The One-Note Fire Organ

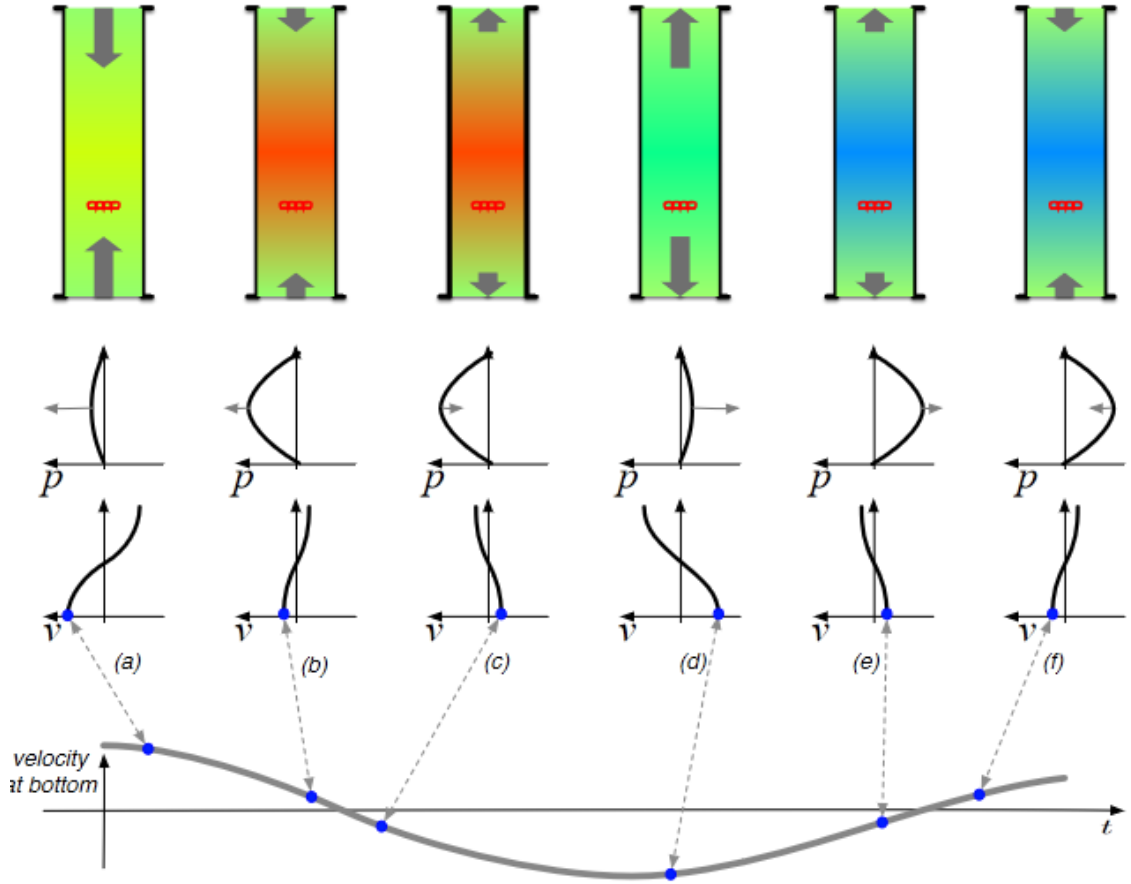
Madeleine Graham, 10/18/2021
Aerospace Engineering Undergraduate,
Georgia Institute of Technology

What is a Rijke Tube?

