrokes:

8 2 . 6 5

ENTER↑

6 8 . 3 6 3

ENTER↑

1 1 5 . 4 5 8

D

output:

```
S-1 = 82.650
A-1 =
 68° 36' 30.0"

S-2 = 115.458
a-2 =
 42° 3' 7.8"

s-3 = 114.893
a-3 =
 69° 20' 22.2"

area = 4,442.601
```

S-1, S-2, A-2

TWO SIDES AND
THE FOLLOWING ANGLE

1 Input side one

ENTER↑

2 Input side two

ENTER↑

3 Input angle two

E

EXAMPLE:

keystrokes:

8 2 . 6 5

ENTER↑

1 1 5 . 4 5 8

ENTER↑

4 2 . 0 3 0 8

E

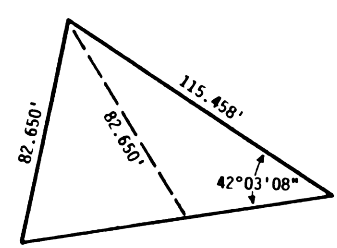
There are two possible solutions for a triangle with this configuration of known parts, and both solutions are output when this routine is used.

NOTE: The output for the first solution shows the correct input information (caps, lower case), but the second solution has been transposed, and the angle which was originally input will not be indicated.

With the above exception, all triangle solutions output indicate which parts were input (by printing in capitals) and which were calculated (printed in lower case letters)

output:

first solution:	second solution
S-1 = 82.650	S-1 = 115.458
a-1 =	a-1 =
68° 36' 29.2"	42° 3' 8.0"
S-2 = 115.458	s-2 = 56.570
A-2 =	a-2 =
42° 3' 8.0"	110° 39' 37.2"
s-3 = 114.893	S-3 = 82.650
a-3 =	a-3 =
69° 20' 22.8"	27° 17' 14.8"
area = 4,442.595	area = 2,187.426



AREA, S-1, A-1

THE AREA, ONE SIDE, AND THE ADJACENT ANGLE KNOWN

1 Input the area (Sq. Ft.)

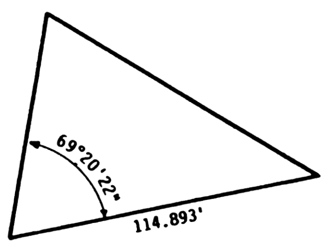
[ENTER↑]

2 Input side one

[ENTER↑]

3 Input angle one

[F]



AREA = 4,442.601□'

EXAMPLE:
keystrokes:

[4] [4] [4] [2] [.] [6] [0] [1]
[ENTER↑]
[1] [1] [4] [.] [8] [9] [3]
[ENTER↑]
[6] [9] [.] [2] [0] [2] [2]
[F]

output:

S-1 = 114.893
A-1 =
69° 20' 22.0"

s-2 = 82.650
a-2 =
68° 36' 30.0"

s-3 = 115.458
a-3 =
42° 3' 8.0"

AREA = 4,442.601

AREA, S-1, S-2

THE AREA AND TWO SIDES KNOWN

1 Input area (Sq. Ft.)

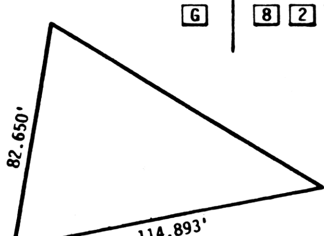
[ENTER↑]

2 Input side one

[ENTER↑]

3 Input side two

[G]



AREA = 4,442.601□'

EXAMPLE:
keystrokes:

[4] [4] [4] [2] [.] [6] [0] [1]
[ENTER↑]
[1] [1] [4] [.] [8] [9] [3]
[ENTER↑]
[8] [2] [.] [6] [5] [0]
[G]

output:

S-1 = 114.893
a-1 =
69° 20' 22.3"

S-2 = 82.650
a-2 =
68° 36' 29.9"

s-3 = 115.458
a-3 =
42° 3' 7.8"

AREA = 4,442.601

Program Listings

The following pages contain the program steps which must be keyed into the calculator in order for the programs to function properly. Since this book has been written with the intention of providing help in the calculations needed for surveying, it is important that the programs provide correct answers when used.

For those users who have card readers, **D'Zign** provides a card-programming service. We will program your cards for you and return them in a labeled card holder which can be inserted directly into the book. The cost for the service is $8.50, and you provide the blank cards.

To take advantage of this option, send 20 blank magnetic cards and your check for $8.50 to **D'Zign land survey & development**, P.O. Box 1370, Pacifica, CA 94044.

KEYING IN A PROGRAM

1. Before beginning to key the program steps into the calculator, keystroke [shift] [GTO] [·] [·] to prepare the calculator for the new program. Set the calculator to **program mode** by pressing the [PRGM] key.

2. Labels are marked with a diamond (♦) in the program listings, as a visual aid. When keying in the program ignore the diamond, and key in **LBL** by keystroking [shift] [LBL] (the STO button), followed by either the label number or [ALPHA] the label name [ALPHA] .

3. Symbols or characters shown with quote marks indicate that they are **alpha** characters, and must be input as program steps in **alpha mode**.

4. Functions which do not appear on the keyboard may be keyed into the program by stroking [ALPHA], spelling out the function, and again stroking [ALPHA]. Some of the functions, such as **FC?01** must be input partly in alpha. Stroke [ALPHA] [F] [C] [?] ; again stroke [ALPHA], and the display will prompt **FC?_ _**, at which time you stroke the **01**. The character * in the listing is the [X] (multiply) button, and the character printed as / is the divide button.

UTILITY PROGRAMS

These are programs which are used as sub-routines by the other programs. For the main programs to function properly these sub-routines must also be in program memory while the other programs are running, as noted below.

```
01♦LBL "STA"
02 CF 29
03 FIX 0
04 CLA
05 STO 27
06 1 E2
07 /
08 ENTER↑
09 INT
10 ARCL X
11 -
12 "⊢+"
13 FIX 3
14 1 E2
15 *
16 10
17 X>Y?
18 "⊢0"
19 ARCL Y
20 RCL 27
21 AVIEW
22 SF 29
23 FIX 4
24 RTN
25 END
```

"**STA**" is a short program that changes the number in the x-register to stationing (in the form XX+XX.xxx) when called up by the other programs. The listing for this program, shown to the left, contains 24 steps.

The two programs shown on the opposite page are also called up by the different main programs as they are working, and should be in program memory, except under the following conditions:

"**AZ**" need not be input if the calculator contains either the Hewlett-Packard Surveying Pac or the D'Zign "COGO 41" module. A similar routine by the same name is already contained in both of these ROMS.

"**DMS**" must be in the calculator memory **if the calculator is used with a printer attached.** It is not necessary when no printer is used. It changes the number in the x-register to the printed form DDD°MM'SS" when called during output of solutions. Other than input by the use of a card reader, this routine CANNOT BE PUT INTO MEMORY UNLESS A PRINTER IS ATTACHED WHILE PROGRAMMING.

Some variations of "**DMS**" are shown in the appendix, one of which can be used without a printer, and groups the output into the form DDD MM SS in the display. The other version does both, but again, cannot be input into the calculator unless a printer is attached while programming.

All of these utility routines may be called up by programs which you write yourself by including steps which execute them as part of your program. Use of some of the other subroutines contained in the appendix may also enhance some of your own programming.

A card containing the utility programs is included in the set of cards available through the card-programming service from D'Zign, using the versions of the routines which are shown here.

```
01♦LBL "AZ"
02 "BRG=?"
03 PROMPT
04 "QD=?"
05 PROMPT
06 X<>Y
07 HR
08 X<>Y
09 ENTER↑
10 ENTER↑
11 2
12 /
13 INT
14 PI
15 R-D
16 *
17 X<>Y
18 LASTX
19 *
20 COS
21 R↑
22 *
23 -
24 FS? 10
25 RTN
26 HMS
27 RTN
```

```
01♦LBL "DMS"
02 STO 23
03 RDN
04 STO 24
05 RDN
06 STO 25
07 RDN
08 STO 26
09 RDN
10 ENTER↑
11 INT
12 CF 29
13 FIX 0
14 ACX
15 -
16 100
17 *
18 ABS
19 STO 22
20 3
21 SKPCOL
22 6
23 ACCOL
24 9
25 ACCOL
26 ACCOL
27 6
28 ACCOL
29 2
30 SKPCOL
31 RCL 22
32 INT
33 ACX
34 39
35 ACCHR
36 RCL 22
37 FRC
38 100
39 *
40 FIX 1
41 ACX
42 34
43 ACCHR
44 PRBUF
45 RCL 26
46 RCL 25
47 RCL 24
48 RCL 23
49 FIX 4
50 SF 29
51 RTN
52 END
```

LO

LO occupies 114 registers of program memory and should be used with the calculator sized to at least 030. The program contains 801 bytes of programming, and may be stored on 8 tracks of magnetic cards.

