An Era Told Trough Electronic Masterpieces

HP: The Golden Age

Volume 3

Counters, Spectrum Analyzers

5335A, 5316B, 8552/53B, 8557A, 8567A, 8568B

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
- [SCLI] 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
- [QTBYOP] 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 standard for electronic instrumentation. Its instruments were not merely tools, but symbols of precision, reliability, and intellectual rigor. (When it came to oscilloscopes, many of us—myself included—often preferred Tektronix, but that is another story.)

Founded in 1939 by Bill Hewlett and David Packard, HP grew from a small Palo Alto garage into one of the most respected electronics companies in the world. Over the decades, it shaped the way measurements were made and understood, establishing reference points for generations of engineers and scientists.

This volume is part of the Technical Art Books collection and belongs to the series HP: The Golden Age – An Era Told Through Electronic Masterpieces, devoted to exploring the most significant period of Hewlett-Packard's production through a selection of representative instruments, calculators, and computers. Rather than aiming at completeness, this series presents a portrait of an era through emblematic examples of electronic design.

This specific volume is dedicated to what Hewlett-Packard called signal sources: an exceptionally broad family of instruments—including signal, pulse, and function generators—produced in a vast number of different models, of which this book presents only a selected group of representative examples.

More than a catalog, this book is intended as a historical and technical journey, combining images, technical investigation, personal experience, and practical restoration, in order to preserve the memory of an exceptional generation of instruments and of the era that produced them.

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To my wife
and my family

Voltmeters and Oscilloscopes

Signal Sources

Counters and Spectrum Analyzers

Calculators, Computers, and HPIB

Hewlett-Packard

Voltmeters

Oscilloscopes

Signal Sources

Counters

Spectrum Analyzers

Calculators

Computers

HP-IB


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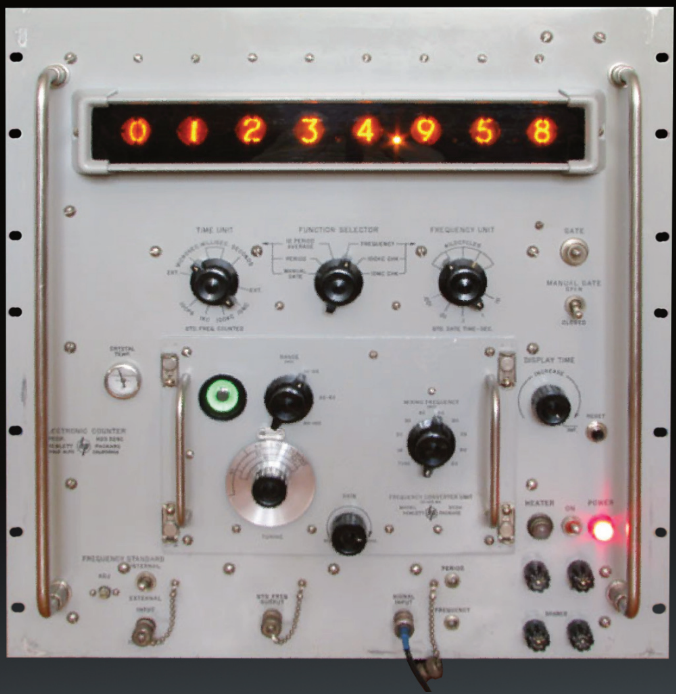
011234

Section

Counters

A primer on the different types of equipment you will see in the chapters that follow


01234.958
TIME UNIT
FUNCTION SELECTOR
FREQUENCY UNIT
GATE
MANUAL GATE
DISPLAY TIME
HEATER
ON
POWER
FREQUENCY STANDARD
PERIOD
FREQUENCY

Section:

Counters

Subsection:

Measuring Frequency

Some small talks about frequency measurement in general.

Not Always So Simple

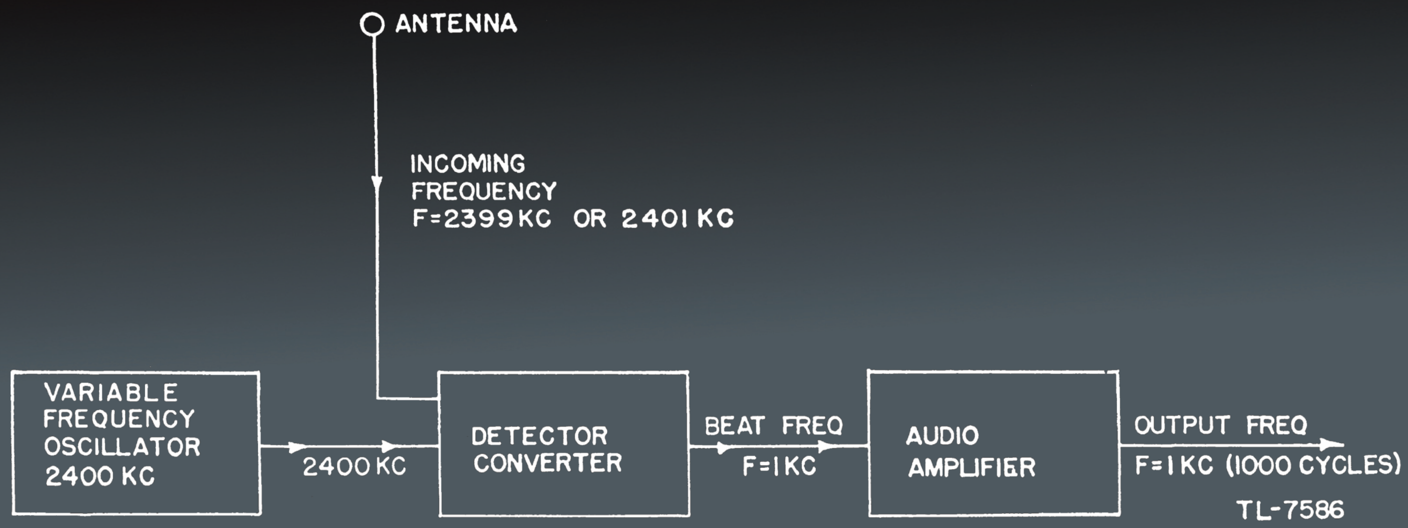
Precisely measuring the frequency of an alternate, repetitive signal is one of the simplest operations today; you can do it with a digital counter or an oscilloscope. For low frequencies, even many VOMs can solve your problem.

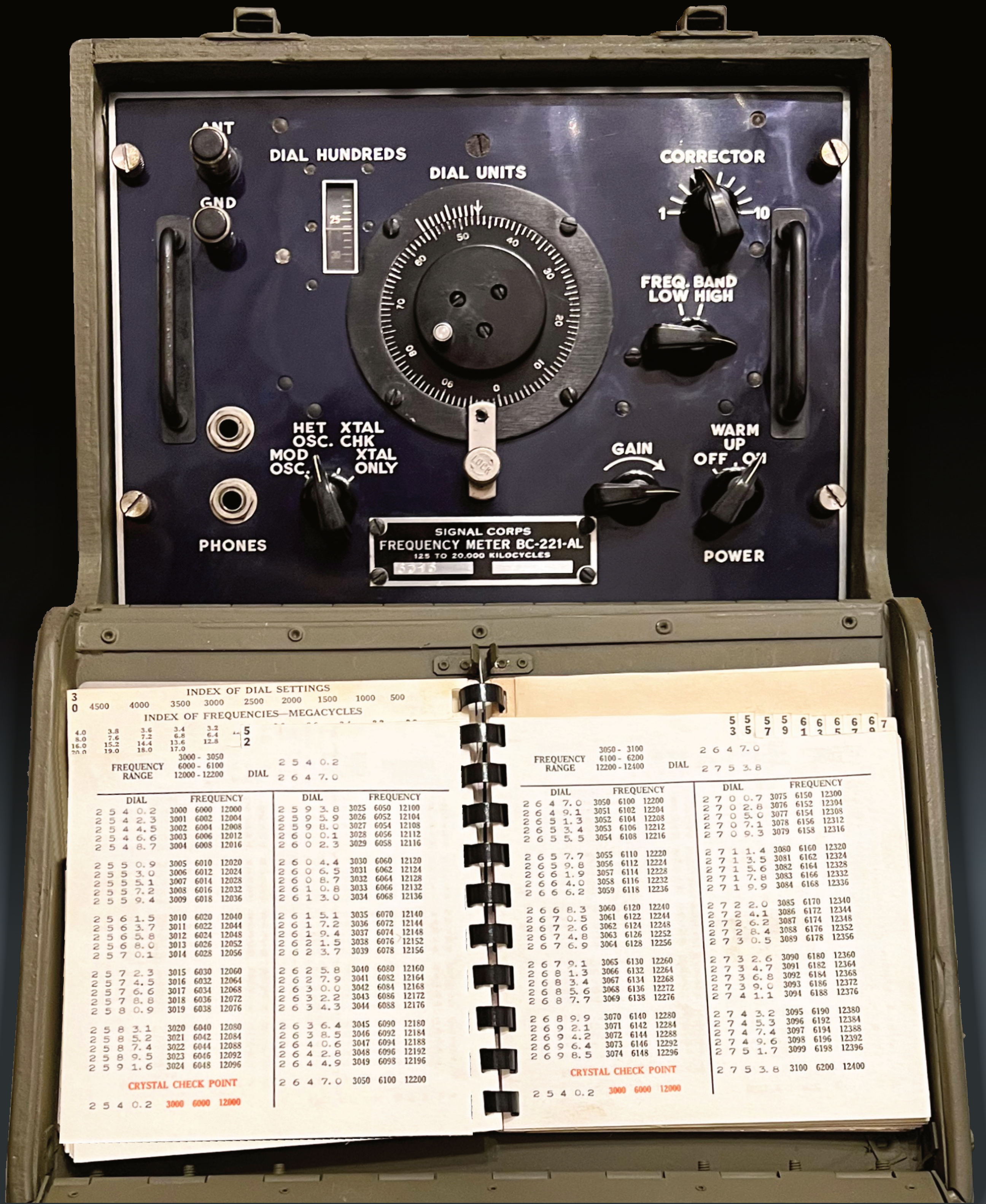
In the past, it was not so simple. The simplest way to measure a frequency is to use a capacitor in series with a voltmeter. The higher the frequency, the lower the capacitive reactance of the capacitor, and so the voltmeter moves more, but certainly the scale will be non-linear and the accuracy low.

The BC-221

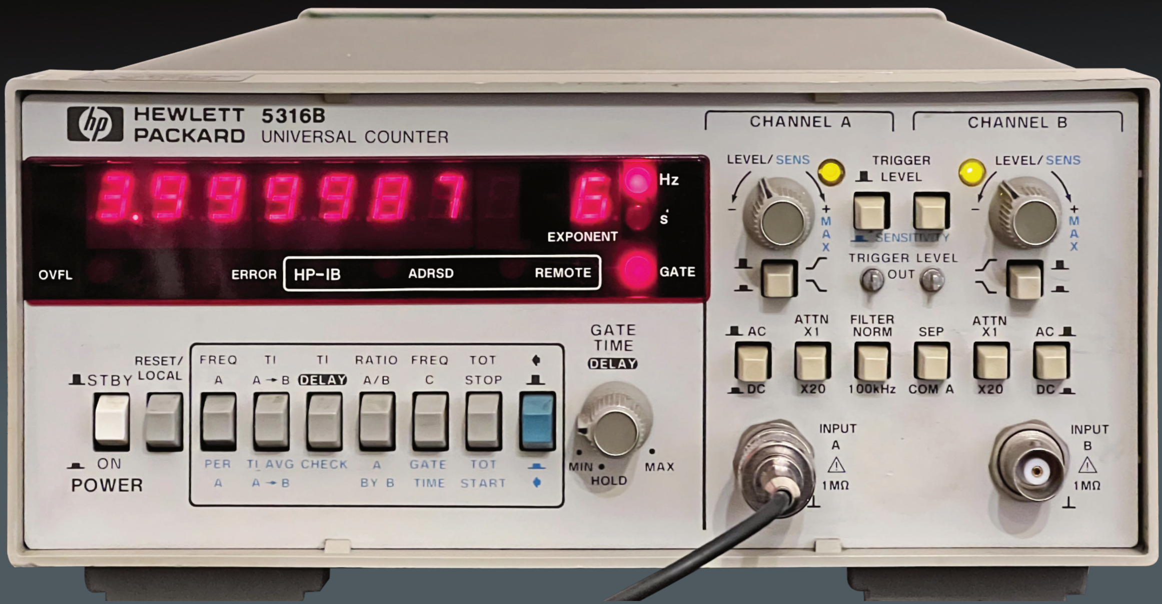
The first time I read the words "frequency meter" was probably in a magazine ad for a 1941 military surplus **BC-221** (photo on the left), very common in the sixties, at least in Italy, but at that time I had no clear idea how it could work.

