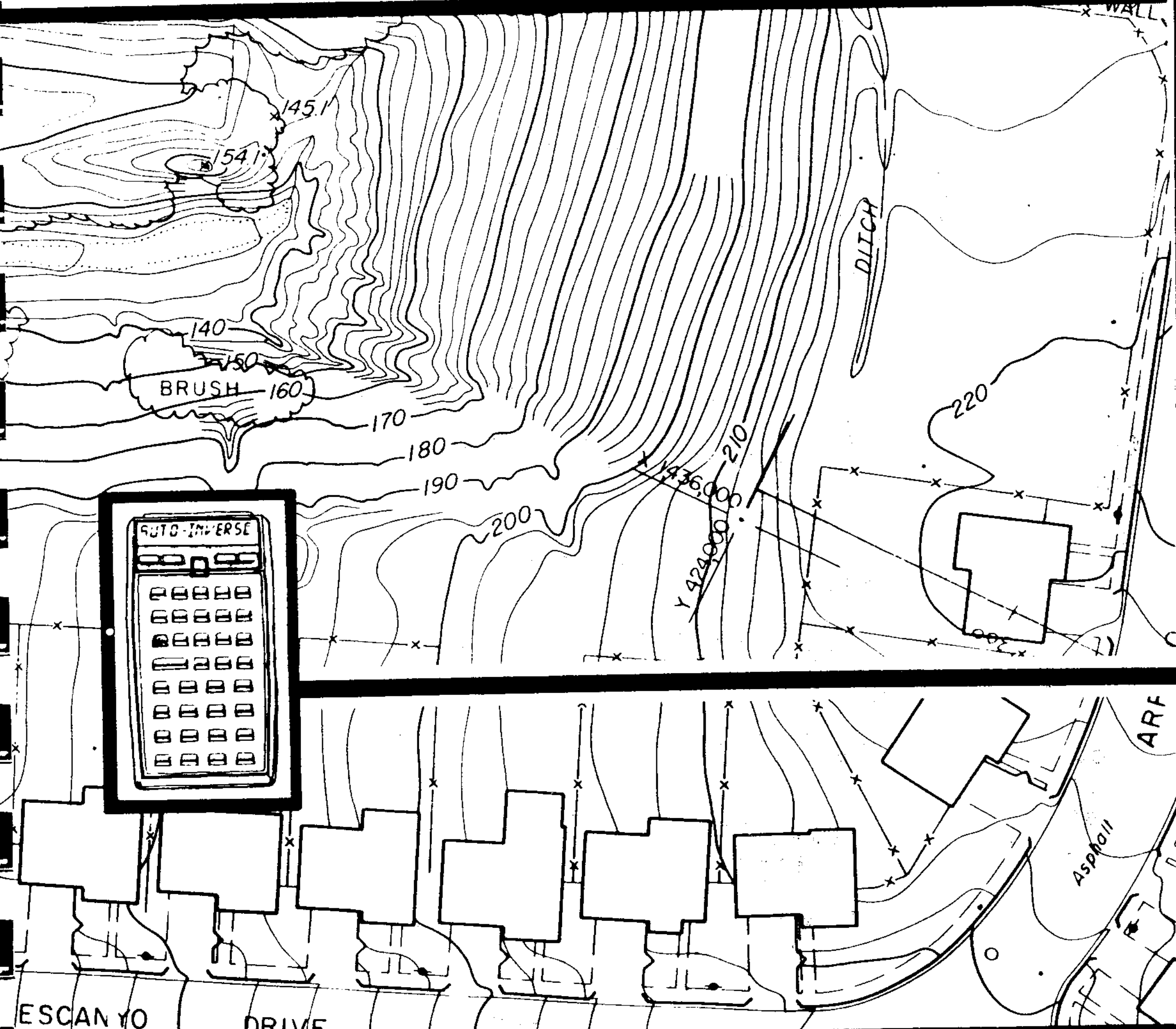
HP-41CV/CX

Surveying Field Solutions



HP-41CV/CX
Surveying
Field Solutions

I wish to thank those Surveyors and Engineers whose suggestions for additional flexibility in the programming have made the programs contained in this book what they are.

Special thanks go to Keith Cameron, my co-worker and friend, for his patience as I revised the programs right after he had learned to use them. More than once.

This book is dedicated to my wife, Phyllis, whose enthusiam kept the whole project going.

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PREFACE

This book of programs was developed to fill the gap in available software for the HP-41C series calculators used by the field surveyor or party chief. They are compatable with the HP Survey Pac, and may be used with or without the Survey Pac module in the calculator. If used without a Survey Pac, the additional program "AZ" should be in the program memory.

In the design of the programs, an attempt was made to address the field problems encountered on a day-to-day basis in surveying.

Remote Slope Staking answers a very real need in the field, as do the Radial Inverse routines, for 'spraying' in a layout.

The programs are assembled into four groups, or sections, and one set of program cards is used for each group. Complete instructions and keystroke examples are included for each group, and most of the steps have been standardized to aid in remembering the keystrokes.

The programs are as close to menu-driven as a hand held calculator can handle, and utilize stack input prior to execution. Execution is by single keystroke, and all of the program routines are fully prompted.

The Alignment & Offset routine is a new concept in layout programs, giving coordinate solutions directly from station input, avoiding the necessity of using a traverse program with side-shots to do the work, and has a subroutine for Auto Inversing from the instrument setup point.

Lastly, those who have had to assign the program alpha labels to the keyboard, instead of typing in a five to seven letter label, will appreciate the fact that all of the global alpha commands have been restricted to two letters, and those letters are close to each other on the keyboard.

CONTENTS

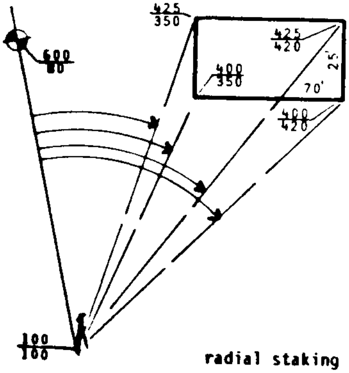
A Radial Inverse 1-1

Radial inversing has become a standard proceedure 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 distance and angle from a known backsight to points with known coordinates 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 their coordinates.

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



radial staking

N= 425.0000
E= 350.0000

HD = 410.030
∡RT=
39° 51' 33"

N= 400.0000
E= 350.0000

HD = 390.512
∡RT=
42° 5' 46"

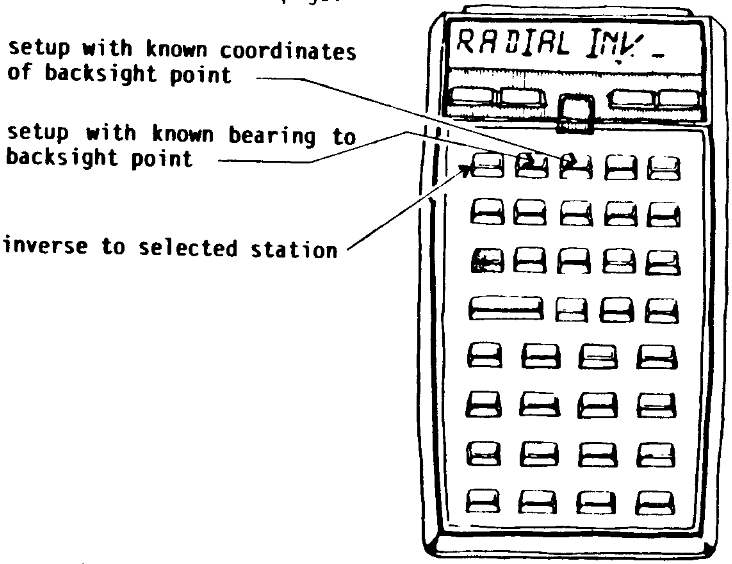
N= 425.0000
E= 420.0000

HD = 456.098
∡RT=
46° 50' 47"

N= 400.0000
E= 420.0000

HD = 438.634
∡RT=
49° 8' 18"

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



KEYBOARD ASSIGNMENTS

1-2 Radial Inverse A

There are two options for input with this program; one for known coordinates at the instrument setup point and at the backsight station, and the other for when the coordinates of the setup station and the bearing to the backsight are known. With the exception of the initial input, the operation is the same for either condition.

To begin the calculator memory should contain the programs "DMS", "STA" and "LO", and should be sized at 030. Initialize and clear to a fix-4 position by keystroking [XEQ] [ALPHA] [L] [O] [ALPHA]. The display will now show 0.0000.

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

1		Input the N-coordinate of the instrument point	[ENTER↑]
2		Input the E-coordinate of the instrument point	[C]
3	BACKSITE?	Input the N-coordinate of the backsite point	[ENTER↑]
4		Input the backsight E-coordinate	[R/S]

or, For backsight bearing known:

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

then:

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

Output will be the coordinates of the point being set, followed by the HORIZONTAL DISTANCE, and the ANGLE RIGHT from the backsight to the point that you wish to set. If there is no printer attached, stroke [R/S] until the prompt **N↑ E** reappears, then repeat steps **6** and **7** until all of the required inverses have been completed.

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

With "DMS", "STA" and "LO" in the memory, and with the calculator in **user** mode at size 030, keystroke [XEQ] [ALPHA] [L] [O] [ALPHA]. 0.0000 will be displayed.

keystroke:

[1] [0] [0] [ENTER↑]

[1] [0] [0] [C]

prompt: BACKSITE?

keystroke:

[6] [0] [0] [ENTER↑]

[8] [0] [R/S]

question: 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"

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"

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"

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' 18"

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:

keystroke:

[1] [0] [0] [ENTER↑]

[1] [0] [0] [B]

prompt: BRG=?

keystrokes:

[2] [·] [1] [7] [2] [6] [R/S]

prompt: QD=?

keystrokes:

[4] [R/S]

question: INV. ONLY?

keystrokes:

[Y] [R/S]

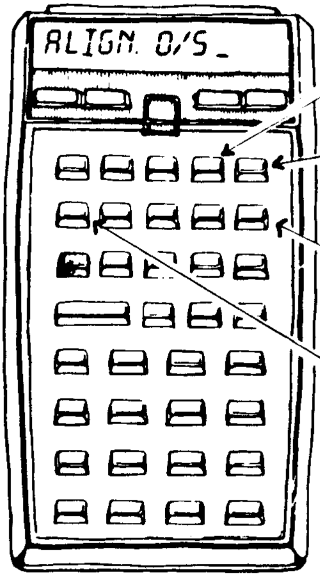
prompt: N↑ E

. . . . . etc.

In most cases, if the bearing to the backsight is known, so are the coordinates. It is mathematically more correct to use the backsight coordinates for input, since the calculator will obtain and store the correct bearing to several decimal places of a second. The bearing you would input has already been rounded off to the nearest second.

A Alignment & Offsets 2-1

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 gives the option of calculated offset coordinates, with or without the centerline coordinates being output.



this routine is started by keystroking [D]

keystroke [E] after input of new station for solution

signal the beginning of a circular curve in the alignment with [J]

a constant offset may be input by keystroking [F] after the offset prompt

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

Initialize the program by keystroking [XEQ] [ALPHA] [L] [O] [ALPHA]. The display will show 0.0000. Remember to have programs "LO", "DMS" and "STA" in program memory. The calculator should be at size 030 and in user mode.

1 begin the station-coordinate routine [D]

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

3 **COORD. N↑ E** Input the N-coordinate of the beginning station [ENTER↑]

4 Input the E-coordinate of the beginning station [R/S]

5 **BRG=?** Input the tangent bearing ahead as DD.mmss [R/S]

6 **QD=?** Input the quadrant code for the bearing [R/S]

7 **STA COORDS?** At this point you can 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".

8 **STA?** input the station at which the coordinates are wanted [E]

The station will be displayed in the form XXX+XX.xx *[R/S]

9 If the answer to step number 7 was NO, proceed at step number 11; if yes, the display will show N= XXXXX.xxxx for the N-coordinate *[R/S]

10 If the answer to step number 7 was yes, the display will show E= XXXX.xxxx for the E-coordinate *[R/S]

11 **O/S?** Input the offset distance. (If left, [CHS]) [R/S]

12 The offset is displayed as O/S= XX.xxxx *[R/S]

13 The N-Coordinate is displayed as N= XXXX.xxxx *[R/S]

14 The E-coordinate is displayed as E= XXXX,xxxx. *[R/S]

O/S? Repeat step 11 until all of the offsets for this station have been calculated. Then return to step number 8 for the next station.

option: If a constant offset is required (3.0' to back of curb on the left side = 18.5' left, for instance) you can set this constant at step 11 by inputing the offset and keystroking [F]. From then on, the program will prompt **STA?** after each calculation instead of **O/S?** and will automatically use the offset which was input at all stations.

CURVE ROUTINE: To go around the curves, input the station at the beginning of the curve (B.C. station) at step number 8, and calculate any needed offsets as in steps 11 through 14.

