

 **National® Brand**

COMPUTATION NOTEBOOK

Department Lab Techniques VI

Subject _____

Name Jack Segal

Address _____

43-648

75 Sheets, 4 x 4 Quad., 11 3/4" x 9 1/4"



0 73333 43648 8

Rediform Inc. • Coppell, TX 75019

Made in Mexico

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CO_2 Pressure Drop in 1000' of $\frac{1}{2}$ " Poly Tubing
 Re-doing CO_2 Pressure drop 35
 Ar/ CO_2 75%/25% + 70%/30% Pressure Drop

40

45

47

Continuing 12VDC Motor Investigations 3/17/13

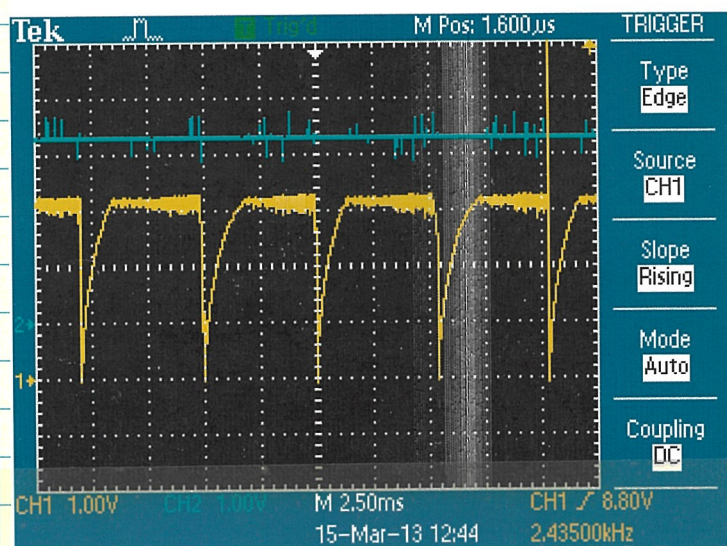
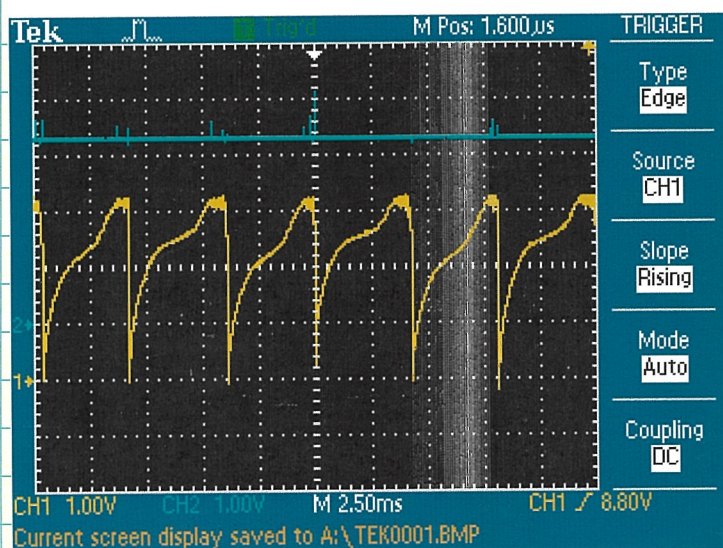
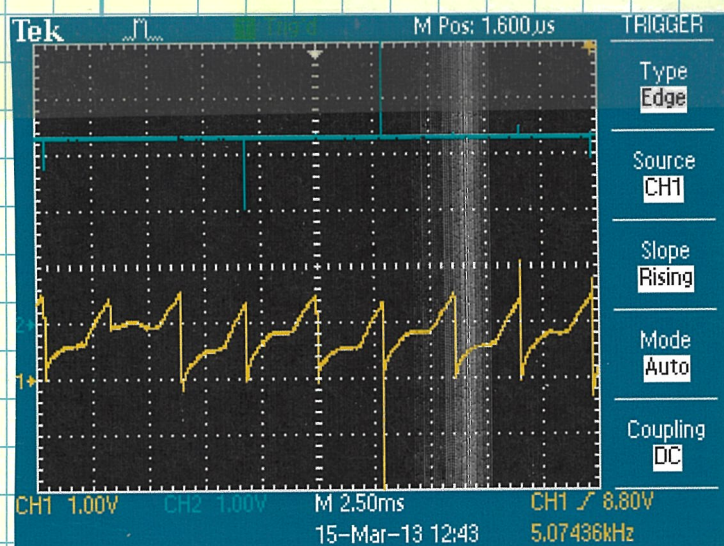
I put the TPS2024 scope on the drive. Ch1 is I_{Read} and Ch2 is I_{set} .

I pressed my thumb on the sprocket to load the motor down. The

first pic is no load. As I load the motor we can see the current increases up to I_{set} and the RPM drops. The second pic is with a load. Third pic is a bit more of a load.

So, the current at no load is not the set current. Is this current limited by the motor inductance and the speed of rotation of the motor?

I had replaced the multiturn 20k pot with a single turn 50k pot. Something easier to adjust.



With I_{set} at 0. Tek 0 and start DATAQ.
 As I increase I_{set} the motor does not
 turn, but the current readback has a waveform.
 Tek 1. Added 10 μ F & 0.47 μ F capacitors. No change.
 0.22 A on the power supply.

0.44 A on the supply. Tek 2. 0.64 A Tek 3.

Motor starts running. Current drops to 0.38 A. Tek 4
 DI-145 hung-up. Restart.

A bit of noise when the commutators switch. Tek 5
 No load. Tek 6.

Increasing load till stalls Tek 7-11.

Tek 12 is at stall.

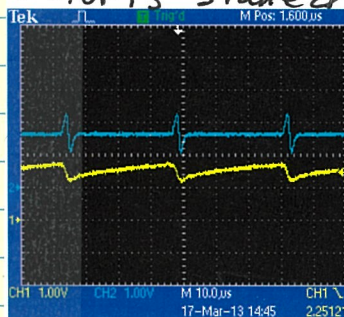
Load the motor a bit. Tek 13.

Trying to keep the load steady increase
 I_{set} . Tek 14.

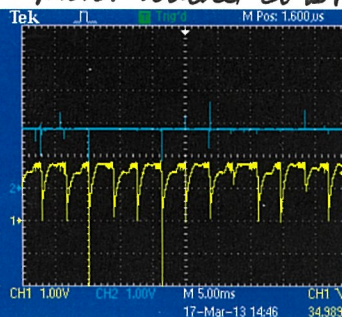
No load with new I_{set} . Tek 15

Load the motor and turn I_{set} up high. Tek 16

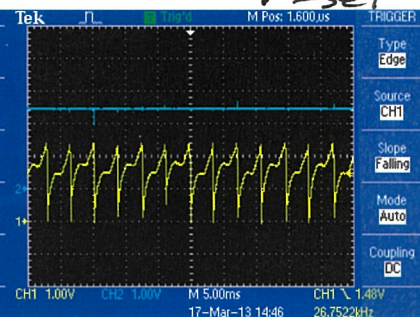
Tek 12
motor is stalled



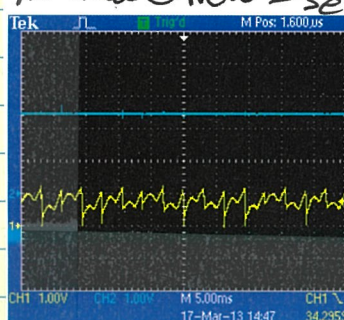
Tek 13
motor loaded a bit



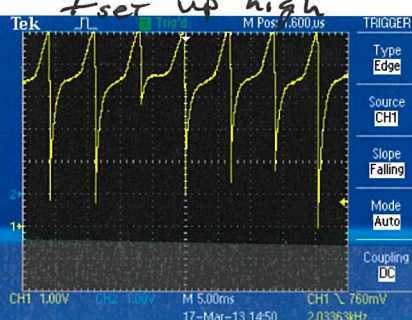
Tek 14
same load $\uparrow I_{set}$



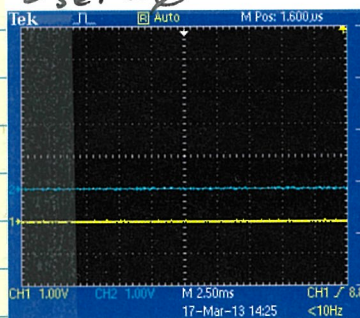
Tek 15
No load @ new I_{set}



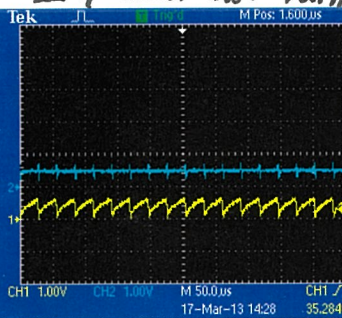
Tek 16
load motor and set
 I_{set} up high



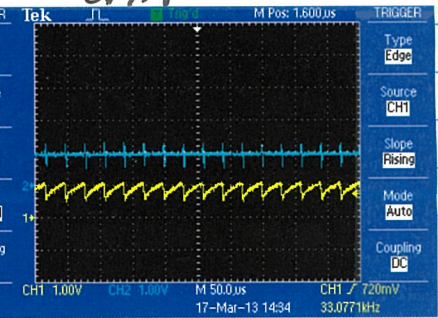
Tek 0
I_{set} = 0



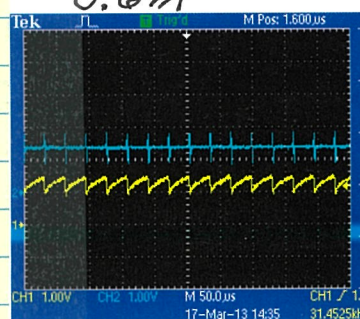
Tek 1
I ↑ motor not turning



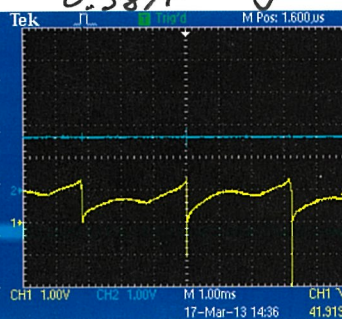
Tek 2
0.4A



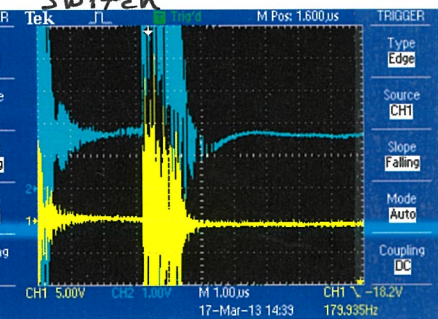
Tek 3
0.64A



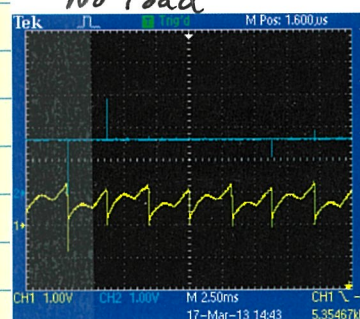
Motor turning
0.38A



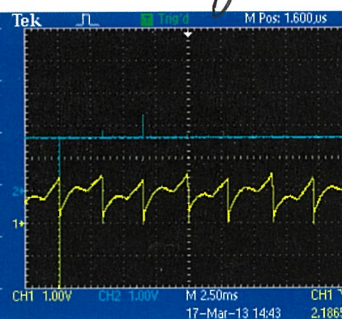
Noise when commutators switch



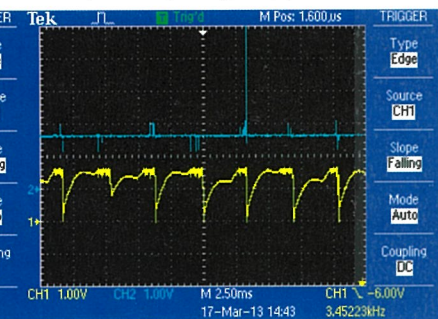
Tek 6
No load



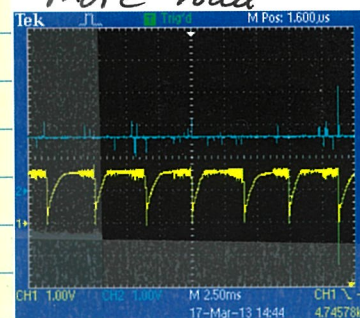
Increasing load



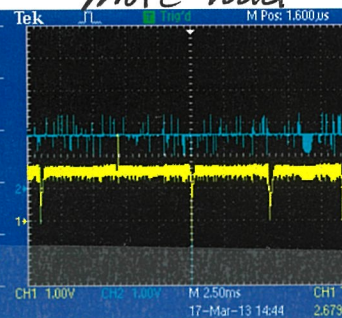
more load



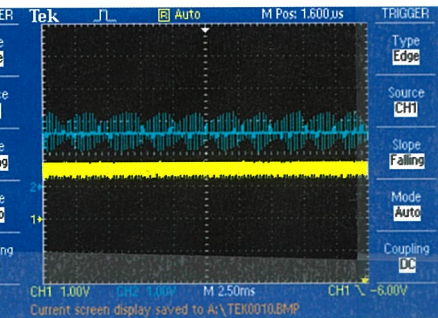
Tek 9
more load



more load



motor is stalled



Current screen display saved to A:\TEK0010.BMP

8/13/14 Trying a LM340 for the CTR Test Circuit

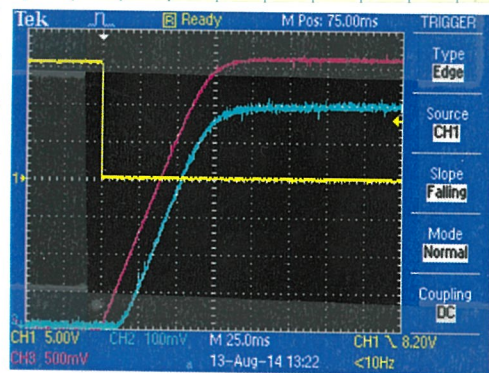
I have some time and thought I'd come back to the optocoupler background monitor.

I found the plug board with the 555 timer chain on it. See p. 147 of Lab Techniques V.

I also found the ramp generator on p. 140 of Lab Techniques V. However, I do not find a MAX6018 voltage reference as is shown in the MAXIM application note. I assume I have lost it over time.

I expanded the plug board and put together the background monitor circuit. Instead of the MAX6018 or the AD586 I used an LM340-5 5V regulator.

While the AD586 was not as nice as the MAX6018, the LM340 seems to have a delay responding to the ramp. I would suspect the higher quiescent current of the LM340.



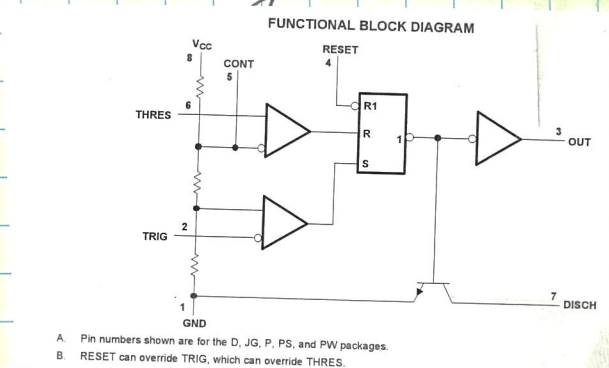
Trying to Develop a 555 Quench Protection 2/24/15
 Checking out a circuit for the quench protection for the LQ1 magnet.

