Plotting Like It's 1989
~
Scrap to Superformula

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softsolder.com

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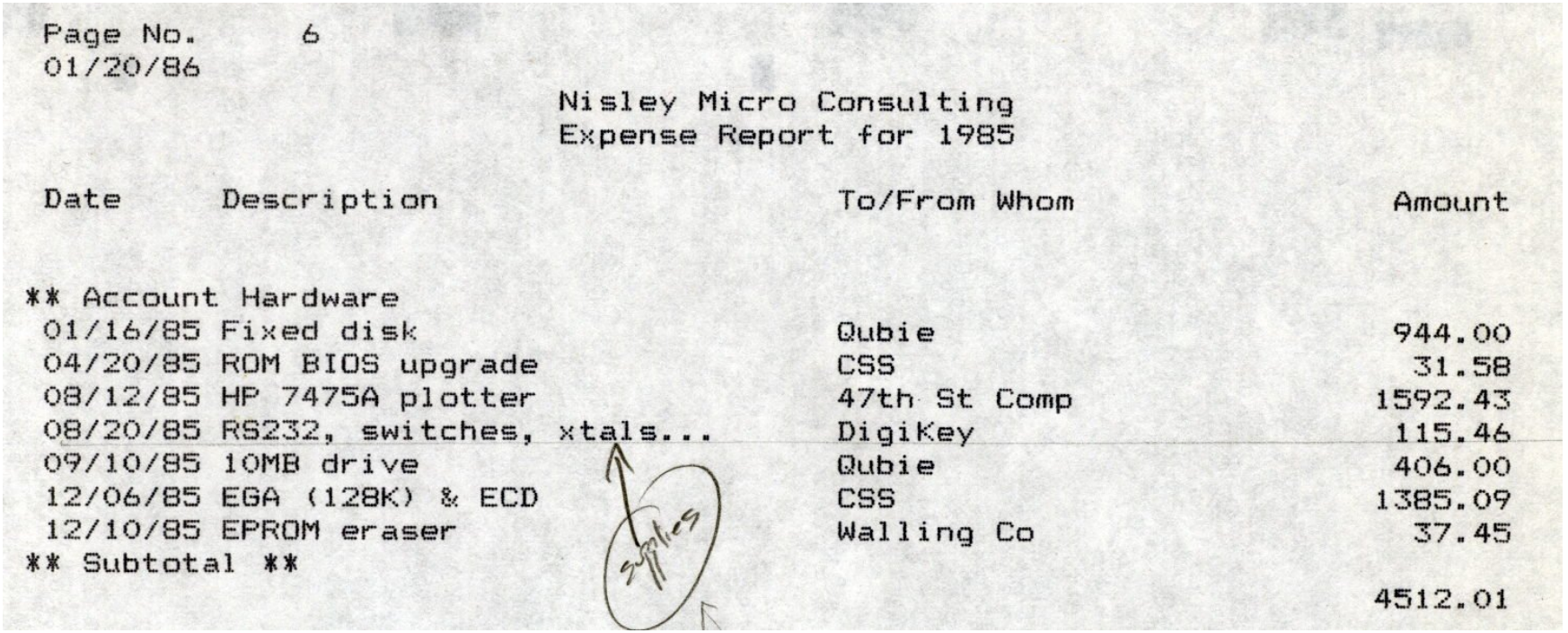
Poughkeepsie ACM Chapter
January 2016

How It All Began



Page No. 6
01/20/86

Nisley Micro Consulting
Expense Report for 1985

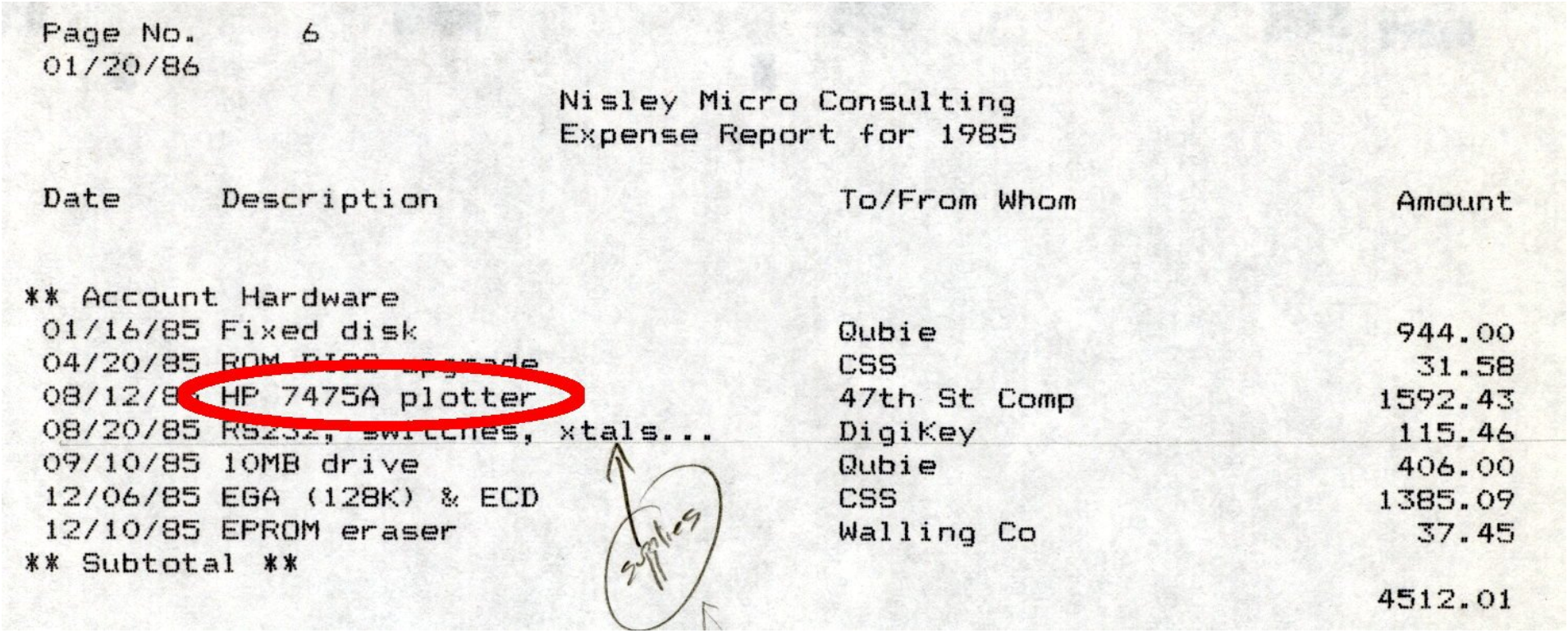
Date	Description	To/From Whom	Amount
** Account Hardware			
01/16/85	Fixed disk	Qubie	944.00
04/20/85	ROM BIOS upgrade	CSS	31.58
08/12/85	HP 7475A plotter	47th St Comp	1592.43
08/20/85	RS232, switches, xtals...	DigiKey	115.46
09/10/85	10MB drive	Qubie	406.00
12/06/85	EGA (128K) & ECD	CSS	1385.09
12/10/85	EPROM eraser	Walling Co	37.45
** Subtotal **			4512.01

- You read that right:
  - $944 for what might have been a 20 MB drive
  - $406 for a 10 MB (!) hard drive
  - $1385 for an EGA graphics board & display

http://softsolder.com/2015/02/07/business-expenses-1985-hardware/

How It All Began

“I wish I still had that HP plotter … ”



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http://softsolder.com/2015/02/07/business-expenses-1985-hardware/

Be Careful What You Wish For

Comment #3 by Dithermaster
on 2015-02-07 - 08:42

I have two of the plotters,
if you want one, it’s yours.

http://softsolder.com/2015/02/07/business-expenses-1985-hardware/

A Few Days Later

From: Dithermaster

Re: Old HP7475 plotters

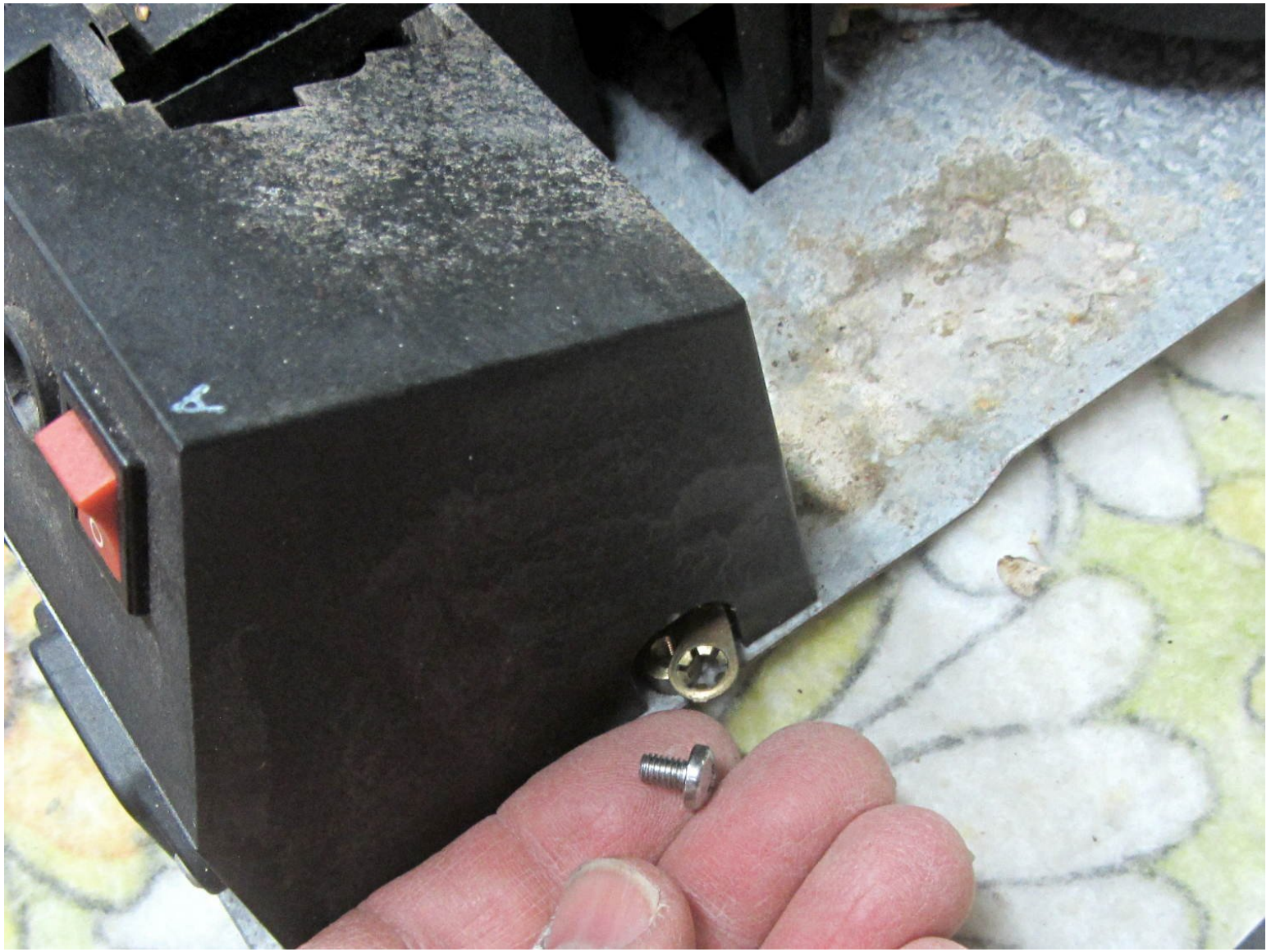
Glad it arrived safely.

Every time I shook it

more seeds came out.

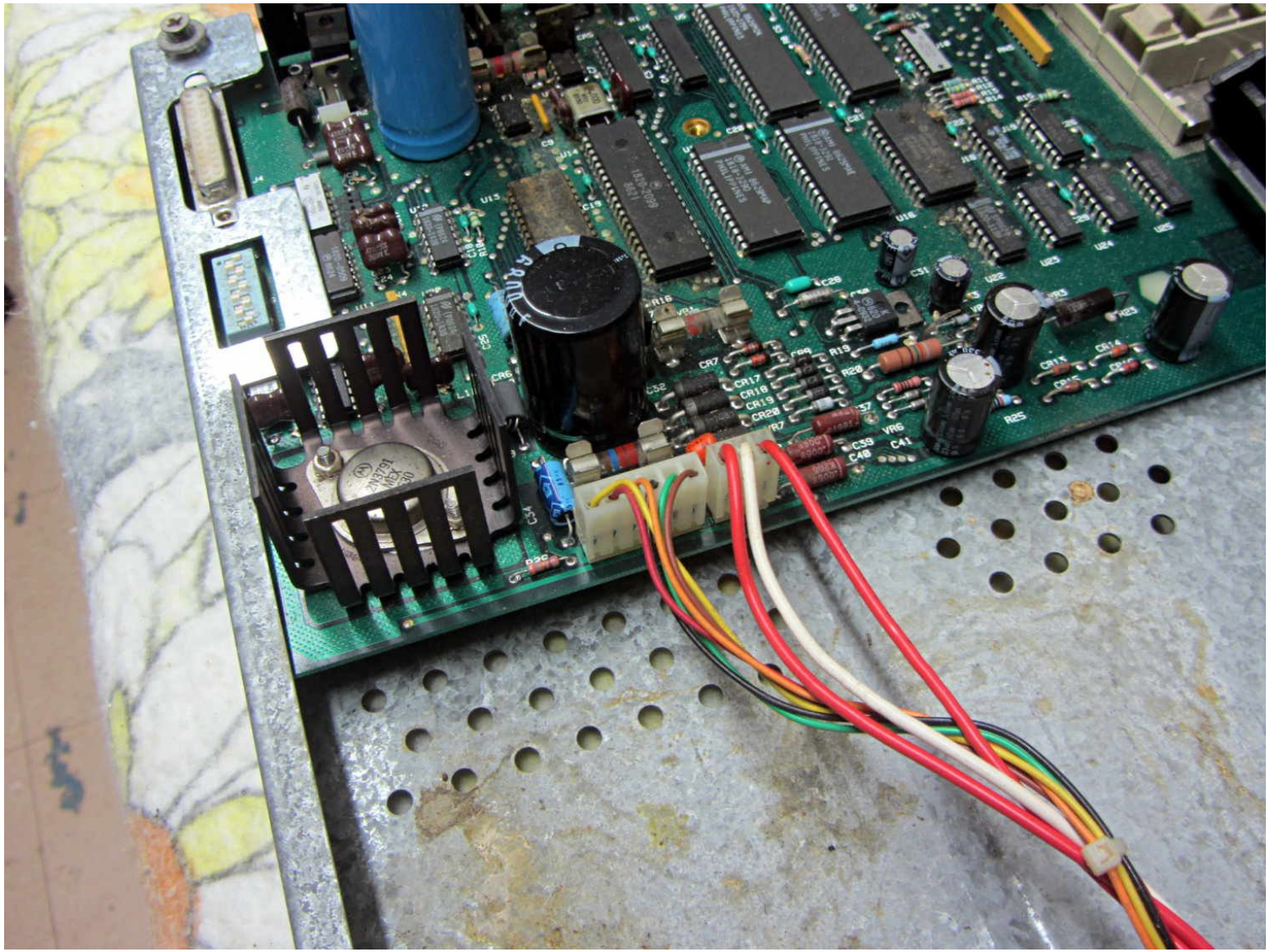
http://softsolder.com/2015/02/07/business-expenses-1985-hardware/

Disassembly Begins...



