Programming the HP 41-CV Calculator

—*Part 1 of 2 parts*—

FIELD TRAVERSE.   USER INSTRUCTIONS.

Read Cards 1 and 2.

KEY	DISPLAY	ENTER
A	FIRST STA NO	Number of starting point.
R/S	NORTH	Northing of starting point.
R/S	EAST	Easting of starting point.
R/S	Print-out:-	Station number, northing, easting.
	NEXT?	

The special function keys B through H are used to advise the calculator what type of data will be input next. The data is entered by first pressing the appropriate special function key followed by the numerical data and the R/S key.

KEY	PREPARES CALCULATOR FOR:-
B	Bearing.
C	Included/Excluded Angle.
D	Deflection Angle.
E	Sideshot.
F	Temperature Correction °F.
G	Temperature Correction °C.
H	Slope Correction.

The calculator will allocate point numbers consecutively, beginning with the station number selected by the user.

To establish orientation, and a subsequent 'back azimuth', the bearing of the first course must be entered.

After the first course has been entered, for each subsequent line first determine if the line is part of the main traverse or a sideshot. If it is a sideshot, key E. If not, omit that step. Then press the function key corresponding to the type of angle being used to determine the direction of the line (B, C or D), and enter the quadrant, if necessary, and the angle. Then key in the measured distance. If there is no correction to the distance, key R/S. If there is a correction, press the function key for the required routine (F, G or H). When the correct distance is visible in the display, key R/S.

FIGURE 1.
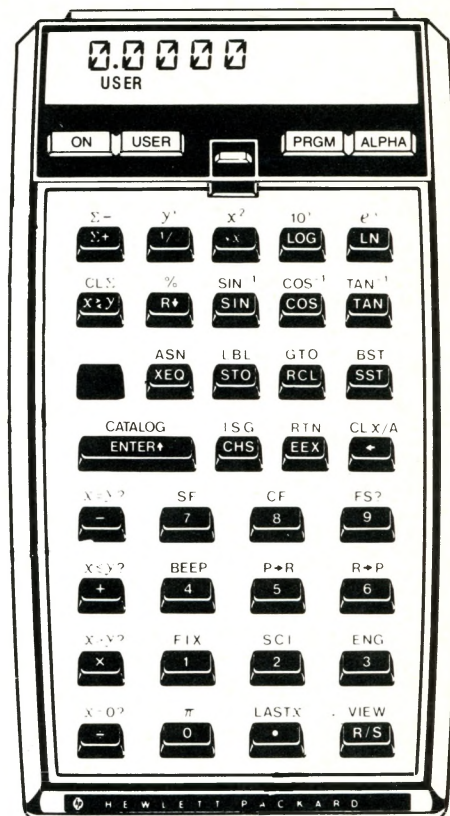
THIS PROGRAM is presented as a fairly typical example of this kind of software prepared for small programmable calculators and computers. Hopefully, it will be of general interest to the membership, and to other readers of this journal.

The 'User Instructions' are in Figure 1, and the flow chart is in Figure 2. Brief explanatory notes on the program, as written for the above calculator, follow herewith.

This program and the Field Traverse Adjustment routine, calculate the co-ordinates of points from data entered from field notes.

Due to the nature of small computers, in this kind of program, the calculator must allocate point numbers consecutively, although the starting point number may be chosen by the user. For example, if Station No. 1 is chosen as the first station number, subsequent stations will be numbered 2, 3, 4, etc. If Station No. 37 is chosen, subsequent stations will be 38, 39, 40, etc. Because of this option to choose the first number, more than one 'job' can be in the storage registers of the calculator memory at the same time, e.g. Job No. 1 = Stations 1 through 15; Job No. 2 = Stations 20 through 36; Job No. 3 = Stations 37 through 59; and so on.

To assist in the explanations, the

imaginary field traverse in Figure 3 is processed.

Key A is pressed to initiate the program operation.

Sixty-five of the available registers within the calculator memory are used to store the program instructions. The other 254 registers store data. Registers 00 through 09 are work registers for the temporary storage of quadrants, azimuths, counters, etc. Registers 10 through 254 store pairs of data on 122 survey stations.

Data on any particular station or traverse leg is stored in the two registers whose numbers are calculated from the formulae $2n + 8$ and $2n + 9$, where 'n' is the station number.

When key A is pressed, processing goes to Label A at line 06 of the program, and the instructions following thereafter begin to execute.

Zeros are stored in registers 00, 01 and 02 to clear them of any unwanted data.

The program stops to prompt for and to accept the number and the northing and the easting of the first traverse station.

The first station number is stored in register 05 as a fraction. Because more than one hundred pairs of co-ordinates may be stored in the memory at one time, it is conceivable that the first station number could contain three digits. The number is divided by one thousand to be sure that it is completely reduced to a fraction, then stored in register 05.

