A NEW STATION POINTER :
THE HEWLETT-PACKARD HP 65

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ABSTRACT

The Hewlett-Packard portable calculator HP 65 can be programmed to convert the two angles of a horizontal sextant angle fix into rectangular coordinates ready for immediate plotting. This method of plotting fixes is easier, quicker and more accurate than the traditional station pointer.

THE CALCULATOR

The programmable HP 65 is very slightly larger than the well-known HP 35 and 45 and is powered by the same battery pack. It can write and record programmes of up to 100 steps on small magnetic cards, which can then be entered into the machine's programme store as required. It has 9 storage registers, though the ninth is subject to alteration by trigonometric and some other functions. There are five alphabetical programme control keys which can be used to call particular programmes or subroutines within that programme.

Its operation and the symbol abbreviations on the photograph (figure 1) will be clear to readers except that, on this black and white illustration, the operation of the three prefix keys (f, f^{-1} and g) is not obvious. The symbol for the primary function appears on the top face of the key itself. Those symbols written above the lower 19 keys are coloured gold, as are the f and f^{-1} prefix keys; to execute a gold alternate function, press the f prefix key immediately before the key associated with that function; to execute the inverse (or complement) of that gold function, press the f^{-1} prefix key and then the key associated with that same gold function. The g prefix key is coloured blue as are the symbols on the front faces of 19 of the keys and they are similarly executed.

The temperature range for efficient operation is slightly restricted. The upper limit is 40 °C. The lowest temperature in which a programme can be recorded onto a card is 10 °C; in which a programme card can be read is 5 °C; and in which the calculator will operate once the programme is entered is 0 °C.

The calculator is supplied with a 240/110 volt battery charger and it is preferable for this to be connected during operation so that the machine is working from mains power. In a boat this voltage may not be available
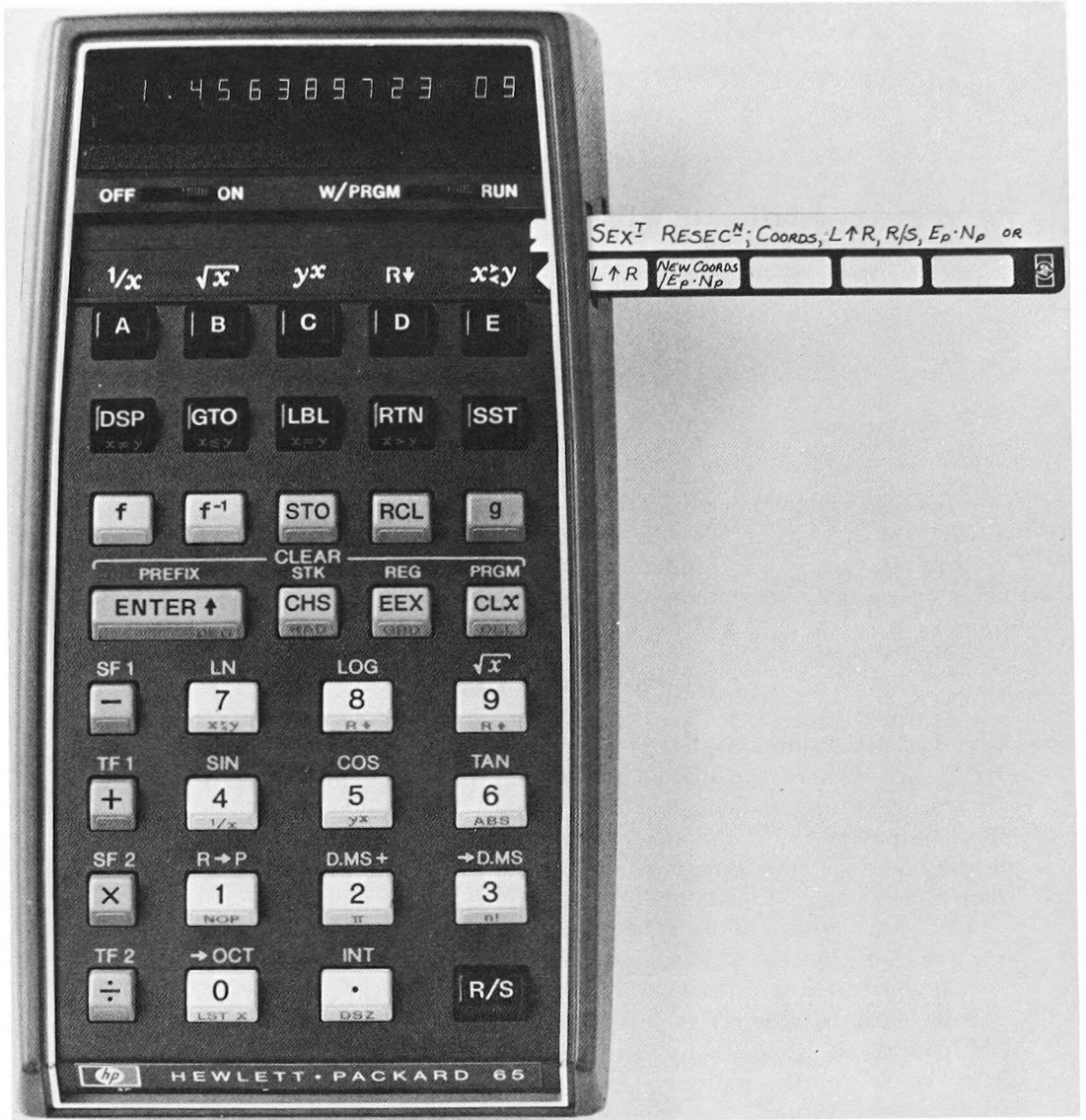
FIG. 1. — The programmable HP 65 at natural size.

