

The Golden Age of HP Through Some of Its Masterpieces

Hewlett-Packard Voltmeters and Oscilloscopes

History, Engineering, and Restoration

400H, 410C, 3403C, 180, 181, 54502A, 54540A

Giovanni Becattini



References

The following references are used in this book:

- [TEO] Tektronix Epic Oscilloscopes – Elektor Books
- [7KS] Tektronix 7000 Series – Elektor Books
- [TREG] Tektronix Oscilloscopes Restoration Guide – Elektor Books
- [HP1] Hewlett-Packard and its Voltmeters and Oscilloscopes – Quacktech
- [HP2] Hewlett-Packard Signal Sources – Quacktech
- [HP3] Hewlett-Packard Counters and Spectrum Analyzers – Quacktech
- [HP4] Hewlett-Packard Calculators, Computers and HP-IB – Quacktech
- [VRE] Vintage Radio Equipment – Elektor Book
- [MAC] Apple Macintosh – History, Engineering, and Restoration – Elektor Books
- [QT602] The Good Giant – Tektronix DSA 602A Oscilloscope – Quacktech
- [QT11KP] The Last Plug-ins – Tektronix 11000-Series Plug-ins – Quacktech
- [SCL] Strumentazione Vintage – Edizioni C&C
- [QTCOL] Collins Classics – KWM-2, 30L-1 and 51S-1: History, Engineering, and Restoration – Quacktech Editions
- [QT324] Two Giants and a Shorty – Tektronix 323/324 - Quacktech
- [QTBYP] Become Your Own Publisher – Quacktech
- [QTHPSS] Hewlett-Packard Signal Sources – Quacktech
- [DAB] Digital but Analog – Quacktech
- [TG7] When Machines Learned to Write - Quacktech

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Preface

For generations of engineers, Hewlett-Packard—simply “HP”—set the benchmark for electronic instrumentation. Its instruments were not merely tools, but expressions of precision, reliability, and a distinctive engineering culture. (When it came to oscilloscopes, many of us—including myself—often leaned toward Tektronix, but that is another story.)

Founded in 1939 by Bill Hewlett and David Packard, HP grew from a modest garage in Palo Alto into one of the most respected electronics companies in the world. Along the way, it shaped how measurements were performed, interpreted, and trusted, leaving an enduring mark on engineering practice.

This volume is part of the Technical Art Books collection and of the series HP: The Golden Age—An Era Told Through Electronic Masterpieces. Rather than striving for encyclopedic coverage, the series explores HP’s most remarkable period through a carefully chosen selection of instruments, calculators, and computers—objects that embody both technical excellence and design clarity.

This book is conceived as a historical and technical journey, blending images, analysis, personal experience, and practical restoration. Its aim is not only to document remarkable instruments, but also to preserve the spirit of an era in which electronic measurement achieved a rare balance of rigor, elegance, and human ingenuity.

Giovanni “Gianni” Becattini
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*To my wife
and my family*

Voltmeters and
Oscilloscopes

Signal Sources

Counters and
Spectrum
Analyzers

Calculators,
Computers,
and GPIB

Hewlett-Packard

Voltmeters

Oscilloscopes

Signal Sources

Counters

Spectrum Analyzers

Calculators

Computers

HP-IB



Section

Hewlett Packard

One of the greatest technology companies in the history



3000



Hanover
Street

Main Lobby

Executive
Briefing
Center

Section:

Hewlett Packard

Subsection:

The Company

Everybody's dream: from a garage to the stars

A Journey from Garage to Global Giant

Beginnings (1939)

In 1939, two Stanford University graduates, William (Bill) Hewlett and David (Dave) Packard, founded Hewlett-Packard in a small garage at 367 Addison Avenue in Palo Alto, California, a site now recognized as the birthplace of Silicon Valley. With an initial investment of \$538 (about 12,120 in 2025), they set out to develop innovative electronic products.

Their first breakthrough was the **HP 200A Audio Oscillator**, an instrument used to test sound equipment. This product's success was highlighted by a substantial order from Walt Disney Studios, which purchased several units to fine-tune the audio for its revolutionary 1940 film *Fantasia*. This early achievement underscored HP's focus on high-quality products and strong customer relationships, a principle that would define the company for decades.

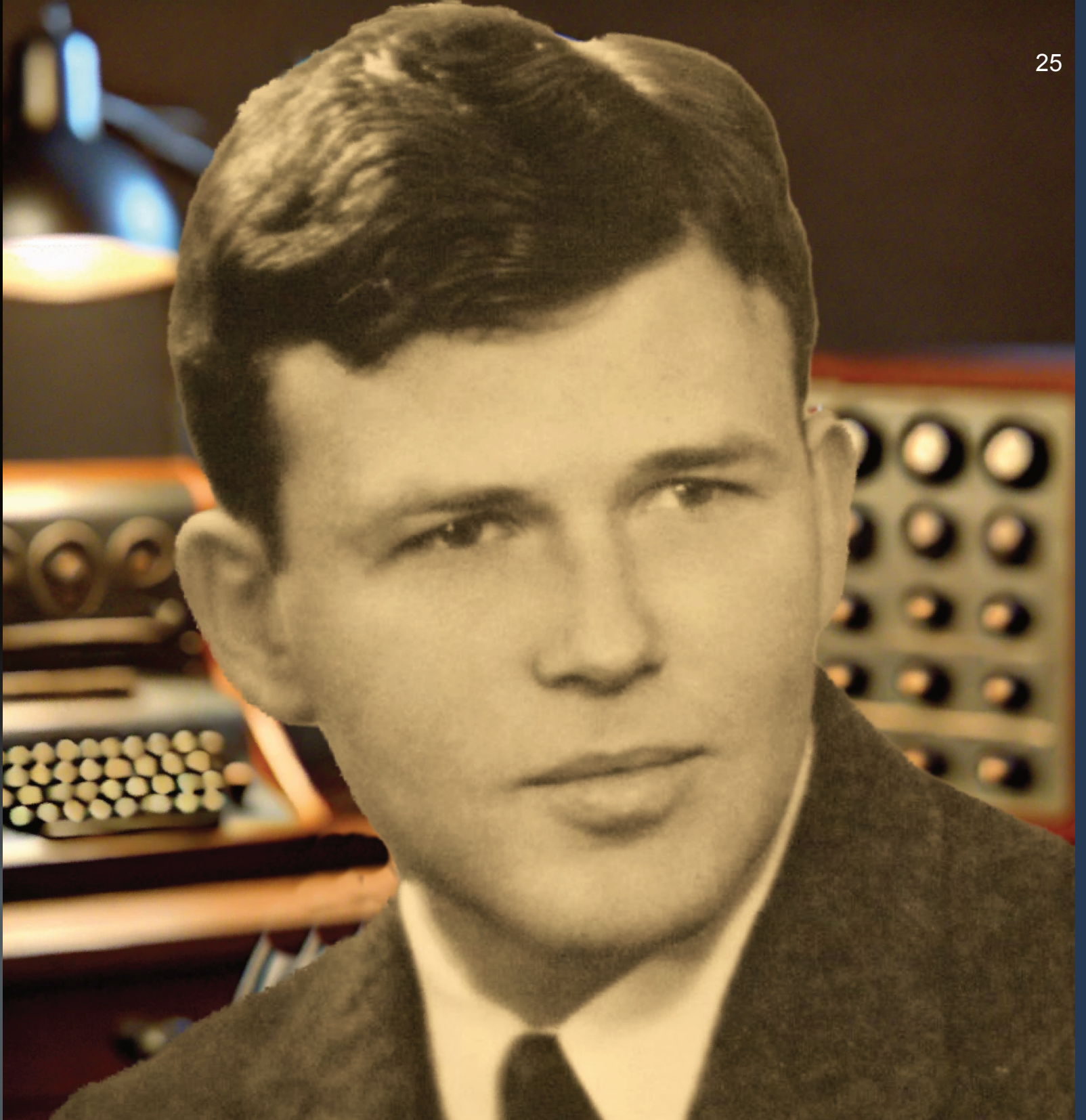
The Expansion (1940s)

The onset of World War II provided HP with significant opportunities as the company supplied essential electronic testing equipment to the U.S. military. This period solidified HP's reputation for producing reliable, high-performance instruments.