15		When all of the required offsets at the B.C. station have been calculated	[J]
16	**DELTA?**	Input the central angle of the curve as DDD.mmss (if the curve is to the left, [CHS])	[R/S]
17	**R?**	Input the radius of the curve	[R/S]
18		Output will show R = XXX.xxxx	*[R/S]
19		Output: N= XXXX.xxxx (radius point)	*[R/S]
20		Output: E= XXXX.xxxx (radius point)	*[R/S]
21		Output: DELTA = DD.mmss	*[R/S]
22		Output: EC=	*[R/S]
23		Output: XXX+XX.xxx	*[R/S]
	STA?	Return to step number 8 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.	

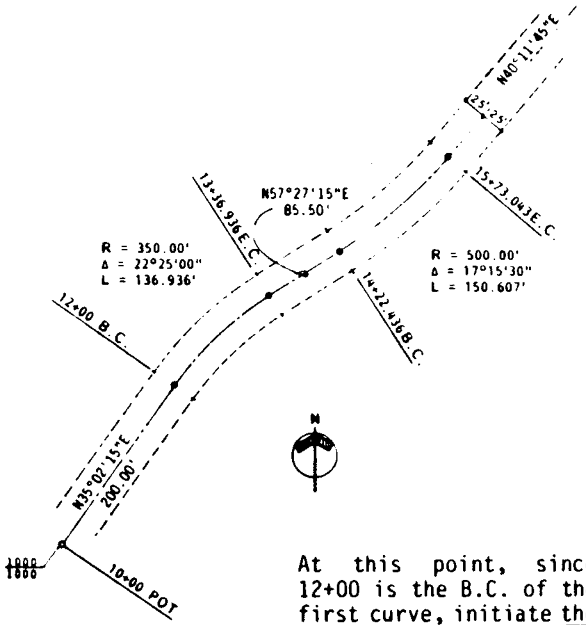
This program routine has been designed in such a way that the station which is input after beginning a curve is compared to the station at the E.C., and when it has exceeded that point reverts to calculations based on the stored tangent bearing.

The stored bearing is modified to the bearing of the tangent ahead of the curve as part of the routine when [J] has been stroked. This eliminates the need for input of the E.C. station unless it is needed for the calculation of offsets.

If the plan stationing gives the B.C. and E.C. stations to the nearest 0.01', it is a little more accurate to use the value for the E.C. which was output during the curve routine (nearest 0.001') to calculate the offsets at the E.C..

2-4 Alignment & Offsets A

In the example below, let's assume that we need to know the coordinates of the even stations (every 100') at centerline, and the coordinates of the right-of-way points opposite the B.C. and E.C. stations. Begin with [XEQ] [ALPHA] [L] [0] [ALPHA] to initialize the program and obtain a display of 0.0000. Then proceed as shown:



keystrokes:

[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"
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: 0/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: 0/S?

keystrokes:

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

output: 0/S= -25.0000
N= 1,278.9267
E= 1,199.6543

prompt: 0/S?

keystrokes:

[2] [5] [R/S]

output: 0/S= 25.0000
N= 1,236.7786
E= 1,226.5530

prompt: 0/S?

keystrokes:

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

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

prompt: 0/S?

keystrokes:

[1] [4] [2] [2] [·] [4] [3] [6] [E]

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

prompt: 0/S?

keystrokes:

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

output: 0/S= -25.0000
N= 1,324.9234
E= 1,271.7275

prompt: 0/S?

keystrokes:

[2] [5] [R/S]

output: 0/S= 25.0000
N= 1,282.7754
E= 1,298.6262

prompt: 0/S?

keystrokes:

[J]

prompt: DELTA?

keystrokes:

[1] [7] [·] [1] [5] [3] [CHS]

(curve is 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"
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: 0/S?

keystrokes:

[1] [5] [7] [3] [·] [0] [4] [3] [E]

output: 15+73.043
N= 1,402.6297
E= 1,398.1116

prompt: 0/S?

keystrokes:

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

output: 0/S= -25.0000
N= 1,418.7638
E= 1,379.0150

prompt: 0/S?

keystrokes:

[2] [5] [R/S]

output: 0/S= 25.0000
N= 1,386.4937
E= 1,417.2071

prompt: 0/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 made. 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. In the example below, the offset is to be 18.50' left of centerline equals 3.00' to the back of curb.

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

Initialize the program with [XEQ] [ALPHA] [L] [O] [ALPHA] and keystroke [D] to call up the first prompt, **BEG. STA?**.

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.

. . . . . :

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

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?**

keystrokes:

[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"
EC =
13+36.936

prompt: STA?

keystrokes:

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

output: 12+25.000

0/S= -18.5000
N= 1,195.3700
E= 1,115.5471

prompt: STA?

keystrokes:

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

output: 12+50.000

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

prompt: STA?

keystrokes:

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

output: 12+75.000

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

prompt: STA?

keystrokes:

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

output: 13+00.000

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

prompt: STA?

keystrokes:

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

output: 13+25.000

0/S= -18.5000
N= 1,266.5875
E= 1,192.6750

prompt: STA?

keystrokes:

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

[E]

output: 13+36.936

0/S= -18.5000
N= 1,273.4474
E= 1,203.1511

prompt: STA?

If more of the offset line were wanted, simply continuing input of the new stations would continue the calculations. The curves are input as in the first example, after calculating the offsets to the B.C. stations as the beginning of each curve is reached (remember to change the sign of delta on the curves to the left).

When the program is run with a printer attached, the output in the curve areas will have a space between the station and the offset/coordinate output, so that the points which are radial rather than normal to the alignment can be seen at a glance. When run without a printer, continue stroking the R/S key for output, until the next prompt appears.

This routine can be used in any of the combinations shown; constant offset coordinates can be generated with or without the centerline coordinates, varied offsets can be calculated (including multiple offsets for each station), or just centerline.

One quick way to run just centerline coordinates is to answer "no" to centerline coordinates output, and then use "0" as a constant offset.

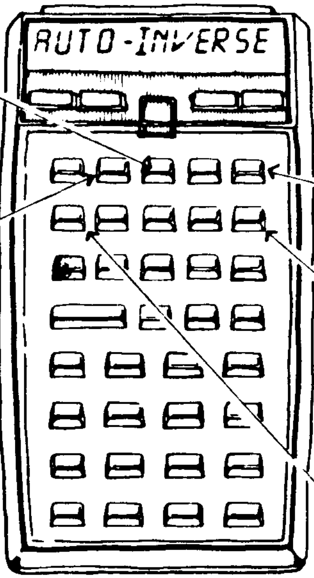
The **Auto-Inverse** routine is a combination of the previous routines. When you are going to do a layout, such as the alignment in the example, from a known instrument setup and backsite location you can inverse the radial ties at the same time that you calculate your centerline or offset points for the proposed alignment.

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

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.

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

3-2 Auto-Inverse A

For our 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 setup position for the instrument, and **C** for the backsight.

Begin with [XEQ] [ALPHA] [L] [O] [ALPHA], and input the coordinates at the instrument point (N=1210, E=930) then select which option you want to use for the **BACKSITE?** prompt input. We'll use coordinate input for the example, so:

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?**

keystrokes:

[N] [R/S]

prompt: **STA INV?**

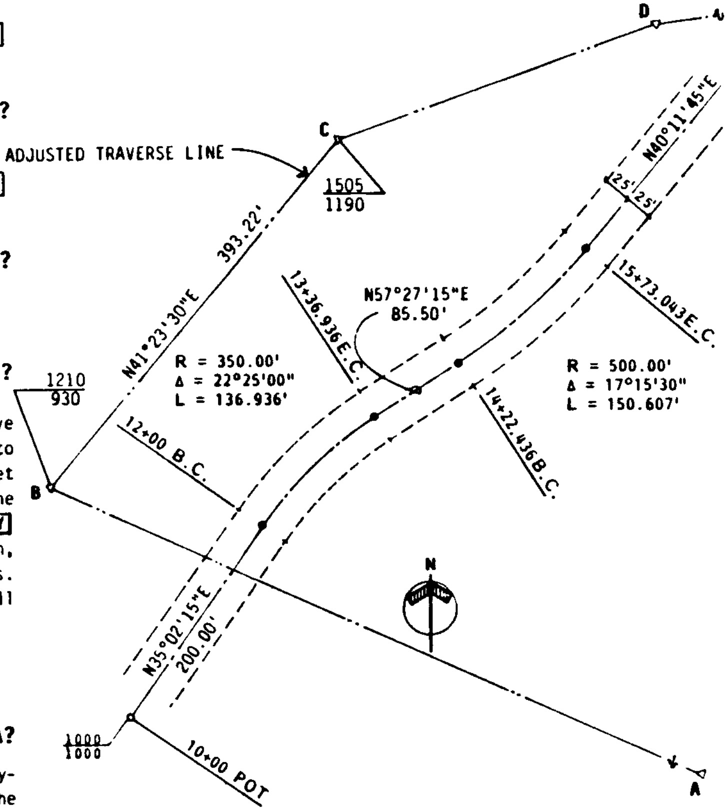
At this point, you have the option of inversing to both centerline and offset points, or just to the offsets. An answer of [Y] will give inverses to both, [N] only to the offsets. For our example, we will say NO.

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 2-1 through 2-3.



With the instrument and backsight information already input, as shown on the previous page, let's do the 25' stations at 18.5' left, from 11+00 through the first curve, as in the last example in section 2.

keystrokes:

[1] [0] [0] [0] ~~[ENTER↑]~~ 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"

prompt: STA?

keystrokes:

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

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

HD = 159.521
∡RT=
86° 4' 23"

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' 56"

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"

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"

prompt: STA?

keystrokes:

[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= 1401.3943

DELTA =
22° 25' 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' 1"

3-4 Auto-Inverse A

prompt: STA?

keystrokes:

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

output: 12+50.000

0/S= -18.5000
N= 1,215.1775
E= 1,132.0689

HD = 202.935
∠RT=
47° 8' 47"

keystrokes:

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

output: 12+75.000

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

HD = 222.828
∠RT=
42° 30' 12"

prompt: STA?

keystrokes:

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

output: 13+00.000

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

HD = 244.961
∠RT=
39° 0' 43"

prompt: STA?

keystrokes:

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

output: 13+25.000

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

HD = 268.684
∠RT=
36° 28' 4"

prompt: STA?

keystrokes:

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

output: 13+36.936
0/S= -18.5000
N= 1,273.4474
E= 1,203.1511

HD = 280.423
∠RT=
35° 31' 54"

prompt: STA?

If we had answered [Y] to the prompt **STA INV?** the output would inverse to the centerline and the offset. Output at each station would be: 11+00.000
N= 1,081.8776
E= 1,057.4112

HD = 180.690
∠RT=
93° 46' 4"

0/S= -18.5000
N= 1092.4987
E= 1042.2639

HD = 162.511
∠RT=
94° 54' 51"

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.

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

0/S= -25.0000
N= 1,255.9176
E= 1,167.4789

HD = 241.877
∠RT=
37° 39' 54"

0/S= 25.0000
N= 1216.8374
E= 1198.6676

HD = 268.755
∠RT=
47° 9' 2"

0/S= -18.5000
N= 1250.8372
E= 1171.5334

HD = 244.961
∠RT=
39° 0' 43"

Unless the centerline coordinates are needed for something else, or have never been calculated before, it is quicker to not display them by [N] at the **STA COORDS?** prompt.

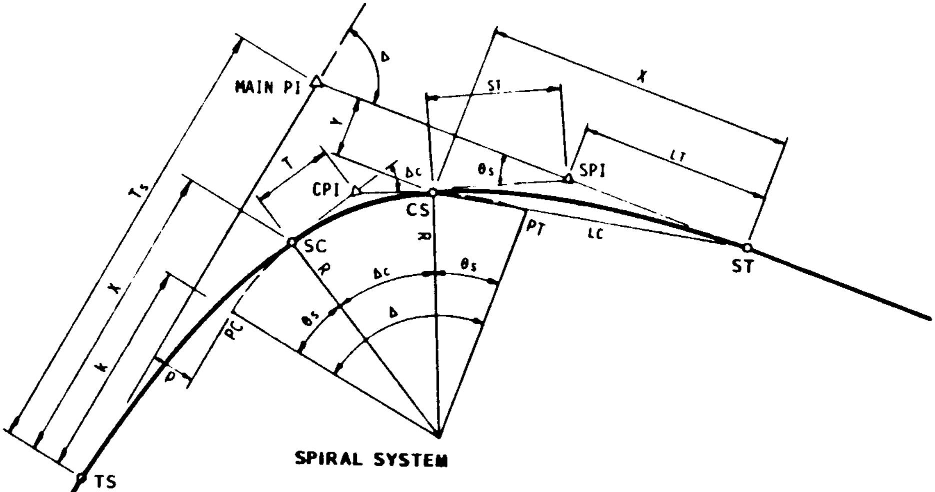
B Deflection & Chord 1-1

This program 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.

In this first routine, the solution is in the form of chord and deflection angle to any point on the spiral. In addition, the angle to turn at the calculated station to be radial to the spiral for setting offsets is output.

The nomenclature used for the spiral system and the alignment data from a typical set of plans are shown below. Curve data input is for the whole system; The entrance spiral is worked first, and then the exit spiral.