Subroutines used with this program are "**STA**" and "**AZ**", both of which are contained in the UTILITY program group. If the calculator is used with a printer attached, the subroutine "**DMS**" must also be in the program memory. "**AZ**" is contained in the HP Surveying Pac and a version of this subroutine is also contained in the D'Zign module "COGO 41". If either of these modules are in the calculator, it is not necessary to enter "**AZ**" again as a subroutine.

```
01♦LBL "LO"       INITIALIZE PROGRAM, SET
02 CLRG           FLAG STATUS
03 CF 00
04 CF 01
05 CF 06
06 CF 07
07 CF 09
08 CF 11
09 CF 02
10 CF 08
11 CF 05
12 CF 10
13 SF 03
14 SF 21
15 SF 04
16 FIX 4
17 CLX
18 RTN
19♦LBL 01         SET REGISTERS FOR ALPHA
20 "Y"            RESPONSE STATUS
21 ASTO X
22 AON
23 "INV. ONLY?"   INVERSE ONLY TO
24 PROMPT         COORDINATES INPUT, OR
25 ASTO Y         WILL ALIGNMENT COORDS
                  BE CALCULATED FOR INV?
26 AOFF
27 X=Y?
28 SF 06          CONTROLS PROMPTS FOR
29 FS? 06         INVERSE ONLY ROUTINE
30 GTO 17
31 "Y"
32 ASTO X
33 AON
34 "STA INV?"
35 PROMPT
36 ASTO Y
37 AOFF
38 X=Y?           INCLUDE CENTERLINE IN
39 CF 04          INVERSE CALCS?
40 RTN
41♦LBL 06
42 FS? 09
43 RTN
44 RCL 02
45 RTN
46♦LBL C          INVERSE ROUTINE FOR USE
47 STO 06         WHEN THE COORDINATES OF
48 RDN            THE BACKSITE ARE KNOWN
49 STO 05
50 "BACKSITE?"
```

```
51 PROMPT
52 RCL 06
53 -
54 X<>Y
55 RCL 05
56 -
57 R-P
58 CLX
59 X<>Y          CALCULATE BACK AZIMUTH
60 X<0?          FOR INVERSE ROUTINE
61 360
62 +
63 HMS
64 STO 01
65 SF 07
66 XEQ 01
67 GTO D
68♦LBL B
69 STO 06
70 RDN
71 STO 05        INVERSE ROUTINE WITH
72 XEQ "AZ"      BACKSIGHT BEARING KNOWN
73 STO 01
74 SF 07
75 XEQ 01
76♦LBL D        ALIGNMENT ROUTINE INPUT
77 "BEG. STA?"
78 PROMPT
79 STO 03
80 "COORD. N↑E"
81 PROMPT
82 STO 08        BEGINNING COORDINATES
83 RDN           STORED
84 STO 07
85 XEQ "AZ"      CONVERT TANGENT BEARING
86 STO 00        TO AZIMUTH AND STORE
87 "Y"
88 ASTO X
89 AON
90 "STA COORDS?"
```

```
91 PROMPT        ARE THE COORDINATES OF
92 ASTO Y        THE CENTERLINE POINTS
93 AOFF          WANTED?
94 X=Y?
95 CF 03
96 "STA?"
97 PROMPT
98♦LBL E        CALCULATE COORDINATES
99 STO 20        FOR STATION SHOWN BY
100 FS? 08       INPUT
101 GTO 02
102♦LBL 10
103 FS? 07
104 SF 11
105 FS? 04
106 CF 11
107 CF 05
108 ADV
109 XEQ "STA"    OUTPUT IN FORM XXX+XX.X
110 FIX 4
111 RCL 03
112 -
113 RCL 00
114 HR
115 X<>Y
116 P-R
117 RCL 07
118 +
119 X<>Y
120 RCL 08
121 +
122 FS? 03
123 GTO 04
124 XEQ 98       OUTPUT COORDINATES
125♦LBL 04
126 FC? 03
127 ADV
128 STO 10
129 X<>Y
130 STO 09
```

```
131 X<>Y
132 FS? 04
133 GTO 03
134 FS? 07
135 XEQ A          CALCULATES INVERSE TO
136♦LBL 03         COORDINATES IN X & Y
137 RCL 00         REGISTERS
138 HR
139 90
140 FS? 05
141 CHS
142 +
143 FS? 09
144 STO 17
145 "O/S?"
146 FS? 09
147 "R?"
148 FC? 01
149 GTO 17
150 FS? 09
151 GTO 17
152♦LBL 18
153 FS? 09
154 STO 04
155 FS? 01
156 XEQ 06         CONSTANT OFFSET BEING
157 "O/S= "        USED
158 FS? 09         LABLE OFFSET OR RADIUS
159 "R = "
160 ARCL X
161 AVIEW
162 P-R
163 RCL 09
164 +
165 FS? 09
166 STO 09
167 X<>Y
168 RCL 10
169 +
170 FS? 09
171 STO 10
172 XEQ 98         OUTPUT OF COORDINATES
173 ADV
174 FS? 09
175 RTN
176 FS? 07
177 XEQ A
178 FS? 01
179 GTO 16
180 GTO 03
181 RTN
182♦LBL 17
183 FS? 06
184 "N↑  E"        INPUT KNOWN COORDINATES
185 PROMPT         FOR SOLUTION
186 GTO 18
187 RTN
188♦LBL F
189 SF 01
190 STO 02
191 GTO 03
192 RTN
193♦LBL A
194 FS? 06
195 ADV
196 FS? 06
197 XEQ 98
198 FS? 06
199 ADV
200 RCL 06
201 -
202 X<>Y
203 RCL 05
204 -
205 R-P
206 FIX 3
207 "HD = "        OUTPUT OF THE INVERSED
208 ARCL X         DISTANCE
209 AVIEW
210 CLX
```

```
211 X<>Y
212 X<0?          CALCULATE   HORIZONTAL
213 360           ANGLE TO STATION OR
214 +             POINT
215 STO 11
216 ENTER↑
217 ENTER↑
218 90
219 /
220 1
221 +
222 INT
223 STO 12
224 2
225 /
226 INT
227 180
228 *
229 -
230 ABS
231 HMS
232 FIX 4
233 RCL 12
234 RCL 11
235 RCL 01
236 HR
237 -
238 ENTER↑
239 CLX
240 X<>Y
241 X<0?
242 360
243 +
244 HMS
245 "∡RT="         OUTPUT HORIZONTAL ANGLE
246 FC? 55
247 ARCL X
248 AVIEW
249 FS? 55
250 XEQ "DMS"      ANGLE TO DD°MM'SS" FORM
251 ADV
252 FS?C 11
253 GTO 03
254 FS? 08
255 GTO 12
256 FS? 01
257 GTO 16
258 GTO 03
259 RTN
260♦LBL J         SIGNALS  BEGINNING  OF
261 SF 09         CURVE  IN  THE  ALIGNMENT
262 ADV
263 RCL 20
264 STO 15
265 "DELTA?"      CENTRAL  ANGLE  OF  CURVE
266 PROMPT
267 STO 14
268 X<0?
269 SF 05         SET IF CURVE IS TO LEFT
270 XEQ 03
271 RCL 14
272 RCL 00
273 HMS+
274 0
275 X<>Y
276 X<0?
277 360
278 HMS+
279 STO 00
280 RCL 14
281 "DELTA ="     OUTPUT   CENTRAL   ANGLE
282 FC? 55
283 ARCL X
284 AVIEW
285 FS? 55
286 XEQ "DMS"
287 HR
288 ABS
289 RCL 04
290 *             CALCULATE   CURVE   DATA
```

```
291 PI
292 *
293 180
294 /
295 STO 18
296 RCL 15
297 +
298 STO 16
299 RCL 14
300 HR
301 RCL 18
302 /                CALCULATE ℓ = L/Δ
303 STO 19
304 RCL 16
305 "EC ="           END OF CURVE STATION
306 AVIEW
307 XEQ "STA"        PRINT AS XX+XX.xxx
308 FIX 4
309 RCL 17
310 180
311 -
312 RCL 14           CALCULATE RADIAL FROM
313 HR               RADIUS POINT FOR OFFSET
314 +                CALCULATION IN CURVE
315 0
316 X<>Y
317 X<0?
318 360
319 +
320 RCL 04
321 P-R
322 RCL 09
323 +
324 STO 07
325 X<>Y
326 RCL 10
327 +
328 STO 08
329 CF 09
330 SF 08
331 RCL 16
332 STO 03
333 GTO 16
334 RTN
335♦LBL 15          OUTPUT OF COORDINATES
336 CF 00
337 "N= "
338 ARCL Y
339 FC? 03
340 AVIEW
341 "E= "
342 ARCL X
343 FC? 03
344 AVIEW
345 ADV
346 FC? 07
347 GTO 12
348 FC? 04
349 XEQ A
350 GTO 12
351♦LBL 02          ENDING LOOP FOR FIXED
352 RCL 20           OFF SET INPUT ON CURVES
353 RCL 03
354 X<=Y?
355 CF 08
356 RDN
357 FC? 08
358 GTO 10
359 SF 00
360 ADV
361 XEQ "STA"
362 FIX 4
363 RCL 15
364 -
365 RCL 19
366 *
367 RCL 17
368 180
369 -
370 +
```

```
371 0
372 X<>Y
373 X<Y?
374 360
375 +
376 STO 21
377 RCL 04
378 FC? 00
379 GTO 12
380•LBL 13        SUBROUTINE TO 02 and 12
381 P-R           ROUTINES
382 RCL 09
383 +
384 X<>Y
385 RCL 10
386 +
387 FS? 00
388 GTO 15
389 XEQ 98
390 ADV
391 FS? 07
392 XEQ A
393•LBL 12
394 FS? 02
395 GTO 16
396 FS? 01        CURVED ALIGNMENT AREA
397 SF 02         SUBROUTINE
398 RCL 21
399 "O/S?"
400 FC? 01
401 PROMPT
402 FS? 01
403 RCL 02
404 "O/S= "
405 ARCL X
406 AVIEW
407 FC? 05
408 CHS
409 RCL 04
410 +
411 XEQ 13
412 GTO 12
413 RTN
414•LBL 16
415 CF 02
416 "STA?"
417 PROMPT
418 RTN
419•LBL 98        OUTPUT COORDINATES
420 "N= "
421 ARCL Y
422 AVIEW
423 "E= "
424 ARCL X
425 AVIEW
426 RTN
```

notes

SP

SP occupies 189 registers of program memory and should be used with the calculator sized to at least 050. The program contains 1327 bytes of programming, and may be stored on 12 tracks of magnetic cards.