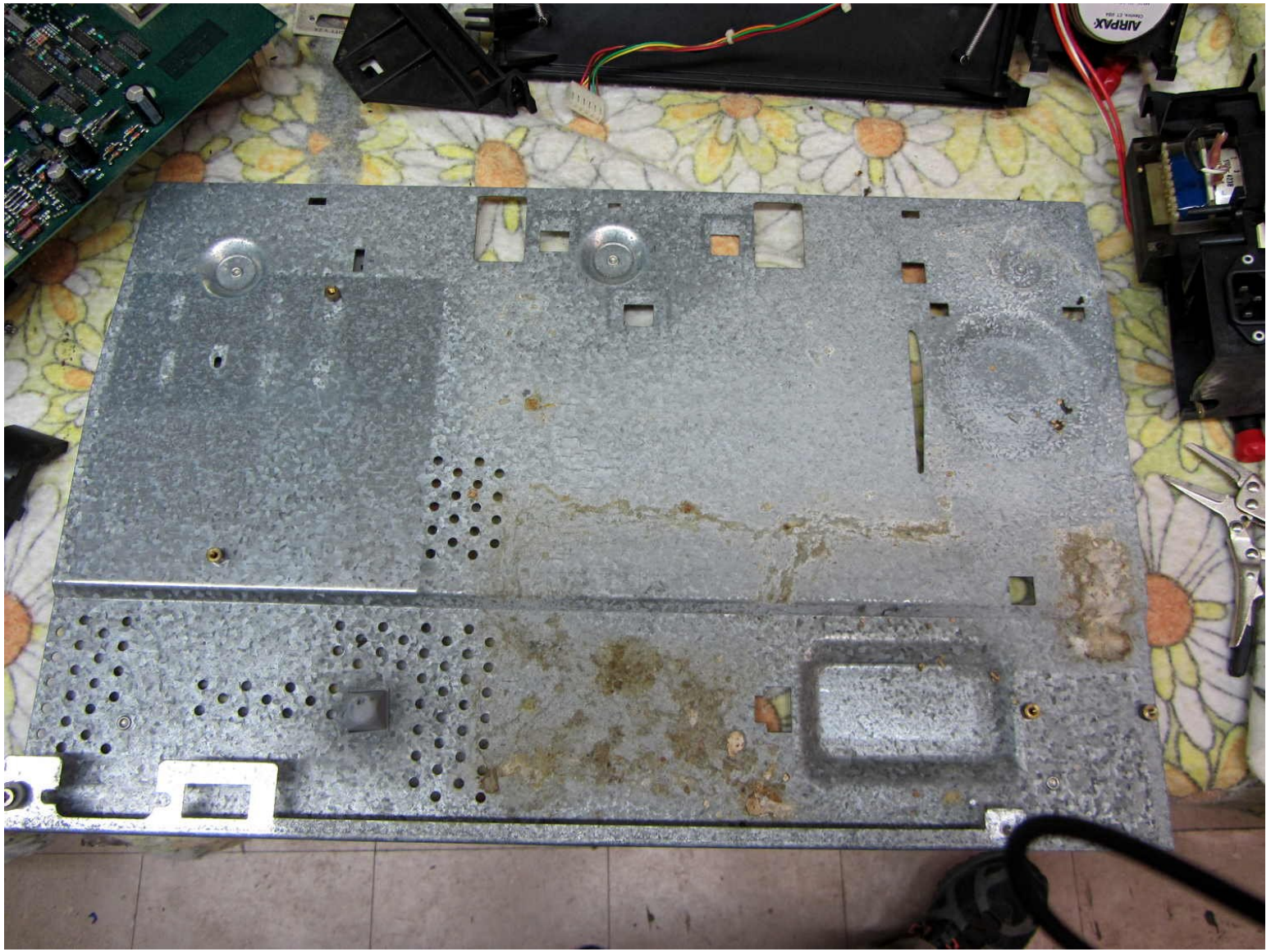
http://softsolder.com/2015/04/20/hp-7475a-plotter-rehabilitation/

Plotter Control Board



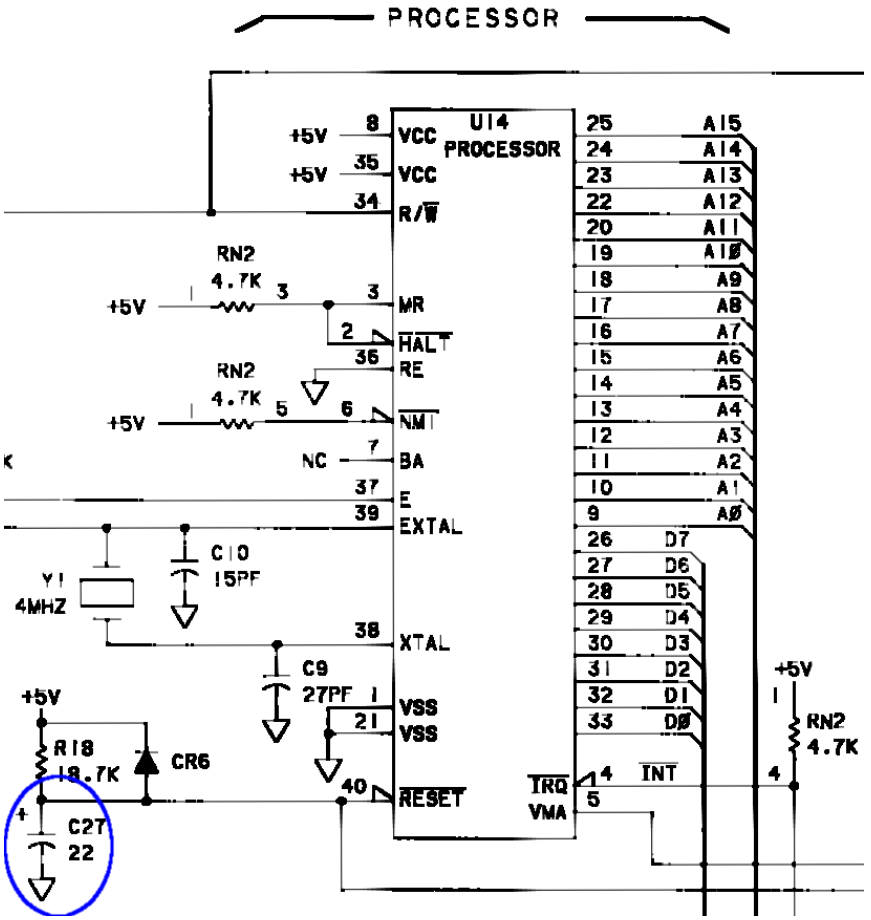
http://softsolder.com/2015/04/20/hp-7475a-plotter-rehabilitation/

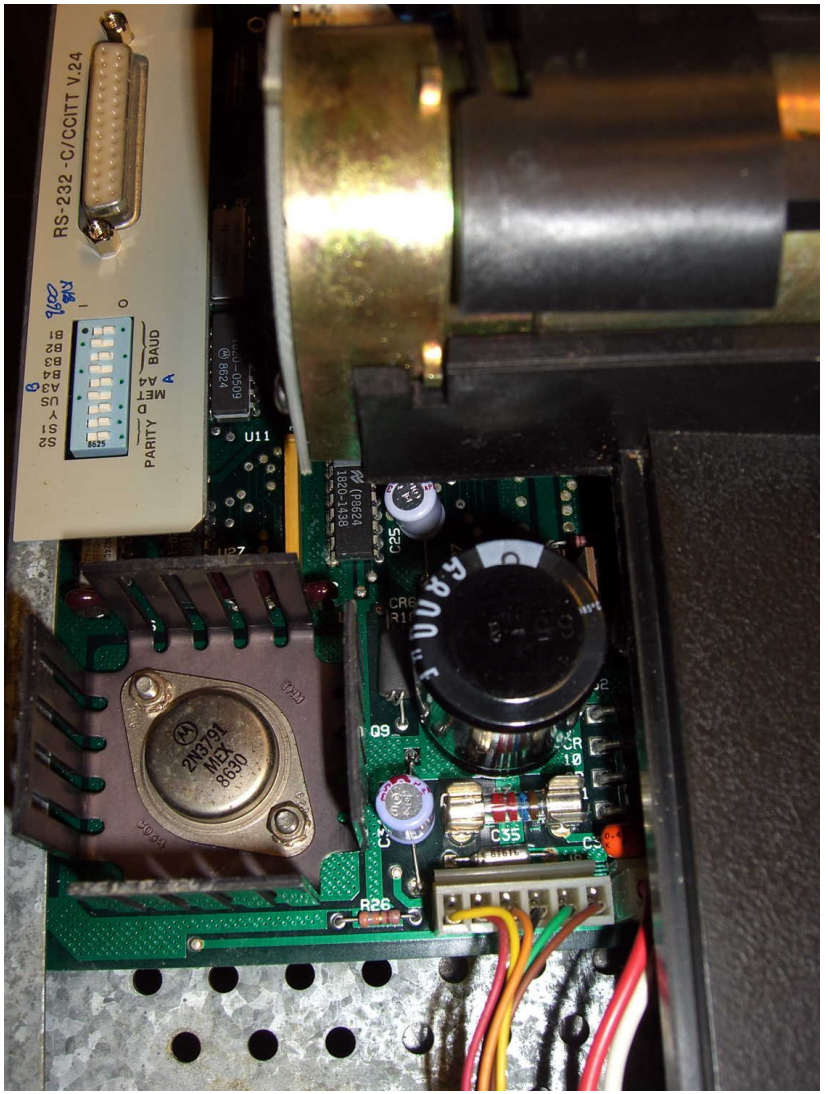
Rodent Hotel / Granary / Latrine



http://softsolder.com/2015/04/20/hp-7475a-plotter-rehabilitation/

Dried Capacitors





http://softsolder.com/2015/04/20/hp-7475a-plotter-rehabilitation/

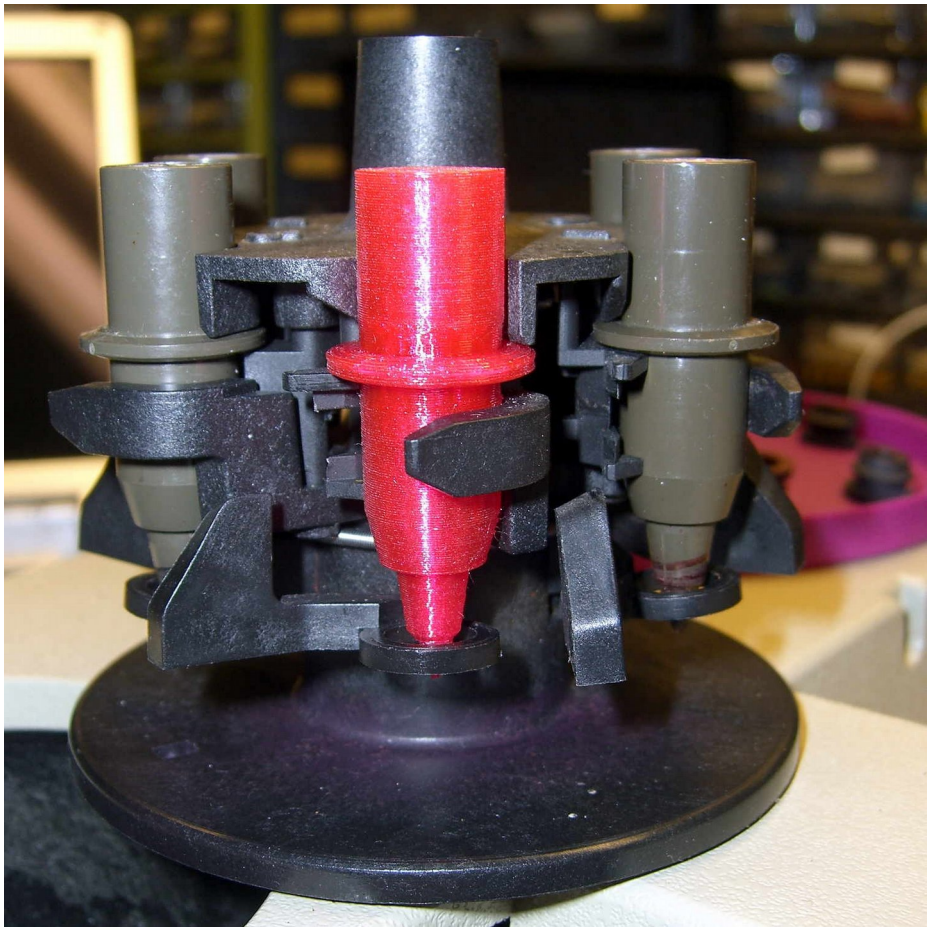
LED Strip Lighting

- White 5050 SMD LEDs
  - 12 VDC @ 120 mA
  - 5 VDC boost converter
  - More internal heat
- They'd have done it
  - If they had white LEDs
  - Remember: 1980-ish

http://softsolder.com/2015/07/09/hp-7475a-plotter-led-lighting/

Fossilized Plotter Pens

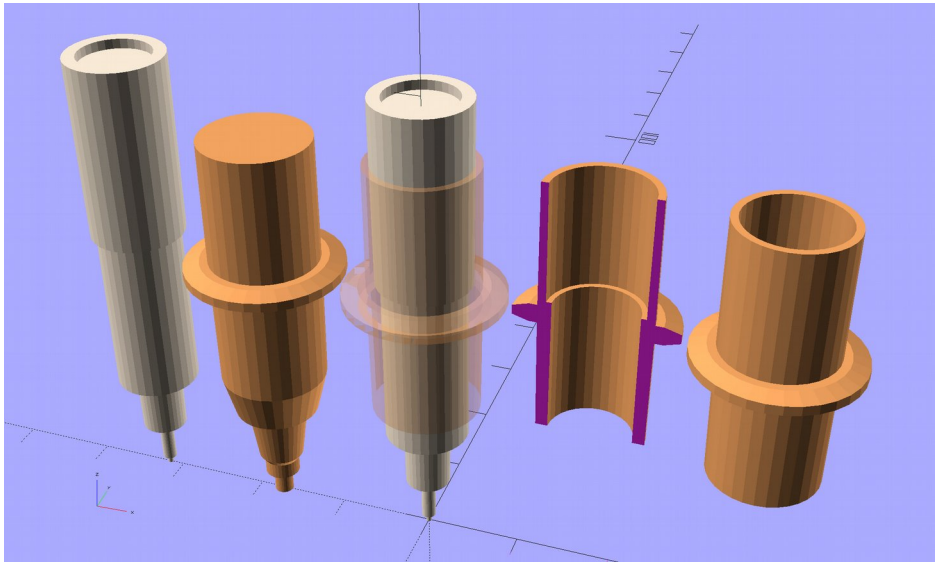
- New Old Stock on eBay
  - Fiber $5+
  - Liquid ink $10+
  - *Each*
    - Plus postage
  - Multi-packs?
- Sealed Pouches
  - Might be good
  - … or not
- Also available: New Stock!



http://softsolder.com/2015/04/21/hp-7475a-plotter-oem-pen-body-model/

Sakura Micron Pen Adapter

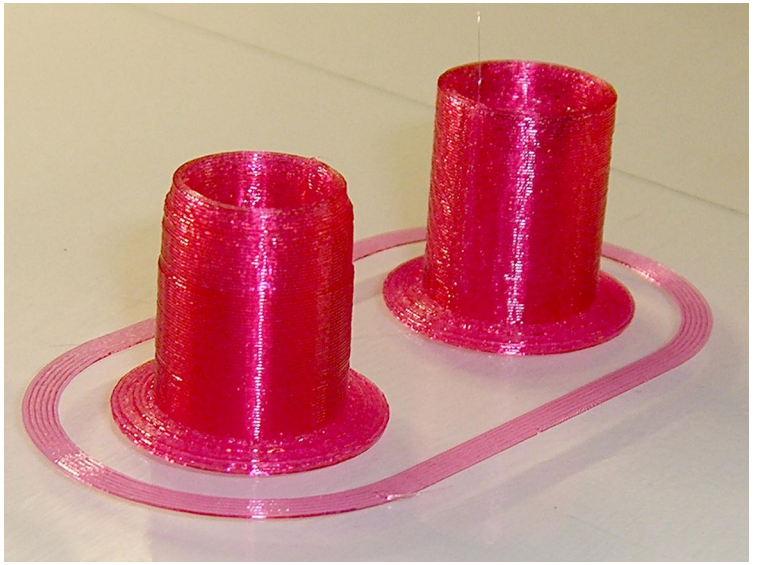
- Model an HP pen
- Model a Sakura pen
- Subtract the models
  - Flange overhang
  - Very thin walls

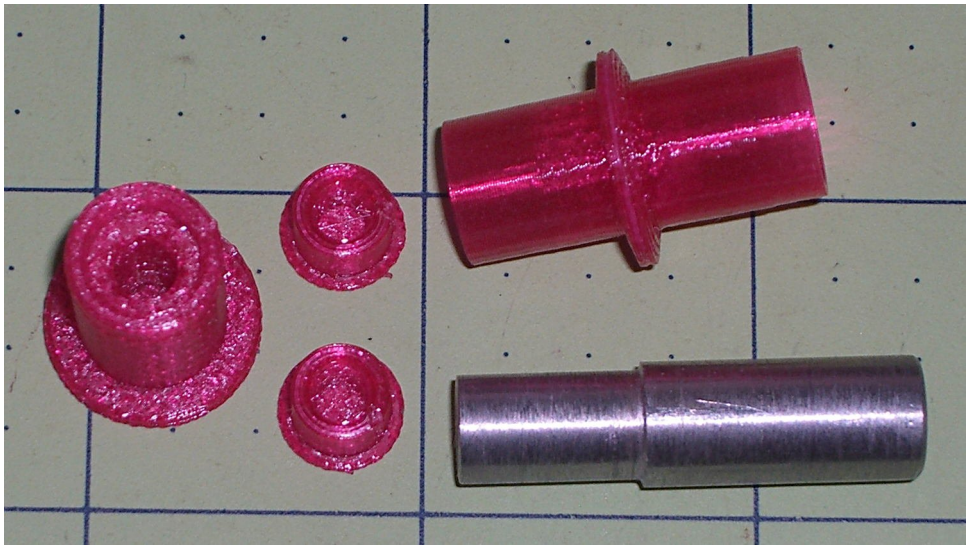


http://softsolder.com/2015/04/22/hp-7475a-plotter-sakura-micron-pen-adapter/

Sakura Micron Pen Adapter

- Realities of 3D Printing
  - Can’t print overhangs
  - Thin walls
  - *Tapered* walls
  - Layer thickness
  - Solvent bonding
  - Alignment mandrel

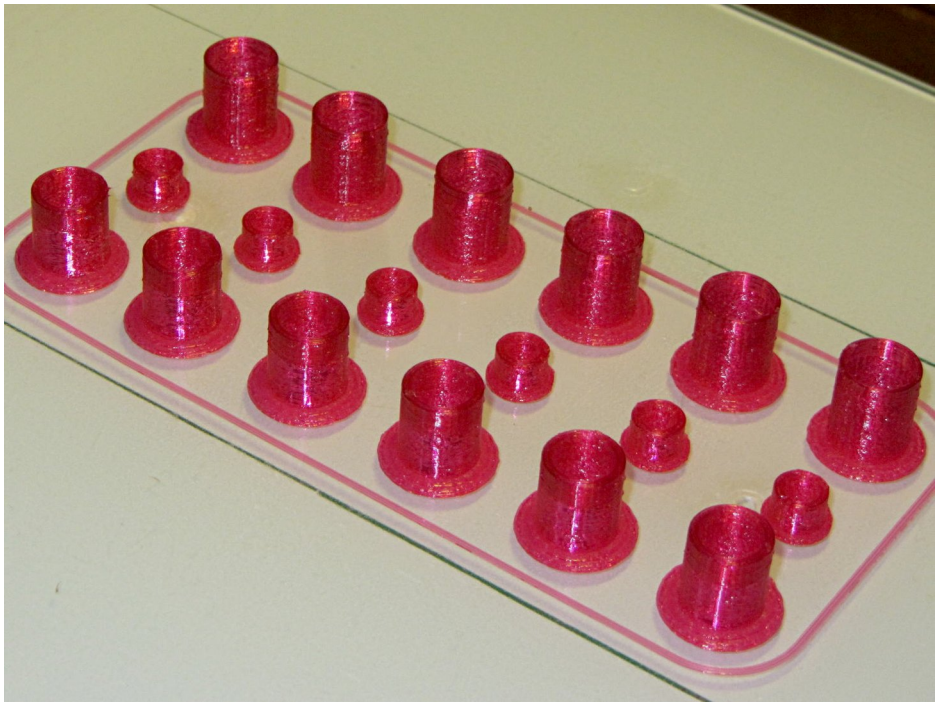




http://softsolder.com/2015/04/22/hp-7475a-plotter-sakura-micron-pen-adapter/

Sakura Micron Pen Adapter

- Realities of 3D Printing
  - It’s really easy
  - Hands-off build
  - OpenSCAD FTW!



