HEWLETT
PACKARD

Surveying Pac

Owner's Manual

Series 70

Notice

HEWLETT PACKARD

Surveying Pac

Owner's Manual

For Use With the HP-75

developed and written for Hewlett-Packard by PacSoft Incorporated

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Introducing the Surveying Pac

The Surveying Pac is a tool to aid the engineer and surveyor in solving many of the common surveying problems. Because it is one large integrated program, and not merely a collection of individual routines, the Surveying Pac exhibits power beyond what you might expect. It simply and easily handles all the calculations involved in:

- Traversing.
- Inversing.
- Curve layout.
- Radial staking.

Its unique data entry system allows inputs to be made in a variety of ways: by using bearings, north and south azimuths, angles left or right, and horizontal deflections left or right. You can choose your input modes regardless of the mode of output you desire. If entries are unknown, the program will ask other questions until enough is known about the situation for an answer to be computed.

Contents

How to Use This Manual

This manual contains detailed information on the operation of the routines in the Surveying Pac. The explanations assume that you know how to use the HP-75 to the level described in sections 1 thru 3 of the *HP-75 Owner's Manual.* It is also assumed that you are familiar with the procedures used in surveying.

There are four sections in this manual. The first one, "Getting Started," introduces you to the use of the Surveying Pac: how to install it, how to begin each surveying problem, and how to establish what measurement conventions you want to use.

The second section, "File Management," explains the manipulation of individual coordinate points: how to enter, clear, list, duplicate, rotate, and translate coordinates. This also includes a program for traverse balancing.

The third section, "Coordinate Geometry," handles angular and linear relationships between two or more coordinate points. This includes the following routines to solve for new points: traverse, bearing-bearing intersection, bearing-distance intersection, distance-distance intersection, curve traverse, and inscribe curve. Other routines return information on the relationship between already solved points. These are the computations for the inverse, curve inverse, radial stakeout, reprint traverse, and area.

The fourth section, "Examples," presents five surveying problems and their solutions using this pac.

The appendices contain reference information:

- Appendix A, "Owner's Information," has warranty and service information.
- Appendix B is "Error Conditions and Recovery" for this pac. (For other error conditions, refer to the *HP-75 Owner's Manual.*)
- Appendix C, "The Surveying Pac Programs," lists the programs and subprograms available in the Surveying Pac.
- Appendix D, "Key Redefinitions," suggests a convenient scheme for redefining the HP-75 keys so you can execute Surveying Pac programs faster.
- Appendix E, "The Coordinate and Data Files," shows the format of the coordinate and PARAM files created when you run the program SURVEY.
- Appendix F is a short glossary of the surveying terms used in this manual.

A complete subject index is also included at the end of this manual.

Section 1

Getting Started

Contents

Installing and Removing the Surveying Module

The surveying module can be plugged into any of the three ports on the front edge of the computer.

CAUTIONS

- Be sure to turn off the HP-75 (press [SHIFT] [ATTN]) before installing or removing any module. If there are any pending appointments, type `alarm off` [RTN] in EDIT mode to prevent the arrival of future appointments (which would cause the computer to turn on). If the computer is on or if it turns itself on while a module is being installed or removed, it might reset itself, causing all stored information to be lost.

CAUTIONS CONTINUED

- Do not place fingers, tools, or other foreign objects into any of the ports. Such actions could result in minor electrical shock hazard and interference with pacemaker devices worn by some persons. Damage to port contacts and internal circuitry could also result.

To insert the Surveying Pac module, orient it so that the label is right-side up, hold the computer with the keyboard facing up, and push in the module until it snaps into place. During this operation be sure to observe the previously described precautions.

To remove the module, use your fingernails to grasp the lip on the bottom of the front edge of the module and pull the module straight out of the port. Install a blank module in the port to protect the contacts inside.

How to Use the Surveying Pac

The Surveying Pac is a system for solving surveying problems. You always start out by running SURVEY. SURVEY asks for information and provides several options for you to follow. In other words, SURVEY sets up or *initializes* the conditions for solving your particular problem.

Running SURVEY

Let's start out by running the program SURVEY and seeing what it does. This example will explain the meaning and purpose of SURVEY's features, and why your input to the computer must follow certain conventions. This program creates a file—called a *coordinate file*—to store the coordinate points for your current problem. To create the coordinate file, the program asks you for a file name and file size.*

Step	Display	Instructions
1		Press [ATTN] [EDIT] to turn the HP-75 on and switch to EDIT mode.
2	>	Type run'survey' [RTN] to run the SURVEY program.

* If the duration of the displays is too short, you can prolong it by adjusting the DELAY. The DELAY command is explained under "Printed Output," page 21.

Step	Display	Instructions
3	FILE NAME?	Enter a name for the coordinate file. (File names can be up to eight letters and digits long, and must begin with a letter.) If the file name you specify already exists, SURVEY skips to step 11.
4	FILE SIZE (*nnn* max)	For the coordinate file size, enter the number of data points you will be using, which cannot be more than the maximum shown.*
5	ABS ANGLE Brg,Naz,Saz (B/N/S)?	Select Bearings ([B]), North azimuths ([N]), or South azimuths ([S]) for the output of the resulting directions. You do not need to press [RTN].
6	REL ANGLES Deflect,Angle (D/A)?	Select Deflection angles ([D]) or Angles left/right or interior/exterior ([A]) for the output of relative (field) angles.
7	UNITS Degrees,Grads (D/G)?	Select Degrees ([D]) or Grads ([G]) for the angular units.
8a	DECIMALS ON SECONDS (0-2)?	If you selected Degrees in step 7, specify the number of decimal places (up to two) for the output of the seconds.
8b	DECIMALS ON ANGLES (0-6)?	If you selected Grads in step 7, specify the number of decimal places (up to six) for the output of the grads.
9	DECIMALS ON COORDS (0-5)?	Select the number of decimal places for the output of the coordinates.
10	DECIMALS ON DISTANCES (0-5)?	Select the number of decimal places for the output of distances.
11	working File,Cogo,User (F/C/U)?	

* If you need more room, you can make more memory available by purging files currently in memory. You might want to copy the files to cards or a cassette first. Refer to "Copying Files to Cards" in section 3, for copying to cards and "Mass Storage Operations" in section 9, for copying to a cassette in the *HP-75 Owner's Manual*.

SURVEY has created a coordinate file to your specifications. You are now ready to start surveying! Press [F] to access the File Management program, press [C] to access the Coordinate Geometry (COGO) program, or press [U] to access a program that you have stored in HP-75 memory.

When you return to the Surveying Pac at a later time to use the same set of data (and therefore the same coordinate file), you will still start with SURVEY, but it will be much shorter. You need only enter the name of the coordinate file. Since the desired coordinate file already exists, SURVEY will skip to the last line, asking you which surveying program you want.

Where To Go From Here

After initializing the Surveying Pac by running SURVEY, you can proceed to one of three surveying programs:

- COGO. The Coordinate Geometry program takes a known starting point and computes a new point or points. This starts on page 31.
- FILE. The File Management program will manipulate points that already exist in a coordinate file. Go here if you want to list, delete, or add points, or if you want to rotate or translate them. This starts on page 23.
- SURV3. SURV3 (User) can be any BASIC program stored in memory. It is not part of the Surveying Pac. This is an option to allow you to access an additional program of your choice while using the Surveying Pac.

Exiting the Surveying Pac

When you are finished with the Surveying Pac, you can stop its execution by pressing [ATTN]. You can then turn off the HP-75 or work on other problems.

Running the Surveying Pac creates and stores two data files in memory—the coordinate file and a data file named PARAM. For safety, if you plan to do more work with these coordinate points, you should copy the coordinate file to a card or cassette. It is not necessary to save PARAM, so it can be purged.

Conventions Used by the Surveying Pac Programs

The Surveying Pac programs use various modes, parameters, options, and files. These conventions are defined below.

Menus

The Surveying Pac contains several different routines for various solutions. These routines are accessed by a series of *menus*. A menu is a list of options from which you can select a programmed routine or function. For example, the menu at the end of SURVEY looks like:

```
File,Cogo,User (F/C/U)?
```

To select the FILE program, press [F] on the keyboard (either upper or lower case will work). [C] selects the COGO program, while [U] selects the user program.

If the option you want does not appear on the display, the next menu is accessed by pressing the [RTN] key. There can be several menus, and each one will be displayed after [RTN] is pressed.

Program Files

The menus in the Surveying Pac allow you to transfer from one routine to another. Although it is not apparent, the Surveying Pac can also be moving from one program to another. There are three major programs in the Surveying Pac. SURVEY sets up the required data files and then transfers computer activity to one of the other main programs. SURV1 contains the File Management program and SURV2 contains the Coordinate Geometry program.

The main SURVEY program can also switch activity to a program named SURV3. SURV3 is not part of the Surveying Pac; rather, it is the name of a potential program that you (or anyone else) can write and store in HP-75 memory. This option allows you to add alternative solutions and incorporate them into the Surveying Pac routines.

The Surveying Pac also contains a number of smaller utility subprograms that you can call from your own BASIC programs. Refer to appendix C, "Programs and Subprograms," for a list and description of those subprograms.

> **Note:** When you name programs or data files, take care to choose file names different from those in the Surveying Pac (as well as other application modules). Appendix C contains a list of the file names used in this Pac.

The Coordinate File

All routines in the Surveying Pac write to and/or read from a *coordinate file.* This file contains northings, eastings, and elevations for all coordinate points that you enter or solve. The points are referenced by *point numbers*, which can range from 1 to 999.

The coordinate file is stored in the user memory (random access memory or RAM) of the HP-75. The maximum possible size of the file depends on the memory available. Before beginning, you might want to purge unneeded programs or data to make more room for the coordinates. Refer to "Purging Files," in section 3 of your owner's manual for instructions.

The coordinate file is referenced by a name that you assign. The name can be from one to eight characters long. The first character must be a letter; the remaining characters can be letters or digits. The file name must be unique—no other file of the same name can exist in memory at the same time.

A coordinate file is created automatically when you run `SURVEY`. This program will request a name for the coordinate file. The program will also have you specify the file size, unless the file was created in an earlier run. When a new file is created and its size specified, space is allocated and all coordinates are *cleared* (set to an unassigned status).

Several different coordinate files can be stored in the HP-75 at the same time as long as the names are different and sufficient space exists. This allows you to maintain coordinates for various jobs in separate files.

Coordinate files can be copied to cards or cassettes via the `COPY` command (refer to section 3 for copying to cards and section 9 for copying to cassettes in the *HP-75 Owner's Manual*). This will provide you with a permanent record of your work on a particular job. Once the file has been copied, you can purge it from memory to make room for other files. When you need to access the coordinates again, copy the file back to the HP-75 memory. In any case, making copies of a file is a good idea for protection in case of accidental loss of data caused by battery failure or a system reset.

You can access the coordinate file from your own (BASIC) programs. Appendix E, "The Coordinate and Data Files," contains information on file structure.

Input and Output Options

The Surveying Pac offers a variety of options for the formats of both inputs and outputs. You can specify angular units in either degrees or grads. You can specify the number of decimal places printed for angles, coordinates, and distances.

Directions can be output as bearings, north azimuths, or south azimuths. Relative (field) angles can be either angles left or right or deflections left or right.

Regardless of what mode you select for *output,* you can still enter *input* by any method: bearings, north or south azimuths, angles left or right, and deflections left or right.

You make these selections whenever a new coordinate file is created.

Data Entry

Whenever input is required, a prompt is displayed. You should end all data entry by pressing [RTN], unless you are making a menu selection. When two or more values are required, separate them with a comma.

When a prompt contains one or more items inside square brackets, those items are optional. For example, when `HORIZONTAL [;VERT ] DISTANCE ?` is displayed, an entry for the horizontal distance is required, while the vertical distance entry is optional. If you enter the optional value, a semicolon must separate it from the first value.

The Surveying Pac programs check all input for validity. If an entry is not understood by the system, the computer will beep and display a warning message. You can then re-enter the data.

Angles

You can work with one of two angular units—degrees or grads. If you select degrees, enter angles in the form *DD.MMSS*. If you need decimal seconds, you can show them in the fifth decimal place: for example, 15°31′16.2″ would be entered as 15.31162. If you select grads, simply enter angles as the decimal number of grads.

Entries for angles can appear as mathematical expressions, involving addition, subtraction, or division.

Following are examples of valid angular entries while running the Surveying Pac.

`31.20`	Equals 31°20′ or 31.2 grads.
`47.3124 + 90.4`	Equals 138°11′24″ or 137.7124 grads.
`133.4651/2 - 30.5`	Equals 36°03′26″ or 36.2326 grads.
`180 + 15.43/3`	Equals 185°14′20″ or 185.1433 grads.

Note: Parentheses and multiplication are not allowed in the angular expressions. Also, the order of expression follows the HP-75 mathematical hierarchy of expression (refer to "Arithmetic Hierarchy" in section 4 of your owner's manual).

Wherever this manual tells you to enter an *angle*, it means that you can specify angles in any of the valid forms described here.

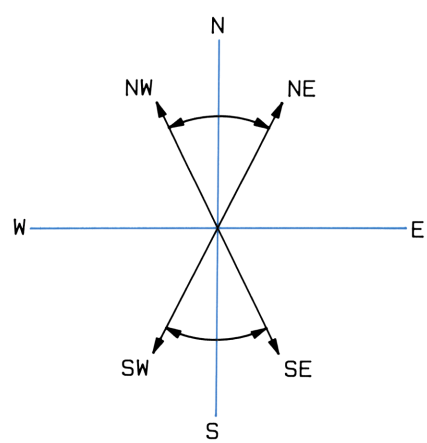
Directions

You can establish directions by 1) entering an angle from an actual or assumed meridian (bearings, north azimuths, or south azimuths); 2) entering an angle relative to the reference direction (angles left or right, deflections left or right); or 3) using previously solved points to define the direction.

Bearings. Bearings are measured clockwise and counter-clockwise from either a north or south meridian.

To enter a bearing, precede the angle with a two-letter quadrant (NE, NW, SE, or SW):

NE *angle*
NW *angle*
SW *angle*
SE *angle*

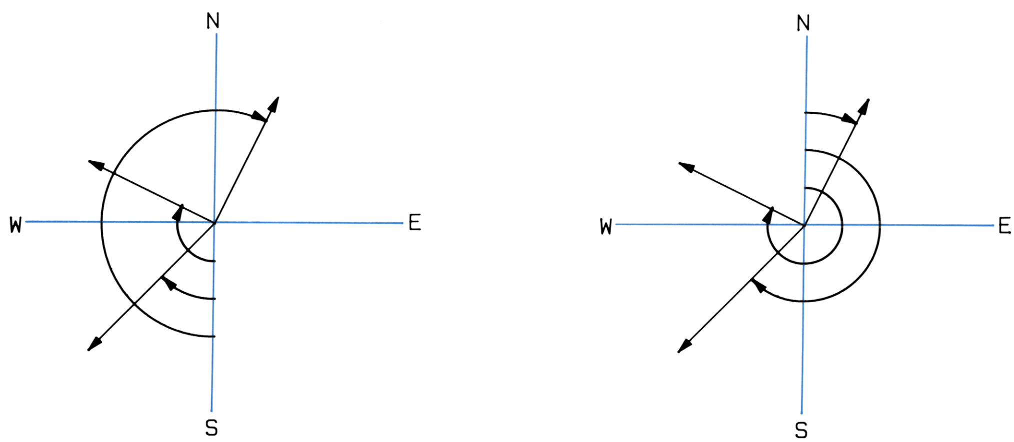


Bearings

Azimuths. Azimuths are measured clockwise from a north (north azimuth) or south (south azimuth) meridian.

To enter a north azimuth, simply enter the angle. To enter a south azimuth, either precede the angle with the SW quadrant notation, or add 180° (200 grads) to the north azimuth:

angle	North azimuth.
SW *angle*	South azimuth.
angle +180°	South azimuth.