Subroutines used with this program are "**STA**" and "**AZ**", both of which are contained in the UTILITY program group. If the calculator is used with a printer attached, the subroutine "**DMS**" must also be in the program memory. "**AZ**" is contained in the HP Surveying Pac and a version of this subroutine is also contained in the D'Zign module "COGO 41". If either of these modules are in the calculator, it is not necessary to enter "**AZ**" again as a subroutine.

```
01♦LBL "SP"        INITIALIZE AND CLEAR
02 CF 02
03 SF 21
04 SF 27
05 CLRG
06 FIX 4
07 CF 01
08 3               STORE SPIRAL CONSTANTS
09 STO 11
10 -10
11 STO 12
12 -42
13 STO 13
14 216
15 STO 14
16 1320
17 STO 15
18 -9360
19 STO 16
20 -75600
21 STO 17
22 685440
23 STO 18
24 6894720
25 STO 19
26 CF 22           RESET STATUS OF FLAGS
27 CF 03
28 CF 14
29 CF 15
30 CF 05
31 CF 06
32 CF 07
33 CF 08
34 CF 09
35 XEQ 21
36 FS? 05
37 XEQ 22
38 FS? 03
39 XEQ 17
40♦LBL 01          INPUT OF SPIRAL DATA
41 "PI STATION?"
42 PROMPT          P.I. STATION
43 STO 06
44 "DELTA?"
45 PROMPT          CENTRAL ANGLE
46 X<0?
47 XEQ 30          IS CURVE TO THE LEFT?
48 HR
49 2
50 /
```

```
51 STO 05       TΔ/2
52 CF 01
53 "R?"
54 PROMPT
55 CF 04
56 STO 20
57 "L=?"
58 PROMPT
59 STO 40
60 ENTER↑
61 ST+ 02
62 RCL 20
63 /
64 2
65 /
66 STO 00       θ (RADIANS)
67 R-D
68 STO 41       θ (DEGREES)
69 HMS
70 1 E2
71 RCL 20       RADIUS
72 /
73 R-D
74 HMS
75 CLA          OUTPUT OF SPIRAL DATA
76 RCL 20
77 RDN
78 RDN
79 "L = "
80 ARCL Y
81 AVIEW        LENGTH
82 "S∡ = "
83 FC? 55
84 ARCL X
85 AVIEW
86 FS? 55
87 XEQ "DMS"    SPIRAL ANGLE
88 "R = "
89 ARCL Z
90 AVIEW        RADIUS
91 CLD
92 ADV
93 FS? 01
94 GTO 15
95 0
96 STO 01       T.S., S.T.
97 RCL 40
98 STO 02       Ls
99 XEQ 09       TO SOLUTION LOOP
100 RCL 41
101 RCL 20
102 P-R
103 RDN
104 -
105 RDN
106 +
107 RCL 05
108 TAN
109 *
110 R↑
111 +
112 STO 42      T.S., TOTAL TAN. LENGTH
113 RCL 06
114 X<>Y
115 -
116 STO 01      T.S., S.T.
117 ST+ 02
118 RCL 05      TΔ/2
119 RCL 41      θ
120 -
121 2
122 *
123 STO 21      Δ
124 D-R
125 RCL 20
126 *
127 RCL 40
128 2
129 *
130 +
```

```
131 +
132 STO 07          S.T. STATION
133 RCL 06
134 RCL 01
135 0
136 RDN
137 CLA
138 "PI = "
139 AVIEW           OUTPUT P.I. STATION
140 RDN
141 XEQ "STA"       OUTPUT IN FORM XX+XX.xx
142 CLA
143 FIX 4
144 "CENTRAL ∠ ="
145 AVIEW           OUTPUT CENTRAL DELTA
146 RCL 05
147 2
148 *
149 HMS
150 CLA
151 ARCL X
152 FS? 55
153 XEQ "DMS"       OUTPUT AS DD°MM'SS" IF
154 FC? 55          PRINTER ATTACHED
155 AVIEW
156 CLD
157♦LBL 15         COMPUTES T.S., S.P.I.
158 XEQ 09          & S.C. STATIONS
159 X<>Y
160 RCL 41
161 TAN
162 /
163 -
164 FS? 02          IS THIS AN EXIT SPIRAL?
165 CHS
166 STO 42
167 0
168 RCL 01
169 RCL 40
170 +               S.C. = S.T. + Ls
```

```
171 STO 03
172 RCL 01
173 RCL 42
174 +
175 RCL 01
176 ADV
177 "TS ="          OUTPUT ENTRANCE SPIRAL
178 FS? 02          BEGIN AND END STATIONS
179 "ST ="                    or
180 AVIEW           OUTPUT THE EXIT SPIRAL
181 RCL 01          BEGIN AND END STATIONS
182 XEQ "STA"
183 CLA
184 "SC ="
185 FS? 02
186 "CS ="
187 AVIEW
188 RCL 03
189 XEQ "STA"
190 ADV
191 "STA?"          PROMPT FOR INPUT OF THE
192 PROMPT          NEW STATION FOR WHICH
193♦LBL D          A SOLUTION IS WANTED
194 SF 08           SWITCH TO EXIT SPIRAL
195 CLA
196 FS? 05
197 XEQ 22
198♦LBL 18
199 RCL 07
200 RCL 01
201 STO 07
202 X<>Y
203 STO 01
204 RCL 40
205 CHS
206 STO 40
207 +
208 STO 02
209 SF 02
210 GTO 15
```

```
211♦LBL E       SET SOLUTION STATION
212 STO 02
213 CF 01
214 ADV
215♦LBL 19      COMPUTE FIELD DATA FOR
216 SF 04       SOLUTION STATION
217 RCL 02
218 -
219 FS?C 22
220 GTO 00      END OF SPIRAL
221 RCL 04
222 CF 02
223 X<0?
224 SF 02       NEGATIVE INTERVAL TO
225 ABS         THE STATION REQUESTED
226 RCL 03
227 RCL 02
228 -
229 ABS
230 X<=Y?
231 GTO 00      END OF SPIRAL
232 X<>Y
233 GTO 07
234♦LBL 00      STOP
235 SF 00
236♦LBL 07
237 FS?C 02     EXIT SPIRAL?
238 CHS
239 ST+ 02
240 RCL 02
241 RCL 01
242 -
243 RCL 40
244 /
245 X↑2
246 RCL 41
247 D-R
248 *
249 STO 00
250 XEQ 09      SPIRAL SOLUTION LOOP
```

```
251 FS? 01
252 GTO 04      SOLUTION FOR DEFLECTION
253 R-P         ANGLE AND CHORD
254 X<>Y
255 HMS
256♦LBL 04
257 FIX 3
258 RCL 02
259 0
260 RDN
261 STO 27
262 RDN
263 STO 30
264 RDN
265 STO 31
266 RDN
267 STO 32
268 RDN
269 FS? 55
270 XEQ "STA"    OUTPUT SOLUTION STATION
271 RCL 32
272 RCL 31
273 RCL 30
274 RCL 27
275 FIX 3
276 "CD = "     OUTPUT LONG CHORD
277 ARCL Z
278 FS? 14
279 AVIEW       OUTPUT DEFLECTION ANGLE
280 RDN
281 FIX 4
282 "DEFLECTION ∠="
283 FS? 14
284 AVIEW
285 FS? 14
286 XEQ 03
287 CHS
288 RCL 00      θ(RADIANS)
289 R-D