Later I discovered that the principle of operation is simple: as shown below, the BC-221 is essentially a broadband receiver and a variable frequency oscillator (VFO). It allows you to hear the beat of this oscillator and the unknown signal. The VFO is not only highly stable, but also individually calibrated.

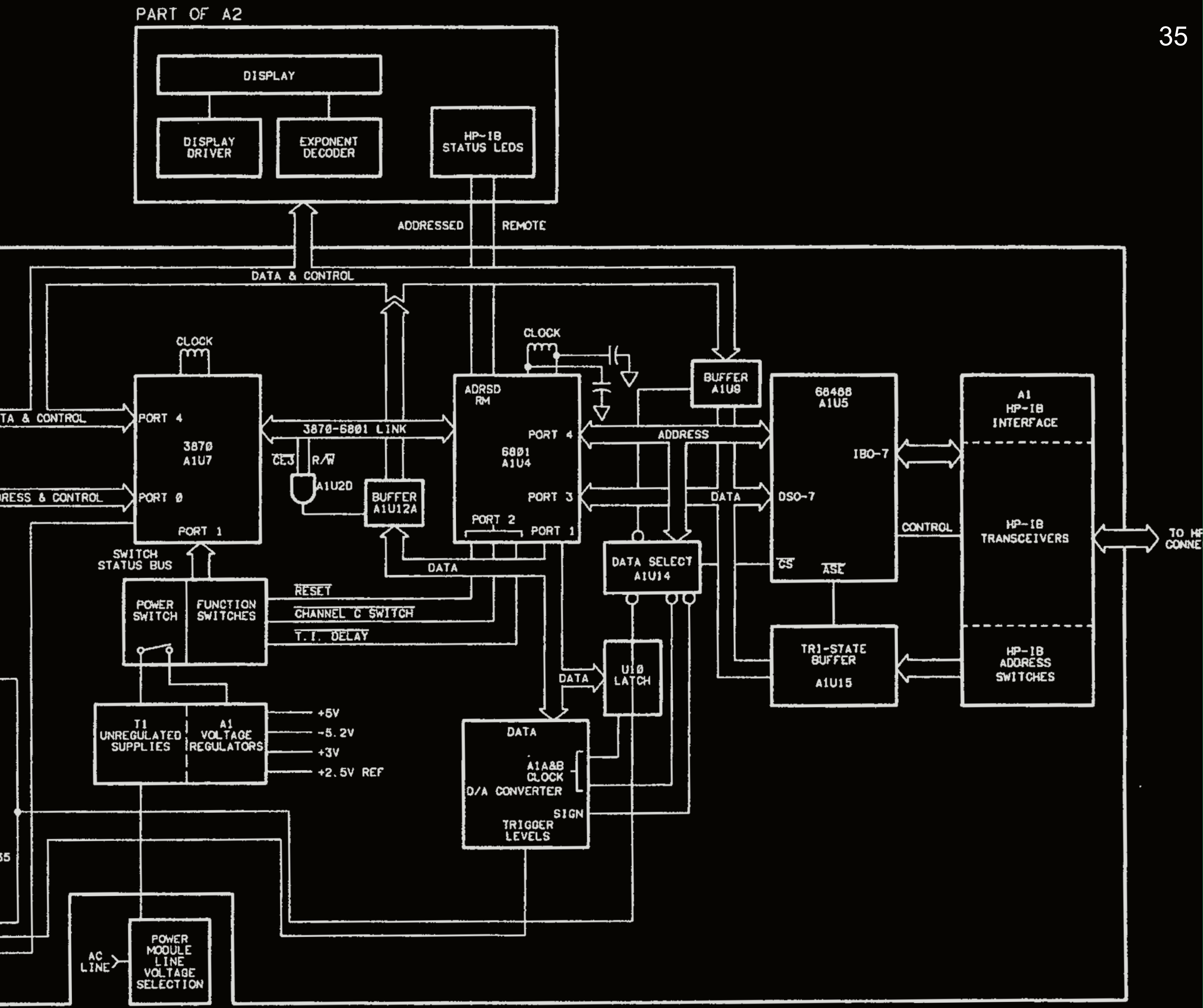



ANT
GND
DIAL HUNDREDS
DIAL UNITS
CORRECTOR
FREQ. BAND
LOW HIGH
HET OSC.
XTAL CHK
MOD OSC.
XTAL ONLY
PHONES
LOCK
GAIN
WARM UP
OFF ON
POWER
SIGNAL CORPS
FREQUENCY METER BC-221-AL
125 TO 20,000 KILOCYCLES
INDEX OF DIAL SETTINGS
INDEX OF FREQUENCIES—MEGACYCLES
FREQUENCY RANGE
DIAL
FREQUENCY
CRYSTAL CHECK POINT

5335A Universal Counter



5316B Universal Counter



With today eyes I liked immediately the 5316B, as soon as I took it out of the box. It was like new and perfectly operating, still with the calibration seals from the last check, performed on November 11, 2003. Even today, within its limits, is perfectly usable and very practical.

Power for the Money

An Innovating Counter

In the early eighties, most electronics was by now going digital, and many digital circuits parameters like **pulse width, duty cycle, and phase** had become significant. A conventional counter could not be used to measure these parameters, or at least multiple setups were needed, accompanied by manual calculation. The 5335A offered **new functions**, or at least functions which I was not used to see in a digital counter, in addition to the **HP-IB** extended programmability. As we explore further below, we could summarize the novelties in two groups, which we have seen and are going to see also in oscilloscopes:

- math and statistics;
- automatic measurements.

In addition to these special functions, the 5335A had also good general performances, with 200 MHz range and **12-digit display**; some interesting options also added other possibilities.

Prices and Options

The price of the 3325A in 1980 was of $2,950, equivalent to $11,243.98 in 2024. But you had available very interesting options (in parentheses the 2024 equivalent):

- **Opt 010**: **Oven Oscillator**: $650 (2,477);
- **Opt 020**: **Digital Voltmeter** (DVM) with auto-ranging, auto-polarity, ±10, ±100, ±1000V ranges, 100 μV to 100 mV sensitivity (depending on range), up to 4 digits: $275 (1,048);
- **Opt 030**: **C Channel**, with 150 MHz to 1.3 GHz with C/A capability: $450 (1,715).

Interesting the voltmeter; it was completely independent from the counter, just like the Tektronix 7D13 oscilloscope plug-in. Digital voltmeters were a novelty and the possibility to share the display was evidently considered important by itself. Surprising that the most expensive was the oven; I would have thought it was the C Channel.