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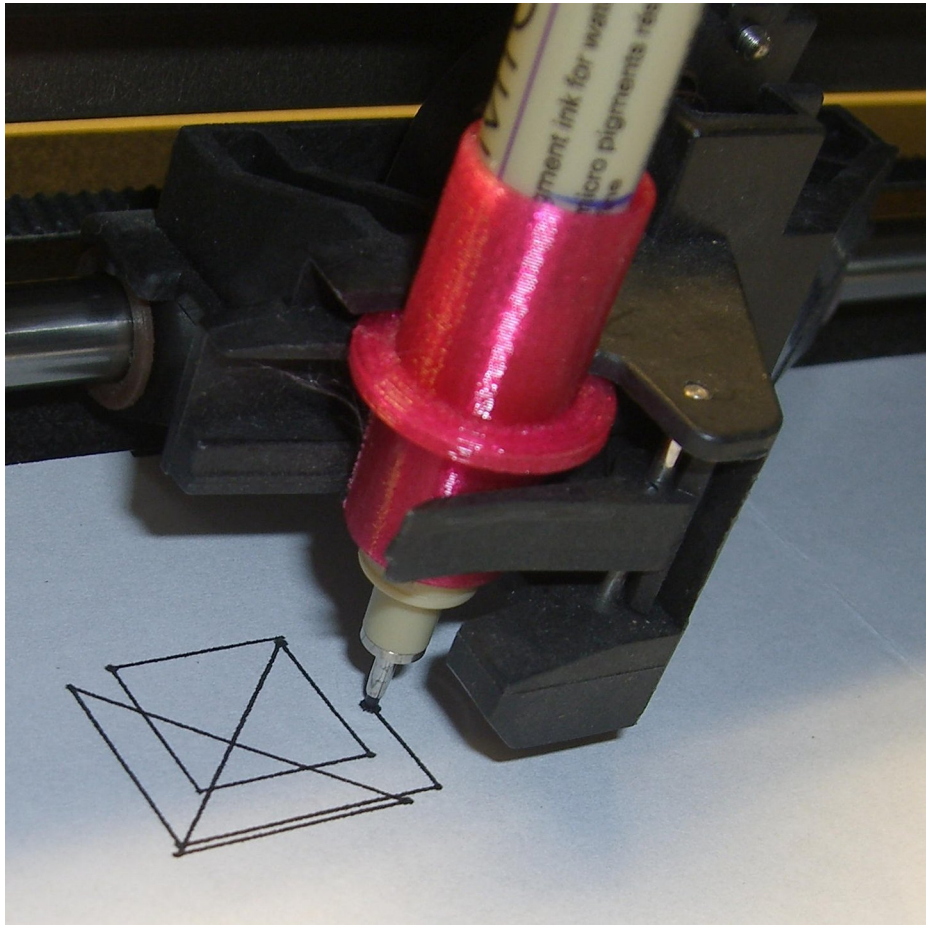
Sakura Micron Pen Adapter



http://softsolder.com/2015/04/22/hp-7475a-plotter-sakura-micron-pen-adapter/

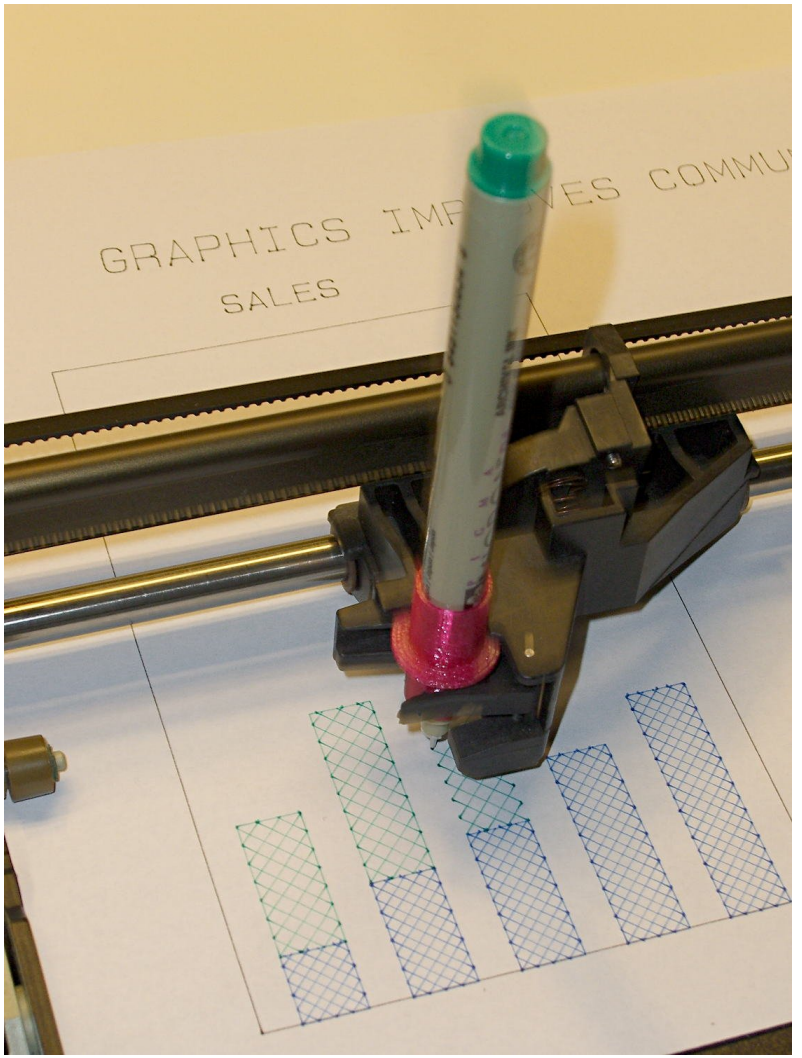
ROM Test Pattern

- Standard pen loadout
  - Black (0.7 mm)
  - Black (0.3 mm)
  - Red
  - Green
  - Blue
  - Violet
- Close enough, I’d say...

http://softsolder.com/2015/04/23/hp-7475a-plotter-full-up-sakura-micron-pen-tests/

ROM Test Pattern

- Built-in Self Test
  - Insert A-size paper
  - Hold P1 + P2
  - Power On
- *It worked!*
  - Pens flop around
  - Low ink flow
  - Bar chart from 1982...



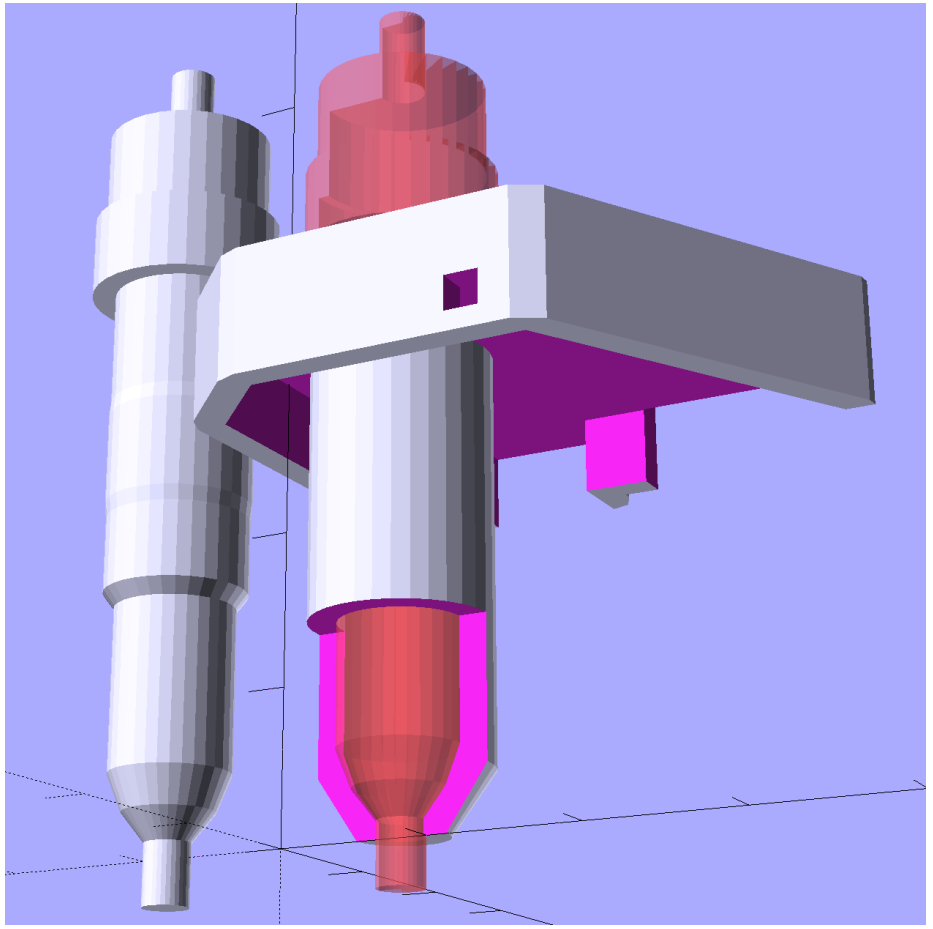
http://softsolder.com/2015/04/23/hp-7475a-plotter-full-up-sakura-micron-pen-tests/

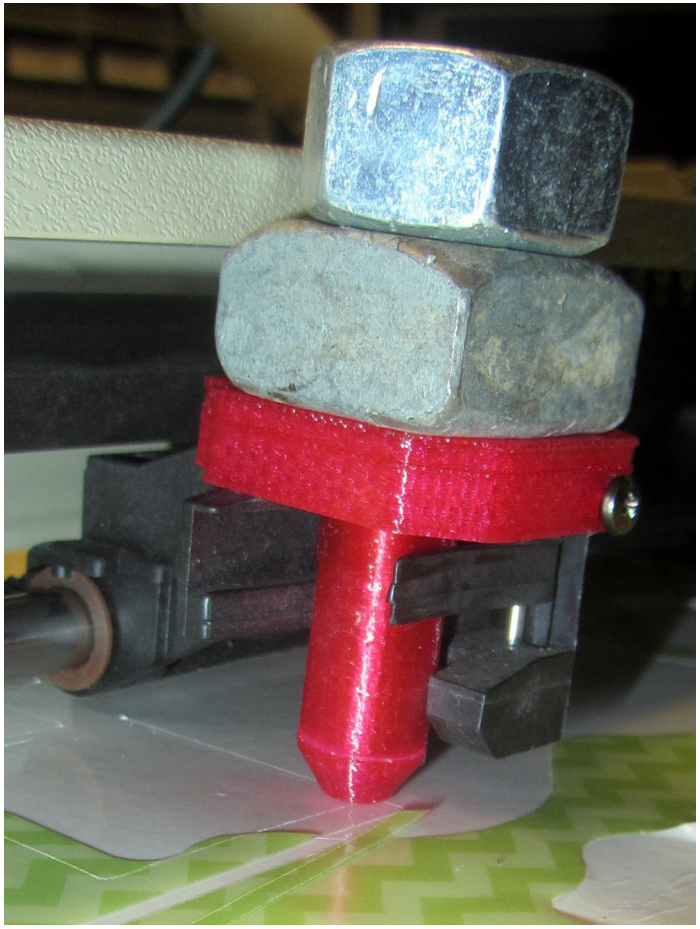
Cut-down Pens

- Less floppy
  - Still too tall
- Smaller ink capacity
  - But the nibs write!
- Low ink flow
  - *But the nibs write!*
- This could work...

http://softsolder.com/2015/04/23/hp-7475a-plotter-full-up-sakura-micron-pen-tests/

Vinyl Cutter = Dead End

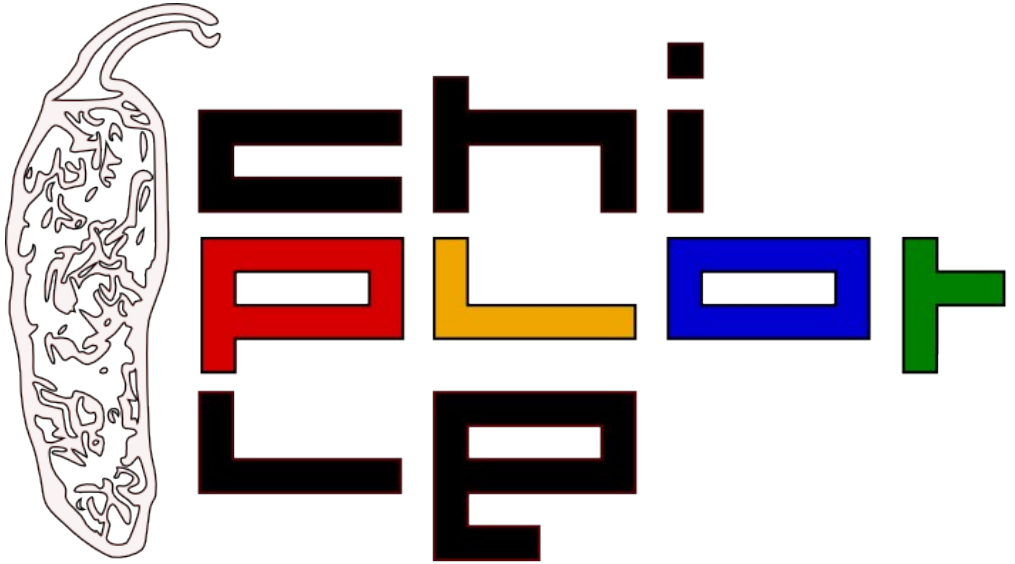




http://softsolder.com/2015/04/30/hp-7475a-plotter-roland-knife-stabilizer-improved/

Chiplotle Plotter Driver

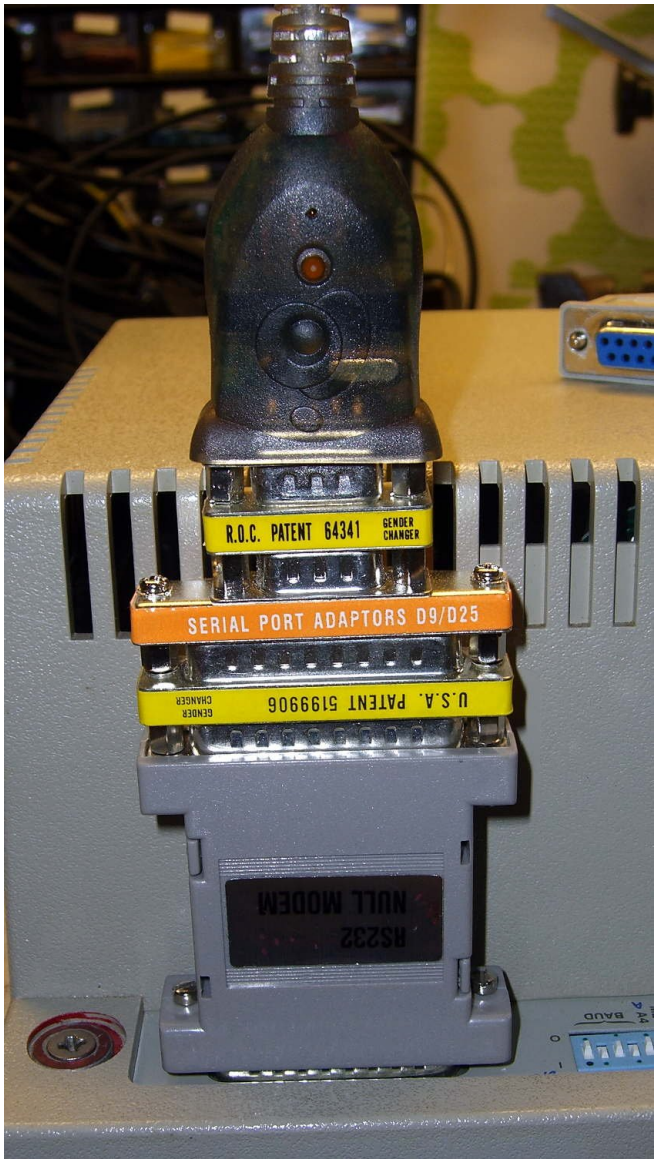
- “Chiplotle: an HPGL (Hewlett-Packard Graphics Language) Python API”
- “Finally, a way to control your grungy old pen plotters with your shiny new laptop!”



