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# Violin Acoustics History - a brief introduction

By Anders Buen

Abstract:

More than thousand years of bowed string instrument history has led to the violin. It was fully developed in Italy with Andrea Amati (1511-1581) and Gasparo da Salò (1542-1609), and came to the acoustical peak of performance with Nicolò Amati (1596-1684), his pupil Antonio Stradivari (1644 – 1737) and Joseph Guarneri "del Gesù" (1698-1744). The years from 1700-1745 is called the "Golden Period" of violin making and "Strads" and "del Gesù" from that time are still standards for superior violin quality! Professional and amateur makers, scientists, players and enthusiasts have ever since been trying to find "the secret" of making such good instruments. Violin acoustics has been studied in at least 150 years.

It is impossible to shed light on the whole history in the limited amount of time available for this here. But a brief story as seen through my own eyes will be presented. References for further and more fulfilling reading will be given.

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## A BRIEF INTRODUCTION INTO THE VIOLIN ACOUSTICS HISTORY

*Anders Buen*

Brekke & Strand akustikk as  
Hovfaret 17, NO-0275 Oslo, Norway  
anb@bs-akustikk.no

### ABSTRACT

More than thousand years of bowed string instrument history has led to the violin. It was fully developed in Italy with Andrea Amati (1511-1581) and Gasparo da Salò (1542-1609), and came to the acoustical peak of performance with Nicolò Amati (1596-1684), his pupil Antonio Stradivari (1644 – 1737) and Joseph Guarneri “del Gesù” (1698-1744). The years from 1700-1745 is called the “Golden Period” of violin making and “Strads” and “del Gesù” from that time are still standards for superior violin quality! Professional and amateur makers, scientists, players and enthusiasts have ever since been trying to find “the secret” of making such good instruments.

Early violin acoustics research is reported after Felix Savart (1791-1841) in co-operation with the French maker Jean-Baptiste Vuillaume (1798-1875). Later names like H. Helmholtz (1821-1894), the Nobel price winner C. V. Raman (1888-1970), F. Saunders (1875-1963), H. Backhaus (1885-1958), H. Meinel (1904-19??), L. Cremer (1905-1990) and C. M. Hutchins have given important contributions to the general understanding of the violin. Lately G. Weinreich, H. Dünwald, E. V. Jansson, J. Woodhouse, G. Bissinger, M. Schleske, J. Stephanek, K. Güettler and J. Loen has given important contributions.

Many violin makers use acoustical methods and instrumentation to help in documentation and in their research and development. But there is still a lot of work to be done improving the general violin acoustics knowledge, and the acoustical properties of the preferred older Italian violins in particular.

### 1. INTRODUCTION

Man has played musical instruments for thousands of years. To be able to make and play an instrument you have to know the empirical connections between the physical parameters involved and e.g. pitch. Examples are the relation between string- and pipe length and pitch, sizes of drumheads and pitch, the amount of tensioning of the string or drum heads and musical pitch and instrument timbre.

Instruments, or information devices, like bells have been tuned by the makers way before the theory of curved plates has been developed. In many respects musical instrument making and playing is still dominated by empirical knowledge gained through direct learning from a master and by a long and hard training to achieve the appropriate skill to make good instruments or to play them well. Both also take a solid amount of talent.

The empirical dealing with instruments like making or playing them is a handicraft and a musical performance. When we start putting numbers on music and musical sounds, then it is acoustics.

Violin acoustics has been studied in at least 150 years. It is impossible to shed light on the whole history in the limited amount of time available for this here. But a brief story as seen through my own eyes will be presented. References for further and more fulfilling reading will be given.

## 2. VIOLIN DEVELOPMENT AND EARLY ACOUSTICS HISTORY

An early contributor to acoustics is Pythagoras about 550 BC when he and his pupils found whole number ratios between string length, the fundamental and the overtones in the string sound. After him there seem to be a large gap in the acoustics history.

