A Novel Continuous Ultrasonic Processing Unit

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Once upon a time……

- There once was a Company…
- … looking to create a new product…
- … had an ultrasonic unit built …
- … sent it to Dr. Walkinshaw for evaluation
- … it flunked …
- … and was the beginning…

...there was a job to be done

- Create an ultrasonic unit that could:
  - Process a continuous flow of paper pulp
  - Apply lots of energy - efficiently
  - Do all manner of other virtuous things

Other virtuous things:

- Maximize energy efficiency by minimizing
  - noise
  - heat
  - erosion
  - energy localization
  - dead zones
  - coupling materials
- Control
  - applied power
  - chamber pressure
  - operating frequency
  - process temperature
- Quick change out of system components
- Be scaleable

The industrial problem: shive reduction

- Shives: brown fibers embedded in newsprint
- Newspaper demand is declining
- Re-focused project on a growing problem

New focus: recycling office paper

- Photocopier and laser jet print cannot be removed with existing equipment
- The paper is burnt, landfilled or downgraded
- Ultrasonic energy shakes the print off paper fibers
- Free print particles are easily removed

Current ultrasonic technology

Active Element

- Piezoelectric Crystals
- Metal magnetostrictive Elements
- Magnets

Basic Unit Construction

- External transducers
- Submersed transducers
- Whistles/valves

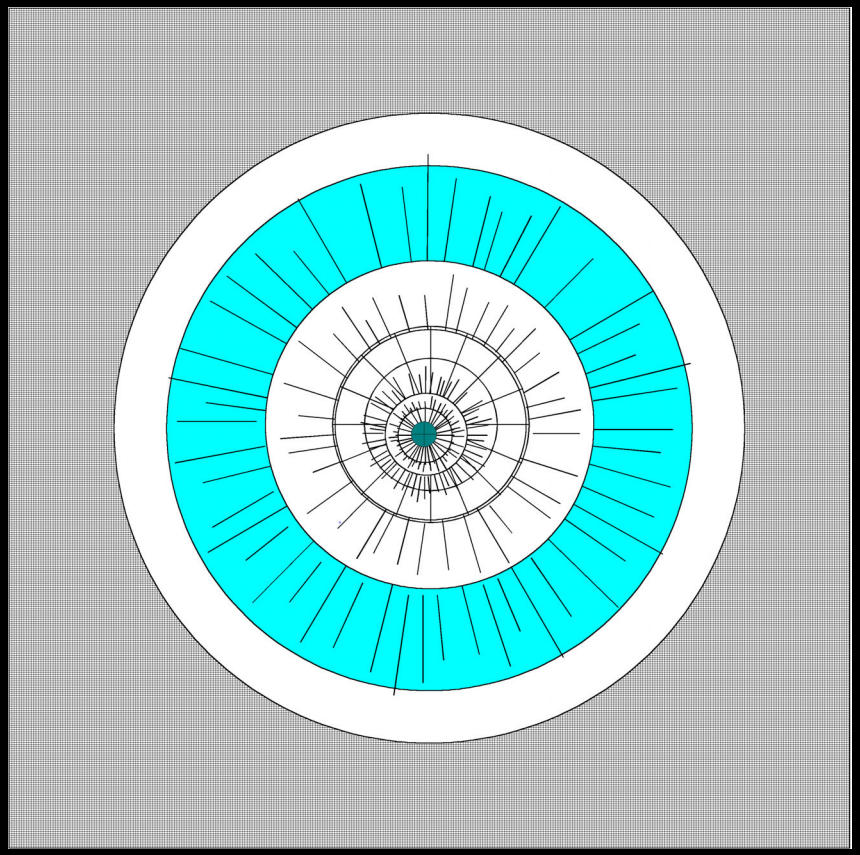
Energy challenge

- Power loss occurs within
  - circuit driving the transducer
  - transducer
  - coupling between transducer and fluid
- Power losses can be in the form of
  - heat
  - noise
  - EMF radiation
  - work performed

Novel continuous ultrasonic processing unit

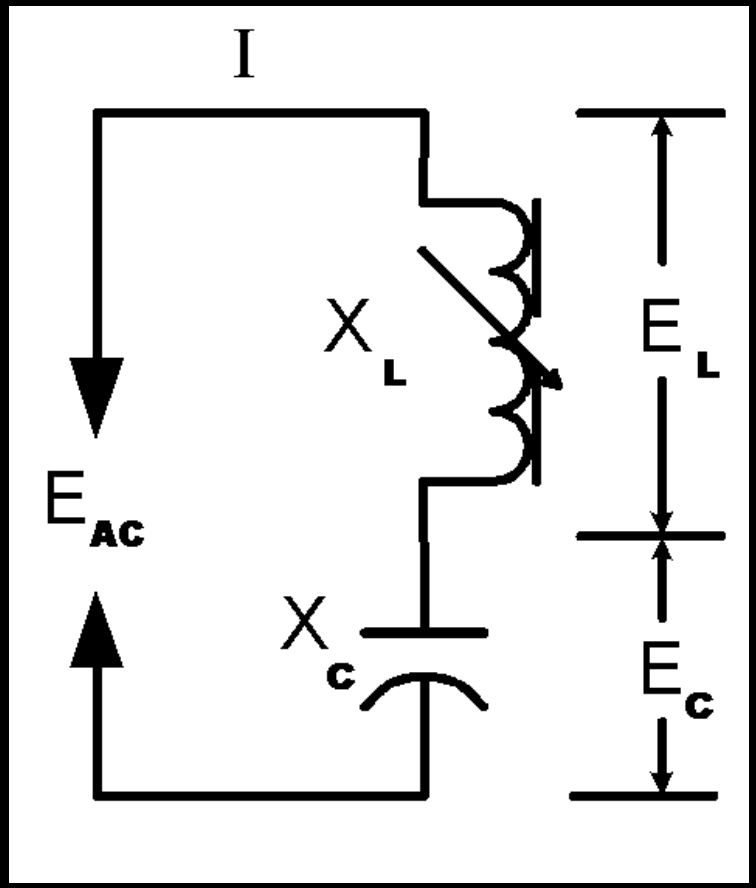
- Singing Tube Design
- Tank Circuits
- Piezoelectric Film

Singing Tube Design



- Chamber wall becomes part of the transducer
- Operates in singing mode
- Curved surface of tube directs energy inward

Tank Circuits: e- table tennis

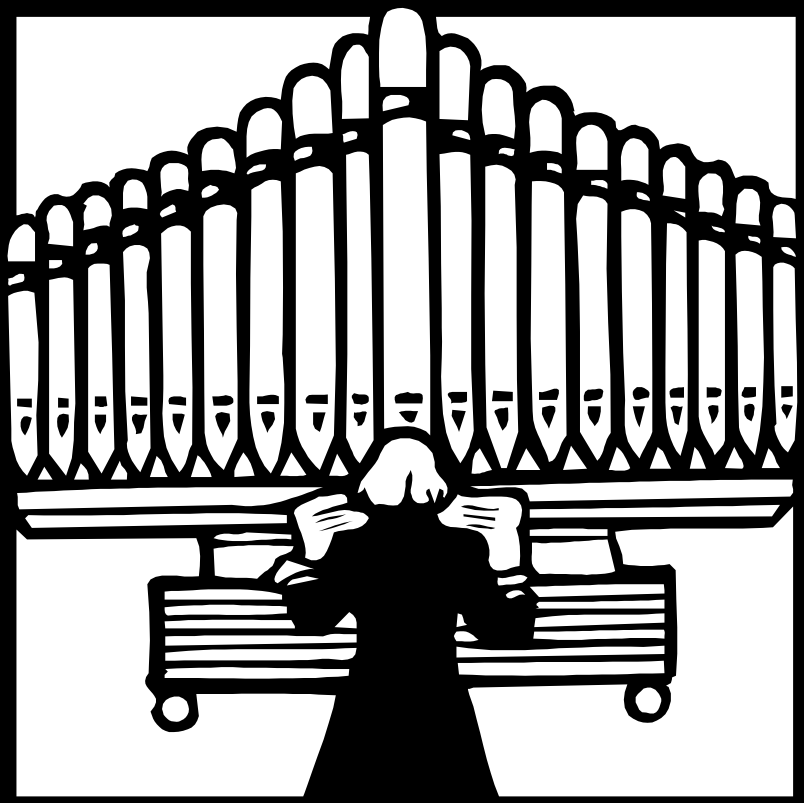


- Energy is stored in the inductor's magnetic field -
- As energy is returned from the capacitor
- And vice versa
- Results: volts applied to transducer and capacitor are greater than E_{AC}