I have redone the input section of the circuit used on the lead flow displays. The lead flow display circuit can be seen on p. 11 of Misc Hardware IV logbook.

I replaced the input section with an INA, an active filter, and an absolute value circuit.

The 2N3906 and the 555 are configured such that the comparator output must be high for a little while before the relay is made to change state. This was done so that brief changes in flow, due perhaps to turbulence in the liquid or some such things, would not cause "nuisance" trips.

Looking at the 555 chip...



If all is OK, the 2N3906 is on and pin 5 is tied to GND. If the 2N3906 turns off, pin 5 starts to rise in voltage with a RC time constant determined by the capacitor on pin 5 and the R to Vcc (affected by the R+R to GND). The data sheet claims $R = 5K$.

I was having problems

Enough time has gone by that I should just re-visit the 555 circuit to determine if we want to keep using it. This will be done at some future date.

4/2/15

6/18/16

4/18/16 Calculation of CO_2 Flow in 500' of $\frac{1}{2}$ " Poly-Flo
 On p. 100 of Lab Techniques II I did
 a measurement of the pressure drop
 over 500' of $\frac{1}{2}$ " O.D. Poly-flo tubing.
 The gas was CO_2 .

Viscosity $\text{Pa}\cdot\text{s} = \frac{\text{kg}}{\text{m}\cdot\text{s}}$

$$\text{Pa}\cdot\text{s} = 1000 \frac{\text{g}}{\text{s}} \cdot 100 \text{ cm}$$

$$\text{Pa}\cdot\text{s} = 10 \frac{\text{g}}{\text{s}} \cdot \text{cm}$$

for CO_2 use $1.4 \cdot 10^{-5} \text{ Pa}\cdot\text{s}$
 $2.4 \cdot 10^{-4} \frac{\text{g}}{\text{s}} \cdot \text{cm}$

$$\text{Flow } Q = \frac{\pi a^4 \Delta p}{8 \eta L}$$

$\eta = \text{viscosity} = \frac{\text{g}}{\text{cm}\cdot\text{s}}$
 Δp in $\frac{\text{dynes}}{\text{cm}^2}$

$$\left(\frac{\text{dynes}}{\text{cm}^2}\right) \cdot 0.000401474 = \text{inches of } \text{H}_2\text{O}$$

Δp in Pa

$$1 \text{ Pa} = 1.45 \cdot 10^{-4} \text{ PSI}$$

$$= 4.015 \cdot 10^{-3} \text{ inches of } \text{H}_2\text{O}$$

$$1 \text{ PSI} = 6897 \text{ Pa}$$

$$1" \text{ of } \text{H}_2\text{O} = 249 \text{ Pa}$$

$$0.45" \text{ of } \text{H}_2\text{O} = 112 \text{ Pa}$$

For Poly-Flo test

0.45" of H_2O @ 472 sccm in 500' of $\frac{1}{2}$ " poly-flo

$$500' = 152.4 \text{ m}$$

$\frac{1}{2}$ " O.D. poly-flo has 0.062" wall

inside radius

$$\frac{0.5" - (0.062" \cdot 2)}{2} = 0.188"$$

$$= 0.0048 \text{ m}$$

$$\dot{V} = \frac{\pi \cdot a^4 \cdot 112 \text{ Pa}}{8 \cdot (1.4 \cdot 10^{-5} \text{ Pa} \cdot \text{s}) \cdot 152.4 \text{ mm}}$$

$$= \frac{\pi \cdot (4.8 \cdot 10^{-3} \text{ m})^4 \cdot 112 \text{ Pa}}{8 \cdot (1.4 \cdot 10^{-5} \text{ Pa} \cdot \text{s}) \cdot 152.4 \text{ mm}}$$

$$= 1.094 \cdot 10^{-5} \text{ m}^3/\text{s}$$

$$= 10.94 \text{ cm}^3/\text{s}$$

$$= 657 \text{ cm}^3/\text{min}$$

This is about 40% off from what I measured.

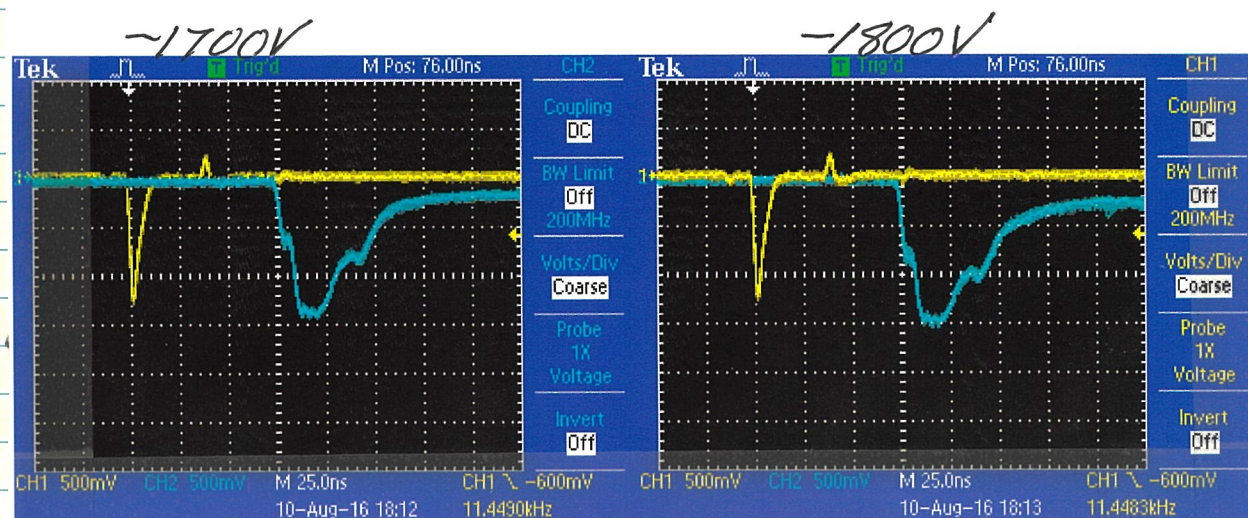
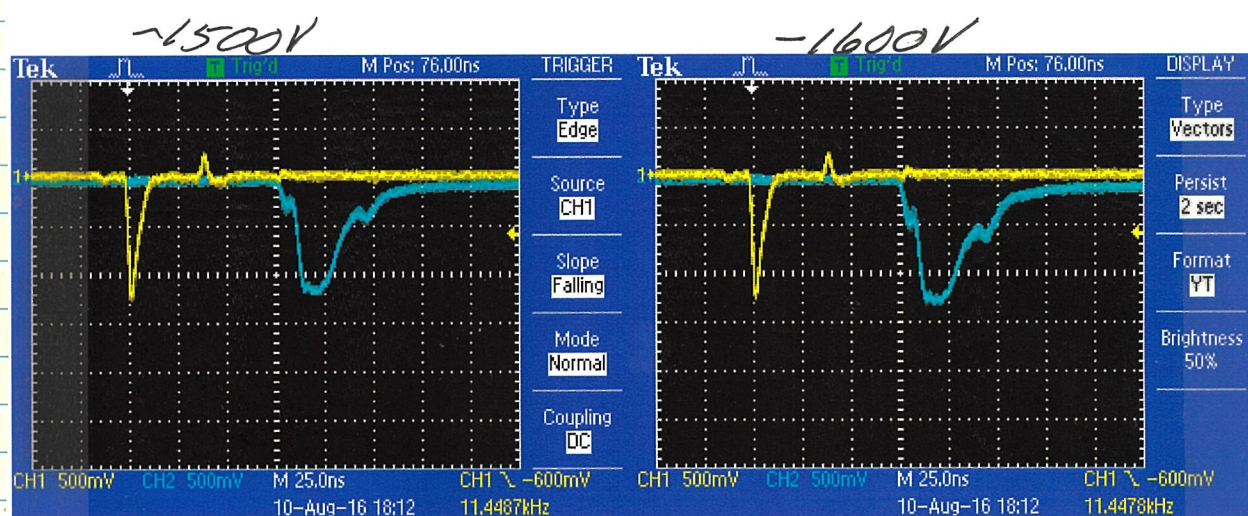
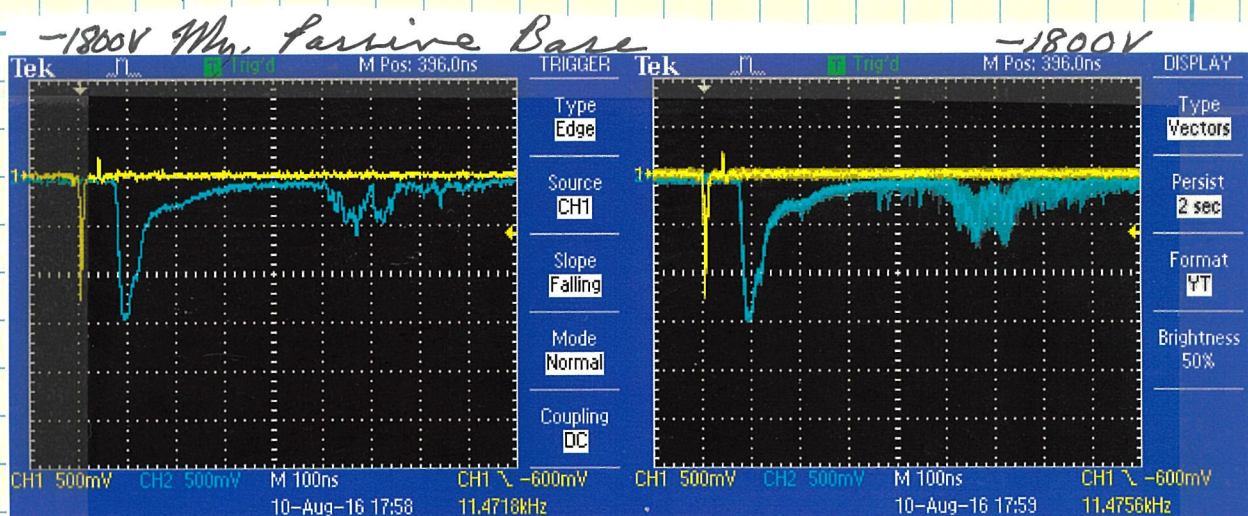
8/10/16 Re-Visiting the Bases for the 8575

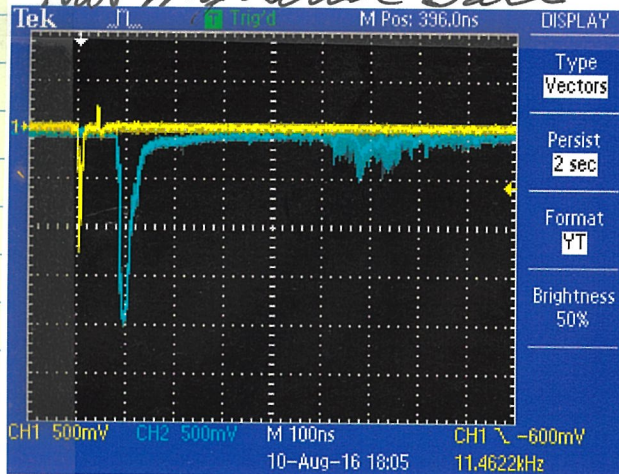
I have gathered the passive base I made, some of the bases from SI, and the active base I had made.

Comparing the gains of the bases.
The PMT for this test is 5/N 5300509
with a manufacturer's test date of 15-May-06
The pulser is the +/-5V USE ME PULSER
and a green LED.

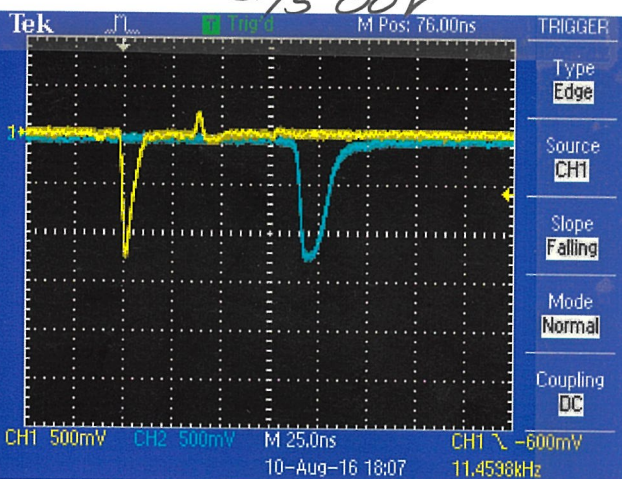
First is the passive base by me at -1800V. Tek0, Tek1
Next is my active base. -1800V Tek2.
-1500 Tek3. -1600 Tek4. -1700 Tek5. -1800 Tek6.
Back to my passive base. -1500 Tek7. -1600 Tek8
-1700 Tek9. -1800 Tek10.
Next is the SI base. The circuit board for the
base says "8575 Tube Base Rev. 3 (SRE)".
-1500 Tek11. -1600 Tek12. -1700 Tek13. -1800 Tek14.
-1800 Tek15.

Ch 1 is the Pocket Pulser ~~drive~~ trigger
signal.
Ch 2 is the PMT output.

