Timing in a Different Time

About 20 years ago, when I was still new to Penn, I was told "to get rid of all the old stuff in that back store room so the contractors rip it down to build an active learning classroom". It was a room I was not aware of and it had some old wooden boxes holding clearly over-the-hill hardware from a previous era. Among the obsolete dust collectors were 3 sets of large, beautifully made tuning forks in what were once fine furniture-grade wood cases. Being an arrogant, 20th century science chauvinist, I thought "I guess after Lord Kelvin tells you your science has nothing left to discover*, you go spend your funding on eye-candy?"

But also being an inveterate pack rat, I took them home and found another nook or cranny to stash them in until I retired and had enough time to see if the answer was more interesting than "nothing else left to do".

Well, that time has come, and I have discovered that I am an arrogant AND IGNORANT 20th century science chauvinist. Those of us who grew up in post WWII America learned about the Civil War, and WWI. It wasn't clear what folks did between wars, but you could imagine they just sat there and wished they had cars and phones. We all considered the second half of the 19th century as the waiting room for the 20th century when in fact it was the construction site for the 20th century—deserving of the same attention cosmologists give to "The First Three Minutes". To wit:

James Clerk Maxwell	Albert Michelson	Albert Einstein
1831 – 1879	measured c in 1879	1879 – 1955

COINCIDENCE?? I THINK NOT!!

(even better than 1642)

Pretty cool time to be alive, eh? When do we convene the 1879 club?

But I digress.

Relevant to our discussion of why anyone would put this kind of time and effort into tuning forks, it should be noted that:

Jules Antoine Lissajous invented his figures in 1857…long before the oscilloscope!

Michelson measured the speed of light to 5 in 1879…with no electronic devices at all (and 5 sig fig precision!)

How do you do that without electronics?

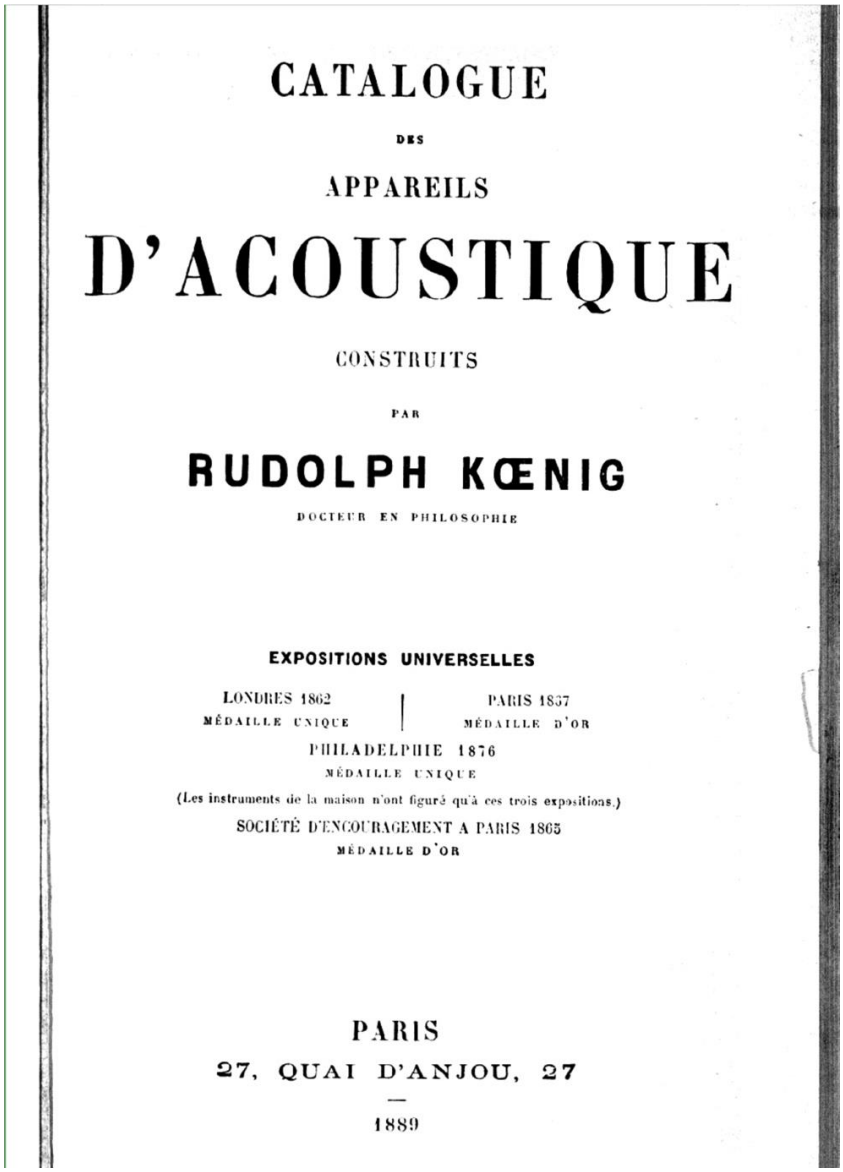
Tuning forks!