290 HMS
```

```
291 HMS+
292 90
293 HMS+
294 "RADIAL ∡ ="
295 FS? 14          OUTPUT RADIAL ANGLE TO
296 AVIEW           TURN AT SOLVED STATION
297 FS? 14
298 XEQ 83
299 HR
300 STO 38
301 FC? 03
302 ADV
303 CLD
304 FS? 05
305 GTO 23
306 FS? 03
307 GTO 23
308 "STA?"
309 FS? 14
310 PROMPT
311 FS?C 00
312 GTO 19
313♦LBL 09        COMPUTE Y AND X VALUES
314 CF 22
315 9
316 STO 43
317 0
318 STO 08
319 STO 09
320♦LBL 02
321 RCL 00          LOOPING POINT
322 RCL 43
323 Y↑X
324 10
325 ST+ 43
326 CLX
327 RDN
328 RCL IND 43      LOOPING CONTROL REG.
329 /
330 10
331 ST- 43
332 CLX
333 RDN
334 RCL 08
335 RCL 09
336 STO 08
337 RDN
338 +
339 STO 09
340 DSE 43
341 GTO 02
342 RCL 09
343 RCL 02
344 RCL 01
345 -
346 ABS
347 *
348 LASTX           x
349 RCL 08
350 1
351 +
352 *               y
353 RTN
354♦LBL 83        SET UP FOR THE TYPE OF
355 CLA             SOLUTION REQUESTED
356 FS? 55
357 XEQ "DMS"
358 ARCL X
359 FC? 55
360 AVIEW
361 RTN
362♦LBL 21
363 "Y"
364 ASTO X
365 AON
366 "COORD-O/S?"    COORDINATE SOLUTION
367 PROMPT          WITH OFFSET OPTIONS
368 ASTO Y
369 AOFF
370 X=Y?
```

```
SF 05
FS? 05
XEQ 22
FS? 05
GTO 16
"Y"
ASTO X
AON
"TAN O/S?"      TANGENT/OFFSET SOLUTION
PROMPT
ASTO Y
AOFF
X=Y?
SF 03
FS? 03
GTO 17
SF 14
RTN
♦LBL 16
"Y"
ASTO X
AON
"INVERSE?"      IS RADIAL INVERSING TO
PROMPT          THE CALCULATED COORDI-
ASTO Y          NATES WANTED?
AOFF
X=Y?
SF 06
FS? 06
XEQ 20
GTO 01
RTN
♦LBL 17
0
STO 44
STO 33
STO 39
GTO 01
RTN
♦LBL a          RADIAL INVERSE TO INPUT
                COORDINATES ONLY
SF 15
♦LBL 20
"INST N↑E"      INPUT INSTRUMENT N,E
PROMPT
STO 49
RDN
STO 48
"BACKSITE?"     INPUT BACKSIGHT N,E
PROMPT
RCL 49
-
X<>Y
RCL 48
-
R-P
CLX
X<>Y
X<0?
360
+
HMS
STO 45          BACKSIGHT AZIMUTH
"N↑ E"
FS? 15
PROMPT          NEXT COORDINATE PAIR?
GTO 01
RTN
♦LBL A
ADV
CLA
ARCL Y
FS? 55
AVIEW
CLA
ARCL X
FS? 55
AVIEW
XEQ 03
"N↑ E?"
PROMPT
```

```
451 RTN
452♦LBL 03
453 ADV
454 RCL 49
455 -
456 X<>Y
457 RCL 48
458 -
459 R-P
460 FIX 3
461 "HD = "          OUTPUT OF THE INVERSED
462 ARCL X           DISTANCE TO COORDINATES
463 AVIEW
464 CLX
465 X<>Y
466 X<0?
467 360
468 +
469 STO 46
470 ENTER↑
471 ENTER↑
472 90
473 /
474 1
475 +
476 INT
477 STO 47
478 2
479 /
480 INT
481 180
482 *
483 -
484 ABS
485 HMS
486 FIX 4
487 RCL 47
488 RCL 46
489 RCL 45
490 HR
```

```
491 -
492 ENTER↑
493 CLX
494 X<>Y
495 X<0?
496 360
497 +
498 HMS
499 "∠RT="           ANGLE RIGHT FROM INST.
500 FC? 55           TO INVERSED POINT.
501 ARCL X
502 AVIEW
503 FS? 55
504 XEQ "DMS"
505 RTN
506♦LBL 30
507 SF 07
508 CHS
509 RTN
510♦LBL 22
511 SF 10
512 XEQ "AZ"         INPUT OF BEARING AND
513 CF 10            QUADRANT CODE
514 STO 39
515 "TS N↑E"         COORDINATE INPUT
516 FS? 08
517 "ST N↑E"
518 PROMPT           EXIT SPIRAL PROMPT FOR
519 STO 33           COORDINATE INPUT
520 RDN
521 STO 44
522 RTN
523♦LBL 23
524 RCL 39
525 RCL 30
526 HR
527 FS? 07
528 CHS
529 FS? 08
530 CHS
```

```
531 +
532 STO 37
533 RCL 31
534 P-R
535 RCL 44
536 +
537 STO 35
538 X<>Y
539 RCL 33
540 +
541 STO 36
542 FIX 4
543 "N = "              OUTPUT NORTH COORDINATE
544 FS? 03              or
545 "TD = "             OUTPUT TANGENT DISTANCE
546 ARCL 35
547 AVIEW
548 "E = "              OUTPUT EAST COORDINATE
549 FS? 03              or
550 "T O/S = "          OUTPUT TANGENT OFFSET
551 ARCL 36
552 AVIEW
553 FS? 06
554 XEQ 03
555 RCL 37
556 RCL 38
557 FS? 07
558 XEQ 31
559 FS? 08
560 CHS
561 +
562 STO 32
563♦LBL 24
564 ADV
565 RCL 32
566 "STA?"
567 FS? 03
568 PROMPT
569 "O/S DIST?"         OFFSET OPTION AFTER THE
570 PROMPT              SOLUTION AT CENTERLINE
571 "O/S = "
572 FS? 09
573 "RADIUS POINT:"
574 FC? 09
575 ARCL X
576 FS? 55
577 AVIEW
578 P-R
579 RCL 35
580 +
581 FS? 09
582 STO 35
583 X<>Y
584 RCL 36
585 +
586 FS? 09
587 STO 36
588 "N = "              OUTPUT O/S N-COORDINATE
589 ARCL Y
590 AVIEW
591 "E = "              OUTPUT O/S E-COORDINATE
592 ARCL X
593 AVIEW
594 FS? 06
595 XEQ 28
596 FS? 09
597 GTO 32
598 GTO 24
599 RTN
600♦LBL J              SET RADIUS POINT FOR
601 SF 09               CIRCULAR PORTION
602 "CIRCULAR:"
603 FS? 55
604 AVIEW
605 GTO 24
606♦LBL 31
607 CHS
608 180
609 +
610 RTN
```

```
611+LBL 32
612 "STA?"
613 PROMPT
614 ADV
615 FS? 55
616 XEQ "STA"
617 FIX 4
618 RCL 03
619 -
620 RCL 32
621 FC? 07
622 180
623 FC? 07
624 -
625 X<>Y
626 180
627 *
628 PI
629 /
630 RCL 20
631 /
632 FS? 07
633 CHS
634 +
635 RCL 20
636 "O/S = "
637 PROMPT
638 ARCL X
639 X≠0?
640 AVIEW
641 FC? 07
642 CHS
643 +
644 P-R
645 RCL 35
646 +
647 X<>Y
648 RCL 36
649 +
650 "N = "
651 ARCL Y
652 AVIEW
653 "E = "
654 ARCL X
655 AVIEW
656 FS? 06
657 XEQ 03
658 CF 09
659 GTO 32
660 RTN
661+LBL 28
662 FC? 09
663 XEQ 03
664 RTN
```