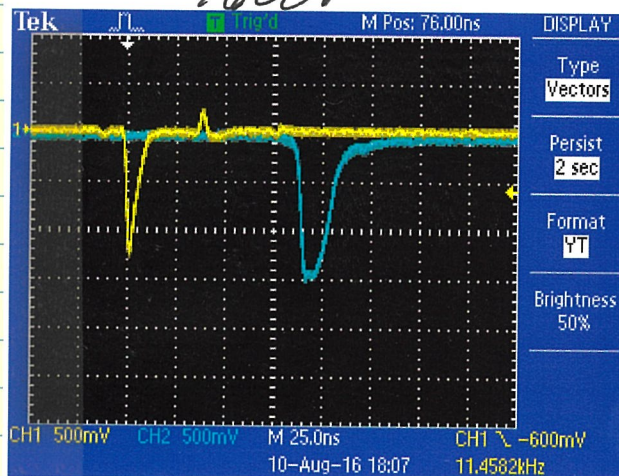


-1800V *Wly Active Base*

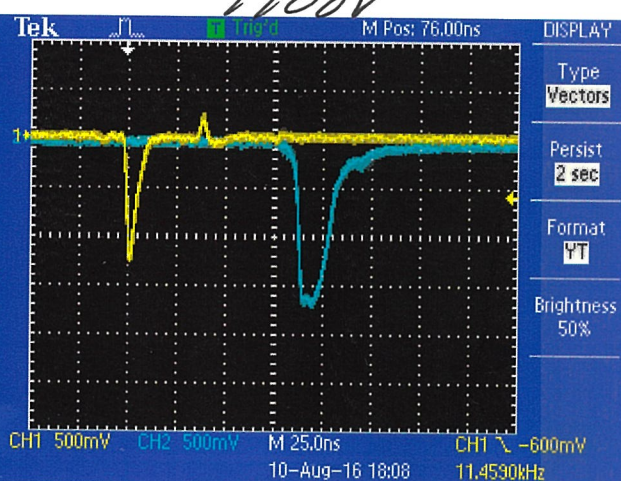
-1500V



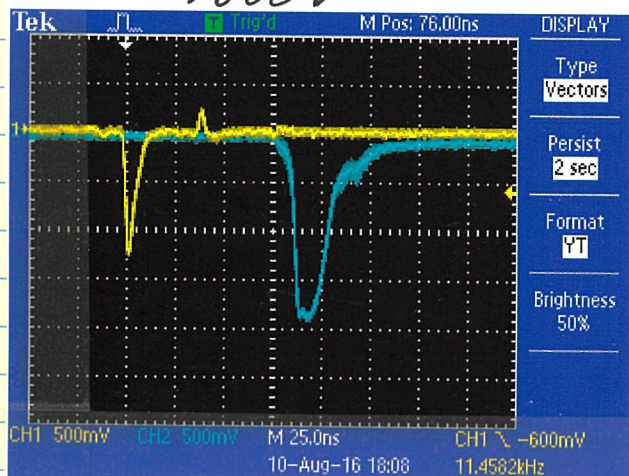
-1600V

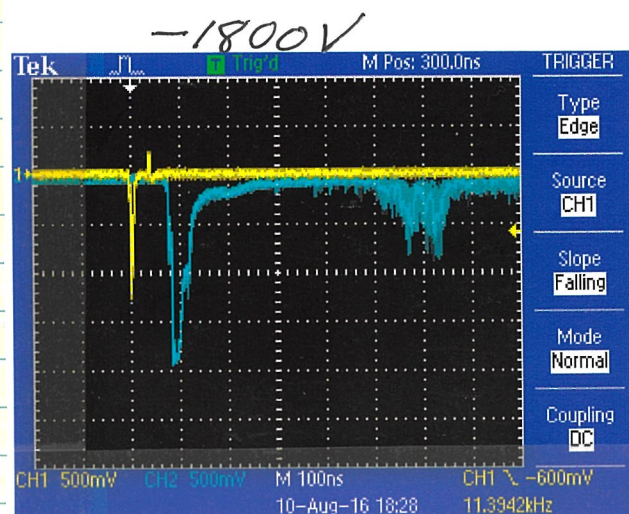
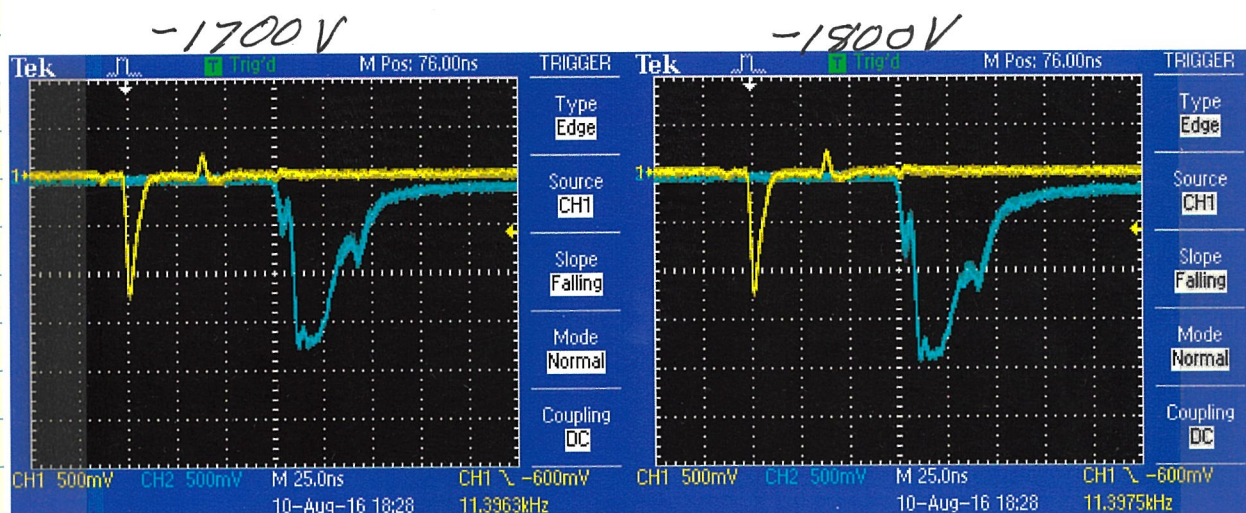
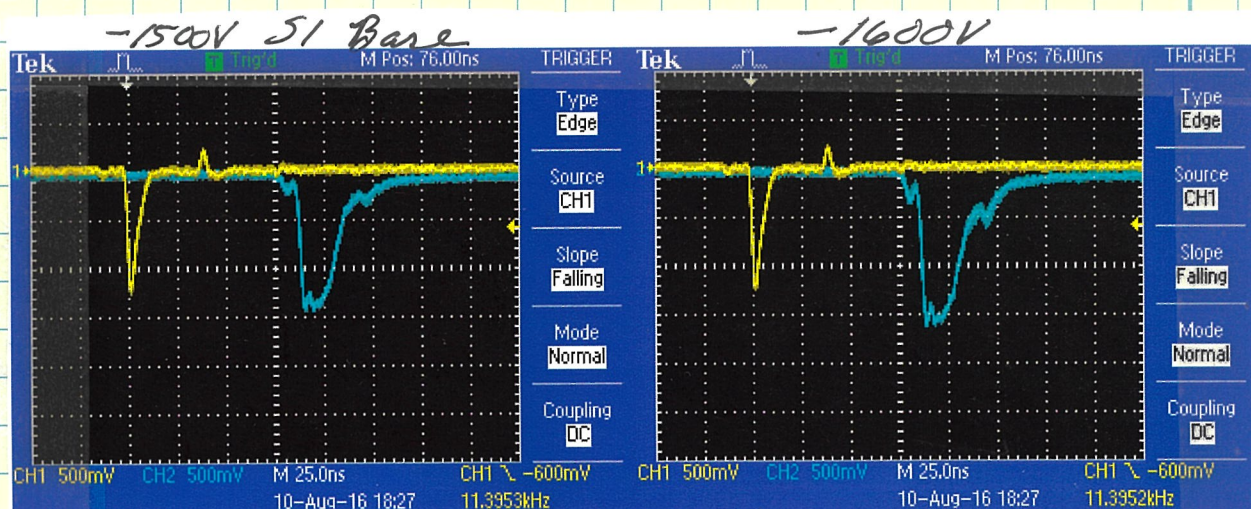


-1700V



-1800V



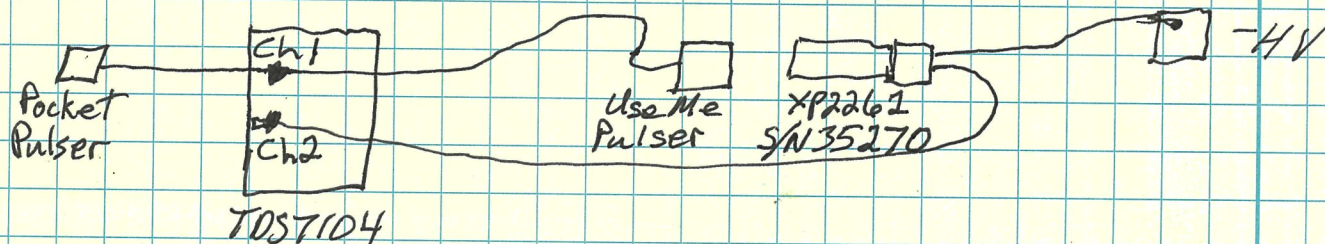
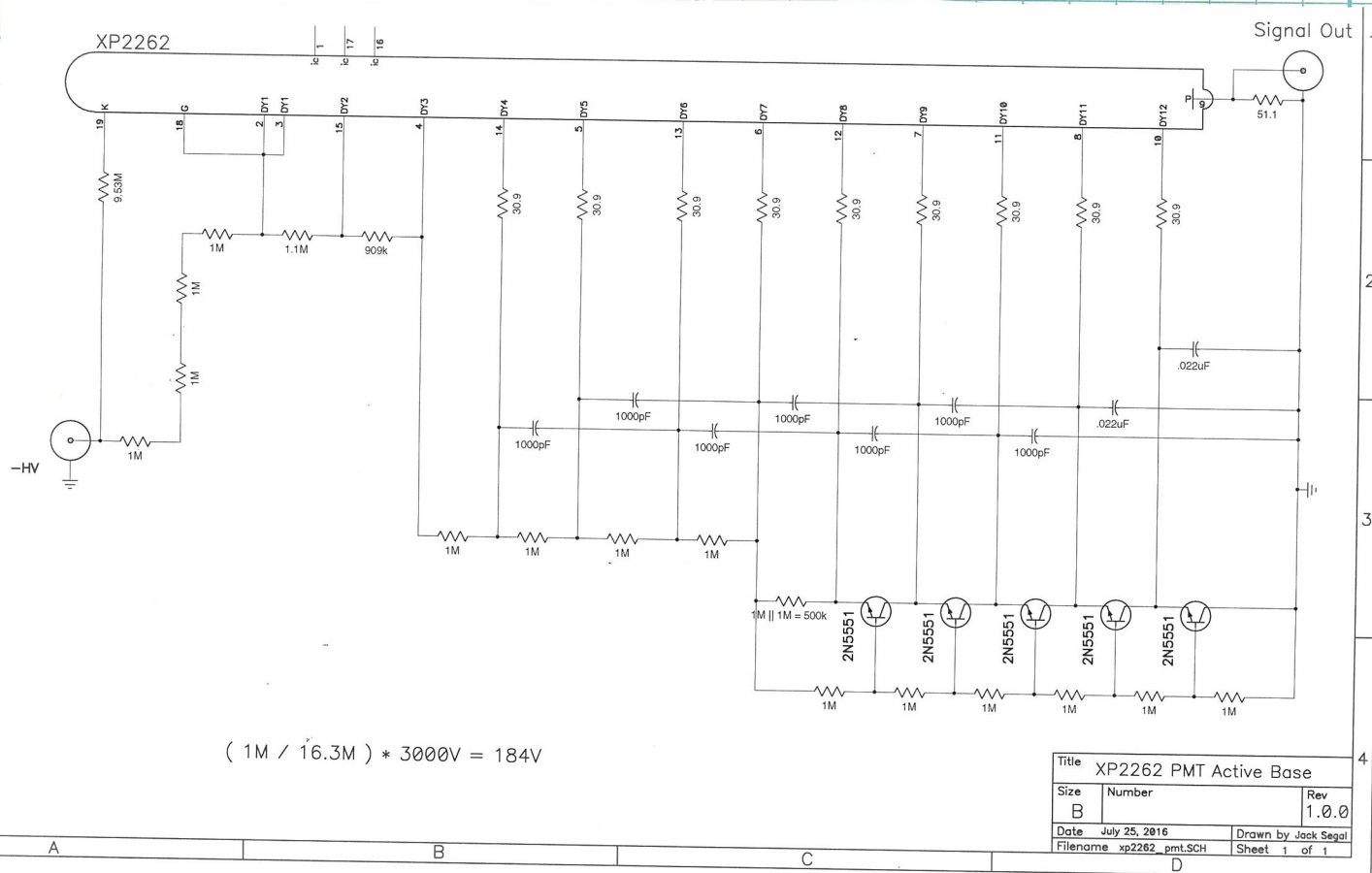


Active Base For The XP2262

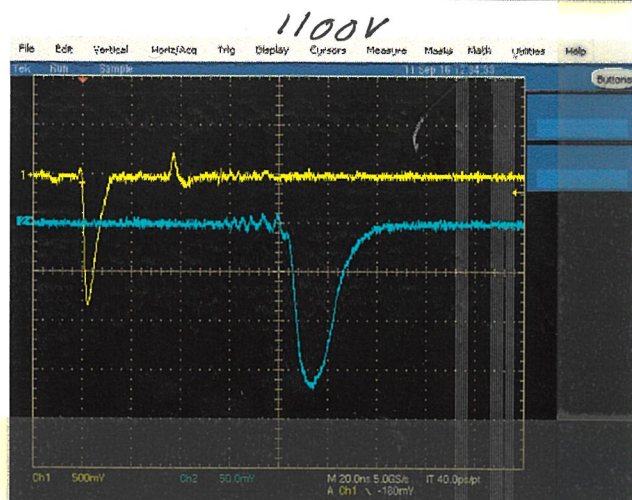
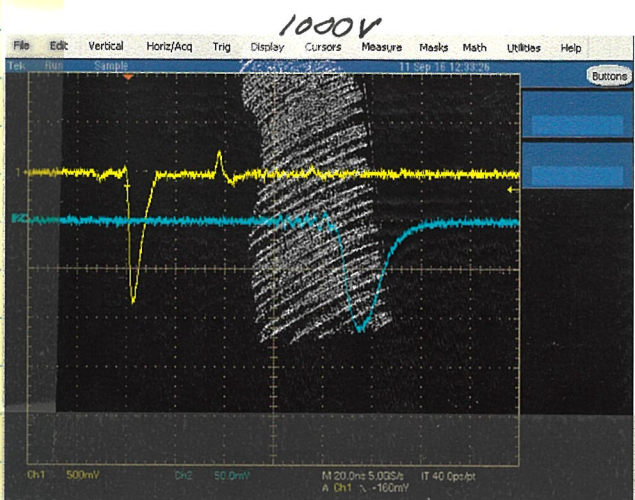
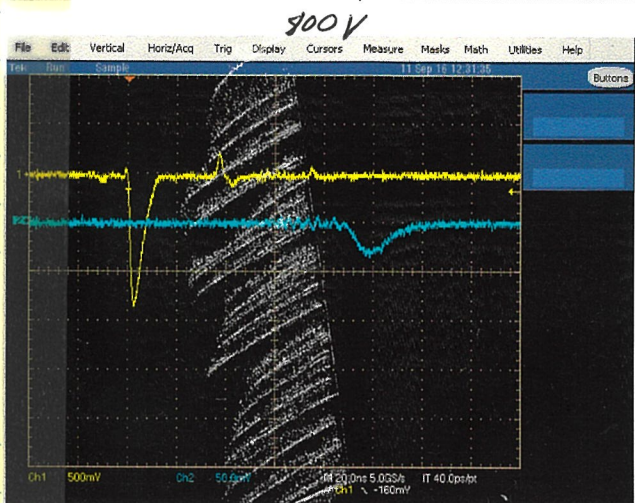
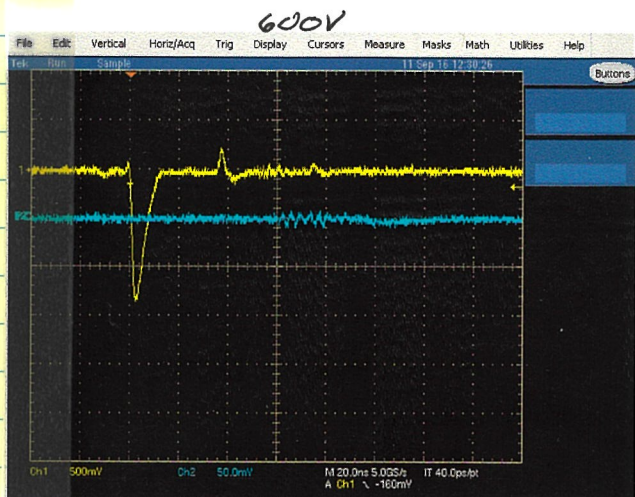
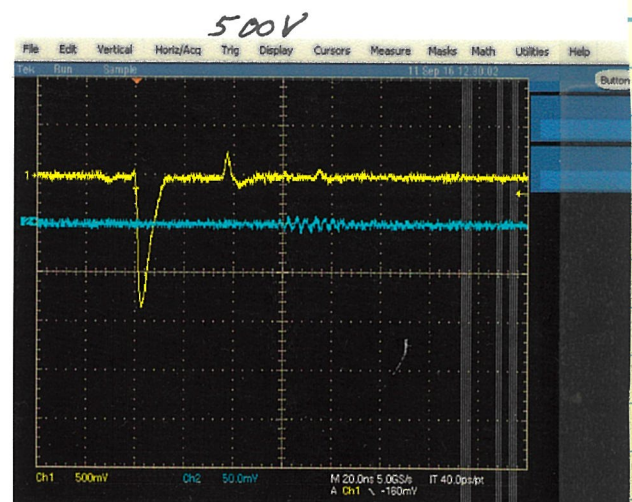
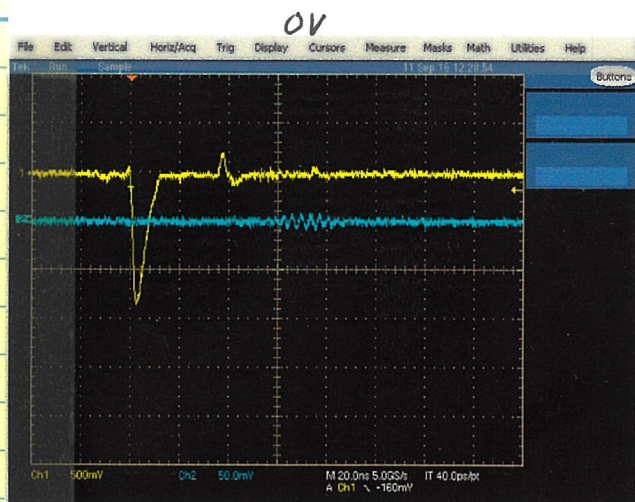
I changed the divider chain of my active base for the XP2262 PMT.

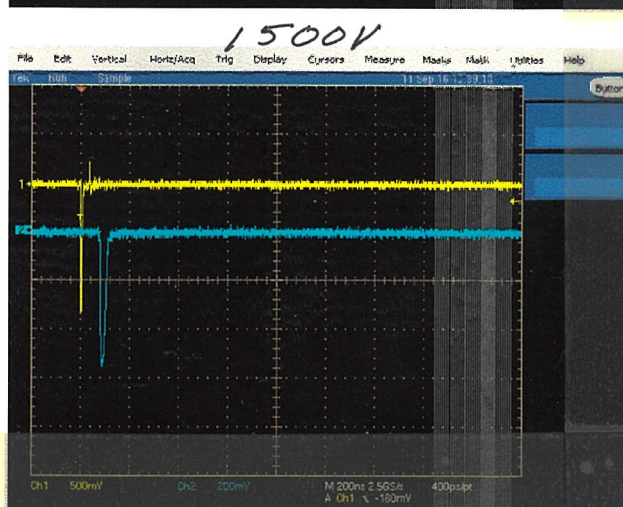
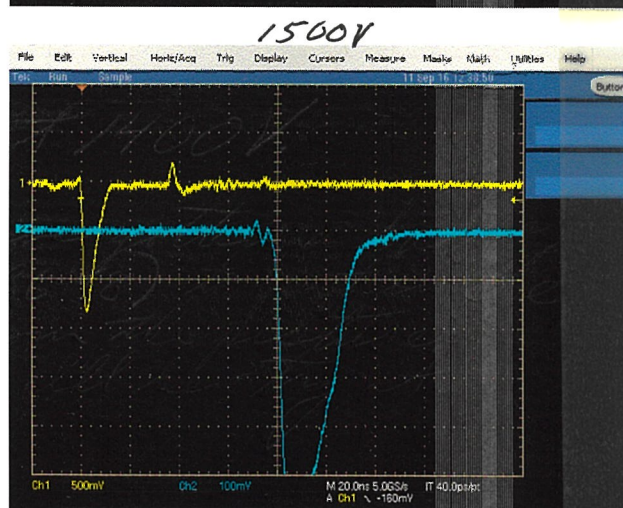
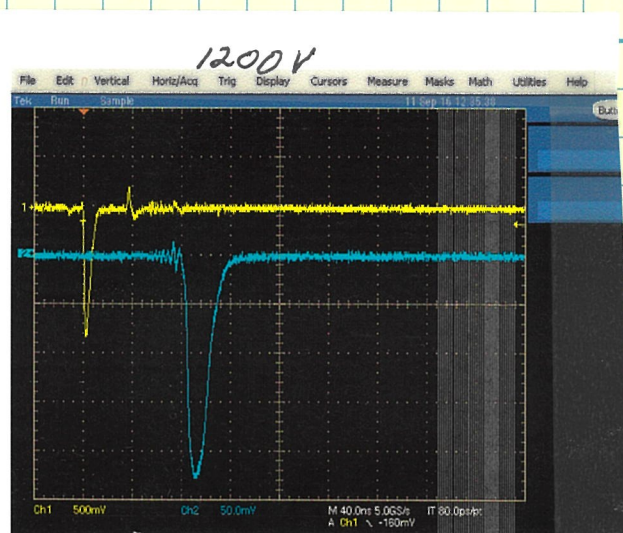
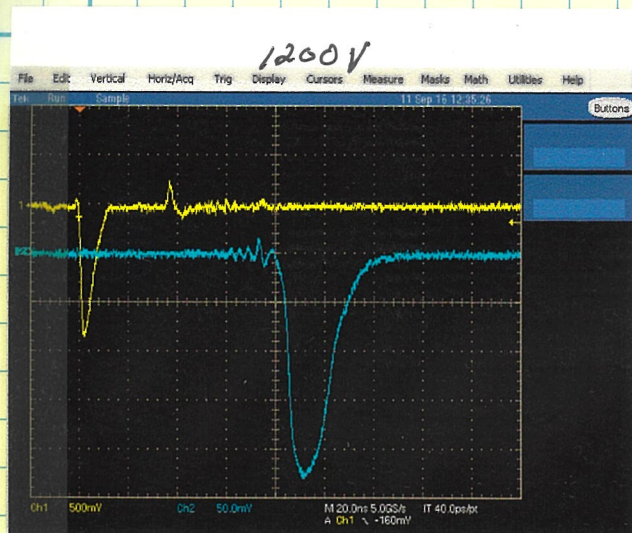
I had used all 1M Ω resistors. I had forgotten I had ordered some 1.1M and 909K resistors, to make the "high gain" version per the Photonix datasheet.

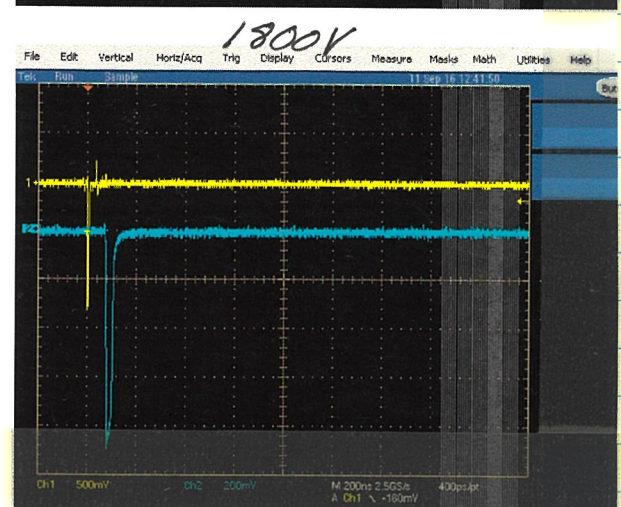
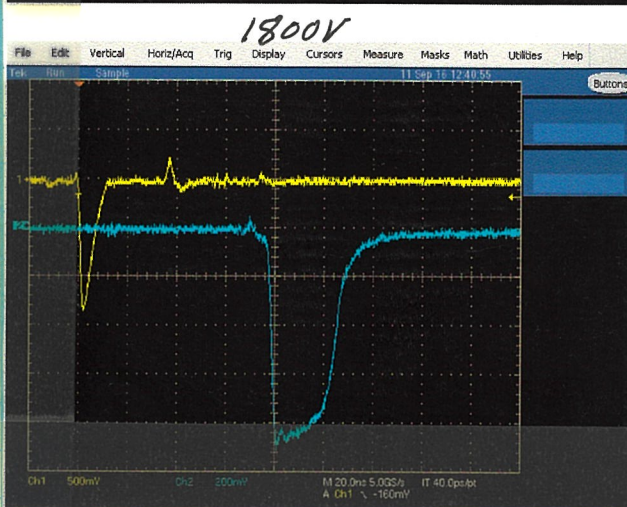
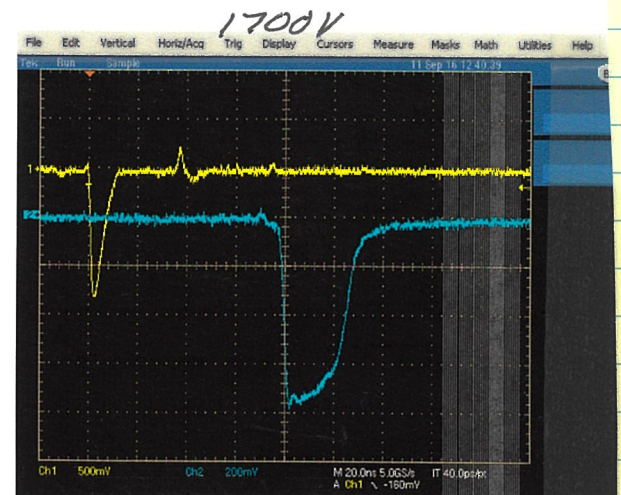
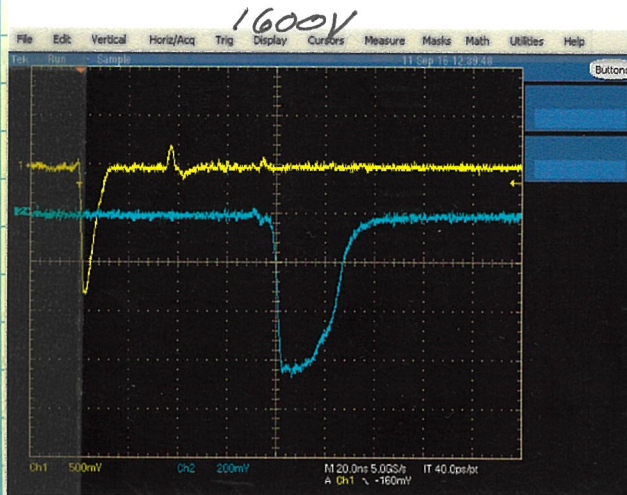
I put a 1/M between D1 & D2. 90°K between D2 & D3.



Cable lengths/times are not well defined.
The cabling was not altered at any time.







Current draw on HV module's display.

Volts	mA
500	.16mA
700	.22
800	.25
900	.27
600	.19
500	.16
1000	.30
1100	.33
1200	.36
1300	.39
1400	.42
1000	.30
1500	.45
1600	.48
1700	.50-.51
1800	.53

9/12/16 A Look At An XP2020 From Hall C

JS

Simona brought over one of the XP2020 (SN 42318) PMTs she is having problems with.

We looked at a few tubes and bases, just to observe some behaviors.

Hall C is using an ET resistive base. ~~with an amplifier in series with the divider chain.~~ No amplifier. The additional amplifier is in the base for the Gas Cerenkov PMT for the HMS.

The ET base for the XP2020 uses +HV.

At one point we noted abrupt changes in the output pulse heights which lasted for a couple of seconds. I got a Photonix VD124 -HV resistive base that was lying around. I did not note this behavior with the Photonix base.

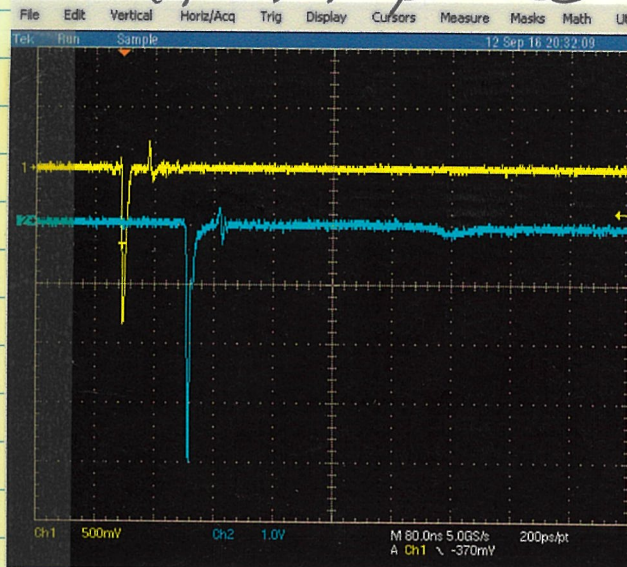
I wanted to verify the source of some of the "features" in the scope traces by adding some extra cable in series on the lines.

All pictures are at 1400V.

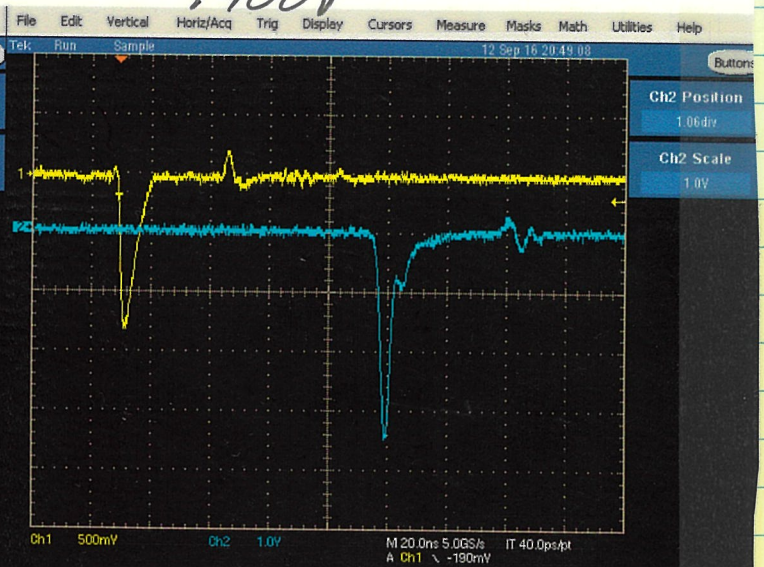
I think I may have gotten a bad 29ms "Pomona" BNC cable (RG-58) to put in the PMT path, judging from the pictures. If I get a chance I'll re-try it.

18)

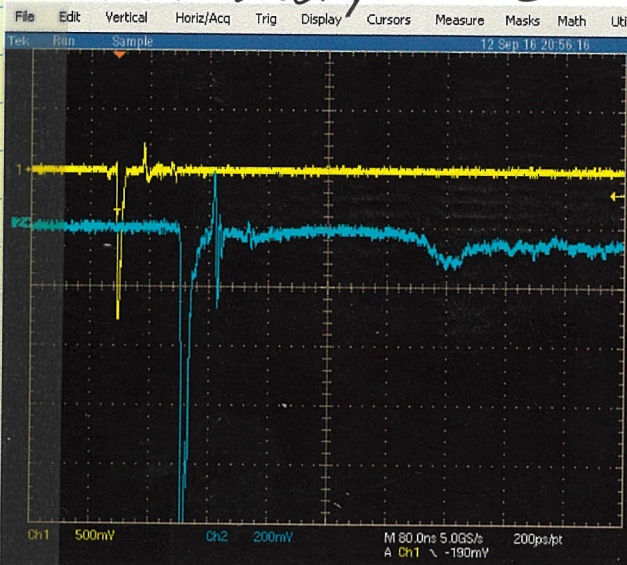
1400V 1st picture



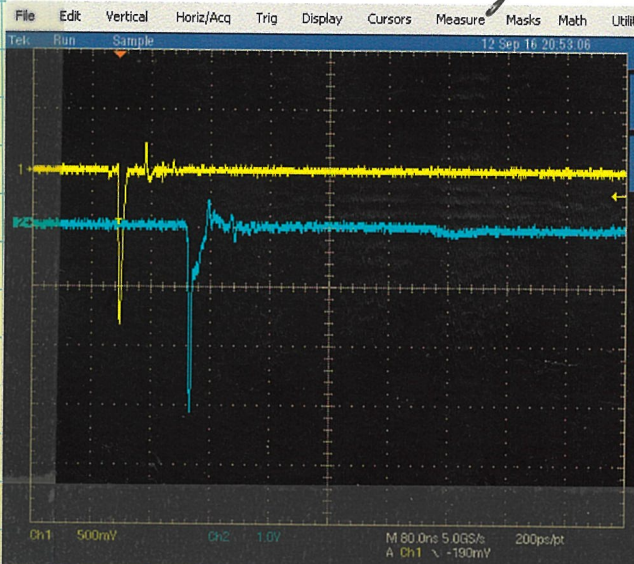
1400V



1400V last picture

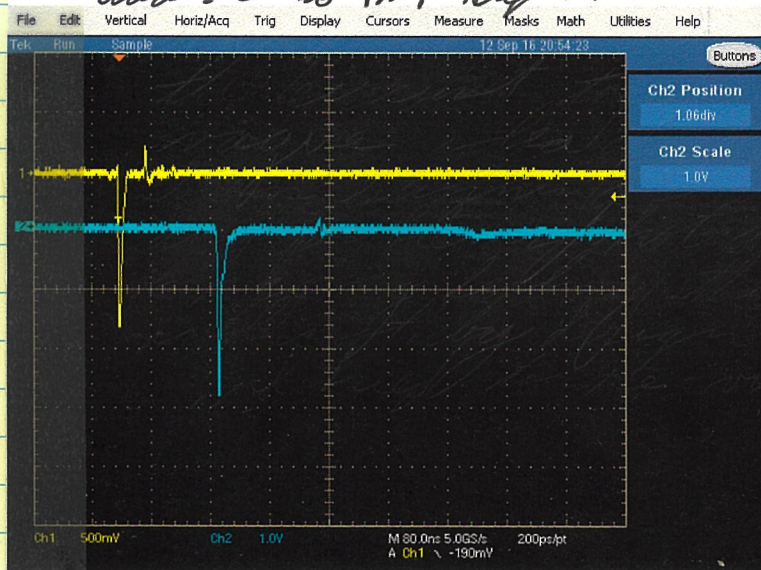
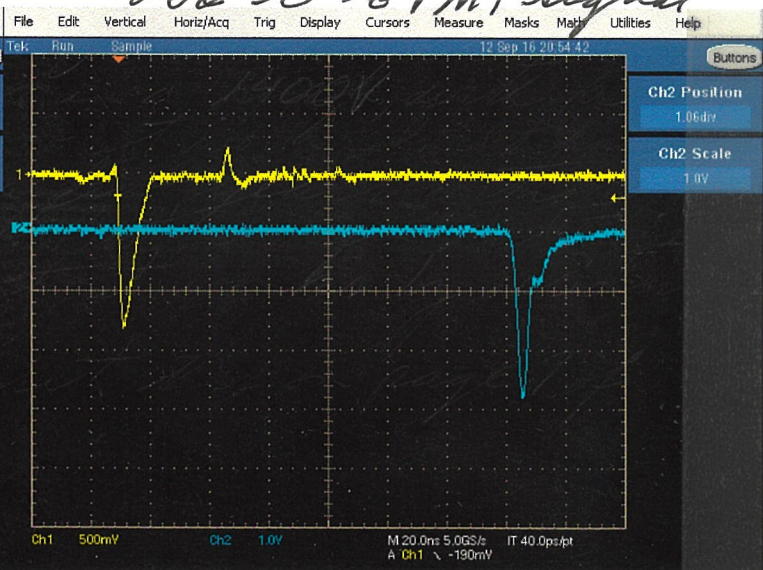
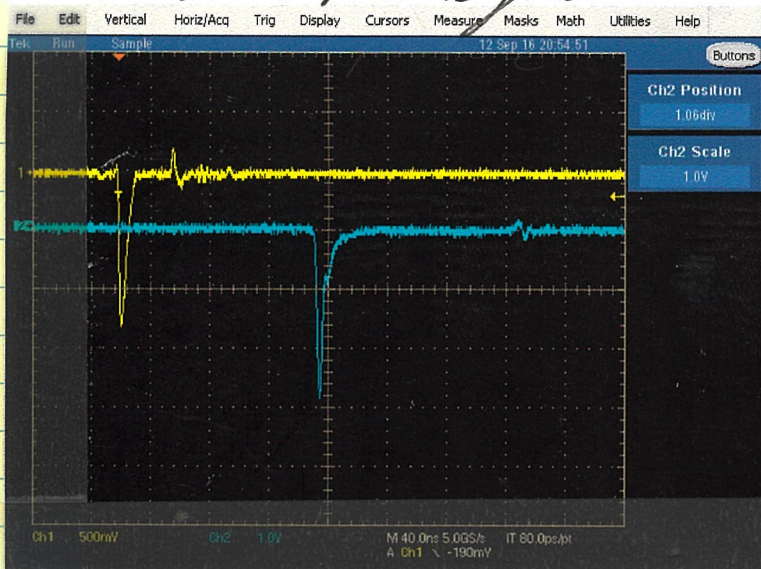
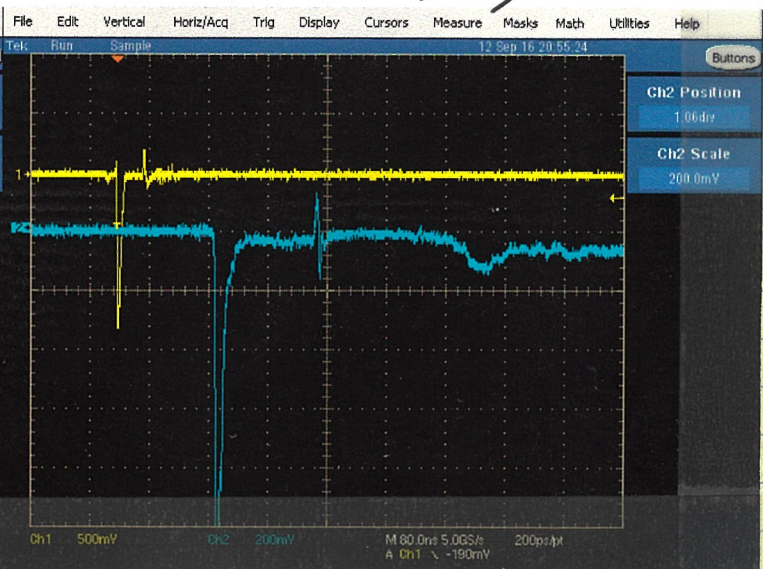
adding bad cable ???
adding 8ms to PMT signal

adding 8ms to PMT signal



adding 8ms to pulser trigger



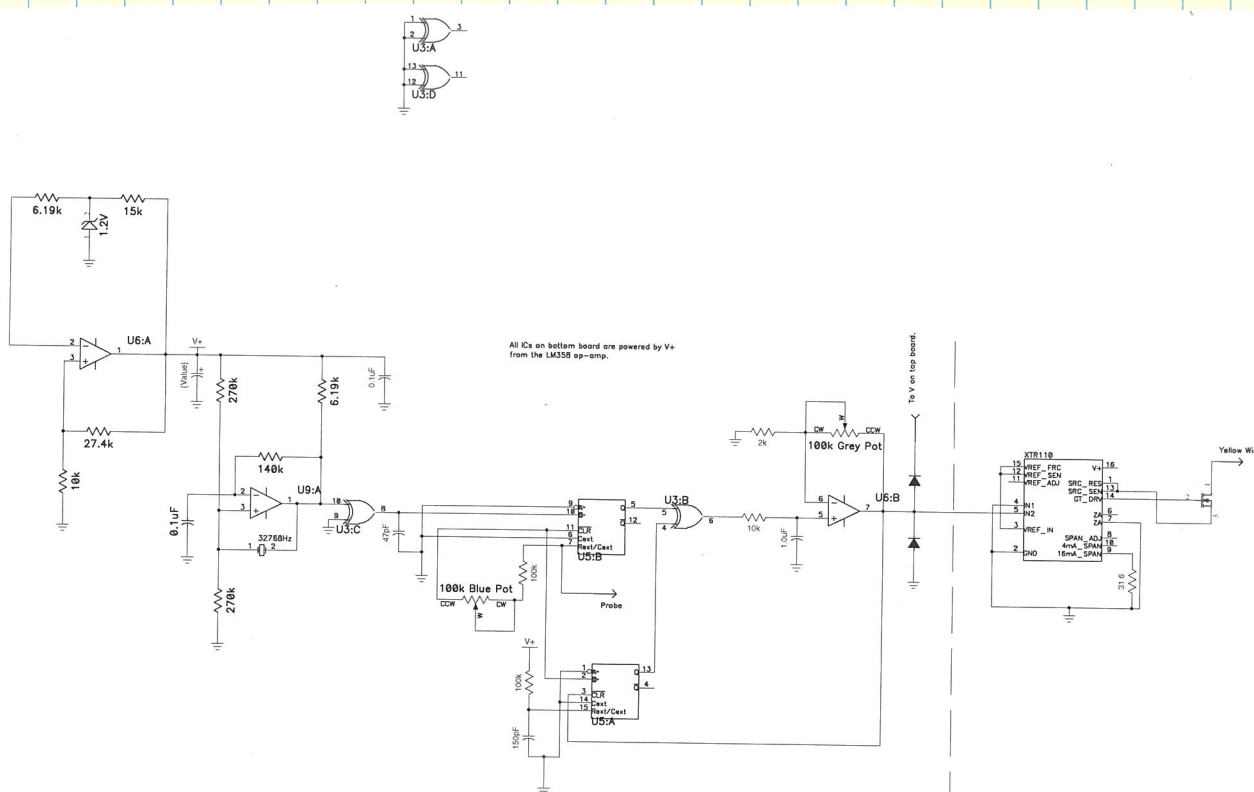
add 30' to PMT signal*add 30' to PMT signal**add 30' to PMT signal**add 30' to PMT signal*

HMS Dipole LN_2 Level Probe Circuit 10/22/16

Hall C had a LN_2 level probe that was not working. It looks like a "home made" job from ELIN??

I bought IC's to replace everything.

Below is my best guess at the circuit.
I did not have time to see how it
worked in detail.

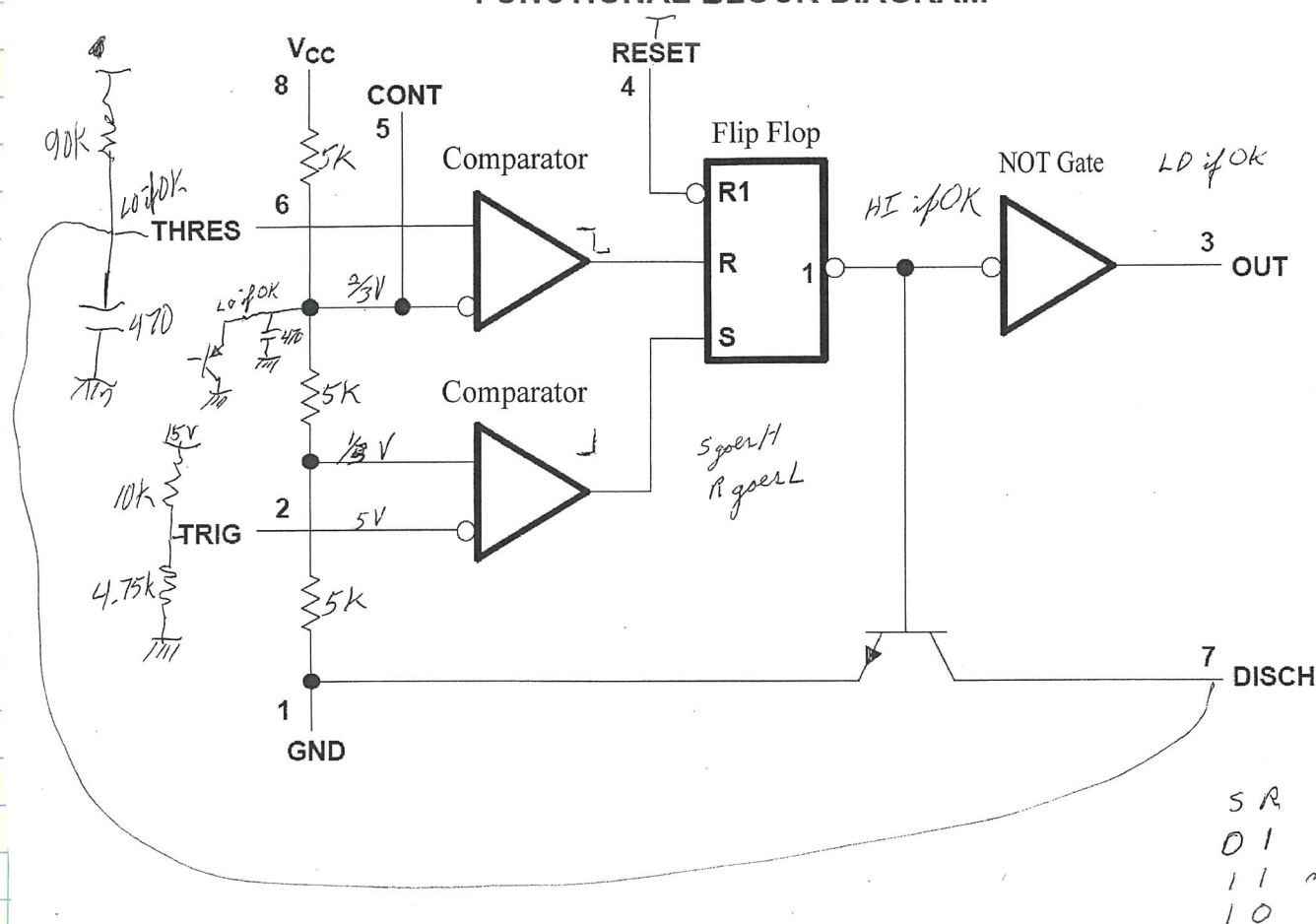


12/9/8 Looking at the 555 Monitoring Circuit

I have been using the 555 for the lead flow monitor and such. I threw the circuit together in a rush, with a vague idea of how it worked. It has been running for a few years without any problems noted. But I have had this nagging feeling that it works by accident and not by design. I tried to re-visit this on page 9 of this volume.

This is essentially how the 555 is configured.