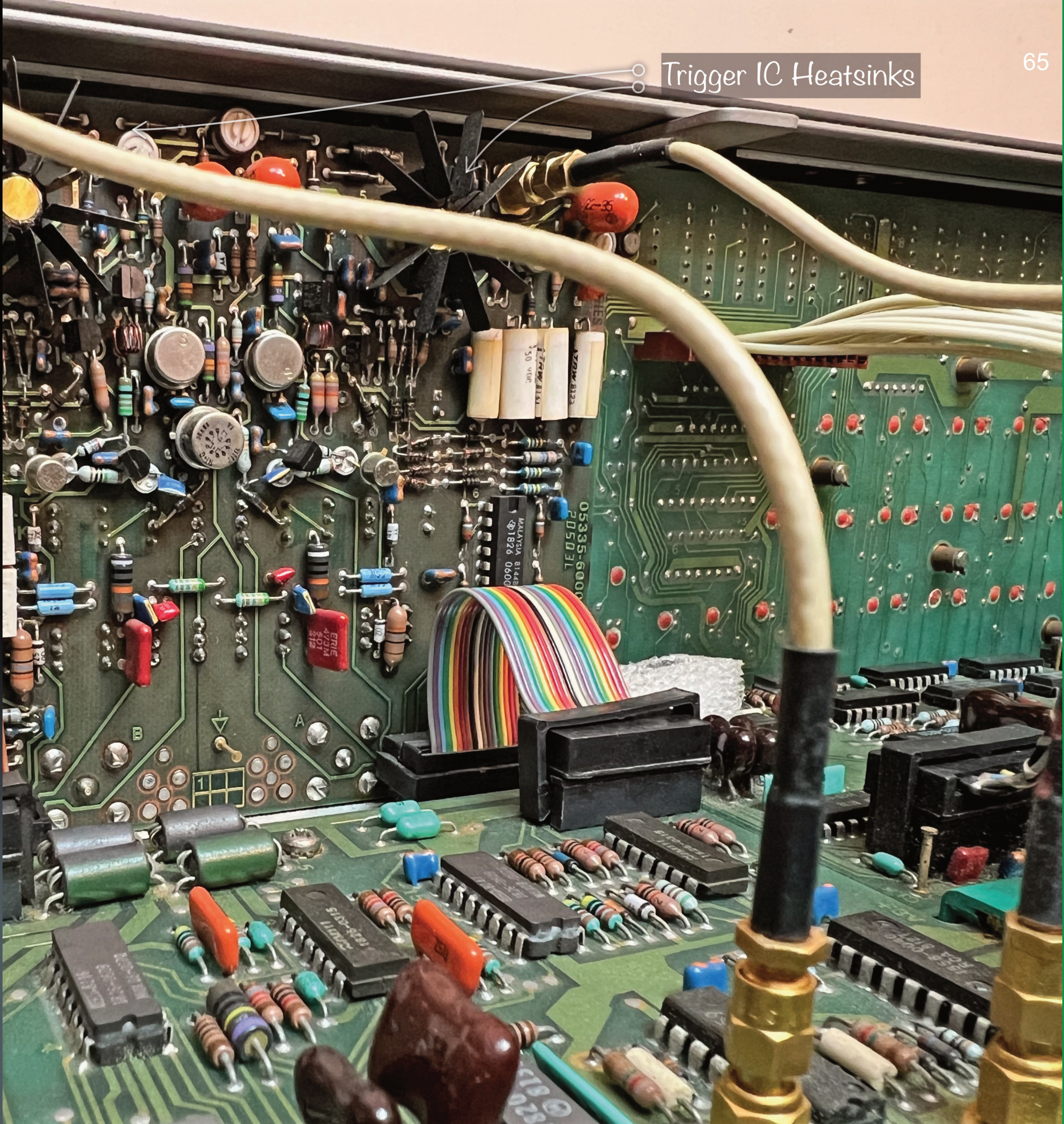
Automatic Functions

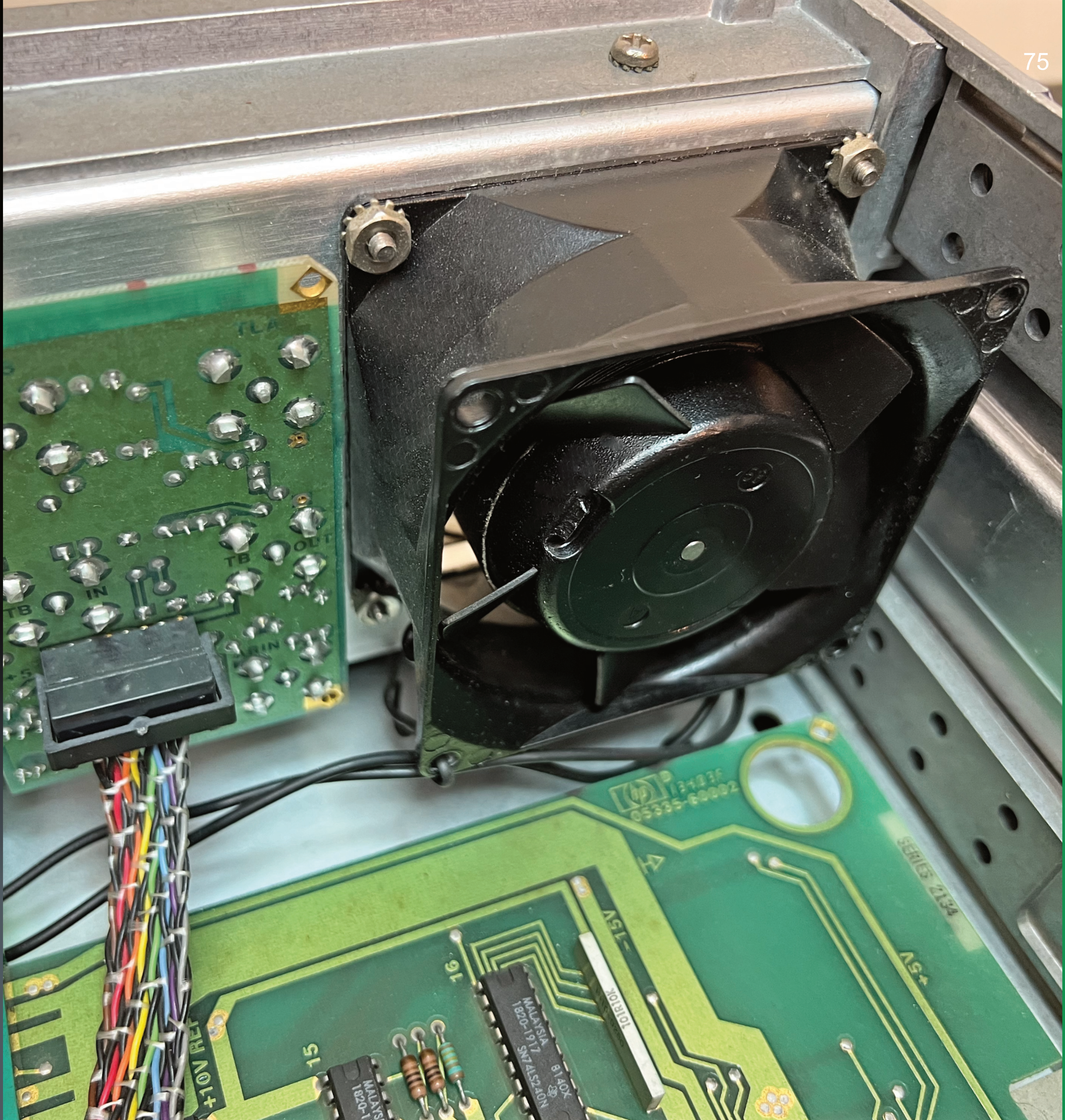
Beyond an Universal Counter

Manual/Automatic Triggering circuits allowed to either set the trigger levels yourself, or have the 5335A set them. Using this capability to the fullest carried the 5335A beyond the usual universal counter measurements of Frequency, Period, Time Interval, Ratio and Totalize to include measurements such as:

- Pulse Width;
- Rise and Fall Time (10% to 90%);
- Slew Rate;
- Duty Cycle;
- Phase A Relative to B;
- Inverse Time Interval (velocity).

All done automatically at the push of a button. Also both A and B channel trigger levels and gate time could be measured and displayed on the standard 5335A.

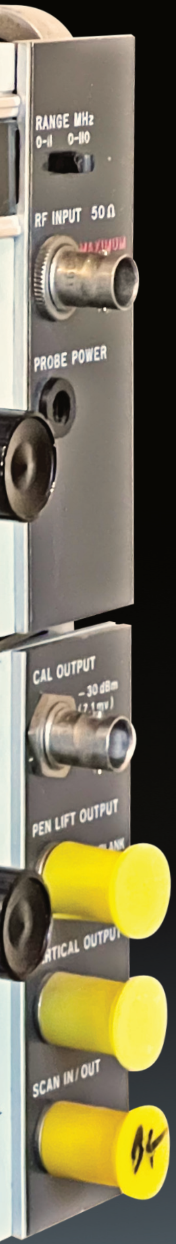

Trigger IC Heatsinks



TB
IN
OUT
+10V REF
16
15
-15V
+5V
MALAYSIA
1820-1917
SN74LS240N
8140X


corcom
MADE IN MEXICO
48-66Hz
US PAT.3728585
8217
5370-60005
2060A
SW1
2000UF
39D243
8139L
3501
MALAYSIA 1820-2075 8201B
SN74LS245N
1820-2099
8201
MD74SC245 AC
S-2576
8210
1820-2312
L2046-139
USA
1858-0063
RDA 8118


8443A TRACKING GENERATOR · COUNTER
HEWLETT · PACKARD
MARKER INTENSITY
18.18974
MARKER POSITION
FREQUENCY MHz
COUNTER INPUT 50 Ω
MODE
EXTERNAL MARKER SCAN HOLD
RESOLUTION
10 Hz 100 Hz 1 kHz
CTR ADJ
FUNCTION
RESTORE SIGNAL
TRACK ANALYZER
RF OUTPUT LEVEL dBm
TENS UNITS TENTHS
POWER
STBY ON
RANGE
100 kHz - 110 MHz
RF OUTPUT 50 Ω
141T DISPLAY SECTION
HEWLETT · PACKARD
Spin electronic instruments
8553B SPECTRUM ANALYZER-RF SECTION
CENTER FREQUENCY MHz
TRACE ALIGN
ASTIG
FREQUENCY
FINE TUNE
BANDWIDTH
SCAN WIDTH
PER DIVISION
INPUT ATTENUATION
TUNING STABILIZER
USE FINE TUNE ONLY
OFF
AMPL CAL
RANGE MHz
RF INPUT 50 Ω
8552B SPECTRUM ANALYZER-IF SECTION
MANUAL SCAN
SCAN TIME PER DIVISION
LOG REF LEVEL · LINEAR SENSITIVITY
BASE LINE CLIPPER
SCANNING
10 dB LOG
2 dB LOG
LINEAR
DISPLAY ADJUST
POSITION
HORIZONTAL VERTICAL
GAIN
VIDEO FILTER
OFF 10 kHz 100 Hz 10 Hz
SCAN MODE
SINGLE MAN EXT INT
SCAN TRIGGER
VIDEO EXT LINE AUTO
CAL OUTPUT
PEN LIFT OUTPUT
VERTICAL OUTPUT
SCAN IN / OUT
STORAGE
WRITING SPEED
NON STORAGE
STORE FAST STD ERASE CONV
LINE
ON
TIME
PERSISTENCE
INTENSITY
FOCUS
MAX
ADVANTEST R3132 SPECTRUM ANALYZER 9kHz-3GHz
30.000 MHz
AUTO TUNE
COUNTER
POWER MEASURE
DATA
SYSTEM
FREQ
SPAN
LEVEL
LOCAL
CONFIG
SHIFT
RECALL
COPY
MARKER
CONTROL
PK SRCH
MKR
MEAS
BW
TRIG
PAS/FAIL
SWEEP
TRACE
DISPLAY
REPEAT
SINGLE
TG
RETURN
POWER
TG OUTPUT
RF INPUT 2
CAL OUT
PROBE PWR
RF INPUT 1



Modularity

The different modules are well integrated. It is easy to extract the plug-in composed by the RF and IF sections (green triangle in the photo). Separating them is also easy, knowing that you have to press the button indicated by the red triangle and then rotate the unit, as shown in the photo.

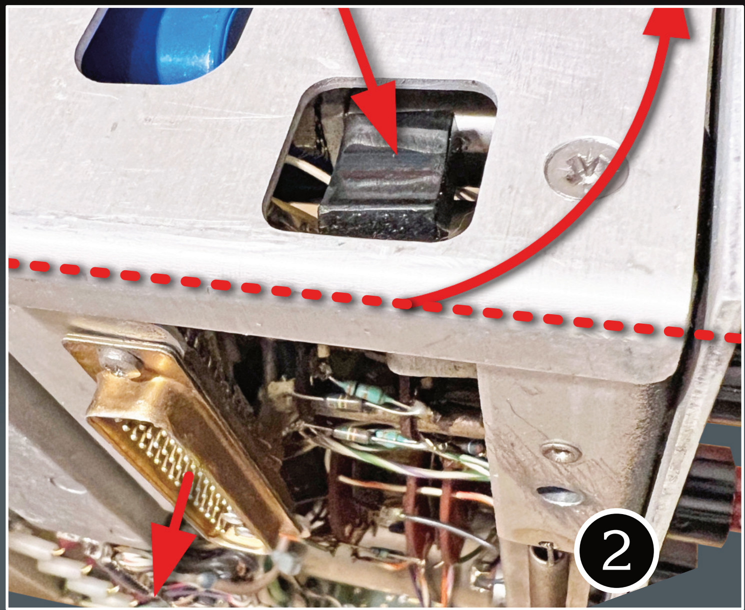
Certainly, the modules are easy to manage and interchangeable among the various models, but they did not claim the modularity. Probably changing the RF or IF section would have required re-calibration of the instrument; it was not a simple plug-in exchange like in the Tektronix 7000-Series, I suppose.

The First Time

According to HP Journal 8/1968, this was the first spectrum analyzer to combine absolute amplitude calibration with wide sweep capability, high sensitivity, low distortion, wide dynamic range, and flat frequency response. The new spectrum analyzer was designed to be a general-purpose measurement tool, to make the frequency domain as scope-accessible as the time domain.