SPIRAL SYSTEM

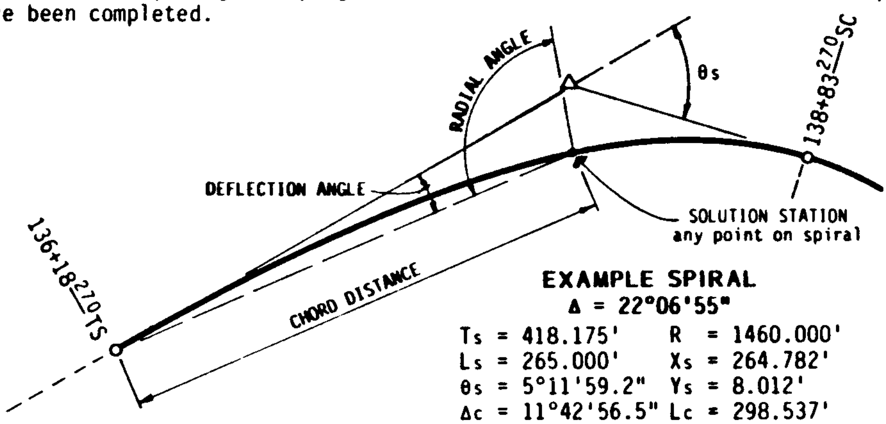
ALIGNMENT DATA - ℄

	POINT	STATION	COORDINATES N	COORDINATES E	CURVE DATA	DESIGN SPEED
M2-LINE	POT	130+99.949	38,156.113	30,142.993	PI STA 140+36.445	
	PI-4		39,026.449	30,394.100	Δ = 88°06'59" T_{s1} = 418.135' T_{s2} = 418.179'	
	TS	136+18.270	38,638.388	30,949.792	L_{s1} = 260.000' X_{s1} = 259.782'	V = 50 MPH
	SC	138+83.270	38,881.117	30,456.646	θ_{s1} = 9°11'59.2" Y_{s1} = 8.012'	
		CC CURVE 4	39,309.651	31,891.310	Δ_c = 11°42'56.3"	
	CS	141+81.807	39,179.855	30,402.800	R_c = 1460.000' L_c = 298.997'	
	ST	144+46.807	39,444.670	30,995.975	L_{s2} = 260.000' X_{s2} = 259.782' θ_{s2} = 9°11'59.2" Y_{s2} = 8.012'	
	PI-10	191+27.019	40,124.871	30,399.025		

17 & 18 WAS AN AD

1-2 Deflection & Chord — B

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.

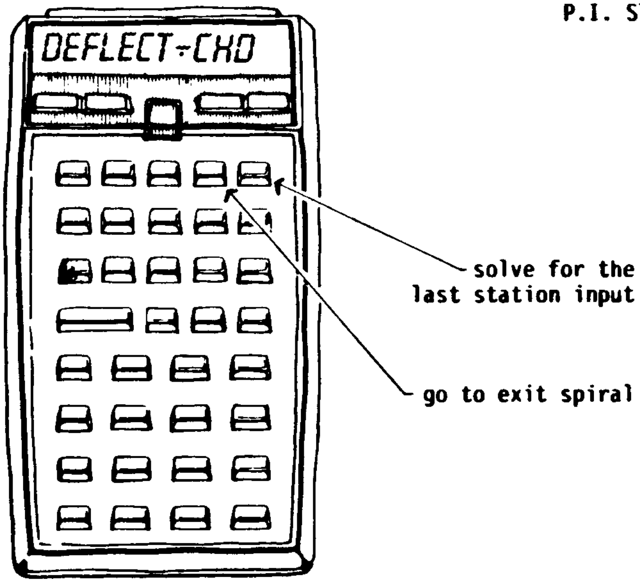


EXAMPLE SPIRAL

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



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

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.

Programs "SP", "STA" and "DMS" must be in the program memory before beginning. With the calculator in **user** mode and sized at 050, initialize by keystroking [XEQ] [ALPHA] [S] [P] [ALPHA]. The program will begin the prompts for the type of solution wanted.

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

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

3 **PI STATION?** Input the main P.I. station. If it is not shown on the curve data provided it can be calculated by inputing the TS station and adding the T distance to it. In this case, it is station 140+36.445 [R/S]

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

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

6 **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

7 **STA?** Input the station for which the deflection and chord are 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.

8 **STA?** Repeat step 7 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

9 **STA?** Input the exit spiral stations for solution in the same manner as before, repeating step 7 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.

1·4 Deflection & Chord B

As an example of the keystrokes used with this routine, and using the information on page 1·1, in the example spiral, we will calculate the entrance and exit spirals at even 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∠ = 5.1159
R = 1,460.0000

PI =
140+36.445
CENTRAL ∠ =
22° 6' 55"

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' 54"
RADIAL ∠ =
90° 19' 47"

keystrokes:
[1] [3] [8] [0] [0] [E]

output: 138+00.000
CD = 181.715
DEFLECTION ∠=
0° 48' 54"
RADIAL ∠ =
91° 37' 49"

keystrokes:
[1] [3] [8] [8] [3] [·] [2] [7]
[E]

output: 138+83.270
CD = 264.903
DEFLECTION ∠=
1° 43' 59"
RADIAL ∠ =
93° 27' 60"

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"
RADIAL ∠ =
93° 27' 60"

keystrokes:
[1] [4] [2] [0] [0] [E]

output: 142+00.000
CD = 246.739
DEFLECTION ∠=
1° 30' 12"
RADIAL ∠ =
93° 0' 25"

keystrokes:
[1] [4] [3] [0] [0] [E]

output: 143+00.000
CD = 146.802
DEFLECTION ∠=
0° 31' 55"
RADIAL ∠ =
91° 3' 50"

keystrokes:
[1] [4] [4] [0] [0] [E]

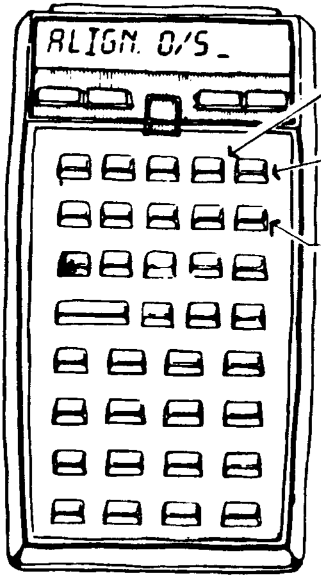
output: 144+00.000
CD = 46.807
DEFLECTION ∠=
0° 3' 15"
RADIAL ∠ =
90° 6' 29"

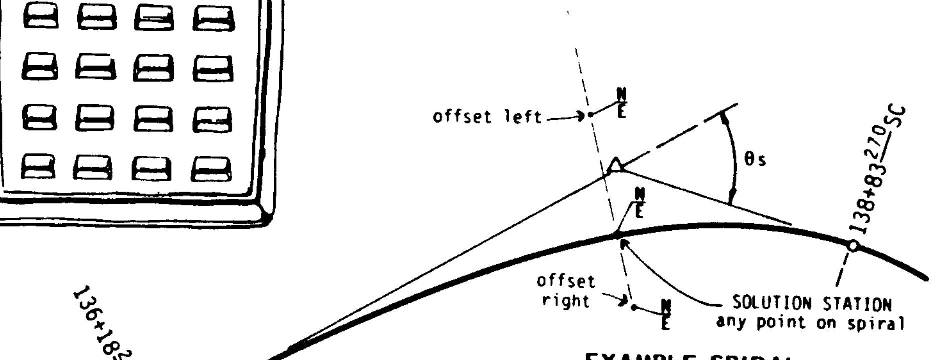
B Alignment & Offsets 2-1

With this routine, output is the coordinates along a spiral curve alignment at any station, including the circular portion. In addition to direct output of the centerline coordinates, the coordinates of 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"

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

2-2 Alignment & Offsets B

With the calculator sized at 050, and with programs "SP", "STA" and "DMS" in program memory, the program is initialized by keystroking [XEQ] [ALPHA] [S] [P] [ALPHA]. The registers are cleared and the prompting for the type of solution wanted will begin, as follows:

1	**COORD-O/S?**	Answer this prompt yes	[Y] [R/S]
2	**BRG=?**	Input the entrance tangent bearing	[R/S]
3	**QD=?**	Input the quadrant code for the bearing **toward** the P.I. of the system	[R/S]
4	**TS N↑E**	Input the north coordinate of the TS	[ENTER↑]
		Input the east coordinate of the TS (Answer the prompt **INVERSE?** no)	[R/S]
5	**PI STATION?**	Input the main P.I. station. If it is not shown on the curve data provided it can be calculated by inputing the TS station and adding the T_s distance to it. In this case, it is station 140+36.445	[R/S]
6	**DELTA?**	Input the system delta. If curve left, [CHS]	[R/S]
7	**R?**	Input the radius for the circular curve	[R/S]
8	**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

9	**STA?**	Input the station for which the 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.

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

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

11	**O/S DIST?**	Repeat step 10 until all of the required offsets for the station

have been calculated, or return to step 9 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:

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

13 **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 format than the spirals. The station will be input each time, for each offset. For the centerline station coordinates, the offset is given as 0.

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

15 **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).

16 **STA?** Repeat steps 14 and 15 until all of the stations and offsets have been calculated through the circular portion. Go to the exit spiral by keystroking [D]

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

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

19 **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.

20 **STA?** Calculate the stations through the exit spiral, beginning with the CS station, by repeating steps 9 and 10 until all of the required stations and offsets have been calculated.

2-4 Alignment & Offsets B

As an example of the keystrokes used with this routine, and using the information on page 2-1, 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∠ = 5.1159
R = 1,460.0000

PI =
140+36.445
CENTRAL ∠ =
22° 6' 55"

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. For an offset left stroke [CHS]

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]

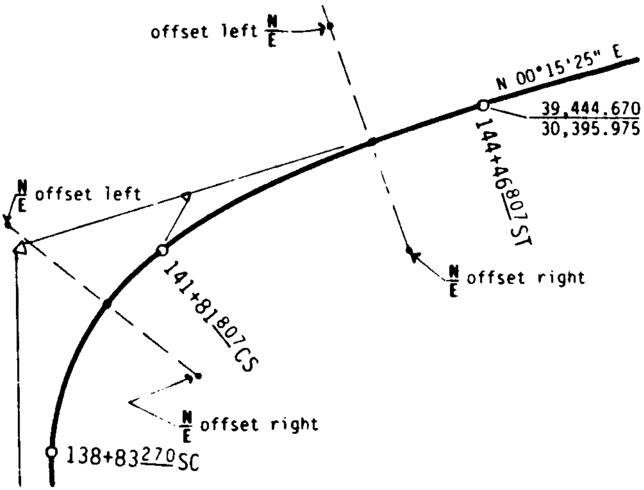
output: 138+83.270

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]



prompt: **O/S DIST?**

keystrokes:

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

output: CIRCULAR
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

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

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

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

prompt: **STA?**

keystrokes:

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

prompt: **O/S DIST?**

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]

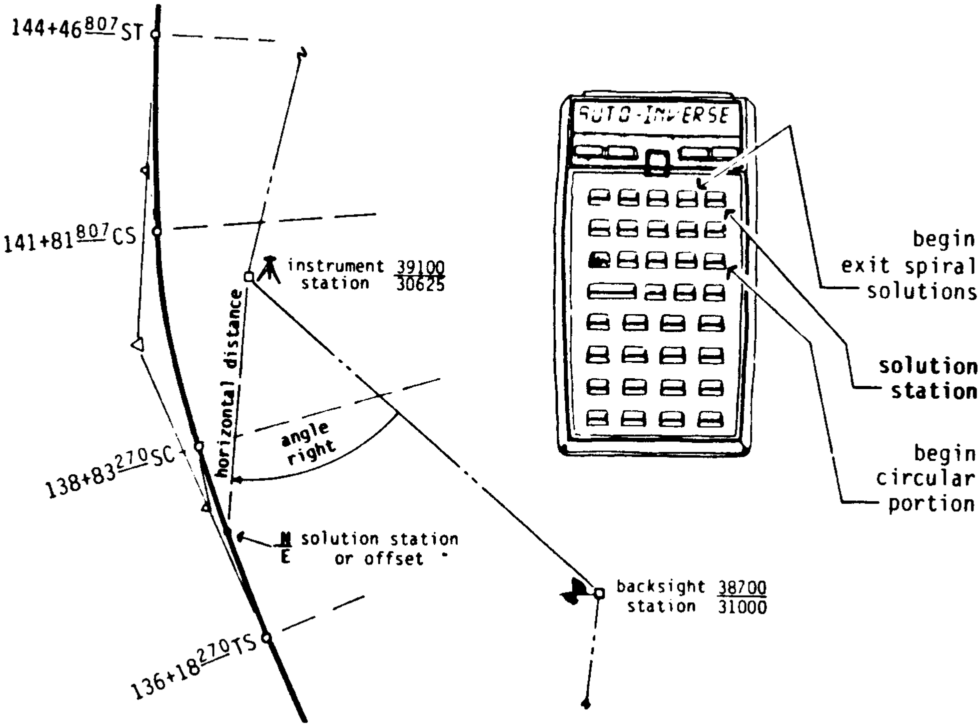
output:

144+00.000

N = 39,397.8630
E = 30,395.8093

This routine is similar to the previous one, in that it calculates the coordinates to the solution station and offsets. In addition, it 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.



With programs "SP", "STA" and "DMS" in the program memory before beginning, and the calculator at size 050, the program can be brought to the top of the program memory by keystroking [XEQ] [ALPHA] [S] [P] [ALPHA]. Prompts for the type of solution wanted will begin as follows:

1	**COORD-O/S?**	Answer this prompt yes	[Y] [R/S]
2	**BRG=?**	Input the entrance tangent bearing	[R/S]

3.2 Auto-Inverse B

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

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

5 **INVERSE?** Answer this prompt yes [R/S]

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

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

8 **PI STATION?** Input the main P.I. station. If it is not shown on the curve data provided it can be calculated by inputing the TS station and adding the Ts distance to it. In this case, it is station 140+36.445 [R/S]

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

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

11 **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

12 **STA?** Input the station for which the 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.

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

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

14 **O/S DIST?**

Repeat step 13 until all of the required offsets for the station have been calculated, or return to step 12 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:

15 **O/S DIST?**

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

16 **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 format than the spirals. The station will be input each time, for each offset. For the centerline station coordinates, the offset is given as 0.

17 **STA?**

Input the next station

[R/S]

18 **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).

19 **STA?**

Repeat steps 17 and 18 until all of the stations and offsets have been calculated through the circular portion. Go to the exit spiral by keystroking

[D]

20 **BRG=?**

Input the bearing of the exit tangent

[R/S]

21 **QD=?**

Input the quadrant code for the exit tangent in the direction **toward** the P.I.

[R/S]

22 **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.

23 **STA?**

Calculate the stations through the exit spiral, beginning with the CS station, by repeating steps 12 and 13 until all of the required stations and offsets have been calculated.

3·4 Auto-Inverse B

The keystrokes for this routine are essentially the same as the previous routine. The difference is that we are also calculating the angle to turn and the distance to measure to the solution station from a known instrument setup. The added input is the coordinates of the instrument and backsight stations.

To use the offset option, and demonstrate the output, we will calculate the coordinates for an offset at 20 feet left and right at one of the stations in the entrance spiral and circular 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:

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

[.] [3] [8] [8] [ENTER↑]

[illegible] [illegible] [5] [4] [9]

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

~~prompt: INVERSE?~~

~~keystrokes:~~

~~[Y] [R/S]~~

prompt: INST N↑E?

keystrokes:

[illegible] [9] [1] [0] [0] [ENTER↑]

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

prompt: BACKSITE?

keystrokes:

[illegible] [8] [7] [0] [0] [ENTER↑]

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

prompt: PI STATION?

keystrokes:

[illegible] [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∠ = 5.1159
R = 1,460.0000

PI =
040+36.445
CENTRAL ∠ =
22° 6' 55"

TS =
036+18.270
SC =
038+83.270

4

prompt: STA?

keystrokes:

[illegible] [3] [7] [0] [0] [E]

NOT **output:** 037+00.000

N = [illegible]8,714.3292
E = [illegible],519.5814

HD = 399.819
∠RT=
58° 26' 24"

prompt: O/S DIST? LINE [illegible]

We will use this station as an example for the offsets. For an offset left stroke [CHS]

keystrokes:

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

output: O/S = -20.0000
N = [redacted]8,707.0434
E = [redacted],500.9556

HD = 412.070
∡RT=
60° 40' 18"

prompt: **O/S DIST?**

keystrokes:

[2] [0] [R/S]

output: O/S = 20.0000
N = [redacted]8,721.6149
E = [redacted],538.2071

HD = 388.212
∡RT=
56° 4' 17"

prompt: **O/S DIST?**

keystrokes:

■ [3] [8] [0] [0] [E]

output: [redacted]38+00.000

N = [redacted]8,807.9846
E = [redacted]0,484.5431

HD = 324.039
∡RT=
68° 50' 22"

prompt: **O/S DIST?**

keystrokes:

■ [3] [8] [8] [3] [.] [2] [7] [E]

output: [redacted]38+83.270

N = [redacted]8,887.1168
E = [redacted],458.6462

HD = 270.172
∡RT=
81° 9' 27"

prompt: **O/S DIST?**

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

keystroke: [J]

prompt: ~~O/S DIST?~~

keystrokes:

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

output: ~~CIRCULAR~~

RADIUS POINT
N = [redacted]9,305.6513
E = [redacted]1,857.3702

prompt: **STA?**

keystrokes:

■ [3] [9] [0] [0] [R/S]

prompt: **O/S DIST?**

keystrokes:

[0] [R/S]

output:

[redacted]39+00.000
N = [redacted]8,903.1717
E = [redacted]0,453.9422

HD = 260.772
∡RT=
84° 8' 43"

prompt: **STA?**

keystrokes:

■ [3] [9] [0] [0] [R/S]

prompt: **O/S DIST?**

keystrokes:

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

output: [redacted]39+00.000
O/S = -20.0000
N = [redacted]8,897.6583
E = [redacted]0,434.7171

HD = 277.758
∡RT=
86° 23' 36"

prompt: **STA?**

keystrokes:

■ [3] [9] [0] [0] [R/S]

prompt: **O/S DIST?**

keystrokes:

[2] [0] [R/S]

output: [redacted]39+00.000
O/S = 20.0000
N = [redacted]8,908.6852
E = [redacted],473.1672

HD = 244.243
∡RT=
81° 35' 20"

prompt: **STA?**

keystrokes:

■ [4] [0] [0] [0] [R/S]

prompt: **O/S DIST?**

keystrokes:

[0] [R/S]

output: [redacted]40+00.000
N = [redacted]9,000.1655
E = [redacted]0,429.6873

HD = 219.349
∡RT=
106° 4' 42"

prompt: STA?

keystrokes:

■ [4] [1] [0] [0] [R/S]

prompt: O/S DIST?

keystrokes:

[0] [R/S]

output: [illegible]41+00.000

N = [illegible]9,898.5919
E = [illegible]0,412.1275

HD = 212.877
∠RT=
132° 46' 24"

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:

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

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

prompt: STA?

keystrokes:

■ [4] [1] [8] [1] [.]
[8] [0] [7] [E]

output: 141+81.807

N = [illegible]9,179.8546
E = [illegible]0,402.7994

HD = 236.114
∠RT=
152° 55' 11"

prompt: O/S DIST?

keystrokes:

■ [4] [2] [0] [0] [E]

output: 142+00.000

N = [illegible]9,197.9891
E = [illegible]0,401.3422

HD = 244.182
∠RT=
156° 48' 42"

prompt: O/S DIST?

keystrokes:

■ [4] [3] [0] [0] [E]

output: 143+00.000

N = [illegible]9,297.8695
E = [illegible]0,396.6796

HD = 302.130
∠RT=
174° 3' 56"

prompt: O/S DIST?

keystrokes:

■ [4] [4] [0] [0] [E]

output: 144+00.000

N = [illegible]9,397.8630
E = [illegible]0,395.8093

HD = 375.833
∠RT=
185° 34' 33"

prompt: O/S DIST?

keystrokes:

■ [4] [4] [4] [6]
[.] [8] [0] [7] [E]

output: 144+46.807

N = [illegible]9,444.6697
E = [illegible]0,395.9750

HD = 413.823
∠RT=
189° 32' 57"

When the calculations are being done for radial stakeout with this program, 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.

B Tangent Offset 4-1

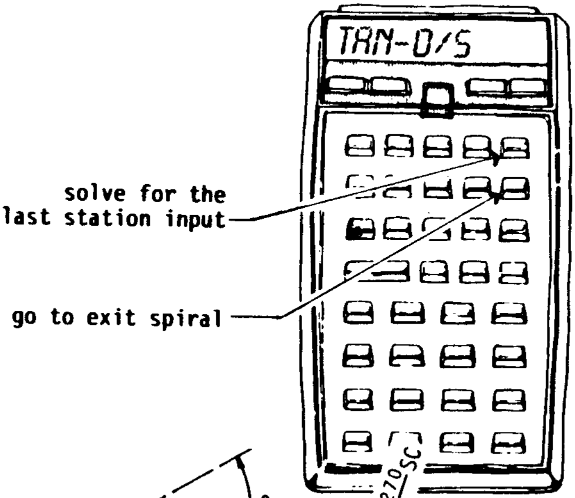
In this routine, the solution is in the form of the tangent distance and the offset from the tangent to any point on the spiral. The tangent distance is the distance along the entrance tangent from the TS, or back along the exit tangent from the ST. The tangent offset is measured at right angles to the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

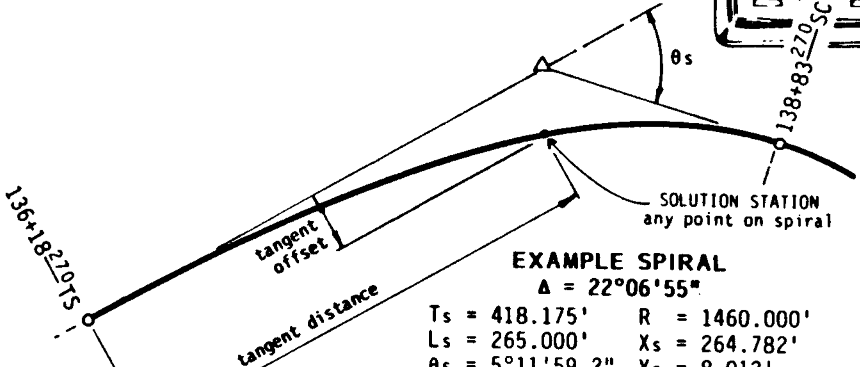
To illustrate this routine, the spiral data below will be used. The entrance spiral is shown below, and the curve data for the spiral portions is the same for both the entrance and exit spirals. Stationing at the CS and ST will be output by the program after calculations for the entrance spiral have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

Step-by-step instructions are shown on the next page, followed by a keystroke example.





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

4-2 Tangent Offset — B

As in the other examples, the program will begin the prompting for the type of solution wanted when you keystroke [XEQ] [ALPHA] [S] [P] [ALPHA]. Remember to be sized at 050 and to have the utility programs "DMS" and "STA" in program memory, as well as "SP".

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

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

3 **PI STATION?** — Input the main P.I. station. If it is not shown on the curve data provided it can be calculated by inputing the TS station and adding the Ts distance to it. In this case, it is station 140+36.445 [R/S]

4 **DELTA?** — Input the system delta. If the curve is a curve to the left, [CHS] [R/S]

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

6 **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

7 **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.

8 **STA?** — Repeat step 7 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

9 **STA?** — Input the exit spiral stations for solution in the same manner as before, repeating step 7 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.

As an example of the keystrokes used with this routine, and using the information on page 4-1, in the example spiral, we will calculate the entrance and exit spirals at even stations.

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∠ = 5.1159
R = 1,460.0000
PI =
140+36.445
CENTRAL ∠ =
22° 6' 55"
TS =
136+18.270
SC =
138+83.270

At this point we begin to calculate the stations along the entrance spiral. While any station may be calculated, we will calculate the 100' even stations for this example

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

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
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?

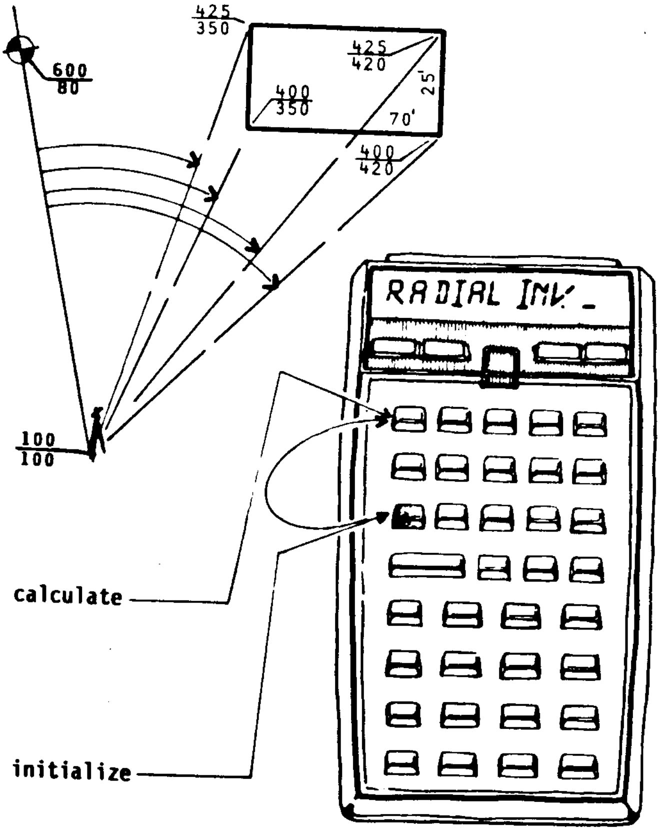
keystrokes:
[1] [4] [4] [0] [0] [E]

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

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.

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.

The calculator should be sized at 050. If the calculator has been off, and a printer is not attached, the numbers will 'flash' by ... in this case SF21 and proceed with the keystrokes as shown below:



keystrokes:

[GTO] (key in [shift] [RCL])
[ALPHA] [S] [P] [ALPHA]
[a] (key in as [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"

prompt: N↑E ?

5-2 Radial Inverse B

keystrokes:

[4] [0] [0] [ENTER↑]

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

output: 400.0000
350.0000

HD = 390.512
∡RT=
42° 5' 46"

keystrokes:

[4] [2] [5] [ENTER↑]

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

output: 425.0000
420.0000

HD = 456.098
∡RT=
46° 50' 47"

keystrokes:

[4] [0] [0] [ENTER↑]

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

output: 400.0000
420.0000

HD = 438.634
∡RT=
49° 8' 18"

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 at 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.

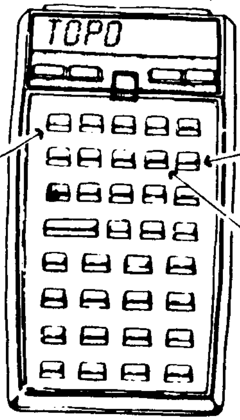
```
T=  127.1625
Z=  94.0235
Y=  206.5400
X= -5.0000

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

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

The baseline for the topo may be two points along a traverse line, or along the existing alignment of a 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.

stroke [A] after input to begin solution



keystroke [J] to enable stack-print option

keystroke [I] to halt stack-print option

KEYBOARD ASSIGNMENTS

1-2 Topo C

To begin, the calculator should contain both of the utility programs "STA" and "DMS", as well as "TT", and be sized at 045. Initialize the program with the keystrokes [XEQ] [ALPHA] [T] [T] [ALPHA]. The program will begin with a prompt for the station at the instrument location.

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

2 **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]

3 **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 is in a curve, answer [Y], and answer the additional prompts for curve data. [R/S]

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

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

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

7 **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 for the purpose of the particular survey [R/S]

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

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

10 **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. If the

answer is yes, but the instrument was not on the curve, the program will prompt for the curve data as shown above in steps 4 thru 6
[R/S]

11 **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 4 through 6. 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]

12 **SHOW GRADE?**

Answer this prompt no,
[N] [R/S]

13 **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]

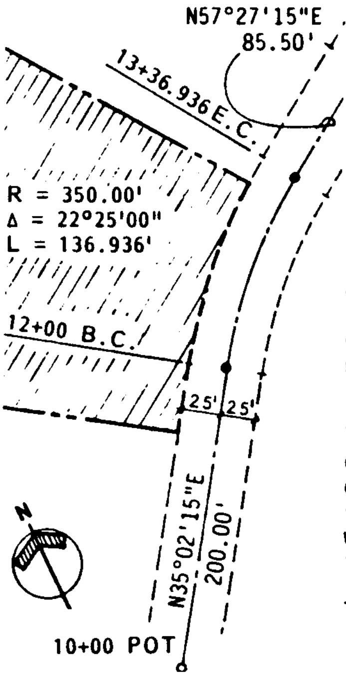
* You can halt the print-stack option by keystroking
[I]

Output will be the station, offset and elevation at the shot. Return to step 13 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 gets slightly longer when you have passed the curve area with the shots.

1-4 Topo C



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 street 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 showing what was shot.*

To begin, initialize the program with [XEQ] [ALPHA] [T] [T] [ALPHA], and begin answering the prompts.

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 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 stack is printed 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
```

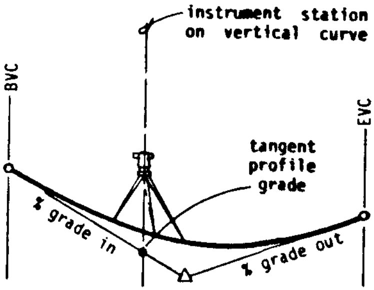
```
6

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

C As-builts 2-1

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 the 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.

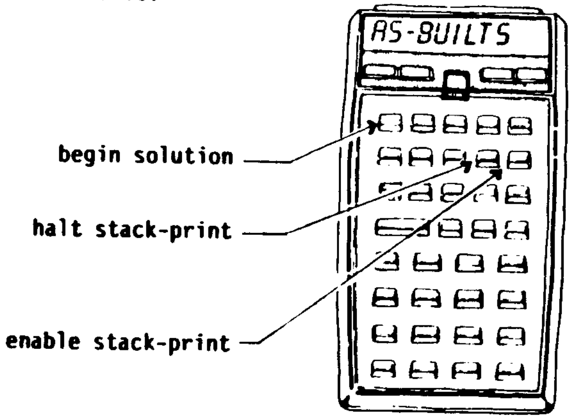


The routine can carry one grade break or vertical curve at a time, together with the entrance and exit grades.

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 the printer is attached.



2-2 As-builts C

Begin with the calculator sized at 045 and with programs "STA", "DMS" and "TT" in the program memory. To initialize the program, keystroke [XEQ] [ALPHA] [T] [T] [ALPHA], and the program will begin with the prompt for the setup location.

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

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

3 **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 for curve data. [R/S]

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

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

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

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

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

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

10 **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]

11 **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 4 through 6. If there is no curve area involved, answer [N] [R/S]

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

13 **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]

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

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

16 **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:

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

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

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

20 **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↑]

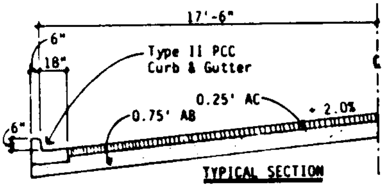
Input the rod reading. If you are sighting directly to a point, and slope chaining to it, input 0. An inverted rod is a 'plus' rod, and a normal rod is a 'minus' rod ([CHS] for minus rod) [A]

Output will be the station, offset, elevation and finished grade at the shot. Return to step 20 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.

2-4 As-builts C

This program routine is used much the same way as TOPO, and areas including horizontal curves can be incorporated in the same way. For this example, we'll use a straight section of alignment, since the new keystrokes are those which deal with the **vertical** alignment.

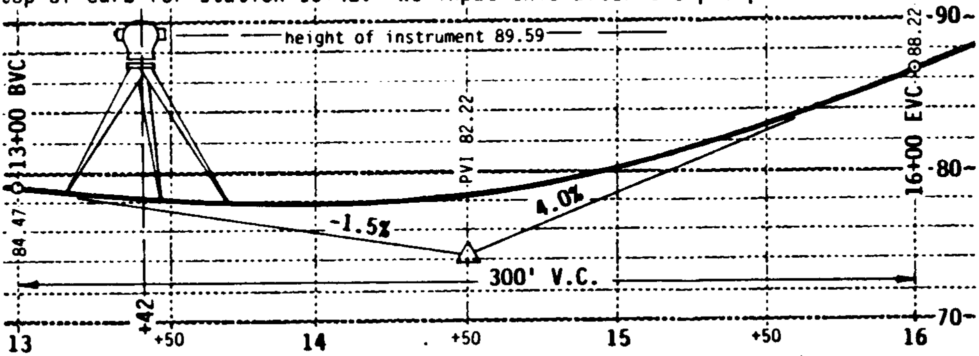


A typical section for a street is shown to the left, and we will 'as-built' the top of curb at the face of curb on the left side of the street for our example. The centerline profile for the street is shown below, and we will assume that the instrument is set up at station 13+42, backsighting station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



For this example we will assume an H.I. 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
3	174°34'38"	89°35'25"	184.76	5.00

To begin, initialize the program with [XEQ] [ALPHA] [T] [T] [ALPHA], and begin answering the prompts.

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]

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

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

prompt: INPUT SHOT

keystrokes:

[1] [7] [4] [.] [3] [4] [3] [8] [ENTER↑]

[8] [9] [.] [3] [5] [2] [5] [ENTER↑]

[1] [8] [4] [.] [7] [6] [ENTER↑]

[5] [CHS] [A]

output: 3
STA 15+25.93
AT 17.46 LT
ELEV = 85.91
GR = 85.91

C Remote Slope Staking 3-1

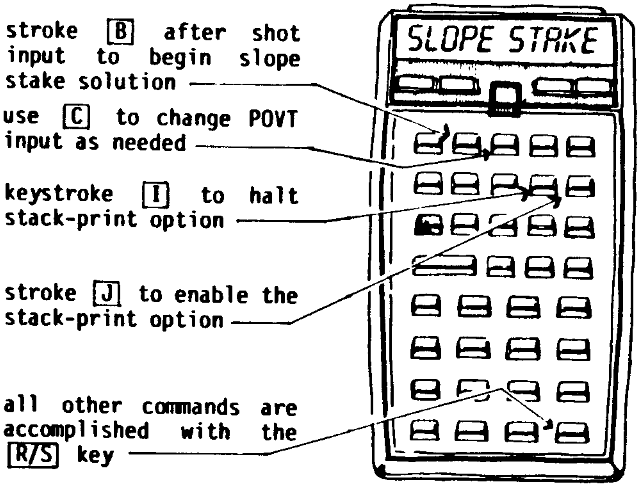
Setting slope stakes along an alignment prior to construction is one of the most time-consuming processes in construction surveying. This routine allows the staking of a large area to be accomplished from each instrument setup. It is still a 'trial and error' procedure, but it has some distinct advantages.

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 usful 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 (a minus sign indicates that the point is closer to centerline) to go 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 half-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 inputing a new value when they are displayed.

3-2 Remote Slope Staking C

To begin, the calculator should be sized at 045 and have the programs "TT", "STA" and "DMS" in the program memory. Initialize the program by keystroking [XEQ] [ALPHA] [T] [T] [ALPHA] to display the first prompt.

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

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

3 **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 for curve data. [R/S]

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

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

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

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

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

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

10 **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]

11 **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 4 through 6. If there is no curve area involved, answer [N] [R/S]

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

GUN FIN ...

13 ~~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]

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

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

16 **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:

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

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

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

20 ~~INPUT SHOT~~ HS HD VD RD S This is the prompt to begin input of the shot information. Input the horizontal angle HS A ~~[ENTER↑]~~

~~Input the vertical (zenith) angle~~ ~~[ENTER↑]~~

~~Input the measured slope distance~~ ~~[ENTER↑]~~

Input the rod reading. ~~[CHS]~~ for 'minus' (normal) rod ~~[B]~~

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

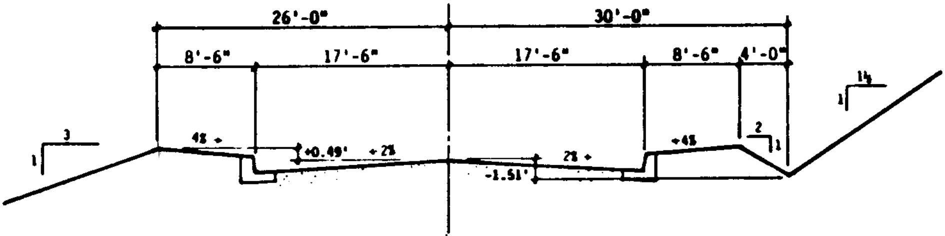
22 **SR=0:1** Input the correct slope ratio value, if different from the value displayed [R/S]

the display will now give the distance to the catch point. If the distance is considered to be within acceptable tolerance, [R/S], or if it is not, return to step 20 and input the next trial shot information.

23 To change the POVT value, input the new elevation H

3-4 Remote Slope Staking C

For the keystroke procedure example, we can assume the same setup and alignment conditions as we had on pages 50 and 51, but use the additional information in the section shown below for slope staking.



TYPICAL FILL SECTION ℄ TYPICAL CUT SECTION

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 inputing the other number and keystroking [illegible] H/ The half-width and the slope ratio also change, and these can be changed be inputing the new number when they are displayed.

To begin, with the calculator sized at 045, initialize the program with [XEQ] [ALPHA] [T] [T] [ALPHA], and begin answering the prompts.

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'

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**

keystrokes:

[R/S]

display: **SR= 3:1**

keystrokes:

[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+49.86
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"
vertical angle = 87°24'00"
slope distance = 188.24'
the rod, again is 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 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:

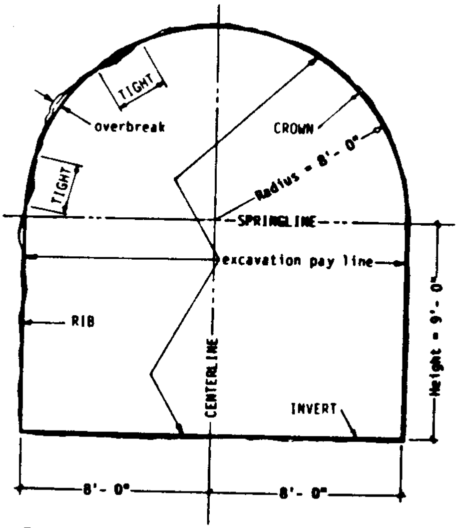
```
CUT 8.9
 AT 13.4
STA 15+24.98
AT 43.34 RT
ELEV = 93.13
GR = 84.23
```

C Tunnel Tights 4-1

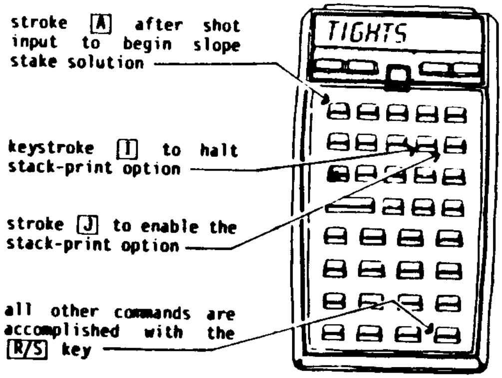
This section of programs originated as a program for tight-checking, and is capable of carrying both a horizontal curve and a vertical curve alignment at the same time.

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 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.



TYPICAL TUNNEL SECTION



The typical section shown above gives the basic nomenclature of the tunnel, and the dimensions which will be used for the keystroke example. The keystrokes used for this routine are also shown above, and input is the same as in the provious 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. Springline elevation is used as profile grade, but the finished grade which is output will be the grade at the tunnel invert.

4-2 Tunnel Tights

Begin with the calculator sized at 045, with programs "TT", "STA" and "DMS" in the program memory. The prompting will begin when you initialize with the keystrokes [XEQ] [ALPHA] [T] [T] [ALPHA].

1 INST. STA.?	Input the instrument station	[R/S]
2 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]
3 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 for curve data.	[R/S]
4 B.C. STA?	Enter the station at which the curve starts	[R/S]
5 RADIUS?	Input the radius of the curve	[R/S]
6 DELTA?	Input delta (DD.MMSS). If curve left, [CHS]	[R/S]
7 H.I.?	Input the elevation at the height of the instrument.	[R/S]
8 BKSITE STA?	Input the backsight station.	[R/S]
9 OFFSET?	Input 0 if on centerline, or the offset distance if not. If the offset is left, [CHS]	[R/S]
10 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]
11 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 4 through 6. If there is no curve area involved, answer [N]	[R/S]
12 SHOW GRADE?	Answer this prompt yes	[Y] [R/S]

13 **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]

14 **GRADE?**

Input the percent of grade. If negative, [CHS] [R/S]

15 **SPRINGLINE?**

Answer this prompt YES [Y] [R/S]

16 **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]

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. In the case of a grade-break instead of a vertical curve, input 0 [R/S]

20 **GRADE OUT?**

Input the percent of grade leaving the vertical curve. If negative, [CHS] [R/S]

21 **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↑]

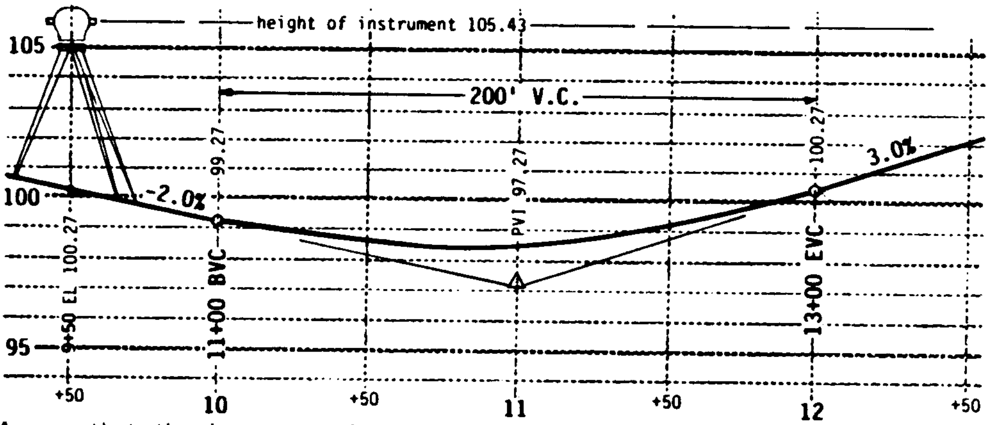
Input 0, since you are sighting directly to the zero end of the tape and there is no rod correction [A]

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 21 for the next shot.

4-4 Tunnel Tights C

For the keystroke example, we will use the dimensions of the tunnel shown in the section on page 61, 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'



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, and programs "TT", "STA" and "DMS" in the progam memory, you can begin once the setup and backsight points are known. Keystroke [XEQ] [ALPHA] [T] [T] [ALPHA] to begin the prompt sequence.

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

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

4.6 Tunnel Tights C

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.

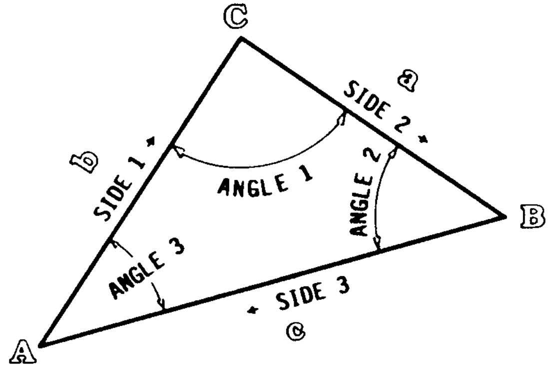
In common practice the whole perimeter of the tight area is painted, like a contour line of "0" tight, and at least one or two spots on the tight are painted to show the depth of material to be removed. It is generally better to paint a little "loose", that is, a little more than necessary, to insure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

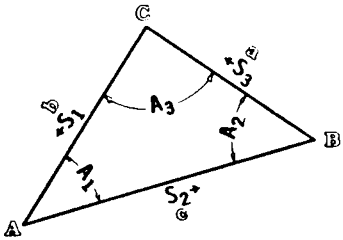
T= 170.2910	T= 166.2115	T= 167.3740	T= 163.5210	T= 162.2645
Z= 75.1820	Z= 87.4015	Z= 80.3155	Z= 90.2710	Z= 79.2500
Y= 35.5000	Y= 34.2000	Y= 35.9000	Y= 28.9000	Y= 26.8000
X= 0.0000	X= 0.0000	X= 0.0000	X= 0.0000	X= 0.0000
STA 9+83.87	STA 9+83.21	STA 9+84.59	STA 9+77.76	STA 9+75.12
AT 5.68 LT	AT 8.06 LT	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

D Triangle Solutions 1-1

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 can 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 in 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 utility program "DMS" must be in the program memory if the program is being used with a printer attached.

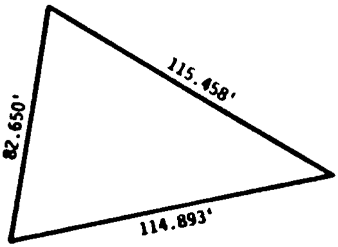
Bring the program to the top of program memory by keystroking [XEQ] [ALPHA] [T] [R] [ALPHA], after which the keystrokes are as shown for each of the solution types. It is not necessary to re-enter the program for each triangle solution and each solution of additional triangles may be calculated by simply starting with the keystrokes to input the next problem.

1-2 Triangle Solutions D

S-1, S-2, S-3 THREE SIDES KNOWN:

1	Input the length of side one	[ENTER↑]
2	Input the length of side two	[ENTER↑]
3	Input the length of side three	[A]

EXAMPLE **keystrokes:** **output:**



[8] [2] [·] [6] [5] [ENTER↑]
[1] [1] [5] [·] [4] [5] [8] [ENTER↑]
[1] [1] [4] [·] [8] [9] [3] [A]

S-1 = 82.650
a-1 =
68° 36' 29.9"

S-2 = 115.458
a-2 =
42° 3' 7.8"

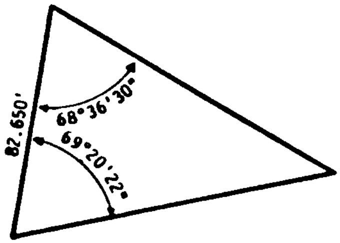
S-3 = 114.893
a-3 =
69° 20' 22.3"

area = 4,442.601

A-3, S-1, A-1 TWO ANGLES AND THE INCLUDED SIDE:

1	Input the value for angle three (D.MMSS)	[ENTER↑]
2	Input the length of side one	[ENTER↑]
3	Input the value of angle one (D.MMSS)	[B]

EXAMPLE **keystrokes:** **output:**



[6] [9] [·] [2] [0] [2] [2] [ENTER↑]
[8] [2] [·] [6] [5] [ENTER↑]
[6] [8] [·] [3] [6] [3] [B]

S-1 = 82.650
A-1 =
68° 36' 30.0"

s-2 = 115.458
a-2 =
42° 3' 8.0"

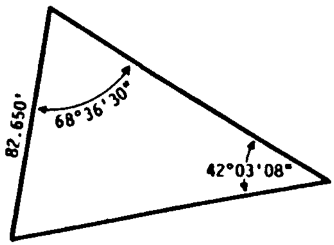
s-3 = 114.893
A-3 =
69° 20' 22.0"

area = 4,442.595

S-1, A-1, A-2 ONE SIDE AND THE TWO FOLLOWING ANGLES KNOWN:

1	Input the length of side one	[ENTER↑]
2	Input the value of angle one (D.MMSS)	[ENTER↑]
3	Input the value of angle two (D.MMSS)	[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"

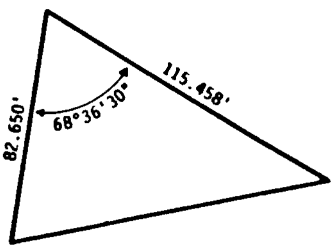
s-3 = 114.893
a-3 =
69° 20' 22.0"

area = 4,442.595

S-1, A-1, S-2 TWO SIDES AND THE INCLUDED ANGLE KNOWN:

1	Input the length of side one	[ENTER↑]
2	Input the value for angle one (D.MMSS)	[ENTER↑]
3	Input the length of 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"

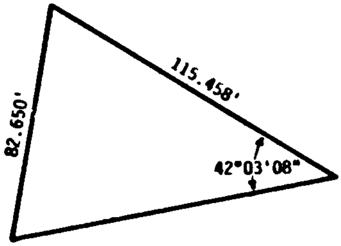
area = 4,442.601

1-4 Triangle Solutions D

S-1, S-2, A-2 TWO SIDES AND THE FOLLOWING ANGLE KNOWN: There are two possible solutions for a triangle with this configuration of known parts, and both solutions are output.

1	Input the length of side one	[ENTER↑]
2	Input the length of side two	[ENTER↑]
3	Input the value for angle two (D.MMSS)	[E]

EXAMPLE



keystrokes:

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

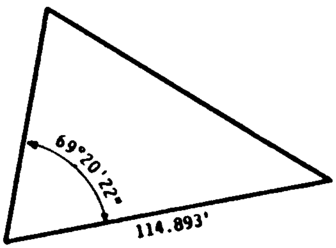
output:

first solution:	second solution
S-1 = 82.650	S-1 = 115.458
a-1 = 68° 36' 29.2"	a-1 = 42° 3' 8.0"
S-2 = 115.458	s-2 = 56.570
A-2 = 42° 3' 8.0"	a-2 = 110° 39' 37.2"
s-3 = 114.893	S-3 = 82.650
a-3 = 69° 20' 22.8"	a-3 = 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	[ENTER↑]
2	Input the length of side one	[ENTER↑]
3	Input the value of angle one (D.MMSS)	[F]

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"

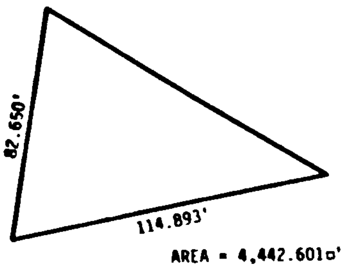
s-3 = 115.458
a-3 = 42° 3' 8.0"

AREA = 4,442.601

AREA, S-1, S-2 THE AREA, AND TWO SIDES KNOWN:

1	Input the area	[ENTER↑]
2	Input the length of side one	[ENTER↑]
3	Input the length of side two	[6]

EXAMPLE



keystrokes:

[4] [4] [4] [2] [·] [6] [0] [1] [ENTER↑]

[1] [1] [4] [·] [8] [9] [3] [ENTER↑]

[8] [2] [·] [6] [5] [0] [6]

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

When the printer is attached, the output is as shown in the above examples. The known information is printed in capital letters and the calculated are in lower case.

There is no solution for a case of three angles known, because this produces an infinite number of similar triangles. At least one side must be known in addition to the angles in order to arrive at a solution for the triangle.

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The Program Listings

This solutions book is intended to help in the calculations of required field information. In order to best accomplish this aim, it is important that the program steps be keyed in properly.

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 (♦) as a visulal aid. When keying in the program ignore the diamond, and key in **LBL** by keystroking [shift] [LBL] (the STO button), followed by either the lable number of [ALPHA] the lable 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]. The character * in the listing is the [X] button (to multiply) and the character printed as / is the divide button.

UTILITY PROGRAMS

The program listings on page 76 are subroutines which are used by the other programs. These subroutines must be in the program memory in order for the other programs to work properly. In addition, the program listed below must be in program memory if the programs are being used in a calculator which does not contain a Hewlett-Packard Survey Pac module.

```
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
28 .END.
```

When executed "STA" will change the output form to XXX+XX.xxx, the form which is normally used by surveyors.

```
01♦LBL "STA"
02 STO 27
03 100
04 /
05 ENTER↑
06 ENTER↑
07 INT
08 X<>Y
09 FRC
10 100
11 *
12 CLA
13 "+"
14 ASTO 28
15 CLA
16 "0"
17 ASTO 29
18 CLA
19 CF 29
20 FIX 0
21 ARCL Y
22 ARCL 28
23 10
24 X>Y?
25 ARCL 29
26 RDN
27 FIX 3
28 ARCL X
29 AVIEW
30 SF 29
31 RCL 27
32 RTN
```

When used with a printer attached, "DMS" changes the output of angles to the form DD°MM'SS", as a way to distinguish the angle as degrees minutes and seconds, rather than decimal degrees.

```
33♦LBL "DMS"
34 STO 23
35 RDN
36 STO 24
37 RDN
38 STO 25
39 RDN
40 STO 26
41 RDN
42 ENTER↑
43 INT
44 CF 29
45 FIX 0
46 ACX
47 -
48 100
49 *
50 ABS
51 STO 22
52 3
53 SKPCOL
54 6
55 ACCOL
56 9
57 ACCOL
58 ACCOL
59 6
60 ACCOL
61 2
62 SKPCOL
63 RCL 22
64 INT
65 ACX
66 39
67 ACCHR
68 RCL 22
69 FRC
70 100
71 *
72 FIX 1
73 ACX
74 34
75 ACCHR
76 PRBUF
77 RCL 26
78 RCL 25
79 RCL 24
80 RCL 23
81 FIX 4
82 SF 29
83 RTN
84 END
```

NOTE:
output as written will give the answer to the nearest 0.1" of angle.

If the nearest second of angle is all that will be required, delete step number 72.

A

Program step	Comment
01♦LBL "LO"	initiate program, set flags to correct status
02 CLRG	
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 response status question
20 "Y"	
21 ASTO X	
22 AON	
23 "INV. ONLY?"	question on inverse to coordinate input only, or to output of station-offset routine.
24 PROMPT	
25 ASTO Y	
26 AOFF	
27 X=Y?	
28 SF 06	controls prompts for inverse only routine (answer Y to the question above sets flag 06)
29 FS? 06	
30 GTO 17	
31 "Y"	
32 ASTO X	
33 AON	
34 "STA INV?"	
35 PROMPT	
36 ASTO Y	
37 AOFF	
38 X=Y?	if the answer to the inverse only was no, questions whether or not centerline inverses are wanted. inverses centerline if flag 04 is clear.
39 CF 04	
40 RTN	
41♦LBL 06	
42 FS? 09	
43 RTN	
44 RCL 02	
45 RTN	
46♦LBL C	inverse routine for input with backsite coordinates known.
47 STO 06	
48 RDN	
49 STO 05	
50 "BACKSITE?"	
51 PROMPT	input of north [ENTER] & east coordinate for inverse routine backsite setup.
52 RCL 06	
53 -	
54 X<>Y	
55 RCL 05	
56 -	
57 R-P	
58 CLX	
59 X<>Y	back azimuth calculated for inverse routine.
60 X<0?	
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 backsight
72 XEQ "AZ"	bearing known.
73 STO 01	
74 SF 07	will inverse when flag 07 is
75 XEQ 01	set.
76♦LBL D	alignment routine input.
77 "BEG. STA?"	
78 PROMPT	sets beginning station.
79 STO 03	
80 "COORD. N↑E"	
81 PROMPT	
82 STO 08	beginning coordinates stored.
83 RDN	
84 STO 07	
85 XEQ "AZ"	converts tangent bearing to
86 STO 00	azimuth and stores for use in
87 "Y"	the alignment routine.
88 ASTO X	
89 AON	
90 "STA COORDS?"	
91 PROMPT	status question for the output
92 ASTO Y	of the centerline coordinates.
93 AOFF	
94 X=Y?	
95 CF 03	retards the display of coord-
96 "STA?"	inates on centerline when set.
97 PROMPT	
98♦LBL E	calculate coordinates for the
99 STO 20	solution station input.
100 FS? 08	
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"	sub-routine changes X register
110 FIX 4	number to XXX+XX.xxx output

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 subroutine.
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 coordi-
136♦LBL 03	nates in X/Y registers.
137 RCL 00	
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 is being used.
157 "O/S= "
158 FS? 09          label 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           inverse to X/Y register coords
178 FS? 01
179 GTO 16
180 GTO 03
181 RTN
182♦LBL 17
183 FS? 06
184 "N↑  E"         input of known coordinates for
185 PROMPT          solution.
186 GTO 18
187 RTN
188♦LBL F
189 SF 01
190 STO 02
```

```
191 GTO 03
192 RTN
193♦LBL A           inverse to coordinates in the
194 FS? 06          X/Y registers; output is the
195 ADV             angle right from the backsight
196 FS? 06          and the distance to the point
197 XEQ 98          from the instrument location.
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 inversed distance.
208 ARCL X
209 AVIEW
210 CLX
211 X<>Y            calculate horizontal angle to
212 X<0?            solution station or point from
213 360             the backsight azimuth.
214 +
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 right.
246 FC? 55
247 ARCL X
248 AVIEW
249 FS? 55
250 XEQ "DMS"       changes the X-register angle
251 ADV             to the form DD°MM'SS".
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 curve in
261 SF 09           the alignment.
262 ADV
263 RCL 20
264 STO 15
265 "DELTA?"        prompt for central angle of
266 PROMPT          the curve.
267 STO 14
268 X<0?
269 SF 05           flag 05 is set when Δ is neg-
270 XEQ 03          ative (indicates curve left).
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       Δ (DD.mmss)
285 FS? 55
286 XEQ "DMS" subroutine for DD°MM'SS" form.
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 ="      station at end of curve output
306 AVIEW
307 XEQ "STA" print in XXX+XX.xxx form.
308 FIX 4
309 RCL 17
310 180
```

```
311 -
312 RCL 14
313 HR
314 +
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
```

calculate radial from radius point for offset calculation.

```
335•LBL 15
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
```

output of coordinates.

inverse to coordinates in the X/Y registers.

```
351•LBL 02
352 RCL 20
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
```

ending loop for fixed offset input on curved area.

```
380•LBL 13
381 P-R
382 RCL 09
383 +
384 X<>Y
385 RCL 10
386 +
387 FS? 00
388 GTO 15
389 XEQ 98
390 ADV
```

output coordinates - 02 and 12 label subroutine.

```
391 FS? 07
392 XEQ A
393•LBL 12
394 FS? 02
395 GTO 16
396 FS? 01
397 SF 02
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
420 "N= "
421 ARCL Y
422 AVIEW
423 "E= "
424 ARCL X
425 AVIEW
426 RTN
```

offset subroutines in curved alignment area.

output coordinates.

GENERAL NOTES:

B

```
01♦LBL "SP"
02 CF 02          initialize and clear.
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 for
41 "PI STATION?"  spiral curve.
42 PROMPT         P.I. station
43 STO 06
44 "DELTA?"
45 PROMPT         Central Angle
46 X<0?           is curve to the left?
47 XEQ 30
48 HR
49 2
50 /
51 STO 05         TΔ /2
52 CF 01
53 "R?"
54 PROMPT         Input value for circular
55 CF 04          curve radius.
56 STO 20
57 "L=?"
58 PROMPT         input length of spiral.
59 STO 40         Ls
60 ENTER↑
61 ST+ 02         station
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            Ls
98 STO 02
99 XEQ 09            to solution loop.
100 RCL 41
101 RCL 20
102 P-R
103 RDN
104 -                Ys - R(Sin  )
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 XXX+XX.xx
142 CLA
143 FIX 4
144 "CENTRAL ∡ ="
145 AVIEW            output Δ
146 RCL 05
147 2
148 *
149 HMS
150 CLA
```

```
151 ARCL X
152 FS? 55
153 XEQ "DMS"
154 FC? 55
155 AVIEW
```

output in form DD°MM'SS" when printer is attached

```
156 CLD
157♦LBL 15
158 XEQ 09
159 X<>Y
160 RCL 41
161 TAN
162 /
163 -
```

computes T.S., S.P.I. & S.C. stations

```
164 FS? 02
165 CHS
```

is this an exit spiral?

```
166 STO 42
167 0
168 RCL 01
169 RCL 40
170 +
171 STO 03
```

S.C. = S.T. + L_s

```
172 RCL 01
173 RCL 42
174 +
175 RCL 01
176 ADV
177 "TS ="
178 FS? 02
179 "ST ="
180 AVIEW
181 RCL 01
182 XEQ "STA"
183 CLA
184 "SC ="
185 FS? 02
186 "CS ="
187 AVIEW
188 RCL 03
189 XEQ "STA"
190 ADV
```

Output entrance spiral begin and end stations

or

output the exit spiral begin and end stations

```
191 "STA?"
192 PROMPT
```

prompt for input of the new station for which a solution is wanted.

```
193♦LBL D
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
212 STO 02
```

set solution station.

```
213 CF 01
214 ADV
215♦LBL 19
216 SF 04
217 RCL 02
218 -
```

compute field data for solution station.

```
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 the station requested.

```
225 ABS
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              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 83
287 CHS
288 RCL 00              θ (radians)
289 R-D
290 HMS
291 HMS+
292 90
293 HMS+
294 "RADIAL ∡ ="         output radial angle to
295 FS? 14              turn at solution station
296 AVIEW
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
```

```
FS?C 00
GTO 19
♦LBL 09                 compute Y and X values
CF 22
9
STO 43
0
STO 08
STO 09
♦LBL 02
RCL 00                  looping point
RCL 43
Y↑X
10
ST+ 43
CLX
RDN
RCL IND 43              looping control register
/
10
ST- 43
CLX
RDN
RCL 08
RCL 09
STO 08
RDN
+
STO 09
DSE 43
GTO 02
RCL 09
RCL 02
RCL 01
-
ABS
*
LASTX                   x
RCL 08
1
+
*                       y
RTN
♦LBL 83                 set up for the type of solution wanted.
CLA
FS? 55
XEQ "DMS"               change to output form of DD°MM'SS" when a printer
ARCL X                  is attached.
FC? 55
AVIEW
RTN
♦LBL 21
"Y"
ASTO X
AON
"COORD-O/S?"            coordinate solution with offset option.
PROMPT
ASTO Y
AOFF
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"
```

```
391 ASTO X
392 AON
393 "INVERSE?"        is radial inversing to
394 PROMPT            the calculated coordi-
395 ASTO Y            nates wanted?
396 AOFF
397 X=Y?
398 SF 06
399 FS? 06
400 XEQ 20
401 GTO 01
402 RTN
403♦LBL 17
404 0
405 STO 44
406 STO 33
407 STO 39
408 GTO 01
409 RTN
410♦LBL a             establishes loop for use
411 SF 15             of radial inverse with-
412♦LBL 20            out spiral calculations.
413 "INST N↑E"        input of the coordinates
414 PROMPT            at the instrument.
415 STO 49            instrument E
416 RDN
417 STO 48            instrument N
418 "BACKSITE?"       input of the coordinates
419 PROMPT            at the backsight.
420 RCL 49
421 -
422 X<>Y
423 RCL 48
424 -
425 R-P
426 CLX
427 X<>Y
428 X<0?
429 360
430 +
```

```
431 HMS
432 STO 45            backsight azimuth.
433 "N↑ E"
434 FS? 15
435 PROMPT            prompt for next pair of
436 GTO 01            coordinates for direct
437 RTN               inversing.
438♦LBL A             inverse from instrument
439 ADV               to the coordinate pair
440 CLA               in the Y and X registers
441 ARCL Y
442 FS? 55
443 AVIEW
444 CLA
445 ARCL X
446 FS? 55
447 AVIEW
448 XEQ 03
449 "N↑ E?"
450 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 the solution
463 AVIEW             coordinates.
464 CLX
465 X<>Y
466 X<0?
467 360
468 +
469 STO 46            inversed azimuth.
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 to point to
500 FC? 55        be set (from instrument)
501 ARCL X
502 AVIEW
503 FS? 55
504 XEQ "DMS"     change output to form of
505 RTN           DD°MM'SS" when printer
506♦LBL 30       is attached
507 SF 07
508 CHS
509 RTN
510♦LBL 22
511 SF 10
512 XEQ "AZ"      input of tangent bearing
513 CF 10         and quadrant code.
514 STO 39
515 "TS N↑E"      coordinate input.
516 FS? 08
517 "ST N↑E"
518 PROMPT        prompt for coordinate
519 STO 33        input when exit spiral.
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 of 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 with the
570 PROMPT               coordinate solution will
571 "O/S = "             calculate the coordinate
572 FS? 09               pair for an offset to
573 "RADIUS POINT:"      the spiral centerline.
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 of the
601 SF 09                circular portion of the
602 "CIRCULAR:"          spiral system.
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               prompt for solution at
614 ADV                  next station.
615 FS? 55
616 XEQ "STA"            output as form XXX+XX.xx
617 FIX 4
618 RCL 03               S.C., C.S.
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          prompt for next offset.
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 = "          output O/S N coordinate.
651 ARCL Y
652 AVIEW
653 "E = "          output O/S E coordinate.
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
```

C