Post-war, HP capitalized on the burgeoning demand for electronic devices. The company's product portfolio expanded to include **voltmeters**, **frequency counters**, and **signal generators**. By the late 1940s, HP had relocated from the humble garage to a larger facility on Page Mill Road, which became its corporate headquarters.

One of the early foundations of HP's enduring success was its emphasis on research and development (R&D). Hewlett and Packard believed that continual innovation was key to long-term growth. This philosophy would soon manifest in a steady stream of industry-leading products.





Marc Mislange and the HP Memory Project

Marc Mislange (October 10, 1946 - July 23, 2014) was a French electronic engineer. Many engineers have childhood interests that fascinate them and has drawn them to something with great force as they grow. Some are drawn to football, others to music or politics. Marc was drawn to electronics. It was in his blood already as a kid and determined the course of his entire life, as electronics probably did for many who will read these pages.

1958 His Own Oscilloscope!

Marc was involved with instruments before he was twelve, when, in 1958, he built his own oscilloscope, using available surplus WWII electronics. It required a DG7-32 CRT tube, which needed to be bought new, with funds that took him a year to accumulate.

1963 Ham License

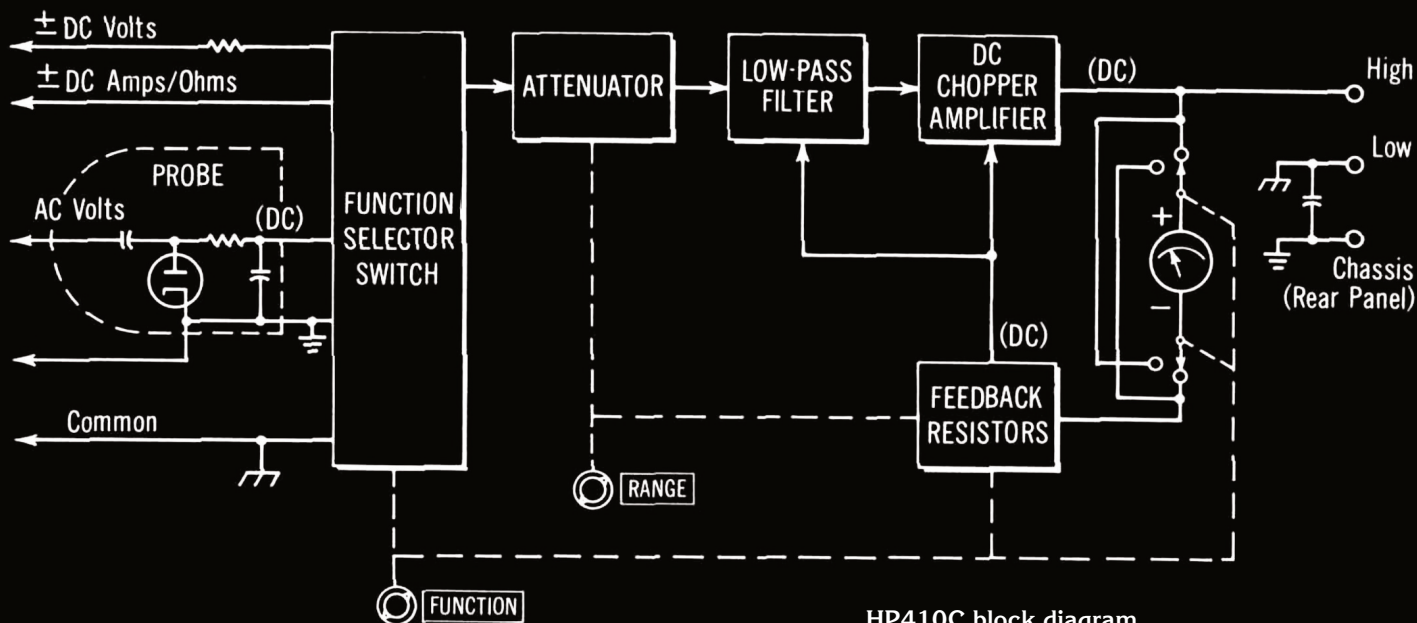
The availability of WWII surplus equipment was a joy for Marc, who in 1963 obtained a Ham Radio license including Morse code proficiency with the call sign F5MM.

This drawing is an idealized image of Marc, but... he could be, like, probably could be many of us who have had electronics in their blood since childhood. Possibly me too, or you reading these notes....