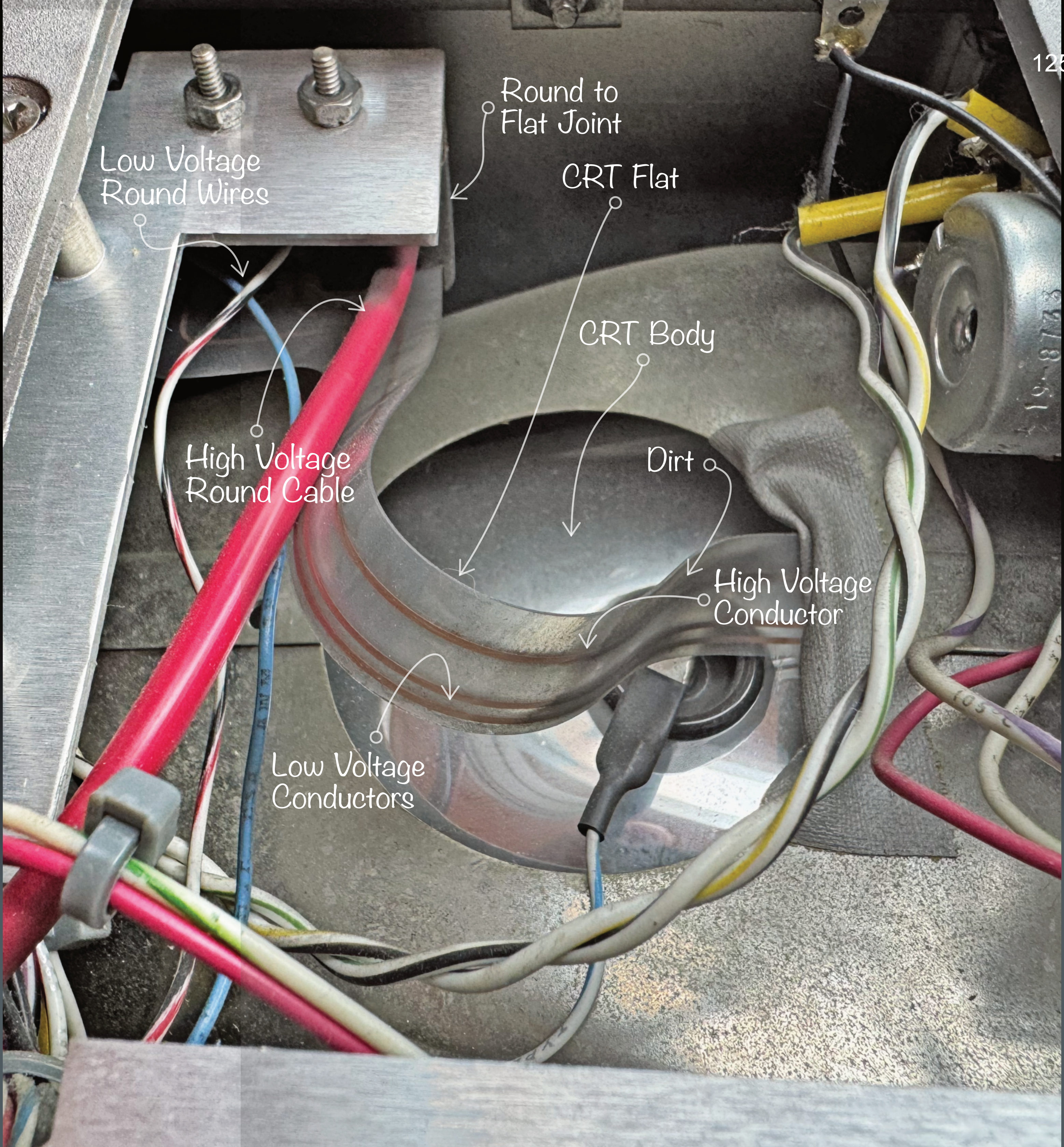
Easy to Use and Interpret

A key design goal was to make the controls and display easy to use and interpret. Automatic frequency stabilization occurs during normal use of the unit without prior adjustment. The display is clutter-free because a low-pass input filter prevents out-of-band signals from overloading the analyzer or causing confusing spurious responses. A red panel light alerts the operator if the display becomes uncalibrated because the scan rate is too fast for the selected bandwidth.



❶ Plug-ins removal (green arrow). The two modules can be then separated by pressing the button pointed by the red arrow.
❷ The button and how to rotate the module to separate it from the other.

8552B IF section


Round to
Flat Joint
Low Voltage
Round Wires
CRT Flat
CRT Body
High Voltage
Round Cable
Dirt
High Voltage
Conductor
Low Voltage
Conductors

feedback voltage is increased, the center frequency of the notch moves closer to 200 MHz, increasing the attenuation of the signal. This type of gain-adjusting element gives a range of more than 30 dB with a minimum of components.

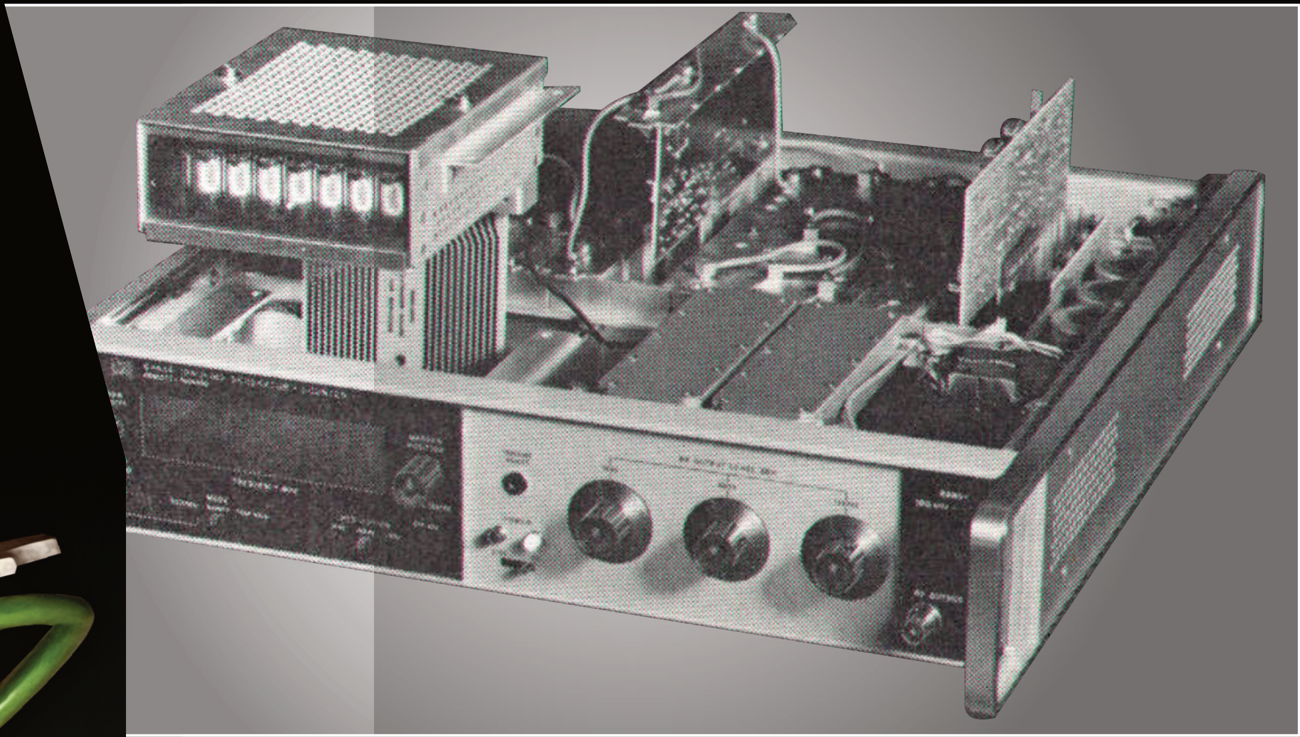
Thin-film Microcircuit

A Thin-film microcircuit technology met the need for flat, high-gain output amplifiers. A high-gain amplifier is required to give a high, level output, since the output of the third mixer is made low in level to minimize spurious signals. Flat frequency response is easier to achieve with a thin-film circuit because of its relative freedom from parasitic inductive and capacitive effects. Placing the detector on the thin-film circuit very close to the 500 thin-film output resistor promotes the achievement of good VSWR characteristics in the leveled output. Microcircuit techniques are also advantageous because of the excellent heat sinking that is obtained by putting the active device directly on the sapphire substrate.

Counter Section

The 8443A marker control circuit stops the scan ramp generator in the 8552 IF Section during a part of each sweep cycle and counts the 8443A output frequency during the period when the scan is stopped and the frequency is fixed.

Because the scan is stopped at the same point on each sweep, the CRT beam is directed at the same point on the CRT for a large percentage of the scan time, causing an intensified spot at that point. This spot is an easily recognizable marker, and its position corresponds precisely to the frequency measured by the counter. By use of a continuously variable MARKER POSITION control, the operator can locate the marker on any point of the swept frequency display.



More Shields

DC connections are made through the motherboard with small circular holes in the ground plane. In addition, the exposed leads and connector pins on the bottom side of the motherboard are shielded with a sheet aluminum cover.

The counter box provides RF shielding of the low-frequency counter circuitry using overlapping riveted sheet metal and a unique metal etched screen in front to attenuate the RF radiating from the numeric indicator tubes. All this results in a unit well shielded against RI susceptibility and radiation.

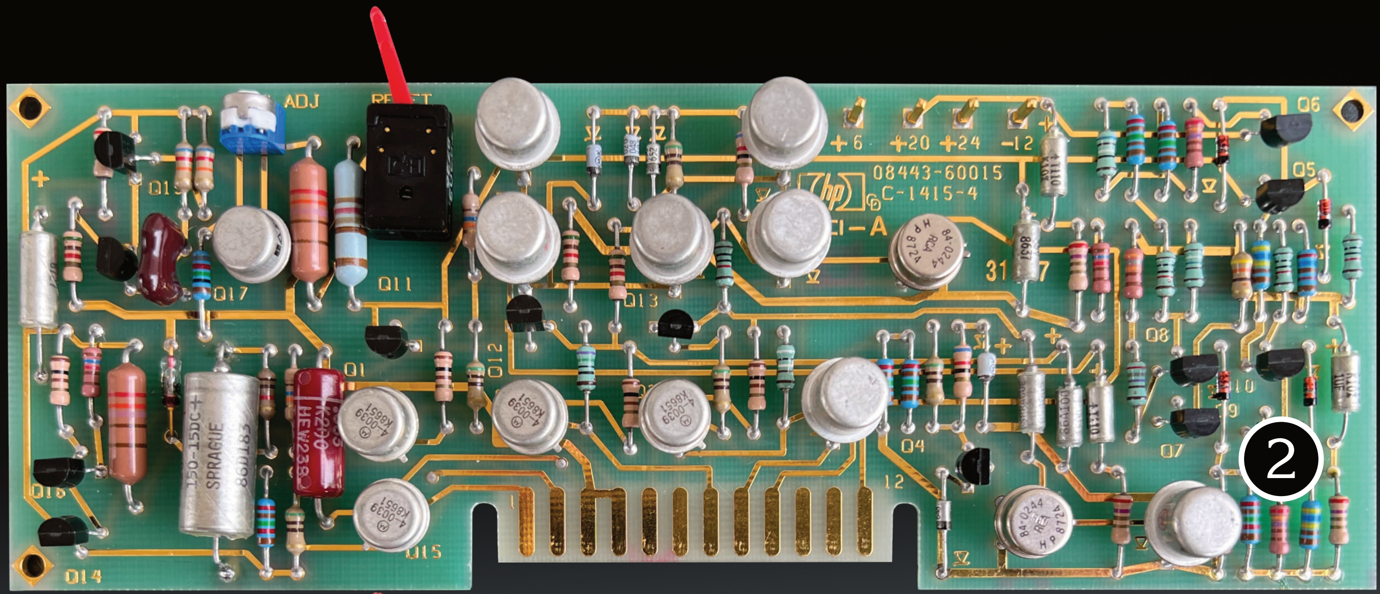
Look and Feel

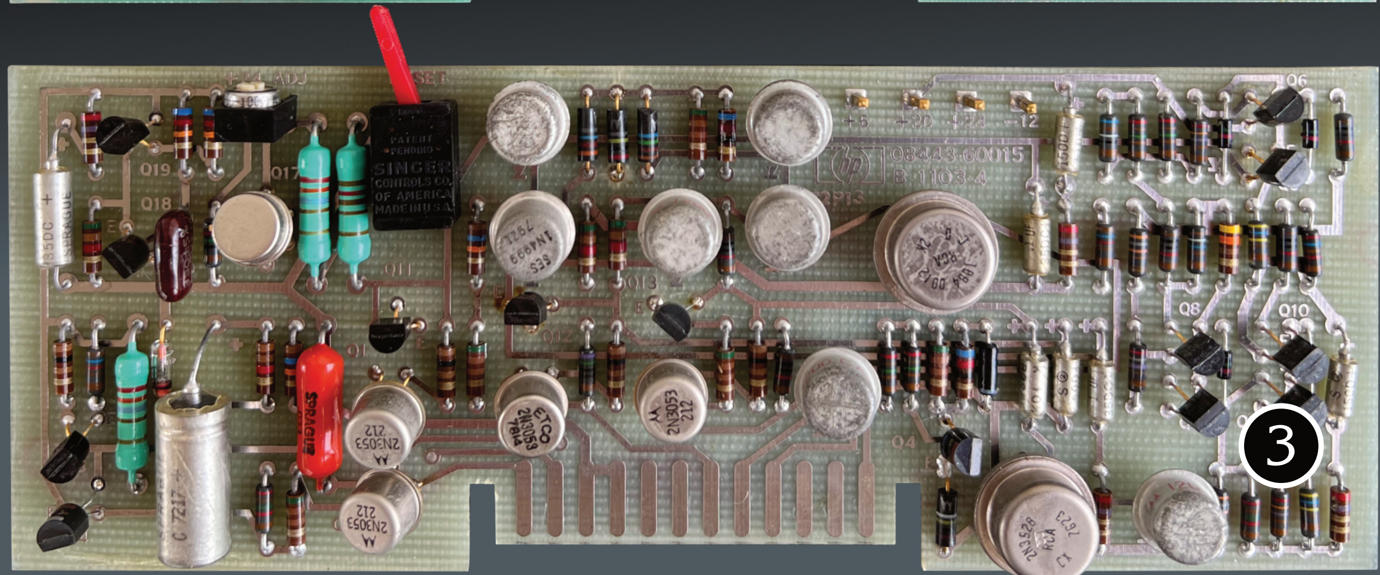
Compatibility with the 8552/8553 Spectrum Analyzer has been accomplished by using the same panel color arrangement, similar panel trim and matching recessed dials for attenuation readout.