### 2.1. The early history of the violin

The violin is believed to be developed from earlier bowed instruments like the Rebec and other bowed fiddles like those seen in figure 1. The origin of the oldest of these is believed to be from the 13<sup>th</sup> century. We also see a copy of baroque violin which was the type of violin Amati, Stradivari and Guarneri originally made. It is generally believed that the violin and the earlier versions of it have been used for dance music [1].

The earliest known picture of a violin like instrument is from a church in Ferrara Italy from 1504 [1]. The instrument is believed to have followed Sephardic Jews, some of which fled to Ferrara in Italy, after Isabella and Ferdinand of Spain expelled them from Spain probably around 1495 [1].

Two of the earliest known violin makers are Andrea Amati (b. ca 1505- 157?) from Cremona Italy, Kaspar Tieffenbrucker (1514-1570) Lyon in France, and Gasparo da Salo (1540-1600) from Brescia, Italy [1, 3, 4].

### 2.2. The peak of violin quality was reached empirically

The art of violin making and the sound is believed to reach the peak with the makers Nicolo Amati (1596-1684), his pupil Antonio Stradivari (1644-1737) and Joseph Guarneri del Gesù (1687 -1744). No maker after these has ever reached their level of reputation. The development of the violin to this point was empirical.



Figur 1. Copies of early bowed, and a plucked, string instruments. Photo: Dominique Barreau. From [2]



Figur 2: Detail of a fresco from 1504 in the domed ceiling of the church of Santa Maria de la Consolazione, Ferrara, Italy. Photo: Ferrara's Musei Civic de Arte Antica-Fototeca. From [1].

### 2.3. The development of the modern violin

The violins during the 18<sup>th</sup> century were so called baroque violins with a shorter string length, gut strings, a smaller bass bar inside the instrument, fastened the neck with nails and used a different bridge than today. During the middle of the 19<sup>th</sup> century the music and soloists and makers developed the modern violin and bow. That basically happened in France.



Figure 3. *Jean Baptiste Vuillaume, Paris (1798-1875) From [3]*

The great French maker J B Vuillaume had contact with the physicists Francis Chanot (1788-1825) and Felix Savart (1791-1841). Savart used a method developed by the first acoustician Ernst Chladni (1756-1827) for visualization of vibration patterns and pitch of a dozen or so violin plates from violins made by Stradivari and Guarneri del Gesù. He also conducted a number of studies into the acoustical role of the different violin parts [5]. He used a special tagged wheel he invented to determine the pitch of the vibrating plates [6].

### 3. MODERN TIME VIOLIN ACOUSTICS

Herman von Helmholtz (1821-1894) and Lord Rayleigh (1842-1919) both gave significant contributions to the understanding of musical instruments and a huge amount of theoretical and practical results to acoustics in general. In his early career the Nobel price winner C. V. Raman (1888-1970) wrote some articles on the transversal vibrations of the bowed violin and on the harmonic nature of the Indian drums [7]. He was probably the first to explain the phenomenon “wolf note”.

#### 3.1. Violin acoustics in the 30ties

In Germany the physicist Hermann Backhaus (1885-1958) studied vibration patterns of violins along with his pupil Hermann Meinel (1904-19??) that managed to map vibration modes and the acoustical frequency response of a number of good violins [8]. His work is among the most important in violin acoustics history. He made pioneer work on the role of plate thicknesses, arc heights, varnish, the sound post and other parts of the violin has on its frequency response.

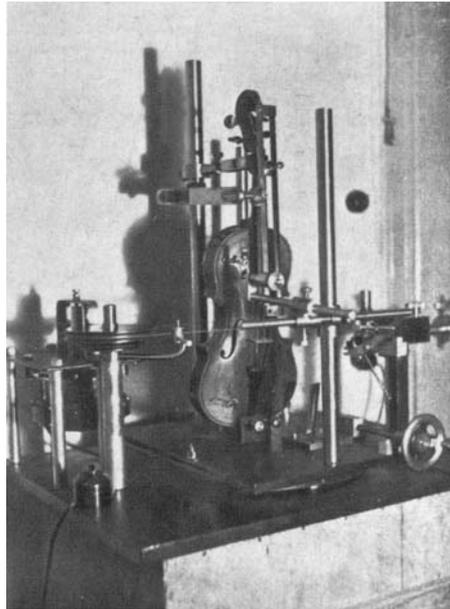


Figure 4: Meinel's set up using an endless hair bowing device [8]