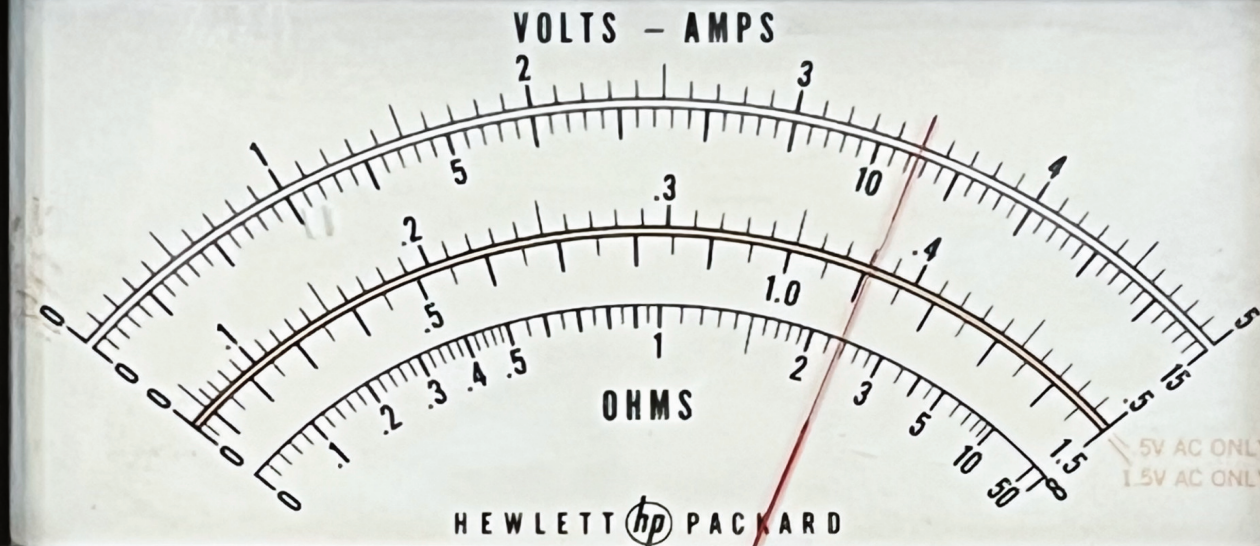




HP400H Front View



HP410C block diagram



410C VOLTMETER

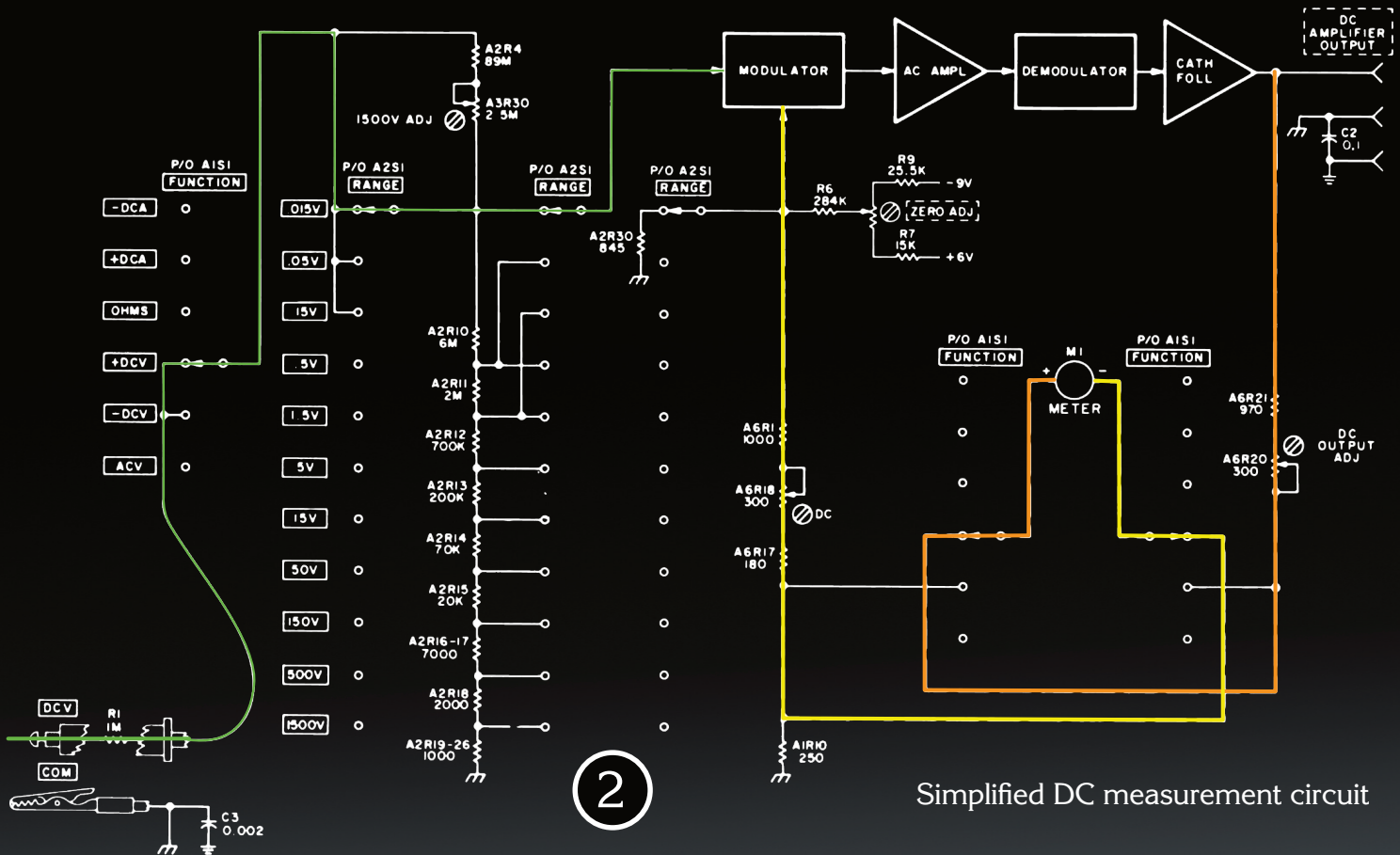
HEWLETT · PACKARD



FUNCTION

RANGE

① Basic chopper amplifier block diagram.



connects to output terminals at the rear of the instrument, supplying a voltage proportional to meter deflection (1.5 V full scale). Negative feedback reduces the output impedance to less than 3 ohms so that up to 1 mA can be taken from this output without affecting accuracy. The instrument also may be used as a narrow-band amplifier (or attenuator) with voltage gains from 100 down to 10^{-3} . Frequency of the amplifier is 0.5 Hz at the -3 dB point.

DC Measurement Circuit

As with all multimeters, the basic measurement is DC voltage; the others are a derivative of it in some way. As you can see above, the input circuit is very simple and easy to understand. Practically a simple voltage divider.

The diagrams on the right are taken from the military version of the manual (TM 11-6625-1614-15) and are more complete than the others, including DC levels and time values.

Don't forget to use at least a 10 Mohm oscilloscope probe or you risk not seeing anything in some cases.

Zero Instability

This overdrive test allowed me to find a problem in my second unit. The problem was zero instability. The test showed that the modulator output (waveform 1) was lower than expected, although the voltmeter was working quite well.

After a lot of work, my suspicions focused on the CR1 and CR2 diodes, which I assumed were there to protect the photoconductor. I tried to remove them, and without them the zero was absolutely stable. I tried replacing them with two 1N5819s, the only ones I had on hand, but the problem returned.

Test in overdrive conditions

Function: +DCV
Range: 0.015V
Input: +0.5V
Probe: 10 Mohm



Modulator output

0 v



Plate A3V1A

+150 v



Base Q1

+30 v



Base Q2

+20 v



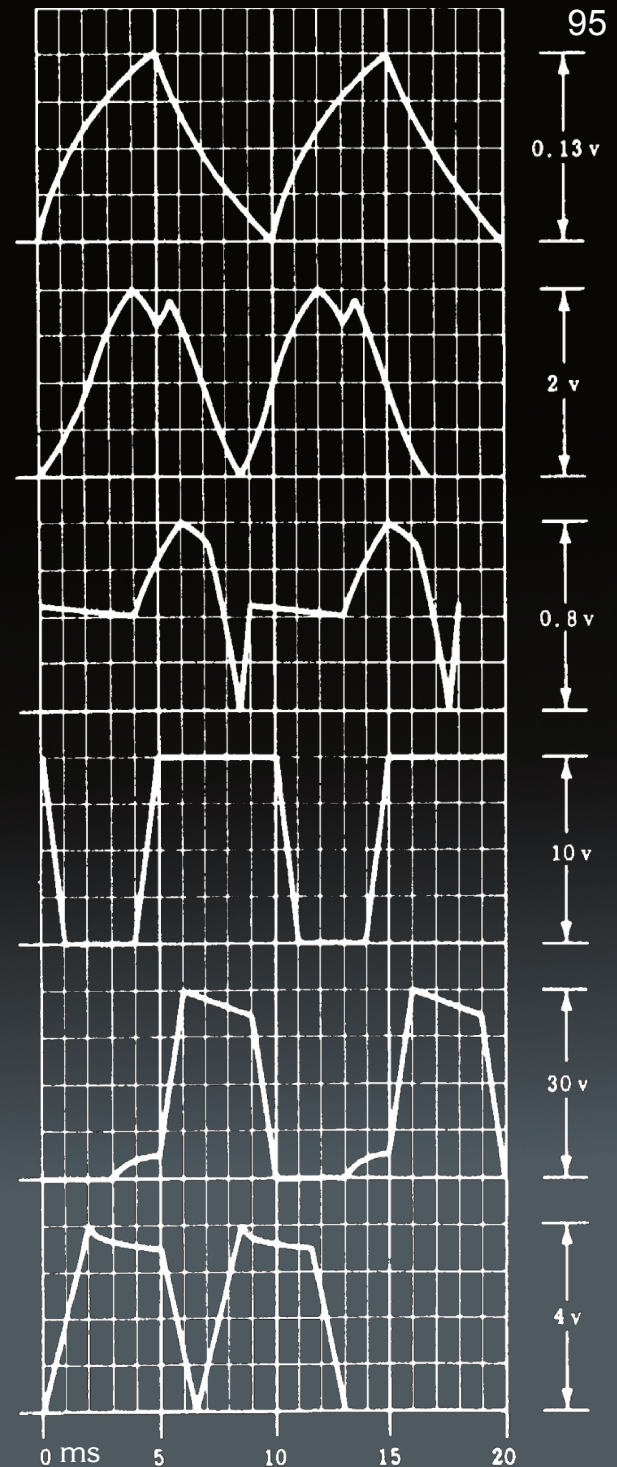
Demodulator input

-5 v



Demodulator output

+5 v



3C TRUE RMS VOLTMETER
WILLYS • PACKARD

98.9 mV
AC

RANGE
1V 10V 100V 1000V
.1V .01V AUTO

RESPONSE TIME

SLOW FAST

INPUT
1000V MAX.