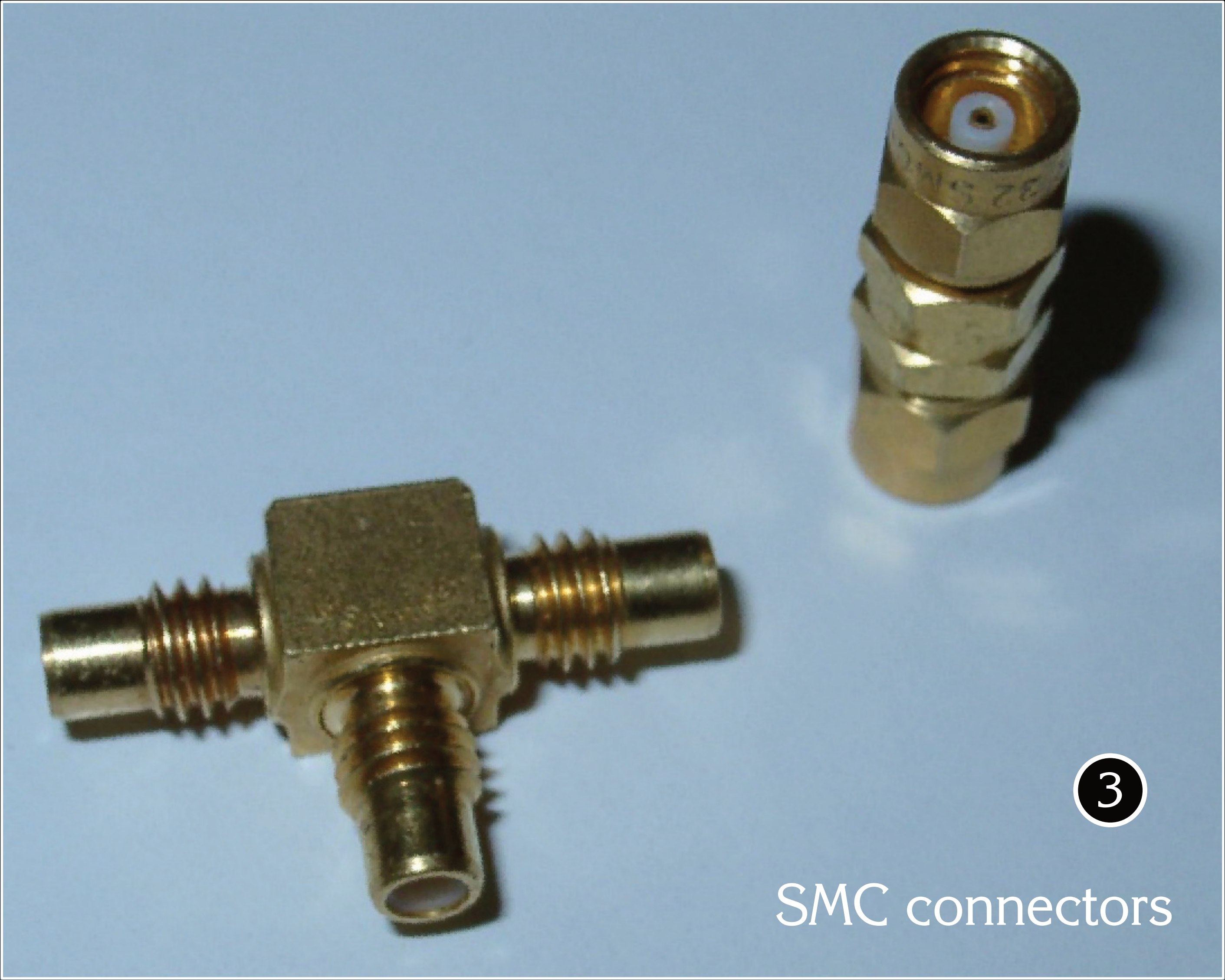
from this 8443A, the one with the seven-segment display, and the other from the older 8443A,
the one with the Nixies. Unexpectedly: the second board worked perfectly, with no noise. This made my job much easier: the problem was definitely in the A14 board.

Here began a long session with few results. Exasperated I replaced all interested capacitors, the 1854-0071 transistors (with 2N3904), the zener diode CR5 and swapped with the other board Q15

❶ A14 Sense Amplifier Board component layout. ❷ The A14 board we are talking about. ❸ Another A14 board from the older 8443A, the one with Nixie display. Note the evolution to a gold-plated PCB.







Connectors' Gender

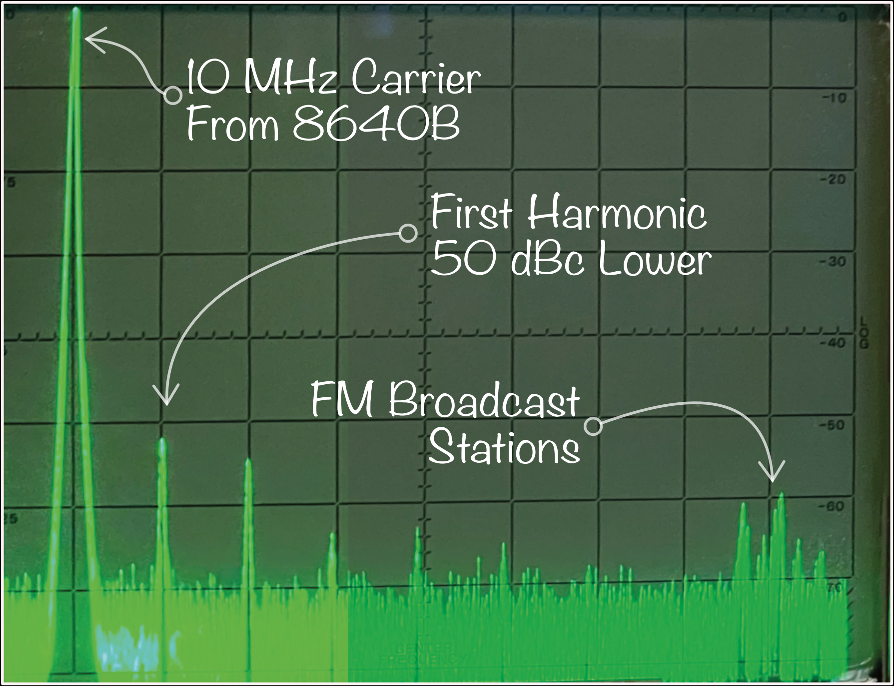
The MIL-STD-348 subminiature connectors follow a rule somewhat different from the others. Normally, a "plug" is called male and a "jack" female. In this case, we consider instead the center pin to define the male, as shown by the photos in these pages.

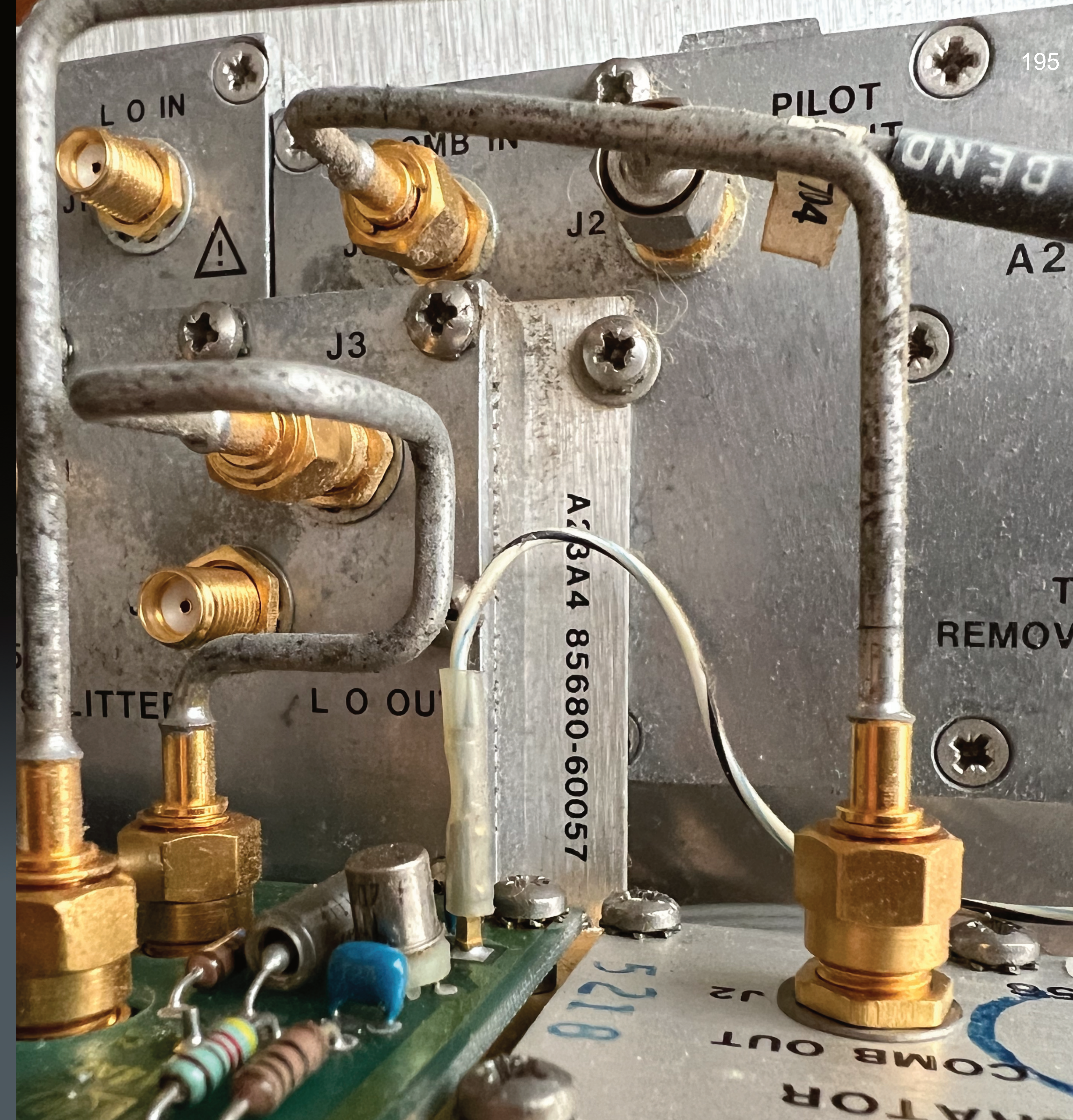

8557A SPECTRUM ANALYZER .01-350 MHz
FREQUENCY MHz
TUNING
REFERENCE LEVEL dBm
OPTIMUM INPUT (PUSH)
FREQ SPAN/DIV
RESOLUTION BW
PULL TO UNCOUPLE
VERT
POSN
GAIN
FREQ ZERO
BASE LINE CLIPPER
VIDEO FILTER
SWEEP
TIME/DIV
TRIGGER
CAL OUTPUT
250 MHz -30 dBm
REF LEVEL CAL
INPUT 50 Ω
PROBE PWR
TRACE
CLEAR WRITE
MAX HOLD
STORE VIEW
STORE BLANK
INTENSITY
1983