http://music.columbia.edu/cmc/chiplotle/

Serial Port

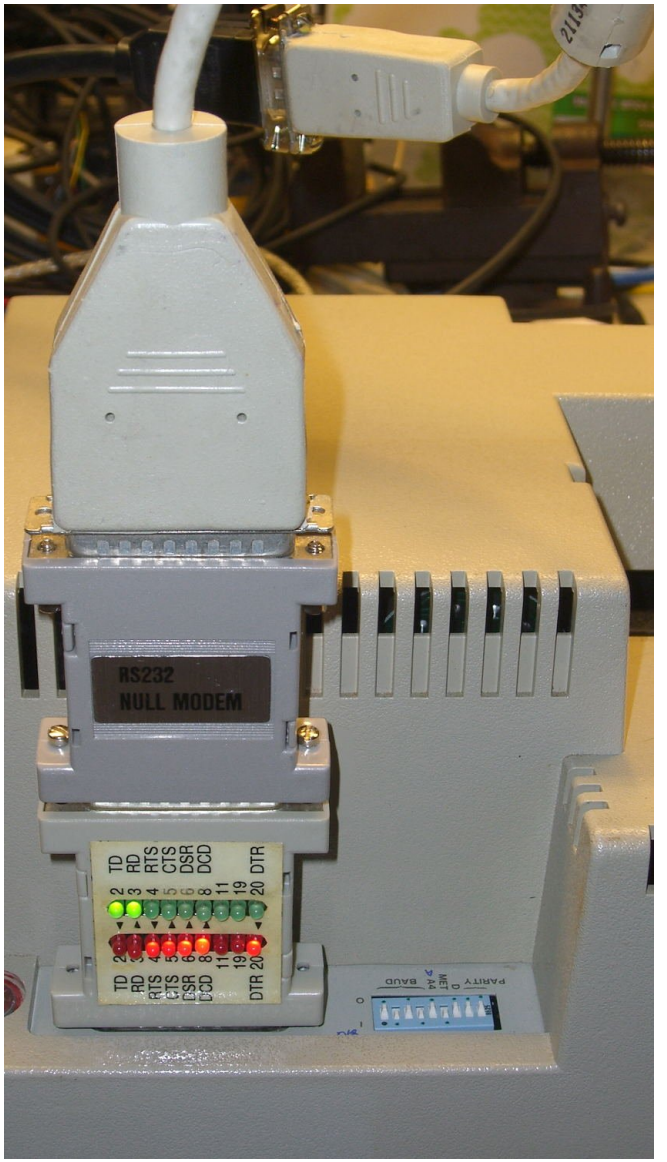
- Remember RS-232?
  - USB-to-Serial adapter
  - Gender bender
  - DB-25 to DE-9 adapter
  - Gender bender
  - Null modem
- Ya gotta have stuff!



http://softsolder.com/2015/05/04/hp-7475a-plotter-serial-cable-for-hardware-handshaking/

Serial Port Configuration

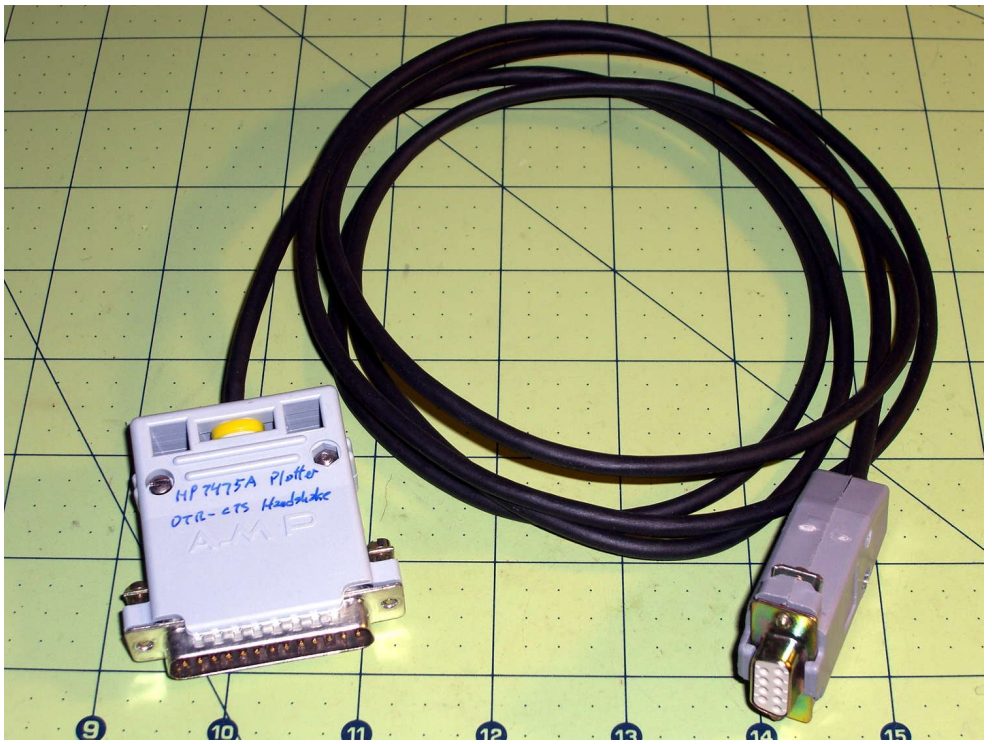
- Remember serial data?
  - 9600 b/s (!)
  - 8 data bits
  - 1 stop bit
  - No parity
- Remember DIP switches?
- Der Blinkenlights!



http://softsolder.com/2015/05/04/hp-7475a-plotter-serial-cable-for-hardware-handshaking/

Serial Cable Wiring

- Remember serial cables?
  - 1 DCD ↔ 4 RTS
  - 2 RXD ↔ 2 TXD
  - 3 TXD ↔ 3 RXD
  - 4 DTR ↔ 5 CTS / 6 DSR
  - 5 GND ↔ 7 GND
  - 6 DSR / 8 CST ↔ 20 DTR
  - 7 RTS ↔ 8 DCD
  - 9 RI → n/c



- Hardware handshaking FTW!

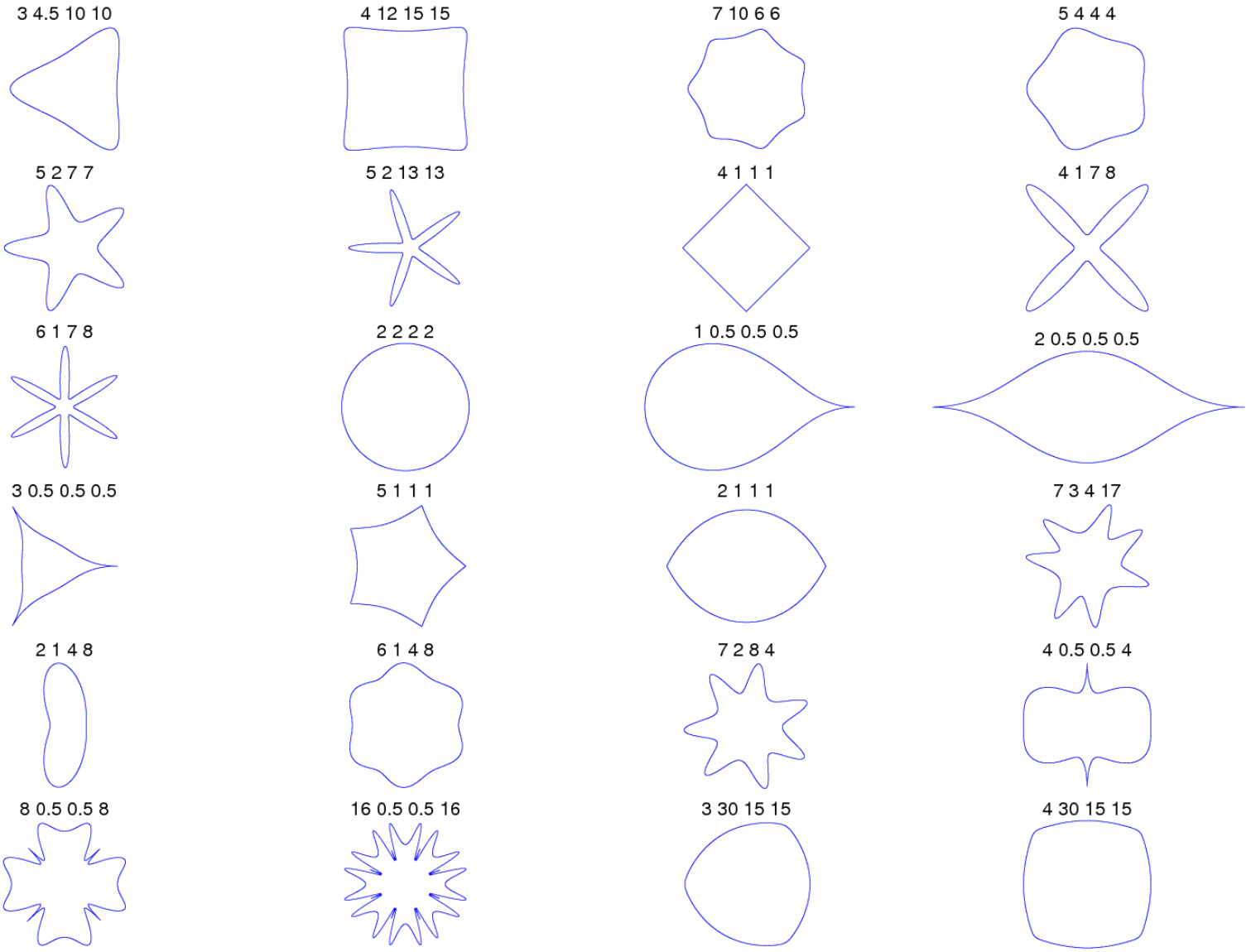
http://softsolder.com/2015/05/04/hp-7475a-plotter-serial-cable-for-hardware-handshaking/

Superformula

- The [super]formula was obtained by generalizing the superellipse, named and popularized by Piet Hein, a Danish mathematician.
- The superformula ... was first proposed by Johan Gielis in 2003. Gielis suggested that the formula can be used to describe many complex shapes and curves that are found in nature.

https://en.wikipedia.org/wiki/Superformula

Superformula



Gielis Superformula

$$r = f(\Theta) = \left(\left| \frac{1}{a} \cdot \cos\left(\frac{m}{4} \cdot \Theta \right) \right|^{n_2} + \left| \frac{1}{b} \cdot \sin\left(\frac{m}{4} \cdot \Theta \right) \right|^{n_3} \right)^{\frac{-1}{n_1}}$$

https://en.wikipedia.org/wiki/Superformula

Gielis Superformula

$$r = f(\Theta) = \left(\left| \frac{1}{a} \cdot \cos\left(\frac{m}{4} \cdot \Theta \right) \right|^{n_2} + \left| \frac{1}{b} \cdot \sin\left(\frac{m}{4} \cdot \Theta \right) \right|^{n_3} \right)^{\frac{-1}{n_1}}$$

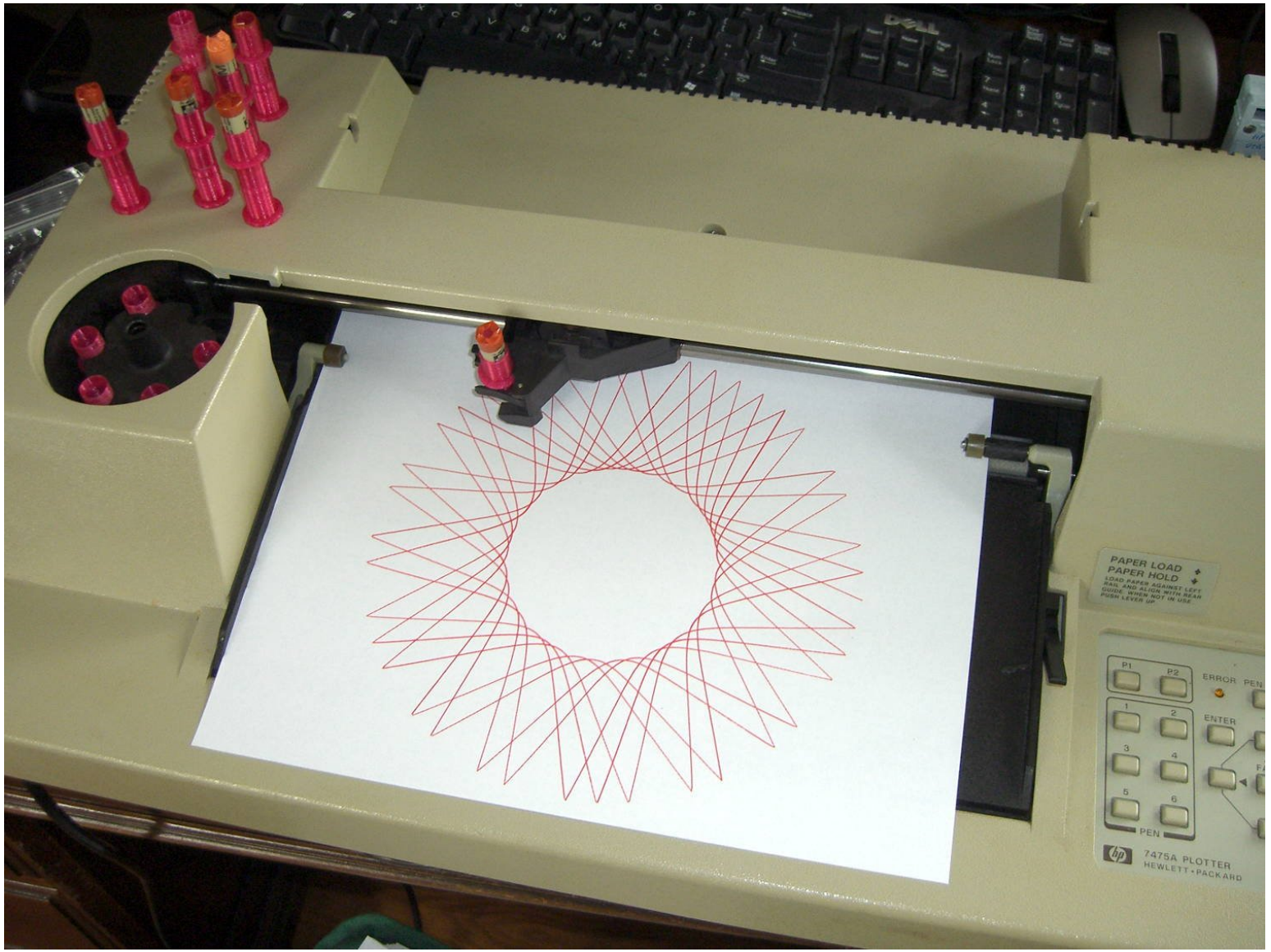
https://en.wikipedia.org/wiki/Superformula

Python With Chiplotle Library

```
from chiplotle import *
import math
plt=instantiate_plotters()[0]
plt.set_origin_center()
plt.write(hpgl.VS(5))
ss=geometry.shapes.supershape(3900,3900,5.3,0.4,1,1,
   point_count=10*1000,travel=10*2*math.pi)
plt.select_pen(1)
plt.write(ss)
plt.select_pen(0)
```

http://softsolder.com/2015/05/07/hp-7475a-plotter-chiplotle-supershape/

Superformula / Supershape



http://softsolder.com/2015/05/07/hp-7475a-plotter-chiplotle-supershape/

Inside the Chiplotle Plotter Driver

```
def _write_string_to_port(self, data):
      if not isinstance(data, basestring):
         raise TypeError('string expected.')
      data = self._filter_unrecognized_commands(data)
      data = self._slice_string_to_buffer_size(data)
      for chunk in data:
#          self._sleep_while_buffer_full( )
         self._serial_port.write(chunk)
```

- There's a lot not to like about that...

http://softsolder.com/2015/05/05/hp-7475a-plotter-hacking-chiplotle-for-hardware-handshaking/

Be Careful What You Wish For

Comment #16 by rkward
on 2015-04-20 – 15:50

Contact me offline regarding plotter pens …

I think I have quite a few ...

http://softsolder.com/2015/04/20/hp-7475a-plotter-rehabilitation

A Few Days Later

From: Keith Ward

Re: Plotter pens

Looks like it will be

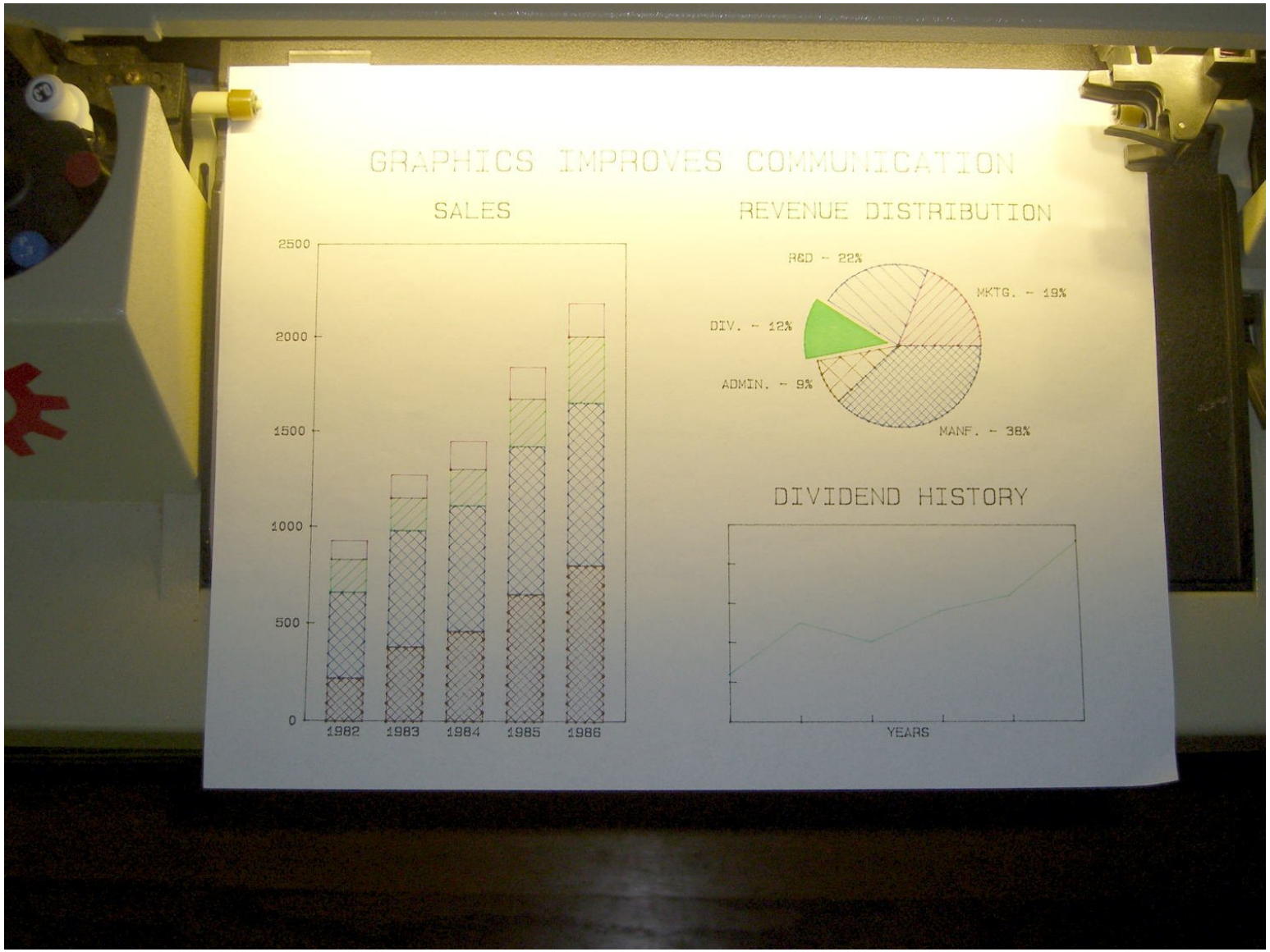
the flat rate box for $20 …

I didn't realize how many I had.