but it is a simple wiring alteration to adapt the charger to accept 12 volts (from the boat's battery); or Hewlett-Packard can supply an adapted charger. These are used by mountaineers, desert expeditions and long distance yachtsmen. When used independently the advertised duration of the fully charged battery pack is three hours, but this varies and deteriorates with age. Entry of programme cards and the display of a large number of digits take the most power. It is best to load the horizontal sextant angle programme just the once and leave the machine switched on between fixes; if there is a long interval, power can be conserved by keying in just the decimal point, though CLx or another number-terminating key must then be pressed before keying in data. Care in this way may get 5 or 6 hours' use out of a battery pack.

THE PROGRAMME

The versatility which has been built into the HP 65 is remarkable and enables the details of any programme to be varied to suit personal preference. That favoured for sextant resections (figure 2) is overleaf :
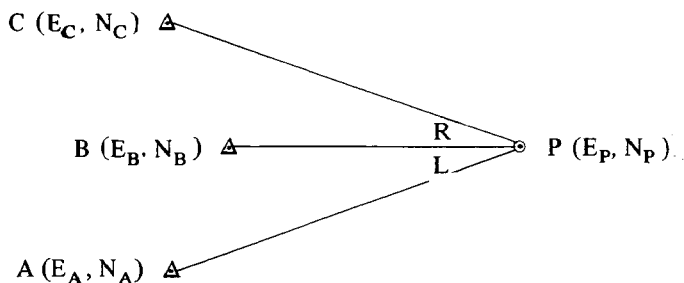

FIG. 2. — A horizontal angle resection.

Before the programme can be run, the coordinates of the three observed marks must be entered in the appropriate addressable registers (E_A to R1, N_A to R2, E_B to R3, N_B to R4, E_C to R5 and N_C to R6) but, because speed in plotting after the calculation is paramount, the unaltered grid coordinates are not used. A grid position is normally put down by converting its coordinates into distances east and north of a convenient local origin and then plotting its exact position from a closely spaced, generally millimetric, rectangular grid. If the coordinates of the sounding marks are thus converted before the calculation then the position of the resected point, P, will also be in this form. Therefore the grid coordinates of all sounding marks are converted into units of a hundredth of a centimetre (or a hundredth of an inch for use with an inch grid) and the result is displayed on the calculator in the same way. This has a further advantage in that there are then less digits in each and their entry into the addressable registers is eased. Making an HP 65 programme for this conversion is quite straightforward.

Next the two observed angles are entered (as Degrees-Minutes) in the order Left Angle, ENTER ↑, Right Angle. Pressing the R/S (run/stop) key now runs the whole programme, taking 8 seconds. It will be noted that the first two steps are LBL A, and steps 15 and 16 are LBL B. Frequently when sounding, particularly when the plotter is one of the anglers, one or more of the fix marks is changed at the last moment, and registers 1 to 6 will not be correct for that fix. These two LBLs are in the programme so that, as is most convenient, the sextant angles are still entered first and then key A is pressed; the programme places the tangents of the two angles in registers 7 and 8 and halts on the RTN at step 14. The surveyor then updates the appropriate coordinate registers and presses key B to order completion of the programme. It must be key B because a feature of the HP 65 is that, after a programme is started by the R/S key,

Step	Code	Keys	Comments	Step	Code	Keys	Comments
1	23	LBL					fix is exactly
2	11	A					circular
3	32	f^{-1}		48	33 08	STO 8	Tan bearing PB
4	03	→ D.MS		49	32	f^{-1}	
5	31	f		50	06	TAN	Nat bearing PB
6	06	TAN		51	34 07	RCL 7	Tan L
7	33 08	STO 8	Tan angle R	52	32	f^{-1}	
8	35 07	g x ⇄ y		53	06	TAN	Nat angle L
9	32	f^{-1}		54	51	−	Nat bearing PA
10	03	→ D.MS		55	31	f	
11	31	f		56	06	TAN	Tan bearing PA
12	06	TAN		57	33 07	STO 7	
13	33 07	STO 7	Tan angle L	58	34 02	RCL 2	N_A
14	24	RTN		59	71	x	
15	23	LBL		60	34 04	RCL 4	N_B
16	12	B		61	34 08	RCL 8	Tan bearing PB
17	34 06	RCL 6	N_C	62	71	x	
18	34 02	RCL 2	N_A	63	51	−	
19	51	−		64	34 01	RCL 1	E_A
20	34 03	RCL 3	E_B	65	51	−	
21	34 01	RCL 1	E_A	66	34 03	RCL 3	E_B
22	51	−		67	61	+	
23	34 07	RCL 7	Tan L	68	34 07	RCL 7	Tan bearing PA
24	81	÷	Blinks if L is zero	69	34 08	RCL 8	Tan bearing PB
25	61	+		70	51	−	
26	34 03	RCL 3	E_B	71	81	÷	
27	34 05	RCL 5	E_C	72	33 07	STO 7	N_P
28	51	−		73	34 04	RCL 4	N_B
29	34 08	RCL 8	Tan R	74	51	−	
30	81	÷	Blinks if R is zero	75	34 08	RCL 8	Tan bearing PB
31	61	+		76	71	x	
32	34 01	RCL 1	E_A	77	34 03	RCL 3	E_B
33	34 05	RCL 5	E_C	78	61	+	E_P
34	51	−		79	83	●	
35	34 04	RCL 4	N_B	80	05	5	
36	34 02	RCL 2	N_A	81	61	+	
37	51	−		82	31	f	
38	34 07	RCL 7	Tan L	83	83	INT	E_P integer
39	81	÷		84	34 07	RCL 7	N_P
40	61	+		85	43	EEX	
41	34 04	RCL 4	N_B	86	05	5	
42	34 06	RCL 6	N_C	87	81	÷	N_P moved to right of decimal point
43	51	−		88	61	+	$E_P . N_P$
44	34 08	RCL 8	Tan R	89	21	DSP ⎫	Display five
45	81	÷		90	83	●	decimal places
46	61	+		91	05	5 ⎭	
47	81	÷	Blinks if PB is exactly 090°, or if	92	24	RTN	

it halts on the first R/S in the programme or the second RTN. When R/S is pressed at the beginning the machine hops over the RTN at step 14 and halts on the second RTN at step 92. However if R/S is pressed instead of key B at step 14 the calculator will ignore the RTN at step 92 and run full circle to present nonsense when it halts on the second RTN at step 14.

It can be seen that the contents of registers 1 to 6 remain undisturbed throughout the programme, whereas registers 7 and 8 hold varying contents. Therefore it is essential that the correct angles are in the x and y registers of the operational stack before the programme is re-run from the start.

The formulae [1] which the programme calculates are :
Steps 17 to 48 :

$$\text{Tan grid bearing PB} = \frac{N_C - N_A + (E_B - E_A) \text{ Cot } L + (E_B - E_C) \text{ Cot } R}{E_A - E_C + (N_B - N_A) \text{ Cot } L + (N_B - N_C) \text{ Cot } R}$$

Step 54 subtracts the left observed angle (L) from the bearing PB to give bearing PA, and thereafter the calculation is as for an intersection of PA and PB.

Steps 55 to 72 solve :

$$N_P = \frac{N_A \tan P_A - N_B \tan PB - E_A + E_B}{\tan PA - \tan PB}$$

and steps 73 to 78 solve $E_P = (N_P - N_B) \tan PB + E_B$.

E_P and N_P are now in units and fractions of hundredths of a centimetre, but the fractions are superfluous for plotting. The fractional part of E_P must be discarded but first $0 \cdot 5$ is added (steps 79 to 81) so that its integer (step 83) is correctly rounded. N_P is recalled at step 84, its decimal point is moved 5 places to the left at step 87, it is added to the rounded integer of E_P and the result is displayed in the form $3982 \cdot 03007$. This indicates that point P lies $39 \cdot 82$ centimetres east and $30 \cdot 07$ centimetres north of the selected local origin, for plotting on a rectangular gridded sheet. The display has the capacity for a ten digit number (in addition to the decimal point); care must be taken that neither E_P nor N_P exceeds five digits or the result will be incorrect; this imposes a limit on the size of the hypothetical plotting sheet — 10 metres square.

The latter part of the programme calculates the intersection of the left and centre marks' rays. A very small angle on the left (even zero) can give a good fix so long as the angle on the right is large, but then the rays containing the left angle give a very narrow intersection and would never normally be used to calculate an intersection. However the HP 65 uses trig functions with 10 significant places and calculates accurately, in this programme, when the left angle is less than 1 second of arc. The calculation is improper, and the machine blinks zeroes, if either angle is entered as zero or if the bearings PA or PB are exactly 090° or 270°. The former can be avoided by using a very small angle, say 10″ (enter as $0 \cdot 001°$); the latter cannot be foreseen, but when the display blinks press RTN twice (to stop the blinking, then to bring the start of the programme to the top of the memory), next enter the same angles again with one varied by, say, $0 \cdot 001°$ and press R/S in the normal way. (One of

these bearings must calculate as exactly 090° or 270°; a difference of one ten-millionth of a degree is acceptable, so this snag will not occur often).

Similarly, the calculation is improper if the fix is exactly circular. For near circular fixes an apparently correct answer is displayed which can be grossly in error, and this can only be avoided in the normal way, e.g. by consulting a plot of the sounding marks. But the position of a fix approaching the circular is calculated far more accurately than it would be possible to plot with a conventional station pointer.

CONCLUSION

Station pointer habits die hard, and it takes time for the mind to forget them and become adapted to the calculator. In particular a mental effort is needed to remember which marks' coordinates have been keyed into the addressable registers. But the HP 65 is useful to the surveyor in a multitude of different ways, many of which are not apparent until it is owned and its capabilities fully understood. For instance, with slight alterations, the above programme can be used to solve a theodolite resection prior to the semi-graphic stage. Eastings and northings cannot be displayed simultaneously, therefore one is stored in the y register of the operational stack and the other displayed in the x register; they are exchanged by pressing key E.

The 8 seconds running time of the resection programme seems an age when waiting to plot but there can be no doubt that it is quicker, as well as being easier and more accurate, than using a station pointer. For large scale river and dock work a boat's course is often carefully controlled along the predetermined sounding lines, but its track may still be recorded by frequent sextant fixes which cannot be plotted at the time. The tedium of plotting all these, on completion of the day's work, by station pointer, or the delay in waiting for the angles to be converted into rectangular coordinates by a distant computer are both avoided with an HP 65. The author's present hydrographic work sometimes involves sounding from a locally hired boat, and it is a big advantage to be able to plot straight onto a rectangular gridded sheet and not to require a plotting table that is solid enough for a sounding board and station pointers.

The HP 65, with the impressive capability built into its small size, effectively enlarges the scope of inshore and coastal survey work controlled by the sextant.

REFERENCE

[1] The Admiralty Manual of Hydrographic Surveying, Volume I (1965), pp. 349, 350, 367.