Piezoelectric film

- PVDF (polyvinylidene fluoride)
- Capacitor in the tank circuit
- Part of the transducer
- Reactance, not resistive, element
- Reactance Power (I^2X) is transferred around circuit
- Voltage across the film is higher than that applied to the circuit

Singing tube reactors



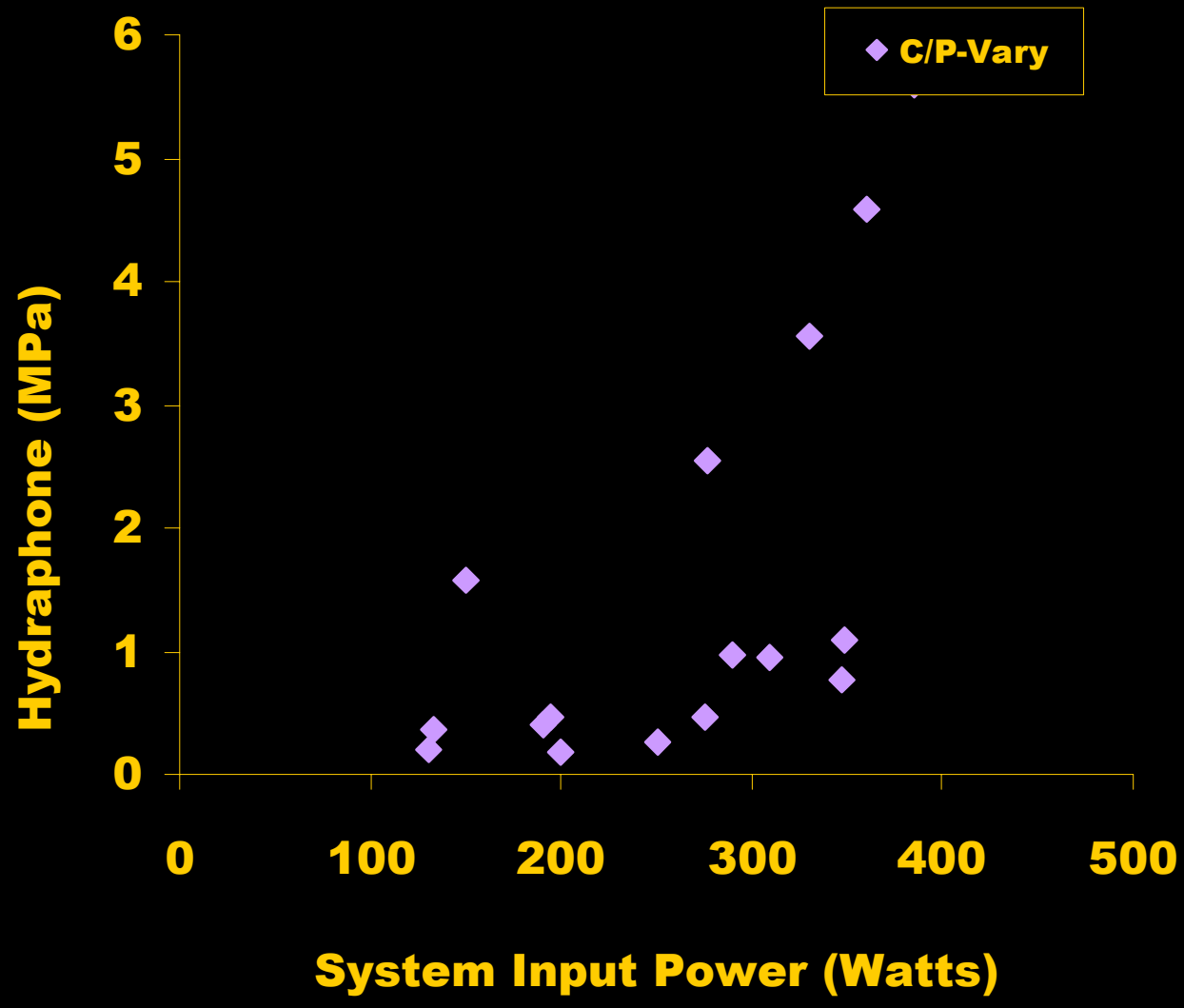
- Energy applied directly
- No erosion
- Variable frequency
- Variable power
- Large energy field
- Scalable
- Silent
- High energy efficiency

Comparative Trials

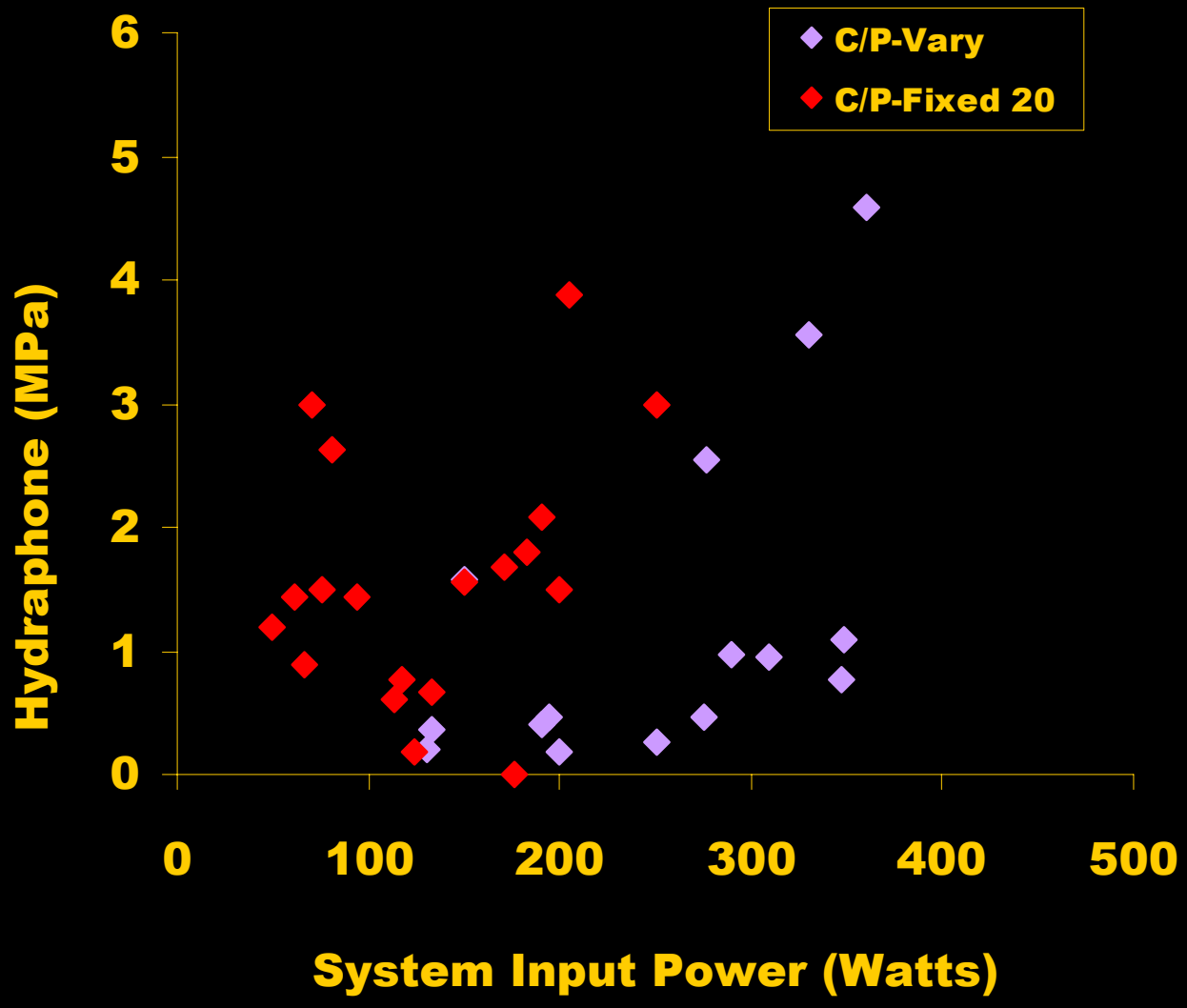
- Variable frequency crystal + probe
- Fixed frequency crystal + probe
- Fixed frequency magnetostrictive chamber