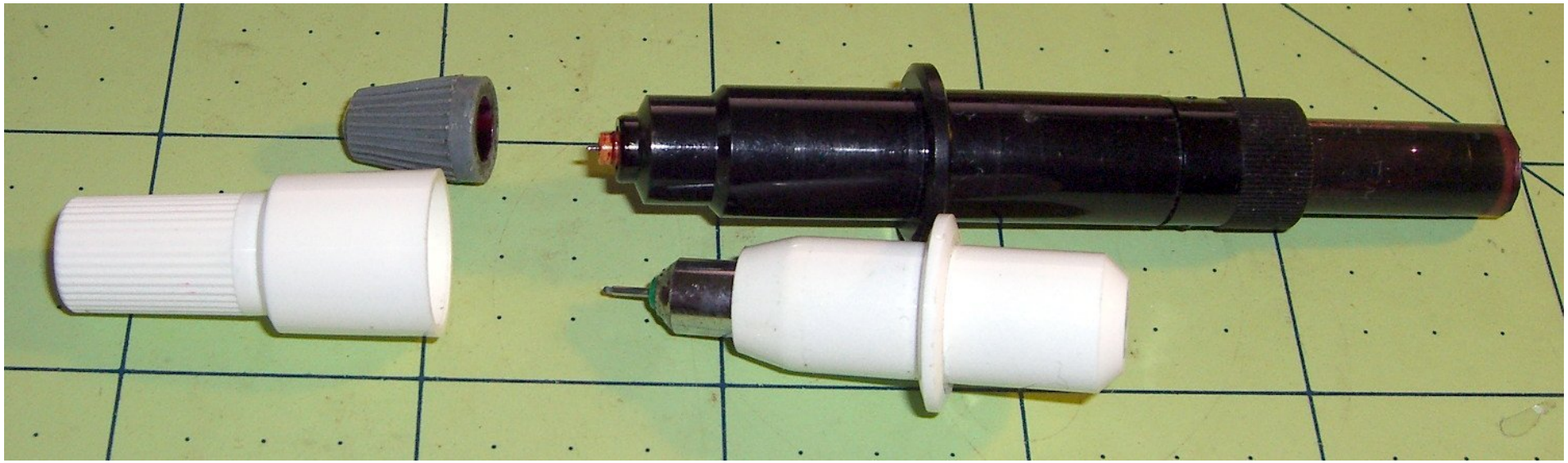
http://softsolder.com/2015/04/20/hp-7475a-plotter-rehabilitation

Pens! Pens Everywhere!

New Old Stock Pens = *It Lives!*

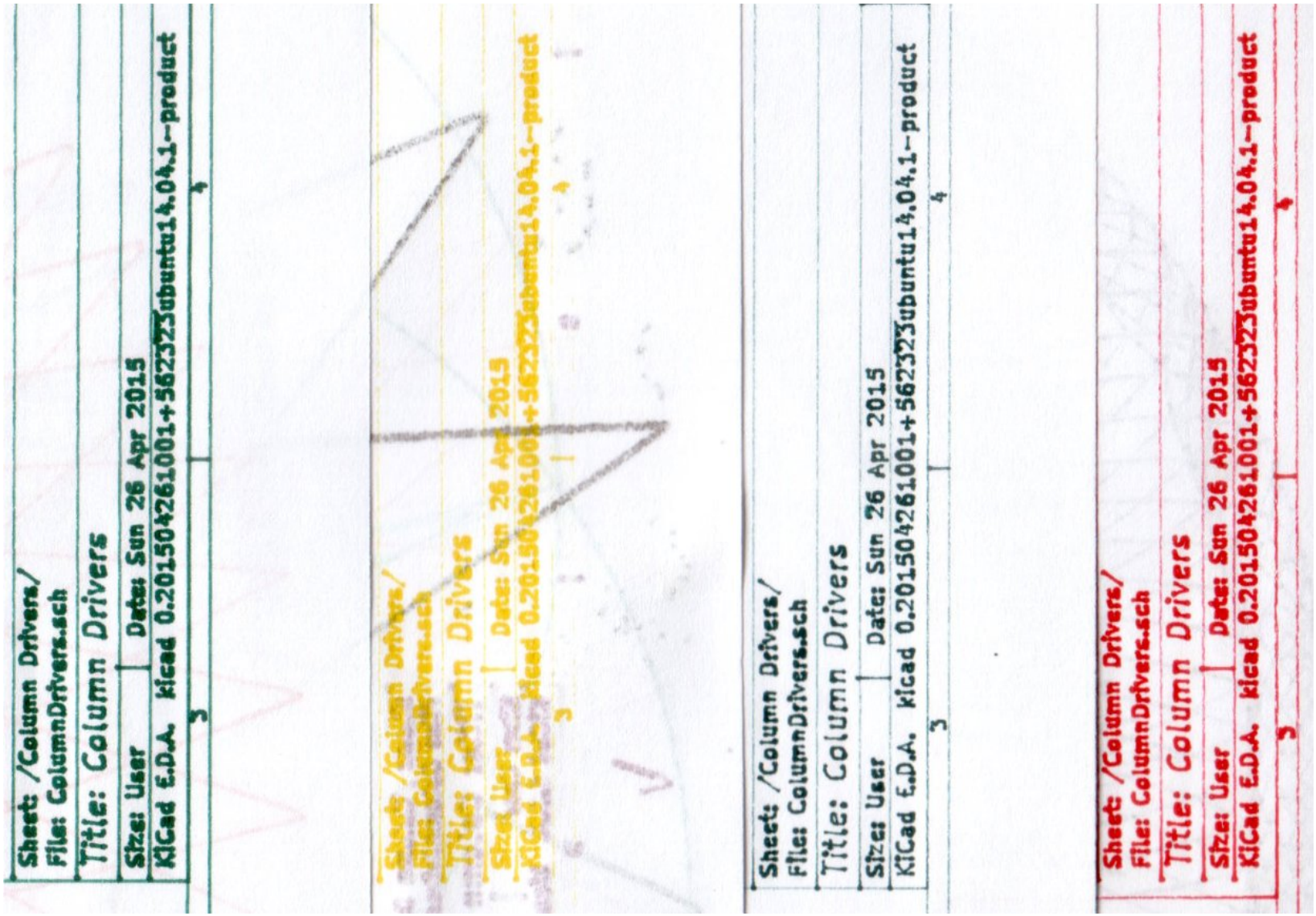


“Disposable” Liquid Ink Pens



http://softsolder.com/2015/06/06/hp-7475a-plotter-refilling-disposable-liquid-ink-pens/

KiCad Schematic → Plotter Output



http://softsolder.com/2015/06/06/hp-7475a-plotter-refilling-disposable-liquid-ink-pens/

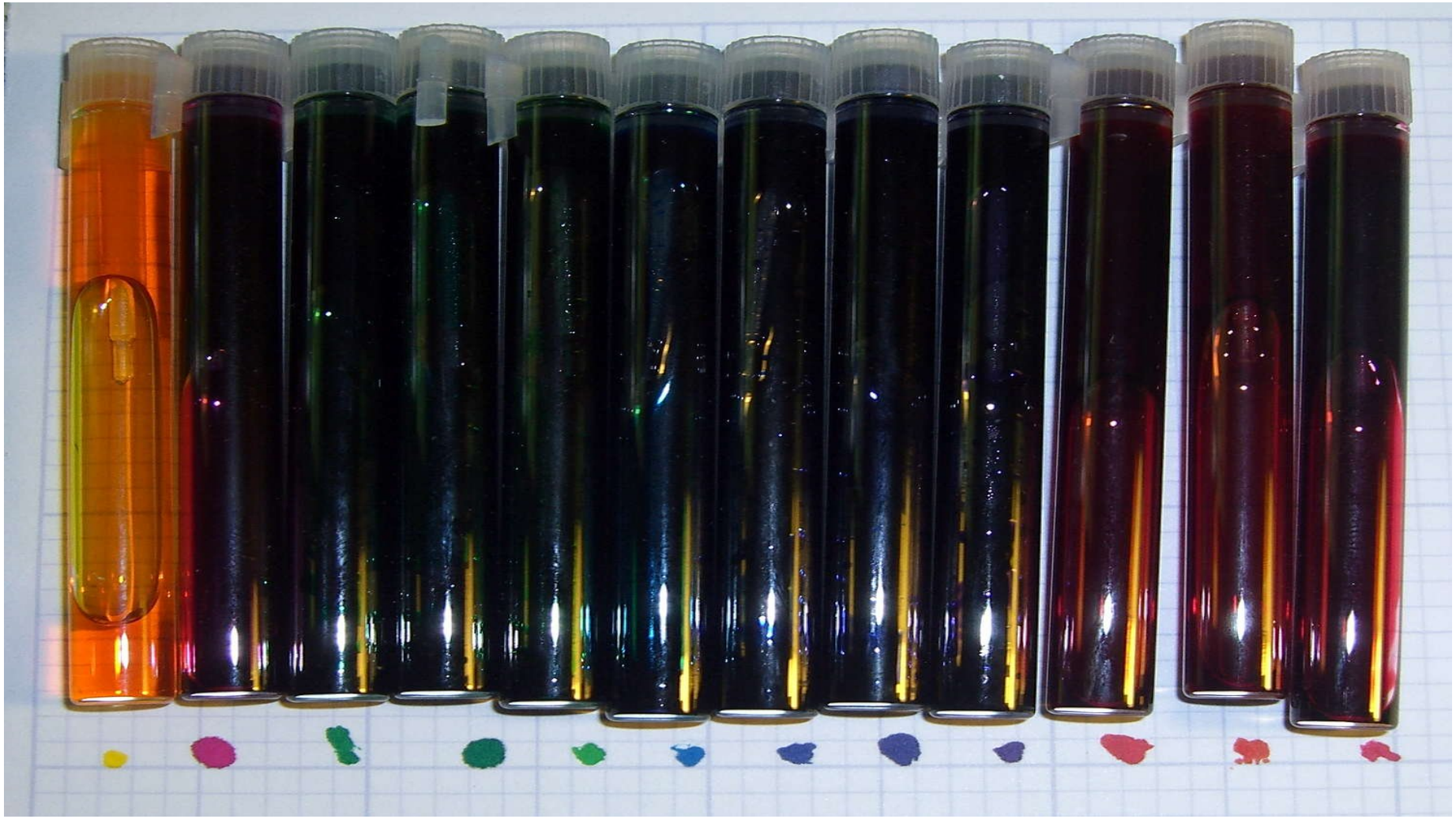
Refilling Plotter Pens: Opening

http://softsolder.com/2015/08/10/hp-7475a-plotter-refilling-the-pens/

CMYK → All! The! Colors!

http://softsolder.com/2015/08/20/hp-7475a-plotter-cmy-ink-mixes/

CMYK → All! The! Colors!

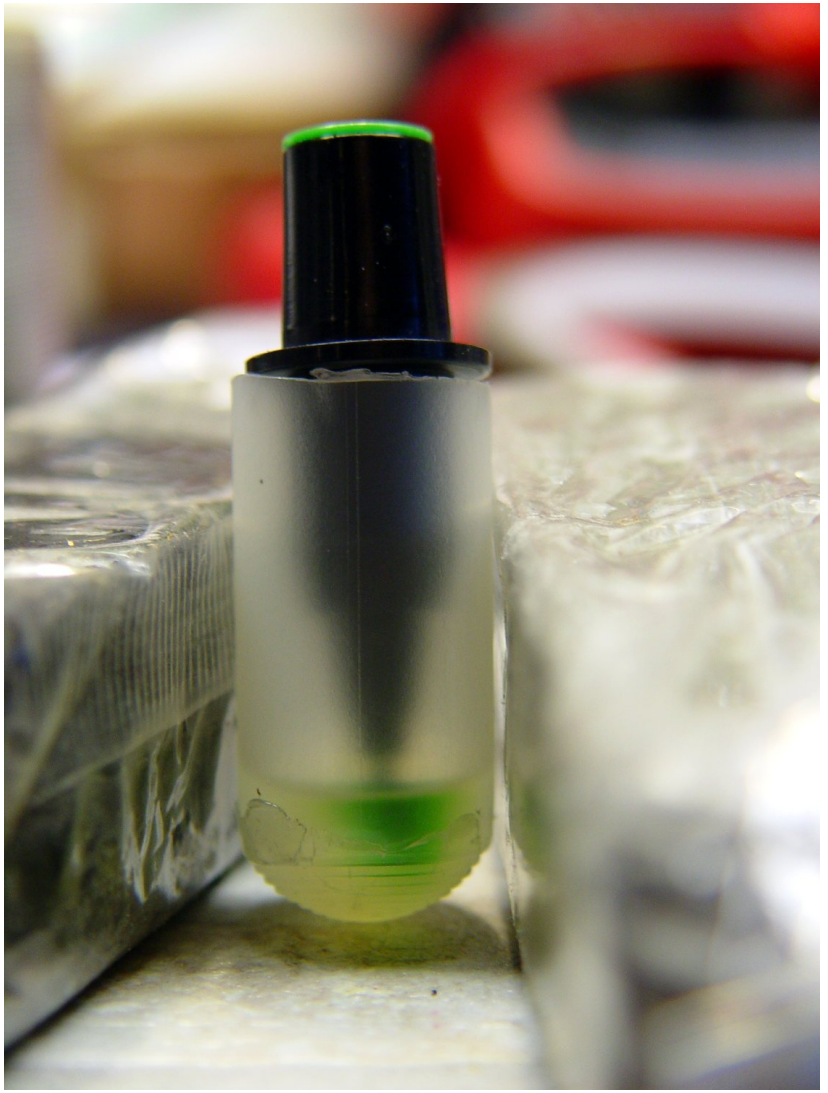


http://softsolder.com/2015/08/20/hp-7475a-plotter-cmy-ink-mixes/

Plotter Pen Refilling Station

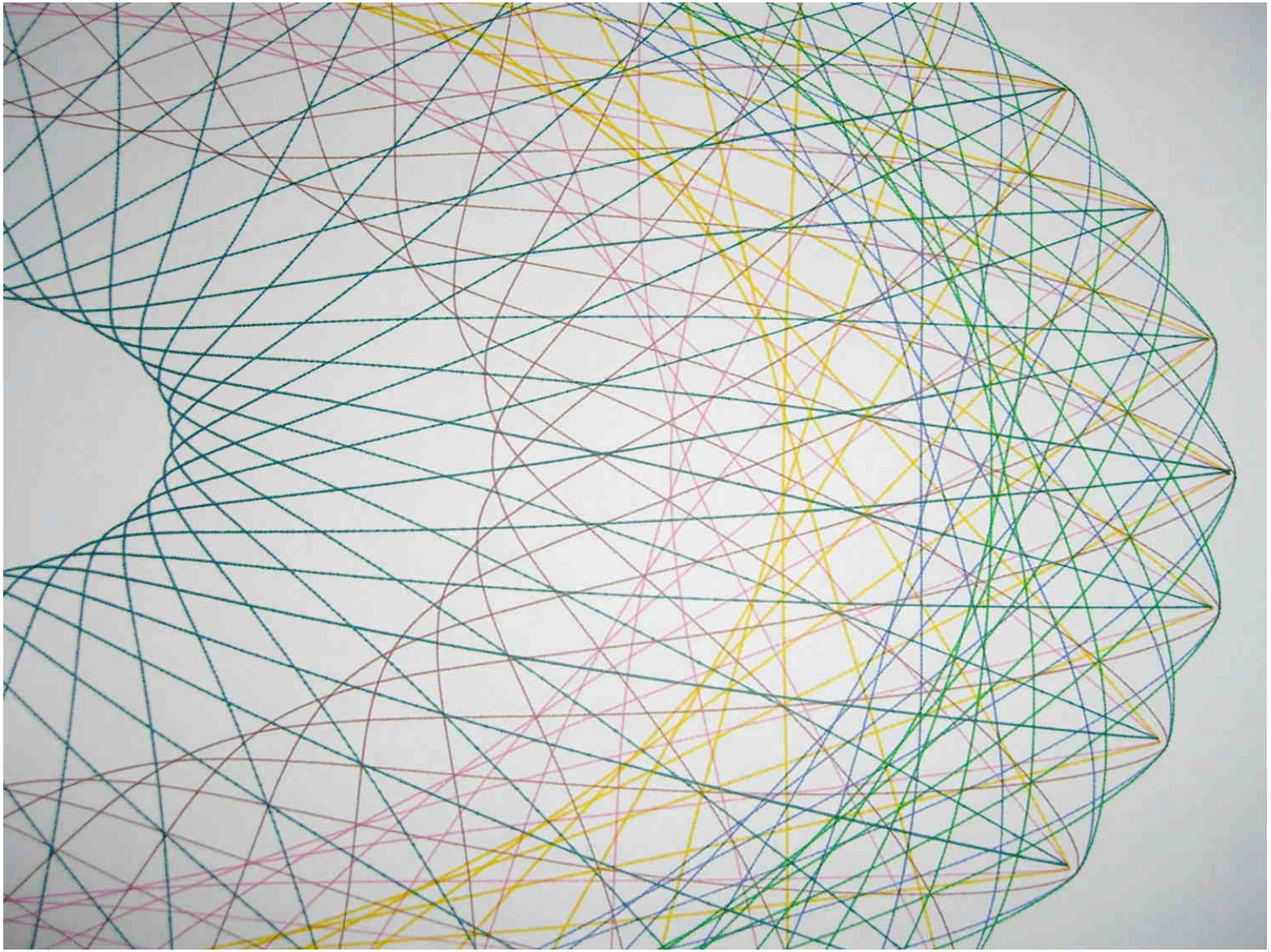
http://softsolder.com/2015/08/21/hp-7475a-plotter-pen-refilling-station/