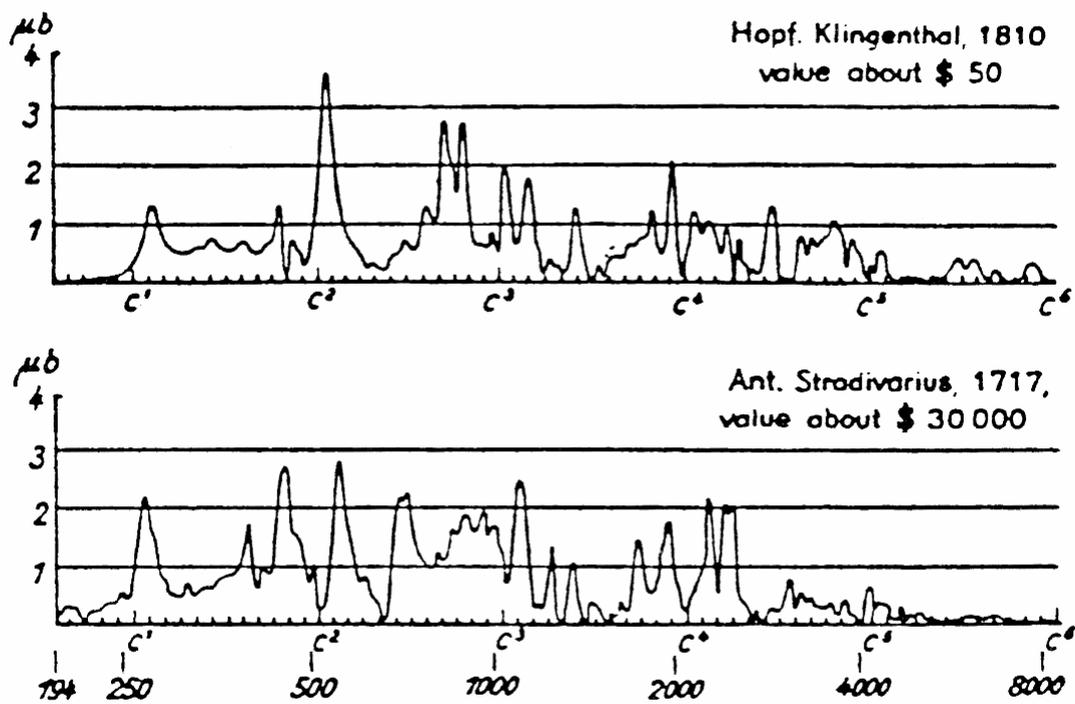


Figure 5. Example of Meinels response curves of a Stradivarius violin with a very good tone quality and a Hopf Klingenthal violin of mediocre quality [9]

In the US Frederick Saunders (1875-1963) started an extensive work on the violin and viola in the 30ties after retiring from his work at Bell Labs.

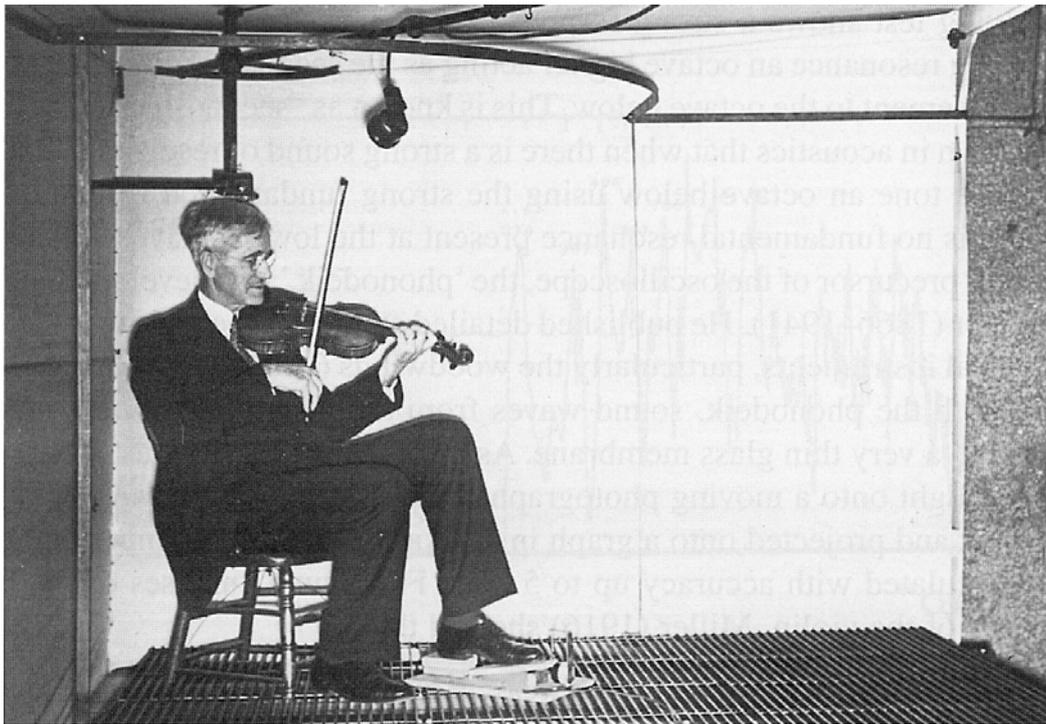


Figure 6. F. A. Saunders in his specially built corner of Cruft Acoustical Laboratory of Harvard University ca 1935 [8].

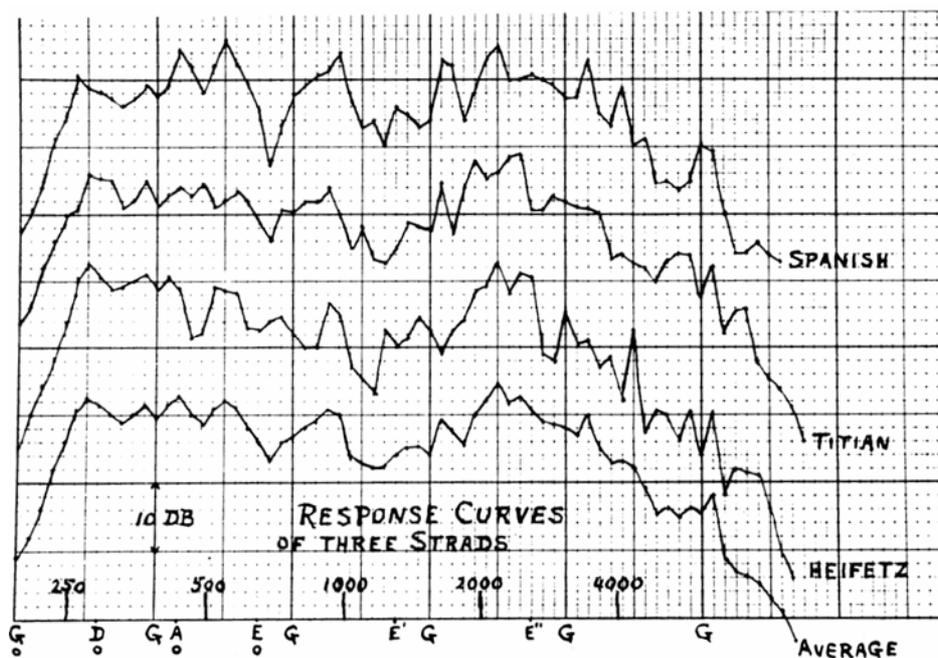


Figure 7. Response curves made by F.A Saunders by combining the strengths of all the partials of each tone. [8]

### **3.2. Schellengs classical work the Violin as a Circuit and the CAS**

A classic work came with Schelleng in 1963 where he explain the additive phase relation between the first and second important resonances of the violin determining much of the low frequency response in a violin. He also gives clue to scale laws for bowed musical instruments. Saunders, Schelleng and Hutchins founded the Catgut Acoustical Society that was devoted to the science and art of making bowed musical instruments. For some 40 years members of CAS were main contributors in the acoustical understanding of the violin publishing their newsletter and later the CAS Journal.