Comparative Laboratory Units

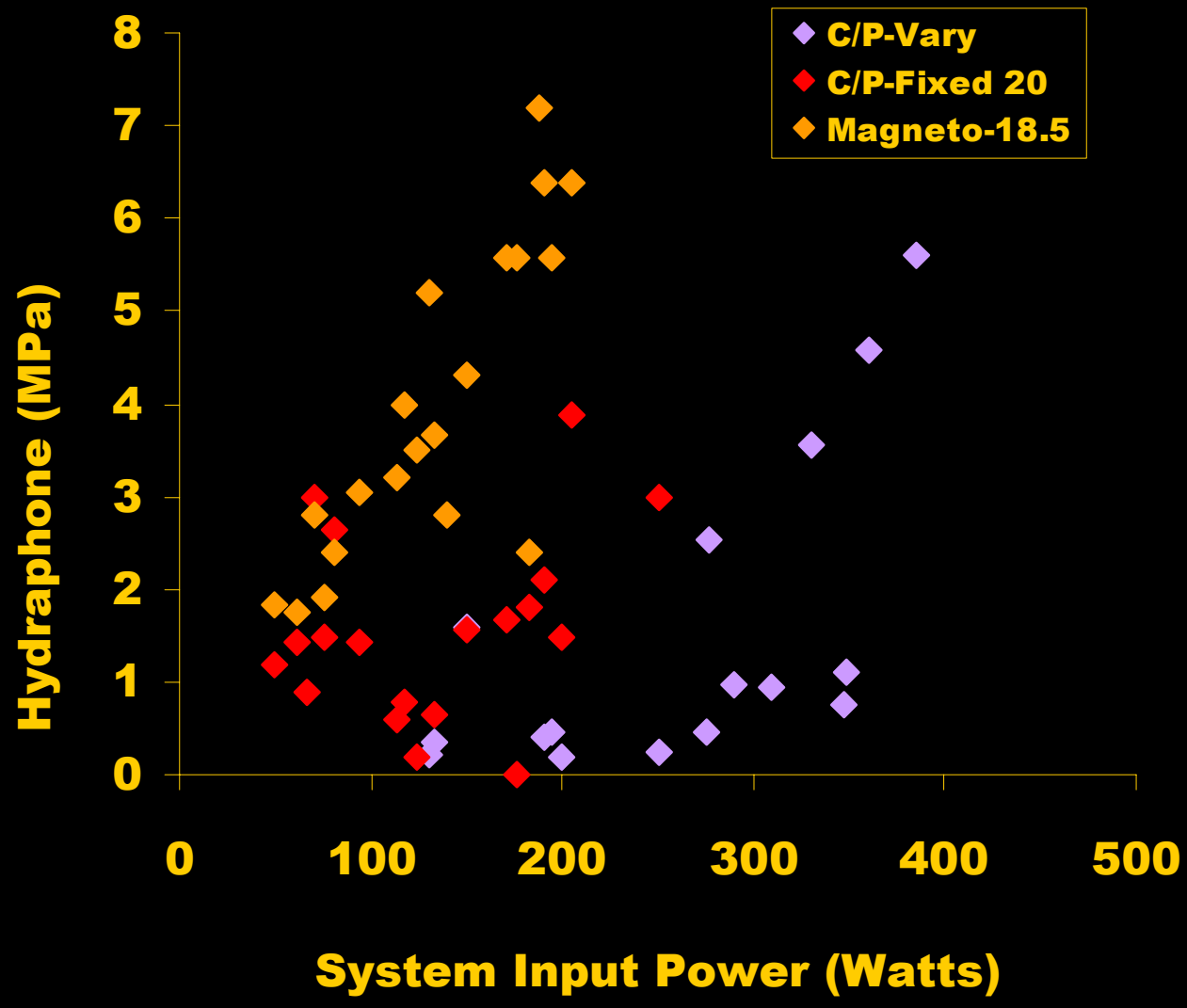
Variable frequency crystal probe unit



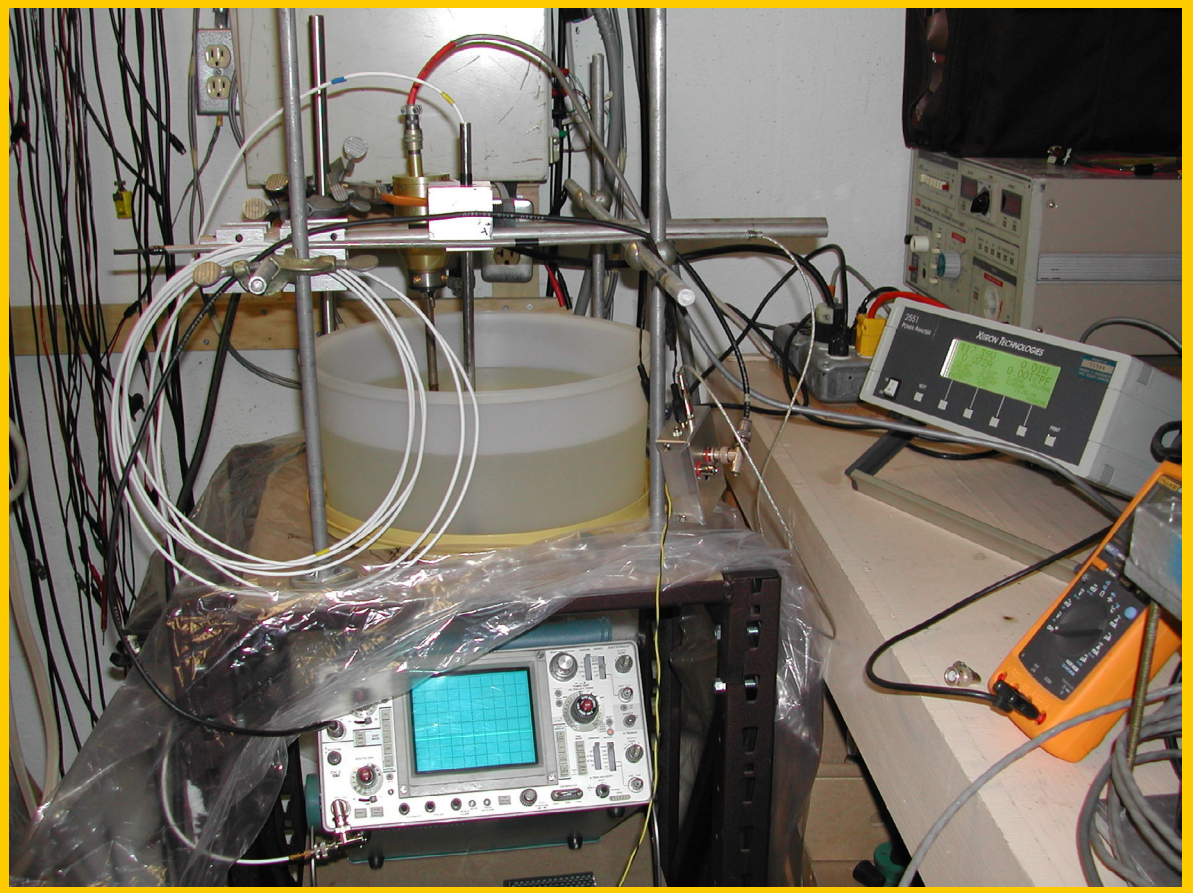
Fixed frequency crystal probe unit



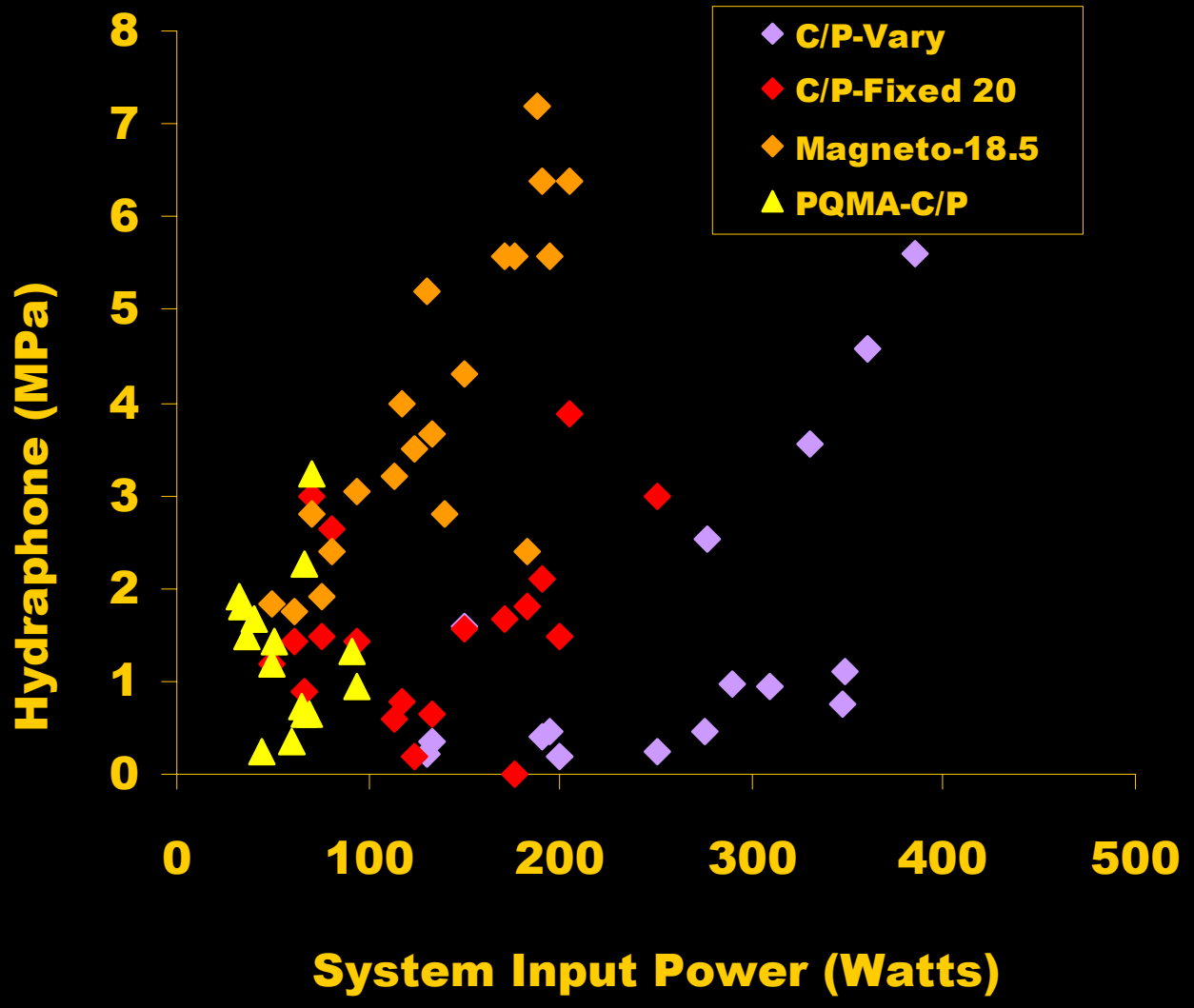
Fixed frequency magnetostrictive unit



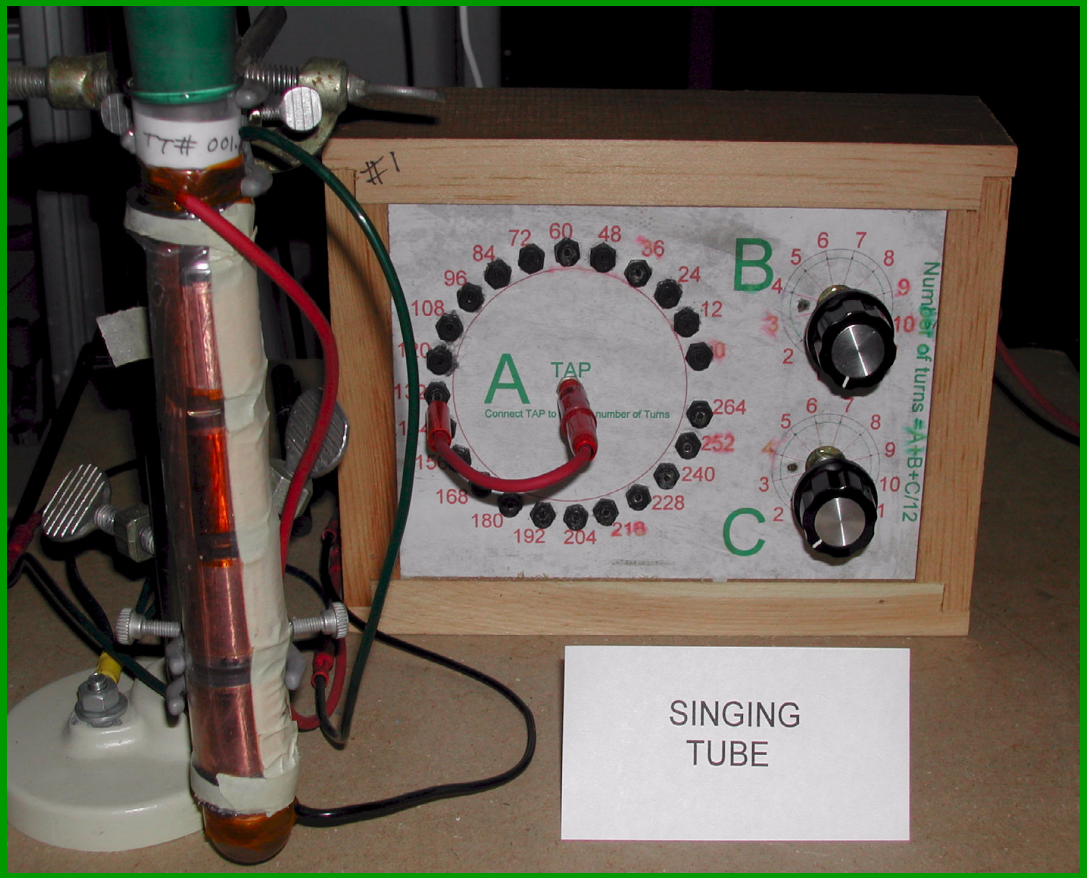
New driver + crystal probe



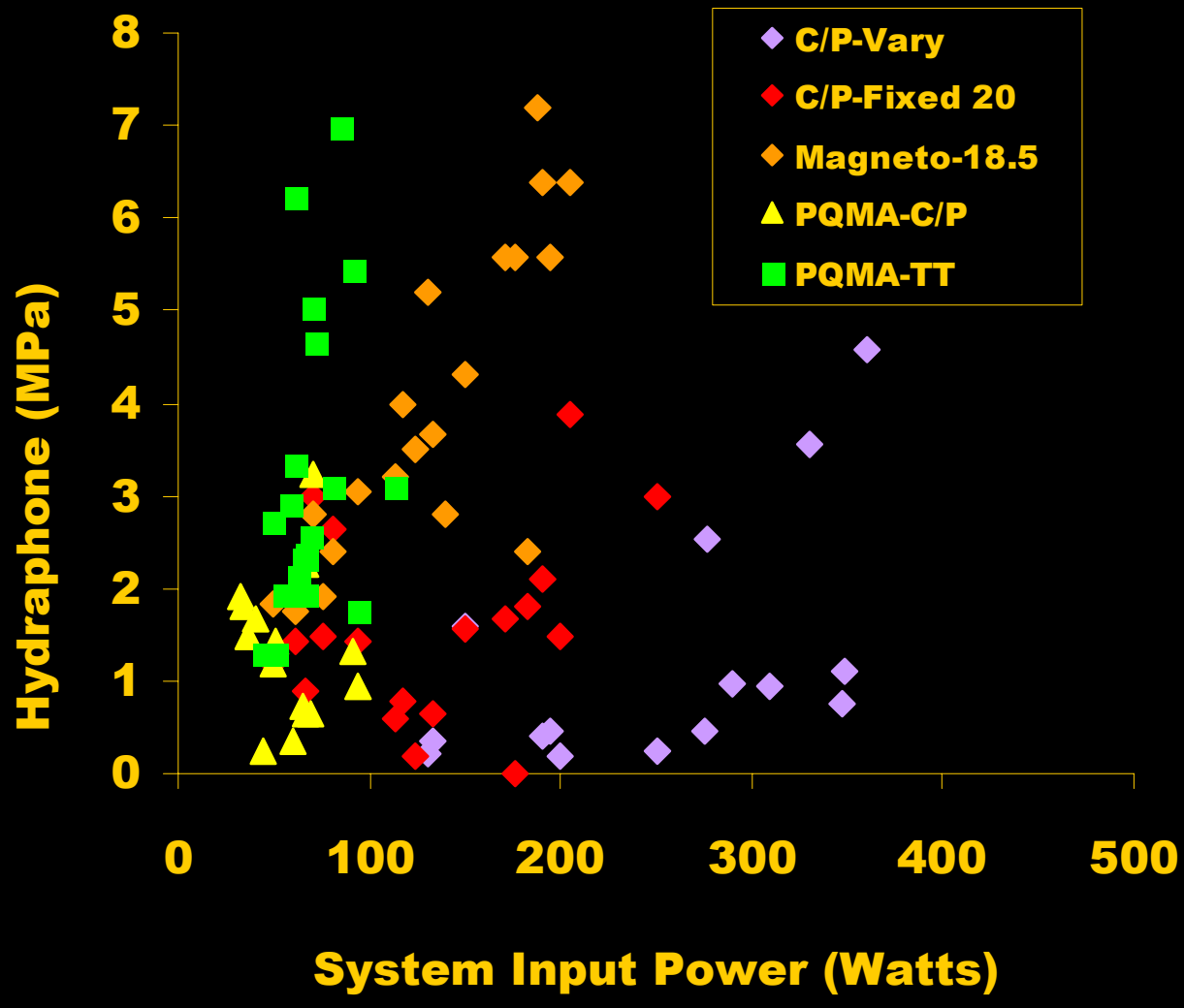
New driver + crystal probe



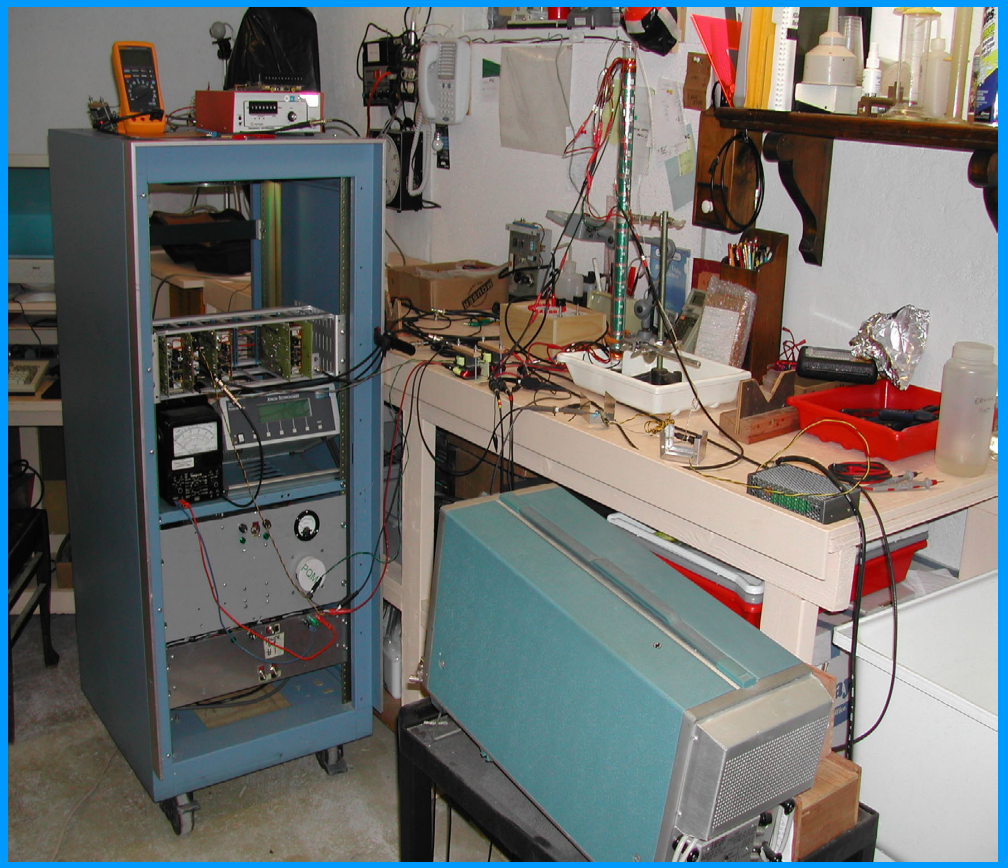
Singing Test Tube

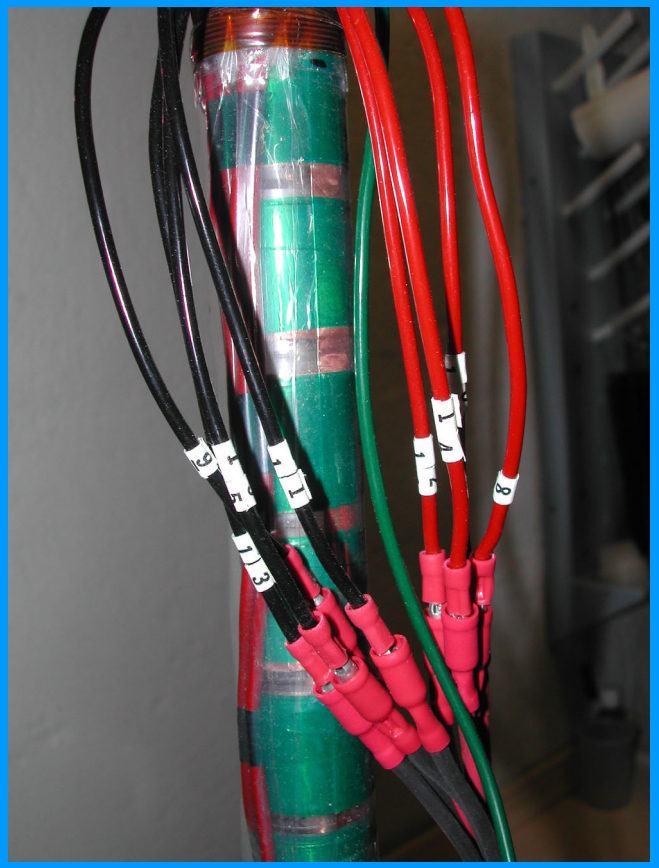