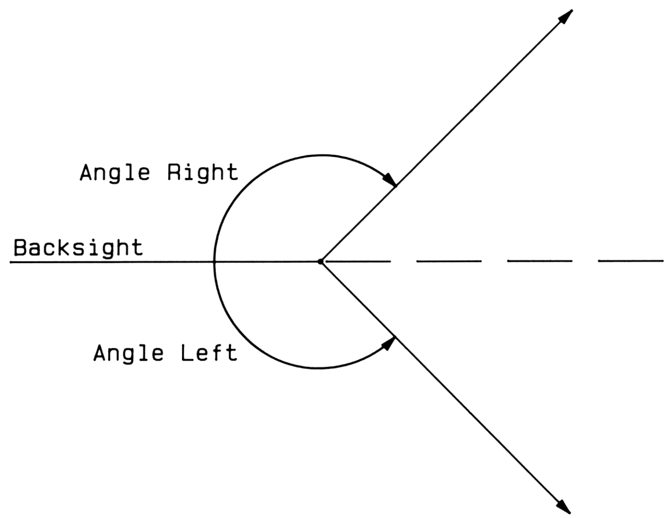


South Azimuths North Azimuths

Angles Right and Angles Left. Angles right and left are measured from a reference backsight which is usually the previous leg of a traverse.

To enter angles right, precede the angle with a plus. To enter angles left, precede the angle with a minus:

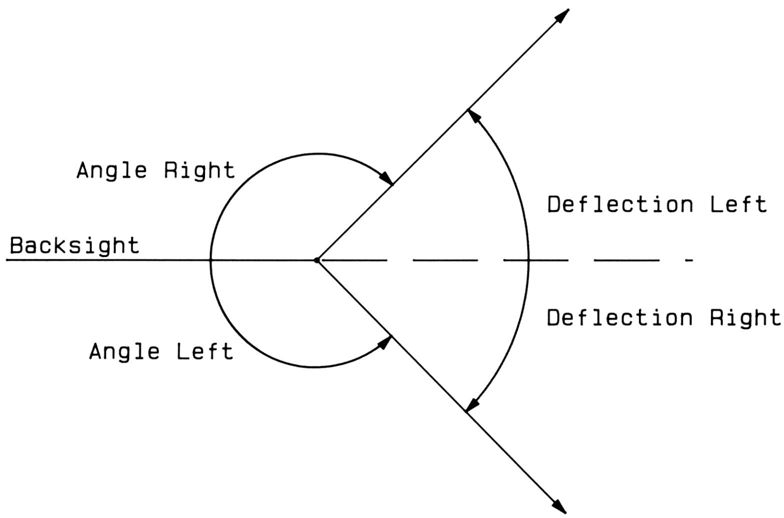
+ *angle*	Angle right.
− *angle*	Angle left.



Deflection Angles. Deflection angles are turned from an extension of the previous traverse leg or backsight.

Since deflection angles differ from angles left or right by 180° (200 grads), enter deflection angles as an angle plus 180°:

+ *angle* +*180*	Deflection right.
− *angle* +*180*	Deflection left.



Defined Direction. A direction can be *defined* by two existing points.

Given two defined points, *p1* and *p2*, you can enter a defined direction as

*p1***p2*

The two defined points must have assigned coordinates.

An angular entry (in any of the allowable forms) can be added to or subtracted from a defined direction:

*p1***p2* + *angle*
*p1***p2* − *angle*

Distances

There are three ways to enter distance values:

- Enter the numeric distance, for instance, `482.5`.
- Enter a *defined distance* using previously solved points. For example, to indicate the defined distance between point #4 and point #8, enter `4*8`.
- Enter an expression that adds, subtracts, or divides an actual or defined distance. For instance, `482.5+357.9/2`.

Following are examples of valid distance entries:

`132.6`	
`4*8`	The distance between points 4 and 8.
`100/4`	25.
`6*2/3`	One-third of the distance from point 6 to point 2.
`300-41*42`	Three hundred minus the distance between points 41 and 42.
`137.9+7*9/2`	137.9 plus half the distance between points 7 and 9.

Point Numbers

You can input a point number directly, or you can enter it as the next consecutive point by entering a +.

Coordinates

When assigning coordinates to a point, you must enter values for the northing and easting. Elevation input is optional—if you don't need it, simply press [RTN] when the display prompts ELEVATION?.

There are several instances when a surveying routine requires input of a point number with known coordinates. If the point number you use is unassigned, you must enter the coordinates at that time. The coordinates will be stored, and you can continue with the problem.

Getting Printed Output

Normally, you will see any output (solved coordinates, bearings, distances, and so on) on the HP-75 display. If the display does not last long enough for you to read it or copy it down, use the HP-75 DELAY command to change the duration of the display. For example, to have each line displayed for 3 seconds, enter delay 3 [RTN].

When a delay is selected, it remains in effect until another DELAY command is executed. The delay can be overridden by pressing any key. You might find it useful to specify a long delay, then use the [TAB] key to scroll through the display at a comfortable pace. Note that the delay rate also affects the display rate of error and status messages.

The Surveying Pac programs do not require a printer for operation. However, if one is available, all output can be directed to it. The printer must first be assigned a device code using the ASSIGN IO command. Then a PRINTER IS command must be executed.

For a complete explanation on how to direct output to a printer, refer to your *HP-75 Owner's Manual*, section 9.

Section 2

File Management

Contents

Introduction

The File Management program contains routines that allow you direct access to and manipulation of the points in a coordinate file. Three menus display the available functions:

Display	Instructions
`List,Clear,Duplicate (L/C/D)?`	Press [L] to access the List Coordinates routine. **or** Press [C] to clear coordinate values. **or** Press [D] to duplicate stored points. **or** Press [RTN] to display the next menu:

Display	Instructions
`Rotate,Translate,Scale (R/T/S)?`	Press [R] to rotate the coordinates. **or** Press [T] to translate points. **or** Press [S] to apply a scale factor. **or** Press [RTN] to display the next menu:
`Balance,Assign,Exit (B/A/E)?`	Press [B] to access the balancing routines. **or** Press [A] to enter and assign coordinates. **or** Press [E] to exit the File Management program and return to the main menu. **or** Press [RTN] to display the first menu again.

Routine: List Coordinates

Purpose: Provides a listing of northing, easting, and elevation for all assigned points within a user-defined range of point numbers.

Step	Display	Instructions
1	`List,Clear,Duplicate(L/C/D)?`	Press [L].
2	`STARTING,ENDING #s ?`	Enter the point numbers of the first and last points you want listed.
3	`working`	The points will be listed on the selected device (display or external printer). When this is done, the display will return to the menu in step 1.

Routine: Clear Coordinates

Purpose: Clears points by resetting the coordinates to an unassigned status.

Step	Display	Instructions
1	`List,Clear,Duplicate(L/C/D)?`	Press [C].
2	`STARTING,ENDING #s ?`	Enter the point numbers of the first and last points you want cleared.
3	`working`	After the points have been cleared, the display will return to the menu in step 1.

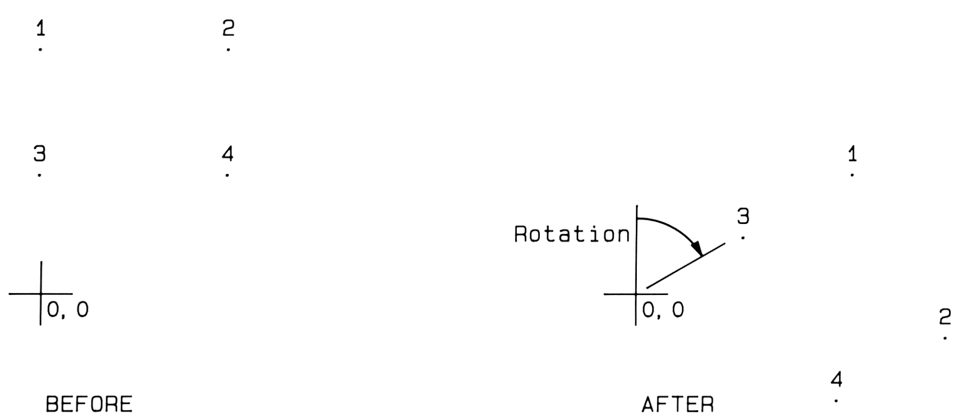
Routine: Duplicate Points

Purpose: Makes a copy of a point or block of points. New point numbers are assigned to the duplicate points, and the original points remain intact.

Step	Display	Instructions
1	`List,Clear,Duplicate(L/C/D)?`	Press [D].
2	`STARTING,ENDING #s ?`	Enter the point numbers of the first and last points of the block of points you want duplicated.
3	`NEW STARTING # ?`	Enter the first point number you want assigned to the new points.
4	`working`	After the points have been copied, the display will return to the menu in step 1.

Routine: Rotate Points

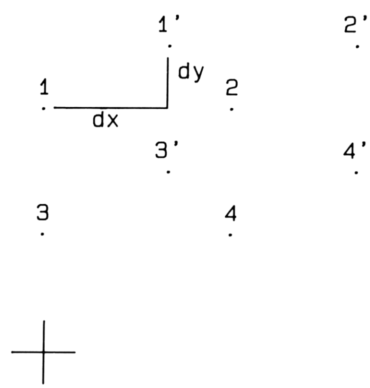
Purpose: Transforms a point or block of points to a new orientation by rotation through the origin (0,0).



Step	Display	Instructions
1	`Rotate,Translate,Scale(R/T/S)?`	Press [R].
2	`STARTING,ENDING #s ?`	Enter the starting and ending points of the block of coordinates you want rotated.
3	`ROTATION ANGLE ?`	The angle may be entered in any of the allowable formats described in section 1, page 14.
4	`working`	The points are rotated about the origin (0,0), then the display returns to the menu in step 1.

Routine: Translate Points

Purpose: Transforms a point or block of points to a new location by translation along any or all three axes.



Step	Display	Instructions
1	`Rotate,Translate,Scale(R/T/S)?`	Press [T].
2	`STARTING,ENDING #s ?`	Enter the starting and ending points of the block of coordinates you want translated.
3	`N,E,H ?`	`N` refers to northing, `E` to easting, and `H` to elevation. Enter the adjustments you want made to each ordinate. If no adjustment is needed, enter 0.
4	`working`	The points are translated, and then the display returns to the menu in step 1.

Routine: Scale Coordinates

Purpose: Applies a multiplier to a point or block of points.

Step	Display	Instructions
1	`Rotate,Translate,Scale(R/T/S)?`	Press [S].
2	`STARTING,ENDING #s ?`	Enter the first and last point numbers of the coordinates you want scaled.
3	`MULTIPLIER ?`	Enter the scale factor you want applied to all coordinates in the defined block.
4	`working`	The points are scaled, and then the display returns to the menu in step 1.

Routine: Enter and Assign

Purpose: Assigns coordinate values to selected points.

Step	Display	Instructions
1	`Balance,Assign,Exit(B/A/E)?`	Press [A].
2	`PT # ?`	Enter the point number you want to store. **or** Enter a + to use the next sequential point number. **or** Press [RTN] with no entry to return to the menu.
3	`N,E OF # p ?`	Enter the northing and easting of the selected point.
4	`H OF # p ?`	Enter the elevation. **or** If no elevation is needed, press [RTN].
5	`working`	After the coordinates are printed, continue with step 2.

Routines for Balance Traverse

The Surveying Pac contains three routines for distributing the errors in a traverse: angle balance, Bowditch rule adjustment, and Crandall's rule adjustment.

Angle Balance

For an angle balance, it is assumed that the angular error is the same at each station. The total correction that you input is divided by the number of legs in the traverse. The resulting angular correction is applied to each leg.

Bowditch Rule

The Bowditch (or Compass) rule distributes the errors in latitude and departure in proportion to the length of each leg:

$$\frac{\text{Correction in Latitude}}{\text{Length of Leg}} = \frac{\text{Total Error in Latitude}}{\text{Total Traverse Length}}$$

$$\frac{\text{Correction in Departure}}{\text{Length of Leg}} = \frac{\text{Total Error in Departure}}{\text{Total Traverse Length}}$$

Crandall's Method

Crandall's method employs the following variation of a least squares adjustment:

$$A = \frac{e_D\left(\sum \frac{LD}{l}\right) - e_L\left(\sum \frac{D^2}{l}\right)}{\left(\sum \frac{D^2}{l}\right)\left(\sum \frac{L^2}{l}\right) - \left(\sum \frac{LD}{l}\right)^2}$$

$$B = \frac{e_L\left(\sum \frac{LD}{l}\right) - e_D\left(\sum \frac{L^2}{l}\right)}{\left(\sum \frac{D^2}{l}\right)\left(\sum \frac{L^2}{l}\right) - \left(\sum \frac{LD}{l}\right)^2}$$

$$C_L = \frac{L}{l}(AL + BD)$$

$$C_D = \frac{D}{l}(AL + BD)$$

where L is the latitude of any leg, D is the departure of any leg, l is the length of any leg, e_D is the total error in departure, e_L is the total error in latitude, C_D is the correction in departure applied to any leg, and C_L is the correction in latitude applied to any leg.

Elevation Adjustment

If elevations have been carried through a traverse, they will be adjusted when a linear balance (Bowditch or Crandall's Rule) is performed. The adjustment for each leg will be proportionate to the length:

$$\frac{\text{Correction in Elevation}}{\text{Length of Leg}} = \frac{\text{Total Error in Elevation}}{\text{Total Traverse Length}}$$

Traverse Input and Adjustment

Field notes are entered and reduced in the Coordinate Geometry program. The unadjusted coordinates are stored in the coordinate file. When a traverse is adjusted, the starting and ending point numbers must be input, and corrections are made directly to the stored coordinates. Points on a traverse to be balanced must be *consecutive.*

Suggestion: Before adjusting a traverse, make a copy of the unadjusted coordinates using the duplicate-points routine.

> **Note:** While in the balance routine, the computer stores intermediate values in the space usually reserved for coordinates. *Do not* interrupt the routine by pressing [ATTN], or allow the computer to shut itself off. For information on keeping your HP-75 on, see Section 1 in your owner's manual.

Routine: Traverse Adjustment

Purpose: Distributes the angular and/or linear error in a traverse.

Step	Display	Instructions
1	`Balance,Assign,Exit(B/A/E)?`	Press [B].
2	`STARTING, ENDING #s ?`	Enter the starting and ending points of the traverse.
3	`ANGLE ADJUSTMENT ?`	Enter the total angular adjustment you want applied. If no angular balance is needed, enter 0.
4	`working`	The angular error is distributed.
5	`UNADJUSTED:` *nnn.nn* N *nnn.nn* E *nnn.nn* H	The display shows the unadjusted coordinates of the ending point.

Step	Display	Instructions
6a	TRUE N,E OF #n ?	Enter the correct coordinates of the traverse ending point.
6b	TRUE H ?	If elevations have been stored, enter the correct elevation.
7	CORRECTION: *nnn.nn* N *nnn.nn* E *nnn.nn* H working closure: error *nnn.nn* 1 in *nnn.nn*	The display shows the correction in latitude, departure, and elevation, along with the linear and relative errors.
8	None,Bowditch,Crandall(N/B/C)?	Press [N] to bypass the linear balance, press [B] to balance using the Bowditch (Compass) rule, or press [C] to balance using Crandall's method.
9	working	Adjustments are made directly to the coordinate file. Afterwards, the routine returns to step 1.

Section 3

Coordinate Geometry

Contents

Introduction

The routines in the Coordinate Geometry section are based on computing a new point or points given a known starting point, bearing, and distance, or data from which the bearing and distance can be calculated. Also included are staking routines for printing angular and linear relationships between existing points.

The COGO menu contains five routines:

- The Start routine establishes the starting (occupied) point and backsight.
- The Lines routine contains five different solutions for lines: traverse, inverse, bearing-bearing intersection, bearing-distance intersection, and distance-distance intersection. The different solutions are accessed by entering the data that is known, and bypassing unknowns.
- The Curves routine solves for a curve traverse (solves the P.T. given the R.P., P.C., and the arc, chord, central angle, or tangent length) or fits a curve to known tangents.

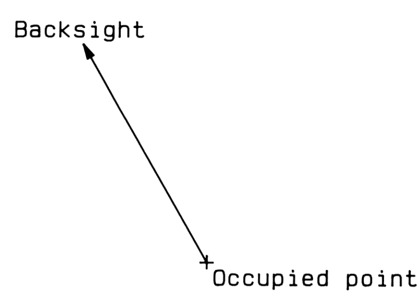
- The Radial Stakeout routine returns the horizontal angle and distances between stored coordinates for radial staking.
- The Traverse Reprint routine operates like the radial stakeout routine, except that the occupied point and backsight are updated at each point on the traverse. This routine also computes the curve inverse and the area.

Throughout the COGO program two parameters are being constantly referenced and updated. The first is the starting (occupied) point. This point establishes the beginning coordinates for most solutions. The starting point is generally moved with each solution; that is, the point solved in one problem becomes the new starting point for the next. The second parameter is the backsight or reference bearing. Whenever a deflection or angle left or right is used to establish a direction, it is turned off the backsight. The backsight is updated every time the starting point moves.

Routine: Start

The Start routine establishes the currently occupied point and backsight. Usually, the starting point is determined from the previous solution. This routine allows you to specify a new point and backsight. *Note that you should enter the backsight as the direction* from *the occupied point* toward *the reference.*

The Start routine also allows you to select absolute or relative angles for subsequent results. Bearings or azimuths will be displayed if you select absolute angles. Relative angles are measured off the current backsight, and may be angles right/left (interior/exterior) or deflections right/left. The Start routine begins running automatically when you select the COGO program.



Step	Display	Instructions
1	START,LINE,CURVE(S/L/C) ?	Press [S]. *This step is skipped when you enter* COGO *from the main menu.*
2	FROM #?	Enter the currently occupied point number. If you enter a point that has not yet been assigned, the HP-75 will request and then display the coordinates.
3	BACKSIGHT?	Enter the backsight bearing, using any allowable format. If you want to use the previous backsight, just press [RTN].
4	b.s. *nnn.nn*	The backsight is printed.
5	ANGLES Abs,Rel (A/R)?	Press [A] to have the output in absolute angles (bearings or azimuths). Press [R] to have the output in relative angles (angles left/right or deflections left/right).

The HP-75 prints the starting coordinates and the backsight, and then returns to step 1.

Routine: Lines

Five different solutions are part of the Lines routine of the COGO program. These five solutions are:

Traverse and Sideshot. This calculates the coordinates of a new point given the bearing and distance from a known point.

Inverse. This finds the bearing and distance between two known points.

Bearing-Bearing Intersection. This finds the intersection of two lines.

Bearing-Distance Intersection. This finds the intersections of a line and a circle.

Distance-Distance Intersection. This finds the intersections of two circles.

The various solutions are accessed by supplying the computer with the data values you do know, and ignoring those values you don't know (just press [RTN] when the program prompts for that information). There are six possible inputs, although no more than four are needed for any given problem. The program stops requesting data as soon as it has enough information.

The chart below shows the seven possible types of solutions and the information required for each solution. An X means the data were entered, while a O means no data were given. Assume that the occupied point, *p1*, was established by the previous solution or by the Start routine. The second known point is *p2*, and the solution point is *p*.

	p	Horiz. Angle, *p1* to *p*	Distance, *p1* to *p*	*p2*	Horiz. Angle, *p2* to *p*	Distance, *p2* to *p*
Inverse	X	0	0			
Traverse	X	X	X			
Sideshot	-X	X	X			
Bearing-Bearing	X	X	0	X	X	
Bearing-Distance	x[;x]	X	0	X	0	X
Distance-Bearing	X[;X]	0	X	X	X	
Distance-Distance	X[;X]	0	X	X	0	X

Multiple Solutions

Some COGO intersection problems have two possible solutions. The choice for solving one or both points is made when the solve point number is entered. To solve and store both points, two different point numbers must be entered, separated by a semicolon.

To avoid calculating one of the points, the point number must be zero or else not given. The following examples illustrate this.

Input/Result

Input	Result
5;0 or 5	Only the first solution is calculated. Point #5 is assigned the solved coordinates.
0;8 or ;8	Only the second solution is calculated, and the coordinates are assigned to point #8.
11;12	Both points are solved. The first solution is assigned to point #11, and the second to point #12.

General Procedure for the Lines Routine

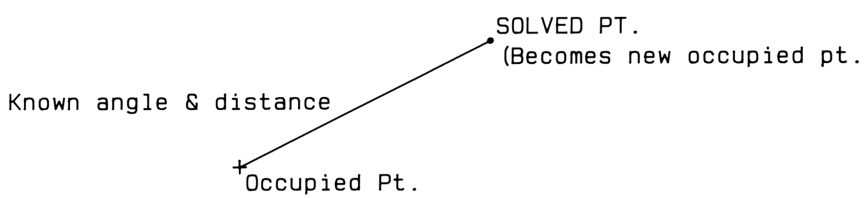
The general procedure for the Lines routine is:

Step	Display	Instructions
1	START,LINE,CURVE(S/L/C)?	Press [L].
2	#*p1* TO # ?	*p1* represents the currently occupied point. Press [RTN] with no entry to loop back to step 1. **or** Enter the point number(s) of the point(s) to be solved. **or** To solve the point without changing the current set-up (location and backsight), enter the number of the point to be solved as a negative value. **or** Enter a + to assign the next consecutive point number (incremented one from the occupied point number).
3	HORIZ [;VERT] ANGLE *p1* * *p*?	Enter the known direction from the starting point to the point to be solved. This may be entered as a direction (bearing, north or south azimuth) or an angle turned from the current backsight. Press [RTN] if the direction is unknown.
4	HORIZ [;VERT] DISTANCE *p1* * *p2* ?	Enter the known distance from the starting point to the solve point. If unknown, press [RTN].
5		If the program has enough information at this point, the results will be printed and execution will continue at step 2. Otherwise, it will continue with step 6.
6	2nd KNOWN # ?	Enter the point number of the second known point (*p2*). If *p2* is not assigned, you must enter the coordinates at this time.

Step	Display	Instructions
7	HORIZ ANGLE *p2* ✱ *p*	Enter the known bearing from the second point to the solve point and proceed to step 9. If the bearing is unknown, press [RTN] and proceed to step 8.
8	DISTANCE *p2* ✱ *p* ?	Enter the known distance from the second point to the solve point.
9		The results will be printed, and execution continues with step 2.

Traversing Lines

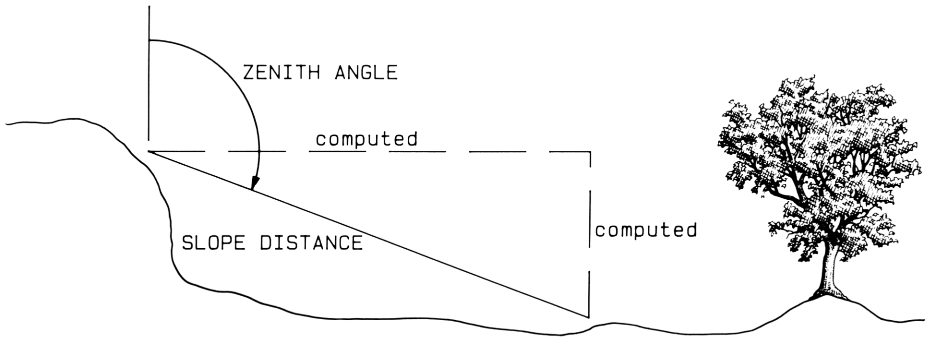
Given: the known starting coordinates of a point, a direction, and the distance.



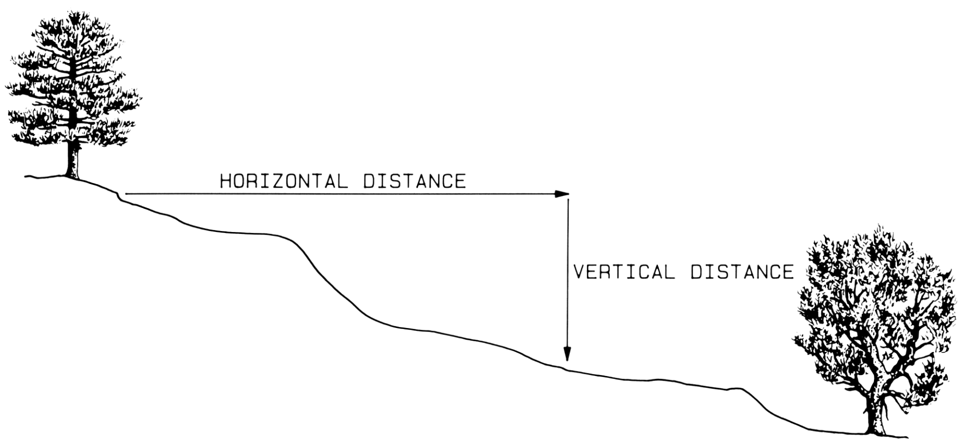
Solve: the coordinates of a new point.

To facilitate field note reduction, the traverse solution also includes slope reduction and vertical control.

Slope Distances. When the prompt appears for the horizontal angle (step 2 below), a vertical angle can also be entered. If it is entered, the distance input in step 3a will be assumed to be a slope distance and will be reduced to horizontal and vertical components. Either a vertical or a zenith angle can be input. The program will then calculate the angle to within 45° of horizontal.



Vertical Distances. Vertical distances are computed when a slope distance and a zenith angle are entered. Alternatively, the vertical distance can be input along with the horizontal distance.

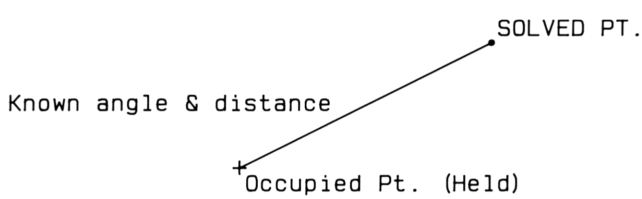


Elevations. If the occupied point has an assigned elevation, a new elevation will be stored with the solved point whenever a vertical distance is entered (whether this distance is entered directly or is computed from a slope distance and a zenith or vertical angle).

Step	Display	Instructions
1	FROM #*p1* TO # ?	Enter the number of the point to be solved. (*p1* is the currently occupied point.)
2	HORIZ [;VERT] ANGLE *p1* * *p* ?	Enter the direction in any allowable form (bearing, azimuth, or relative angle). Optionally, a vertical or zenith angle can be entered, separated from the first entry by a semicolon.
3a	HORIZ [;VERT] DISTANCE *p1* * *p* ?	Enter the horizontal distance to the traverse, which can be followed by a semicolon and a vertical distance.
3b	SLOPE DISTANCE *p1* * *p* ?	If a zenith or vertical angle were used in step 2, enter the slope distance.
4		The direction, distance, and coordinates of the solved point are printed. The solved point becomes the new starting point, and the new backsight is to the old occupied point. Execution continues with step 1.

Sideshots

The Sideshot solution is identical to the Traverse solution, except that the occupied point and backsight are not changed.



Step	Display	Instructions
1	#*p1* TO # ?	Enter the *negative* point number of the point to be solved.
2	HORIZ [;VERT] ANGLE *p1* * *p* ?	Enter the direction in any allowable form (bearing, azimuth, or relative angle). Optionally, a vertical or zenith angle can be entered, separated from the first entry by a semicolon.
3a	HORIZ [;VERT] DISTANCE *p1* * *p* ?	Enter the horizontal distance to traverse, which can be followed by a semicolon and vertical distance.
3b	SLOPE DISTANCE *p1* * *p* ?	If a zenith or vertical angle were entered in step 2, enter the slope distance.
4		The direction, distance and coordinates are printed. The occupied point and backsight are not changed. Execution continues with step 1.

Inverse

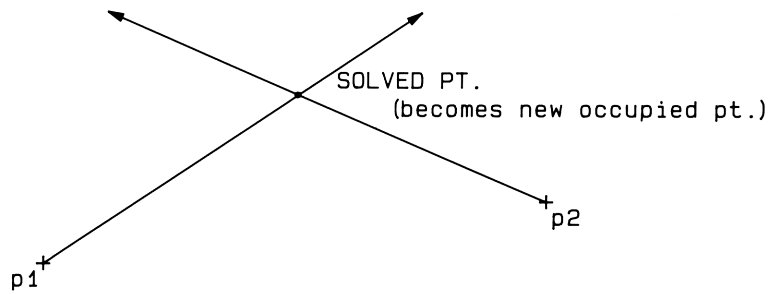
Given: two known points.

Solve: the direction and distance between them.

Step	Display	Instructions
1	#*p1* TO # ?	Enter the number of the second known point.
2	HORIZ [;VERT] ANGLE *p1* * *p* ?	Skip (press RTN).
3	HORIZ [;VERT] DISTANCE *p1* * *p* ?	Skip (press RTN).
4		The angle, distance, and coordinates are printed. Returns to step 1.

Bearing-Bearing Intersection of Lines

Given: two known points and the bearings from each.

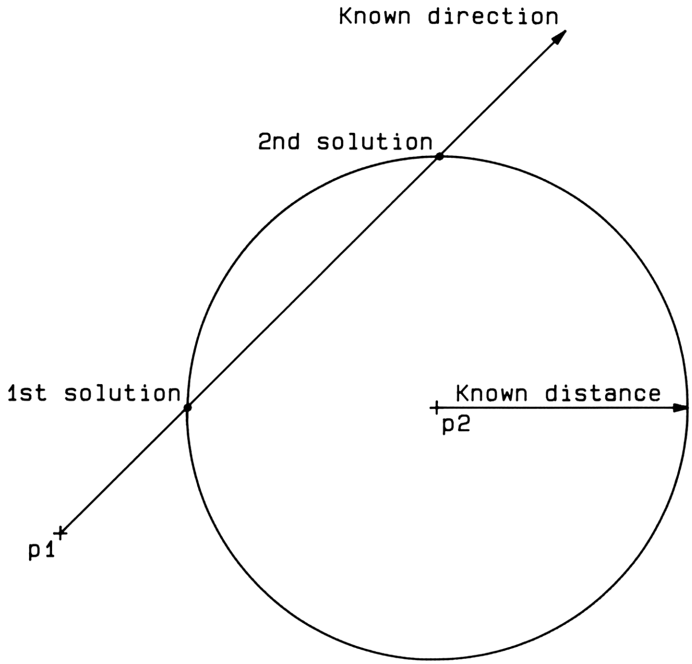


Solve: coordinates of the point of intersection.

Step	Display	Instructions
1	#*p1* TO # ?	Enter the point number of the point to be solved. To maintain the current occupied point and backsight, enter a negative number.
2	HORIZ [;VERT] ANGLE *p1* * *p* ?	Enter the direction or angle turned.
3	HORIZ [;VERT] DISTANCE *p1* * *p* ?	Skip.
4	2nd KNOWN # ?	Enter the number of the second known point.
5	HORIZ ANGLE *p2* * *p* ?	Enter the direction from the second point to the unknown point.
6		The directions and distances from both known points to the solved point are printed. The new coordinates are also printed. If the solve point number was entered as a positive number, it becomes the new occupied point, and the new backsight is toward the second known point.

Bearing-Distance Intersection of Lines

Given: two known points, a bearing from the first and the distance from the second.



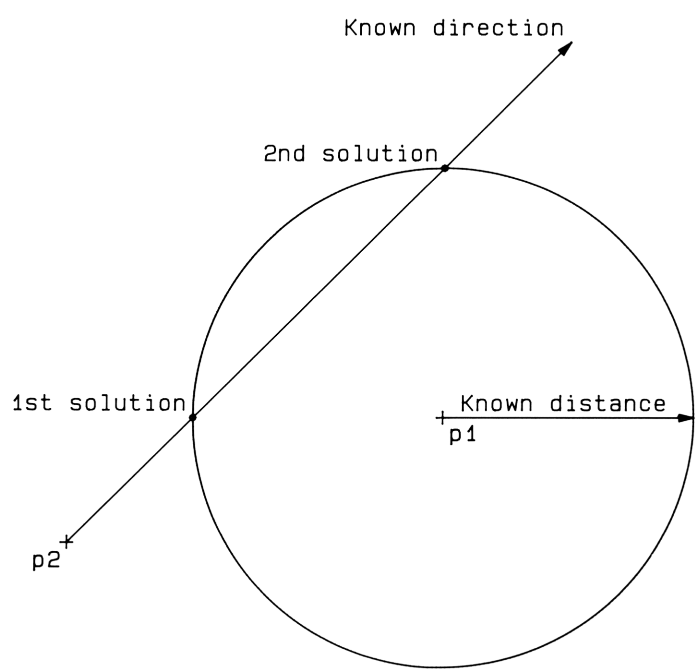
Solve: the coordinates of the points of intersection (there are two possible solutions).

Step	Display	Instructions
1	#*p1* TO # ?	*p1* is the currently occupied point. Enter the point number(s) of the coordinates to be solved. If only the first solution is required, enter a single point number. For both points, enter two different point numbers separated by a semicolon. To obtain only the second solution, precede the solve point number by a semicolon or a zero value (0;).
2	HORIZ [;VERT] ANGLE *p1* * *p* ?	Enter the direction from the first known point to the solve point(s).

Step	Display	Instructions
3	HORIZ [;VERT] DISTANCE *p1* * *p* ?	Since the distance from the first point is unknown, skip this entry.
4	2nd KNOWN # ?	Enter the point number of the second known point (*p2*). The coordinates will be printed.
5	HORIZ ANGLE *p2* * *p* ?	Since the second direction is unknown, skip this entry.
6	DISTANCE *p2* * *p* ?	Enter the distance from the second known point to the solve point.
7		Directions, distances, and solved coordinates are printed. Unless entered as a negative, the solve point becomes the new occupied point, with a backsight to the second known point.

Distance-Bearing Intersection of Lines

Given: two known points, the distance from the first point, and a bearing from the second.



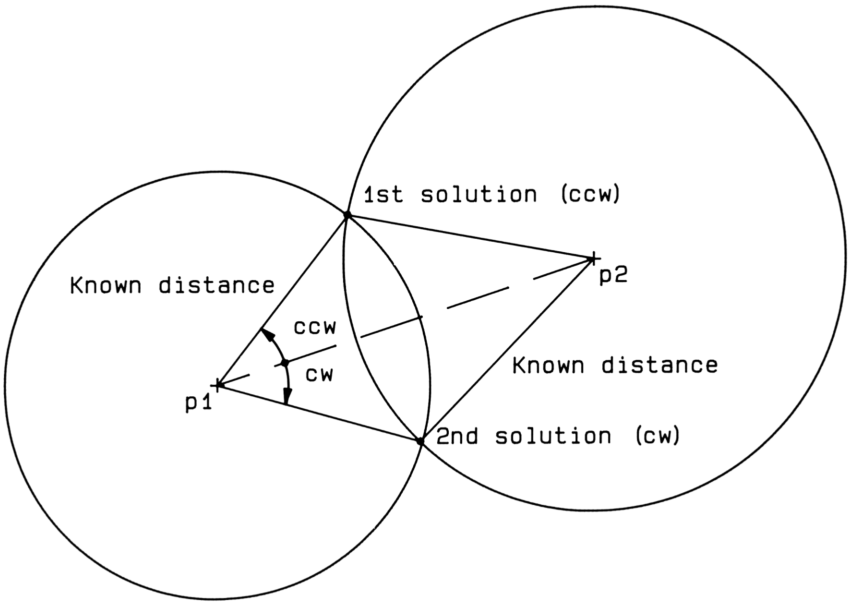
Solve: the coordinates of the points of intersection (there are two possible solutions).

This routine is identical to the Bearing-Distance solution, except that the order of input is reversed.

Step	Display	Instructions
1	*p1* TO # ?	*p1* is the number of the currently occupied point. Enter the point number(s) of the point(s) to be solved. If only the first solution is required, enter a single point number. For both points, enter two different point numbers separated by ;. To obtain only the second solution, precede the solve point number by ; or 0;.
2	HORIZ [;VERT] ANGLE *p1* * *p* ?	Since the direction from the first input is unknown, skip this entry.
3	HORIZ [;VERT] DISTANCE *p1* * *p* ?	Enter the distance between the first known point and the solve point.
4	2nd KNOWN # ?	Enter the point number of the second known point.
5		Enter the direction or angle turned to the solve point from the second known point.
6		The results are calculated and printed. If entered as a positive value, the solve point becomes the new occupied point, and the backsight is to the second known point.

Distance-Distance Intersection of Lines

Given: two known points and the distance from each to a third point.



Solve: the coordinates of the third point (there are two possible solutions).

Step	Display	Instructions
1	#*p1* to #?	Enter the point number(s) of the coordinates to be solved. To get both solutions, enter both point numbers, separated by a semicolon. To obtain only the first solution, enter one number. To obtain only the second solution, use zero for the first number (or just enter one number preceded by a semicolon). (In the display, *p1* refers to the number of the currently occupied point.)
2	HORIZ [;VERT] ANGLE *p1*‡*p*?	Since the bearing is unknown, press [RTN] without entering data.

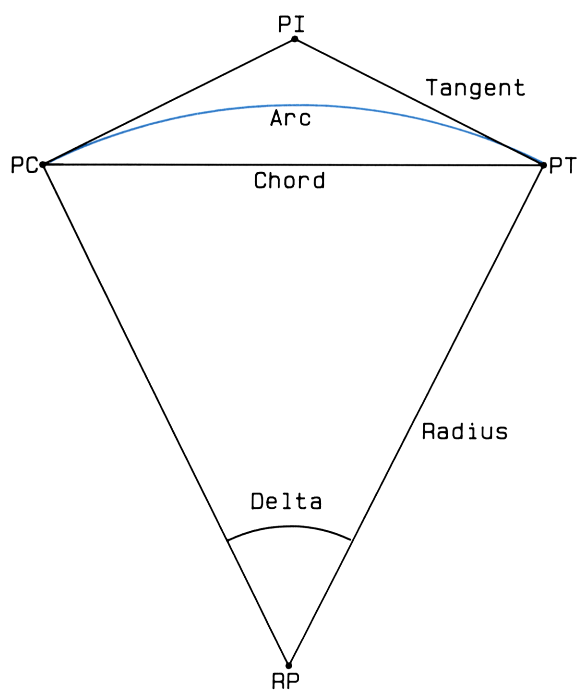
Step	Display	Instructions
3	HORIZ [;VERT] DISTANCE p1*p?	Enter the known distance from the first point.
4	2nd KNOWN #?	Enter the second known point number.
5	HORIZ ANGLE *p2*p*?	Since the bearing is not known, just press RTN.
6	DISTANCE p2*p?	Enter the distance from the second known point to the solve point.
7		The HP-75 will now print the angles, distances, and solved coordinates, and then return to step 1.

Routine: Curves

The Curves routine of COGO solves two types of problems:

Curve Traverse. Solves for the point of tangency (PT) from a known point of curvature (PC) and a known radial point (RP), given the arc, chord, tangent, or delta (central angle).

Inscribe Curve. Solves for the PC, PT, and RP, given a known radius and two known tangents (straight or curved).



Call the Curves routine from the COGO menu:

Start, Line, Curve (S/L/C)?	Press [C] for the Curve routine.

Curve Traverse

The Curve Traverse routine will solve the point of tangency (PT), given the point of curvature (PC), radial point (RP), and the arc, chord, tangent, or delta (central angle) of a curve.

The PC is the currently occupied point. Use the Start routine to change the PC if necessary.

Curve Traverse—Arc Length.

Step	Display	Instructions
1	Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R)?	Press [A].
2	ARC LENGTH?	Enter the arc length. If the curve is counter-clockwise, enter a negative value.
3	RP?	Enter the point number of the known radial point.
4	*p1* TO #?	Enter the point number to be assigned to the PT (*p1* is the PC).
5		The HP-75 now calculates the PT and prints the curve data. If the point number for the PT was positive, the PT becomes the new starting point, and the backsight is toward the radial point. The routine returns to step 1.

Curve Traverse—Chord Length.

Step	Display	Instructions
1	Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R)?	Press [C].
2	CHD LENGTH?	Enter the chord length. If the curve is counter-clockwise, enter a negative value.
3	RP?	Enter the point number of the known radial point.

Step	Display	Instructions
4	#p1 TO #?	Enter the point number for the PT. (*p1* is the PC.)
5		The routine now calculates the PT and prints the curve data. If the point number for the PT was positive, the PT becomes the new starting point, and the backsight is toward the radial point. The routine returns to step 1.

Curve Traverse—Tangent Length.

Step	Display	Instructions
1	Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R)?	Press [T].
2	TAN LENGTH?	Enter the tangent length. If the curve is counter-clockwise, enter a negative value.
3	RP?	Enter the point number of the known radial point.
4	#*p1* TO #?	Enter the point number for the PT. (*p1* is the PC.)
5		The routine now calculates the PT and prints the curve data. If the point number for the PT was positive, the PT becomes the new starting point, and the backsight is toward the radial point. The routine returns to step 1.

Curve Traverse—Central Angle (Delta).

Step	Display	Instructions
1	Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R)?	Press [D].
2	DELTA?	Enter the central angle. If the curve is counter-clockwise, enter a negative value.
3	RP?	Enter the point number of the known radial point.

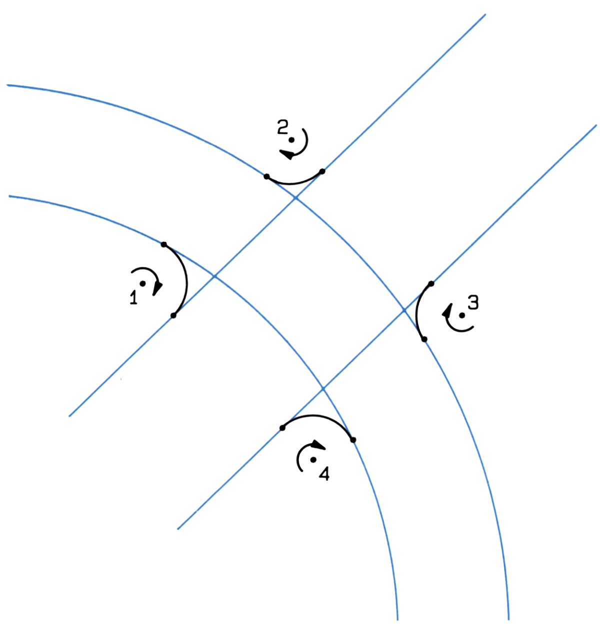
Step	Display	Instructions
4	#*p1* TO #?	Enter the point number for the PT. (*p1* is the PC.)
5		The routine now calculates the PT and prints the curve data. If the point number for the PT was positive, the PT becomes the new starting point, and the backsight is toward the radial point. The routine returns to step 1.

Inscribe Curve

The Inscribe Curve routine will solve three points (the PC, PT, and RP) defining a curve, given the curve radius and the tangent lines. Straight tangents are defined by a known point and bearing, and curved tangents are defined by a known radial point and radius.

Since there are several solutions in any given case, a few rules must be observed when entering data. The first is that data must be entered as it occurs in a clockwise direction. In other words, the angle from the PC to the PT must be clockwise.

If one of the tangents is a curve, you must indicate whether it turns clockwise or counter-clockwise. The examples in the following table illustrate these rules.



Curve #	Tangent In	Tangent Out
1	Clockwise curve	SW bearing
2	SW bearing	Counter-clockwise curve
3	Counter-clockwise curve	NE bearing
4	NE bearing	Clockwise curve

Inscribe Curve—Straight/Straight.

Step	Display	Instructions
1	`Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R)?`	Press [R].
2	`RADIUS?`	Enter the radius of the curve to be solved.
3	`# ON TAN IN? (-IF RP)`	Enter any point that falls on the line tangent to the curve at the PC.
4	`ANGLE IN?`	Enter the direction of the line from the PC to the curve PI (Point of Intersection).
5	`# ON TAN OUT? (- IF RP)`	Enter any point that falls on the line tangent to the curve at the PT.
6	`ANGLE OUT?`	Enter the direction of the line from the curve PI to the PT.
7	`SOLVE #?`	Enter the first of three consecutive point numbers to be assigned to the solved coordinates.
8		The routine now solves the PC, PT, and RP of the curve, and the curve data is printed. If the solve number was entered as a positive value, the PT becomes the new starting point with a backsight to the radial point.

Inscribe Curve—Straight/Curved.

Step	Display	Instructions
1	Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R)?	Press [R].
2	RADIUS?	Enter the radius of the curve to be solved.
3	# ON TAN IN? (- IF RP)	Enter the radius of the tangent curve. If the curve turns counter-clockwise, enter a negative value.
4	RADIUS IN? (- IF CCW)	Enter the radial point of the tangent curve as a negative number.
5	# ON TAN OUT? (- IF RP)	Enter any point that falls on the line tangent to the curve at the PT.
6	ANGLE OUT?	Enter the direction of the line from the curve PI to the PT.
7	SOLVE #?	Enter the first of three point numbers to assign to the solved coordinates.
8		The routine now solves the PC, PT, and RP of the curve, and the curve data is printed. If the solve number was entered as a positive value, the PT becomes the new starting point with a backsight to the radial point.

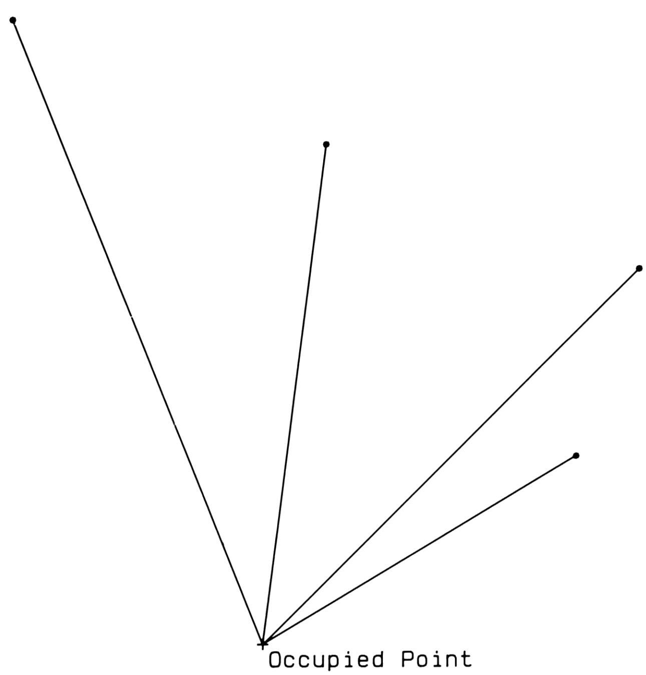
Inscribe Curve—Curved/Curved.

Step	Display	Instructions
1	Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R)?	Press [R].
2	RADIUS?	Enter the radius of the curve to be inscribed.
3	# ON TAN IN? (- IF RP)	Enter the radial point of the tangent curve as a negative number.
4	RADIUS IN? (- IF CCW)	Enter the radius of the tangent curve. If the curve turns counter-clockwise as it approaches the inscribed curve, enter a negative number.
5	# ON TAN OUT? (- IF RP)	Enter the radial point of the second tangent curve as a negative number.

Step	Display	Instructions
6	RADIUS OUT? (- IF CCW)	Enter the radius of the second tangent curve. If it turns counter-clockwise as it exits the inscribed curve, enter a negative value.
7	SOLVE #?	Enter the first of three point numbers to assign to the solved coordinates.
8		The routine now solves the PC, PT, and RP of the curve, and the curve data is printed. If the solve number was entered as a positive value, the PT becomes the new starting point with a backsight to the radial point.

Routine: Radial Stakeout

The Radial Stakeout routine prints the angles and distances from a fixed occupied point to a series of existing points. The occupied point and backsight are selected in the Start routine or determined by the previous solution.



Step	Display	Instructions
1	START,LINE,CURVE (S/L/C)?	Press [RTN].
2	RADIAL,TRAV,EXIT (R/T/E)?	Press [R].
3	#p1 TO #? [;THRU] ?	Enter a single point to be staked. If you have a series of numbers to be staked, enter the first and last number, separated by a semicolon. If you want to exit the Radial Stakeout routine, just press [RTN] to return to step 1.
4		After you make your entries, the routine prints the angles and distances between the points, and then returns to step 2.

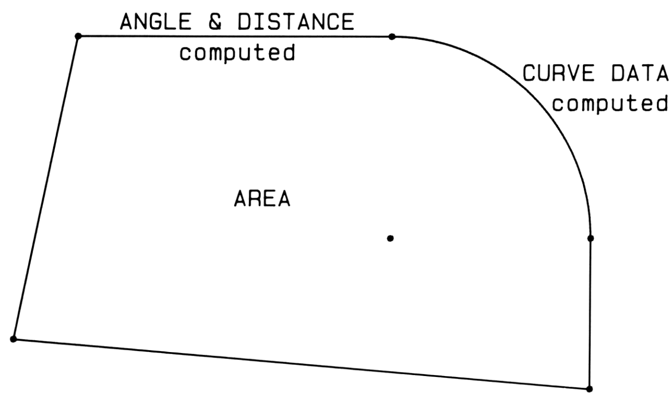
Traverse Reprint and Area Computations

The Traverse Reprint routine is similar to the Radial Stakeout routine, except that after inversing to a point, that point becomes the new occupied point, and the backsight is toward the old occupied point. This program can be used to:

- Calculate the area within a defined boundary.
- Inverse lines and curves.
- Reprint a traverse after adjustments are made.