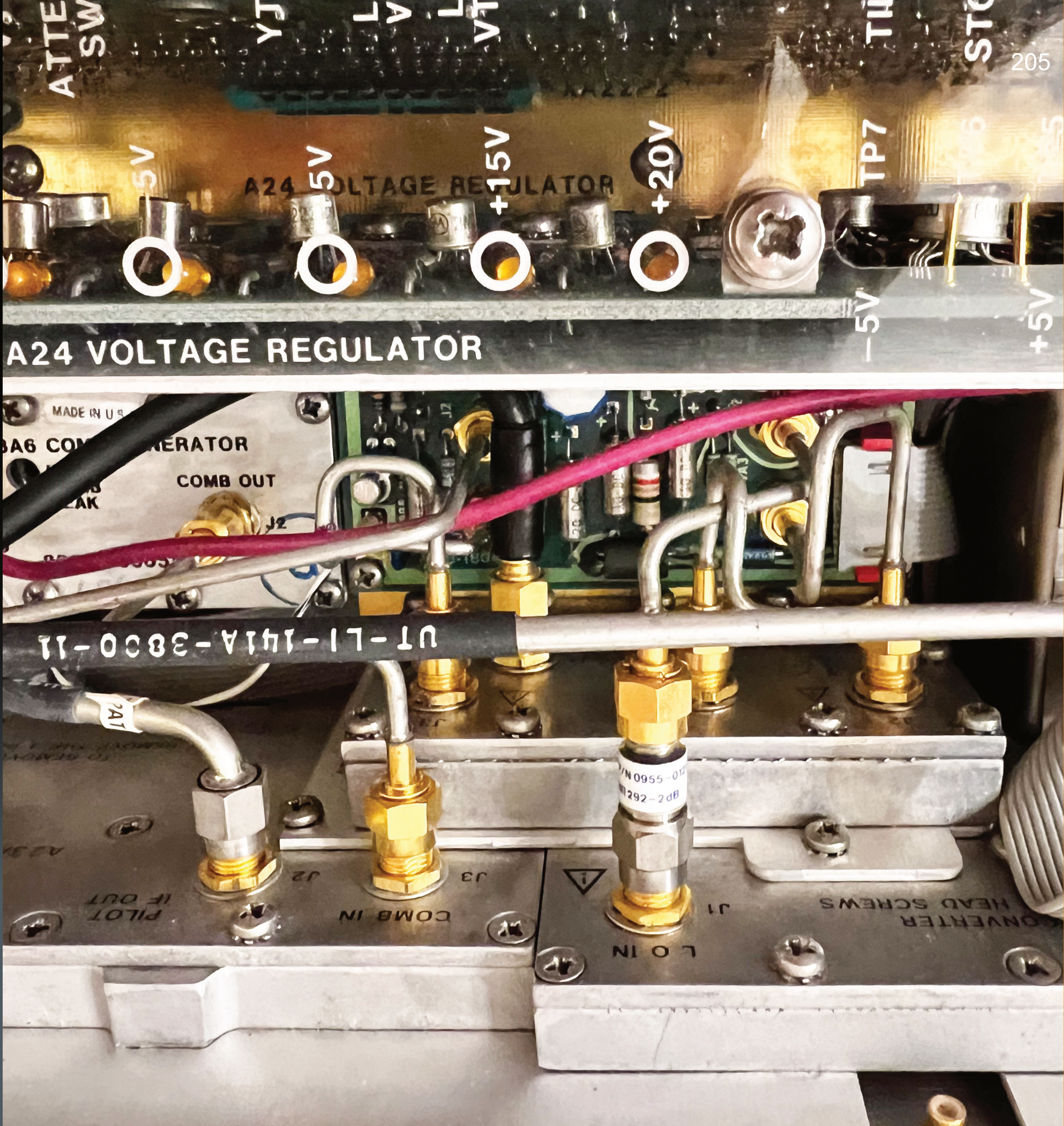
8640B

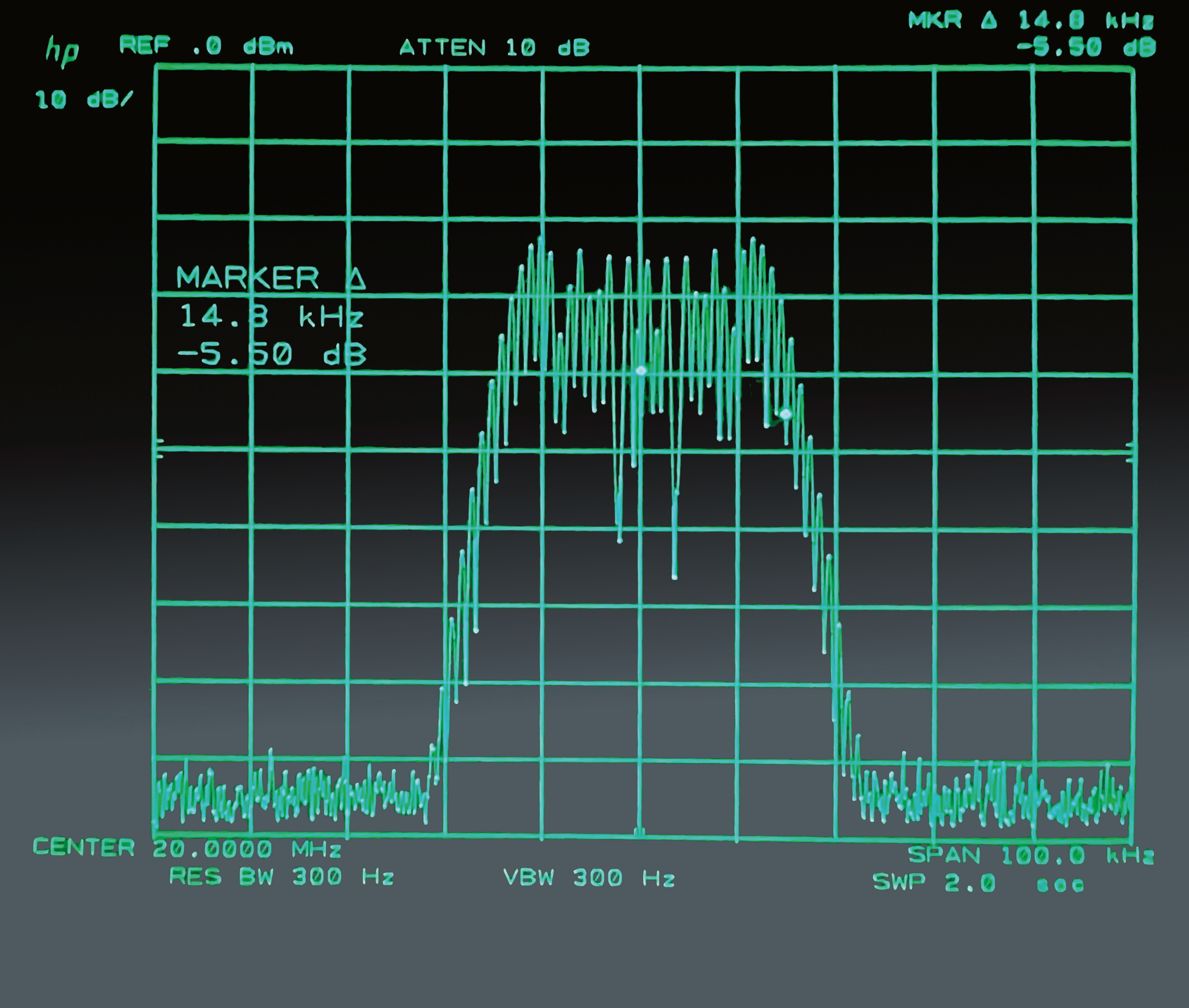
I wanted to check the spectral purity of the famous **8460B Signal Generator**.

At first I thought of a failure: how many harmonics! But the scale is logarithmic, and the old 8640B is still well within spec (+10dBm: <–30 dBc). In this case, we are at –50 dBc (dBc refers to the carrier).




L O IN
OMB IN
PILOT
J2
A2
J3
85680-60057
REMOV
LITTER
L O OUT
COMB OUT
J2
5218


A24 VOLTAGE REGULATOR
+15V
+20V
TP7
-5V
+5V
COMB OUT
J2
UT-LI-141A-3800-11


hp REF .0 dBm
ATTEN 10 dB
MKR Δ 14.8 kHz
-5.50 dB
10 dB/
MARKER Δ
14.8 kHz
-5.50 dB
CENTER 20.0000 MHz
RES BW 300 Hz
VBW 300 Hz
SPAN 100.0 kHz
SWP 2.0 sec

It Left Its Mark

The HP-IB Interface

An 8-bit microprocessor architecture was chosen for the HP-IB interface. This frees the main instrument controller from handling the HP-IB protocol. In addition, the power of the microprocessor allows pre-processing of the incoming data. This mainly involves interpreting the 171 mnemonics for the main instrument controller, which define the front panel keys in terms of the single ASCII code character printed next to each key. For example, when the HP-IB microprocessor receives CF, it converts it to v, the character adjacent to the CENTER FREQUENCY key, and passes it to the main controller.

This microprocessor was onboard of the same A15 where the main processor is.

A Modular Approach

It was decided to design the hardware on a modular basis with a minimum of interfaces between modules. The primary interface is to the 50-line main microprocessor bus, which also connects to the display unit via the cables described earlier.

The result is that more than **50 circuit boards** make up the 8564B, with a component count that I fear to guess.

