



## NOTES ON THE HISTORY OF ACOUSTICS AT ETH ZÜRICH AND EMPA DÜBENDORF (SWITZERLAND)

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### ABSTRACT

A brief history of acoustics at the Swiss Federal Institute of Technology (ETH) in Zurich and at the Swiss Federal Laboratories for Materials Science and Technology (Empa) in Dübendorf is presented, focusing on the period between 1920-1970. A first acoustics laboratory was set up by lecturer Franz Max Osswald at the ETH in the 1920s. The work was continued by Prof. Willi Furrer who, together with Prof. Anselm Lauber, wrote a standard work on acoustics. Both authors were associate professors at ETH. However, it was never possible to establish a dedicated chair or institute for acoustics despite the status of the prestigious technical university. Early on, at a meeting in September 1944, the ETH management stated that no separate chair should be established for acoustics because it "eludes scientific research, since it deals mainly with questions of practical application and empiricism". Since then, lectures on acoustics have been held regularly at various faculties of ETH and some research projects have been carried out with remarkable results. However, in 1962 a laboratory for acoustics and noise control was founded at Empa, which is part of the ETH Domain, and is today a recognised laboratory with considerable scientific output.

**Keywords:** *ETH, Empa, Switzerland, History of Acoustics.*

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### 1. INTRODUCTION

The main part of the following contribution is based on a PhD thesis completed at ETH Zurich entitled "Hellhörige Häuser. Akustik als Funktion der Architektur, 1920-1970" by Sabine von Fischer [1], a related conference paper [2], the book "Das akustische Argument" based on the PhD thesis [3], as well as the licentiate thesis "Gedämpfter Lärm – die Schweizerische Liga gegen den Lärm 1956-1966" by Mischa Gallati at the University of Zurich [4]. It becomes clear how difficult it is to classify the field of acoustics in disciplinary terms, a fact that is still relevant today and not only in Switzerland. The fundamentals of acoustics seem to have been established long ago, which means that the discipline of acoustics is hardly a subject for physics departments today. But where, if not there, should acoustic sciences be researched and taught at universities?

### 2. ACOUSTICS AT ETH ZÜRICH AFTER 1920

ETH Zurich was founded in 1855 under the name *Polytechnikum* and received its current name, the *Swiss Federal Institute of Technology (Eidgenössische Technische Hochschule, in short: ETH)*, in 1911. The extent to which acoustics was a subject at ETH before 1920 was not investigated here, but it can be assumed that it was only dealt with theoretically. In 1924, the mechanical engineer Franz Max Osswald (1879-1944) set up a laboratory for applied acoustics and room acoustics (Figure 1). He himself described it as the first laboratory set up specifically for acoustics at a technical university, which seems plausible, especially since the building for acoustics designed by Wallace C. Sabine (1868-1919) at the research institute of the Riverbanks Laboratories in Illinois USA was completed in 1918. With its director Paul E. Sabine (1879-1958), Franz Max Osswald sought exchange with international research



through correspondence [1]. In the comparatively small ETH laboratory and with modest financial and personal resources, Osswald made efforts to follow the international developments in modern acoustics.



Figure 1 Part of Osswald's laboratory at ETH around 1932 with set-up for sound wave photography with Schlieren technique. Image Archive, ETH Library.

As Switzerland's first university researcher in acoustics, Franz Max Osswald's field of research was linked to a wide variety of disciplines. Osswald later described acoustics as an indispensable complement to architecture, engineering and hygiene. However, as will be shown later, this was not always advantageous for the discipline of acoustics. The two reviews of Osswald's habilitation in 1928 show that the young science of acoustics lacked a disciplinary affiliation: the reviews give the impression that the interest in the scientific research work came mainly from physics, while the architects welcomed the possible applications without being interested in the more precise derivations. In 1929, Osswald was awarded the *venia legendi* of the ETH, neither at the faculty of Physics nor at that of Architecture, but at the Department XII for Electives Courses.

In 1927, Franz Max Osswald's expert report on acoustic designs submitted for the competition for a headquarters of the League of Nations in Geneva, founded after the First World War, the Palais des Nations, was published in detail in Switzerland and later also in the United States. Together with the founding of the Acoustical Society of America (ASA), this episode at the end of the 1920ies marks the moment when room acoustics was recognised as a proper discipline and a crucial function of architecture. Also, the sound wave photographs made by Osswald using a further developed Schlieren technique were of greatest value in communicating the concerns of room acoustics (Figure 2).

However, it seems that the great appeal of the photographs to architects, as well as his own fascination, led Osswald to continue to attach importance to the technique for too long. In the 1930s, however, international experts described it as outdated and inaccurate.

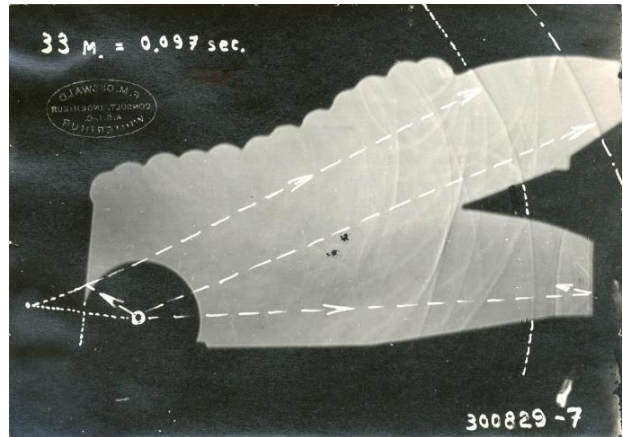


Figure 2 Sound wave photograph in the model of a “concert hall with variable volume” (1930). Image Archive, ETH Library

Osswald also developed his own methodological approaches, such as the “Poch-Variator” (1935), an apparatus for generating airborne and impact sound that could ultimately be judged by the ear (Figure 3), or the “Luftschall-Verzögerungsrohr” (1937), which was intended to serve as a time delay element between different loudspeakers of a sound reinforcement systems of the time (Figure 4) [1].

From 1942, Willi Furrer (1906-1985), an electrical engineer working at the PTT (Swiss Postal Telegraph and Telephone agency), who had habilitated with a thesis on the acoustics of radio studios, taught the subject “Electroacoustics I” at the ETH. After Osswald's death in May 1944, Furrer also took over the teaching of “Room acoustics and sound insulation” at the department of architecture.

The change of generations became an occasion to question the status and scope of the field of acoustics at ETH. In 1944, Alois Muri, General Director of the PTT, approached ETH with the request of establishing a professorship in the field of acoustics. Muri's application was rejected among others on the grounds that room acoustics “eludes scientific research, because it deals mainly with questions of practical application and empiricism”<sup>1</sup> [5].

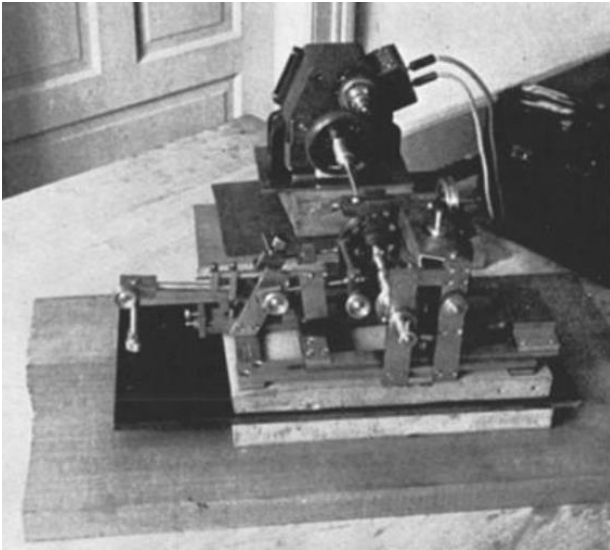


Figure 3 Poch-Variator by F. M. Osswald, 1935. Image: J. Acoust. Soc. Am. 7, 261 (1936).

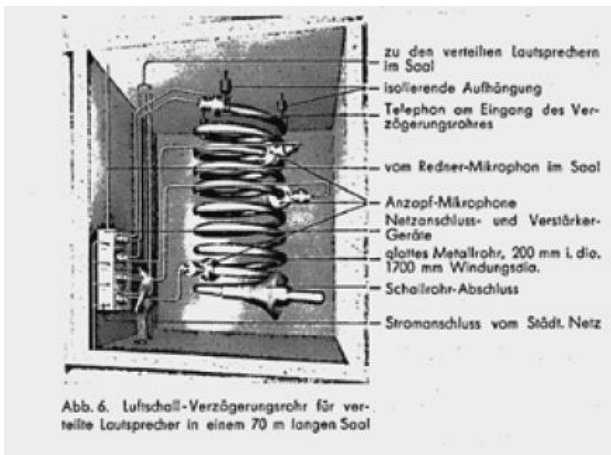


Figure 4 “Luftschall-Verzögerungsrohr“ by F. M. Osswald, 1937. Image: Empa Archive.