In every case, a path is defined by entering a sequence of point numbers. Curves are flagged by entering the radial point as a negative number, after which the computer requests the point of tangency. Curves are always assumed to be less than 180°. If a curve is greater than 180°, it must be broken into two parts.

For each segment, the program prints the coordinates, point numbers, angles, and distances (plus curve information, where applicable). The area is printed when the routine is exited (by pressing [RTN] with no entry at step 2). The area will be meaningful only if you return to the starting point.



Step	Display	Instructions
1	RADIAL,TRAV,EXIT (R/T/E)?	Press [T].
2a	#*p1* TO #? [;THRU] ?	For straight segments, enter the next point on the line, *or* enter the first and last points of a series of points, separated by a semicolon. The inverse data will be printed, and the last point becomes the occupied point.
2b	#*p1* TO #? [;THRU] ?	For curved segments, enter the radial point of the curve as a negative number. (*p1* is the point of curvature, or PC.)
2c	#*p1* TO #? [;THRU] ?	To obtain a valid area and then exit the routine, you must first inverse back to the first point of the boundary. Then press [RTN] with no entry at this step. The area will be printed in square feet and acres, and the HP-75 returns to step 1, above.
3	PT?	Enter the point of tangency. The curve data is printed, and the point of tangency becomes the new occupied point.

Note: If the computed radii differ by more than 1%, the computer will beep and display `radii unequal`. It will then return to step 2, with the occupied point unchanged.

Section 4

Examples

Contents

Introduction

This section contains eight examples for you to work through using the Surveying Pac. You start at the beginning by establishing a coordinate file. Then you solve five common problems using the Surveying Pac's integrated subprograms and routines.

Example 1: File Creation and Coordinate Storage

Purpose: Set up a coordinate file and store the coordinates which will serve as the reference points of a traverse.

The surveying problem will require approximately 40 points. Create a coordinate file named DEMO that holds 50 points. Directions should be output as bearings, and relative angles should be deflections. Use degrees for angular units. Specify the output to have two decimal places for coordinates and distances, and zero places for angles (seconds).

After the file has been created, store point #1 with coordinates N 1600, E 4150, (no elevation) and point #2 with coordinates N 1735.68, E 7716.40, and H 506.8 (elevation).

Creating the Coordinate File

Input/Result

```
>
```

run 'survey' [RTN] — Execute the surveying program, SURVEY.

```
FILE NAME ?
```

demo [RTN] — Name the coordinate file DEMO.

```
FILE SIZE (### max)?
```

50 [RTN] — Allocate room for 50 points.

```
ABS ANGLES Brg,Naz,Saz (B/N/S)?
```

[B] — Specify bearing for output of directions.

```
REL ANGLES Deflect,Angle (D/A)?
```

[D] — Select deflections for relative angle output.

```
UNITS Degrees,Grads (D/G)?
```

[D] — Angular Units in degrees.

`DECIMALS ON SECONDS (0-2)?`	
[0]	No fractional seconds will be printed.
`DECIMALS ON COORDS (0-5)?`	
[2]	Coordinates will be printed with 2 decimal places.
`DECIMALS ON DISTANCES (0-5)?`	
[2]	Distances will be output to the hundredths place.
`working`	There will be a short delay while the file is created.
`File,Cogo,User (F/C/U)?`	
[F]	Select the File Management program.
`File Management` `List,Clear,Duplicate (L/C/D)?`	
[RTN]	Press [RTN] to access the next menu.
`Rotate,Translate,Scale (R/T/S)?`	
[RTN]	Press [RTN] to access the next menu.

Assigning Points #1 and #2

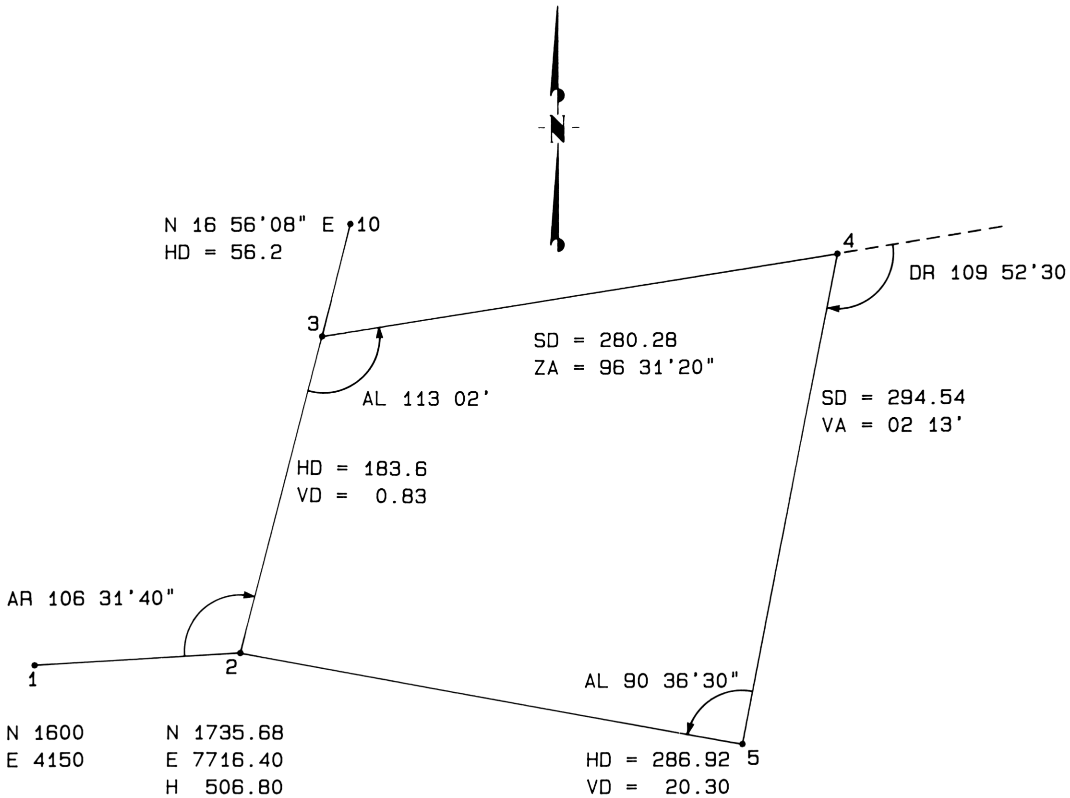
Input/Result

`Balance,Assign,Exit (B/A/E)?`	
[A]	Select the Assign routine.
`POINT # ?`	
1 [RTN]	Assign point #1.

`N,E OF #1 ?`	
1600,4150 [RTN]	Enter the coordinates of point #1.
`H OF #1 ?`	
[RTN]	No elevation is known.
`#1` `1600.00 N` `4150.00 E` `POINT # ?`	The values are printed.
+ [RTN]	Auto-increment to assign point #2.
`N,E of #2 ?`	
1735.68,7716.4 [RTN]	Input the coordinates of point #2.
`H OF #2 ?`	
506.8 [RTN]	The elevation is known.
`#2` `1735.68 N` `7716.40 E` `506.80 H` `POINT # ?`	The coordinates are printed.
[RTN]	Press [RTN] to exit the Assign routine.
`Balance,Assign,Exit (B/A/E) ?`	
[E]	Exit the File Management program.
`File,Cogo,User (F/C/U) ?`	The main menu is displayed.

Example 2: Field Traverse

Purpose: Enter and reduce field notes for the traverse below.



The points stored in example #1 are used as the starting point and backsight for the traverse. The Start routine in COGO establishes the occupied point and backsight. Each leg is traversed using the traverse option of the Lines routine.

From the last point on the traverse (#5), the closing angle and distance were measured. A temporary point (#6) will be stored to account for any errors in closure (if no errors were present, points #6 and #2 would have the same coordinates).

Establishing the Occupied Point and Backsight

Input/Result

```
File,Cogo,User (F/C/U) ?
```

[C] Select the Coordinate Geometry program.

```
FROM # ?
```

2 [RTN] Point #2 is the occupied point.

```
#2
                1735.68 N
                7716.40 E
                 506.80 H
BACKSIGHT ?
```

The coordinates of point #2 are printed.

2*1 [RTN] Use a defined direction (from #2 to #1) to establish backsight.

```
b.s.      SW  87°49'17"
ANGLES abs,Rel  (A/R) ?
```

[A] Select absolute angle output (directions).

Entering the Traverse

Input/Result

```
Start,Line,Curve (S/L/C) ?
```

[L] Select the Lines routine.

```
#2 TO # ?
```

3 [RTN]

```
HORIZ [;VERT] ANGLE 2*3 ?
```

+106.3140 [RTN]	Angle right from backsight 106°31'40".

```
HORIZ [;VERT] DISTANCE 2*3 ?
```

183.6;-.83 [RTN]	Horizontal distance = 183.6; Vertical distance= .83.

```
2-3         NE 14°20'57"
2-3              183.60
#3
                1913.55 N
                7761.90 E
                 505.97 H
#3 TO # ?
```

Bearing, distance, and coordinates are printed.

-10 [RTN]	A negative point number indicates a sideshot.

```
HORIZ [;VERT] ANGLE 3*10 ?
```

NE16.5608 [RTN]	Bearing NE 16°56'08".

```
HORIZ [;VERT] DISTANCE 3*10 ?
```

56.2 [RTN]	Horizontal distance = 56.2.

```
3-10        NE 16°56'08"
3-10              56.20
#10
                1967.32 N
                7778.27 E
                 505.97 H
#3 TO # ?
```

+ [RTN]	Use the auto-increment to select point #4.

```
HORIZ [;VERT] ANGLE 3*4 ?
```

-113.02;2.13 RTN — Backsight is to point #2. Enter angle left and vertical angle.

```
SLOPE DISTANCE 3*4 ?
```

294.54 RTN — The slope distance will be reduced to horizontal.

```
3-4          NE   81°18'57"
3-4                 294.32
#4
                  1957.99 N
                  8052.85 E
                   517.36 H
#4 TO # ?
```

+ RTN — Auto-increment.

```
HORIZ [;VERT] ANGLE 4*5 ?
```

+180+109.5230; 96.3120 RTN — Deflection right = 109°52'30"; Zenith angle = 96°31'20".

```
SLOPE DISTANCE 4*5 ?
```

280.28 RTN — Slope distance entry.

```
4-5          SW   11°11'27"
4-5                 278.47
#5
                  1684.82 N
                  7998.80 E
                   485.53 H
```

Closing on the Starting Point

Input/Result

```
#5 TO # ?
```

+ [RTN] — Point #6 holds the unadjusted coordinates of the starting point.

```
HORIZ [;VERT] ANGLE 5*6 ?
```

-90.3630 [RTN] — Angle left = 90°36'30″.

```
HORIZ [;VERT] DISTANCE 5*6 ?
```

286.92;20.5 [RTN] — Horizontal distance = 286.92; Vertical distance = 20.5.

```
5-6        NW  79°25'03"
5-6              286.92
#6
              1737.51 N
              7716.76 E
               506.03 H
#6 TO # ?
```

[RTN] — Press [RTN] to return to the menu.

```
Start,Line,Curve (S/L/C) ?
```

[RTN] — Press [RTN] to access the next menu.

```
Radial,Trav,Exit (R/T/E) ?
```

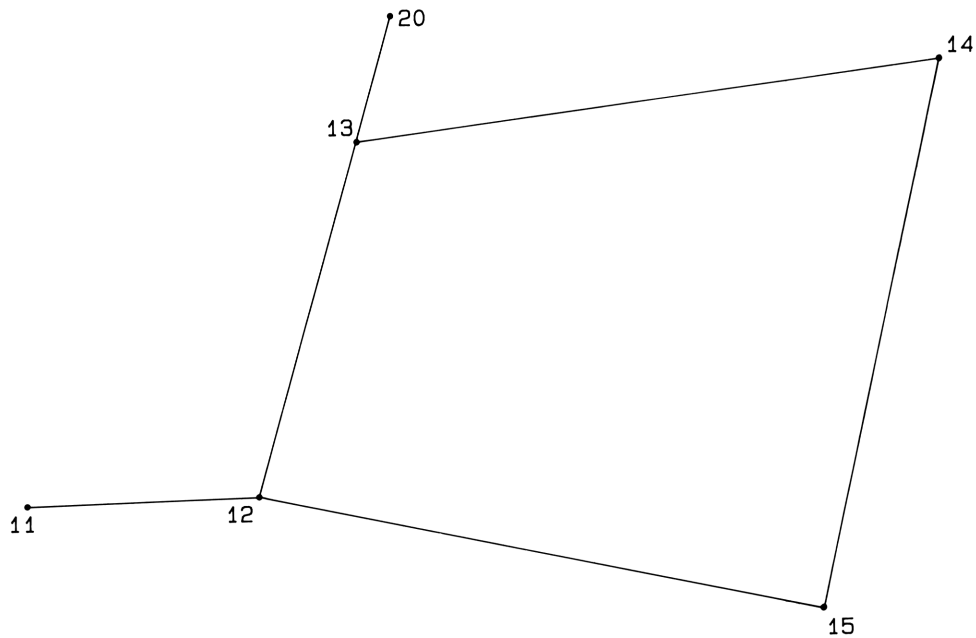
[E] — Exit the Coordinate Geometry program.

```
File,Cogo,User (F/C/U) ?
```

The main menu is displayed.

Example 3: Duplicate Points and Balance Traverse

Purpose: Make a duplicate set of the points solved in example 1 and 2, and balance the traverse according to the Compass Rule.



Points 1-10 will be duplicated as points 11-20. The adjustment will be made to the duplicated points.

Duplicate Points

Input/Result

```
File,Cogo,User (F/C/U) ?
```

[F] Select the File Management program.

```
File Management
List,Clear,Duplicate (L/C/D) ?
```

[D] Select the Duplicate routine.

Input/Result	
`STARTING,ENDING #s`	
1,10 [RTN]	Duplicate points 1 thru 10.
`NEW STARTING # ?`	
11 [RTN]	Assign point #11 to the first duplicate point.
`working`	There is a short delay while the points are copied.
`List,Clear,Duplicate (L/C/D) ?`	
[RTN]	Press [RTN] to access the next menu.
`Rotate,Translate,Scale (R/T/S) ?`	
[RTN]	Press [RTN] to access the next menu.

Balance Traverse

Input/Result

`Balance,Assign,Exit (B/A/E) ?`	
[B]	Select the Balance routine.
`STARTING,ENDING #s ?`	
12,16 [RTN]	The main traverse is made up of points 12 thru 16.

`ANGLE ADJUSTMENT ?`	
0 [RTN]	No angle balance will be performed.
`UNADJUSTED:` `#16` `1737.51 N` `7716.76 E` `506.03 H` `TRUE N,E OF 16 ?`	The unadjusted values of point #16 are displayed.
1735.68,7716.4 [RTN]	The true coordinates of #16 should match the coordinates of point #12 (2).
`TRUE H ?`	
506.8 [RTN]	Enter the correct elevation.
`CORRECTION:` `#16` `-1.83 N` `-0.36 E` `0.77 H`	The corrections are printed.
`working`	Do not interrupt the program.
`CLOSURE:` `error 1.87` `1 in 558.38` `None,Bowditch,Crandall (N/B/C) ?`	The error of closure is displayed.
[B]	Select a Bowditch rule balance.
`working`	Again, do not interrupt the computations.
`Balance,Assign,Exit (B/A/E) ?`	
[E]	When the menu appears the balance is complete. Exit the File Management program.

```
File,Cogo,User (F/C/U) ?
```

The main menu is displayed.

Example 4: Reprint Traverse

Purpose: Reprint the adjusted traverse showing deflection angles, distances, coordinates, and total area.

The Start routine allows selection of relative angles (deflections). The Trav routine will inverse between the adjusted coordinates and calculate the total enclosed area of the traverse.

Input/Result

```
File,Cogo,User (F/C/U) ?
```

[C] Select the Coordinate Geometry program.

```
Coordinate Geometry
FROM # ?
```

12 [RTN] Start from point #12.

```
#12
                1735.68 N
                7716.40 E
                 506.80 H
BACKSIGHT ?
```

The coordinates are printed.