acoustic pressure

$$p(t) = \bar{p} + p'(t)$$

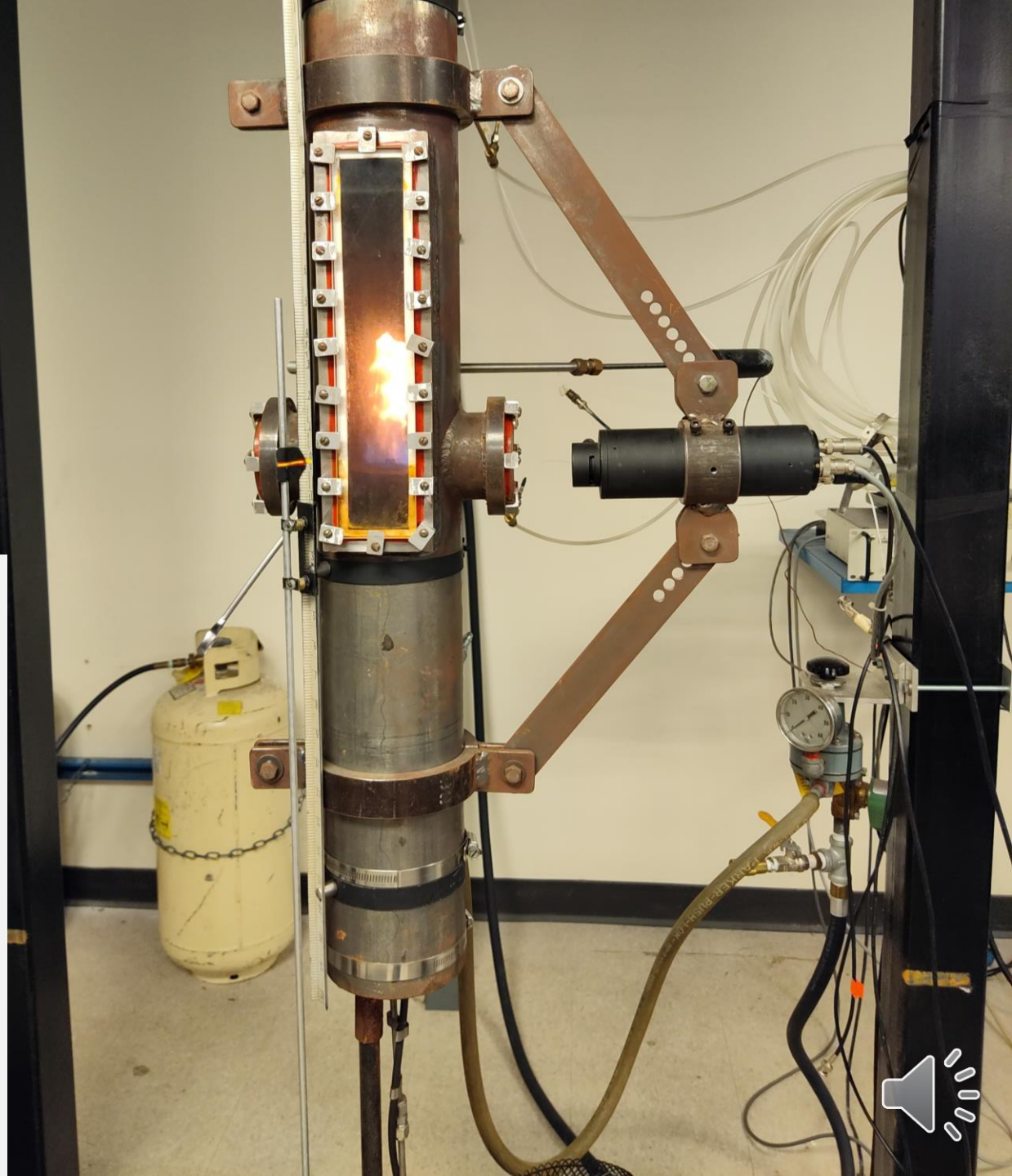
$$p'(x,t) = A(x)\sin\omega t$$



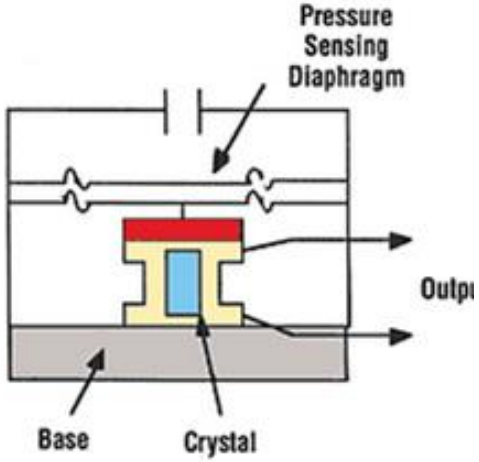
- A Rijke tube is a long tube! But it's more than that :
  - Heat source + draft = combustion
  - Heat causes air to swell, pushes up against the air around it
  - Causes pressure waves and velocity waves
  - Waves reflect and reinforce, creating a standing wave
- A Rijke tube is used for…
  - Mathematical modeling
  - Demonstrating thermoacoustic phenomena
  - maximizing effectiveness of **combustion**

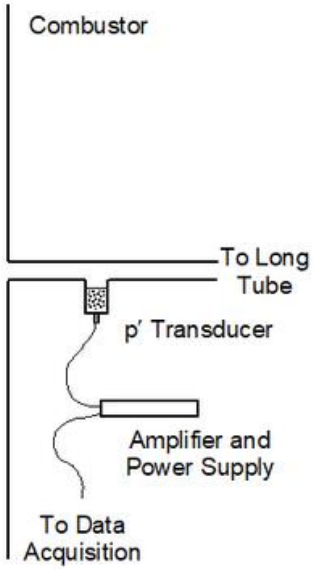
Georgia Tech’s AE2610 Approach

- The Rijke tube use at Georgia Tech
  - 72” metal tube
  - 3 Transducers, 18” apart

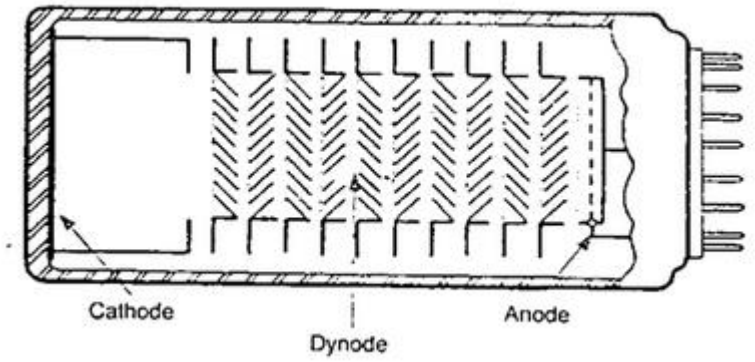


Georgia Tech's AE2610 Approach



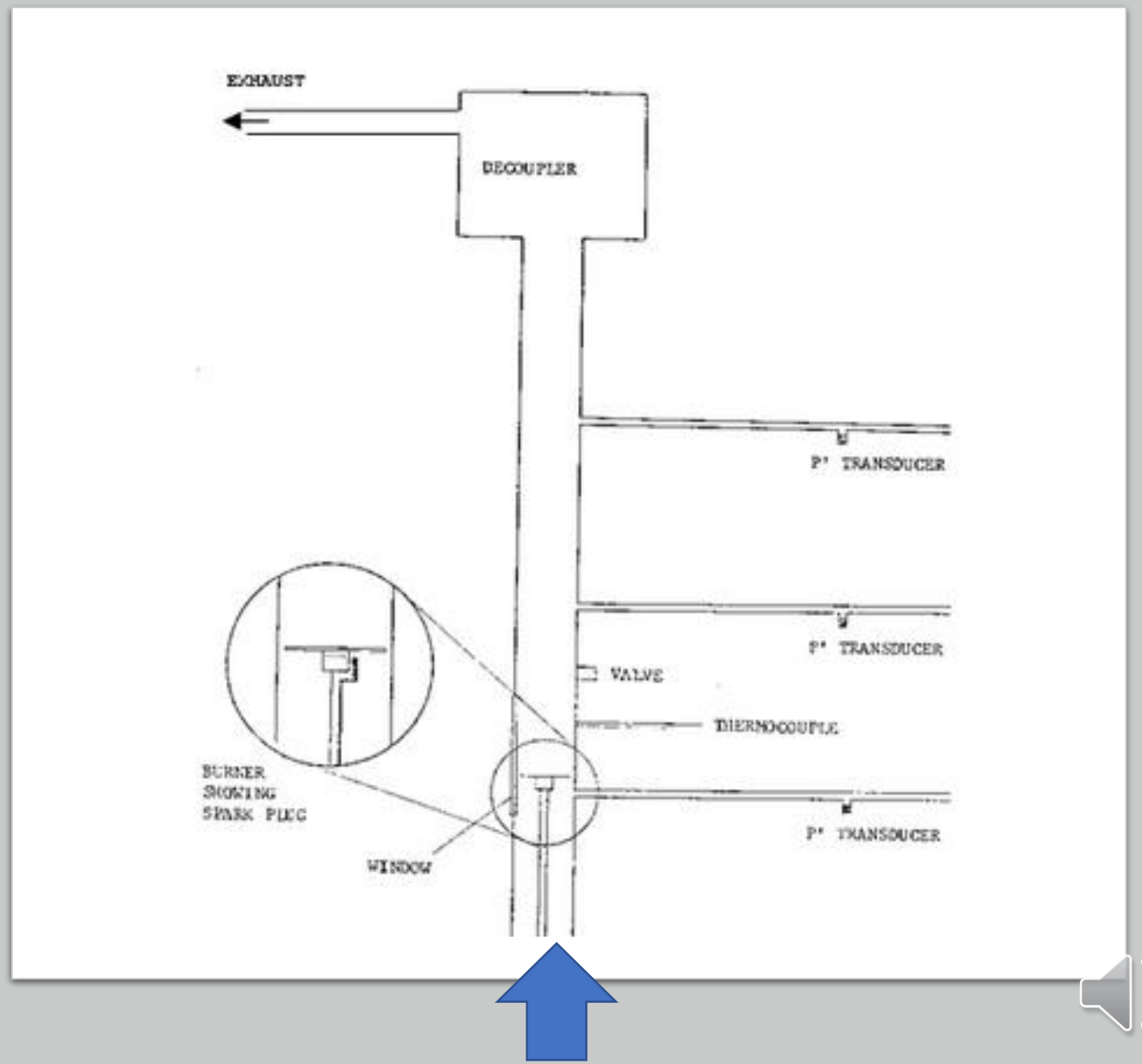


- Piezoelectric effect
- Photomultiplier



Four Modes

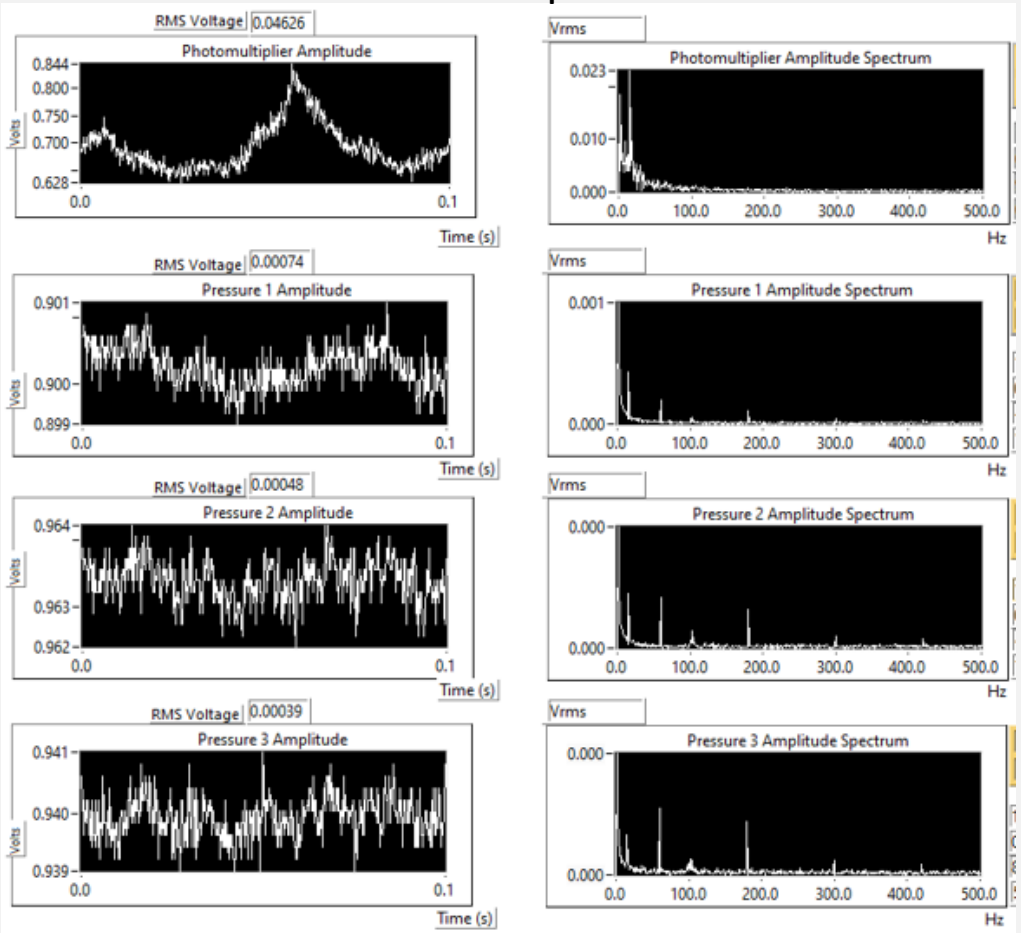
- Experiment consisted of opening/closing the tube and moving the heat source
- -0 position “closed”
- -0 position “open”
- -Finding the point of no resonance “closed”
- -Finding the point of resonance “closed”