1973



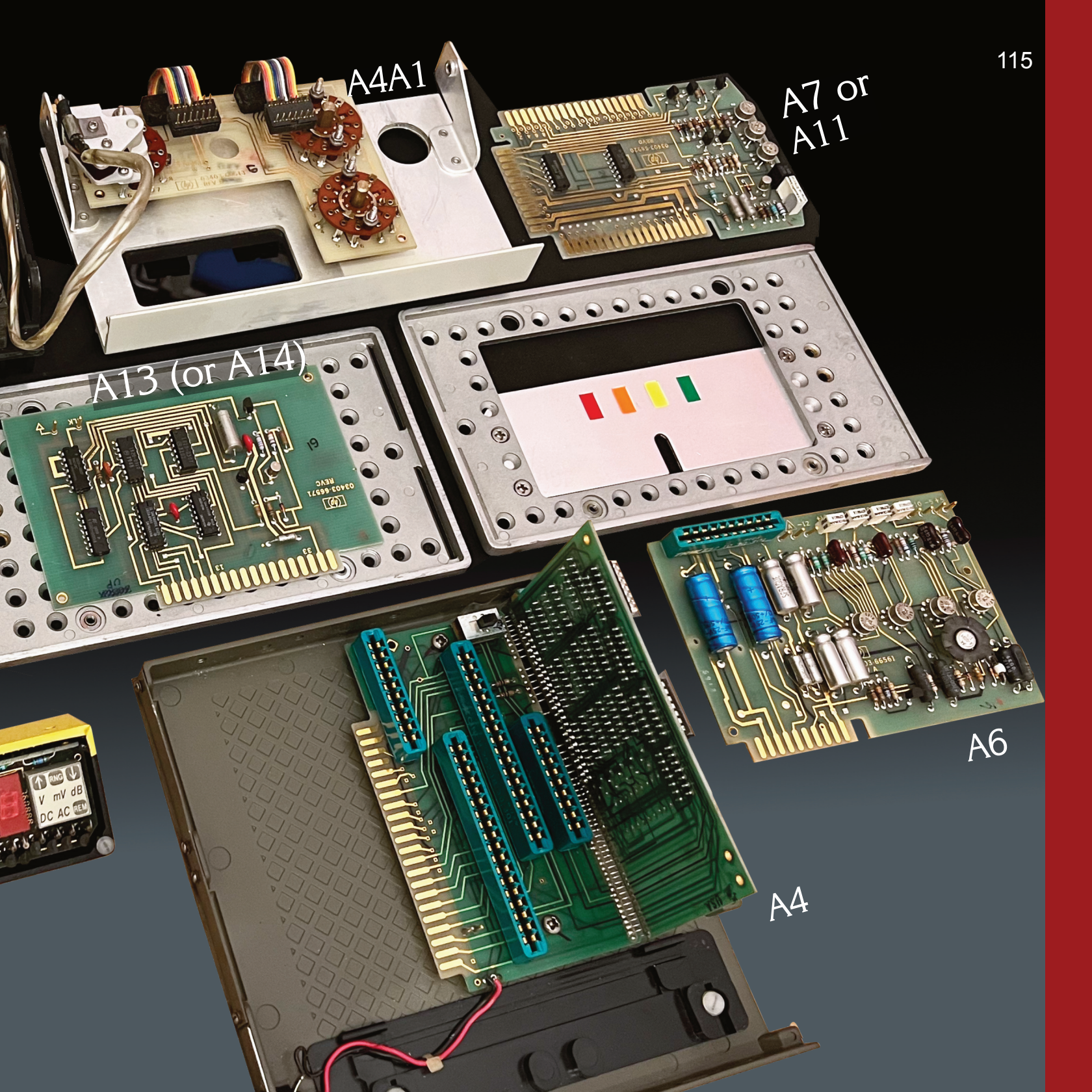
A4A1

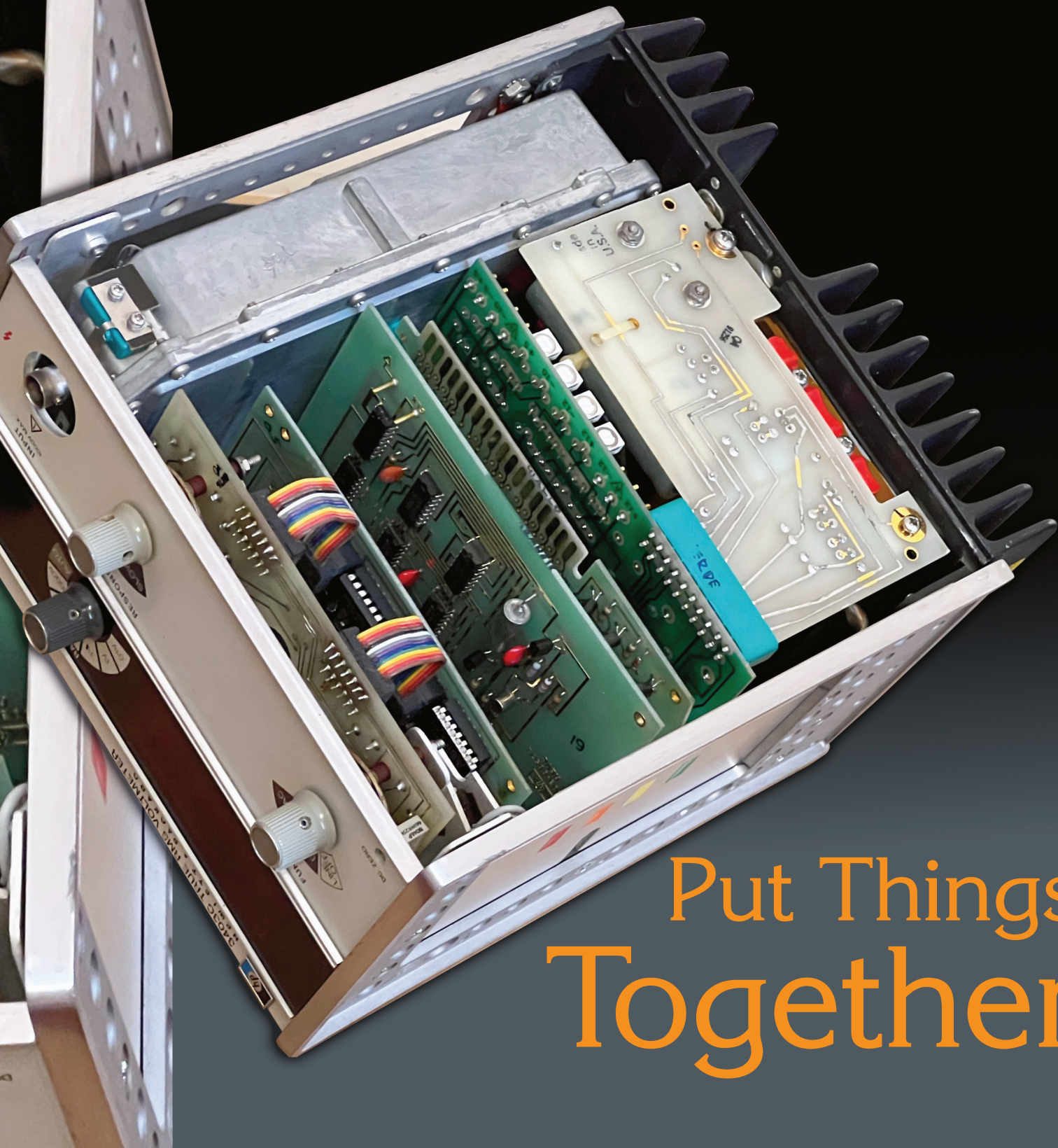
A7 or
A11

A13 (or A14)

A6

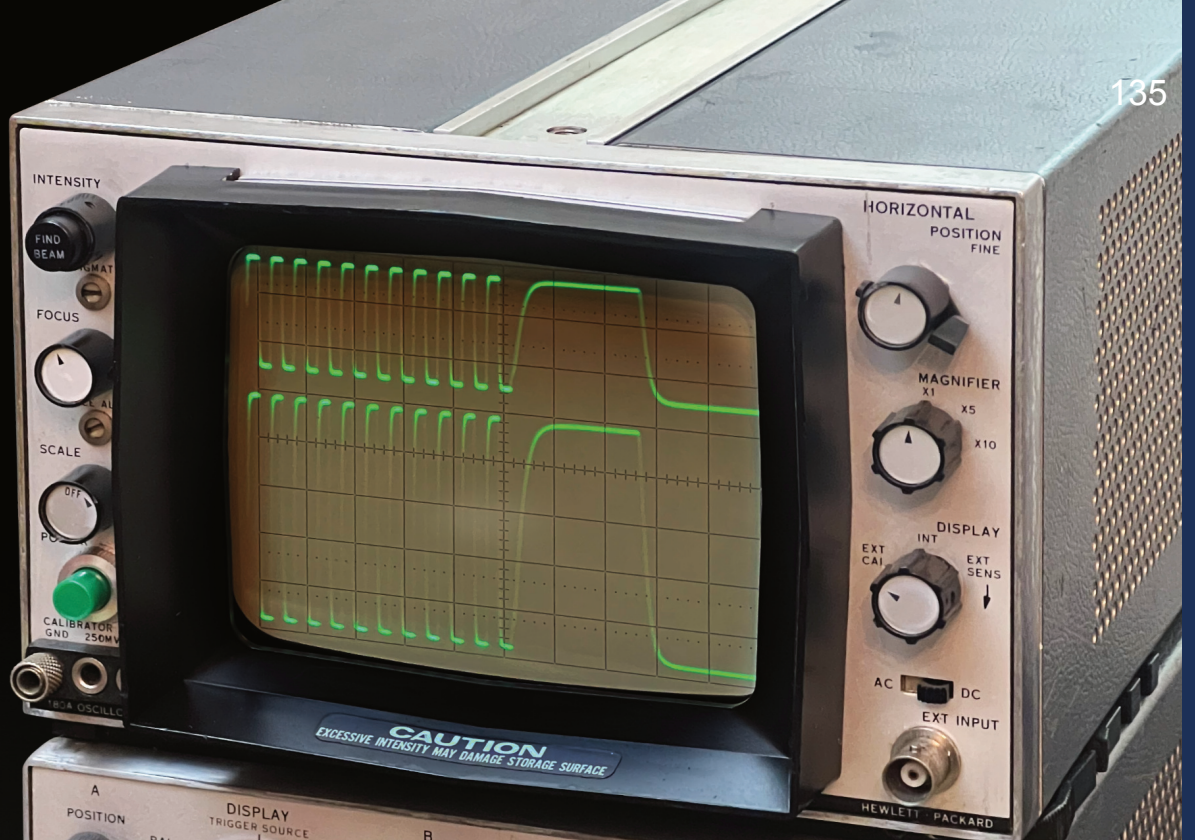
A4



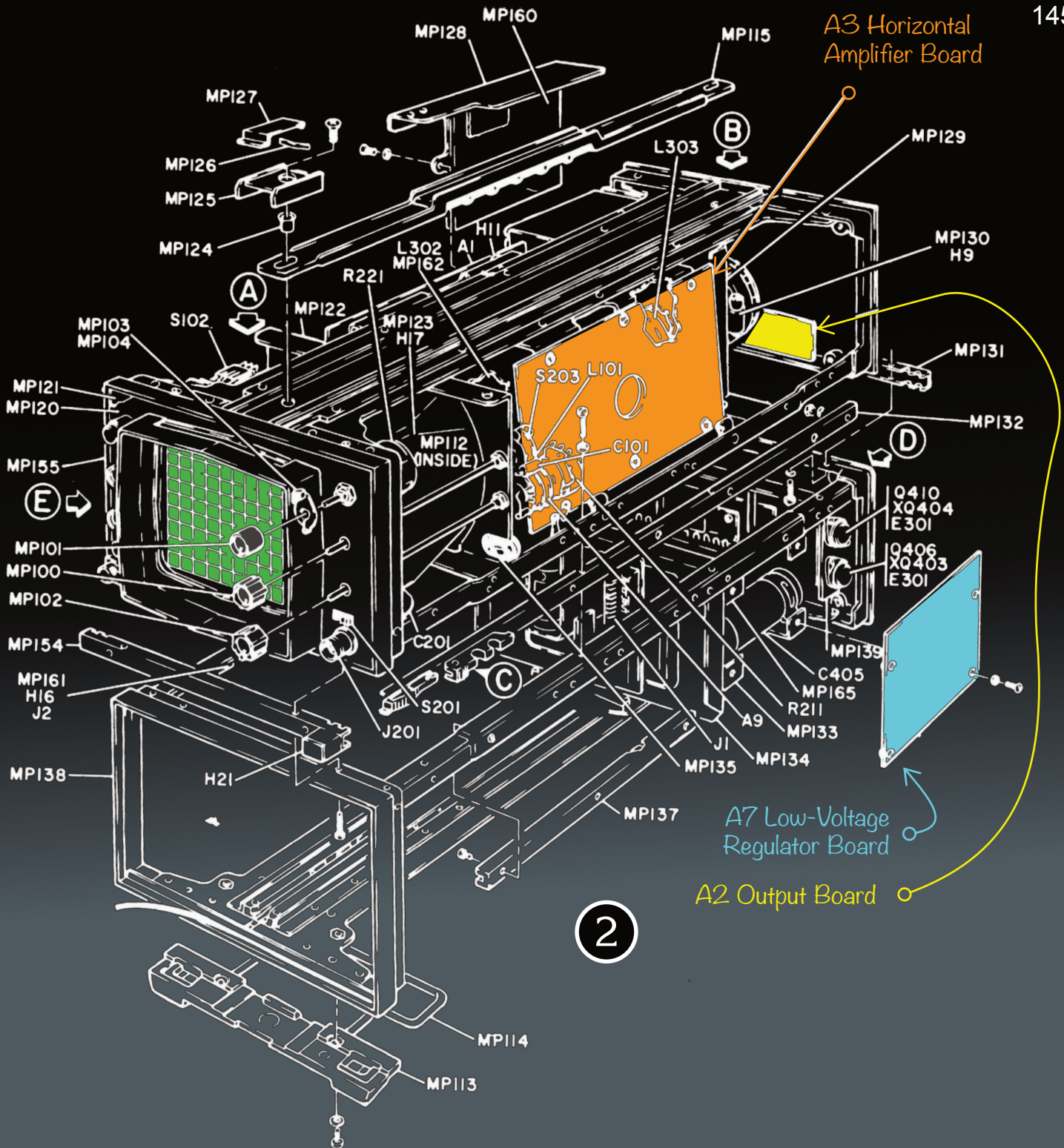


Put Things
Together

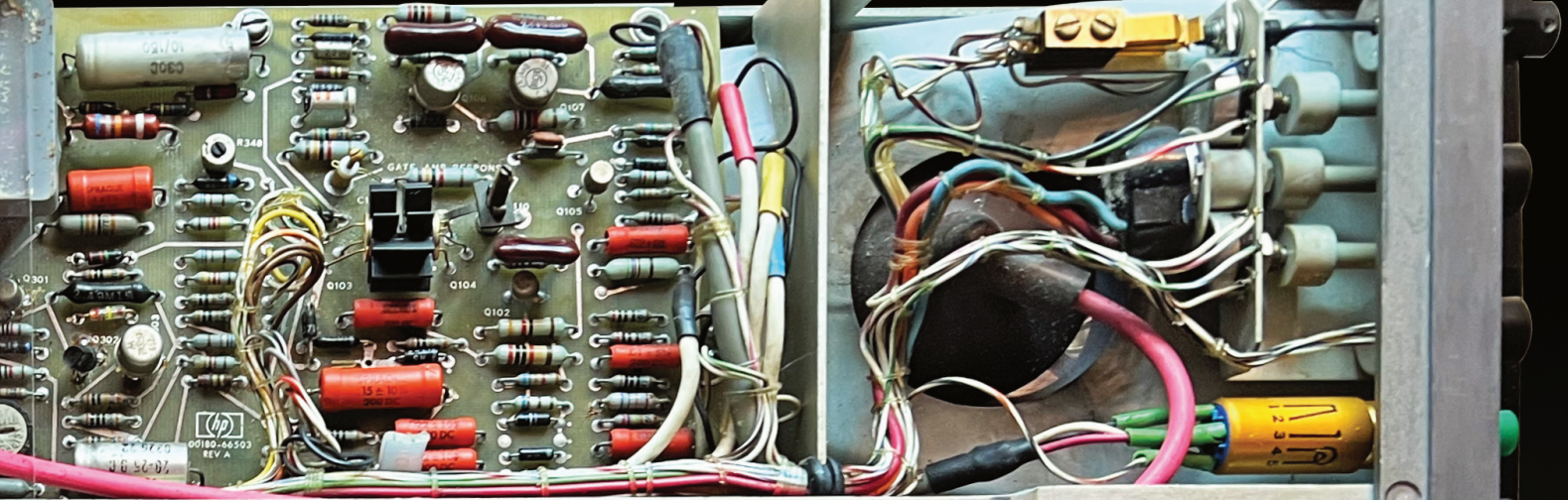
1966



HP180A Oscilloscope



AI Gate Amp and High