An example of such a contribution is Beldie which explain the first deep valley between the second and the third resonance in the violin using a four mass model for the instrument body [12]. Gabi Weinreich has developed this further in his work with measurements and theories around the radiativity from violins [13]

CAS has now joined the Violin Society of America and continues to live in the CAS forum and the VSA Papers that come out twice annually [18].

### **3.3. Present time**

There are several groups working on the violin today. At KTH in Sweden a group around Erik Jansson, and Anders Askenfeldt has been working on the violin and the bow for at least 35 years. During the 80ties Jesus A Moral made his PHD work at the laboratories there, a work that deserve more attention. Especially his correlation study of properties of free plates to assembled instruments is interesting [15].

Heirich Dünwald made a large statistical study in the 80ties measuring frequency responses of a large amount (more than 700) of violins from machine made ones, to old Italian top class violins. He established parameters that were able to distinguish between most modern violins and the Old Italian high class violins from extracting data from the frequency responses [19, 20].

There is a group in the New South Wales University in Sidney Australia, working with the violin, the guitar, flutes and brass instruments [21].

A group is working on the guitar around Bernhard Richardson at Cardiff University UK [22].

In the later decade a mapping work done by Jeff Loen has shed light into the thickness patterns of old Italian violins [17]. From acoustics we know that thickness of a plate is important for the vibrational and acoustical radiation properties from it.

Jim Woodhouse at Cambridge UK [23] and George Bissinger at East Carolina University US [24] are probably the most important academic contributors to the understanding of the violin today.

For a summary of violin research I can recommend the books edited by C. M Hutchins covering the main activities since the early 1900ds up to 1993 [5, 12, 16]. Lothar Cremers book on the Physics of the Violin is also good reading as well as Fletcher and Rossings book on the Physics of the Musical

Instruments [10, 15]. In 2002 Erik Jansson published a free version of his lectures on the violin and the guitar which is a reference work for those interested in stringed musical instruments [17].

### 3.4. Many makers take advantage of violin acoustics research and methods

Among makers Martin Schleskes violin studio outside Hamburg in Germany may be the maker of highest utilization of acoustical instrumentation in his copying of old good sounding violins [25].

There is also a group of makers in the VSA that take advantage of acoustics literature and instrumentation in their workshop and share results from experiments and interest with other makers on annual meetings held by the VSA. Examples are Joseph Curtin, Gregg Alf and Samuel Zygmuntowicz, all well known makers with a high reputation.

It is quite common today in many workshops to use methods from violin acoustics research together with the empirical methods. It is a challenge however to make the testing fast and efficient enough to be able to use it in the rather limited time a maker has to “play with acoustical tools”. But by experience I may tell that imported Chinese violins seem to be made after methods developed by CAS and C. M. Hutchins for their tuning of plates. It is not easy to compete with their prices and written knowledge is easy to export and achieve.

## 4. CONCLUSION

Some 150 years of violin acoustics research has led to use of some of acoustical methods in violin workshops around the world. However the aim of the academic approach might be the general understanding and not necessarily the knowledge of how to make better violins.

Many players, dealers and makers still have the opinion that the best violins were made some 350 years ago based on empirical development and knowledge. I think the gap between the skills of the old and contemporary makers is about to be narrowed now as we emerge at a greater overview of the violin, how it works and what data they carry. But there is still a long way to go.

The best and most valuable violins circulate outside the academic world, while the best equipment and scientific skills are within the academies. I believe it is very important that the makers, dealers and scientific personnel work together in the task of learning how to make good violins, available at a reasonable price for young and more mature musicians. This task will improve the general academic knowledge as well.

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