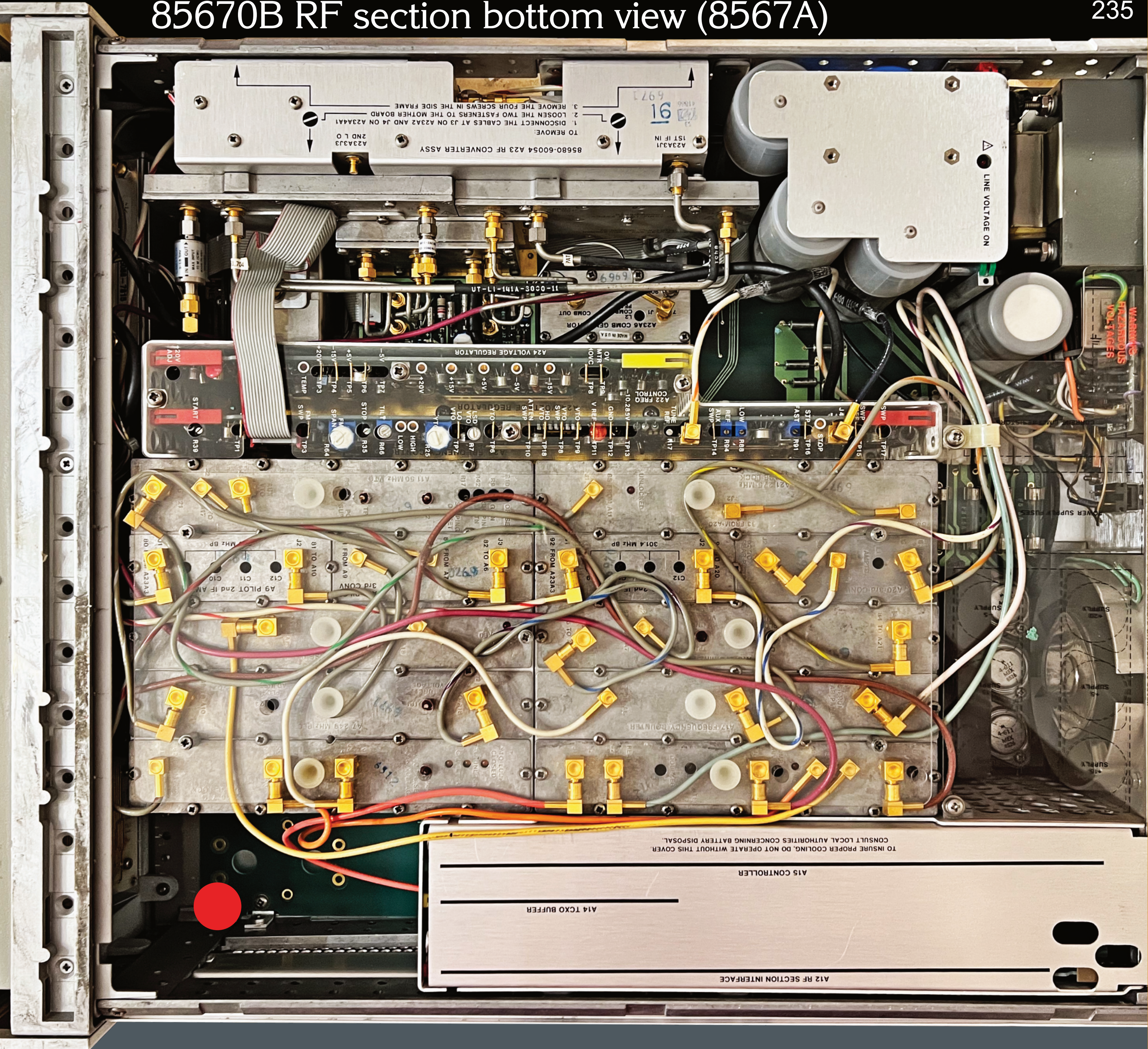
My Prayers Always

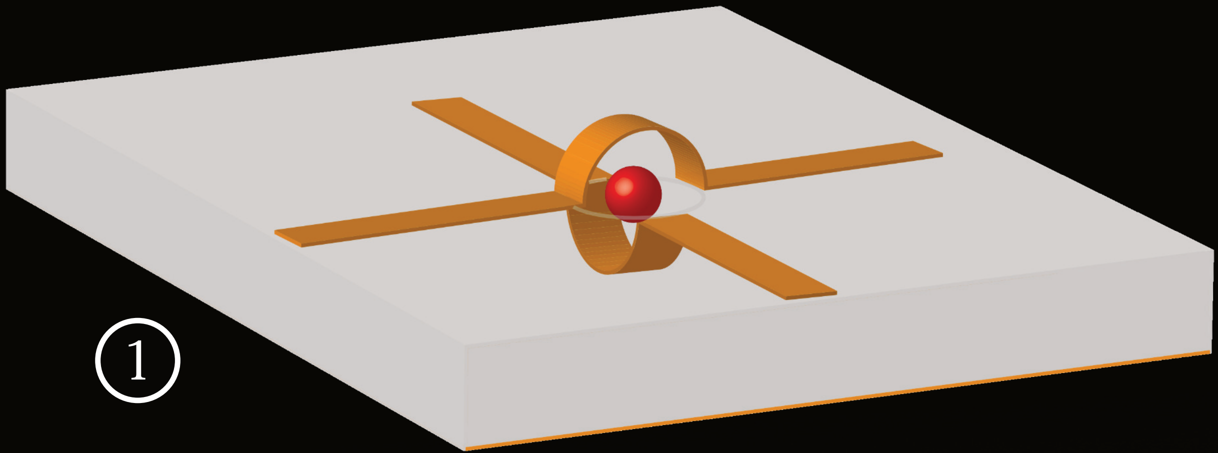
I use the 8568B quite often, and if I have no particular reason to do so, I turn it on anyway and invent some weird measurement just for fun. But when I turn it on, while the CRT is warming up, **I pray** that none of these little devices decide that it is time to retire after more than 40 years of honorable service…

Nevertheless, the glorious HP 8568B is still doing very well for now, and with its **100 Hz** lowest frequency and **10 Hz** selectivity, it can still look down on many of its very young descendants.

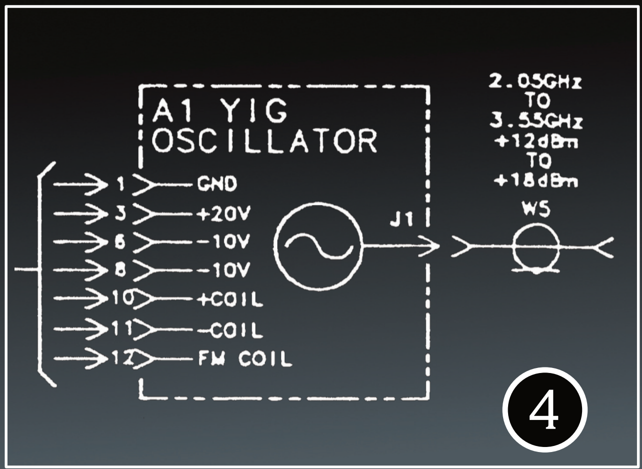
It has left its **mark** on the history of instruments.

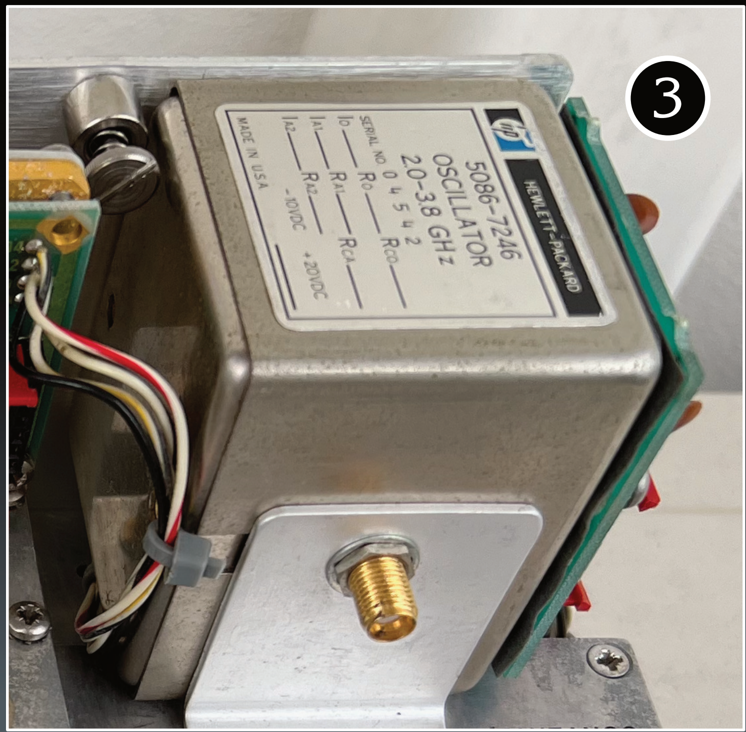
85670B RF section bottom view (8567A)





Hyper-technological inside, from a practical point of view it is a very simple object, as you can see in the electrical diagram reported here. Note the separate coil for frequency modulation.



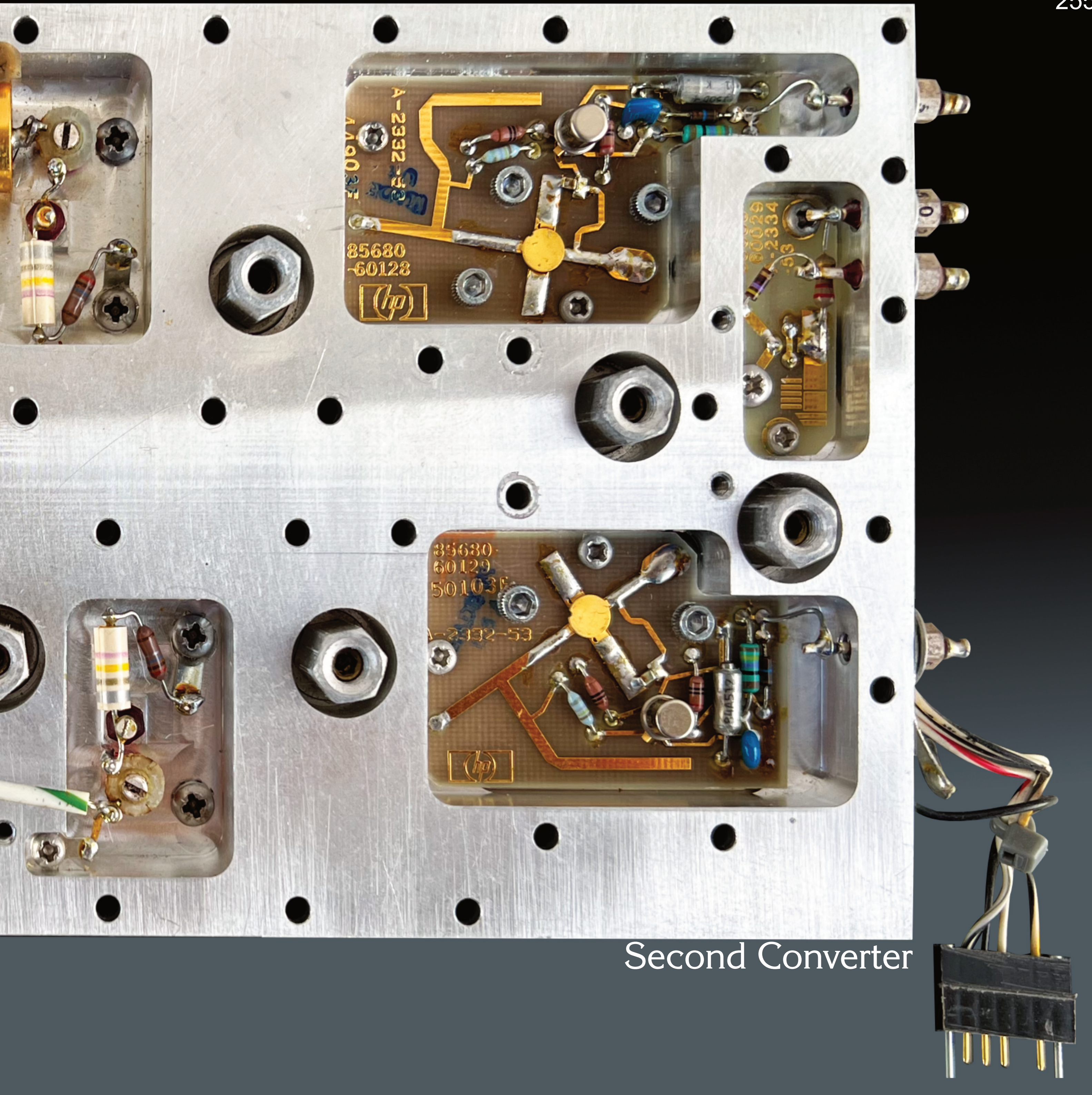


❶ Simplified schematics of YIG-resonator coupling to micro-strip network (By c.w. - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=36884929)