Singing test tube

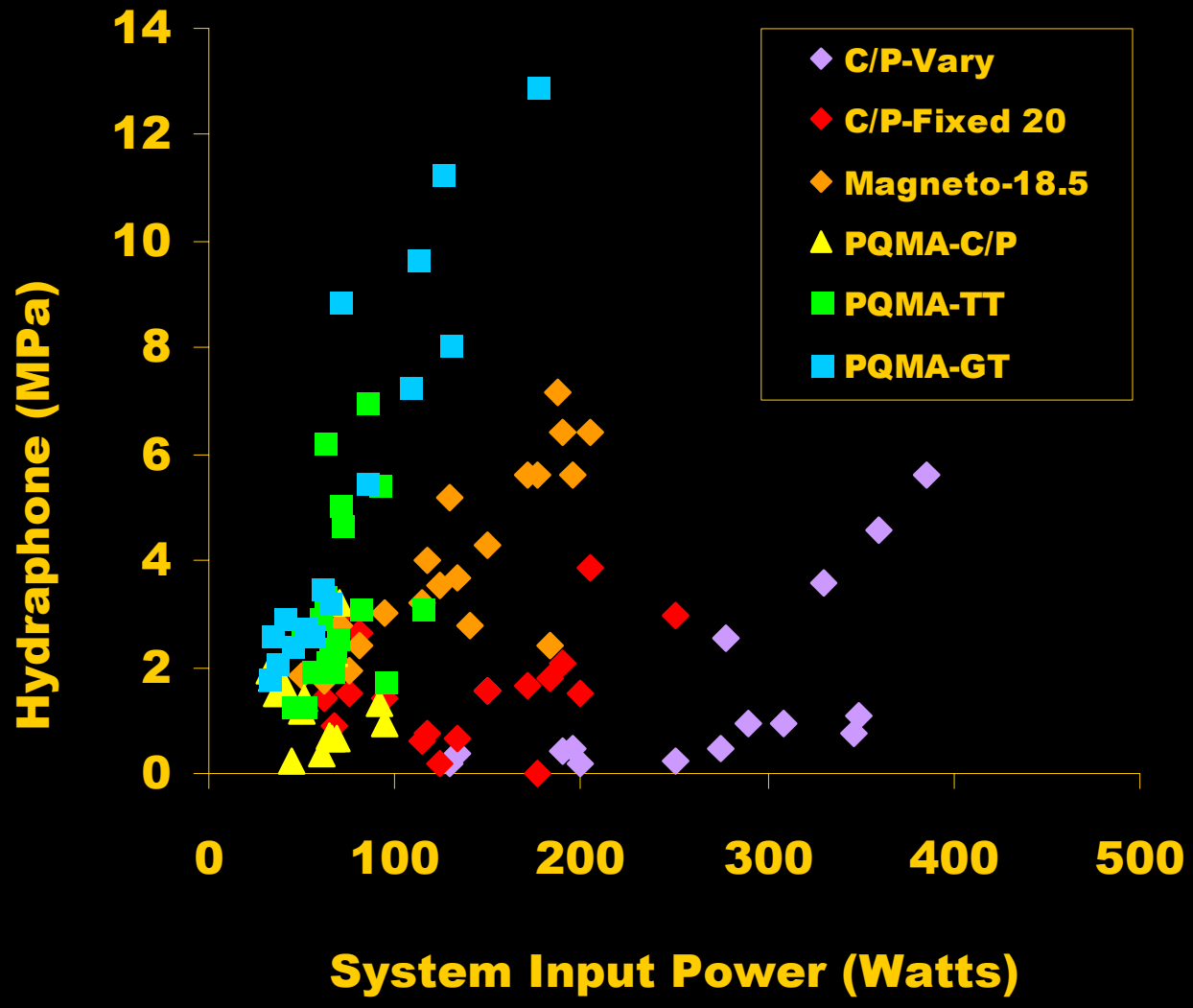


Patent Pending
Glass Process Tube

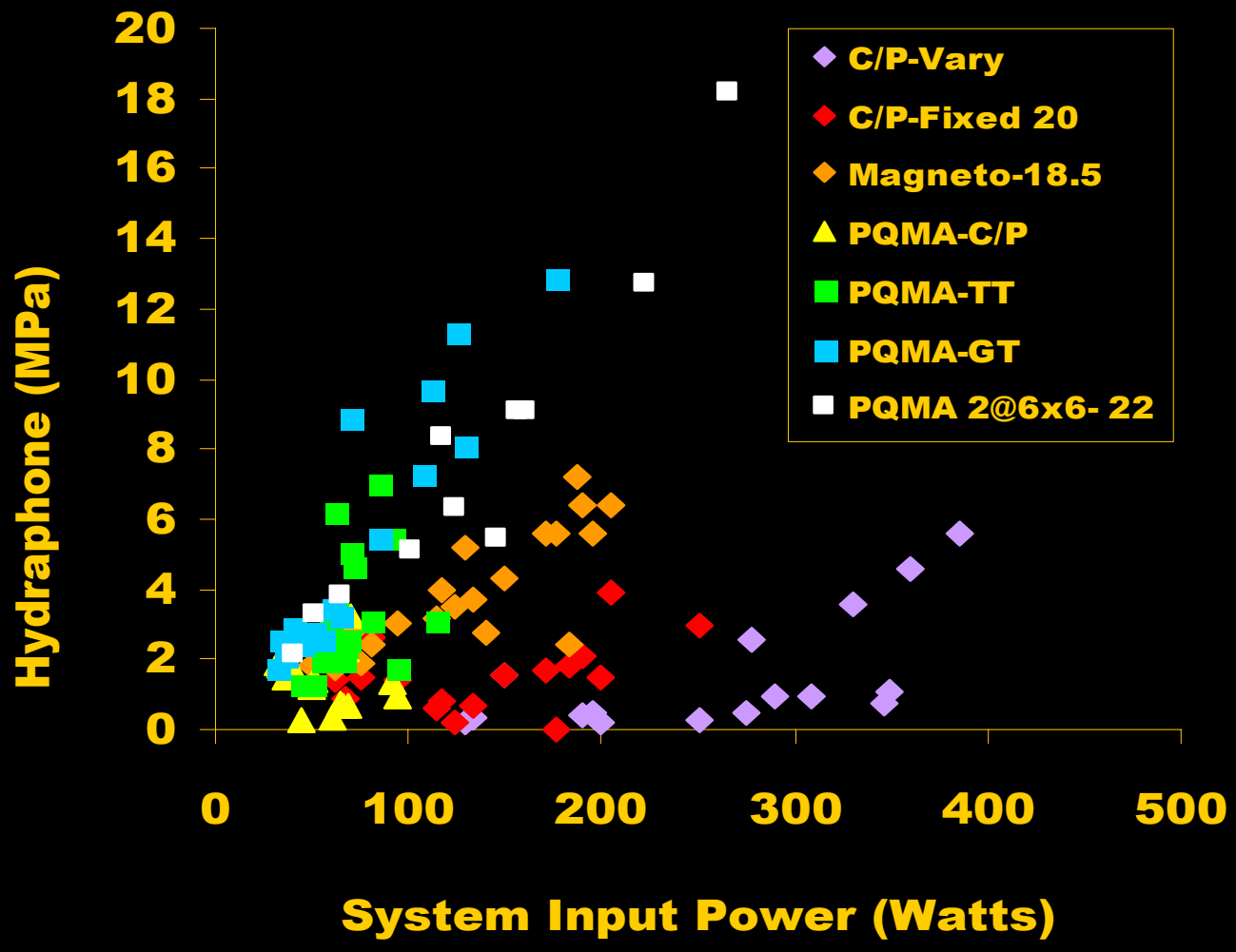




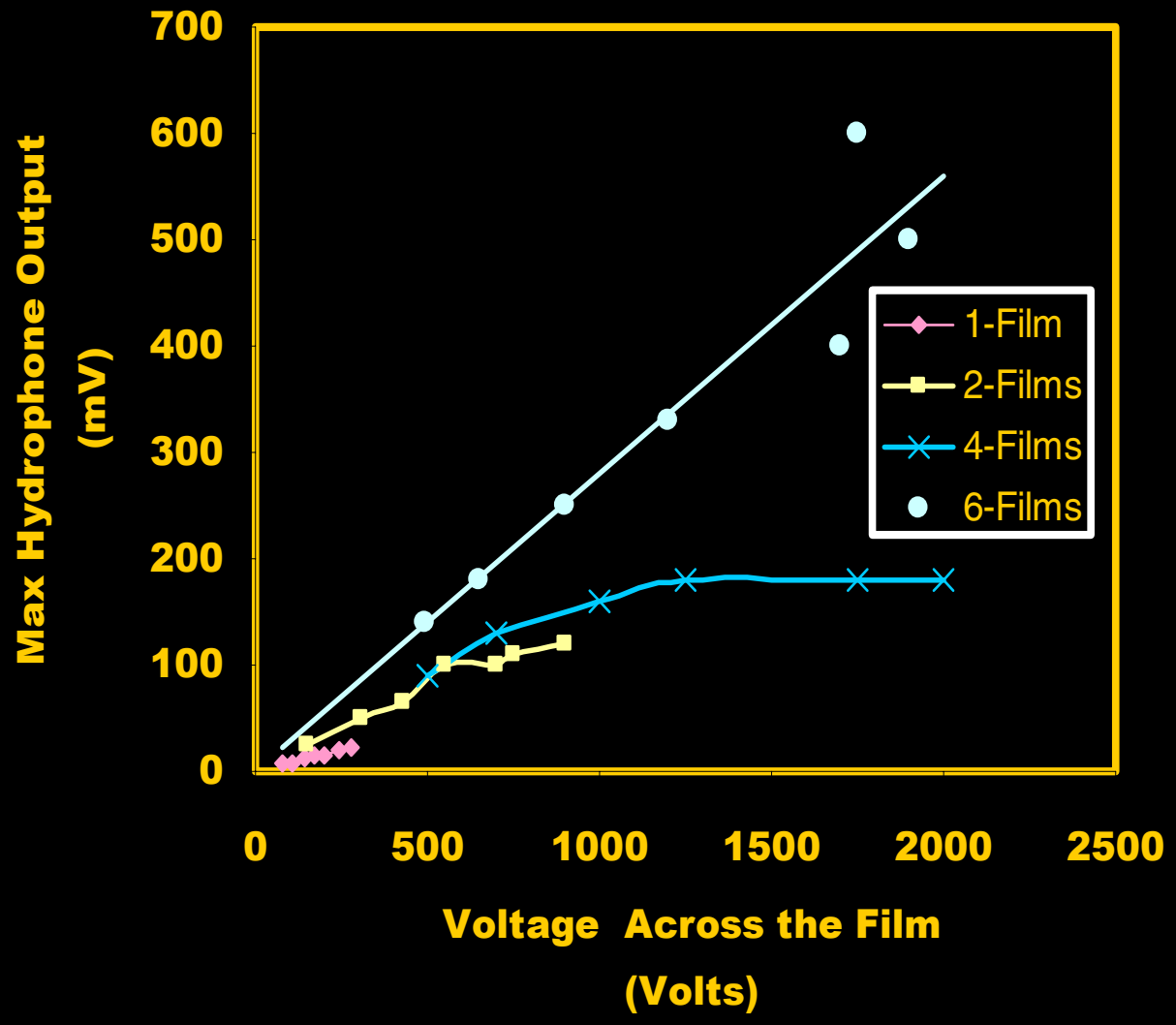
Glass tube: 1” 58kHz



SS Tube: 2” 22 kHz

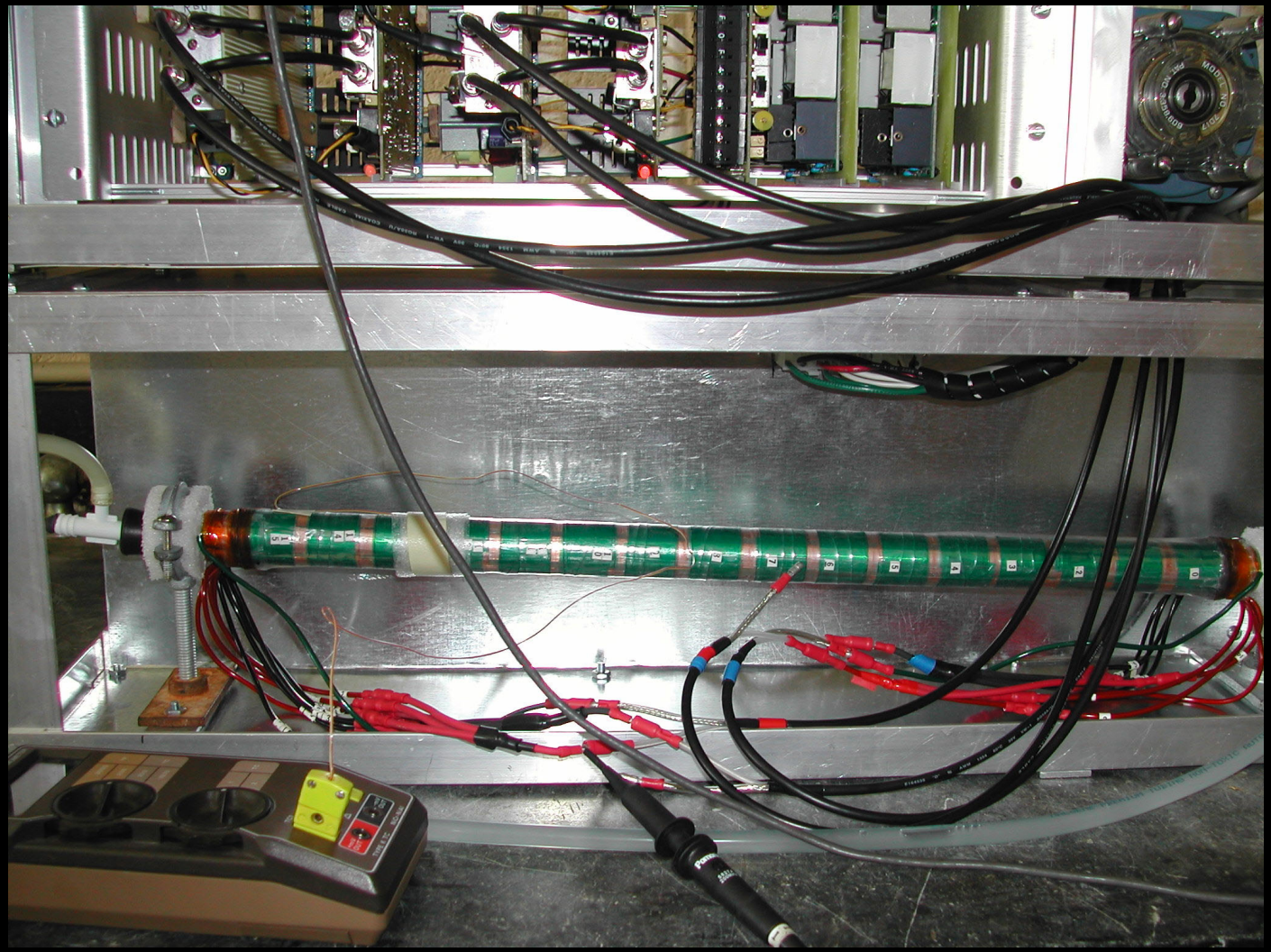