Voltage Regulator Board



Rectifier
Capacitors

Left Side

Low-Voltage
Fuses

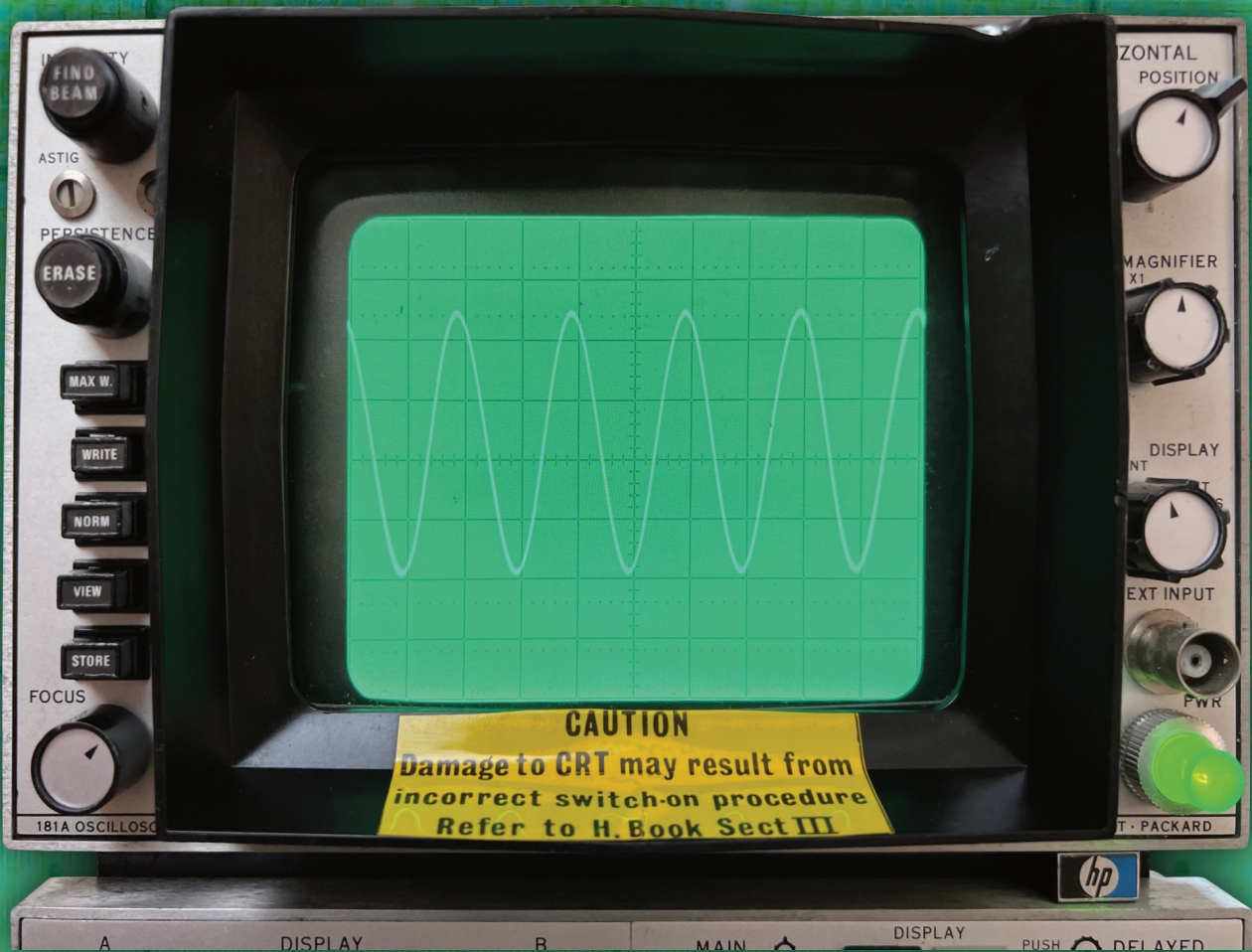
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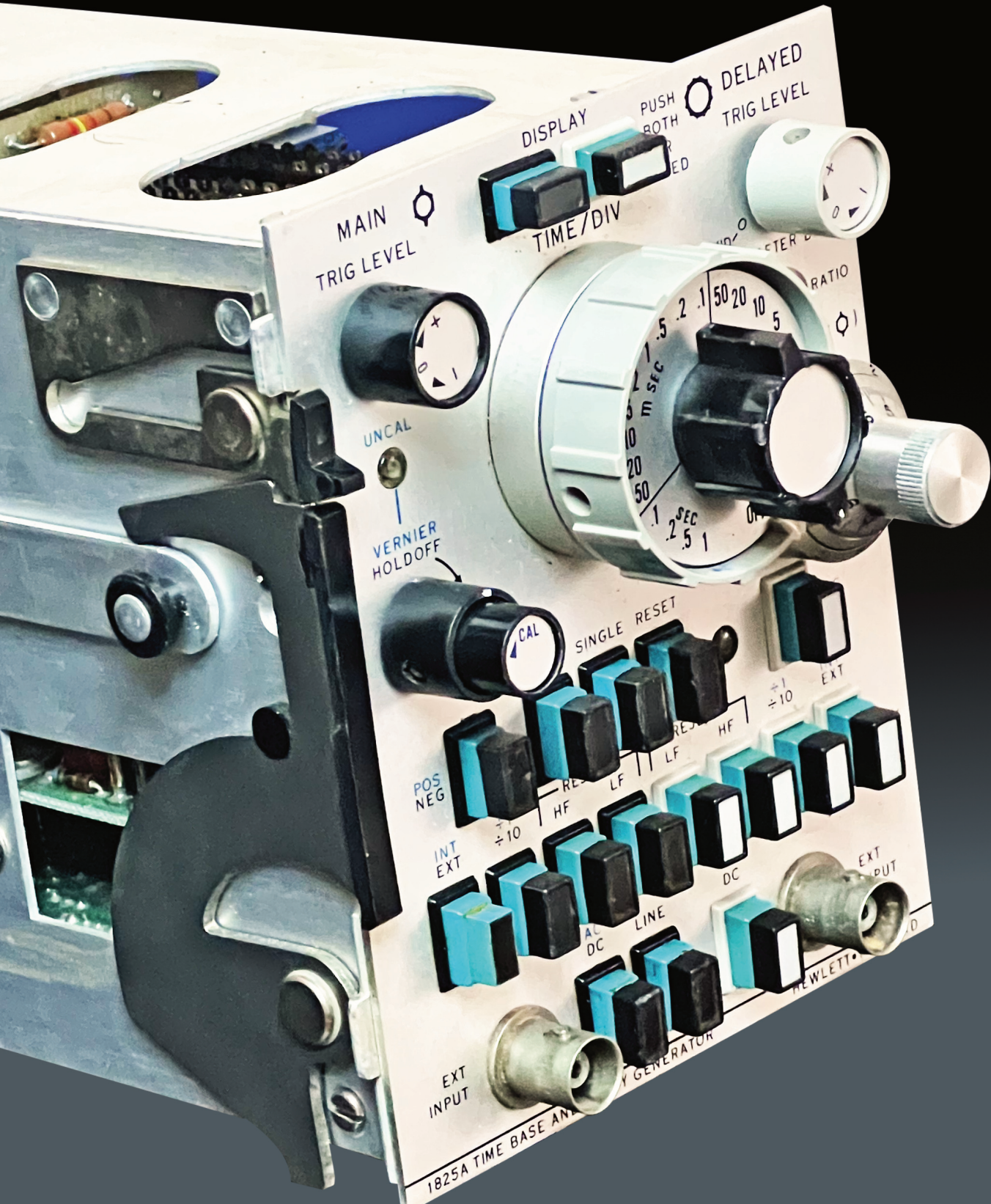
Oscilloscopes