notes

TT

TT occupies 125 registers of program memory and should be used with the calculator sized to at least 045. The program contains 1227 bytes of programming, and may be stored on 11 tracks of magnetic cards.

```
01♦LBL "TT"
02 FIX 4          INITIALIZE AND CLEAR
03 SF 21
04 SF 01
05 CF 02
06 CF 03
07 CF 04
08 CF 05
09 CF 00
10 CF 10
11 CF 11
12 SF 06
13 CLRG
14 1.99901        COUNTER REGISTER
15 CHS
16 STO 41
17 " LT"
18 ASTO 31
19 " RT"
20 ASTO 32
21 "+"
22 ASTO 33
23 "+0"
24 ASTO 34
25 "INST. STA.?"
26 PROMPT         INPUT SETUP INFORMATION
27 STO 05
28 STO 30
29 "OFFSET?"
30 PROMPT
31 STO 06
32 XEQ 16
33 "ON CURVE?"
34 PROMPT
35 ASTO Y
36 AOFF
37 X=Y?
38 XEQ 00
39 FC? 01
40 XEQ 01
41 "H.I. = ?"
42 PROMPT         HEIGHT OF INSTRUMENT
43 STO 11
44 "BKSITE STA?"
45 PROMPT         INPUT BACKSIGHT DATA
46 STO 03
47 "OFFSET?"
48 PROMPT
49 STO 04
50 XEQ 16
```

```
51 "ON CURVE?"
52 PROMPT
53 ASTO Y
54 AOFF
55 X=Y?
56 XEQ 02
57 RCL 03
58 RCL 04
59 RCL 06
60 -
61 X<>Y
62 RCL 05        CALCULATE BACKSIGHT AZ
63 -
64 R-P
65 CLX
66 X<>Y
67 X<0?
68 360
69 +
70 STO 07
71 ENTER↑        SETUP FOR STA/OFFSET
72 ENTER↑        COMPUTATION
73 90
74 /
75 1
76 +
77 INT
78 STO 08
79 2
80 /
81 INT
82 180
83 *
84 -
85 ABS
86 HMS
87 STO 02        (D.mmss)
88 RCL 03
89 RCL 04
90 RCL 02
91 RCL 08
92 2
93 X=Y?
94 XEQ 17
95 CLX
96 4
97 X=Y?
98 XEQ 18
99 RDN
100 RDN
101 1
102 -
103 90
104 *
105 +
106 STO 21
107 FS? 01
108 XEQ 20
109♦LBL 19
110 XEQ 16
111 "SHOW GRADE?"
112 PROMPT       WILL GRADE BE CARRIED?
113 ASTO Y
114 AOFF
115 X=Y?
116 XEQ 07
117 GTO 10
118 RTN
119♦LBL 20
120 XEQ 16
121 "CURVE AREA?"
122 PROMPT       IS ANY OF THE WORK AREA
123 ASTO Y       ON CURVED ALIGNMENT?
124 AOFF
125 X=Y?
126 XEQ 00
127 RTN
128♦LBL 17
129 RDN
130 RDN
```

```
131 CHS
132 180
133 HMS+
134 STO 21
135 FS? 01
136 XEQ 20
137 GTO 19
138♦LBL 18
139 RDN
140 RDN
141 CHS
142 360
143 HMS+
144 STO 21
145 FS? 01
146 XEQ 20
147 GTO 19
148♦LBL 02
149 FS? 01
150 XEQ 00
151 FC? 01
152 XEQ 05
153 RTN
154♦LBL 00          INPUT OF CURVE DATA IF
155 CF 01           ALIGNMENT IS ON CURVE
156 "B.C. STA?"
157 PROMPT
158 STO 15
159 "RADIUS?"
160 PROMPT
161 STO 14
162 "DELTA?"
163 PROMPT
164 HR
165 X<0?
166 SF 05
167 STO 13
168 ABS
169 PI
170 *
171 RCL 14
172 *
173 180
174 /
175 RCL 15
176 +
177 STO 42
178 RCL 13
179 ABS
180 2
181 /
182 TAN
183 RCL 14
184 *
185 STO 44
186 -
187 STO 43
188 RCL 15
189 ST+ 44
190 RTN
191♦LBL 45
192 RCL 19
193 RCL 18
194 RCL 44
195 -
196 R-P
197 X<>Y
198 RCL 13
199 -
200 X<>Y
201 P-R
202 RCL 43
203 +
204 ENTER↑
205 GTO 11
206 RTN
207♦LBL 01
208 RDN
209 CLX
210 RCL 14
```

```
211 PI
212 *
213 RCL 15
214 RCL 05
215 XEQ 03
216 RCL 06
217 XEQ 04
218 STO 06
219 X<>Y
220 RCL 15
221 +
222 STO 05
223 RTN
224•LBL 05
225 RCL 14
226 PI
227 *
228 RCL 15
229 RCL 03
230 XEQ 03
231 RCL 04
232 XEQ 04
233 STO 04
234 X<>Y
235 RCL 15
236 +
237 STO 03
238 RTN
239•LBL B          REMOTE SLOPE STAKING
240 CF 06
241 SF 10
242 XEQ A
243•LBL 35         PROMPT FOR HALF-WIDTH
244 RCL 38
245 "W/2= "
246 ARCL X
247 PROMPT
248 STO 38
249 SF 08
250 RCL 36
251 ENTER↑
252 INT
253 X=Y?
254 CF 08
255 RDN
256 CF 29
257 FIX 0
258 FS? 08
259 FIX 2
260 "SR= "
261 ARCL X
262 "⊢:1"
263 PROMPT         PROMPT FOR SLOPE RATIO
264 SF 29
265 FIX 2
266 STO 36
267 RCL 40
268 RCL 00
269 +
270 RCL 12
271 -
272 STO 37
273 ABS
274 RCL 36
275 *
276 RCL 38
277 +
278 STO 39
279 RCL 21
280 X<0?
281 CHS
282 -
283 CHS
284 STOP
285 FIX 1
286 CLA
287 ADV
288 "FILL "        OUTPUT OF CUT OR FILL
289 RCL 37         IN SLOPE STAKE ROUTINE
290 X<0?
```

ERRATA

On page 95, Please add the steps **FS? 05** & **CHS** between steps 321(+) and 322(RTN). Add **FC? 05** after step 314(LBL 04).

```
291 "CUT "
292 ABS
293 ARCL X
294 AVIEW
295 RCL 36
296 *
297 "  AT "          DISTANCE TO CENTERLINE
298 ARCL X
299 AVIEW
300 CF 10
301 RCL 21
302 RCL 35
303 ENTER↑
304 GTO 11
305 RTN
306♦LBL 03
307 -
308 CHS
309 180
310 *
311 X<>Y
312 /
313 RTN
314♦LBL 04
315 CHS
316 RCL 14
317 +
318 P-R
319 CHS
320 RCL 14
321 +
322 RTN
323♦LBL 07
324 SF 02
325 "PROFILE EL?"
326 PROMPT          INPUT OF VERTICAL GRADE
327 STO 20          DATA IF GRADE IS TO BE
328 "GRADE?"        CARRIED AS PART OF THE
329 PROMPT          CALCULATION
330 100
331 /
332 STO 10
333 XEQ 16
334 "SPRINGLINE?"
335 PROMPT          IS THIS A TUNNEL?
336 ASTO Y
337 AOFF
338 X=Y?
339 XEQ 08
340 XEQ 16
341 "VERT CURVE?"
342 PROMPT
343 ASTO Y
344 AOFF
345 X=Y?
346 XEQ 09          INPUT VERTICAL DATA
347 RTN
348♦LBL 16
349 "Y"
350 ASTO X
351 AON
352 RTN
353♦LBL 08
354 CF 06
355 SF 03
356 "HEIGHT?"
357 PROMPT
358 CHS
359 STO 00
360 RTN
361♦LBL 09
362 SF 04
363 "BVC STA?"
364 PROMPT          INPUT BEGINNING STATION
365 STO 16          OF VERTICAL CURVE
366 "LENGTH?"
367 PROMPT
368 STO 17          LENGTH OF VERT. CURVE
369 "GRADE OUT?"
370 PROMPT          OUTGOING GRADE (%)
```

```
371 100
372 /
373 STO 09
374♦LBL 10
375 ADV
376 ADV
377 "INPUT SHOT"
378 PROMPT        INPUT OF FIELD DATA FOR
379 RTN           SOLUTION OF SHOT
380♦LBL C
381 STO 20
382 "INPUT SHOT"
383 PROMPT
384 RTN
385♦LBL A
386 ISG 41        COUNTER REGISTER
387 FIX 0
388 CF 29
389 FS? 06
390 XEQ 44        CALCULATE SOLUTIONS
391 SF 29
392 FIX 4
393 FS? 11
394 XEQ 99
395 FIX 2
396 STO 01
397 RDN
398 X<>Y
399 HR
400 X<>Y
401 P-R
402 RCL 11
403 +
404 RCL 01
405 +
406 STO 12
407 RDN
408 X<>Y
409 HR
410 RCL 07
411 +
412 X<>Y
413 P-R
414 RCL 05
415 +
416 STO 18
417 X<>Y
418 RCL 06
419 +
420 STO 19
421 X<>Y
422 RCL 15
423 FS? 01
424 GTO 11
425 X>Y?
426 GTO 11
427 -
428 X<>Y
429 FS? 05
430 CHS
431 RCL 14
432 -
433 CHS
434 R-P
435 CHS
436 RCL 14
437 +
438 X<>Y
439 RCL 14
440 *
441 PI
442 *
443 180
444 /             LENGTH
445 RCL 15
446 +
447 RCL 42
448 X<=Y?
449 GTO 45
450 RDN
```

```
451 X<>Y
452 FS? 05
453 CHS
454 X<>Y
455 ENTER↑
456 GTO 11
457 RTN
458◆LBL 99          PRINTS COPY OF STACK
459 FS? 55          WHEN PRINTER IS PRESENT
460 PRSTK
461 RTN
462◆LBL 44
463 CLA
464 ARCL 41
465 FS? 55
466 AVIEW
467 RTN
468◆LBL 11
469 RDN
470 XEQ 12
471 CLX
472 X<>Y
473 RND
474 STO 21
475 X>Y?
476 GTO 13
477 CHS
478 "AT "            OFFSET DISTANCE
479 ARCL X
480 ARCL 31         OFFSET LEFT OUTPUT
481◆LBL 15
482 FC? 10
483 AVIEW
484 "ELEV = "        ELEVATION AT SHOT
485 ARCL 12
486 FC? 10
487 AVIEW
488 FS? 02
489 XEQ 14
490 FS? 10
491 GTO 35
492 GTO 10
493 RTN
494◆LBL 13
495 "AT "            OFFSET DISTANCE
496 ARCL X
497 ARCL 32         OFFSET RIGHT OUTPUT
498 GTO 15
499◆LBL 12
500 CF 29
501 100
502 /
503 ENTER↑
504 INT
505 X<>Y
506 FRC
507 100
508 *
509 FIX 0
510 "STA "
511 ARCL Y
512 FIX 2
513 10
514 X>Y?
515 SF 00
516 RDN
517 RND
518 FS? 00
519 ARCL 34
520 FC? 00
521 ARCL 33
522 CF 00
523 ARCL X
524 FC? 10
525 AVIEW
526 X<>Y
527 100
528 *
529 +
530 SF 29
```

```
531 STO 35
532 RTN
533♦LBL 14
534 RCL 35
535 FS? 04
536 GTO 21
537♦LBL 26
538 RCL 35
539 RCL 30
540 -
541 RCL 10
542 *
543 RCL 20
544♦LBL 24
545 +
546 STO 40
547 RCL 00
548 +
549 "GR = "
550 ARCL X
551 FC? 10
552 AVIEW
553 FS? 03
554 XEQ 25
555 FS? 10
556 GTO 35
557 GTO 10
558 RTN
559♦LBL 22
560 RCL 17
561 -
562 X>Y?
563 GTO 26
564 GTO 23
565 RTN
566♦LBL 21
567 RCL 16
568 RCL 17
569 +
570 X>Y?
571 XEQ 22
572 X<>Y
573 RCL 16
574 RCL 17
575 2
576 /
577 +
578 ENTER↑
579 RCL 30
580 -
581 RCL 10
582 *
583 RCL 20
584 +
585 X<>Y
586 RCL 16
587 -
588 RCL 17
589 2
590 /
591 -
592 RCL 09
593 *
594 GTO 24
595 RTN
596♦LBL 23
597 -
598 ENTER↑
599 ENTER↑
600 RCL 09
601 RCL 10
602 -
603 100
604 *
605 RCL 17
606 /
607 *
608 2
609 /
610 RCL 10
```

```
611 100                                    631 -
612 *                                      632 ENTER↑
613 +                                      633 *
614 *                                      634 RCL 21
615 100                                    635 ENTER↑
616 /                                      636 *
617 RCL 16                                 637 +
618 RCL 30                                 638 SQRT
619 -                                      639 FIX 2
620 RCL 10                                 640 "  RAD. = "
621 *                                      641 ARCL X
622 RCL 20                                 642 AVIEW
623 +                                      643 RTN
624 GTO 24                                 644♦LBL J       ENABLE STACKPRINT
625 RTN                                    645 SF 11
626♦LBL 25    CALCULATE RADIUS WHEN        646 RTN
627 RCL 12    SHOT ABOVE SPRINGLINE        647♦LBL I       CANCEL STACKPRINT
628 RCL 40                                 648 CF 11
629 X>Y?                                   649 RTN
630 RTN                                    650 .END.
```