The decision was based on a statement by Paul Scherrer (1890-1969), Chairman of the Department of Mathematics and Physics. He grouped acoustics into “three clearly separate fields of research, which are never to be found in the same institute”<sup>2</sup> [6], namely electroacoustics, room acoustics/noise control and physiological acoustics. Scherrer thus interpreted the multiple references to other disciplines not as a potential, as Osswald once did, but as a disadvantage. Only with regard to electroacoustics did Scherrer

support Muri's proposal, but with considerable restrictions. In contrast to electroacoustics, Scherrer found little interest in research into room acoustics and noise control: “This is a field in which the theoretical issues are largely resolved, but in which the often very complicated practical situation requires a great deal of practical experience, and in which feeling plays an important role. This field is usually represented by a practical engineer; it offers little real scientific interest.”<sup>3</sup>[6]. The third field of research named by Scherrer, physiological acoustics, however, belonged in his opinion to a medical faculty. Ultimately, acoustics was never able to establish itself as an independent discipline at ETH. In 1958 Furrer became director of Radio Schweiz AG (telecommunications and air traffic control), but continued to teach at ETH. In addition to Furrer, the professors Heinrich Weber (1907-1997) and Eric Rathe (1931-2016; 1965-1997 private lecturer for electroacoustics, 1978 titular professor) should also be mentioned, who contributed to acoustics at ETH.

### 3. ESTABLISHMENT OF AN ACOUSTICS AND NOISE CONTROL DEPARTMENT AT EMPA

The establishment of the Laboratory for Acoustics and Noise Control (Abteilung Akustik und Lärmbekämpfung) at the then *Federal Materials Testing and Experimental Institute for Industry, Civil Engineering and Trade, EMPA* (today: *Swiss Federal Laboratories for Materials Science and Technology, Empa*) in 1961 is not directly related to the debates about a chair of acoustics at ETH. Rather, it was the result of the persistent efforts of the League against Noise (Liga gegen den Lärm), which was founded in 1956 by people affected by noise, experts and politicians, including many influential personalities. With its commitment against noise, the League was already campaigning for environmental issues at a time when the concept of ecology was completely unknown in politics [4]. In this way, the League also helped to raise the awareness of Swiss citizens about environmental issues. The mainly conservative environmental movement brought together an expert network of academics with strong political connections. The initial spark was a paper by Karl Oftinger (1909-1977), who was the first in Switzerland to present noise as a legal problem [7]. As Gallati wrote, Oftinger freed the issue of noise from its “double isolation; on the one hand, from a cultural-critical-elitist discussion that emphasised education for a quiet, thoughtful life, and on the other hand, from a technical-scientific approach to solving the problem, which was based on the attenuation of unwanted sound waves”<sup>4</sup> [4]. The spark quickly spread to the political arena. After consultation in both chambers of the Swiss parliament (legisla-

tive), the extra-parliamentary "Expertenkommission für Lärmbekämpfung" was established. Its purpose was to submit proposals to the Federal Council (executive) on how and at what level measures of a legal or administrative nature should be taken to control noise. After lengthy work in sub-commissions, a report was published in 1963 [8], which influenced noise abatement in Switzerland until the 1980s and formed the basis for the noise legislation aspects of the Swiss Environmental Protection Act (1983) [9] and the Noise Abatement Ordinance (1986) [10].

Even before the commission's report was completed, a Laboratory for Acoustics and Noise Control was founded at Empa on 1 January 1961 as a research, testing and consulting unit, headed by Anselm Lauber (1920-1995). For "objective and also psychological reasons"<sup>5</sup>, the laboratory name was given the addition "Noise Control" at the last moment [11]. Comparable to Willi Furrer's standard work "Raum- und Bauakustik für Architekten" [12], whose title was supplemented with "Lärmabwehr" (noise control) in the 2nd and 3rd editions [13][14], it was also the problem of noise that legitimised acoustic research when the Acoustics Laboratory was founded.