Subsection:

181A CRT Storage Mainframe

One of the first CRT storage oscilloscopes of the new transistor age. Simple yet powerful, it remains a very capable instrument even today.





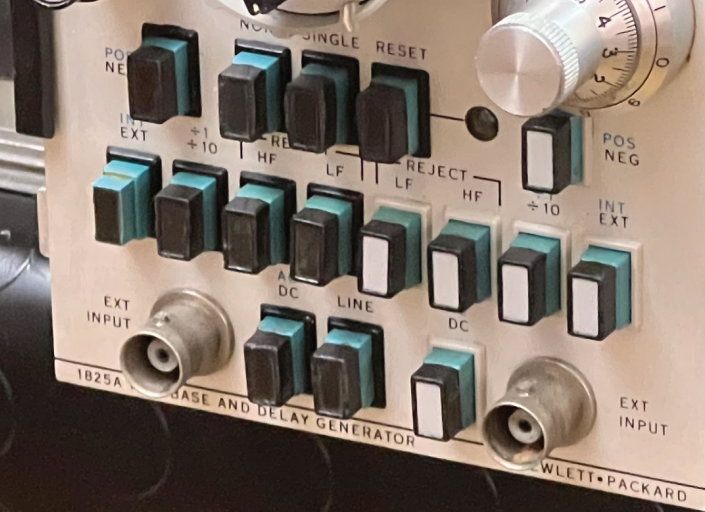
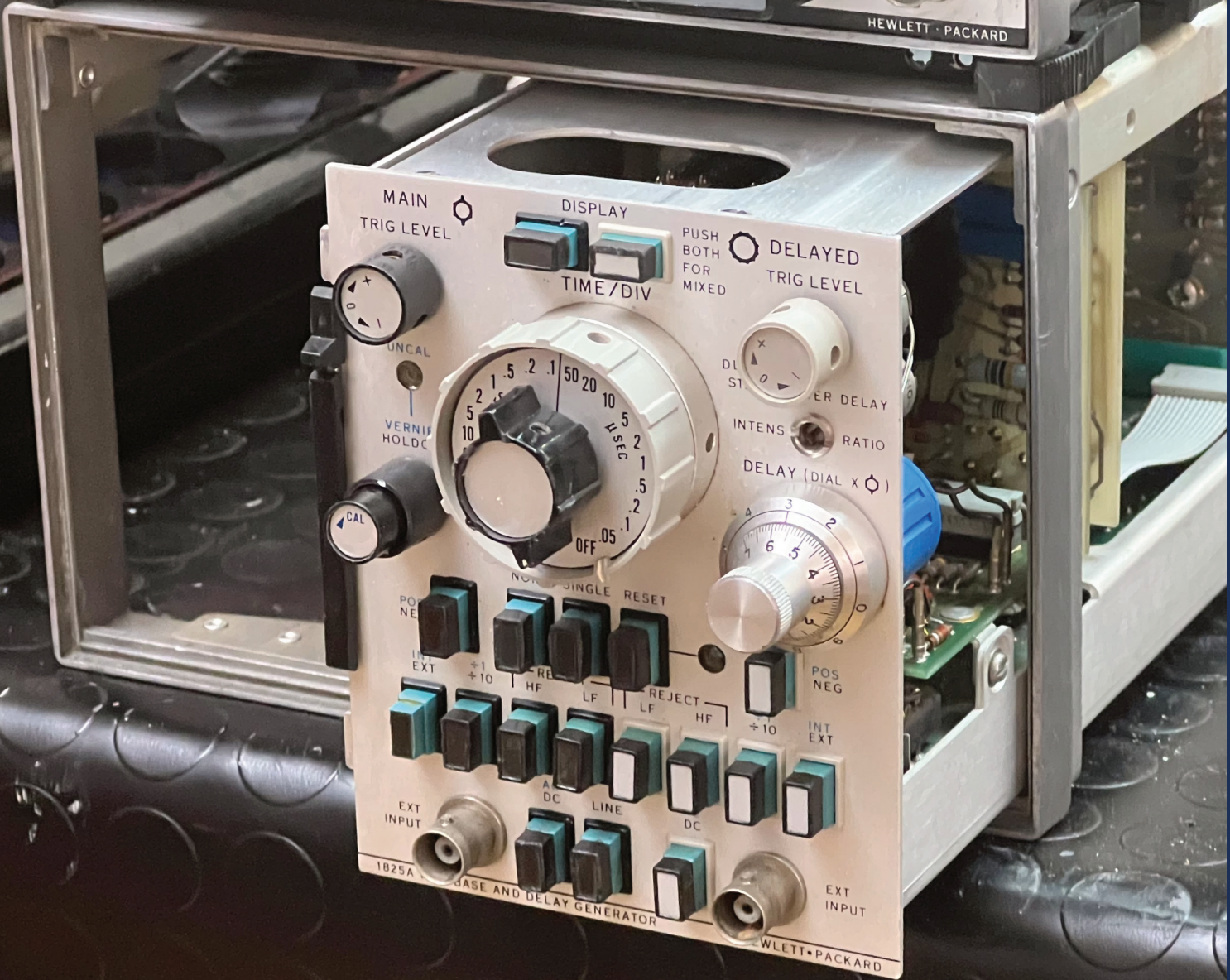
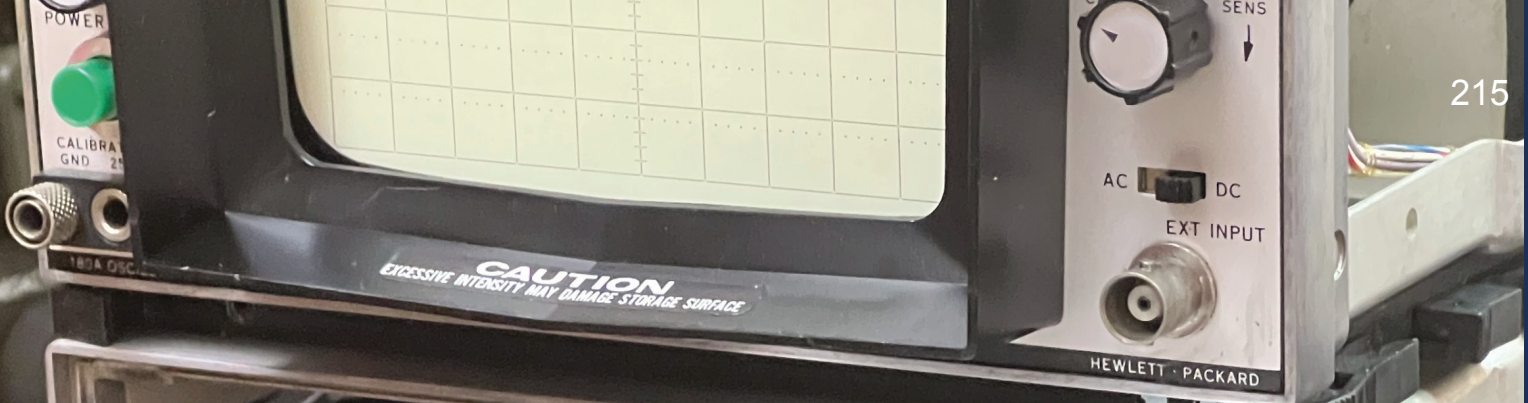
Section:

Oscilloscopes

Subsection:

1806A Dual Differential

Officially denominated “100 μ V Dual Differential (500 kHz)”



Section:

Oscilloscopes

Subsection:

54540 Quad 500 MHz

Almost a modern four-channel, full-featured DSO with 1 GSa/s sampling and FFT, still outperforming many modern low-cost oscilloscopes.

Window or Fake?

Main and Delayed Time Bases

On this subject, I must admit that in earlier editions I may have written some nonsense. This section is therefore an attempt to put some order into a topic that is often misunderstood.

Many analog oscilloscopes—starting with the progenitor Tektronix 545—were equipped with two time bases. One could be delayed with respect to the other in order to analyze a specific portion of the input signal. As an example, consider the signal shown in Figure 1: the upper trace displays the complete input waveform, while the portion of interest is intensified and expanded in the lower trace on a 7854 oscilloscope using the main and delayed time bases. A digitized trace of the same signal is shown in Photo ❶, while Photo ❷ shows the same experiment performed on a 7633 CRT storage oscilloscope.

Main and Delayed Time Bases in DSOs

This naturally raises a question: are main and delayed time base functions available on most digital storage oscilloscopes? The answer is simple: digital storage oscilloscopes have only one time base.

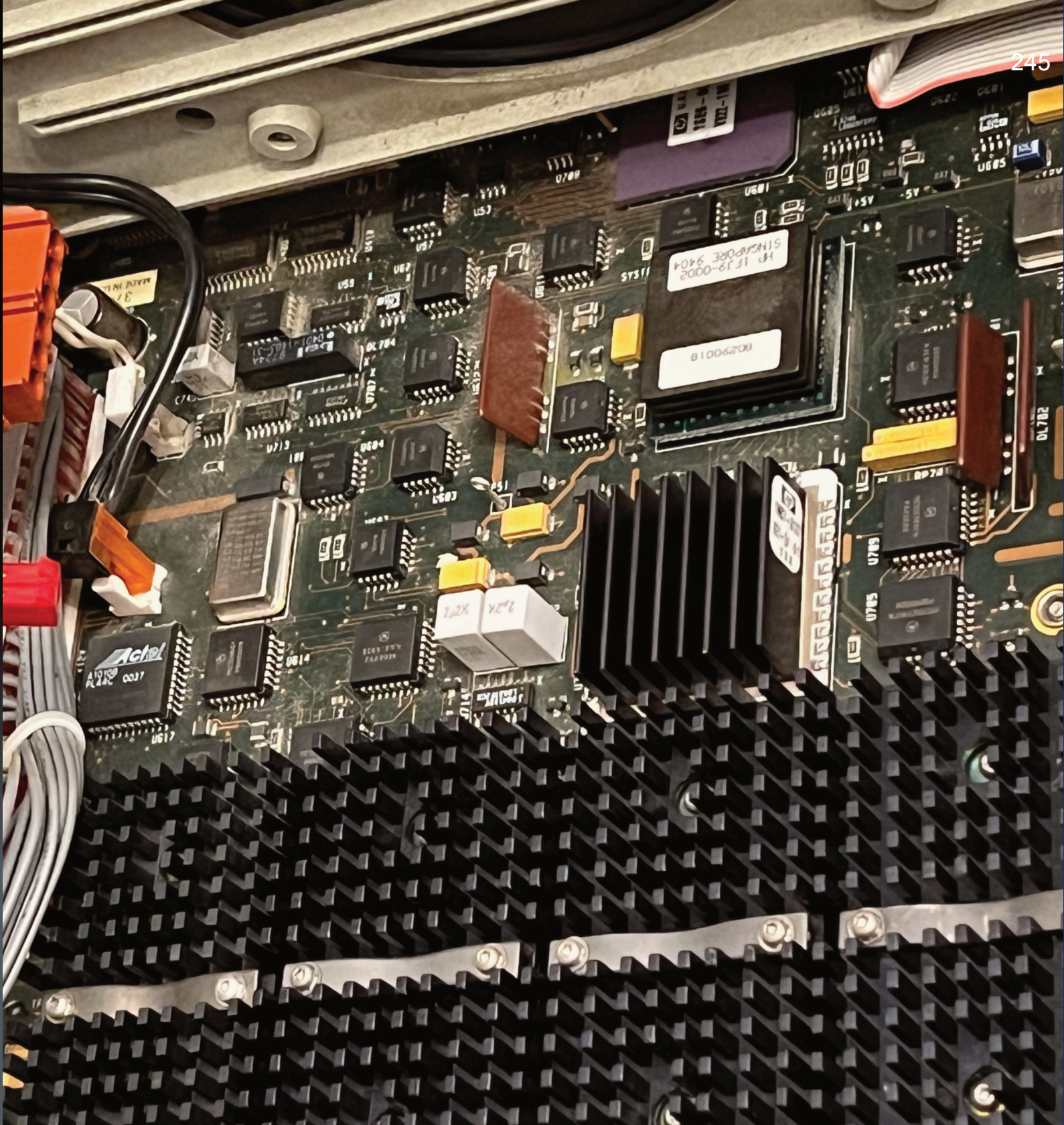
Tektronix's Position

According to Tektronix, only Tektronix oscilloscopes truly simulate the delayed time base operation found in analog instruments. In their DSOs, delayed time base accuracy is calculated in the same way as main time base accuracy, because in reality there is still only a single time base.

The Tektronix implementation simulates the delayed sweep by performing a second triggering operation after the delay, thereby eliminating much of the jitter error. It also provides an intensified-zone display that shows where the delayed sweep is positioned within the main sweep, closely mimicking the behavior of classic analog oscilloscopes.

Other Manufacturers

Again according to Tektronix, most other manufacturers adopt different approaches. Some use a horizontal position control that allows very long post-trigger delays; others rely on a zoom function, which requires a long record length and assumes that the region of interest is already contained within that record.



Marco, my son, is a genuine 3D design wizard. Through his project (toolsfix.eu), he develops clever and practical systems to keep tools and technical equipment perfectly organized.

Over time, he has also helped me by designing custom parts for some of my beloved boatanchors and vintage instruments — small components that are no longer available, yet essential to restore these machines to their proper dignity.

Several of these designs are now freely available for download from www.quacktech.it:

- ② Plastic front frame for the HP 54540A oscilloscope
- ② Replacement feet for the HP 180A oscilloscope and similar models
- ③ Lever tips for various Tektronix instruments
- ④ Upper and lower housings for the LeCroy 9000 Series oscilloscopes

A small example of how modern digital fabrication can serve the preservation of classic electronic art.



Top and bottom housing
(4 pieces)

toolsfix.eu