notes

TR

TR occupies 80 registers, contains 559 bytes of programming, and may be stored onto 5 tracks of magnetic cards. This program uses "**DMS**" as a subroutine, and should be used with the calculator sized to at least 030.

```
01♦LBL "TR"          INITIALIZE AND CLEAR
02 SF 21
03 SF 27
04 CLRG
05 FIX 4
06 CLX
07 CF 00
08♦LBL 06            RESET FLAG STATUS
09 CF 01
10 CF 02
11 CF 03
12 CF 04
13 CF 05
14 CF 06
15 CF 07
16 RTN
17♦LBL A             S-1, S-2, S-3
18 SF 01             S1 CAPITALS WHEN SET
19 SF 02             S2 CAPITALS WHEN SET
20 SF 03             S3 CAPITALS WHEN SET
21♦LBL 11
22 STO 04
23 RDN
24 STO 02
25 RDN
26 STO 09
27 RDN
28 RDN
29 +
30 +
31 2
32 /
33 STO 07
34 X↑2
35 LASTX
36 RCL 02
37 *
38 -
39 RCL 09
40 RCL 04
41 *
42 /
43 SQRT
44 ACOS
45 2
46 *
47 STO 05
48 SIN
49 RCL 09
50 *
```

```
51 STO 08
52 RCL 07
53 X↑2
54 LASTX
55 RCL 09
56 *
57 -
58 RCL 02
59 /
60 RCL 04
61 /
62 SQRT
63 ACOS
64 2
65 *
66 STO 03
67 RCL 05
68 XEQ 00      CALCULATE MISSING ANGLE
69 STO 01      A1
70 GTO 01
71 RTN
72♦LBL B       A-3, S-1, A-1
73 SF 01       S1 CAPITALS WHEN SET
74 SF 04       A1 CAPITALS WHEN SET
75 SF 06       A3 CAPITALS WHEN SET
76♦LBL 10      LOOP FOR SECOND SOLUTION
77 SF 13       WITH 2 SIDES AND FOLLOW-
78 FS? 00      ING ANGLE KNOWN
79 XEQ 07
80 "SECOND SOLUTION"
81 FS?C 00
82 AVIEW
83 CF 13
84 HR
85 STO 01      A1
86 RDN
87 STO 09      S1
88 RDN
89 HR
90 STO 05
91♦LBL 03
92 RCL 01
93 XEQ 00      CALCULATE A2
94 STO 03
95 RCL 05      A3
96 RCL 09      S1
97 P-R
98 X<>Y
99 STO 08
100 RCL 03
101 1
102 P-R
103 RDN
104 /
105 STO 02     S2
106 R↑
107 *
108 +
109 STO 04     S3
110 GTO 01     OUTPUT SOLUTION
111 RTN
112♦LBL C      S-1, A-1, A-2
113 SF 01      S1 CAPITALS WHEN SET
114 SF 04      A1 CAPITALS WHEN SET
115 SF 05      A2 CAPITALS WHEN SET
116 HR
117 STO 03     A2
118 RDN
119 HR
120 STO 01     A1
121 RDN
122 STO 09     S1
123 RCL 03
124 RCL 01
125 XEQ 00     CALCULATE A3
126 RCL 09
127 RCL 01
128 XEQ 04
129 GTO 03     SOLVE AS ASA
130 RTN
```

```
131♦LBL 05
132 RCL 09
133 RCL 01
134 HMS
135 RCL 02      S2
136 GTO 08
137 RTN
138♦LBL D       S-1, A-1, S-2
139 SF 01       S1 CAPITALS WHEN SET
140 SF 02       S2 CAPITALS WHEN SET
141 SF 04       A1 CAPITALS WHEN SET
142♦LBL 08
143 STO 02      S2
144 RDN
145 HR
146 STO 01      A1
147 RDN
148 STO 09      S1
149 RCL 01      A1
150 RCL 02      S2
151 P-R         CALCULATE S3
152 RCL 09
153 -
154 R-P
155 STO 04
156 RCL 09
157 RCL 02
158 RCL 04
159 GTO 11      SOLVE AS SSS
160 RTN
161♦LBL E       S-1, S-2, A-2
162 SF 13
163 "FIRST SOLUTION:"
164 AVIEW
165 CF 13
166 XEQ 07      RESET FLAGS
167 HR
168 STO 03      A2
169 RDN
170 STO 02      S2
171 RDN
172 STO 09      S1
173 RCL 03
174 SIN
175 RCL 02
176 *
177 RCL 09
178 /
179 ASIN
180 STO 05      A3
181 RCL 03
182 XEQ 00
183 STO 01
184 RCL 05
185 RCL 09
186 RCL 01
187 XEQ 04
188 XEQ 03
189 180
190 RCL 05
191 -
192 RCL 03
193 +
194 CHS
195 180
196 +
197 HMS
198 RCL 02
199 RCL 03
200 HMS
201 XEQ 06      CALCULATE THIRD ANGLE
202 SF 00
203 SF 03
204 GTO 10
205♦LBL 07
206 SF 01
207 FC? 00
208 SF 02
209 FC? 00
210 SF 05
```

```
211 RTN
212♦LBL 00          Ax = Cos-1[-Cos(Ay+Az)]
213 +
214 COS
215 CHS
216 ACOS
217 RTN
218♦LBL 01          OUTPUT SOLUTIONS
219 FIX 3
220 SF 13
221 FS? 01
222 CF 13
223 "S-1 = "
224 ARCL 09
225 AVIEW
226 RCL 01
227 HMS
228 FIX 4
229 SF 13
230 FS? 04
231 CF 13
232 "A-1 = "
233 FC? 55
234 ARCL X
235 AVIEW
236 FS? 55
237 XEQ "DMS"  PRINT AS DD°MM'SS"
238 ADV
239 FIX 3
240 SF 13
241 FS? 02
242 CF 13
243 "S-2 = "
244 ARCL 02
245 AVIEW
246 RCL 03
247 HMS
248 FIX 4
249 SF 13
250 FS? 05
251 CF 13
252 "A-2 = "
253 FC? 55
254 ARCL X
255 AVIEW
256 FS? 55
257 XEQ "DMS"  PRINT AS DD°MM'SS"
258 ADV
259 FIX 3
260 SF 13
261 FS? 03
262 CF 13
263 "S-3 = "
264 ARCL 04
265 AVIEW
266 RCL 05
267 HMS
268 FIX 4
269 SF 13
270 FS? 06
271 CF 13
272 "A-3 = "
273 FC? 55
274 ARCL X
275 AVIEW
276 FS? 55
277 XEQ "DMS"  PRINT AS DD°MM'SS"
278 ADV
279 RCL 08
280 RCL 04
281 *
282 2
283 /
284 FIX 3
285 SF 13
286 FS? 07     WAS AREA INPUT?
287 CF 13
288 "AREA = "
289 ARCL X
290 AVIEW
```

```
291 ADV
292 FIX 4
293 ADV
294 XEQ 06
295 RTN
296♦LBL 09
297 RDN
298 RDN
299 RTN
300♦LBL 04       FILING AND STORAGE
301 STO 01
302 RDN
303 STO 09
304 RDN
305 STO 05
306 RTN
307♦LBL F        AREA, S-1, A-1
308 SF 07        AREA CAPITALS WHEN SET
309 SF 01        S1 CAPITALS WHEN SET
310 SF 04        A1 CAPITALS WHEN SET
311 HR
312 STO 01
313 SIN
314 XEQ 02
315 STO 02       S2
316 XEQ 05
317 RTN
318♦LBL G        AREA, S-1, S-2
319 SF 07        AREA CAPITALS WHEN SET
320 SF 01        S1 CAPITALS WHEN SET
321 SF 02        S2 CAPITALS WHEN SET
322 STO 02
323 XEQ 02
324 ASIN
325 STO 01
326 XEQ 05
327 RTN
328♦LBL 02
329 X<>Y
330 STO 09
331 *
332 /
333 2
334 *
335 RTN
336 END
```

notes

APPENDIX A

We often are asked, "How do you store coordinates by point number without X-function in a 41?" There are a number of ways this can be done, but this little routine is one of the easiest.