The station number is also multiplied by two, and the product is added to eight. The answer is the address, or number, of the storage register in which the northing of this first station will be stored. This answer is added to the fraction in register 05. The value in register 05 is incremented as the calculation progresses. The integer portion serves as the indirect address to the various storage registers.

The first station number of the traverse in Figure 3 is sixty. In this case, register 05 at this time would contain the value 128.060.
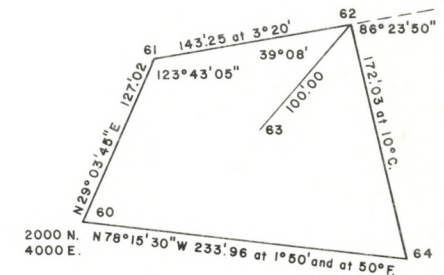
When the northing of the first station is keyed in, it is stored 'indirectly' in the register indicated by the integer in 05, and the northing is also stored in register 03.

One is added to the value in 05 (integer = $2n + 9$), the easting is keyed in, and stored indirectly in the register indicated, and the easting is also stored in register 04.

Flag 21 is set automatically by the calculator any time a printer is attached.

If Flag 21 is not set, processing branches around the following steps to line 59 to prompt with the display message "NEXT?" for the user to press the next function key.

If a printer is attached to the calculator, the paper tape is advanced, and the instructions between lines 24 and 58 are executed to calculate and to print the station number, northing and easting. The prompt "NEXT?" appears in the display, and the program stops.
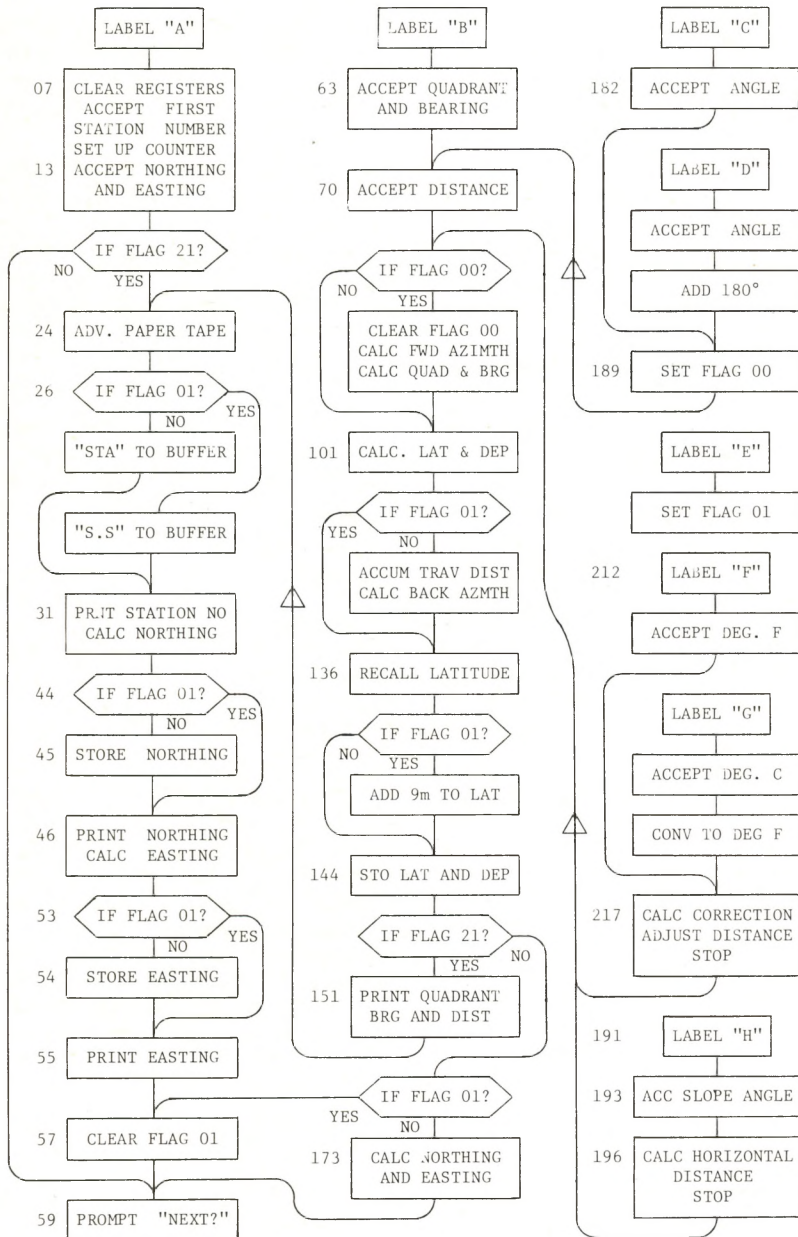
FIGURE 2.