12*11 [RTN] Use a defined direction to establish the backsight.

```
b.s.   SW  87 49' 17"
ANGLES Abs,Rel  (A/R) ?
```

[R] Select relative angle output. Deflections will be used, according to the specifications established when the file was created.

```
Start,Line,Curve (S/L/C) ?
```

[RTN] Skip to the next menu.

```
Radial,Trav,Exit (R/T/E) ?
```

T — Select the Traverse Reprint program.

```
#12 TO # ? [;THRU] ?
```

13;15 RTN — The THRU command automatically inverses between 12-13, 13-14, and 14-15.

```
12-13      DL   73°28'00"
12-13             183.27
#13
                1913.23 N
                7761.84 E
                 506.11 H
```

#12 to #13.

```
13-14      DR   67°03'27"
13-14             294.14
#14
                1957.15 N
                8052.68 E
                 517.72 H
```

#13 to #14.

```
14-15      DR  109°46'43"
14-15             278.96
#15
                1683.49 N
                7998.54 E
                 486.09 H
#15 TO # ? [;THRU] ?
```

#14 to #15.

12 RTN — Return to the starting point #12 to ensure a valid area.

```
15-12      DR   89°17'21"
15-12             286.93
#12
                1735.68 N
                7716.40 E
                 506.80 H
#12 TO # ? [;THRU] ?
```

#15 to #12.

[RTN] Bypass this entry to end input and print the area.

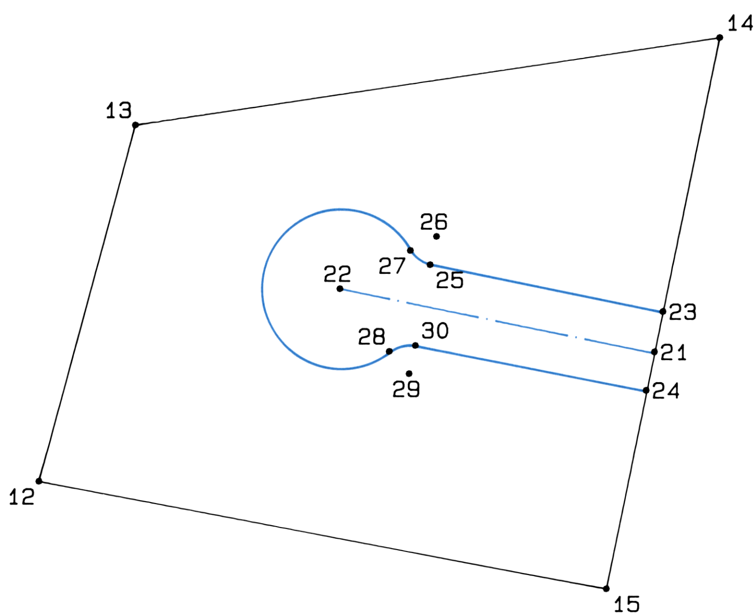
```
sq ft        64839.74
acres            1.49
Radial,Trav,Exit (R/T/E) ?
```

[RTN] The COGO menu is displayed. Press [RTN] to access the main menu.

```
Start,Line,Curve (S/L/C) ?
```

Example 5: Solve Roadway Center Line and Curb Line

Purpose: Solve and store points defining the roadway center line and curb using the dimensions shown below.



- Center line begins on the east boundary line (14-15) at a point 120 feet from point #15.
- Center line projects perpendicular to line (14-15) for a distance of 160 feet.
- Roadway is 40 feet wide and terminates with a cul-de-sac with a 40 foot radius.
- Curb returns on the cul-de-sac have a 15 foot radius.

Input/Result

```
Start,Line,Curve (S/L/C) ?
```

[S] — Select the Start routine to reset the occupied point.

```
FROM # ?
```

15 [RTN] — Select point #15 as the occupied point.

```
#15
                    1683.49 N
                    7998.54 E
                     486.09 H
BACKSIGHT ?
```

The coordinates of point #15 are printed.

15*12 [RTN] — Actually, the backsight is unimportant since it is not used in the next solution.

```
b.s          NW   79°31'13"
ANGLES Abs,Rel (A/R) ?
```

[A] — Select absolute angle output (directions).

```
Start,Line,Curve (S/L/C) ?
```

[L] — Choose the Lines routine.

Solving Roadway Center Line

Input/Result

```
#15 to # ?
```

21 [RTN] — Solve point #21.

```
HORIZ [;VERT] ANGLE 15*21 ?
```

15*14 [RTN] — Point #21 falls on the line from #15 to #14...

```
HORIZ [;VERT] DISTANCE 15*21 ?
```

120 [RTN] — at a distance of 120 feet from point #15.

```
15-21        NE     11°11'27"
15-21                120.00
#21
                  1801.21 N
                  8021.83 E
                   486.09 H
#21 TO # ?
```

Point #21 is solved, and the values are displayed.

-22 [RTN] — Points #22, #23 and #24 will be set from #21. Use the sideshot designation to maintain the occupied point and backsight.

```
HORIZ [;VERT] ANGLE 21*22 ?
```

+90 [RTN] — The center line is perpendicular to line 14-15.

```
HORIZ [;VERT] DISTANCE 21*22 ?
```

160 [RTN] — The center line is 160 feet long.

```
21-22       NW     78°48'33"
21-22               160.00
#22
                  1832.26 N
                  7864.87 E
                   486.09 H
```

Solving the Curb Line

Input/Result

```
#21 TO # ?
```

-23 RTN

```
HORIZ [;VERT] ANGLE 21*23 ?
```

+180 RTN — A defined direction of 21*14 could also be entered.

```
HORIZ [;VERT] DISTANCE 21*23 ?
```

20 RTN — Half the 40 foot roadway width.

```
21-23     NE    11°11'27"
21-23              20.00
#23
                 1820.83 N
                 8025.71 E
                  486.09 H
#21 TO # ?
```

24 RTN

```
HORIZ [;VERT] ANGLE 21*24 ?
```

+0 RTN — Sight along the backsight.

```
HORIZ [;VERT] DISTANCE 21*24 ?
```

20 [RTN]

```
21-24     SW    11°11'27"
21-24              20.00
#24
                1781.59 N
                8017.95 E
                 486.09 H
#24 TO # ?
```

[RTN] — Bypass this entry to return to the menu.

Solving the Cul-de-Sac Curb Returns

Input/Result

```
Start,Line,Curve (S/L/C) ?
```

[C] — Select the Curve routine.

```
Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R) ?
```

[R] — Curb returns are tangent to the cul-de-sac curve and the straight curbs are parallel to the center line.

```
RADIUS ?
```

15 [RTN] — Curb radius = 15 feet.

```
# ON TAN IN (- IF RP) ?
```

23 [RTN] — The tangent going into the curb begins at point #23.

```
ANGLE IN ?
```

21*22 RTN — The straight tangent is parallel to the center line.

```
# ON TAN OUT (- IF RP) ?
```

-22 RTN — Center of the cul-de-sac.

```
RADIUS OUT (- IF CCW) ?
```

-40 RTN — Radius of cul-de-sac, entered as a negative since it turns counter-clockwise.

```
SOLVE # ?
```

25 RTN — Three points will be solved, beginning with #25.

```
#25
                 1843.65 N
                 7910.37 E
```

PC

```
#27
                 1851.24 N
                 7900.08 E
```

PT

```
#26
                 1858.36 N
                 7913.28 E
delta      AR   50°28'44"
arc                13.22
tan                 7.07
chord:
25-27      NW   53°34'11"
25-27              12.79
radials:
25-26      NE   11°11'27"
25-26              15.00
26-27      SW   61°40'10"
26-27              15.00
```

RP

```
Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R) ?
```

[R] Solve the second return.

```
RADIUS ?
```

15 [RTN] Radius of the curb return.

```
# ON TAN IN (- IF RP) ?
```

-22 [RTN] The tangent going into the solved curve is a curve with RP #22.

```
RADIUS IN (- IF CCW) ?
```

-40 [RTN] The curve turns counter-clockwise, with a 40 foot radius.

```
# ON TAN OUT (- IF RP) ?
```

24 [RTN]

```
ANGLE OUT ?
```

22*21 [RTN] Parallel to the center line.

```
SOLVE # ?
```

28 [RTN] Solve three points beginning with #28.

```
#28
                    1801.30 N
                    7890.20 E
```

PC

```
#30
                    1804.41 N
                    7902.61 E
```

PT

```
#29
                 1789.69 N
                 7899.70 E
delta     AR    50°28'44"
arc                 13.22
tan                  7.07
chord:
28-30     NE    75°57'05"
28-30               12.79
radials:
28-29     SE    39°17'17"
28-29               15.00
29-30     NE    11°11'27"
29-30               15.00
```

RP

```
Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R) ?
```

RTN — Bypass this entry to return to the COGO menu.

```
Start,Line,Curve (S/L/C) ?
```

L — Select the Lines routine.

```
#30 TO # ?
```

24 RTN — Inverse back to point #24 to establish the starting point for the next example.

```
HORIZ [;VERT] ANGLE 30*24 ?
```

RTN — Bypass.

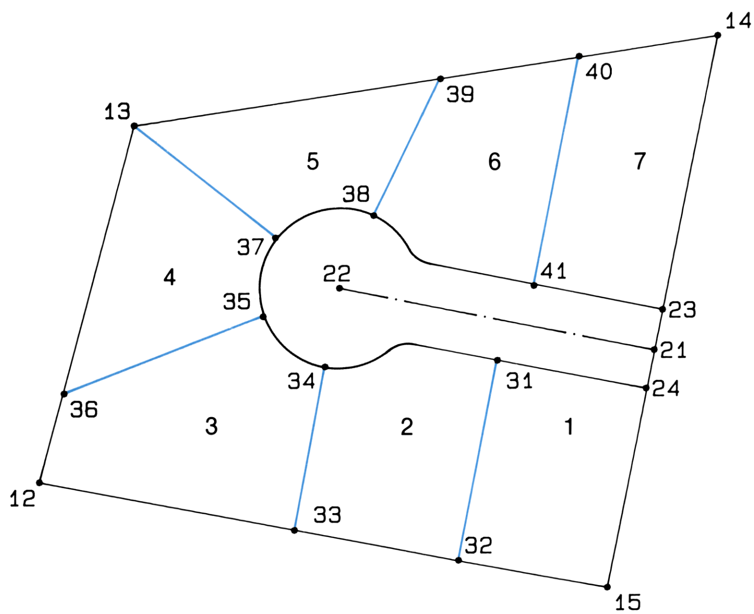
```
HORIZ [;VERT] DISTANCE 30*24 ?
```

RTN — Bypass.

```
30-24       SE   78°48'33"
30-24              117.57
#24
                 1781.59 N
                 8017.95 E
                  486.09 H
#24 TO # ?
```

Example 6: Subdivision

Purpose: Subdivide the parcel as shown.



LOT 1	75 foot frontage; west boundary is perpendicular to the street.
LOT 2	The west boundary is perpendicular to the south parcel boundary (12-15) and radial to the cul-de-sac.
LOT 3	The northwest lot boundary is radial to the cul-de-sac, and the lot has a 40 foot frontage as measured on the curve.
LOT 4	The northeast lot line is radial to the cul-de-sac and extends to the northwest corner of the parcel (pt #13).
LOT 5	The lot has a 50 foot frontage measured along the chord, and the east boundary is radial to the cul-de-sac.
LOTS 6 & 7	Point #40 is the midpoint between #39 and #14, and the common lot line is perpendicular to the street.

Lot 1

Input/Result

```
#24 TO # ?
```

31 [RTN] — Solve point #31.

```
HORIZ [;VERT] ANGLE 24*31 ?
```

21*22 [RTN] — 24*30 would also work.

```
HORIZ [;VERT] DISTANCE 24*31 ?
```

75 [RTN] — Frontage = 75 feet.

```
24-31     NW    78°48'33"
24-31              75.00
#31
                1796.15 N
                7944.37 E
                 486.09 H
#31 TO # ?
```

+ [RTN] — Increment to #32.

```
HORIZ [;VERT] ANGLE 31*32 ?
```

+90 [RTN] — West boundary line is perpendicular to the street.

```
HORIZ [;VERT] DISTANCE 31*32 ?
```

[RTN] — Bypass this entry, since the distance is unknown.

```
2nd KNOWN # ?
```

15 [RTN] — Use a bearing-bearing intersection with the south parcel boundary.

```
#15
               1683.49 N
               7998.54 E
                486.09 H
HORIZ ANGLE 15*32 ?
```

15*12 [RTN] — Defined direction.

```
31-32    SW    11°11'27"
31-32            100.93
15-32    NW    79°31'13"
15-32             75.01
#32
               1697.13 N
               7924.79 E
```

Lot 2

Input/Result

```
#32 TO # ?
```

+ [RTN] — Auto-increment to point #33.

```
HORIZ [;VERT] ANGLE 32*33 ?
```

15*12 [RTN]

```
HORIZ [;VERT] DISTANCE 32*33 ?
```

[RTN] Unknown, so bypass.

```
2nd KNOWN # ?
```

22 [RTN] Cul-de-sac radial point.

```
#22
                 1832.26 N
                 7864.87 E
                  486.09 H
HORIZ ANGLE 22*33 ?
```

15*12-90 [RTN] Perpendicular to the boundary.

```
32-33     NW   79°31'13"
32-33             83.49
22-33     SW   10°28'47"
22-33            121.98
#33
                 1712.32 N
                 7842.69 E
#33 TO # ?
```

+ [RTN] Auto-increment to point #34.

```
HORIZ [;VERT] ANGLE 33*34 ?
```

33*22 [RTN] Radial to cul-de-sac.

```
HORIZ [;VERT] DISTANCE 33*34 ?
```

33*22-40 [RTN] Computed distance minus 40 foot radius.

```
33-34     NE    10°28'47"
33-34              81.98
#34
                1792.93 N
                7857.60 E
```

Lot 3

Input/Result

```
#34 TO # ?
```

RTN — Bypass to return to the COGO menu.

```
Start,Line,Curve (S/L/C) ?
```

C — Select the Curve routine.

```
Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R) ?
```

A — Traverse on the curve with a known arc distance.

```
ARC LENGTH ?
```

40 RTN — 40 foot frontage.

```
RP ?
```

22 RTN — RP of cul-de-sac.

```
#34 TO # ?
```

35 RTN — Solve point #35.

```
#35
                1817.13 N
                7827.84 E
#22
                1832.26 N
                7864.87 E
                 486.09 H
delta     AR     57°17'45"
arc                 40.00
tan                 21.85
chord:
34-35     NW     50°52'20"
34-35               38.35
radials:
34-22     NE     10°28'47"
34-22               40.00
22-35     SW     67°46'32"
22-35               40.00
Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R) ?
```

[RTN] Exit the Curve routine.

```
Start,Line,Curve (S/L/C) ?
```

[L] Select the Lines routine.

```
#35 TO # ?
```

+ [RTN] Solve point #36 by a bearing-bearing intersection.

```
HORIZ [;VERT] ANGLE 35*36 ?
```

22*35 [RTN] Radial bearing.

```
HORIZ [;VERT] DISTANCE 35*36 ?
```

[RTN] Unknown, so bypass.

```
2nd KNOWN # ?
```

12 [RTN]

```
#12
                   1735.68 N
                   7716.40 E
                    506.80 H
HORIZ ANGLE 12*36 ?
```

12*13 [RTN] Second known bearing.

```
35-36    SW    67°46'32"
35-36            109.30
12-36    NE    14°21'17"
12-36             41.41
#36
               1775.79 N
               7726.67 E
```

Lot 4

Input/Result

```
#36 TO # ?
```

13 [RTN] Inverse to point #13 to establish the next starting point.

```
HORIZ [;VERT] ANGLE 36*13 ?
```

[RTN]

```
HORIZ [;VERT] DISTANCE 36*13 ?
```

[RTN]

```
36-13    NE    14°21'17"
36-13            141.87
#13
               1913.23 N
               7761.84 E
                506.11 H
#13 TO # ?
```

37 [RTN] Traverse to point #37.

```
HORIZ [;VERT] ANGLE 13*37 ?
```

13*22 RTN — Radial to the cul-de-sac.

```
HORIZ [;VERT] DISTANCE 13*37 ?
```

13*22-40 RTN — Computed distance minus 40 foot radius.

```
13-37     SE    51°50'18"
13-37              91.04
#37
                 1856.98 N
                 7833.42 E
                  506.11 H
```

Lot 5

Input/Result

```
#37 TO # ?
```

RTN — Bypass to exit the Lines routine.

```
Start,Line,Curve (S/L/C) ?
```

C — Select the Curve routine.

```
Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R) ?
```

