Canadian Audiologist

The Official Publication of the Canadian Academy of Audiology

From the Audimeter to the Audiometer

Published May 8th, 2017

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When we look at today's audiometer, it is a far cry from what it was more than one hundred years ago, not only visibly, but also in technology.

Early Induction Coil Audiometers

Early electronic audiometers followed the development of the induction coil as a means of controlling electrical stimulus intensity, and the telephone by Bell served as an appropriate transducer. Such induction coil audiometers were produced in a number of countries, and developed within 4 years of Bell's telephone invention[1].

One of the best documented of the first-generation audiometers used in testing patients (Figure 1) is that by Hughes in London.[2] The basic principle consisted of 2 electrical circuits linked by an induction coil. The primary circuit consisted of a battery, an interrupter (clock), and the primary windings (a) and (c) of the induction coil. The secondary circuit (sound) consisted of the windings of the induction coil and the telephone.

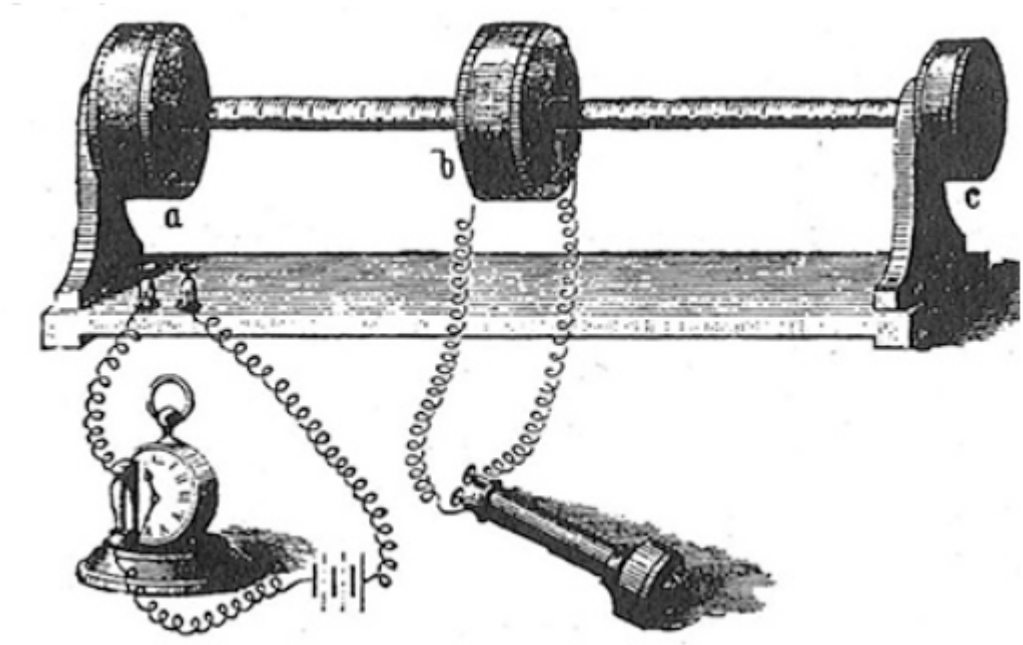

Figure 1. The Hughes audiometer, consisting of a carbon microphone attached to a clock. Coils (a) and (c) were the 2 primary coils and (b) is the secondary coil. The clock served as the interrupter. (Hughes, 1879).

Of this device, Benjamin Ward Richardson (England), wrote:

"The world of ... medicine... is under a deep debt to Professor Hughes for his simple and beautiful instrument which I have christened the audimeter, or less accurately but more euphoniously, the

audiometer."[3]

Vacuum Tube Audiometers

By the early 1900s audiometers had become much more sophisticated (Figure 2). This device, developed in 1919 by Schwarz (Germany), and commercialized by Medico-Technical Company in Berlin, was the first electronic audiometer with masking, an interrupter key to switch the test tone on and off in order to prevent auditory fatigue, and a Politzer balloon attached to a "pneumatic earphone" for threshold measurements under condition of altered air pressure in the external auditory canal.[4]