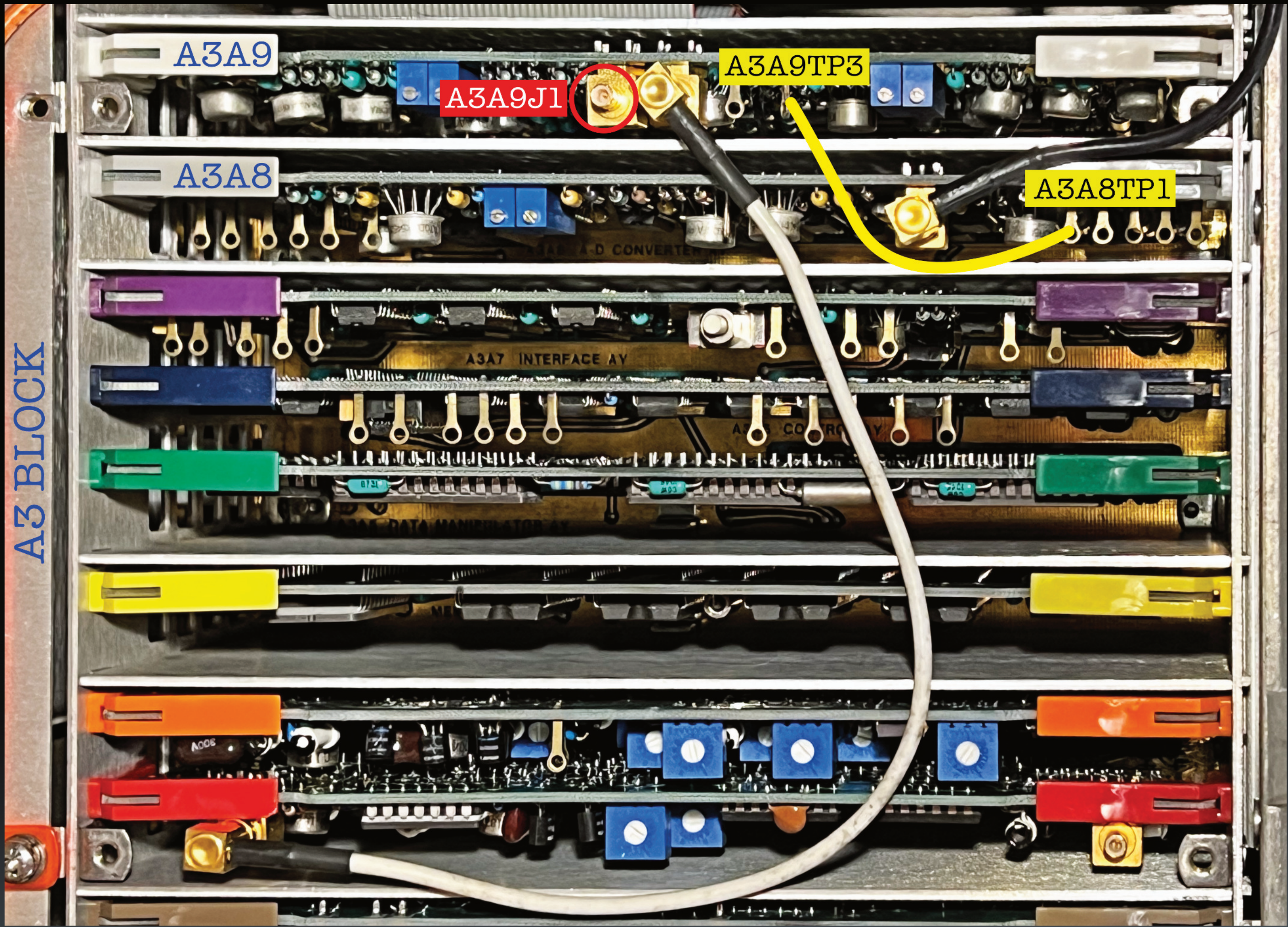
❷ YIG filter partially disassembled. The electromagnet is on the left. The module with YIG sphere and input and output coils is on the right. (By Avpu - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=6969531)

❸ The 8568 YTO is identified as A23A1 in the manuals and is contained in the RF section A23.

❹ The YTO in the electrical schematic diagram. Besides the power supply, it requires only the current for the main coil and for the frequency modulation coil.



Second Converter

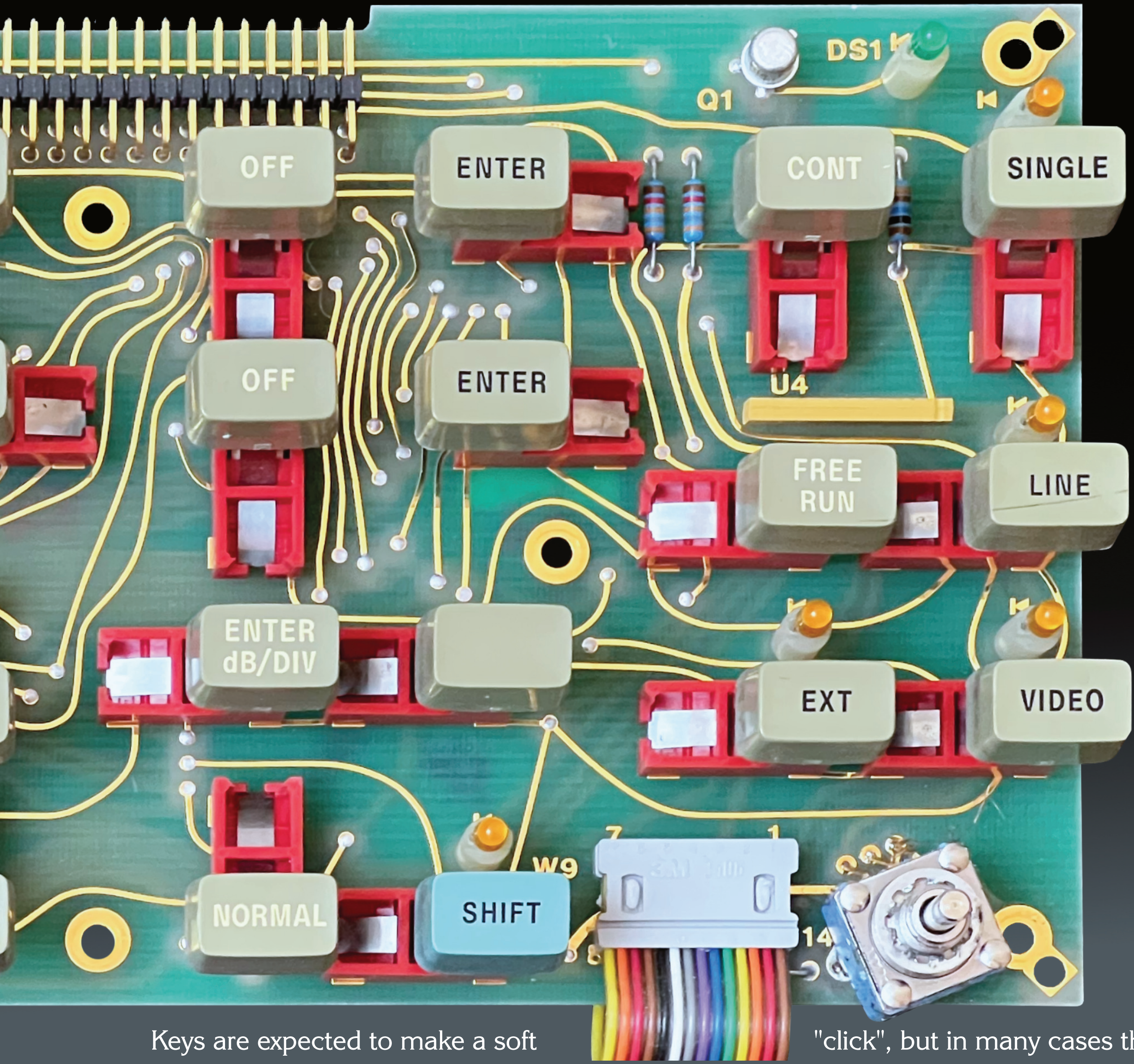


❸

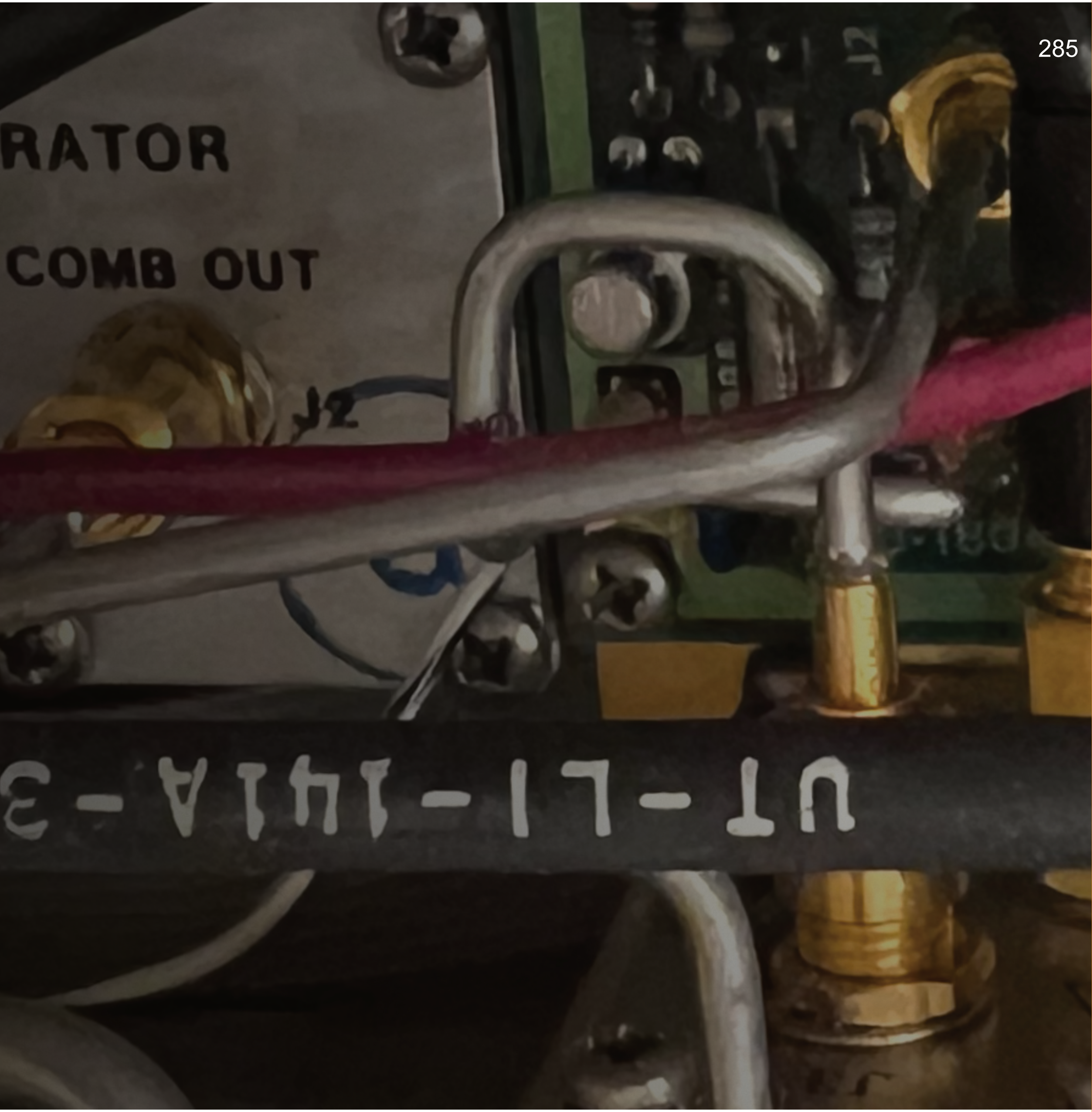
❶ The KSR command output. From this unretouched screenshot, you can also see the high quality of the CRT display, which allows you to read even the smaller fonts.

❷ The diagonal line produced as described in the text confirms that the ADC and subsequent stages are working properly. The image in my manual (and probably yours) is not well digitized and I was not sure that a complete diagonal line was expected (even if you can understand it from the text).

❸ These boards of the upper module (CRT) go under the name A3, and are ordered from A3A9 downward. If you remove the A3A9J1 connector and connect the A3A9TP3 and A3A8TP1 test points, you get the diagonal line shown in the photo ❷. All these boards are protected by a cover that must be removed for the access.



Keys are expected to make a soft "click", but in many cases they make an ugly KLACK, very unpleasant. The cure is quite simple. Remove the front panel by removing the screw on the four sides, remove the keyboard board, spray the key mechanism with WD40 Contact (definitely not normal WD40!), and try again. The keys will magically click again, and the effect will last even after the WD40 dries. It is also an opportunity for a better panel and key cleaning. It's worth it; your instrument will look newer and be more comfortable to use.


RATOR
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