C — 50 foot frontage is measured along the chord.

```
CHD LENGTH ?
```

50 RTN

```
RP ?
```

22 RTN

```
# 37 to # ?
```

38 RTN

```
#38
                1868.36 N
                7882.11 E
#22
                1832.26 N
                7864.87 E
                 486.09 H
delta     AR     77°21'52"
arc                 54.01
tan                 32.03
chord:
37-38     NE     76°50'38"
37-38               50.00
radials:
37-22     SE     51°50'18"
37-22               40.00
22-38     NE     25°31'34"
22-38               40.00
Arc,Cd,Tan,Dlt,Rad (A/C/T/D/R) ?
```

RTN — Exit the Curve routine.

```
Start,Line,Curve (S/L/C) ?
```

L — Select the Lines routine.

```
#38 TO # ?
```

+ RTN — Increment to point #39.

```
HORIZ [;VERT] ANGLE 38*39 ?
```

22*38 RTN — Radial.

```
HORIZ [;VERT] DISTANCE 38*39 ?
```

RTN — Unknown.

```
2nd KNOWN # ?
```

13 RTN — Point on north parcel boundary.

```
#13
                1913.23 N
                7761.84 E
                 506.11 H
HORIZ ANGLE 13*39 ?
```

13*14 RTN — Intersect with the boundary.

```
38-39     NE   25°31'34"
38-39             75.28
13-39     NE   81°24'44"
13-39            154.44
#39
                1936.29 N
                7914.55 E
```

Lot 6 and 7

Input/Result

```
#39 TO # ?
```

40 RTN

```
HORIZ [;VERT] ANGLE 39*40 ?
```

39*14 RTN — Point #40 is located on the north boundary...

```
HORIZ [;VERT] DISTANCE 39*40 ?
```

39*14/2 [RTN] — and is midway between #39 and #14.

```
39-40       NE     81°24'44"
39-40                  69.85
#40
                   1946.72 N
                   7983.61 E
#40 TO # ?
```

41 [RTN]

```
HORIZ [;VERT] ANGLE 40*41 ?
```

14*15 [RTN] — The line between lots 6 and 7 is parallel to the east parcel boundary.

```
HORIZ [;VERT] DISTANCE 40*41 ?
```

[RTN] — Unknown.

```
2nd KNOWN # ?
```

23 [RTN]

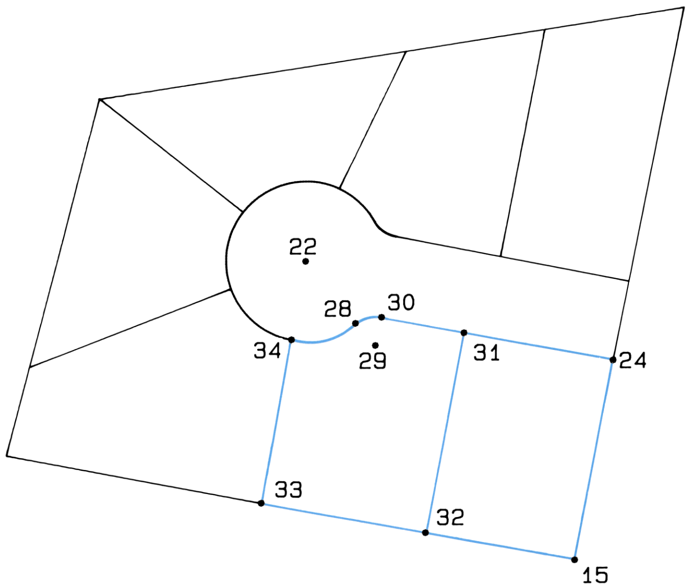
```
#23
                   1820.83 N
                   8025.71 E
                    486.09 H
HORIZ ANGLE 23*41 ?
```

21*22 [RTN] — 23*30 is also valid.

```
40-41       SW     11°11'27"
40-41                 115.33
23-41       NW     78°48'33"
23-41                  65.73
#41
                   1833.59 N
                   7961.23 E
```

Example 7: Lot Summary

Purpose: Compute the areas of lots 1 and 2.



Input/Result

```
#41 TO # ?
```

31 RTN — Inverse back to #31 to establish the next starting point.

```
HORIZ [;VERT] ANGLE 41*31 ?
```

RTN

```
HORIZ [;VERT] DISTANCE 41*31 ?
```

RTN

```
41-31      SW   24°14'28"
41-31              41.06
#31
                1796.15 N
                7944.37 E
                 486.09 H
#31 TO # ?
```

[RTN] Exit the Lines routine.

```
Start,Line,Curve (S/L/C) ?
```

[RTN] Skip to the next menu.

```
Radial,Trav,Exit (R/T/E) ?
```

[T] Select the Traverse Reprint function.

```
#31 TO # ? [;THRU] ?
```

32 [RTN] Traverse around Lot 1.

```
31-32      SW   11°11'27"
31-32             100.93
#32
                1697.13 N
                7924.79 E
#32 TO # ? [;THRU] ?
```

31-32-15-24-31.

15 [RTN]

```
32-15       SE   79°31'13"
32-15             75.01
#15
                1683.49 N
                7998.54 E
                 486.09 H
#15 TO # ? [;THRU] ?
```

24 [RTN]

```
15-24       NE   11°11'27"
15-24            100.00
#24
                1781.59 N
                8017.95 E
                 486.09 H
#24 TO # ? [;THRU] ?
```

31 [RTN]

You must return to the starting point.

```
24-31       NW   78°48'33"
24-31             75.00
#31
                1796.15 N
                7944.37 E
                 486.09 H
#31 TO # ? [;THRU] ?
```

[RTN]

Make no entry to close.

```
sq ft              7534.90
acres                 0.17
Radial,Trav,Exit (R/T/E) ?
```

[T]

Begin Lot 2.

```
#31 TO # ? [;THRU] ?
```

32;34 [RTN]

Automatically inverses between 31-32-33-34.

```
31-32      SW   11°11'27"
31-32             100.93
#32
                 1697.13 N
                 7924.79 E
32-33      NW   79°31'13"
32-33              83.49
#33
                 1712.32 N
                 7842.69 E
33-34      NE   10°28'47"
33-34              81.98
#34
                 1792.93 N
                 7857.60 E
#34 TO # ? [;THRU] ?
```

-22 [RTN] Use a negative radial point to flag the curve.

```
PT ?
```

28 [RTN] Point of tangency.

```
#28
                 1801.30 N
                 7890.20 E
#22
                 1832.26 N
                 7864.87 E
                  486.09 H
delta      AL   49°46'04"
arc                34.74
tan                18.55
chord:
34-28      NE   75°35'45"
34-28              33.66
radials:
34-22      NE   10°28'47"
34-22              40.00
22-28      SE   39°17'17"
22-28              40.00
#28 TO # ? [;THRU] ?
```

-29 [RTN] Radial point of curb return.

```
PT ?
```

30 [RTN] — Point of tangency.

```
#30
                1804.41 N
                7902.61 E
#29
                1789.69 N
                7899.70 E
delta     AR    50°28'44"
arc                13.22
tan                 7.07
chord:
28-30     NE    75°57'05"
28-30              12.79
radials:
28-29     SE    39°17'17"
28-29              15.00
29-30     NE    11°11'27"
29-30              15.00
#30 TO # ? [;THRU] ?
```

31 [RTN] — Return to the starting point.

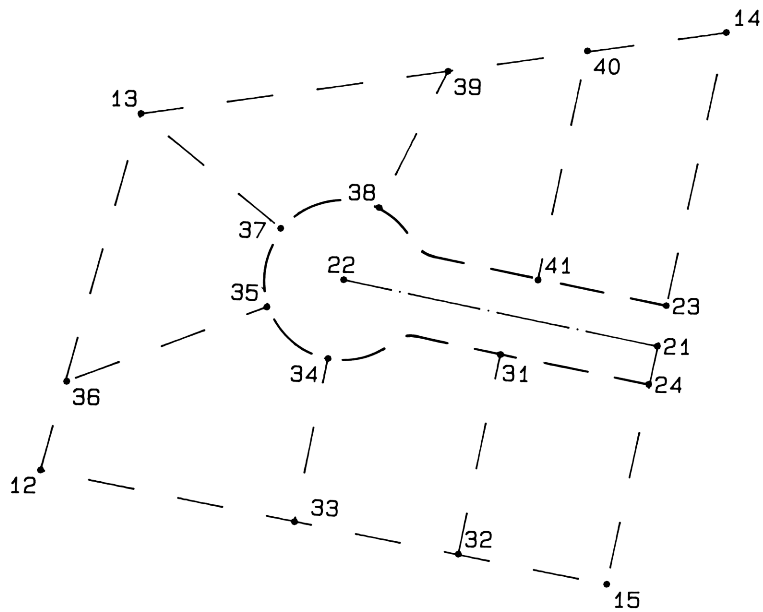
```
30-31     SE    78°48'33"
30-31              42.57
#31
                1796.15 N
                7944.37 E
                 486.09 H
#31 TO # ? [;THRU] ?
```

[RTN] — Close the figure to print the area.

```
sq ft             8041.92
acres                0.18
Radial,Trav,Exit (R/T/E) ?
```

Example 8: Radial Stakeout

Purpose: From point #22 (center of the cul-de-sac), compute and print the staking data for all solved points.



Input/Result

Radial,Trav,Exit (R/T/E) ?

[RTN] Skip to the next menu.

Start,Line,Curve (S/L/C) ?

[S] Select the Start function to establish the instrument point and backsight.

FROM # ?

22 [RTN] Set up on point #22 (center of the cul-de-sac).

```
#22
                     1832.26 N
                     7864.87 E
                      486.09 H
BACKSIGHT ?
```

22*21 [RTN] — Backsight down the roadway center line.

```
b.s.       SE  78°48'33"
ANGLES Abs,Rel  (A/R) ?
```

[R] — Select relative angles (deflections) for output.

```
Start,Line,Curve (S/L/C) ?
```

[RTN] — Next menu.

```
Radial,Trav,Exit (R/T/E) ?
```

[R] — Select the Radial Stakeout routine.

```
#22 TO # ? [;THRU] ?
```

31;41 [RTN] — Staking data for points #31 thru #41, inclusive, will be printed.

All distances are from point #22 and deflection angles are turned from the street center line.

```
22-31      DL 166°45'34"
22-31             87.32
#31
                     1796.15 N
                     7944.37 E
                      486.09 H
22-32      DL 125°06'10"
22-32            147.81
#32
                     1697.13 N
                     7924.79 E
22-33      DL  90°42'39"
22-33            121.98
#33
```

```
                  1712.32 N
                  7842.69 E
22-34      DL     90°42'39"
22-34                 40.00
#34
                  1792.93 N
                  7857.60 E
22-35      DL     33°24'55"
22-35                 40.00
#35
                  1817.13 N
                  7827.84 E
22-36      DL     33°24'55"
22-36                149.30
#36
                  1775.79 N
                  7726.67 E
22-37      DR     26°58'15"
22-37                 40.00
#37
                  1856.98 N
                  7833.42 E
                   506.11 H
22-38      DR    104°20'07"
22-38                 40.00
#38
                  1868.36 N
                  7882.11 E
22-39      DR    104°20'07"
22-39                115.28
#39
                  1936.29 N
                  7914.55 E
22-40      DR    124°51'41"
22-40                164.93
#40
                  1946.72 N
                  7983.61 E
22-41      DR    168°01'20"
22-41                 96.37
#41
                  1833.59 N
                  7961.23 E
```

Appendix A

Owner's Information

Contents

Maintenance

The Surveying Pac module does not require maintenance. However, there are several precautions, listed below, that you should observe.

CAUTIONS

- Do not place fingers, tools, or other objects into the plug-in ports. Damage to plug-in module contacts and the computer's internal circuitry may result.
- Turn off the computer (press [SHIFT][ATTN]) before installing or removing a plug-in module.
- If a module jams when inserted into a port, it may be upside down. Attempting to force it further may result in damage to the computer or the module.
- Handle the plug-in modules very carefully while they are out of the computer. Do not insert any objects in the module connector socket. Always keep a blank module in the computer's port when a module is not installed. Failure to observe these cautions may result in damage to the module or the computer.

Limited One-Year Warranty

What We Will Do

The Surveying Pac is warranted by Hewlett-Packard against defects in materials and workmanship affecting electronic and mechanical performance, but not software content, for one year from the date of original purchase. If you sell your unit or give it as a gift, the warranty is transferred to the new owner and remains in effect for the original one-year period. During the warranty period, we will repair or, at our option, replace at no charge a product that proves to be defective, provided you return the product, shipping prepaid, to a Hewlett-Packard service center.

What Is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by other than an authorized Hewlett-Packard service center.

No other express warranty is given. The repair or replacement of a product is your exclusive remedy. **ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY.** Some states, provinces, or countries do not allow limitations on how long an implied warranty lasts, so the above limitation may not apply to you. **IN NO EVENT SHALL HEWLETT-PACKARD COMPANY BE LIABLE FOR CONSEQUENTIAL DAMAGES.** Some states, provinces, or countries do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights that vary from state to state, province to province, or country to country.

Warranty for Consumer Transactions in the United Kingdom

This warranty shall not apply to consumer transactions and shall not affect the statutory rights of a consumer. In relation to such transactions, the rights and obligations of Seller and Buyer shall be determined by statute.

Obligation to Make Changes

Products are sold on the basis of specifications applicable at the time of manufacture. Hewlett-Packard shall have no obligation to modify or update products once sold.

Warranty Information

If you have any questions concerning this warranty, please contact an authorized Hewlett-Packard dealer or a Hewlett-Packard sales and service office. Should you be unable to contact them, please contact:

- In the United States:

  Hewlett-Packard Company
  Portable Computer Division
  1000 N.E. Circle Blvd.
  Corvallis, OR 97330
  Telephone: (503) 758-1010
  Toll-Free Number: (800) 547-3400 (except in Oregon, Hawaii, and Alaska)

- In Europe:

  Hewlett-Packard S.A.
  150, route du Nant-d'Avril
  P.O. Box CH-1217 Meyrin 2
  Geneva
  Switzerland
  Telephone: (022) 83 81 11
  Note: Do *not* send units to this address for repair.

- In other countries:

  Hewlett-Packard Intercontinental
  3495 Deer Creek Rd.
  Palo Alto, California 94304
  U.S.A.
  Telephone: (415) 857-1501
  Note: Do *not* send units to this address for repair.

Service

Service Centers

Hewlett-Packard maintains service centers in most major countries throughout the world. You may have your unit repaired at a Hewlett-Packard service center any time it needs service, whether the unit is under warranty or not. There is a charge for repairs after the one-year warranty period.

Hewlett-Packard products are normally repaired and reshipped within five (5) working days of receipt at any service center. This is an average time and could vary depending upon the time of year and the work load at the service center. The total time you are without your unit will depend largely on the shipping time.

Obtaining Repair Service in the United States

The Hewlett-Packard United States Service Center for battery-powered computational products is located in Corvallis, Oregon:

Hewlett-Packard Company
Service Department
P.O. Box 999
Corvallis, Oregon 97339, U.S.A.
or
1030 N.E. Circle Blvd.
Corvallis, Oregon 97330, U.S.A.
Telephone: (503) 757-2000

Obtaining Repair Service in Europe

Service centers are maintained at the following locations. For countries not listed, contact the dealer where you purchased your unit.

AUSTRIA
HEWLETT-PACKARD Ges.m.b.H.
Kleinrechner-Service
Wagramerstrasse-Lieblgasse 1
A-1220 Wien (Vienna)
Telephone: (0222) 23 65 11

BELGIUM
HEWLETT-PACKARD BELGIUM SA/NV
Woluwedal 100
B-1200 Brussels
Telephone: (02) 762 32 00

DENMARK
HEWLETT-PACKARD A/S
Datavej 52
DK-3460 Birkerod (Copenhagen)
Telephone: (02) 81 66 40

EASTERN EUROPE
Refer to the address listed under Austria.