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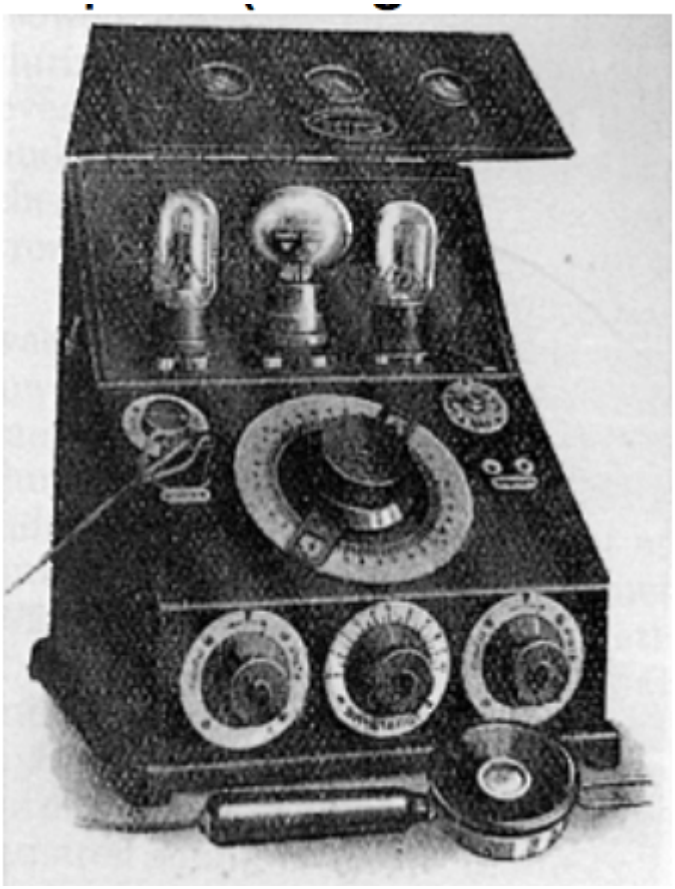

Figure 2. The "Otaudion", developed by Schwarz and based on the suggestion of Griessmann and Schwartzkoph.

Western Electric

Western Electric 1A. In 1914, Western Electric patented the electric audiometer, and produced the first commercially available electronic audiometer for the measurement of the sensitivity of hearing, the Western Electric 1A (Figure 3). This instrument allowed frequency testing using a specially designed earphone. With a price tag of $1500, it cost slightly less than a house. Designed by E. P. Fowler and R. L. Wegel, 25 units were sold in 1922. It allowed for hearing testing from 32 through 16,384 Hz.[5]