The foundation of the acoustics laboratory at Empa coincided with Empa's move from Zurich to the new site in Dübendorf. The acoustics laboratories were among the first buildings on the site (Figure 5). On 26 March 1962 Lauber looked back on the first year. Six members of staff, including one of the first physics laboratory trainees in Switzerland, were intensively engaged in setting up the activities and equipping the laboratories. In the corresponding letter to the Empa director, Lauber wrote: "I also agree with you that we should use today's widespread noise psychosis and the spectre of noise (with a real background) to expand and consolidate the new section. There is certainly enough work to do"<sup>6</sup> [15].

#### 4. DEVELOPMENT OF ACOUSTICS AT ETH AND EMPA AFTER 1960

##### 4.1 ETH

Although acoustics has never been able to establish itself as a separate discipline with its own chair or institute at ETH, various research projects have been completed with remarkable results. A systematic overview of these has not yet been drawn up. However, a list of Swiss doctoral theses in acoustics by Beat W. Hohmann, himself an ETH graduate, is currently being compiled. It covers a wide range of topics, from which a selection of theses from various ETH institutes is presented below.

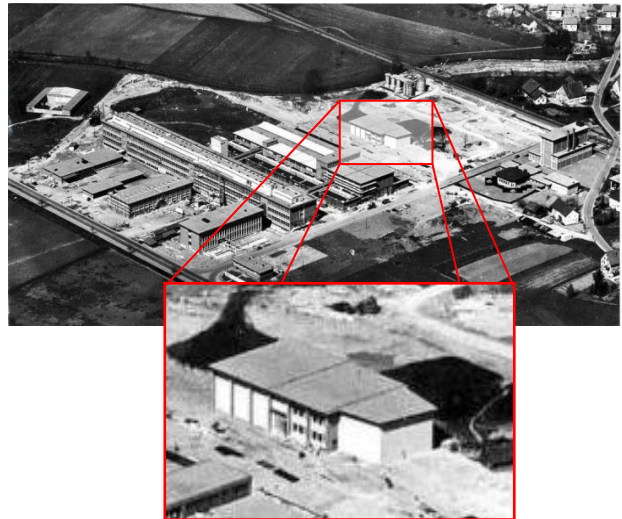


Figure 5 Empa buildings in 1962 showing the acoustics laboratory building (today SH1) with building acoustics laboratories (left) and reverberation chamber (right).

Let us start with a famous name: Jörg Sennheiser (\*1944, Supervisory Board Sennheiser electronic GmbH & Co. KG, Honorary Professor Leibniz University Hanover). In 1974, he completed a PhD thesis at ETH in which he investigated the sound radiation of plates [16]. The PhD thesis of Eric Rathe, who later became a titular professor of acoustics at the ETH in 1960, on the use of transistors in communication equipment, is still on the periphery of acoustics [17], in contrast to his habilitation on the acoustic measurements on motor vehicles five years later [18]. It should also be mentioned that the ETH habilitation of his predecessor Willi Furrer dealt with the acoustics of radio studios [19]. Norbert Dillier's PhD thesis was about cochlear implants at a very early stage and he himself is still a leader in this field today [20]. Other PhD students worked in the field of hearing impairment, such as the above mentioned Beat W. Hohmann [21], who continued to work in this field throughout his professional career, and more generally on hearing [22][23] or the connection of perception of sound and vibrations [24]. Obviously, contrary to Prof. Scherrer's opinion presented above, it was possible to work on such topics at a technical university. Even contributions to research on noise effects can be found, e.g. on industrial noise [25] and sleep disturbances caused by noise [26], this also in a habilitation [27], there somewhat more broadly on noise effects in general. More obviously for a technical university, there are PhD theses focusing on technical acoustics, such as one on the acoustic localisation of

leaks [28], one on the acoustics in street canyons [29] and two on the squealing of railway curves [30][31]. There is even a thesis on musical instruments at ETH, which is also attributed to Empa [32]. Finally, the work on the history of acoustics from the Department of Architecture should be mentioned, on which most of this paper is based [1].

Lectures on acoustics have been and are still being given at ETH. In the past, the lecturers were the above-mentioned professors Osswald, Furrer and Rathe, but later other professors of ETH were also involved from time to time and finally, to a large extent, lectures were given from Empa staff (e.g. Acoustics I & II, Noise Abatement, Room Acoustics).