```
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 begin
15 CHS               constant storage
16 STO 41
17 " LT"             store alpha for output
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 infor-
46 STO 03            mation
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 P-P
65 CLX
66 X<>Y
67 X<0?
68 360
69 +
70 STO 07
71 ENTER↑
72 ENTER↑            setup for sta./offset
73 90                computation
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?"     will grade be carried?
112 PROMPT
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?"     any of the alignment on
122 PROMPT           a curve?
123 ASTO Y
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 GTO 19
146♦LBL 02
147 FS? 01
148 XEQ 00
149 FC? 01
150 XEQ 05
151 RTN
152♦LBL 00
153 CF 01
154 "B.C. STA?"
155 PROMPT
156 STO 15
157 "RADIUS?"
158 PROMPT
159 STO 14
160 "DELTA?"
161 PROMPT
162 HR
163 X<0?
164 SF 05
165 STO 13
166 ABS
167 PI
168 *
169 RCL 14
170 *
171 180
172 /
173 RCL 15
174 +
175 STO 42
176 RCL 13
177 ABS
178 2
179 /
180 TAN
181 RCL 14
182 *
183 STO 44
184 -
185 STO 43
186 RCL 15
187 ST+ 44
188 RTN
189♦LBL 45
190 RCL 19
191 RCL 18
192 RCL 44
193 -
194 R-P
195 X<>Y
196 RCL 13
197 -
198 X<>Y
199 P-R
200 RCL 43
201 +
202 ENTER↑
203 GTO 11
204 RTN
205♦LBL 01
206 RDN
207 CLX
208 RCL 14
```

INSERT: FS?01 XEQ 20 between 144 & 145

input of curve data if any of the alignment is on a curve

```
209 PI
210 *
211 RCL 15
212 RCL 05
213 XEQ 03
214 RCL 06
215 XEQ 04
216 STO 06
217 X<>Y
218 RCL 15
219 +
220 STO 05
221 RTN
222+LBL 05
223 RCL 14
224 PI
225 *
226 RCL 15
227 RCL 03
228 XEQ 03
229 RCL 04
230 XEQ 04
231 STO 04
232 X<>Y
233 RCL 15
234 +
235 STO 03
236 RTN
237+LBL B          slope staking
238 CF 06
239 SF 10
240 XEQ A
241+LBL 35
242 RCL 38
243 "W/2= "        output prompt for slope
244 ARCL X         staking routine
245 PROMPT
246 STO 38
247 SF 08
248 RCL 36
```

```
249 ENTER↑
250 INT
251 X=Y?
252 CF 08
253 RDN
254 CF 29
255 FIX 0
256 FS? 08
257 FIX 2
258 "SR= "         output prompt for slope
259 ARCL X         staking routine
260 "├:1"
261 PROMPT
262 SF 29
263 FIX 2
264 STO 36
265 RCL 40
266 RCL 00
267 +
268 RCL 12
269 -
270 STO 37
271 ABS
272 RCL 36
273 *
274 RCL 38
275 +
276 STO 39
277 RCL 21
278 X<0?
279 CHS
280 -
281 CHS
282 STOP
283 FIX 1
284 CLA
285 ADV
286 "FILL "        output of cut or fill
287 RCL 37         in slope stake routine
288 X<0?
```

```
289 "CUT "
290 ABS
291 ARCL X
292 AVIEW
293 RCL 36
294 *
295 "  AT "          distance to centerline
296 ARCL X
297 AVIEW
298 CF 10
299 RCL 21
300 RCL 35
301 ENTER↑
302 GTO 11
303 RTN
304♦LBL 03
305 -
306 CHS
307 180
308 *
309 X<>Y
310 /
311 RTN
312♦LBL 04
313 CHS
314 RCL 14
315 +
316 P-R
317 CHS
318 RCL 14
319 +
320 RTN
321♦LBL 07
322 SF 02
323 "PROFILE EL?"    input of vertical grade
324 PROMPT           data if grade is to be
325 STO 20           carried
326 "GRADE?"
327 PROMPT
328 100
329 /
330 STO 10
331 XEQ 16
332 "SPRINGLINE?"
333 PROMPT           is this a tunnel?
334 ASTO Y
335 AOFF
336 X=Y?
337 XEQ 08
338 XEQ 16
339 "VERT CURVE?"
340 PROMPT
341 ASTO Y
342 AOFF
343 X=Y?
344 XEQ 09           input vertical data
345 RTN
346♦LBL 16
347 "Y"
348 ASTO X
349 AON
350 RTN
351♦LBL 08
352 CF 06
353 SF 03
354 "HEIGHT?"
355 PROMPT
356 CHS
357 STO 00
358 RTN
359♦LBL 09
360 SF 04
361 "BVC STA?"
362 PROMPT           input beginning station
363 STO 16           of vertical curve
364 "LENGTH?"
365 PROMPT           input vertical curve
366 STO 17           length
367 "GRADE OUT?"
368 PROMPT           outgoing grade
```

```
369 100
370 /
371 STO 09
372♦LBL 10
373 ADV
374 ADV
375 "INPUT SHOT"          input field data
376 PROMPT
377 RTN
378♦LBL C
379 STO 20
380 "INPUT SHOT"
381 PROMPT
382 RTN
383♦LBL A
384 ISG 41                counter
385 FIX 0
386 CF 29
387 FS? 06
388 XEQ 44                calculate solutions
389 SF 29
390 FIX 4
391 FS? 11
392 XEQ 99
393 FIX 2
394 STO 01
395 RDN
396 X<>Y
397 HR
398 X<>Y
399 P-R
400 RCL 11
401 +
402 RCL 01
403 +
404 STO 12
405 RDN
406 X<>Y
407 HR
408 RCL 07
409 +
410 X<>Y
411 P-R
412 RCL 05
413 +
414 STO 18
415 X<>Y
416 RCL 06
417 +
418 STO 19
419 X<>Y
420 RCL 15
421 FS? 01
422 GTO 11
423 X>Y?
424 GTO 11
425 -
426 X<>Y
427 FS? 05
428 CHS
429 RCL 14
430 -
431 CHS
432 R-P
433 CHS
434 RCL 14
435 +
436 X<>Y
437 RCL 14
438 *
439 PI
440 *
441 180
442 /                     length
443 RCL 15
444 +
445 RCL 42
446 X<=Y?
447 GTO 45
448 RDN
```

```
449 X<>Y
450 FS? 05
451 CHS
452 X<>Y
453 ENTER↑
454 GTO 11
455 RTN
456♦LBL 99
457 FS? 55          prints stack copy of
458 PRSTK           input data when printer
459 RTN             is attached
460♦LBL 44
461 CLA
462 ARCL 41
463 FS? 55
464 AVIEW
465 RTN
466♦LBL 11
467 RDN
468 XEQ 12
469 CLX
470 X<>Y
471 RND
472 STO 21
473 X>Y?
474 GTO 13
475 CHS
476 "AT "
477 ARCL X
478 ARCL 31          output of offset left
479♦LBL 15
480 FC? 10
481 AVIEW
482 "ELEV = "
483 ARCL 12          output shot elevation
484 FC? 10
485 AVIEW
486 FS? 02
487 XEQ 14
488 FS? 10
489 GTO 35
490 GTO 10
491 RTN
492♦LBL 13
493 "AT "
494 ARCL X
495 ARCL 32          output of offset right
496 GTO 15
497♦LBL 12
498 CF 29
499 100
500 /
501 ENTER↑
502 INT
503 X<>Y
504 FRC
505 100
506 *
507 FIX 0
508 "STA "
509 ARCL Y
510 FIX 2
511 10
512 X>Y?
513 SF 00
514 RDN
515 RND
516 FS? 00
517 ARCL 34
518 FC? 00
519 ARCL 33
520 CF 00
521 ARCL X
522 FC? 10
523 AVIEW
524 X<>Y
525 100
526 *
527 +
528 SF 29
```

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

```
100
*
+
*
100
/
RCL 16
RCL 30
-
RCL 10
*
RCL 20
+
GTO 24
RTN
♦LBL 25        calculate radius when
RCL 12         shot above springline
RCL 40
X>Y?
RTN
```

```
-
ENTER↑
*
RCL 21
ENTER↑
*
+
SQRT
FIX 2
"  RAD. = "    output of radius when
ARCL X         shot elevation is above
AVIEW          springline elevation
RTN
♦LBL J         enable printstack
SF 11
RTN
♦LBL I         cancel printstack
CF 11
RTN
END
```

D

```
01*LBL "TR"
02 SF 21
03 SF 27        initialize and clear
04 CLRG
05 FIX 4
06 CLX
07 CF 00
08*LBL 06       reset flag status prior to new
09 CF 01        input for solution
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        S-1 capitals when set
19 SF 02        S-2 capitals when set
20 SF 03        S-3 capitals when set
21*LBL 11
22 STO 04       S-3
23 RDN
24 STO 02       S2
25 RDN
26 STO 09       S-1
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       A-3
48 SIN
49 RCL 09
50 *
51 STO 08       H
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       A-2
```

```
67 RCL 05
68 XEQ 00     calculate missing angle
69 STO 01     A-1
70 GTO 01     output solution
71 RTN
72♦LBL B      A-3, S-1, A-1
73 SF 01      S-1 capitals when set
74 SF 04      A-1 capitals when set
75 SF 06      A-3 capitals when set
76♦LBL 10     loop for second solution with 2
77 SF 13      sides and following angle
78 FS? 00
79 XEQ 07     reset flags for output
80 "SECOND SOLUTION"
81 FS?C 00
82 AVIEW
83 CF 13
84 HR
85 STO 01     A-1
86 RDN
87 STO 09     S-1
88 RDN
89 HR
90 STO 05
91♦LBL 03
92 RCL 01
93 XEQ 00     calculate A-2
94 STO 03
95 RCL 05     A-3
96 RCL 09     S-1
97 P-R
98 X<>Y
99 STO 08
100 RCL 03
101 1
102 P-R
103 RDN
104 /
105 STO 02    S-2
106 R↑
107 *
108 +
109 STO 04    S-3
110 GTO 01    output solution
111 RTN
112♦LBL C     S-1, A-1, A-2
113 SF 01     S-1 capitals when set
114 SF 04     A-1 capitals when set
115 SF 05     A-3 capitals when set
116 HR
117 STO 03    A-2
118 RDN
119 HR
120 STO 01    A-1
121 RDN
122 STO 09    S-1
123 RCL 03
124 RCL 01
125 XEQ 00    calculate A-3
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    S-2
136 GTO 08
137 RTN
138♦LBL D     S-1, A-1, S-2
139 SF 01     S-1 capitals when set
140 SF 02     S-2 capitals when set
141 SF 04     A-1 capitals when set
142♦LBL 08
143 STO 02    S-2
144 RDN
145 HR
146 STO 01    A-1
```

```
147 RDN
148 STO 09      S-1
149 RCL 01      A-1
150 RCL 02      S-2
151 P-R         calculate S-3
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      A-2
169 RDN
170 STO 02      S-2
171 RDN
172 STO 09      S-1
173 RCL 03
174 SIN
175 RCL 02
176 *
177 RCL 09
178 /
179 ASIN
180 STO 05      A-3
181 RCL 03
182 XEQ 00      reduced to A-3, S-1, A-1 for the
183 STO 01      first solution
184 RCL 05
185 RCL 09
186 RCL 01
187 XEQ 04
188 XEQ 03      converts parts for the second
189 180         solution
190 RCL 05
191 -
192 RCL 03      sort stack
193 +
194 CHS
195 180
196 +
197 HMS
198 RCL 02
199 RCL 03      calculate third angle
200 HMS
201 XEQ 06
202 SF 00
203 SF 03
204 GTO 10
205•LBL 07      solve as A-3, S-1, A-1
206 SF 01
207 FC? 00
208 SF 02       S-1 capitols when set
209 FC? 00      S-2 capitols when set
210 SF 05       A-2 capitols when set
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      was S-1 input?
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     was A-1 input?
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     was S-2 input?
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     was A-2 input?
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     was S-3 input?
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     was A-3 input?
271 CF 13
272 "A-3 = "
273 FC? 55
274 ARCL X
275 AVIEW
276 FS? 55
277 XEQ "DMS"print asDD°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     reset flag status for the next
295 RTN        routine or usage
296♦LBL 09     sort stack
297 RDN
298 RDN
299 RTN
300♦LBL 04     filing and storing
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      S-1 capitals when set
310 SF 04      A-1 capitals when set
311 HR
312 STO 01
313 SIN
314 XEQ 02
315 STO 02     S-2
316 XEQ 05
317 RTN
318♦LBL G      AREA, S-1, S-2
319 SF 07      area capitals when set
320 SF 01      S-1 capitals when set
321 SF 02      S-2 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
```