They were still working with Galileo's simple harmonic oscillators, but developed to a level that Arthur C. Clark might call magic. Lissajous and Michelson both used mirrors to accurately synchronize their known tuning forks with their unknown rapid motions. The Michelson work is documented in many places but the article from The Physics Teacher referenced below really focuses on the timing process. Lissajous simply used mirrors on the ends of two horizontal forks one vibrating vertically and the other horizontally. This is easily duplicated today with double sided tape and the "cut-to-fit" mirror replacement sheets from auto supply stores. But modern, affordable aluminum tuning forks do not have the large amplitudes of the old steel monsters so the projection length must be increased.

In the 1870s, the folks doing serious science got their tuning forks from a Parisian instrument maker named Rudolf Koenig. He was the "Hewlett-Packard" of his time, and all of his instruments were

engraved with his “RK” logo. Both Lissajous and Michelson used his stuff, as well as the University of Pennsylvania. Arguably, Penn purchased it at the 1876 Centennial Exposition in Philadelphia, which Koenig notes on his catalog. Even Heinrich Hertz was a customer, a fact supported by the tuning fork frequency labels in units of “VS” (vibrations per second) because the “hertz” unit was yet to be earned (in part through the use of RK tuning forks not yet using the hertz unit)
Case Western still has Michelson’s calibration tuning fork in their display case, an RK 128 VS unit. From a Case Western article on the experiment:

“The angular speed of the mirror was measured by comparison with a calibrated tuning fork. (The 128 Hz fork, made in Paris by the famous instrument maker Rudolph Koenig, is preserved in the CWRU physics department archives.)”



CATALOGUE

DES

APPAREILS

D'ACOUSTIQUE

CONSTRUITS

PAR

RUDOLPH KŒNIG

DOCTEUR EN PHILOSOPHIE

EXPOSITIONS UNIVERSELLES

LONDRES 1862
MÉDAILLE UNIQUE

PARIS 1937
MÉDAILLE D'OR

PHILADELPHIE 1876
MÉDAILLE UNIQUE

(Les instruments de la maison n'ont figuré qu'à ces trois expositions.)

SOCIÉTÉ D'ENCOURAGEMENT A PARIS 1865
MÉDAILLE D'OR

PARIS
27, QUAI D'ANJOU, 27

1889

Kleppner, Daniel, Master Michelson's Measurement, The Physics Teacher, August 2007
Unlocked pdf available at either of the following:

https://www.semanticscholar.org/paper/Master-Michelson's-measurement-Kleppner/0e87ce6297b649582a00cabecbe531850048ceb7

http://www.nhn.ou.edu/~johnson/Education/Juniorlab/C_Speed/2007-PhysToday-RefFrame-Michelson.pdf

Michelson's original paper:
Michelson, A.A. (1879), Experimental Determination of the Speed of Light
https://ajs.scholasticahq.com/article/63624
American Journal of Science, Vol. s3-18, Issue 107, 1879
Michelson, A. A. (1879). Experimental determination of the velocity of light. *American Journal of Science*, *s3-18*(107), 390–393. https://doi.org/10.2475/ajs.s3-18.107.390

* Lord Kelvin never actually said this. It's actually a paraphrase of a quote from Albert Michelson:
https://4gravitons.com/2016/03/11/in-defense-of-lord-kelvin-michelson-and-the-physics-of-decimals/

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