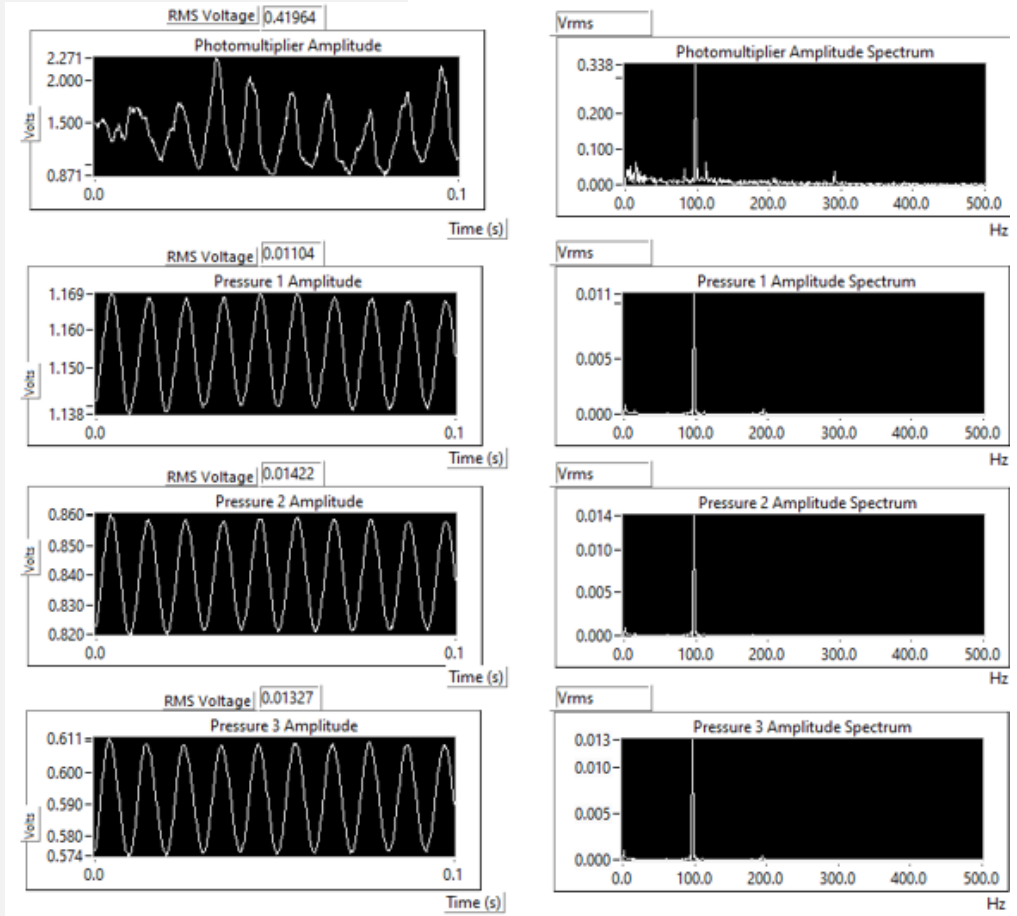
Results

0” opened		0” closed		6.1" closed		2" closed	
Flame: Short or Long?	Was there a hum?	Flame: Short or Long?	