
Acoustics Research in the 19th Century

Hermann von Helmholtz, 1821 – 1894

The scientific study of acoustics was revolutionized in the 1860s through the introduction of fundamentally new theories explaining acoustic phenomena, the invention and usage of new instruments as well as the spread of acoustics research into laboratories around the world. One of the main figures of this reform was the physicist Hermann von Helmholtz. His ground-breaking theory of acoustics sets out individual tones with a single frequency as the basis of acoustics. Combinations of these "simple tones" create more complex sounds and acoustic phenomena like interference. In his book "On the Sensations of Tone as a Physiological Basis for a Theory of Music" Helmholtz combined physics, mathematics, physiology and music theory into a comprehensive work on acoustics that became the basis for following acoustic research.

Rudolph Koenig, 1832 – 1901

"I have gradually accumulated a considerable amount of material for the reform of physiological acoustics, and am waiting for instruments to carry it out."
Hermann von Helmholtz in a letter to a colleague, May 1857

The experimental validation of Helmholtz' work required acoustic instruments with enormous accuracy and high reproducibility. Rudoph Koenig was the only instrument maker able to build these high-precision apparatus, which were build specifically after Helmholtz' designs or with the single purpose to test his theories. Without his instruments, Helmholtz's "reform of acoustics" would not have been possible.

The instruments from Koenig's workshops were renowned for their quality and were sold world-wide to universities and research institutes where they helped to advance acoustics research. The objects in this display are all manufactured by Koenig and were acquired by McGill University around 1890 for teaching demonstrations.

Double Siren, ca. 1890

The double siren was the first instrument that Koenig build after a design by Helmholtz to facilitate his experiments. It uses pressured air send through rotating perforated disks to produce two tones. These two sounds can be overlapped as well as phase-shifted with respect two each other, which allows for the study of combinations of tones and interreference effects between them. In Koenig's catalogue, the instrument is advertised as the means to investigate the "coexistence of two or more sounds in the air."

A video demonstration of a working double siren can be found here:

Instrument for Lissajous Figures, ca. 1890

This instrument can be used to generate Lissajous figures, which are a means of comparing two frequencies: A light ray is send to a mirror attached to a vibrating tuning fork, from which it is reflected onto another mirror on a tuning fork with a different resonance frequency. Marking the path of the double-reflected light ray on a paper reveals the Lissajous figure that depends on the ratio of the two resonance frequencies. This apparatus has several tuning forks with different frequencies installed on a rotating drum, so various Lissajous figures can be generated.

The principle behind generating Lissajous figures with two tuning forks is shown in this video:

Tuning Forks with Resonators, ca. 1890

These two instruments consist of tuning forks in a cast iron stand placed before large brass resonators. The tuning forks are driven by an electromagnet. One of the fork's prongs is hollow and can be filled with mercury which allows to change the pitch of the generated tone. The phase of the tone can be precisely adjusted by a weight mechanism. Accordingly, these instruments allow for the generation of very precise and fine-tuned sounds and were used in demonstrations and experiments on the combination and interferences of different tones.

Siren Disk, ca. 1890

The siren disk is an instrument for the generation of single tones as well as chords and complex composed sounds. The brass disk has concentric rows of regularly spaced holes. It is meant to be rotated at a uniform speed while pressured air from a wind bellows is blown through a row of holes. This produces a musical note as the air pulses from the holes blend into a single tone. The frequency is determined by the speed of rotation and the number of holes. Chords and composed sounds can be generated by using multiple nozzles with pressured air.

A demonstration of the use of a siren disk can be found here:

Helmholtz Resonators, ca. 1890

Tuning forks and resonators were essential for Helmholtz' work which was based upon building complex sounds out of simple tones. Koenig's tuning forks were able to precisely and reproducibly generate tones while resonators like the ones shown here could be used to detect them. These brass apparatus are tuned to a specific frequency. When they are held to the ear they allow for the decomposition of a complex sound and for the detection of a tone at the specific resonator frequency.

The advertisement for these resonators in a catalogue from Koenig from 1889 can be found here: