HP-35 50th Anniversary 1972 - 2022

The ‘Powerful Pocketful’: an Electronic Calculator Challenges the Slide Rule

WHEN AN ENGINEER OR SCIENTIST NEEDS A QUICK ANSWER to a problem that requires multiplication, divsion, or transcendental functions, they usually reach for the ever present slide rule. Before long, however, that faithful 'slip stick' may find itself retired. There's now an electronic pocket calculator that produces those answers more easily, more quickly, and much more accurately. Despite its small size, the new HP-35 is a powerful scientific calculator.

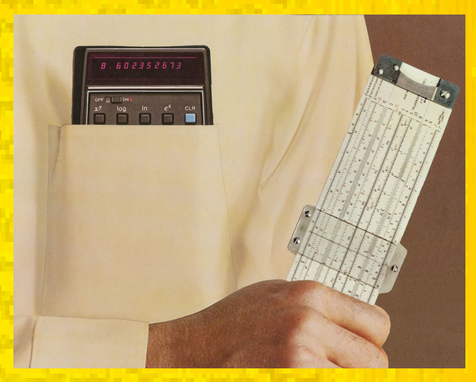
HewlettPackard Journal June 1972

The HP-35 calculator project started out as just that, a scientific calculator that would fit in Mr. Hewlett's shirt pocket.

Prior to the first prototype Mr. Hewlett named the calculator “The HP-35” after the number of keys. The innovation of the HP-35 is that it was the first handheld able to calculate transcendental functions.

The initial goals set for the design of the HP-35:

- **Shirt-pocket-sized scientific calculator.**
- **Capability of calculating transcendental functions (that is, trigonometric, logarithmic, exponential) or even (simple) square root.**
- **Perform these operations over a full two-hundred-decade range, allowing numbers from 10^{-99} to $9.999999999 \times 10^{99}$ to be**
- **represented in scientific notation.**
- **The display was to consist of 15 seven-segment, with decimal-point, light-emitting-diode (LED) numerals.**
- **The calculator would have five registers for storing constants and results, four of these registers arranged to form an operational stack, (a feature found only in some mainframe computers at the time).**
- **Four-hour operation from rechargeable batteries.**
- **A cost that laboratories and scientists could afford.**



The HP-35

- **was the first hand-held scientific calculator**
- **was the first handheld calculator to perform transcendental functions**
- **was the first scientific calculator to fly in space in 1972**
- **were used on the US space station, Skylab, between May 1973 and February 1974**
- **was the first pocket calculator with a numeric range that covered 200 decades**
- **used double injection moulded keys and still work and are readable to this day**
- **was used by Stanley Kubrick, director of 2001, A Space Odyssey**

The HP-35 had numerical algorithms that exceeded the precision of most mainframe computers at the time and eventually was manufactured in 6 versions. It quickly became a sought after item far exceeding initial market expectations with over 300,000 units being delivered in the 3 years following introduction. However, going unnoticed in early versions until after production began, a problem occurred when calculating the natural log of 2.02 using the ln key. Reversing the process with the e^x key gave an answer of 2 rather than the correct 2.02. This bug was discovered after many units were sold and while it could have been ignored, all affected owners were notified and offered replacements. Interestingly some owners decided not to take up the offer and some of those buggy calculators are still floating around today making expensive collector’s items.

The HP-35, named after the number of keys it has, was Hewlett-Packard's first pocket calculator and the world's first scientific pocket calculator with trigonometric and exponential functions.

Type:	**Scientific**
Introduced:	**1972**
Discontinued:	**1975**
Sales	**Over 300,000**
Number Entry:	**Reverse Polish Notation**
Display type	**Red LED seven-segment display**
Display size	**15 digits**
Memory	**1 register**
Stack	**Automatic, 4 registers**
Power	**Rechargeable battery and/or Mains AC, 500mW**
Battery Life	**About 3 ½ hours**
Weight	**9 ounce**
Dimensions	**L - 5.8 in, W - 3.2 in, H - 1.3 in**
Price	**$US395 Including ac adapter, battery recharger, soft leather case, travel case, operating manual, and owner name-tags.**

Internally, each operational word consists of 14 binary-coded-decimal digits, equivalent to 56 bits long. Ten of the 14 digits are allocated to the mantissa, one to the mantissa sign, two to the exponent, and one to the exponent sign. The decimal point occupies the 15th digit.

Preprogrammed mathematical routines were stored in three ROM chips, each of which contains 256 instructions of 10 bits each. Pretty amazing when you consider what the calculator does.

Code Example

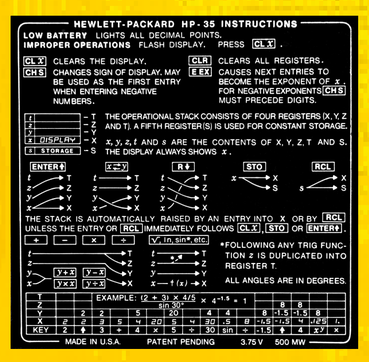
```
          eex4:   a exchange c[wp]
                  0 - c - 1 -> c[xs]
                  c -> a[w]
                  if c[xs] = 0
                    then go to eex5
                  0 -> c[xs]
                  0 - c -> c[x]
          eex5:   13 -> p
          eex6:   shift left a[ms]
                  c - 1 -> c[x]
                  if a[s] >= 1
```

The development of the earlier HP-9100 desktop calculator suggested the use of *Reverse Polish* logic as a cornerstone in the design of the HP-35 and affected every aspect from number of keys to internal logic architecture.

Reverse Polish required entering the operator after the operands therefore eliminating parenthesis; requiring less key-strokes as well as simpler hardware.

	T						a + b	a + b		
	Z						c	c	a + b	
	Y		a	a		a + b	c	d	c + d	(a + b) X (c +
STACK	X	a	a	b	a + b	c	c	d	c + d	X
Reverse Polish		a	ENTER	B	+	c	ENTER	d	+	X

The HP-35 contained five MOS/LSI - Metal-Oxide Semiconductor Large Scale Integration circuits: three read-only-memories (ROMs), an arithmetic and register circuit (A&R) and a control and timing circuit (C&T). Each of these chips had the equivalent of around 6000 transistors. There was also three custom bipolar circuits: a two-phase clock driver, an LED anode driver/clock generator, and an LED cathode driver. The HP-35 was assembled on two printed circuit boards. The upper board contains the display and drivers and the keyboard. The lower and smaller board has all the MOS logic, the clock driver, and the power supply.



Based on experience with the full ten digit display on the Hewlett-Packard desktop calculators, the display of the HP-35 was set up similarly consisting of 15 seven-segment light-emitting-diode (LED) displays including decimal points.

Answers between 10^{10} and 10^{-2} were always displayed as floating-point numbers with the decimal point properly located and the exponent digits blank. The display was left justified with trailing zeros suppressed.

Outside this range the HP-35 displayed the answer in scientific notation with the decimal point to the right of the first significant digit and the proper power of 10 showing at the far right of the display.

The LED displays were specifically developed for the HP-35 and to make them more readable, a separate digit position was provided for the decimal point. The readability of the display, even in bright sunlight was so important that the individual segments were “tuned” by adding a slight serif to the left edge of the top and bottom bar segments.