PIN (point in) assigns the next consecutive number in the counter register to any coordinate pair when the N-coord is in the Y register and the E-coord is in X. **POUT** (point out) replaces the coordinate pair into the Y and X registers for whatever point number is in the X register when executed.

These two routines (©1983, Ted J. Kerber), combined with short programs that tap the subroutines of the HP SURVEYING PAC, give you a complete traverse and inverse package. It may also be extended into storage of three-dimensional coordinates by using similar steps to store the Z register, and have the elevation of the point reside there.

The number of points you can store by this method is only limited by the total number of available registers (it requires two registers per point number), and this is dictated by how many registers you have to use up with the other routines.

In the example listings, with the calculator sized at 120, we're storing N-coordinates in registers 20 thru 69, and E-coordinates in registers 70 thru 119 (a total of 49 points), with register 17 used as the counter. Begin with 0 in register 17.

You can custom fit the routine to your own needs by varying step 19 (first E register), steps 26 and 38 (first N register) and step 43 (difference between registers). Data cards can be used to input or dump the coordinates for later use. You can recall and use the coordinates without having to look at them by adding a PRINT/DON'T PRINT flag in front of the "AVIEW" steps.

```
01♦LBL "PIN"
02 RCL 17
03 1
04 +
05 FIX 0
06 CF 29
07 CLA
08 ARCL X
09 AVIEW
10 STO 17
11 FIX 4
12 CLA
13 ARCL Z
14 AVIEW
15 CLA
16 ARCL Y
17 AVIEW
18 ADV
19 70
20 +
21 STO 19
22 RDN
23 STO IND 19
24 CLX
25 RCL 17
26 20
27 +
28 STO 19
29 RDN
30 STO IND 19
31 RTN
32♦LBL "POUT"
33 FIX 0
34 CLA
35 ARCL X
36 AVIEW
37 FIX 4
38 20
39 +
40 STO 19
41 RCL IND 19
42 X<>Y
43 50
44 +
45 STO 19
46 RDN
47 RCL IND 19
48 CLA
49 ARCL Y
50 AVIEW
51 CLA
52 ARCL X
53 AVIEW
54 ADV
55 RTN
56 END
```

The program steps listed below are a different version of the utility program "**DMS**" that divides the register display into groupings of DD MM SS when the subroutine is called up, but no printer is attached, as well as printing out as DD°MM'SS" when the printer is attached.

This routine contains functions which are in the printer itself, rather than in the calculator, and a printer must be attached in order to input the program.

```
01♦LBL "DMS"
02 XEQ 00
03 FS? 55
04 XEQ 01
05 FC? 55
06 XEQ 02
07 XEQ 03
08 RTN
09♦LBL 00
10 STO 23
11 RDN
12 STO 24
13 RDN
14 STO 25
15 RDN
16 STO 26
17 RDN
18 CLA
19 ENTER↑
20 INT
21 CF 29
22 FIX 0
23 RTN
24♦LBL 03
25 RCL 26
26 RCL 25
27 RCL 24
28 RCL 23
29 FIX 4
30 SF 29
31 CLA
32 RTN
33♦LBL 02
34 ARCL X
35 -
36 100
37 *
38 ABS
39 STO 22
40 INT
41 "⊢ "
42 ARCL X
43 RCL 22
44 FRC
45 100
46 *
47 FIX 1
48 "⊢ "
49 ARCL X
50 AVIEW
51 RTN
52♦LBL 01
53 ACX
54 -
55 100
56 *
57 ABS
58 STO 22
59 3
60 SKPCOL
61 6
62 ACCOL
63 9
64 ACCOL
65 ACCOL
66 6
67 ACCOL
68 2
69 SKPCOL
70 RCL 22
71 INT
72 ACX
73 39
74 ACCHR
75 RCL 22
76 FRC
77 100
78 *
79 FIX 1
80 ACX
81 34
82 ACCHR
83 PRBUF
84 RTN
```

DMS - SOME VARIATIONS

Another version (shown to the right) which may be used as a replacement for "**DMS**" will divide the register display and printout . . . but the printout will NOT contain the °,' or " symbols.

This is handy if you know that you will not be using a printer, and still works if you happen to hook up to a printer while using the programs in the future. The output just isn't quite as 'fancy'.

All three versions of "**DMS**" pre-store and recall the stack when operating, which is part of the reason for the length of the subroutine. If that is not required for a particular operation you want to program, those steps could be deleted.

If you wish to substitute either of these routines for the one given in the utility programs you will also have to do some minor editing of the main programs.

Go through and remove all of the conditionals "**FS? 55**" which occur just prior to **XEQ DMS** calls. In the version on the opposite page that conditional isn't required, and in this last version the subroutine isn't affected by whether or not the printer is attached.

Finally, if you're into synthetics, the degree symbol may be constructed as θ◆◆◆BC◆ (hex 7F 10 00 00 00 C2 43 00) or, in another form commonly used, as θ◆◆ρ ◆(hex 7F 10 00 00 70 A1 C0 00), which actually produces a little square, instead of using the printer accumulation functions. The ' symbol is hex F2 7F 27, and the " is hex F2 7F 22, where the F2 is the append.

A program for printing out bearings (uses "**DMS**" as a subroutine) is shown on the next page.

```
01♦LBL "DMS"
02 XEQ 00
03 XEQ 02
04 XEQ 03
05 RTN
06♦LBL 00
07 STO 23
08 RDN
09 STO 24
10 RDN
11 STO 25
12 RDN
13 STO 26
14 RDN
15 CLA
16 ENTER↑
17 INT
18 CF 29
19 FIX 0
20 RTN
21♦LBL 03
22 RCL 26
23 RCL 25
24 RCL 24
25 RCL 23
26 FIX 4
27 SF 29
28 RTN
29♦LBL 02
30 ARCL X
31 -
32 100
33 *
34 ABS
35 STO 22
36 INT
37 "⊦ "
38 XEQ 01
39 ARCL X
40 RCL 22
41 FRC
42 100
43 *
44 FIX 1
45 "⊦ "
46 XEQ 01
47 ARCL X
48 AVIEW
49 RTN
50♦LBL 01
51 10
52 X<>Y
53 X<Y?
54 "⊦0"
55 RTN
56 END
```

Those who would rather have a character of some kind between the digits can substitute a colon or a comma (or the character of your choice) in place of the space, at steps 41 and 48 in the routine on the opposite page, or steps 37 and 45 in this version.

This program requires 22 registers of memory, and contains 159 bytes of programming.

It is designed to be used with the version of "**DMS**" on page 108 and requires that a printer be attached while programming. You will also need to modify DMS slightly; in the version on page 108, insert **FC? 14** between steps 82 and 83 (ACCHR and PRBUF) and in front of the **CLA** at steps 18 and 31. This program may also be used with the UTILITY version of "**DMS**" by adding the **FC? 14** step between steps 43 and 44.

In use, the bearing is in the y-register and the quadrant code is in the x-register. It may be executed with **XEQ B-** as a program step in another program, or by keystroking XEQ ALPHA B shift − ALPHA.

```
01♦LBL "B-"
02 SF 14
03 CLA
04 X<>Y
05 XEQ IND Y
06 RTN
07♦LBL 01
08 "N"
09 FS? 55
10 XEQ 06
11 XEQ "DMS"
12 FS? 55
13 XEQ 07
14 "⊢E"
15 XEQ 05
16 RTN
17♦LBL 09
18 83
19 ACCHR
20 RDN
21 RTN
22♦LBL 08
23 87
24 ACCHR
25 RDN
26 RTN
27♦LBL 02
28 "S"
29 FS? 55
30 XEQ 09
31 XEQ "DMS"
32 FS? 55
33 XEQ 07
34 "⊢E"
35 XEQ 05
36 RTN
37♦LBL 06
38 78
39 ACCHR
40 RDN
41 RTN
42♦LBL 07
43 69
44 ACCHR
45 RDN
46 RTN
47♦LBL 03
48 "S"
49 FS? 55
50 XEQ 09
51 XEQ "DMS"
52 FS? 55
53 XEQ 08
54 "⊢W"
55 XEQ 05
56 RTN
57♦LBL 04
58 "N"
59 FS? 55
60 XEQ 06
61 XEQ "DMS"
62 FS? 55
63 XEQ 08
64 "⊢W"
65 XEQ 05
66 RTN
67♦LBL 05
68 FS? 55
69 PRBUF
70 FC? 55
71 AVIEW
72 CF 14
73 X<>Y
74 RTN
75 END
```

BEARING OUTPUT

A version of the bearing printout program which will work with the "short & simple" version of "**DMS**" (page 109) is shown below.

Modify the DMS program by adding the conditional **FC? 14** in front of the CLA at step 15 and between steps 47 and 48 (ARCL X and AVIEW).

This is the no-frills version of both the bearing and angle output, but it does the job . . . . it keeps us from thinking that it is a decimal instead of D°MM'SS".

```
01♦LBL "B-"        13♦LBL 02          25♦LBL 04
02 SF 14           14 "S"             26 "N"
03 CLA             15 XEQ "DMS"       27 XEQ "DMS"
04 X<>Y            16 "⊢E"            28 "⊢W"
05 XEQ IND Y       17 XEQ 05          29 XEQ 05
06 RTN             18 RTN             30 RTN
07♦LBL 01          19♦LBL 03          31♦LBL 05
08 "N"             20 "S"             32 AVIEW
09 XEQ "DMS"       21 XEQ "DMS"       33 CF 14
10 "⊢E"            22 "⊢W"            34 X<>Y
11 XEQ 05          23 XEQ 05          35 CLA
12 RTN             24 RTN             36 RTN
```

One for the road. The little program to the right is for use with a 41CX that has a printer attached.