FUNCTIONAL BLOCK DIAGRAM



I put the circuit together on a plug board. One of the kits with the supplies, buffers, and extras.

One thing which bothers me is that when all is ok both pins 5 & 6 are shorted

to go through a transistor.

Looking at p.11 of Misc. Hardware IV I note that the 555 changes output after 5 or 6 seconds.

The circuit I assembled uses a TLC555 from TI. The delay to change state is over 30 seconds. Maybe 45 seconds or so.

Although the TLC555 says it operates to 15V supply, it seems to have a problem starting around 12V. Looking at the voltage at pin 5 it stalls at $V_{CC} = 12V$ and remains at that value.

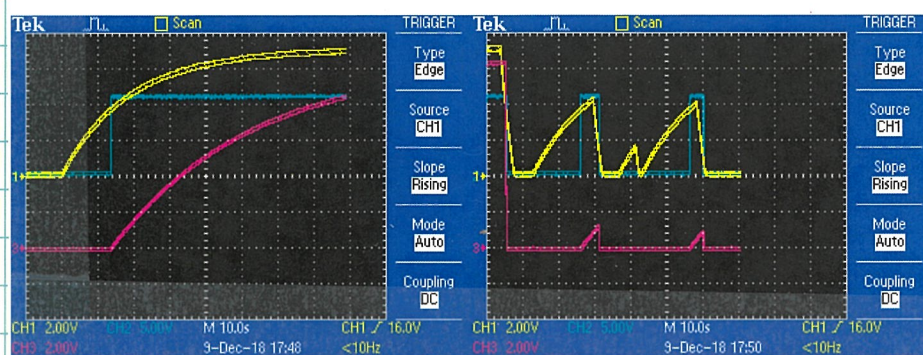
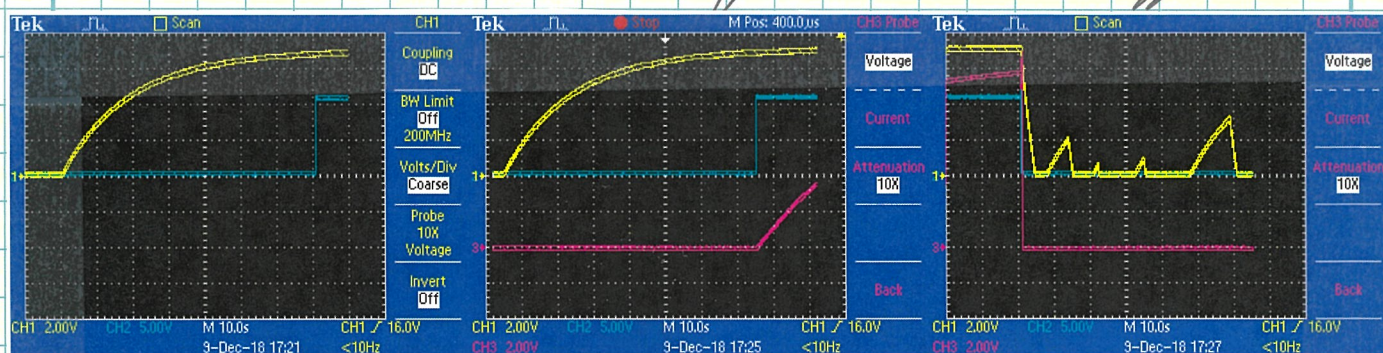
I set V_{CC} to about 10.6V.

I took a few pictures. Ch1 is pin 5
Ch2 is pin 3
Ch3 is pins 6-7

Tek0

1
2
3
4

I changed the 4.75K to 2.1K
I tried pushing the button at different times

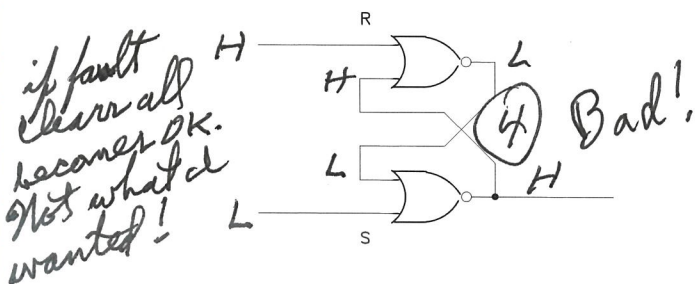
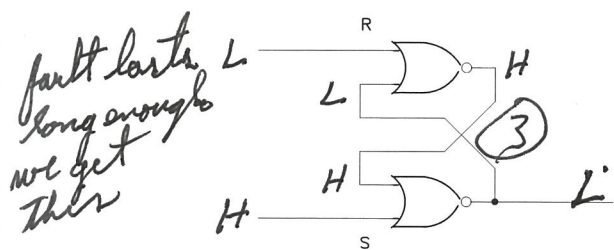
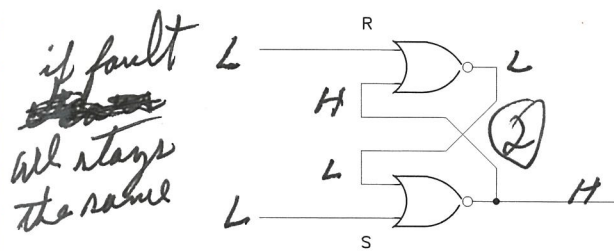
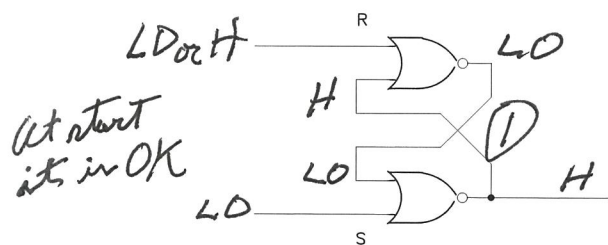


12/13/18 More Thoughts On The 555 Circuit

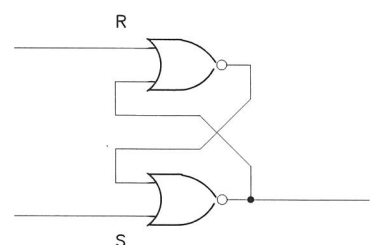
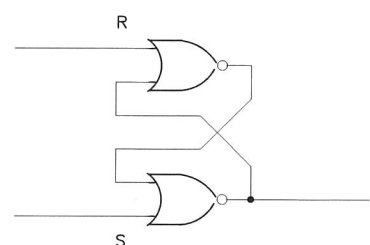
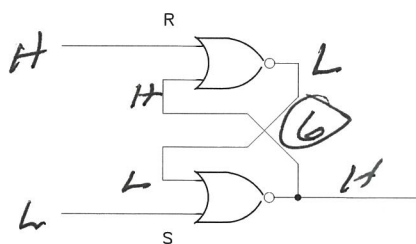
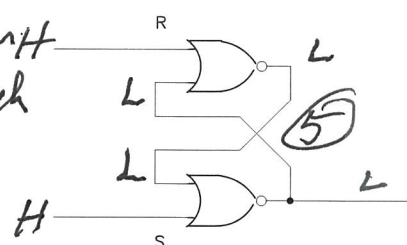
I have tried to work through the logic of the 555 circuit I used for generating a fault signal.

As far as I can tell it "works" by accident.

The sequence at the RS flip-flop section of the 555 seems to be this:



If fault doesn't clear
Eventually, when H
Thres gets high enough



I will just replace this with 2 comparators and a retriggerable one-shot. That way the threshold, time to be under threshold, and minimum output pulse width are all independent.

Remember Ken's Axiom!! "The greedy will be punished."

Measure The Pressure Drop in 100' of $\frac{1}{2}$ " Poly N_2 3/14/20
 Trying to measure the pressure drop in a $\frac{1}{2}$ " O.D. Poly-Flo tube.

I set up a N_2 cylinder with a regulator set to ~ 45 psi output.

This feeds to one of the Mass Flow Controllers on the small portable gas mixing system.

All the manual valves are open.

MFC 1 is capped off.

MFC 2 is connected to the N_2 cylinder.

Gas flow is controlled by the MFC 2 voltage input. This is monitored with a Fluke DMM.

The gas exits the mixer through a short piece of $\frac{1}{2}$ " polyflow, through an adapter to $\frac{1}{2}$ " polyflo.

After a short piece of $\frac{1}{2}$ " poly-flo is a $\frac{1}{2}$ " "T"

Each "T" is a push-to-fit with ~~a~~ adapters on the "T" to connect on ~ 4 " Tygon tubing that has an adapter. MPRLS ported pressure sensor breakout board. The sensor is a Honeywell IZC 0-25 psia range 24 bit sensor.

The output of the "T" is connected to a new spool of 500 ft. $\frac{1}{2}$ " O.D. polyflow.

The end of the spool connects to three "T" push-to-fit fittings spaced apart by ~ 4 " pieces of $\frac{1}{2}$ " poly-flo.

The output of the third "T" is connected another new spool of 500 ft of $\frac{1}{2}$ " poly-flo.

I used a "T" with a plug and a short piece of $\frac{1}{8}$ " tubing to put a Seniors SFM3000-200-C mass flow sensor to the final end of the second spool.

So, I set the flow with the MFC, read the pressure at the start and middle of 100 ft of $\frac{1}{2}$ " poly-flo, and measure the flow out the end of the 100 ft of poly flo.

After a few ~~prob~~ programming problems, I'm good to go.

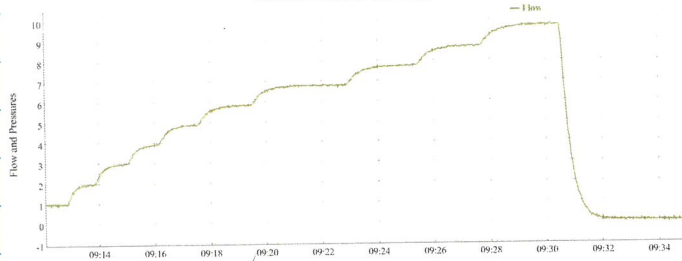
The regulator delivery pressure to the MFC is ~ 45 psi.
 The MFC takes $0 \rightarrow 5V$ for $0 \rightarrow$ full flow.
 Full flow is 10 SLM.

All the pressure and flow data are collected by a Raspberry Pi and stored in a CSV file.

MFC set voltage	From the Plot	PSI Middle	PSI Start
0.5005 VDC	1.0 SLM (data taking started at this flow)	14.46	14.50
1.0019	2.0 SLM	14.51	14.58
1.5058	2.9	14.56	14.67
2.0043	3.9	14.61	14.77
2.5051	4.9	14.67	14.88
3.0025	5.8	14.73	14.99
3.5007	6.8	14.80	15.12
4.0027	7.7	14.86	15.24
4.5010	8.7	14.94	15.38
4.9993	9.7 SLM	15.02	15.52
regulator pressure is still ~ 45 psi closed the cylinder valve & let it run down.		14.44	14.44
		$\emptyset$	

Click the check boxes to toggle data visibility

Flow and Pressures Over Time



Show Series:

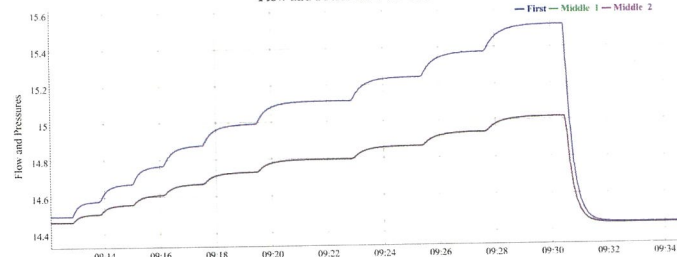
☒ Flow ☐ First ☐ Middle_1

☐ Middle_2 ☐ Middle_3

visibility = true,false,false,false

Click the check boxes to toggle data visibility

Flow and Pressures Over Time



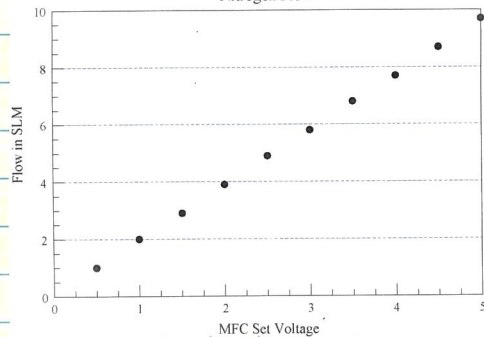
Show Series:

☐ Flow ☒ First ☒ Middle_1

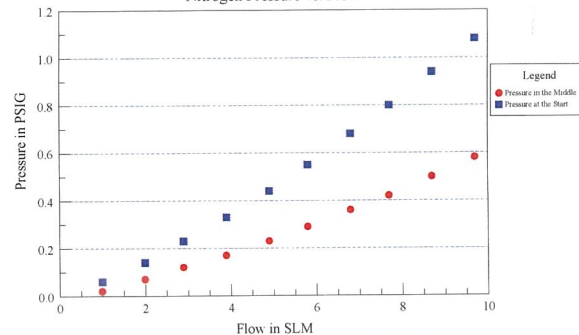
☒ Middle_2 ☐ Middle_3

visibility = false,true,true,true,false

Nitrogen Flow



Nitrogen Pressure vs. Flow



N_2 + Ar Pressure Drops in 1000' of $\frac{1}{2}$ " Poly Tubing 3/15/20
 Back at it with the gas flow. JS

I connected both MFC's in parallel.
 a separate DMM reading each set
 voltage.

Start with N_2 .
 Cylinder is valved off at start.
 Both MFC's are set to 0.5 V.
 Cylinder valve opened and then proceed.

MFC 1	MFC 2
0.5030	0.502
1.0085	1.006
1.5004	1.504
2.0083	2.004
2.5054	2.507
3.0162	3.004

The flow looks too low. Valve "stuck"?
 Power cycled I-ZC bus & restarted program.
 still low.

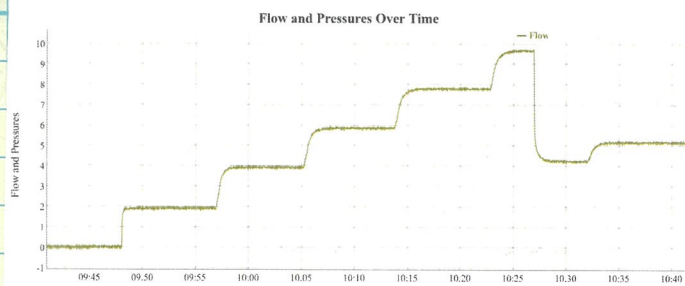
Ah! The small tygon tube came off the first
 of the middle sensors. The plug board rotated
 around the tube & the tygon tube came off. Put
 things back in place.

Let the program run a bit.
 Stopped the program, again.

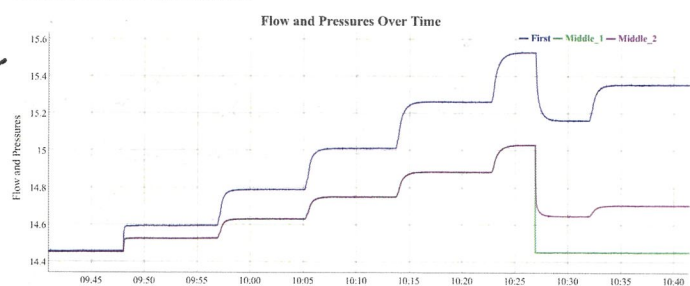
2.5064	2.506
2.0182	2.007

N_2 cylinder valve closed and things allowed to
 bleed down.