FINLAND
HEWLETT-PACKARD OY
Revontulentie 7
SF-02100 Espoo 10 (Helsinki)
Telephone: (90) 455 02 11

FRANCE
HEWLETT-PACKARD FRANCE
Division Informatique Personnelle
S.A.V. Calculateurs de Poche
F-91947 Les Ulis Cedex
Telephone: (6) 907 78 25

GERMANY
HEWLETT-PACKARD GmbH
Kleinrechner-Service
Vertriebszentrale
Berner Strasse 117
Postfach 560 140
D-6000 Frankfurt 56
Telephone: (611) 50041

ITALY
HEWLETT-PACKARD ITALIANA S.P.A.
Casella postale 3645 (Milano)
Via G. Di Vittorio, 9
I-20063 Cernusco Sul Naviglio (Milan)
Telephone: (2) 90 36 91

NETHERLANDS
HEWLETT-PACKARD NEDERLAND B.V.
Van Heuven Goedhartlaan 121
NL-1181 KK Amstelveen (Amsterdam)
P.O. Box 667
Telephone: (020) 472021

NORWAY
HEWLETT-PACKARD NORGE A/S
P.O. Box 34
Oesterndalen 18
N-1345 Oesteraas (Oslo)
Telephone: (2) 17 11 80

SPAIN
HEWLETT-PACKARD ESPANOLA S.A.
Calle Jerez 3
E-Madrid 16
Telephone: (1) 458 2600

SWEDEN
HEWLETT-PACKARD SVERIGE AB
Skalholtsgatan 9, Kista
Box 19
S-163 93 Spanga (Stockholm)
Telephone: (08) 750 20 00

SWITZERLAND
HEWLETT-PACKARD (SCHWEIZ) AG
Kleinrechner-Service
Allmend 2
CH-8967 Widen
Telephone: (057) 31 21 11

UNITED KINGDOM
HEWLETT-PACKARD Ltd
King Street Lane
GB-Winnersh, Wokingham
Berkshire RG11 5AR
Telephone: (0734) 784 774

International Service Information

Not all Hewlett-Packard service centers offer service for all models of HP products. However, if you bought your product from an authorized Hewlett-Packard dealer, you can be sure that service is available in the country where you bought it.

If you happen to be outside of the country where you bought your unit, you can contact the local Hewlett-Packard service center to see if service is available for it. If service is unavailable, please ship the unit to the address listed above under "Obtaining Repair Service in the United States." A list of service centers for other countries can be obtained by writing to that address.

All shipping, reimportation arrangements, and customs costs are your responsibility.

Service Repair Charge

There is a standard repair charge for out-of-warranty repairs. The repair charges include all labor and materials. In the United States, the full charge is subject to the customer's local sales tax.

Computer products damaged by accident or misuse are not covered by the fixed repair charge. In these situations, repair charges will be individually determined based on time and materials.

Service Warranty

Any out-of-warranty repairs are warranted against defects in materials and workmanship for a period of 90 days from date of service.

Shipping Instructions

Should your unit require service, return it with the following items:

- A completed Service Card, including a description of the problem.
- A sales receipt or other proof of purchase date if the one-year warranty has not expired.

The product, the Service Card, a brief description of the problem, and (if required) the proof of purchase date should be packaged in adequate protective packaging to prevent in-transit damage. Such damage is not covered by the one-year limited warranty; Hewlett-Packard suggests that you insure the shipment to the service center. The packaged unit should be shipped to the nearest Hewlett-Packard designated collection point or service center. Contact your dealer for assistance.

Whether the unit is under warranty or not, it is your responsibility to pay shipping charges for delivery to the Hewlett-Packard service center.

After warranty repairs are completed, the service center returns the unit with postage prepaid. On out-of-warranty repairs in the United States and some other countries, the unit is returned C.O.D. (covering shipping costs and the service charge).

Further Information

Service contracts are not available. Computer products circuitry and design are proprietary to Hewlett-Packard, and service manuals are not available to customers. Should other problems or questions arise regarding repairs, please call your nearest Hewlett-Packard service center.

Technical Assistance

The keystroke procedures and program material in this manual are supplied with the assumption that the user has a working knowledge of the concepts and terminology used. Hewlett-Packard's technical support is limited to explanations of operating procedures used in the manual and verification of answers given in the examples. Should you need further assistance, you may write to:

Hewlett-Packard
Portable Computer Division
Customer Support
1000 N.E. Circle Blvd.
Corvallis, OR 97330

Dealer and Product Information

For additional product information, refer to the accessory brochure that was included with your HP-75, contact your local Hewlett-Packard dealer, or call toll-free in the United States (800) 547-3400. In Oregon, Alaska, and Hawaii, call (503) 758-1010.

Appendix B

Error Conditions and Recovery

The Surveying Pac programs have been designed to trap errors without aborting program execution. All input values are checked for valid syntax and, if an error is found, the computer will beep, display a warning message (such as `invalid angle`), then return the previous prompt. You can then enter the correct value.

Syntax errors commonly occur when a letter or symbol is entered when a number is expected. You can also get an error message when using unassigned point numbers to define a direction or distance, or entering a point number larger than the file size.

Incorrect use of commas is another common cause of problems. Commas are used to separate two or more input values. They should not be used as digit separators or radix symbols. For example, the number ten thousand should be entered as `10000`, and not `10,000`.

The Coordinate file is continually and immediately updated as you work. If an error does occur that causes program execution to stop, you generally will have lost no more than a single point. The program can easily be restarted, and work continued at the point where the error occurred.

Appendix C

Programs and Subprograms

Contents

Introduction

The following programs and subprograms are included in the Surveying Pac:

Programs

SURVEY Initializes data file, calls main programs.

Subprograms

SURV1 Contains File Management routines.

SURV2 Contains Coordinate Geometry routines.

Utility Subprograms

IA	Decodes strings for angles (Input Angle).
IB	Decodes strings for directions (Input Bearing).
ID	Decodes strings for distances (Input Distance).
IP	Decodes strings for points (Input Points).
OA	Outputs angular information (Output Angle).
BB	Solves bearing-bearing intersections.
BD	Solves bearing-distance intersections.
DD	Solves distance-distance intersections.

Note: When running the Surveying Pac programs, care should be taken to ensure that no other files with the same names exist in RAM or in another ROM.

The subprograms may be called by user-written programs. All the subprograms require that the coordinate and PARAM files be open, and that the parameters in lines 1 to 7 of the PARAM file be assigned as shown in appendix E. Both the input to the subprograms and the output from the subprograms are passed through the PARAM file (the file that has been assigned Buffer #99). Information on input and output variables for the utility subprograms follows.

Subprogram IA (Input Angle)

This subprogram accepts an input string and returns a numeric angle in decimal degrees.

Input to the subprogram:(from your program)	Comments:
`PRINT #99,0 ; A$` `CALL 'IA'`	A$ is input string.

Output from the subprogram:(to your program)	Comments:
`READ #99,0 ; F,A`	F is the success flag. If F=1, input was accepted. If F=-1, input was bypassed. If F=0, input was invalid. A is the angle in decimal degrees.

Subprogram IB (Input Bearing)

This subprogram accepts an input string and converts it to a numeric azimuth in decimal degrees. It will also reduce a vertical or zenith angle input and normalize the result.

Input to the subprogram:

```
PRINT #99,0 ; B$,Z$
CALL 'IB'
```

Comments:

B$ is the string for the horizontal angle. Z$ is the string for the vertical or zenith angle. (If not used, enter a null string.)

Output from the subprogram:

```
READ #99,0 ; F,H,V
```

Comments:

F is the success flag.
If F=1, input was accepted.
If F=-1, input was bypassed.
If F=0, input was invalid.
H is the horizontal angle in decimal degrees. V is the vertical angle, measured from the horizontal plane.

Subprogram ID (Input Distance)

This subprogram accepts an input string and returns a numeric distance.

Input to the subprogram:

```
PRINT #99,0 ; D1$,D2$
CALL 'ID'
```

Comments:

D1$ is the horizontal or slope distance. D2$ is the vertical distance (null string if not required).

Output from the subprogram:

```
READ #99,0 ; F,D1,D2
```

Comments:

F is the success flag.
If F=1, input was accepted.
If F=-1, input was bypassed.
If F=0, input was invalid.
D1 is the horizontal or slope distance. D2 is the vertical distance.

Subprogram IP (Input Points)

This subprogram accepts input strings for point numbers, and returns numeric values for the point numbers and signs.

Input to the subprogram:

```
PRINT #99,0 ; P1$,P2$
CALL 'IP'
```

Comments:

P1$ and P2$ are input strings for point numbers (either may be null).

Output from the subprogram:

```
READ #99,0 ; F,P1,P2,S1,S2
```

Comments:

F is the success flag.
If F=1, input was accepted.
If F=0, input was invalid.
P1 is the point number of the first point. P2 is the point number of the second point. S1 is the sign of the first point. S2 is the sign of the second point.

Note: P1 or P2 will equal 0 if a null string is entered. P1 and P2 will always be positive or zero.

Subprogram BB (Bearing-Bearing Intersection)

This subprogram solves the intersection of two lines.

Input to the subprogram:

```
PRINT #99,0 ; N1,E1,N2,E2,A1,A2
CALL 'BB'
```

Comments:

N1,E1 refer to the northing and easting of point #1. N2,E2 refer to the northing and easting of point #2. A1 refers to the azimuth from point #1. A2 refers to the azimuth from point #2.

Output from the subprogram:

```
READ #99,0 ; F,N,E
```

Comments:

F is the success flag.
If F=0, solution is valid.
If F=1, solution is impossible.
N,E refer to the northing and easting of the intersection point.

Subprogram DD (Distance-Distance Intersection)

This subprogram solves the intersections of two circles.

Input to the subprogram:

```
PRINT #99,0 ; N1,E1,N2,E2,D1,D2
CALL 'DD'
```

Comments:

N1,E1 refer to the northing and easting of point #1. N2,E2 refer to the northing and easting of point #2. D1 refers to the distance from point #1. D2 refers to the distance from point #2.

Output from the subprogram:

```
READ #99,0 ; F,N1,E1,N2,E2
```

Comments:

F is the success flag.
If F=0, solution is valid.
If F=1, solution is impossible.
N1,E1 refer to the northing and easting of the first solution. N2,E2 refer to the northing and easting of the second solution.

Subprogram BD (Bearing-Distance Intersection)

This subprogram solves the intersections between a line and circle.

Input to the subprogram:

```
PRINT #99,0 ; N1,E1,N2,E2,A1,D2
CALL 'BD'
```

Comments:

N1,E1 refer to the northing and easting of point #1. N2,E2 refer to the northing and easting of point #2. A1 refers to the azimuth from point #1. D2 refers to the distance from point #2.

Output from the subprogram:

```
READ #99,0 ; F,N1,E1,N2,E2
```

Comments:

F is the success flag.
If F=0, solution is valid.
If F=1, solution is impossible.
N1,E1 refer to the northing and easting of the first solution. N2,E2 refer to the northing and easting of the second solution.

Subprogram OA (Output Angles)

This subprogram prints angles using selected units and formats.

Input to the subprogram:

```
PRINT #99,0 ; A,AO,M,S$
CALL 'OA'
```

Comments:

A refers to azimuth in degrees. AO refers to back-sight azimuth.
M refers to the output mode.
M=1 is bearing.
M=2 is north azimuth.
M=3 is south azimuth.
M=4 is deflection.
M=5 is angle right or left.
S$ refers to the string for description of the angle. It has a maximum length of 7 characters. (It is used in the Surveying Pac for showing the end points of a line.)

Output from the subprogram:

All output is to the selected printer.

Comments:

Redefining Keys

It is handy to redefine some of the keys on the HP-75 keyboard when running the Surveying Pac programs. The following layout is suggested:

To aid in entering bearings, [SHIFT][T], [SHIFT][Y], [SHIFT][G], and [SHIFT][H] are redefined as `NW`, `NE`, `SW`, and `SE` respectively. [^] is redefined as `+180` (or `+200` if you are using grads) to simplify entering deflections or reversing directions. []] and [@] are redefined to `+90` and `-90` (`+100` or `-100` in grads) for turning perpendicular angles. Other keys are redefined to provide the familiar ten-key numeric keypad. (To get the numeric keypad, press [CTL][LOCK].)

To make these key redefinitions, type the following commands:

```
def key "]","+90"; [RTN]
def key "@","-90"; [RTN]
def key "^","+180"; [RTN]
def key "T","nw"; [RTN]
def key "Y","ne"; [RTN]
def key "G","sw"; [RTN]
def key "H","se"; [RTN]
```

This creates a `keys` file, which redefines your keyboard. To disable this file, type `rename keys to "ksurv"`. To enable this file again, type `rename "ksurv" to keys`.

When you disable the surveying key definitions, all keys return to their original definitions, and the surveying key definitions are saved in a file named `ksurv`.

> **Note:** If you have another `keys` file in memory, you must purge it or rename it before creating the surveying definitions.

Appendix E

The Coordinate and Data Files

Coordinate File Format

The coordinate file is created in the SURVEY program and is assigned to file #1. In addition to the coordinates, it contains the variables for units and output modes. Line 0 contains the following:

P0 The number of points.

U Angular units (where 1 refers to degrees and 2 to grads).

M1 The direction mode in absolute angles (where 1 refers to bearings, 2 to north azimuths, and 3 to south azimuths).

M2 The relative angle mode (where 4 refers to deflections and 5 to angles right/left).

P1 The number of fractional digits on angles.

P2 The number of fractional digits on coordinates.

P3 The number of fractional digits on distances.

Lines 1 to P0 contain the N, E, and H coordinates. (N, E or H = -999999 when initialized or unassigned.)

PARAM File Format

PARAM is a data file which is used to pass parameters between programs and subprograms. It is initialized in SURVEY and assigned file #99. It may be purged after work with the Surveying Pac programs is complete, since it contains only temporary data. It will be recreated next time SURVEY is run.

The file lines and their descriptions are as follows:

Line 0 Used to pass variables between the main program and a called subprogram.

Line 1 The currently occupied point.

Line 2 The backsight azimuth.

Line 3 Angle modes `M1` and `M2` (same as coordinate file).

Line 4 Angle units, last fractional digit (`U, 10^P1`).

Line 5 The image string for angles.

Line 6 The image string for coordinates.

Line 7 The image string for distances.

Appendix F

Glossary

A

angle balance: The process of distributing the angular error in a traverse by applying a correction to the direction of each leg.

arc: The curved portion of a circular segment.

azimuth: The direction of a line defined by the clockwise angle between a meridian and the line.

B

backsight: A sight or observation taken to a point, usually in the rear, to establish a reference direction from which to measure horizontal angles.

bearing: The direction of a line defined by the quadrant and acute angle (clockwise or counter-clockwise) between a meridian and the line.

C

central angle: See **delta**.

chord: The straight line from the PC to PT of a curve.

D

delta: The central angle of a curve; the angle between radials to the PC and PT of a curve, or between the tangents.

E

easting: The distance of a point from the origin as measured parallel to the X-axis.

elevation: The vertical distance of a point above or below an arbitrarily assumed level surface or datum.

F

foresight: A sight taken to a point along a line whose direction is to be determined or established.

G

grad: A unit of angular measurement equal to one four-hundredth of a circle.

H

horizontal angle: An angle formed by the intersection of two lines in a horizontal plane.

horizontal distance: The distance between two points as measured along the projection onto a horizontal plane.

I,J,K

inverse: An operation to determine the direction and length of a line between two points.

L

linear balance: A method for distributing the linear error of closure in a traverse by applying a correction to the length of each leg.

M

meridian: A fixed line of reference for measuring horizontal angles.

N

northing: The distance of a point from the origin as measured parallel to the Y-axis.

O

origin: An arbitrary point with assigned coordinate values 0,0 which will serve as a reference for other points in the coordinate system.

P,Q

point of curvature (PC): The point where a circular curve begins. It also refers to "beginning of curve" and "tangent to curve."

point of tangency (PT): The point where a circular curve ends. It also refers to "end of curve" and "curve to tangent."

R

radial point (RP): The center point of a circular curve.

radius: The line extending from the center of a circle to the curve.

S

slope distance: The distance between two points as measured on a slope or grade.

T,U

tangent: A line which intersects a circular curve at a single point and is perpendicular to the radial at that point.

traverse: The operation to establish the location of a new point at a given distance and direction from another point.

Also, a series of straight lines connecting a succession of points along the route of a survey.

V,W,X,Y

vertical angle: An angle between two intersecting lines in a vertical plane. In surveying, a vertical angle is usually measured from a line on the horizontal plane.

vertical distance: The difference in elevation between two points.

Z

zenith angle: A vertical angle measured from a line perpendicular to the horizontal plane (as a plumb line).

Index

Page numbers in **bold** indicate primary reference; page numbers in regular type indicate secondary references. Index references to routines are followed by *routine*.

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