Zombie Pens



http://softsolder.com/2015/09/06/hp-7475a-plotter-zombie-pens/

Multiple SuperFormula Curves



http://softsolder.com/2015/08/05/hp-7475a-plotter-superformula-demo/

Multiple SuperFormula Curves

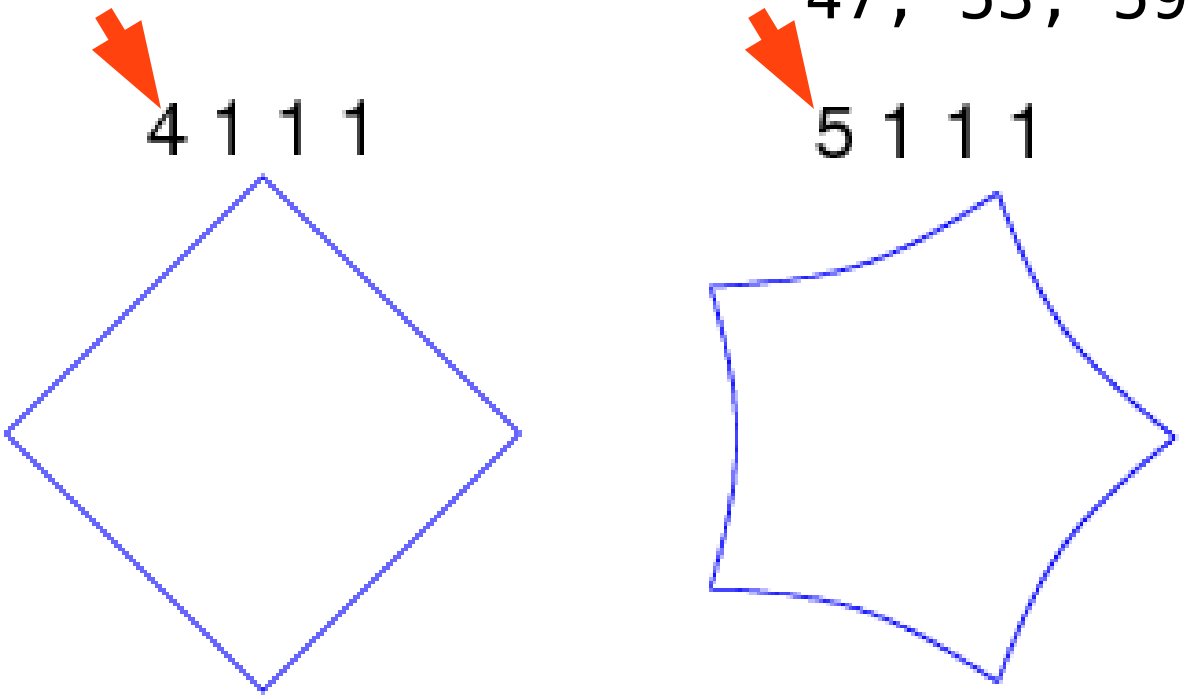
```
pen = 1
for m in [3.7]:
   for n1 in [0.20, 0.60, 0.8]:
     for n2 in [1.0, 1.5]:
         n3 = n2
         e = supershape(paperx, papery, m, n1, n2, n3)
         plt.select_pen(pen)
         if pen < 6:
            pen += 1
         else:
            pen = 1
         plt.write(e)
plt.select_pen(0)
```

- There's *a lot* not to like about that...

http://softsolder.com/2015/08/05/hp-7475a-plotter-superformula-demo/

Parameterizing: m

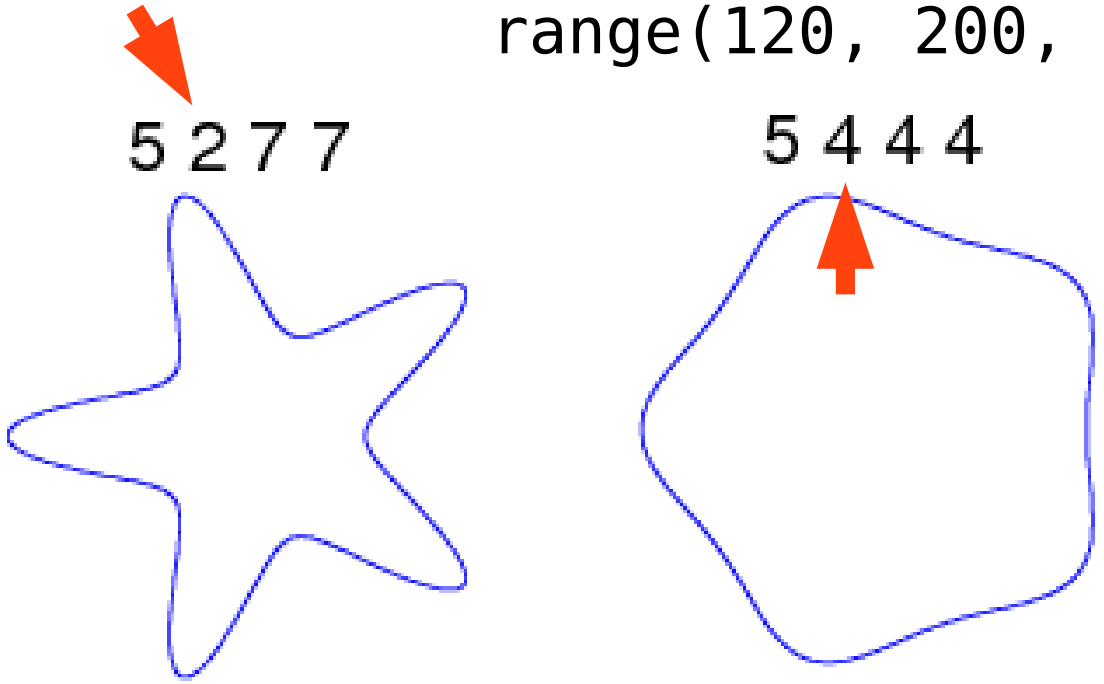
```
# prime/10 = number of spikes

m_values = [n / 10.0 for n in [11, 13, 17, 19,
                               23, 29, 31,
                               37, 41, 43,
                               47, 53, 59]]
```



http://softsolder.com/2015/08/27/hp-7475a-plotter-superformula-demo-madness/

Parameterizing: n1

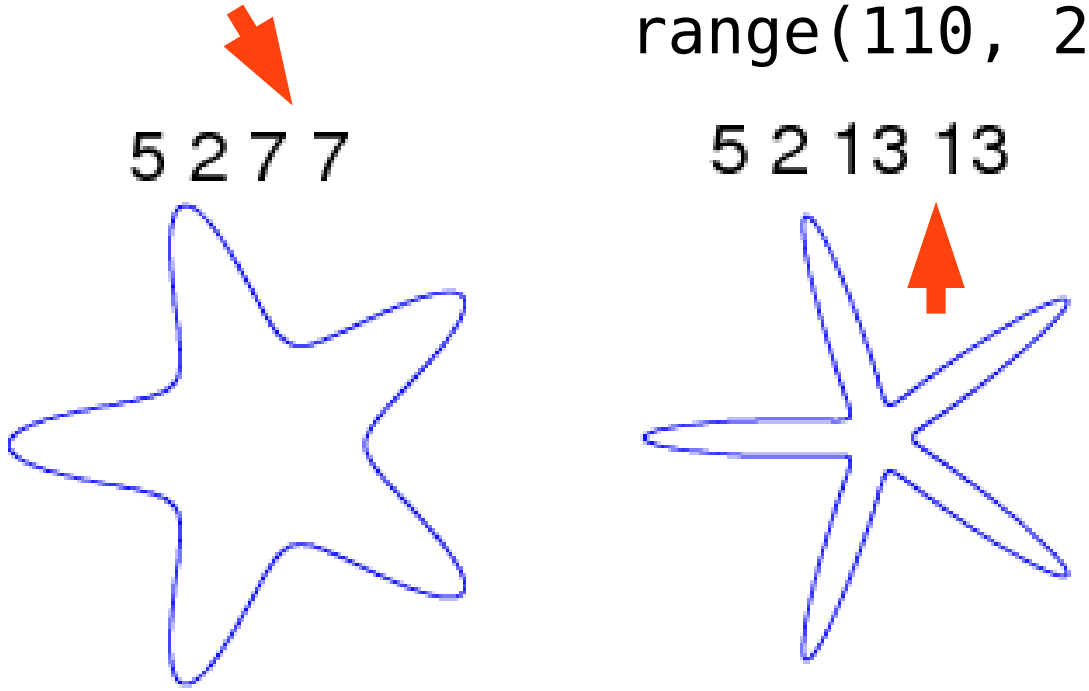
```
# ring-ness 0.1 to 2.0, higher is larger

n1_values = [
    n / 100.0 for n in range(15, 75, 2) +
                      range(80, 120, 5) +
                      range(120, 200, 10)]
```



http://softsolder.com/2015/08/27/hp-7475a-plotter-superformula-demo-madness/

Parameterizing: n2 & n3

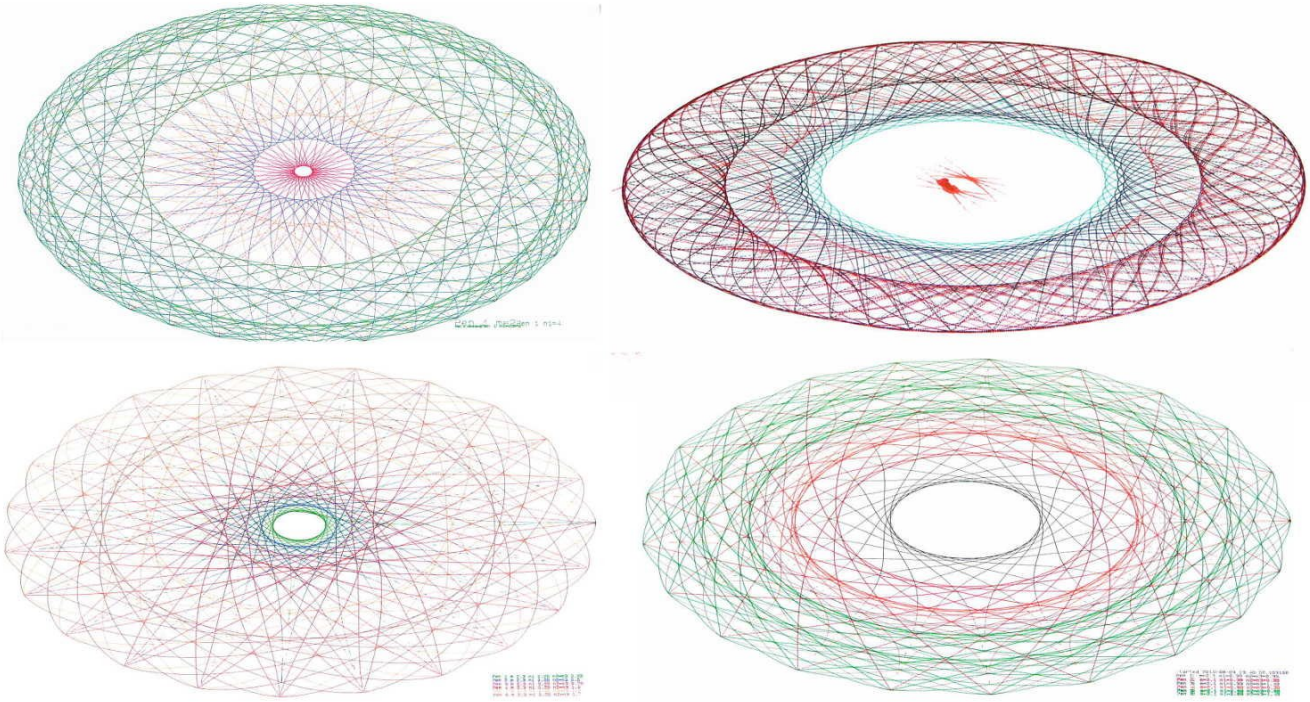
```
# spiky-ness 0.1 to 2.0, higher is spiky-er (?)

n2_values = [
        n / 100.0 for n in range(10, 60, 2) +
                         range(65, 100, 5) +
                         range(110, 200, 10)]
```



http://softsolder.com/2015/08/27/hp-7475a-plotter-superformula-demo-madness/

Parameter Selection

```
m = random.choice(m_values)

n1_list = random.sample(n1_values, numpens)

n2_list = random.sample(n2_values, numpens)
```



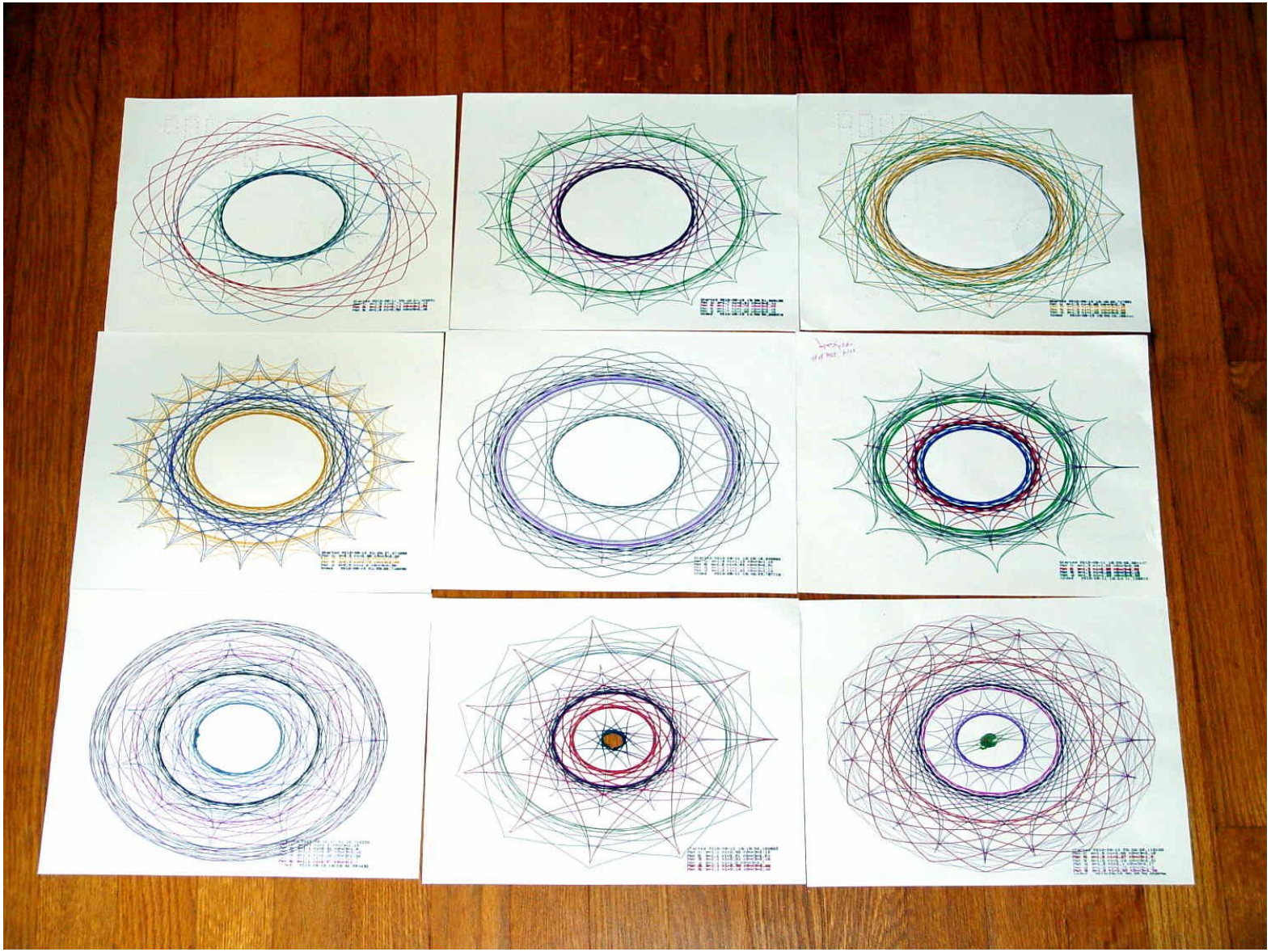
http://softsolder.com/2015/08/27/hp-7475a-plotter-superformula-demo-madness/