Effect of Film Layers on Hydraphone Output

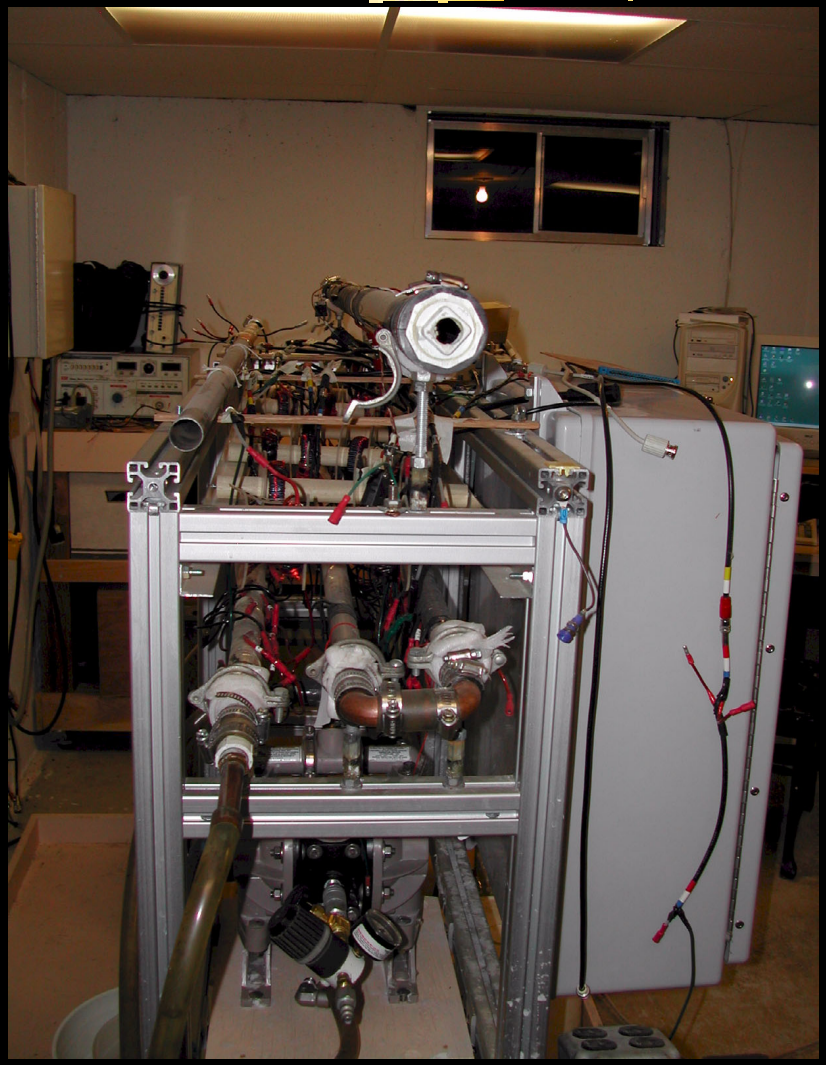


Patent Pending
Beta Site Laboratory Unit

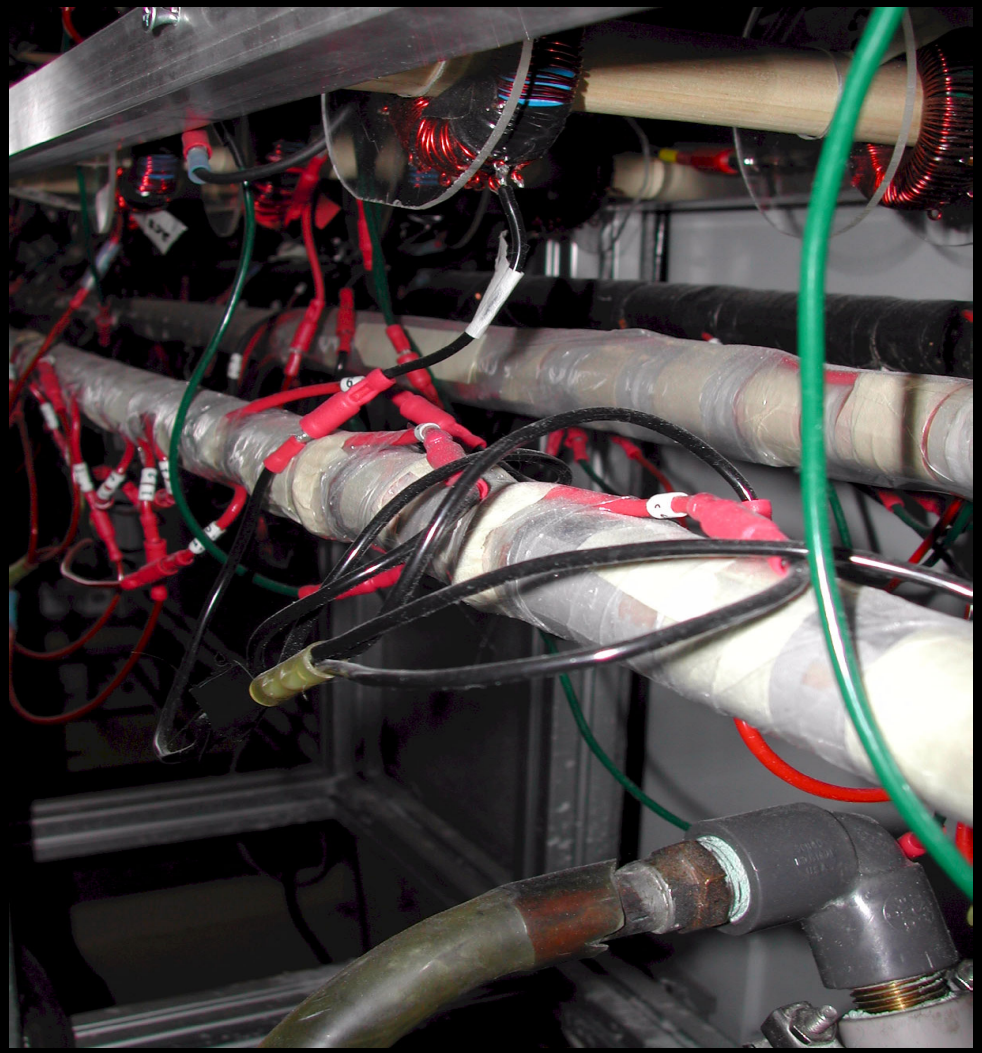
Detail of Laboratory Unit



Patent Pending
Beta Site Pilot Plant Unit



Beta Site Pilot Plant Unit



Experimental trials

- Removal of laser print from paper
- Particle size reduction
- Paper fiber fibrillation
- Chemical reaction acceleration
- Ozone production and reactions
- Baker's yeast cells lysine

Personnel

- John W Walkinshaw - Manufacture & Test
- John E Poniatowski - Engineering
- Susan E Poniatowski - Project Support

- Lahive & Cockfield,LCC- Patent Attorney USSN 09/798,677

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Paper Quality Management Associates