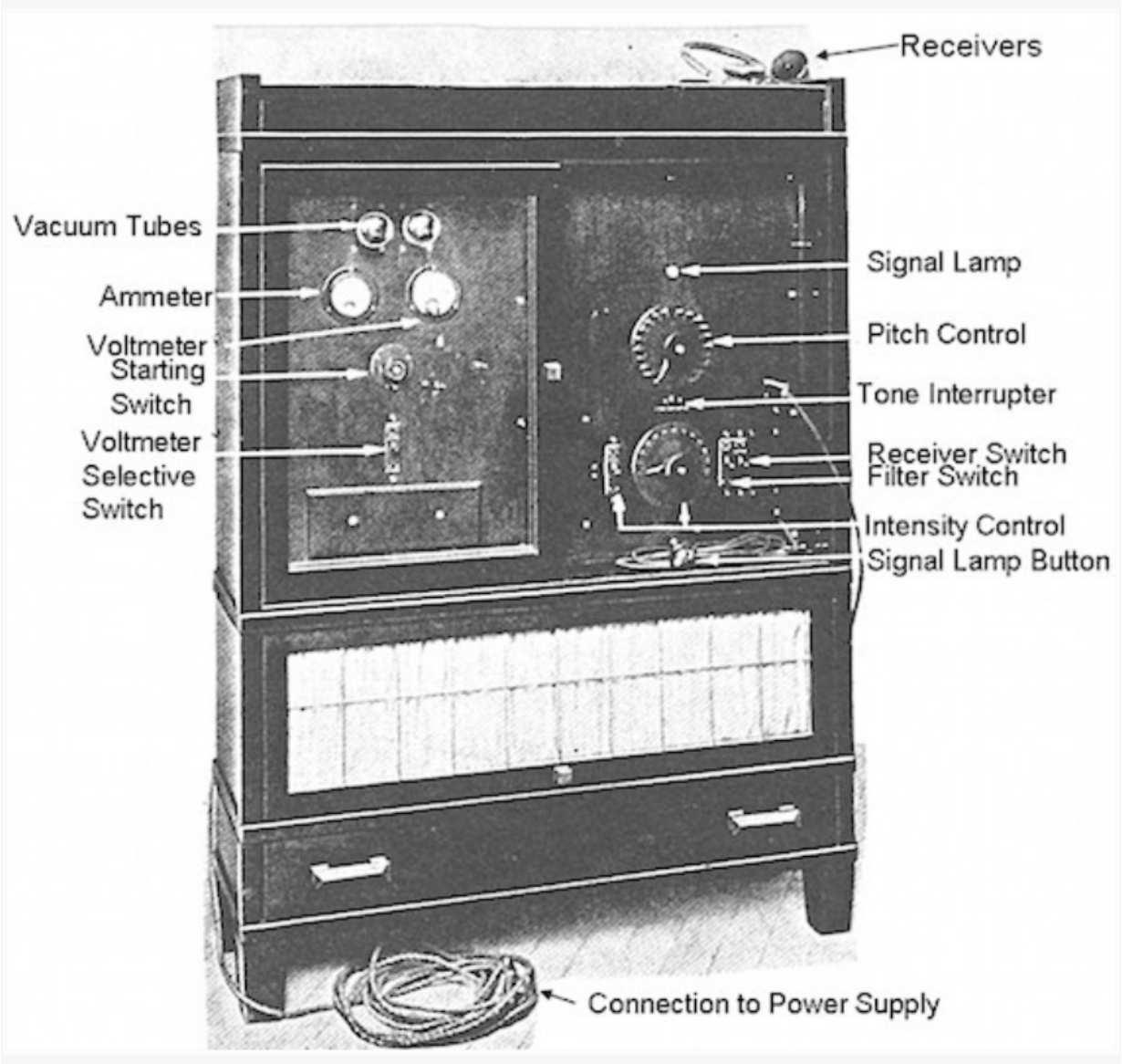

Figure 3. Western Electric 1A audiometer. This was not a portable device.

Western Electric 2-A. The first widely-used audiometer was the Western Electric 2-A audiometer (1923). It ran on dry cells and was designed to meet clinical needs. In the early instruments, normal threshold values for each test frequency had to be established first to provide a reference. The instrument was limited to 8 frequencies at octave intervals between 64 Hz and 8,192 Hz. The intensity range was limited, and an additional booster amplifier was needed to determine the threshold of feeling.[6] Bone-conduction testing was added in 1928.[7]

Figure 4. Western Electric 2-A audiometer.

Use of Audiometer Hearing Levels Based on the Threshold of the Normal Human Ear

Figure 5. Beltone model 12D audiometer. Audiometers similar to this by Beltone and other manufacturers were commonly used in the late 1960s and 1970s.

The first audiometer to incorporate circuitry based on the threshold of the normal human ear, the Maico D-5 (1937), was produced by Maico (Medical Acoustics Instrument Company). Maico was founded in Minneapolis, MN (USA) by Leland Watson, the son of a prominent otolaryngologist, and began production of audiometers in 1936.[8]

A representative audiometer used throughout the 1960s and early 1970s is represented in Figure 5. This audiometer consisted of pure-tone air- and bone-conduction testing, with a masking stimulus, and possibly a microphone for monitored live voice testing.

Clinical/Diagnostic Audiometer

The late 1960s and early 1970s produced more advanced two-channel audiometers capable of tests in addition to pure-tone audiometry, consisting of differential diagnostics tests (SISI, Tone Decay, Stenger, Delayed Auditory Feedback, ABLB, MLB, alternate test signals), and included microphones for monitored live voice testing or recorded testing for SRT (Speech Reception) and Speech Discrimination. Controls were dominated by features such as push buttons, knobs, and other mechanical devices mounted on or near the instrument's front panel (Figure 6). These units, as were previous units, were based on a mechanical user interface in which the design was essentially "frozen" and difficult to change. These were used primarily in two-room audiometric booths.