Multiple “Pretty” Plots

```
pen = 1
for n1, n2 in zip(n1_list, n2_list):
    n3 = n2
    print "{0} - m: {1:.1f}, n1: {2:.2f}, n2=n3: {3:.2f}".format(pen, m, n1, n2)
    plt.select_pen(pen)
    plt.write(hpgl.PA([(legendx, legendy - 100 * pen)]))
    plt.write(
        hpgl.LB("Pen {0}: m={1:.1f} n1={2:.2f} n2=n3={3:.2f}".format(pen, m, n1, n2)))
    e = supershape(maxplotx, maxploty, m, n1, n2, n3)
    plt.write(e)
    pen = pen + 1 if (pen % numpens) else 1
```

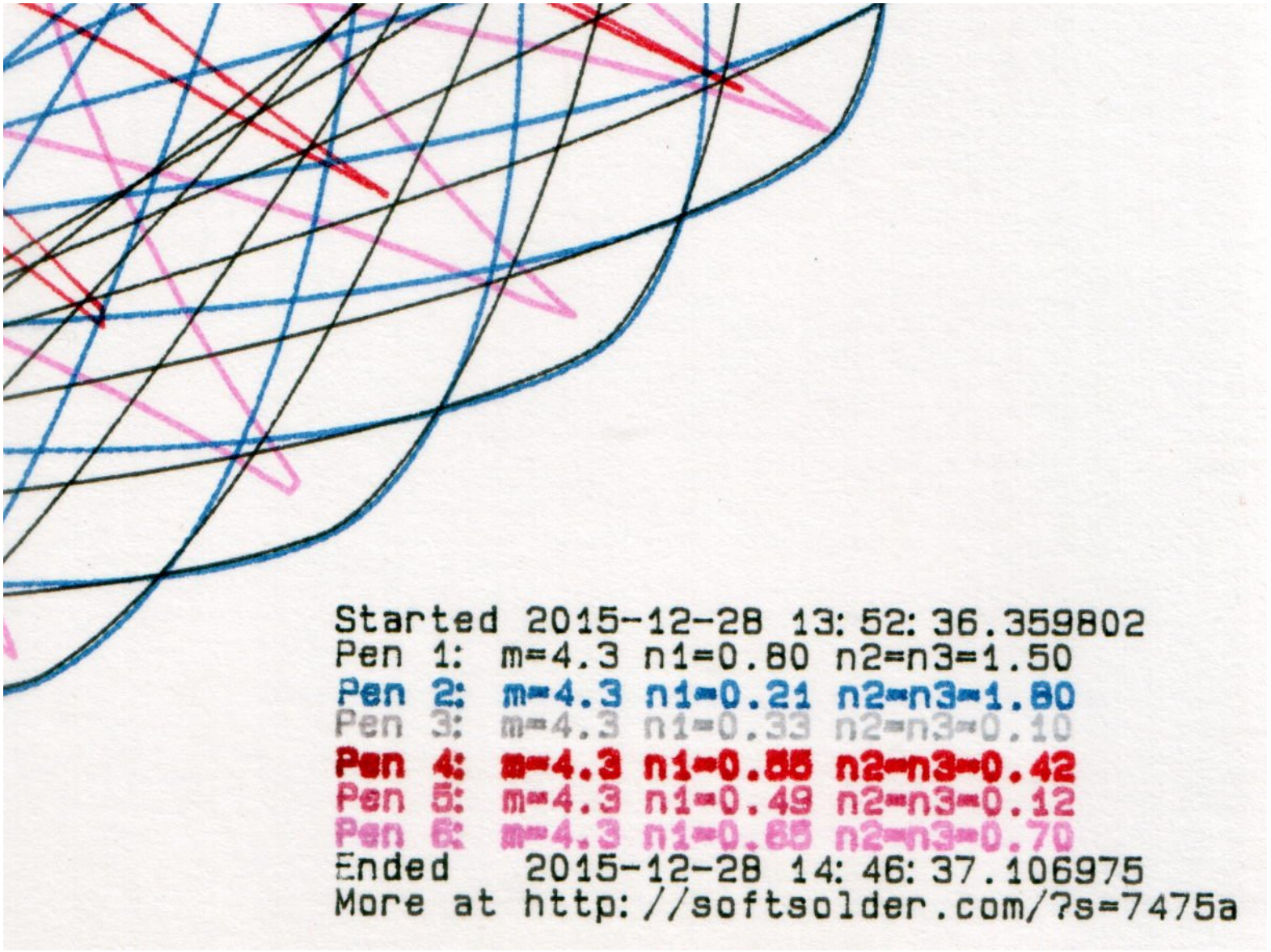
http://softsolder.com/2015/08/27/hp-7475a-plotter-superformula-demo-madness/

Multiple “Pretty” Plots



http://softsolder.com/2015/09/02/hp-7475a-plotter-superformula-with-paper-size-sensing/

Because Engineer

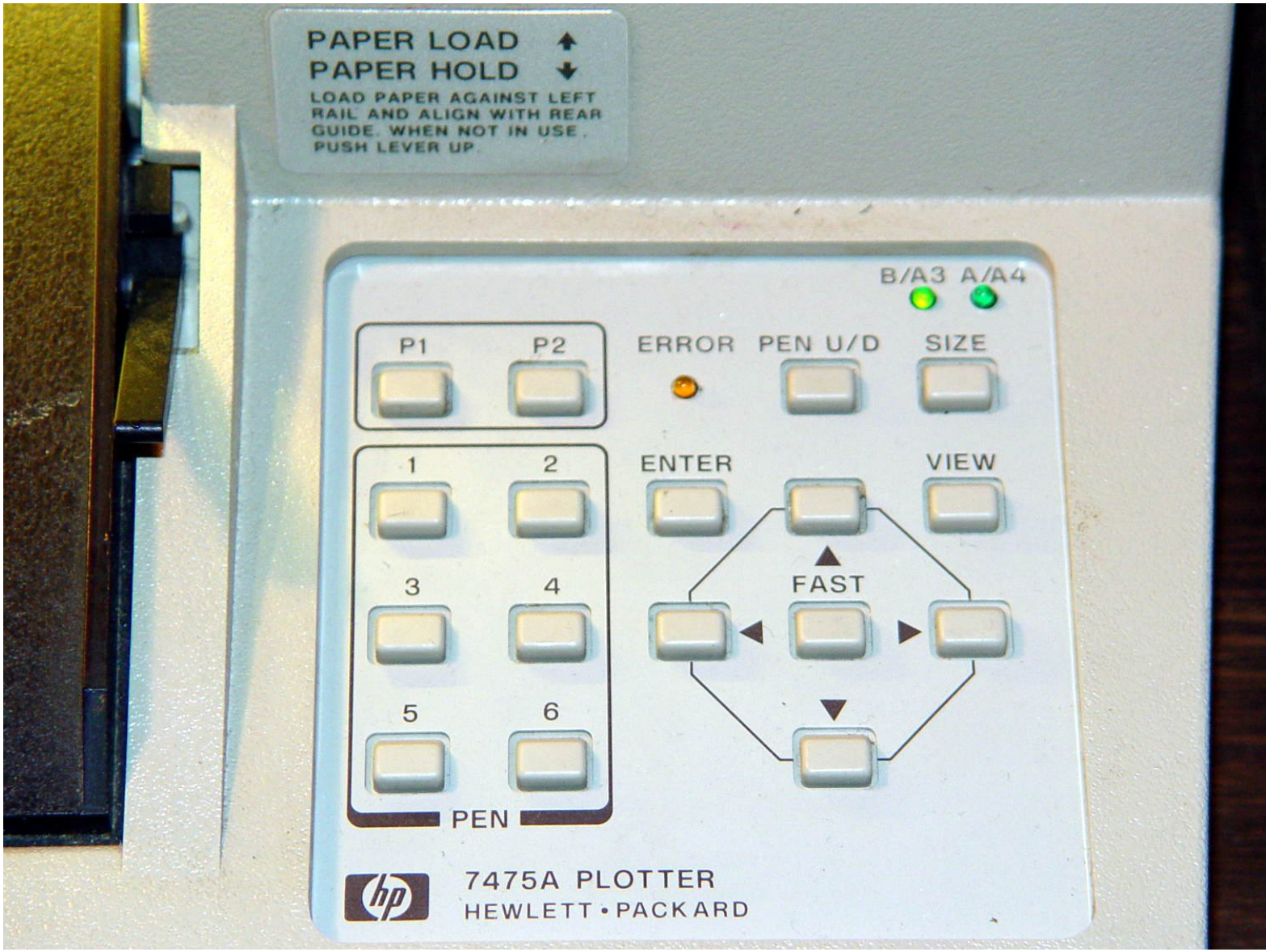


http://softsolder.com/2015/08/27/hp-7475a-plotter-superformula-demo-madness/

HP 09872-60066 Digitizing Sight

http://www.hpmuseum.net/display_item.php?hw=888

Plotter User Interface



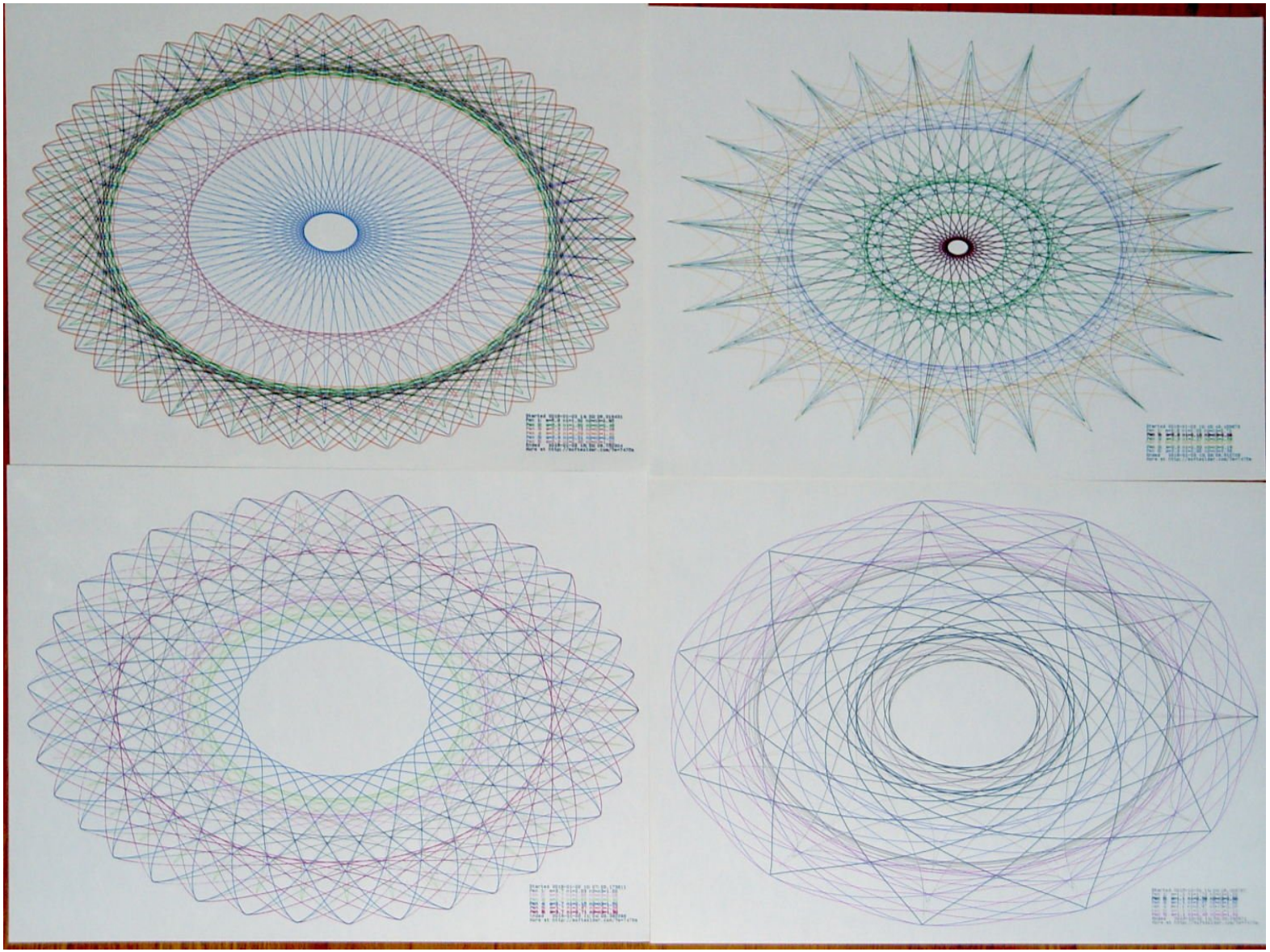
http://softsolder.com/2015/11/02/hp-7475a-plotter-one-button-demo-madness/

Chiplotle Digitizer Support!

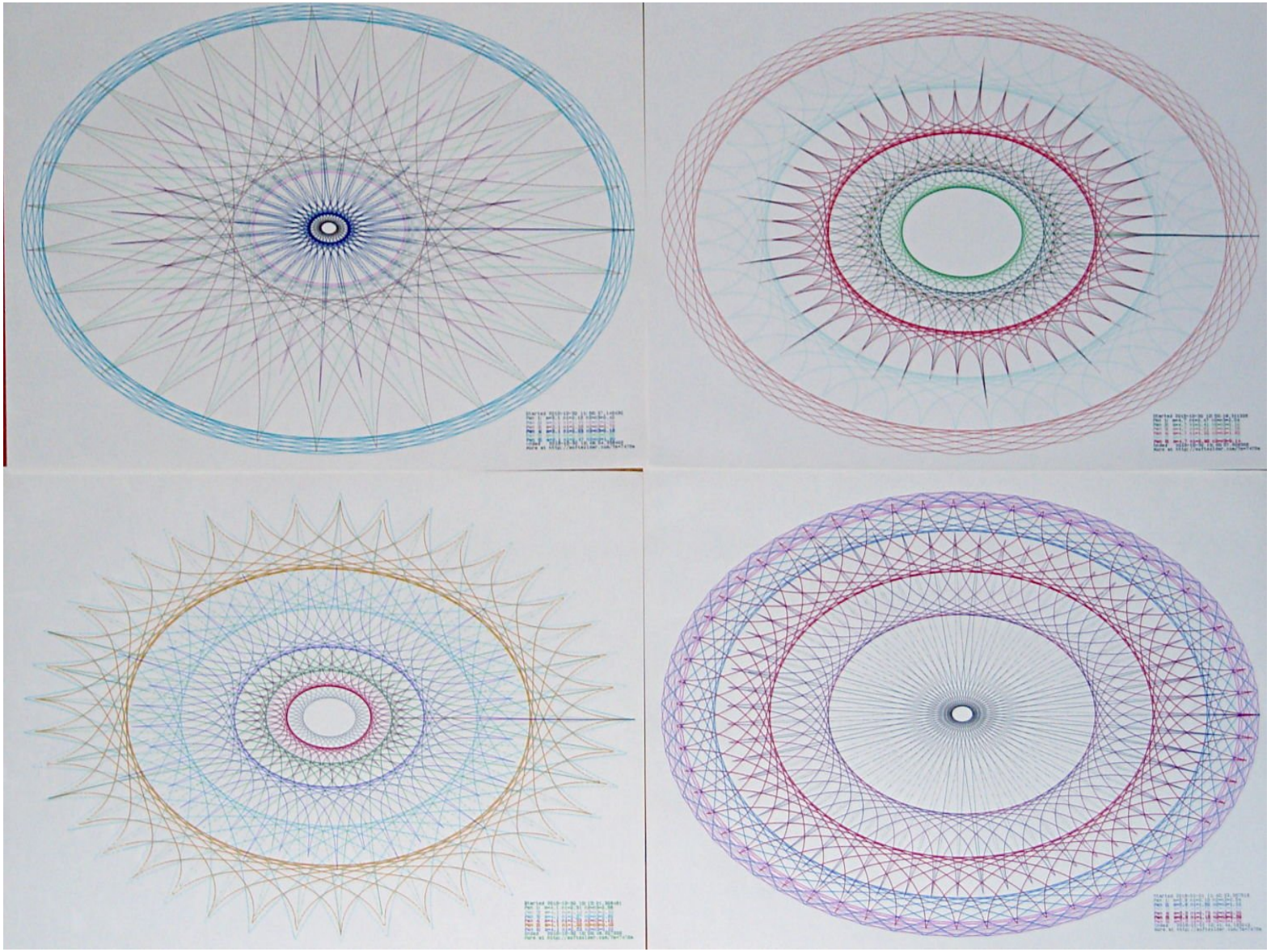
```
print "Waiting for plotter... ignore timeout errors!"
sleep(40)
while NoneType is type(plt.status):
    sleep(5)

print "Load more paper, then ..."
print "  ... Press ENTER on the plotter to continue"
plt.clear_digitizer()
plt.digitize_point()

plotstatus = plt.status
while (NoneType is type(plotstatus)) or (0 == int(plotstatus) & 0x04):
    plotstatus = plt.status

print "Digitized: " + str(plt.digitized_point)
```