BEARING

Key B is pressed to advise the calculator that a bearing and distance are to be entered. The program pointer goes to Label B.

In the example, the quadrant 1 and the bearing 29.0345 are keyed in and stored in registers 06 and 07. The distance, 127.02, is keyed in, and it is stored in register 08.

Flag 00 is tested. It is not set at this time, so processing branches to line 101 and computes the latitude and departure of the traverse leg in registers 00 and 01.

A plus or minus one is the first computed in these registers to correspond with the quadrant in register 06. In the example, a plus one will be stored in each of these registers.

The bearing is recalled to the 'Y' register and reduced to decimal degrees. The distance is recalled to "X". The instruction 'Polar to Rectangular' computes the latitude in 'X' and the departure in 'Y'. These are multiplied into 00 and 01 to assume their proper signs.

Flag 01 is not set at this time, so the conditional branch is not made.

The latitude and departure are recalled to 'X' and 'Y' respectively, and their signs changed. The instruction 'Rectangular to Polar' computes the distance of the traverse leg in 'X', and because the signs were changed, the back azimuth of the traverse leg is computed in 'Y'.

The distance is added into register 02. Register 02 will contain the total distance around the main traverse.

The back azimuth just calculated is adjusted to lie between 0° and 360°, and is stored in register 09.

The counter in 05 is incremented by one.

The latitude is recalled and stored in the storage register indicated by the counter, in this example, register 130.

The counter is incremented, the departure is recalled, and stored indirectly in register 131.

Flag 21 is tested. If there is no printer, and Flag 01 is not set, the latitude is recalled from 00 and added into register 03, to compute the unadjusted northing of the next station. Similarly, the unadjusted easting of the next station is computed in register 04. Processing branches to line 59 to prompt for the next function key.

If Flag 21 is positive, the quadrant, bearing and distance are recalled from registers 06, 07 and 08 and printed, and a branch is made to line 24 to compute and print the next station number, and its unadjusted coordinates.

The first ten 'work' registers, and registers 128 through 131, now contain the following data:-

00	Latitude	+111.0270
01	Departure	+61.7017
02	Total distance	127.0200
03	Northing	2111.0270
04	Easting	4061.7017
05	Counter	131.060
06	Quadrant	1
07	Bearing	29.0345
08	Distance	127.0200
09	Back azimuth	109.0625
10 through 127	Unrelated data.	
128	Northing 1st. sta.	2000
129	Easting 1st. sta.	4000
130	Lat. 1st. leg	+111.0270
131	Dep. 1st. leg	+61.7017

If the next traverse leg is to be defined by a bearing and distance, key B would be pressed again to return the program pointer to that part of the program that processes this kind of data.

INCLUDED ANGLE

The direction of the traverse leg between Stations 61 and 62 is established from the counter-clockwise angle of 123° 43' 05" at Station 61.

Key C is pressed in accordance with the 'User Instructions', to continue the calculation at Label C. This routine begins at line 181 and the program stops at line 182 to accept the angle. -123.4305 is keyed in, and when the program begins again, this is stored in register 01. Processing branches to line 189 where Flag 00 is set, and then branches again to line 70 and stops to accept the distance. The distance of 143.25 is entered.

Because this is a slope distance, key H is pressed to reduce it to the horizontal. Label H is located at line 191.

The distance is temporarily stored in register 08, and the program stops to accept the slope angle. After this has been keyed in, and the R/S key pressed, the slope angle is reduced to decimal degrees, and its cosine generated. This is multiplied into register 08, and the resulting horizontal distance is recalled to the display, as the program is stopped once more.

Because no more corrections are to be made to this distance, when the R/S key is pressed processing branches to line 74 to continue the calculation, as if the just computed horizontal distance had been entered from the keyboard.

Flag 00 is tested, and found positive. Processing continues to line 76.

Because this flag has served its present purpose, it is cleared. The forward azimuth of the traverse leg is computed. The contents of registers 01 (included angle) and 09 (back azimuth) are added, and adjusted to lie between 0° and 360°.

The quadrant and bearing of the line are computed from the forward azimuth, and are stored in registers 06 and 07.

At line 101 the latitude and departure, etc. etc. are computed as already described.

SIDESHOT

The line between Stations 62 and 63 is a sideshot. Key E is pressed to set Flag 01. Anytime this Flag is tested and found positive, the program will react to process a sideshot.

Another included angle establishes the direction of the sideshot. Key C is pressed, the program pointer goes to Label C, and the program stops to accept the angle. -39.08 is keyed in, and when the program starts again, the angle is stored in register 01. Processing branches to line 189 to set Flag 00, and branches again to line 70 to accept the distance.

When the distance is in, Flag 00 is tested, the conditional branch is made, and the flag is cleared. The forward azimuth, quadrant and bearing, and latitude and departure are calculated.

Flag 01 is tested. Because it is set, the sideshot distance is not accumulated into register 02, and the back azimuth of line 62 - 63 is not computed. The back azimuth of line 61 - 62 is allowed to remain in register 09; it will be required to establish the direction or bearing of line 62 - 64.

The counter in register 05 is incremented by one, the latitude of the sideshot is recalled from register 00, and because it is a sideshot, it is added to nine million, and then stored in the main memory in the register indicated by the incremented counter. This serves to identify this sideshot. Anytime a latitude is recalled during the adjustment to follow that has a value between eight and ten million, will indicate to the calculator that a sideshot is to be processed.

The departure is stored in the usual way. There is no need to identify this as well.

If Flag 21 is not set, and Flag 01 is set, then Flag 01 is cleared and processing stops at line 59 to prompt for the next function key.

When a printer is attached, the quadrant, bearing and distance are recalled from registers 06, 07 and 08 and printed, and the paper tape is advanced.

Because a sideshot is under process the label "S.S." for the station number, instead of the usual lable "STA", is sent to the print buffer, as an indication of the stations status on the paper tape.

The unadjusted northing of Station 63 is computed by adding the contents of registers 00 and 03, and printed. This value is not stored in register 03. The northing of Station 62 is allowed to remain in register 03, because it will be required to compute the northing of Station 64.

Similarly, the easting of Station 63 is computed and printed, but not stored. Flag 01 is cleared before the program stops at line 59.

DEFLECTION ANGLE
Key D is pressed to enable the right deflection angle of 86° 23′ 50″ to be entered.

Before this angle is stored, it is added to 180°. This converts this deflection angle to an included or excluded angle. From line 189 onwards the program steps are the same as those described for traverse leg 61 - 62.

The distance is corrected for temperature by keying G.

Key B is pressed once more to enter the data on line 64 - 65. Keys F and H are both pressed to adjust this distance.

When this last course, or traverse leg, has been processed, latitudes and departures will be resting in registers 130 through 139 inclusive. The counter in register will be at 139.060, and the total of the distances along the main traverse will be in register 02. The unadjusted coordinates of Station 65 (60) will be in 03 and 04, and the starting coords of Station 60 are still in registers 128 and 129. ●
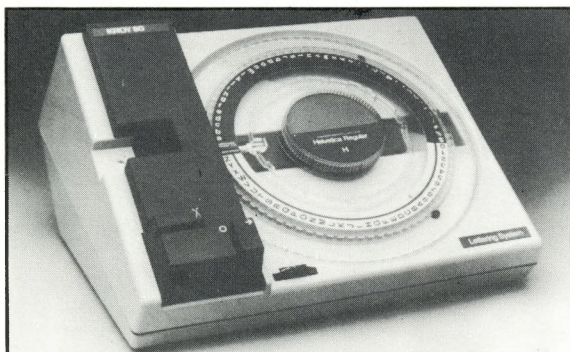
Wojciech Wronski, the Ontario government's senior planner, has left Municipal Affairs and Housing to be a private planning and development consultant. He has been succeeded as assistant deputy minister, community planning, by Milt Farrow, formerly executive director, plans administration division.

Milt Farrow, 50, has been with the provincial government for 18 years, all of them in community planning. He was named an executive director in 1974 and, in 1979, a special advisor to the minister.

Previously, he was an Ontario Land Surveyor and had also spent several years as a planning consultant, and two years with the Hamilton-Wentworth planning board.

In addition to planning, Farrow has had a long love affair with flying, and has logged some 500 hours in the air. Last year, he and a friend came first in the Great Canadian Air Dash, flying their vintage 1947 Aeronca Champ from Vancouver to Charlottetown.

He lives in Oakville with his wife and four children.

Numbers Puzzle

Example:- 16 = O. in a P.
(16 ounces in a pound)

1 =	W. on a U.
3 =	B.M. (S.H.T.R.)
4 =	Q. in a G.
6 =	C. in a P. C.
7 =	W. of the A. W.
7 =	B. for S. B.
8 =	S. on a S. S.
9 =	P. in the S. S.
10 =	P. in C.
12 =	S. of the Z.
12 =	P. on a F. T.
13 =	S. on the A. F.
18 =	H. on a G. C.
24 =	H. in a D.
26 =	L. of the A.
29 =	D. in F. in L. Y.
32 =	D. F. at which W. F.
40 =	D. and N. of the G. F.
54 =	C. in a D. (with the J.)
57 =	H. V.
64 =	S. on a C. B.
88 =	P. K.
90 =	D. in a R. A.
200 =	D. for P. G. in M.
1000 =	W. that a P. is W.
1001 =	A. N.