Was there a hum?	Flame: Short or Long?	Was there a hum?	Flame: Short or Long?	Was there a hum?
Long	No	Short	Yes	Short	No	Long	Yes

0 opened



0 closed



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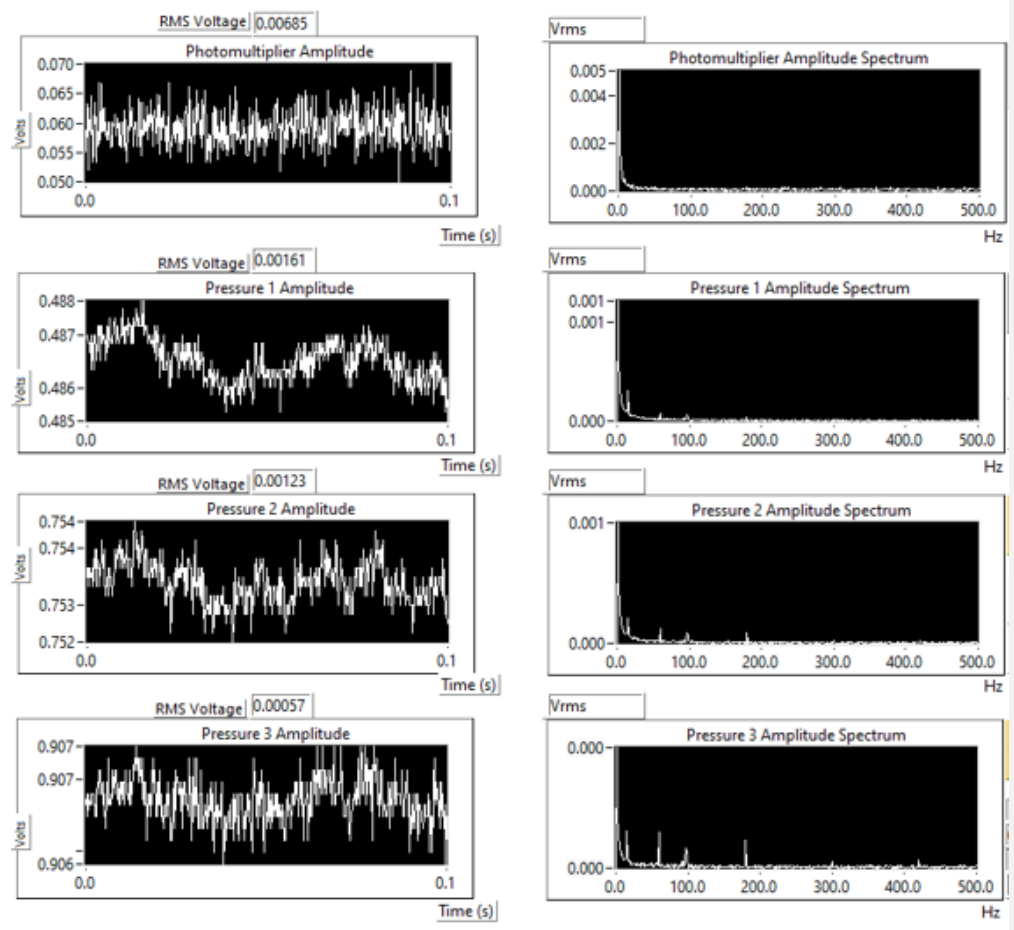
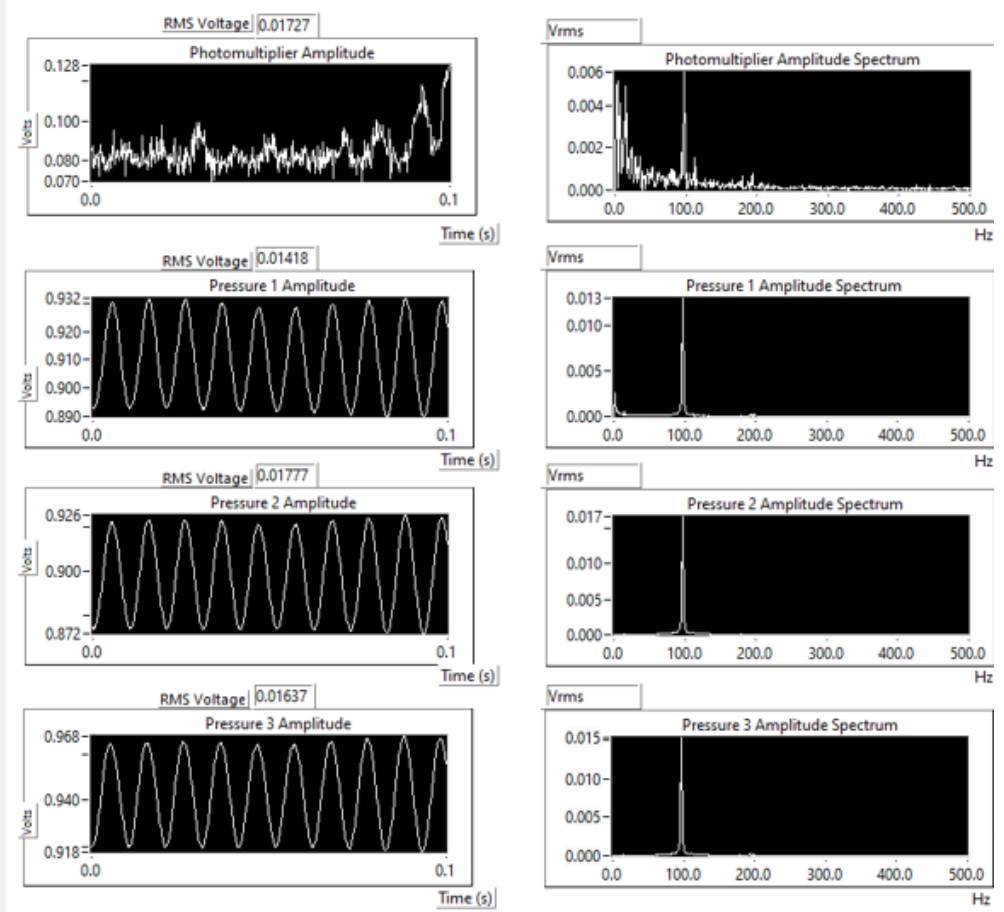
Long	No	Short	Yes	Short	No	Long	Yes