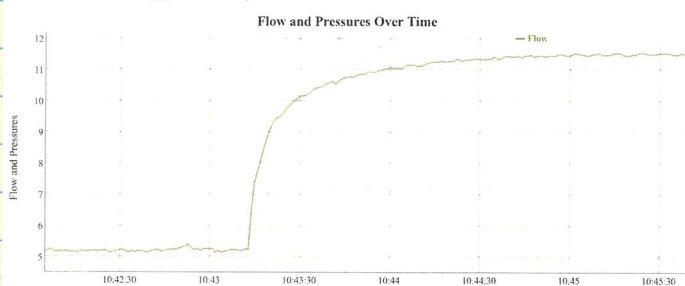
Click the check boxes to toggle data visibility



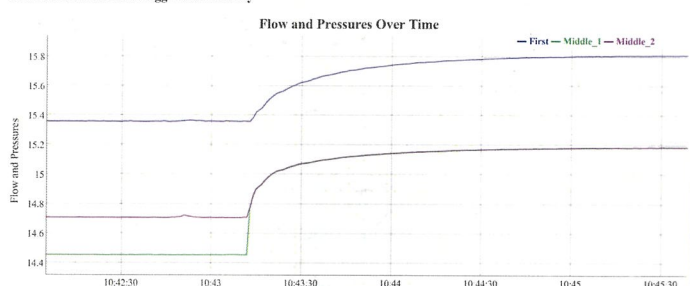
Click the check boxes to toggle data visibility



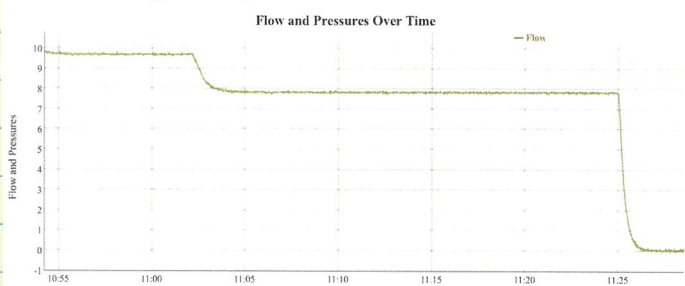
Click the check boxes to toggle data visibility



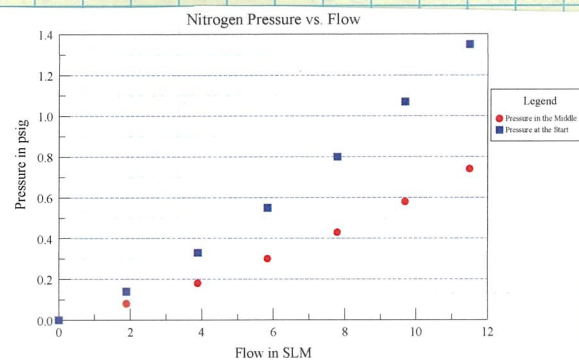
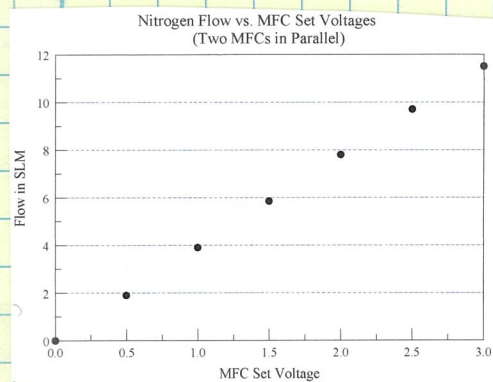
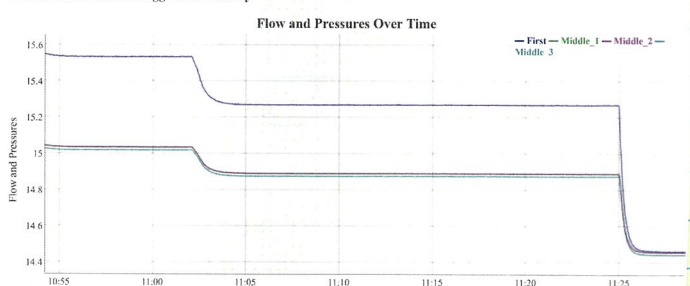
Click the check boxes to toggle data visibility



Click the check boxes to toggle data visibility



Click the check boxes to toggle data visibility

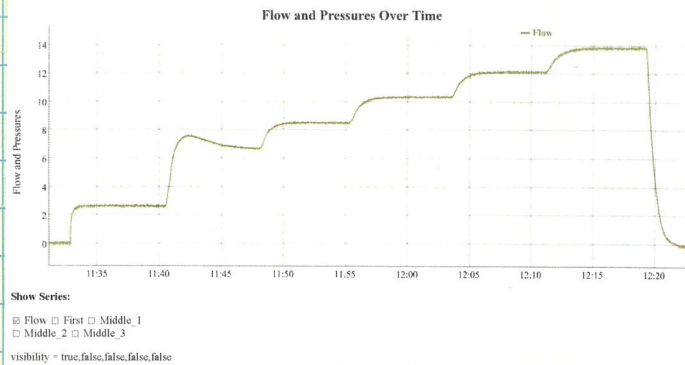


Change to Argon.
 Start with the gas cylinder closed.
 Both MFCs are set to 0.5 V.
 Cylinder valve opened and then proceed.

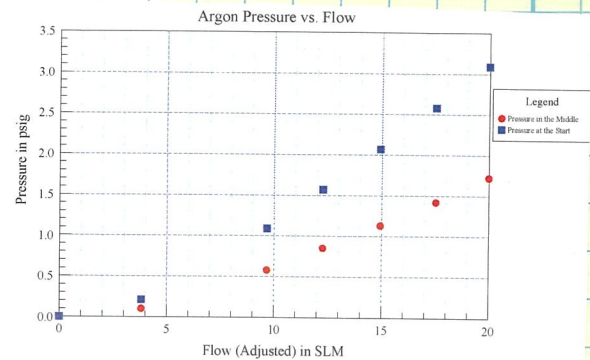
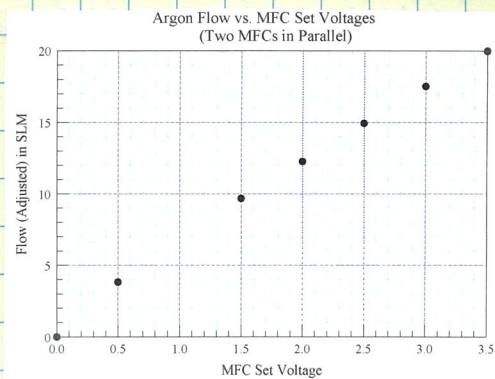
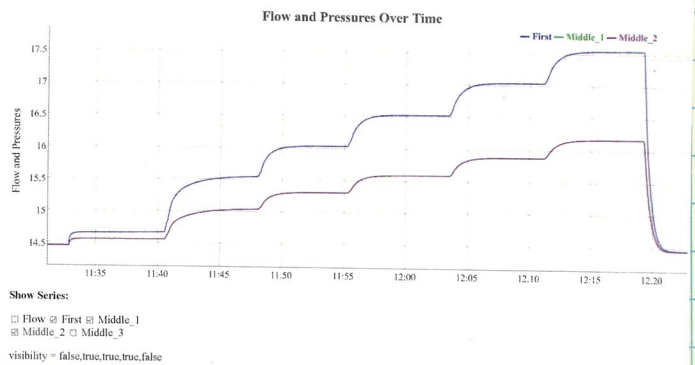
MFC1	MFC2	SLM	psig _{Start}	psig _{Middle}	SLM (Adjusted)
0.5003	0.500	0	14.46	14.46	0
0.5003	0.500	2.65	14.67	14.56	3.82
1.5036	1.506	6.70	15.55	15.04	9.67
2.0047	2.002	9.5	16.03	15.31	12.27
2.5072	2.502	10.35	16.53	15.59	14.94
3.0200	3.013	12.14	17.04	15.88	17.52
3.5057	3.503	13.85	17.55	16.18	19.97

The regulator is cold but seems to be working.
 Cylinder valved off.

Click the check boxes to toggle data visibility



Click the check boxes to toggle data visibility



3/7/20 MFC Drive Voltage For Ar/CO₂ 70%/30%

Thinking a bit about 1/2" poly-flu and the GENi gas mixing system.

1/2" O.D. Poly Flu has 0.376" I.D.

$$1 \text{ ft}^3 = 28 \text{ L} \quad (\text{actually } \sim 28.3 \text{ L}) \quad \Rightarrow 0.111 \text{ in}^2$$

$$1728 \text{ in}^3 / 28 \text{ L} = 61.7 \text{ in}^3/\text{L}$$

$$0.111 \text{ in}^2 \Rightarrow 556 \text{ in}^3/\text{L} \quad (550 \text{ in}^3/\text{L})$$

$$100 \text{ ft} = 12000 \text{ in.} \Rightarrow 21.58 \text{ L in } 100 \text{ ft of tubing}$$

(21.8 L)

$$3.79 \text{ L/gal}$$

$$30 \text{ gal} = 114 \text{ L for GENs' buffer tank}$$

$$15 \text{ psig to } 13 \text{ psig} \Rightarrow 13.3\% \text{ change}$$

$$13.3\% \text{ of } 114 \text{ L is } 15.2 \text{ L}$$

The MFCs I got for this are 15 SLM of N₂

The correction factors for:

$$\text{Argon is } 1.443$$

$$\text{CO}_2 \text{ is } 0.745$$

for x SLM of mixture flow

$$0.7x = r_a \cdot 1.443 \quad (r_a \text{ is MFC setting for } \text{Ar})$$

$$0.3x = r_c \cdot 0.745 \quad r_c$$

$$r_a = \frac{0.7}{1.443} x = 0.4851 x$$

$$r_c = \frac{0.3}{0.745} x = 0.4027 x$$

$$\text{From } 0 \rightarrow 5 \text{ V} = 0 \rightarrow 15 \text{ SLM}$$

if we want Ar flow at 14 SLM of N₂
it will be

$$\frac{14 \cdot 5 \text{ V}}{3} = 9.6 \text{ SLM}$$

$$x \text{ will be } \frac{14}{0.4851} = 10.97 \text{ SLM}$$

I'm not sure where I'm making the mistakes.

We want a total flow of x SLM
 0.7 in Ar
 0.3 in CO_2

Set maximum Ar flow be 14 SLM of N_2
 (as the MFC is set)

$$r_a = 14 \text{ SLM of } \text{N}_2$$

14 SLM of N_2 on the MFC means
 $14 \cdot 1.443$ SLM of Ar

$$14 \cdot 1.443 = 20.202 \text{ SLM of Ar}$$

★ So, $20.202 = .7x$
 $\rightarrow x = 28.86 \text{ SLM of Ar/CO}_2 \text{ 70/30}$
 $.3x = 8.658 \text{ SLM of CO}_2$

$$r_c \cdot 0.745 = 8.658 \text{ SLM of CO}_2$$

where r_c is the flow rate of
 N_2 on the MFC

$$r_c = 11.62 \text{ SLM of } \text{N}_2 \text{ (setting on CO}_2 \text{ MFC)}$$

This gives, for the set voltages for the MFC's

$$\frac{14}{3} = 4.67 \text{ V for the Ar MFC}$$

$$\text{and } \frac{11.62}{3} = 3.87 \text{ V for the CO}_2 \text{ MFC}$$

We have a buffer of 30 gal = 114 l + 21.58 l (in 1000' tubing)

$$114 + 21.58 \approx 136 \text{ l}$$

13.3% of 136 l is 18 l
 if flow is 12 SLM then drop occurs in 1.5 minutes
 Fill is at $28.86 \text{ SLM} - 12 \text{ SLM} = 16.86 \text{ SLM}$
 $18 \text{ l} \div 16.86 \text{ SLM} = 1.07 \text{ minutes}$
 $\sim 50\%$ duty cycle expected.

3/2/20 CO₂ Pressure Drop In 100' of 1/2" Poly Tubing

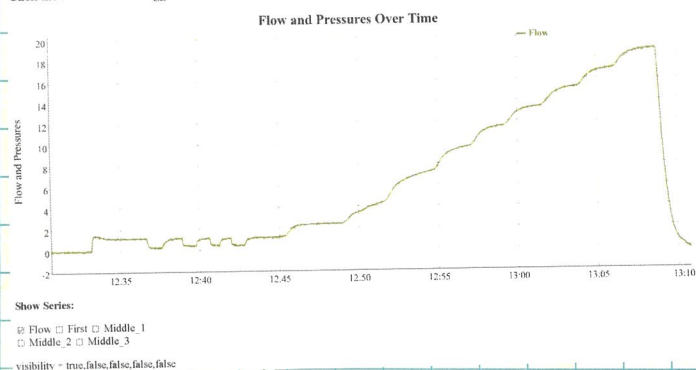
Thursday evening I did a quick run of straight CO₂. It turned out I went a bit too fast. But, I'm putting it in here because I stepped through the pressure sensors and pulled the small Sygon tube off them one at a time. I started with the one at the start of the 100' of tubing and went through them in order.

Started with the MFCs set to 0.5V and the ~~cylinder~~ cylinder valve closed.

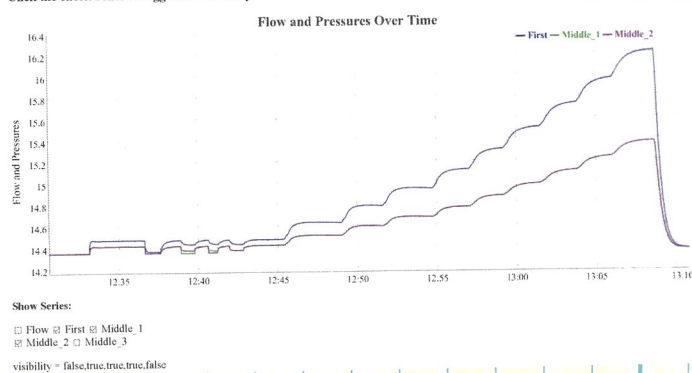
Cylinder valve opened.

MFC1	MFC2	SLM	psia start	psia middle	SLM (adjusted)
0.5042	0.500	1.23	14.47	14.42	
		pull tubes off pressure sensors one at a time from start toward end.			
1.0087	1.000	1.23			
1.5022	1.502	2.4			
2.0103	2.003				
2.5026	2.507				
3.0082	3.002				
3.5040	3.502				
4.0278	4.008				
4.5063	4.507				
5.0000	4.996	18.9	16.22	15.37	
cylinder valve closed					

Click the check boxes to toggle data visibility



Click the check boxes to toggle data visibility



Redoing CO₂ Pressure Drop

3/21/20

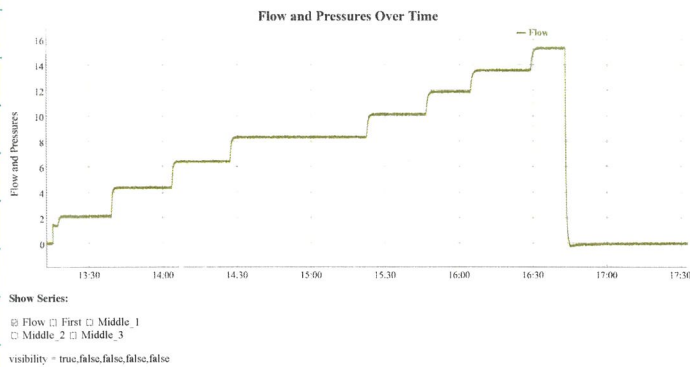
Re-doing the CO₂ measurements from yesterday.

	MFC1	MFC2	SLM	psia start	psia middle	SLM (adjusted)
open valve	0.5041	0.5000	2.14	14.44	14.39	
	1.0095	1.005	4.43	14.57	14.46	
	1.5031	1.509	6.43	14.72	14.54	
	2.0127	2.001	8.34	14.89	14.63	
	2.5082	2.503	10.14	15.07	14.72	
	3.0145	3.003	11.91	15.27	14.83	
	3.5042	3.505	13.6	15.47	14.93	
	4.0020	4.006	15.31	15.68	15.05	

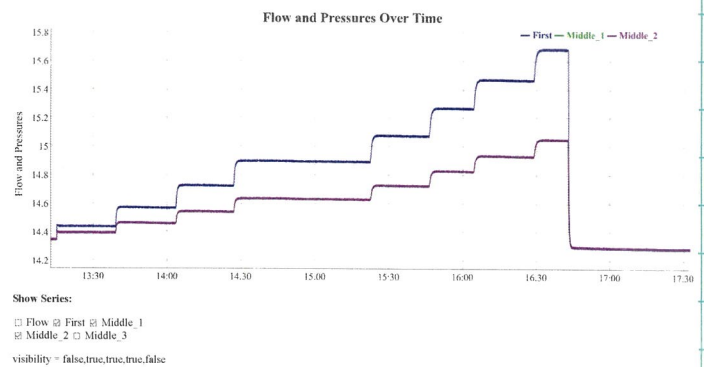
Cylinder valve closed.

Regulator has ice on the back end.

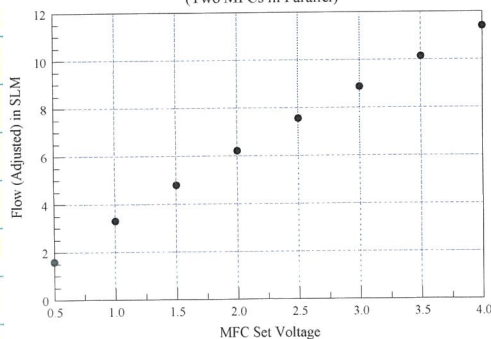
Click the check boxes to toggle data visibility



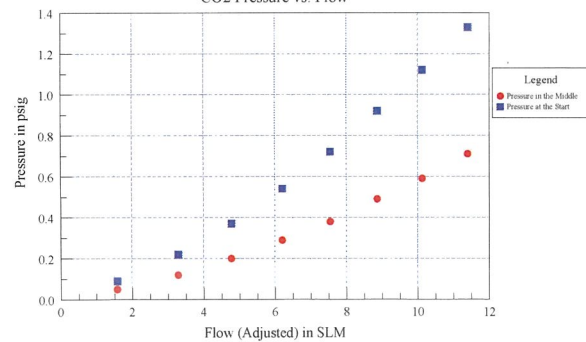
Click the check boxes to toggle data visibility



CO₂ Flow vs. MFC Set Voltages
(Two MFCs in Parallel)



CO₂ Pressure vs. Flow



3/21/20 Ar/CO₂ 75%/25% & 70%/30% Pressure Drop

Measuring the pressure drop for
Ar/CO₂ 70%/30%.

Correction factors are: Ar is 1.443
CO₂ is 0.745
if x is SLM

$$.7x = r_a \cdot 1.443$$

$$.3x = r_c \cdot 0.745$$

$$r_a = \frac{.7}{1.443} x = 0.4851 x$$

$$r_c = \frac{.3}{0.745} x = 0.4027 x$$

Desired voltage settings will be $\left(\frac{0 \rightarrow 25V}{2} \text{ for } \frac{0 \rightarrow 10 \text{ SLM}}{2} \right)$

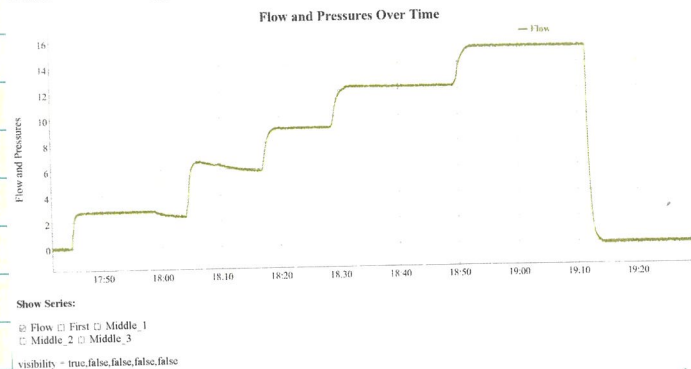
x	r_a	r_c
2 x	0.4851	0.4027
6 x	1.4553	1.2081
10 x	2.4255	2.0135
14 x	3.3957	2.8189
18 x	4.3659	3.6243

Argon cylinder to MFC 1. CO₂ cyl. to MFC 2
Start with cylinders valved off.

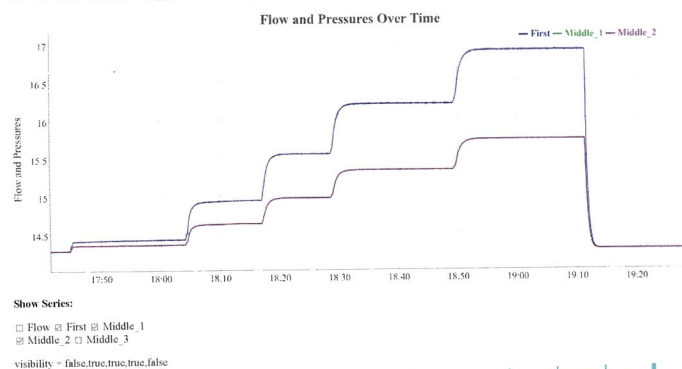
Ar MFC 1	CO ₂ MFC 2	SLM	psia start	psia middle
0.4897	0.401	2.8	14.29	14.29
0.4897	0.401	2.83	14.43	14.36
1.4533	1.208	5.86	14.94	14.63
2.4252	2.014	9.11	15.55	14.97
3.3965	2.820	12.23	16.20	15.33
4.3602	3.624	15.26	16.91	15.73

cylinders valved off.

Click the check boxes to toggle data visibility



Click the check boxes to toggle data visibility



Measuring the pressure drop for Ar/CO₂ 15g/25g
 $rc = \frac{0.75}{1.443} K = 0.5198 K$

$$rc = \frac{0.25}{0.745} K = 0.3356 K$$

Desired MFC voltage settings will be

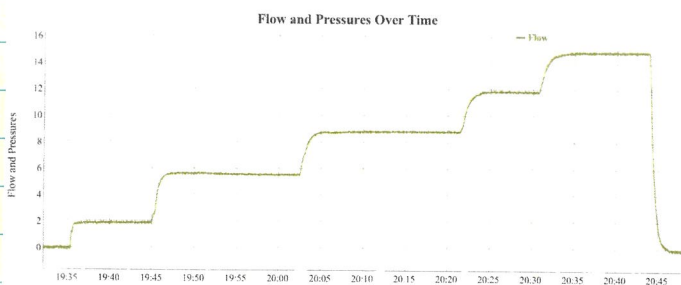
K	rc	rc
2X	0.5198	0.3356
6X	1.5593	1.007
10X	2.5988	1.678
14X	3.6383	2.349
18X	4.6778	3.020

Start with the cylinders valved off and MFCs set to first voltage.
 Open cylinder valves.

Ar	CO ₂	SLM	psia start	psia middle
MFC1	MFC2			
0.5189	0.334	1.86	14.44	14.37
1.5585	1.006	5.51	14.95	14.64
2.6004	1.678	8.83	15.56	14.98
3.6287	2.347	11.86	14.98 15.78	15.34
4.6804	3.020	14.83	16.94	15.76

cylinders valved off.

Click the check boxes to toggle data visibility

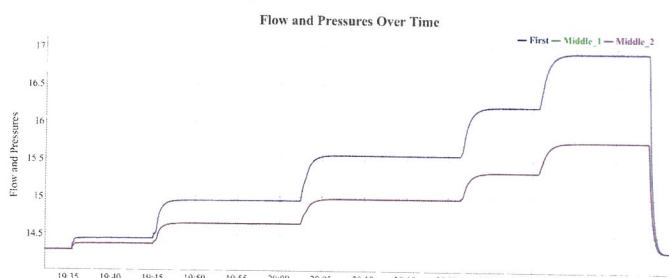


Show Series:

☒ Flow ☐ First ☐ Middle_1
☐ Middle_2 ☐ Middle_3

visibility = true,false,false,false

Click the check boxes to toggle data visibility



Show Series:

☐ Flow ☒ First ☒ Middle_1
☒ Middle_2 ☐ Middle_3

visibility = false,true,true,true,false

just to be as clear as I can be:

if we want 10 SLM of Ar/CO₂ at 70/30

$$.7 \cdot 10 \text{ SLM} = 7 \text{ SLM of Ar}$$

$$.3 \cdot 10 \text{ SLM} = 3 \text{ SLM of CO}_2$$

$$(7 \text{ SLM of Ar}) \div 1.443 = (4.85 \text{ SLM of N}_2)$$

$$(3 \text{ SLM of CO}_2) \div 0.745 = (4.03 \text{ SLM of N}_2)$$

$$0 \rightarrow 5 \text{ V for } 0 \rightarrow 10 \text{ SLM} \Rightarrow 2 \text{ SLM/V}$$

$$(4.85 \text{ SLM of N}_2) \div 2 \text{ SLM/V} = 2.425 \text{ V for Ar MFC}$$

$$(4.03 \text{ SLM of N}_2) \div 2 \text{ SLM/V} = 2.015 \text{ V for CO}_2 \text{ MFC}$$

For 18 SLM of 70/30:

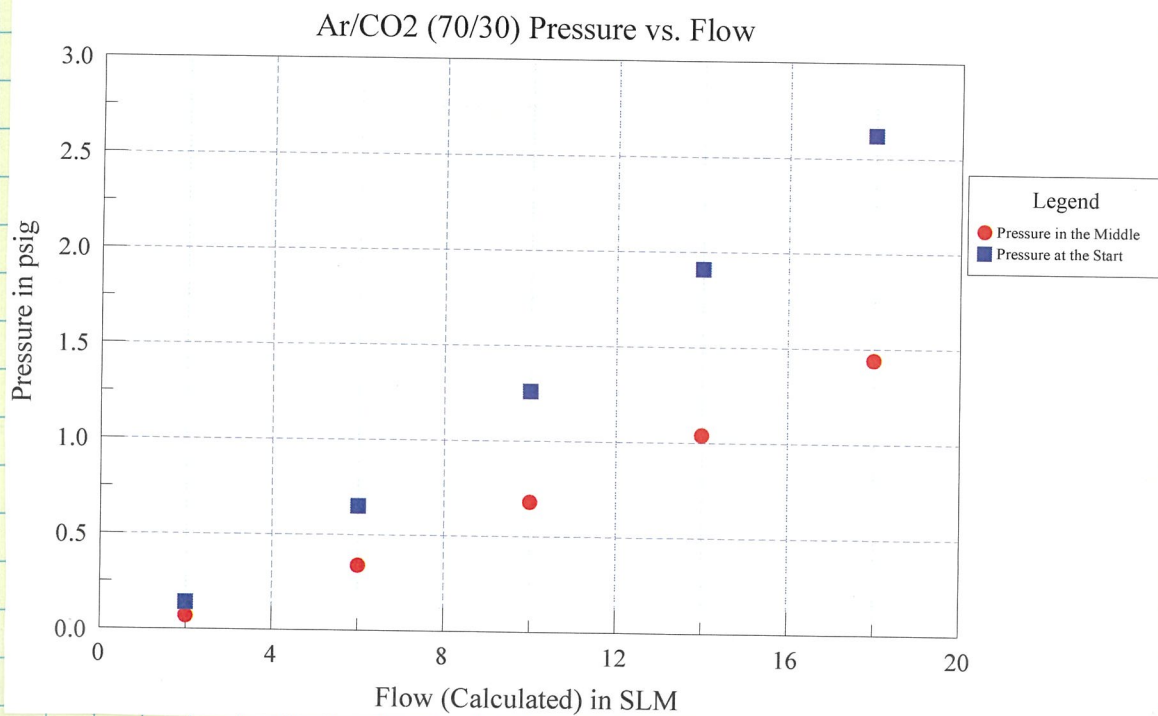
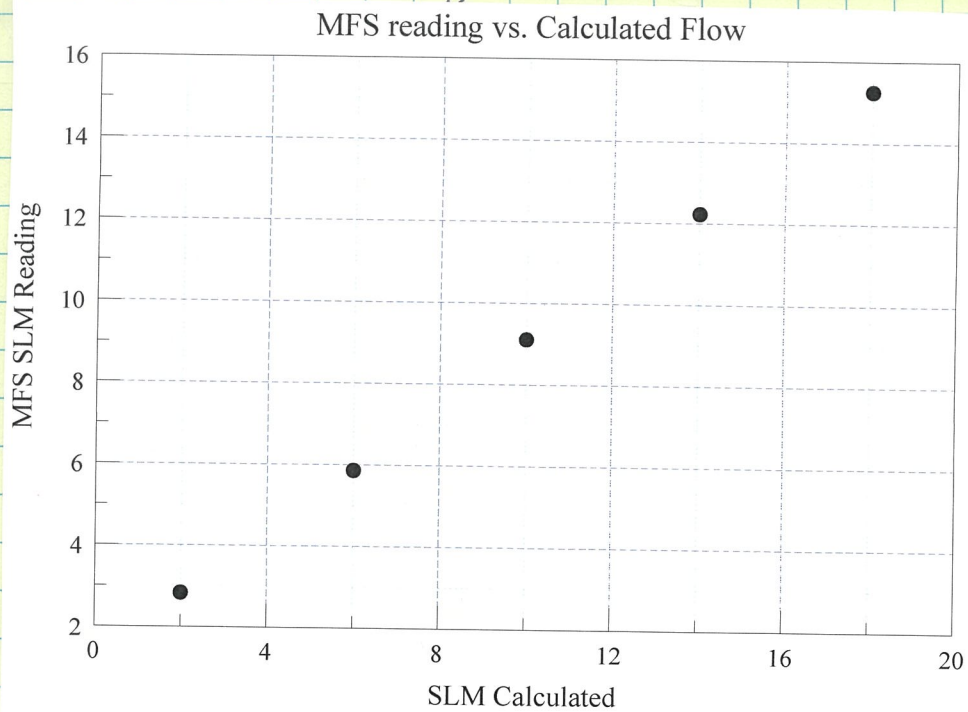
$$4.3659 \text{ for Ar MFC}$$

$$3.6242 \text{ for CO}_2 \text{ MFC}$$

Similarly for the 75/25 mixture.

I corrected the values of x in the tables on p.36 & p.37 of this volume.

Ar/CO₂ 70%/30% Pressure Drop
in 1000' of coiled 1/2" tubing.



Ar/CO₂ Pressure Drop
In 1000' of coiled 1/2" tubing.