It may be executed manually or by inserting an execute command at the beginning of each program. What does it do?

It labels your calculations with the time and date, to help keep all of the little strips of paper straight!

```
05/23/1987
12:46:15 PM
```

```
01♦LBL "D*"     09 FIX 4
02 CLA          10 ATIME
03 FIX 6        11 AVIEW
04 DATE         12 ADV
05 ADATE        13 CLX
06 AVIEW        14 CLA
07 CLA          15 RTN
08 TIME         16 .END.
```

```
            CLA
            "INST. AT"
            FS? 55
46♦LBL C -- AVIEW
47 STO 06   FS? 55
48 RDN      XEQ 98
49 STO 05   ADV
50 "BACKSITE?" <-- change ? to :
51 PROMPT
52 RCL 06 \ FS? 55
53 -        AVIEW
54 X<>Y     FS? 55
   RCL 05   XEQ 98
73 ..
74 SF 07
75 XEQ 01
76♦LBL D ---- ADV
77 "BEG. STA?" <-- change ? to .
78 PROMPT
79 STO 03 --- FS? 55
80 "COORD. N↑E" AVIEW
81 PROMPT     FS? 55
82 STO 08 \   XEQ "STA"
83 RDN
84 STO 07     FS? 55
85 XEQ "AZ"   XEQ 98
```

Someone once told me that a program is never finished . . . It's true, there is always something else that you wish it would do, so you keep revising it. That was the case with "**LO**", for instance.

Cynthia (my Party Chief) was working on a footing layout, and cussing 'cause using "LO" would have been a quick way to calculate it, but it doesn't do corners.

She had figured out that she could trick it into doing an angle point by using the curve routine and giving it an 'almost zero' radius, but these footing corners were mitered. She could get the offsets, but still had to use the Surveying Pac to bearing-bearing the corners later.

Along those same lines, she pointed out that I gripe about the fact that the intersection routines in the Surveying Pac don't print out the input (no way to check wrong input strokes), but didn't print the input on mine either. We'll look at that first, and then I'll get back to the corner-turning problem.

We inserted steps, as shown above, to get the output of the input. To print out the bearing it was necessary to have a version of the "**B-**" in memory, and we also had to add an azimuth to bearing routine to program memory. That was called "**A↑B**", and is shown to the right.

It, in turn uses "**B-**" as a subroutine, which then uses "**DMS**", etc. It isn't fast, but it prevents errors by catching them before they happen.

```
♦LBL "A↑B"
HR
360
MOD
STO Y
90
/
1
+
INT
STO Z
2
/
INT
180
*
-
ABS
HMS
X<>Y
RTN
END
```

```
INST. AT
N= 2,564.3580
E= 1,659.7840

BACKSITE:
N= 3,019.2560
E= 1,400.5890

BEG. STA.
12+00.000
N= 2,015.470
E= 1,545.601

BEARING:
S 13° 25' 45.0"E
```

Now we had the printout as shown to the left (the example is with coordinate and backsight coordinates input for layout, keystroke [C]). Another example of the output is shown on the next page, where we solved the corner-turning problem.

So, back to that. We added two new labels to the program, **H** and **I**. **LBL "H"** works in the same way as **"J"**, except that it treats the point as an angle point instead of as the B.C. of a curve.

LBL "I" does the mitered corners that Cynthia wanted. To make it work, it was necessary to again do a little editing to the main program, adding the **FS? 19** and **RCL** steps as shown, and a **CF 19** in Label E to stop the miter process when the next station was input.

```
457♦LBL I
458 SF 19
459 RCL 00
460 STO 27
461 XEQ 50
462 RCL 00
463 HR
464 RCL 27
465 HR
466 -
467 2
468 /
469 STO 12
470 COS
471 STO 13
472 XEQ 03
473 RTN
474♦LBL 50
475 "Y"
476 ASTO X
477 AON
478 "INPUT BRG?"
479 PROMPT
480 ASTO Y
481 AOFF
482 X=Y?
483 GTO 00
484 "DEFL. ∡?"
485 PROMPT
486 ST+ 00
487 "BEARING:"
488 AVIEW
489 RCL 00
490 XEQ "A↑B"
491 XEQ "B-"
492 ADV
493♦LBL 05
494 RCL 20
495 STO 03
496 RCL 09
497 STO 07
498 RCL 10
499 STO 08
500 "STA?"
501 RTN
502♦LBL H
503 XEQ 50
504 RCL 00
505 RTN
506♦LBL 00
507 XEQ "AZ"
508 STO 00
509 XEQ 05
510 RTN
```

```
 95 CF 05
 96 "STA?"
 97 PROMPT
 98♦LBL E        CF 19
 99 STO 20
100 FS? 08

136♦LBL 03
137 RCL 00
138 HR           FS? 19
139 90           RCL 27
140 FS? 05
141 CHS          FS? 19
142 +            RCL 12
143 FS? 09       FS? 19
    STO 17       +
157 "O/S
158 FS? 09
159 "R = "
160 ARCL X       FS? 19
161 AVIEW        "⊢ M"
162 P-R
163 RCL 09       FS? 19
164 +            RCL 13
165 FS? 09       FS? 19
    ..           /
```

EDITING

THE KEYSTROKES

BEG. STA.
0+00.000
N= 500.000
E= 500.000

BEARING:
N 8° 15' 0.0"E

0+00.000
O/S= -3.0000
N= 500.4305
E= 497.0310

O/S= 1.0000
N= 499.8565
E= 500.9897

O/S= 6.5000
N= 499.0673
E= 506.4327

0+82.000
[I]
INPUT BRG?
[N] [R/S]
DEFL. ∡?
[4] [5] [R/S]
BEARING:
N 53° 15' 0.0"E

O/S? [3] [CHS] [R/S]
O/S= -3.0000 M
N= 582.8117
E= 508.9758

O/S= 1.0000 M
N= 580.5980
E= 512.6966

O/S= 6.5000 M
N= 577.5542
E= 517.8128

1+32.000
[I]
INPUT BRG?
[Y] [R/S]
BRG=?
[3] [6] [.] [4] [5]
[R/S]
QD=?
[4] [R/S]
BEARING:
N 36° 45' 0.0"W
O/S? [3] [CHS] [R/S]
O/S= -3.0000 M
N= 611.6764
E= 547.6304

O/S= 1.0000 M
N= 610.8647
E= 553.2287

O/S= 6.5000 M
N= 609.7486
E= 560.9263

1+80.000
O/S= -3.0000
N= 647.7329
E= 520.7057

O/S= 1.0000
N= 650.1262
E= 523.9108

O/S= 6.5000
N= 653.4169
E= 528.3177

The south end of the wall was considered 0+00 for the calculations, and the stations were arrived at by adding the distances along the face of the wall. For the example, an assumed coordinate of 500/500 was used. The example keystrokes (page 113) indicate the procedure. Label "H" works the same way but does not miter the corner. Note that the mitered corners have an **M** at the offset to show that they are mitered rather than right-angle offsets.

N1=500.4305
E1=497.0310

N 8.1500 E
HD=83.2427

N2=582.8117
E2=508.9758

N 53.1500 E
HD=48.2426

N3=611.6764
E3=547.6304

N 36.4500 W
HD=45.0001

N4=647.7329
E4=520.7057

N 53.1503 E
HD=9.5000

N5=653.4169
E5=528.3177

S 36.4460 E
HD=54.4999

N6=609.7486
E6=560.9263

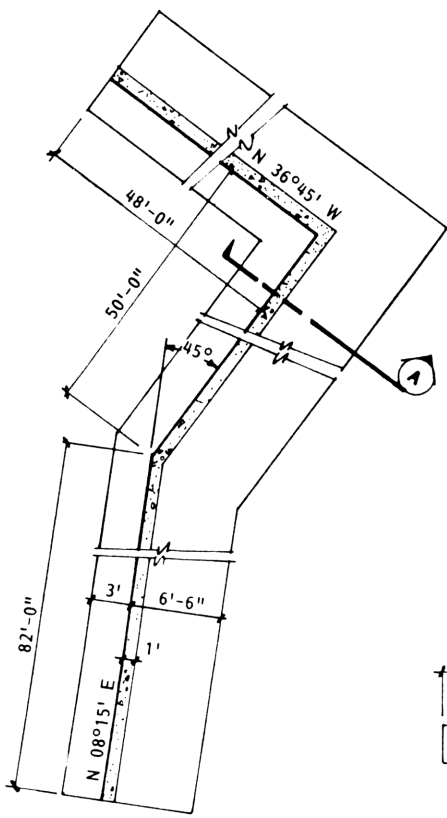
S 53.1460 W
HD=53.8076

N7=577.5542
E7=517.8128

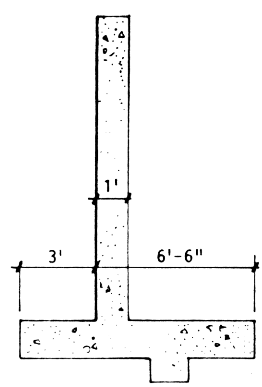
S 8.1500 W
HD=79.3076

N8=499.0673
E8=506.4327

INVERSED TRAVERSE



THE FOOTING



TYPICAL SECTION A

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