6.1” closed

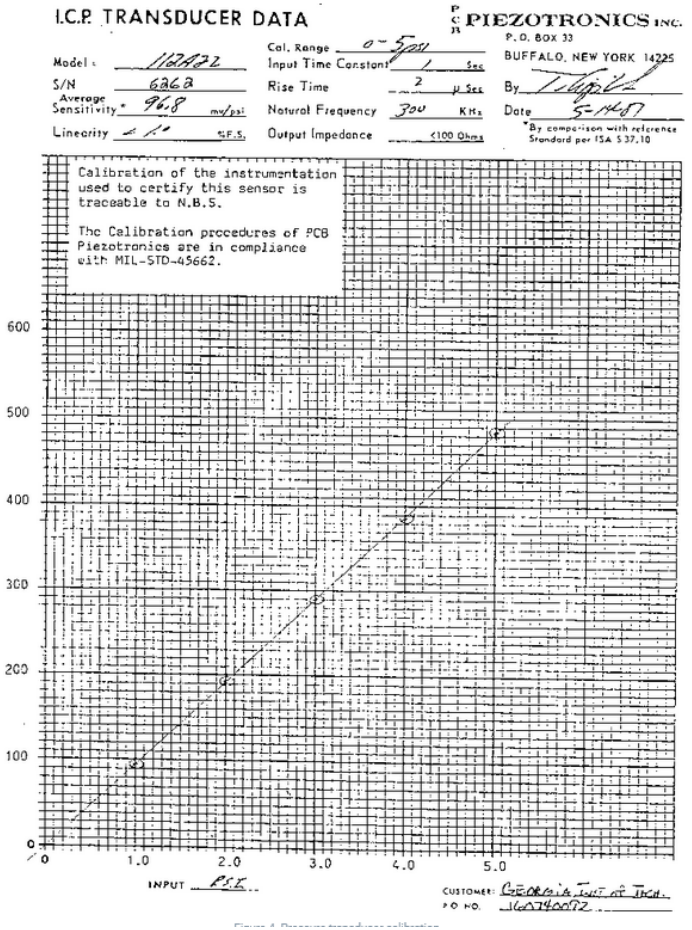


2” closed



Results

$$SPL(dB) = 20\log_{10}\left\{\frac{p_{RMS}}{p_{RMS\,threshold}}\right\}$$



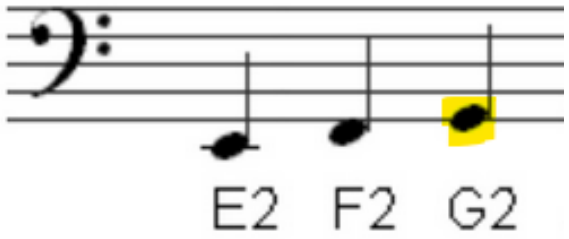
	0 opened			0 closed			2 closed			6.1 Closed		
	RMS (V)	PSI	**dB**	RMS (V)	PSI	**dB**	RMS (V)	PSI	**dB**	RMS (V)	PSI	**dB**
PMT	0.037	0.408	**162.972**	0.384	3.977	**182.743**	0.015	0.175	**155.621**	0.007	0.092	**150.057**
P1	0.000	0.030	**140.171**	0.010	0.128	**152.930**	0.015	0.175	**155.624**	0.002	0.042	**143.144**
P2	0.000	0.030	**140.156**	0.013	0.159	**154.782**	0.018	0.213	**157.337**	0.001	0.037	**142.166**
P3	0.000	0.029	**139.970**	0.012	0.151	**154.308**	0.017	0.198	**156.672**	0.001	0.030	**140.360**

Results

Gamma	R (air) (ft-lbf/slug-R)	T (R)	a (ft/s)	Length of tube (in)	Length of tube (ft)	**Resonance frequency (Hz)**
1.4	1,716.49	534.67	1133.516	72	6	**94.45964716**

$$a = \sqrt{\gamma RT}$$

$$f = a/\lambda = a/2L$$



Results

					Phase Variance with PMT		
	PMT	P1	P2	P3	P1 relative	P2 relative	P3 Relative
0 opened	119.140111	-86.979482	-90.5327	91.517961	**187.16**	**181.43**	**5.58**
0 closed	-152.33439	127.032017	128.295	129.59397	**84.64**	**83.39**	**82.06**

Conclusions

Importance of learning to utilize pressure waves

-efficient use of fuel

-reduction of smoke

-transfer of energy type (heat to pressure) without moving parts

Danger of utilizing pressure waves

-loud!

-reinforcement sometimes explosive

-easily interrupted

Resources

- https://web.stanford.edu/~cantwell/AA284A_Course_Material/AA284A_Resources/ThermoAcoustics%20and%20the%20Rijke%20Tube%20Experiments%20Identification%20and%20Modeling.pdf
- http://inside.mines.edu/~jjechura/Common/ConversionFactors.pdf
- https://www.thoughtco.com/flame-temperatures-table-607307
- https://www.gcaudio.com/tips-tricks/decibel-loudness-comparison-chart/