## 4.2 Empa

From its beginnings in 1961 until around 1990, the Laboratory for Acoustics/Noise Control, as a national centre of competence, not only carried out testing activities and independent expert assessments, but also made a number of internationally recognised research contributions, e.g. on aircraft noise, shooting noise and noise effects. It was an important partner for the authorities for the technical-scientific aspects of formulating and implementing noise protection legislation [9][10]. Examples of research results are the development of a at that time very advanced software for the simulation of aircraft noise on the basis of elaborate own source measurements [33] and contributions to noise effect research [34]–[36].

Since 1988 - and even more clearly since 2001 - Empa has concentrated on application-oriented cutting-edge research in material science and technology. As in 1944 at ETH, the scientific character of acoustics at Empa was questioned in this context in comparison with the excellence of the ETH Domain. Should the acoustics laboratory be closed, spun off or sold to an engineering company? Only after an extremely difficult process lasting several years was it possible to confirm the laboratory's place at Empa, where it now makes its contribution to research and the transfer of knowledge to society and industry, entirely in the spirit of Empa.

Over time, the excellent testing facilities, including high-level measurement technology, were further developed and expanded, for example with a platform for research on lightweight construction and an audio laboratory for listening tests (Figure 6). They were complemented by competences in modern calculation and simulation methods, which together with the outstanding experimental facilities result in an excellent research environment.



Figure 6 AuralLab at Empa: Auralisation, Visualisation

The following are just a few examples of noteworthy projects of the Laboratory for Acoustics/Noise Control:

- Development of methods for evaluation of noise effects and calculation of sound propagation, especially for aircraft noise [37][38] but also railway noise [39] and road traffic noise [40], finally also based on exact wave based methods [41].
- Research on noise effects and psychoacoustics, such as the development of noise assessment indices. [42][43] and listening tests on the annoyance caused by wind turbines. [44].
- Auralisation of environmental noise [45] such as from wind turbines [46][47], road traffic [48][49] and aircrafts [50][51]
- And finally, last but not least, in the field of materials science, Empa's core area: the development of materials and measurement as well as characterisation methods for acoustic materials in buildings [52]– [55], and the promising development of metamaterials like phononic crystals [56]–[58].

## 5. CONCLUSION

At ETH, the difficulty of establishing acoustics as separate discipline in an academic department has manifested itself clearly. However, the examples of PhD theses later carried out at ETH show that, contrary to the statements made in the mid-20<sup>th</sup> Century at ETH, a variety of topics in acoustics are worth exploring at a technical university. Of course, an institute or a chair for acoustics would still have been beneficial for the development of the discipline. Fortunately, however, a competence centre for acoustics was established

within the ETH Domain. The corresponding Laboratory for Acoustics/Noise Control at Empa today has an excellent international reputation.

## 6. ACKNOWLEDGMENT

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<sup>1</sup> “sich der wissenschaftlichen Forschung entzieht, da sie hauptsächlich Fragen der praktischen Anwendung und der Empirie behandelt.”

<sup>2</sup> “deutlich drei ganz getrennte Forschungsrichtungen, die sozusagen nie am gleichen Institut bearbeitet werden.”

<sup>3</sup> “Es handelt sich um ein Gebiet, bei dem die theoretischen Fragestellungen weitgehend geklärt sind, wo aber wegen der oft praktisch sehr komplizierten Sachlage grosse praktische Erfahrung nötig ist, und bei dem das Gefühlsmoment eine grosse Rolle spielt. Dieses Gebiet wird meist von einem praktisch arbeitenden Ingenieur vertreten; es bietet wenig wirklich wissenschaftliches Interesse.”

<sup>4</sup> “... doppelten Isolation; einerseits aus einer kulturkritisch-elitären Diskussion, welche Erziehung zum ruhigen, bedächtigen Leben betonte, und andererseits aus einem technisch naturwissenschaftlichen Lösungsansatz, der auf der Eindämmung unerwünschter Schallwellen beruhte.”

<sup>5</sup> “... aus sachlichen und auch psychologischen Gründen dürfte es zweckmässiger sein ...”

<sup>6</sup> “Auch ich bin durchaus Ihrer Ansicht, dass wir die heute so verbreitete Lärmpsychose und das Lärmgespenst (mit realem Hintergrund) dazu benützen sollten, die neue Sektion A6 auszubauen und zu festigen. – Arbeit gibt es jedenfalls sicher genug.”