

# Op Amp History Highlights

**1928**

Harold S. Black applies for patent on his feedback amplifier invention.

**1930**

Harry Nyquist applies for patent on his regenerative amplifier (patent issued in 1933).

**1937**

U.S. Patent No. 2,102,671 issued to H.S. Black for “Wave Translation System.”

B.D.H. Tellegen publishes a paper on feedback amplifiers, with attributions to H.S. Black and K. Posthumus.

Hendrick Bode files for an amplifier patent, issued in 1938.

**1941**

Stewart Miller publishes an article with techniques for high and stable gain with response to dc, introducing “cathode compensation.”

Testing of prototype gun director system called the T10 using feedback amplifiers. This later leads to the M9, a weapon system instrumental in winning WWII.

Patent filed by Karl D. Swartzel Jr. of Bell Labs for a “Summing Amplifier,” with a design that could well be the genesis of op amps. Patent not issued until 1946.

**1946**

George Philbrick founds company, George A. Philbrick Researches, Inc. (GAP/R). His work was instrumental in op amp development.

**1947**

Medal for Merit award given to Bell Labs’s M9 designers Lovell, Parkinson, and Kuhn. Other contributors to this effort include Bode and Shannon.

Operational amplifiers first referred to by name in Ragazzini’s key paper “Analysis of Problems in Dynamics by Electronic Circuits.” It references the Bell Labs work on what became the M9 gun director, specifically referencing the op amp circuits used.

Bardeen, Brattain, and Shockley of Bell Labs discover the transistor effect.

**1948**

George A. Philbrick publishes article describing a single-tube circuit that performs some op amp functions.

**1949**

Edwin A. Goldberg invents chopper-stabilized vacuum tube op amp.

**1952**

Granino and Theresa Korn publish textbook *Electronic Analog Computers*, which becomes a classic work on the uses and methodology of analog computing, with vacuum tube op amp circuits.

**1953**

First commercially available vacuum tube op amp introduced by GAP/R.

**1954**

Gordon Teal of Texas Instruments develops a silicon transistor.

**1956**

GAP/R publishes manual for K2-W and related amplifiers, that becomes a seminal reference.

Nobel Prize in Physics awarded to Bardeen, Brattain, and Shockley of Bell Labs for the transistor.

Burr-Brown Research Corporation formed. It becomes an early modular solid-state op amp supplier.

**1958**

Jack Kilby of Texas Instruments invents the integrated circuit (IC).

**1959**

Jean A. Hoerni files for a patent on the planar process, a means of stabilizing and protecting semiconductors.

**1962**

George Philbrick introduces the PP65, a square outline, 7-pin modular op amp which becomes a standard and allows the op amp to be treated as a *component*.

**1963**

Bob Widlar of Fairchild designs the  $\mu$ A702, the first generally recognized monolithic IC op amp.

**1965**

Fairchild introduces the milestone  $\mu$ A709 IC op amp, also designed by Bob Widlar.

Analog Devices, Inc. (ADI) is founded by Matt Lorber and Ray Stata. Op amps were their first product.

**1967**

National Semiconductor Corp. (NSC) introduces the LM101 IC op amp, also designed by Bob Widlar, who moved to NSC from Fairchild. This device begins a second generation of IC op amps.

*Analog Dialogue* magazine is first published by ADI.

**1968**

The  $\mu$ A741 op amp, designed by Dave Fullagar, is introduced by Fairchild and becomes the standard op amp.

**1969**

Dan Sheingold takes over as editor of *Analog Dialogue* (and remains so today).

**1970**

Model 45 high speed FET op amp introduced by ADI.

**1972**

Russell and Frederiksen of National Semiconductor Corp. introduce an amplifier technique that leads to the LM324, the low cost, industry-standard general-purpose quad op amp.

**1973**

Analog Devices introduces AD741, a high-precision 741-type op amp.

**1974**

Ion implantation, a new fabrication technique for making FET devices, is described in a paper by Rod Russell and David Culner of National Semiconductor.

**1988**

ADI introduces a high speed 36V CB process and a number of fast IC op amps. High performance op amps and op amps designed for various different categories continue to be announced throughout the 1980s and 1990s, and into the twenty-first century.

*Chapter 8 provides a detailed narrative of op amp history.*