http://softsolder.com/2015/11/02/hp-7475a-plotter-one-button-demo-madness/

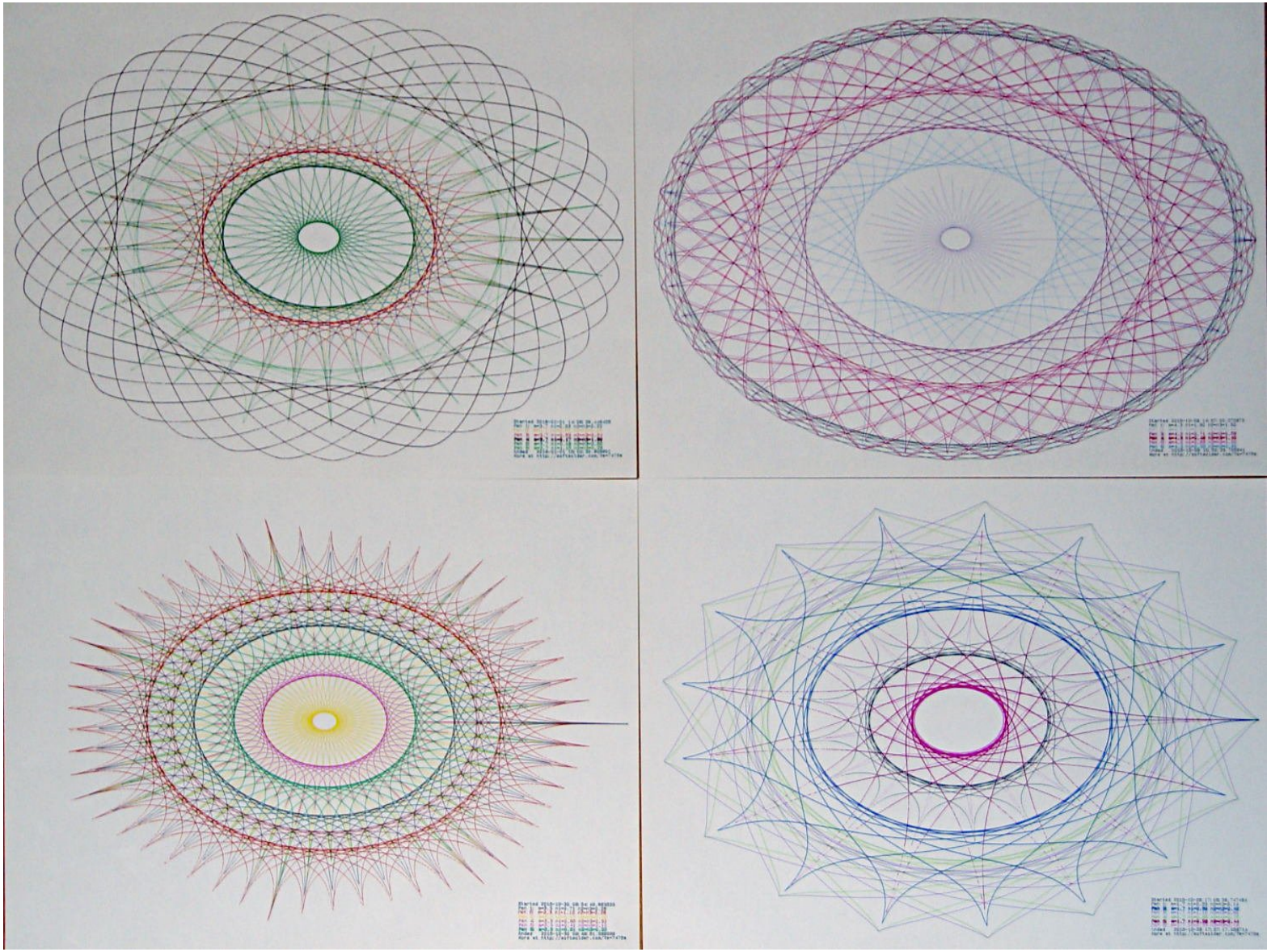
Each One Is Unique ...



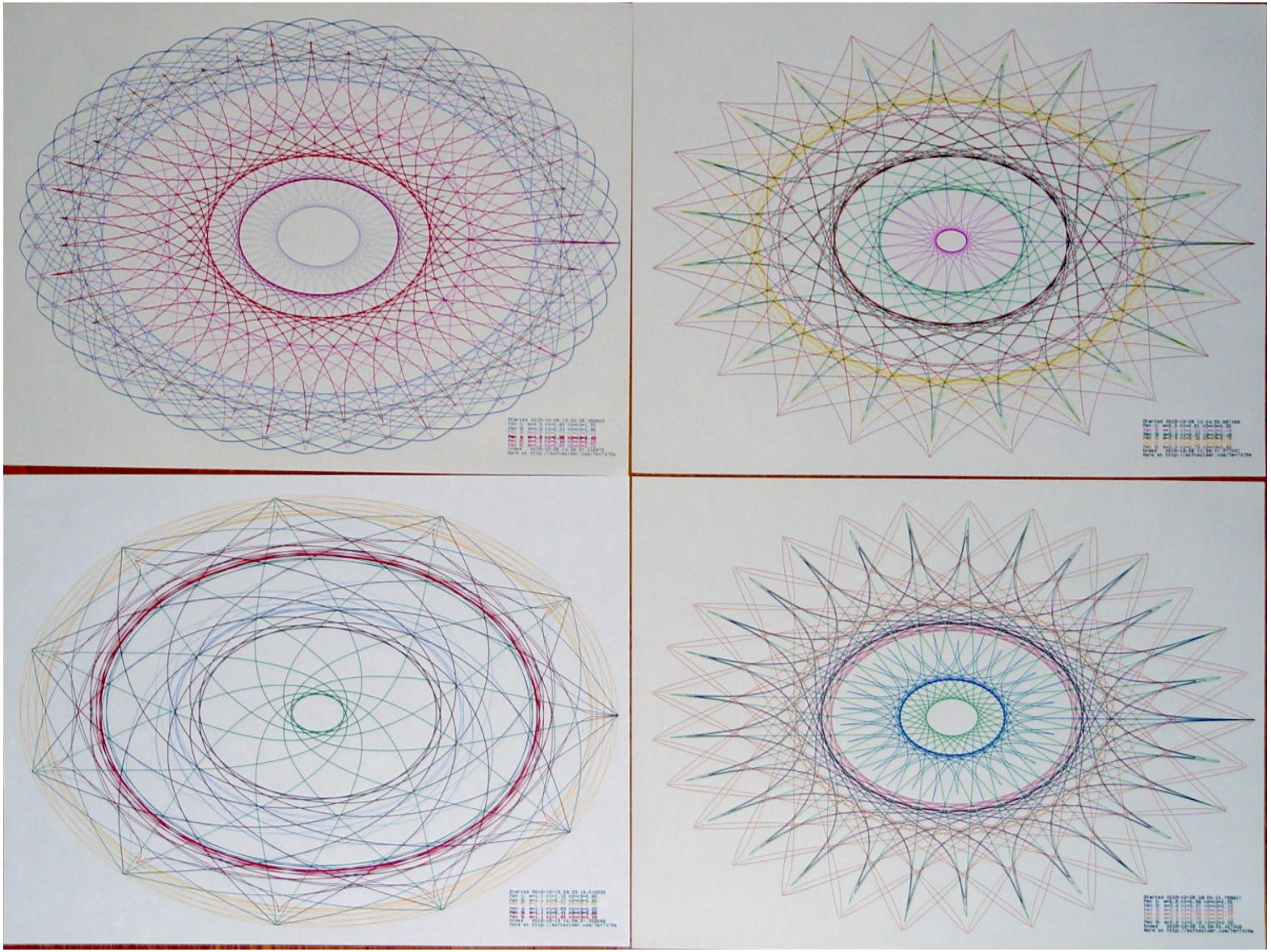
… Just Like a Snowflake ...



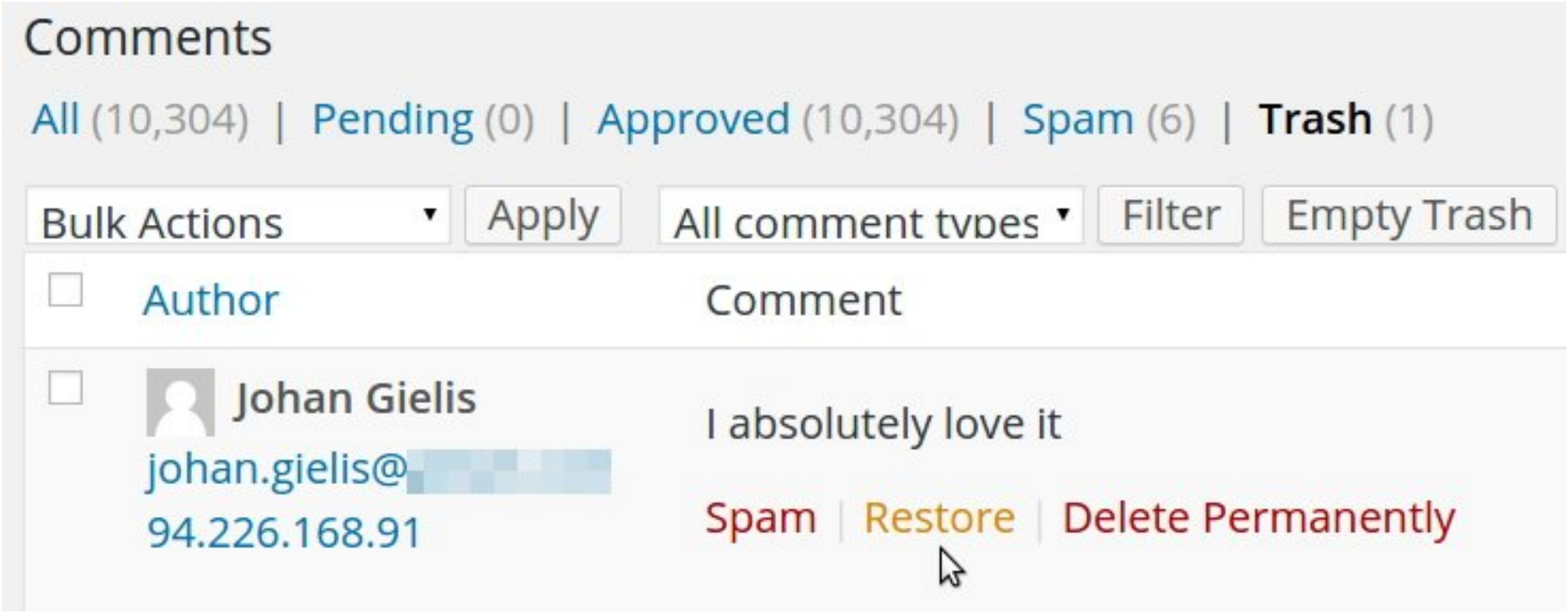
... The Plots Never Repeat ...



… but They're All Kinda the Same



Blog Comment: Pending Moderation



http://softsolder.com/2015/09/02/hp-7475a-plotter-superformula-with-paper-size-sensing/

Johan Gielis

- … the use of pens simply reminded me of Spirograph, which I loved, long time ago
- ... I also like very much the imperfection of pens
- There are many images on Google with super formula, but this is one of the best in my opinion

http://genicap.com/
http://www.antennacompany.com/

Piet Hein

PAST PLUPERFECT

The past, -- well, it's just like
our Great-Aunt Laura,
who cannot or will not perceive
that though she is welcome,
and though we adore her,
yet now it is time to leave.

http://www.archimedes-lab.org/grooks.html

Questions?

Copyright-ish Stuff

Some web images probably copyrighted, but
shown & attributed here under “fair use”
[whatever that is]

The rest is my own work

•

Ed Nisley

Say “NISS-lee”, although we're on the half-essed branch of the tree

Engineer (ex PE), Hardware Hacker, Programmer, Author

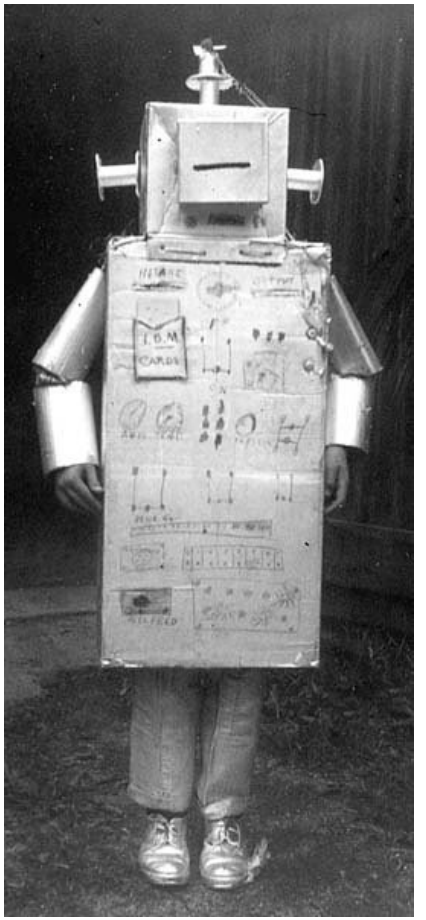
The Embedded PC's ISA Bus: Firmware, Gadgets, Practical Tricks

Circuit Cellar www.circuitcellar.com
- Firmware Furnace (1988-1996) - Nasty, grubby hardware bashing
- Above the Ground Plane (2001 ...) - Analog and RF stuff

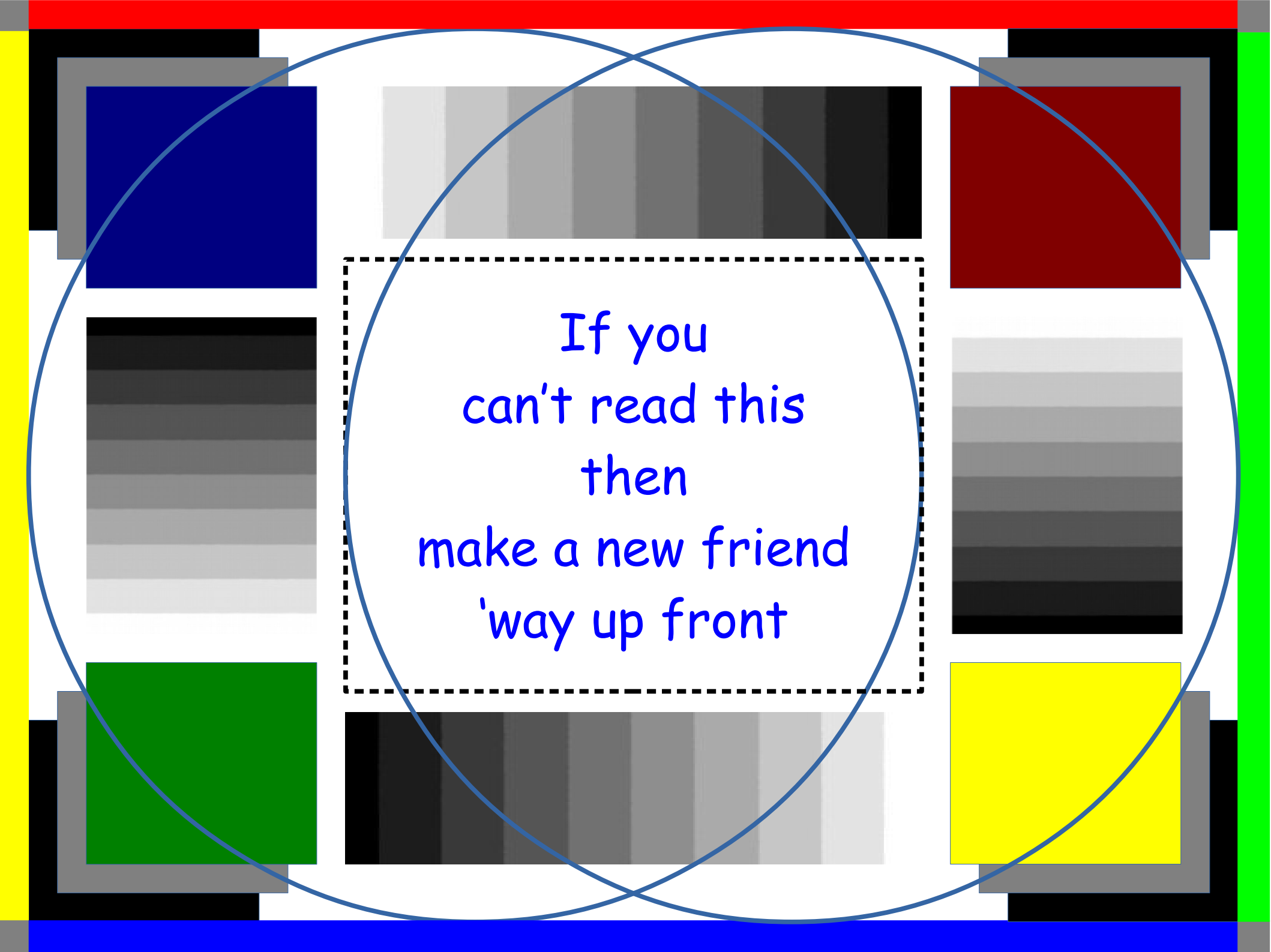
Digital Machinist www.homeshopmachinist.net
- Along the G-Code Way (2008 ...) - G-Code, math, 3D printing

Dr. Dobb’s Journal www.ddj.com
- Embedded Space (2001-2006) - All things embedded
- Nisley’s Notebook (2006-2007) - Hardware & software collisions

Blog: The Smell of Molten Projects in the Morning
softsolder.com



September 1962


If you
can't read this
then
make a new friend
'way up front