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TURNING AND PROVIDING ACOUSTICS TO ENGINEERING PRACTICE - FOUNDATION AND EARLY DEVELOPMENT OF MÜLLER-BBM IN GERMANY

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ABSTRACT

After repeated efforts and achievements in applying physical understanding of acoustics to practical applications before the 1950s, the sharp increase in needs of acoustical guidance for massive reconstructions after World War II suddenly required both: advanced scientific insight and advanced skills and experience in its practical implementation. This was the natural starting point for professional acoustic consultancy start-ups, ideally as spin-offs from proven scientific units.

It was exactly this coincidence of technical and social requirements and high technical/scientific skills and potential which, in Germany in the 1950s, led to the foundation of a small office which later, since 1962, was operated as Müller-BBN and, since 1974, as Müller-BBM GmbH. The names of the founders themselves were program: Leo Beranek (with BBN), Lothar Cremer and his students Helmut Müller, Manfred Heckl and Ludwig Schreiber stood, from the very beginning, for further developing and applying latest state-of-the-art acoustics to the many practical challenges of the time.

The paper reviews the driving forces, the development and the achievements of Müller-BBM from the very beginning through the first decades to one of the leading engineering companies in acoustics and environmental technologies and planning then and today.

Keywords: *History of Technical Acoustics, Mueller-BBM, Lothar Cremer, Helmut Müller, Manfred Heckl*

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1. INTRODUCTION

Although its long and successful tradition in acoustic research had placed and kept Germany in the forefront of scientific and applied acoustics, in the mid of 20th century this physical discipline suffered the image of being mostly explored and conclusively understood, thus lacking the fascination of new challenges. However, this outer appearance should not mislead about successful efforts to better understand acoustics for various occasional problems, particularly in electroacoustics, room acoustics and, in the years of war, marine applications.

Nevertheless, it likely was preserved to exclusive insight of insiders only to anticipate the relevance of acoustics for future technical progress. The well-respected German acoustician Lothar Cremer belonged to them. From him it is reported that in one of his early lectures he had predicted that the task of future physicists was not so much to make new discoveries and developments but the more to cope with negative consequences of existing technologies - long before terms and concepts of environmental protection have been introduced.

Lothar Cremer was to be right. The years of fast reconstruction and rapid mechanization after World War II together with growing demands for environmental compatibility and better quality of life finally turned acoustics into an indispensable engineering discipline. This can be ideally exemplified by reviewing pre-history, foundation and development of Müller-BBM, an engineering consultancy which, at the same time, successfully managed both: to be continuously driven by technical needs as well as to drive forward necessary acoustic know-how.

This paper will review the foundation of Müller-BBM in Munich, Bavaria, and trace its successful development in the second half of 20th century, widely following the valuable references given in [1] and [2].

Since the very roots of Müller-BBM are found in the private consulting activities of Lothar Cremer, the paper also is linked to his further heritage, the Institute of Technical Acoustics (ITA) of Technical University of Berlin (TUB). In fact, both institutions continued the business Lothar Cremer had started immediately after World War II: his research and teaching activities which led him from an adjunct professorship in Munich to the appointment as professor and founding director of ITA in 1958 and from his private research and consulting activities to co-foundation and promotion of Müller-BBM. More details on Lothar Cremer and the history of the Berlin Institute of Technical Acoustics can be found in a companion paper ([3]).

2. ACOUSTICS BEFORE 1950

By the prominent milestones

- "On the sensations of tones" (1862) by von Helmholtz
- "Theory of Sound by Lord Rayleigh (1894/96)
- "Methods of Mathematical Physics" by Courant and Hilbert (1924)

the essential relationships of physical acoustics could be seen as known and well understood in early 20th century.

In parallel with the scientific exploration of acoustics, the end of the 19th century saw a rapid development of electro-acoustic technologies to transduce, register, transmit, reproduce and - finally - broadcast sound (newly introduced in Germany in 1923). Thus established, technical acoustics was the starting point for growing relevance and involvement of acoustic issues within the process of industrialization in the 20th century. At first, this development focused on providing and supporting desired sounds (electric sound recording, transmission, -reproduction and distribution). In addition to developing and extending worldwide broadcasting of sound signals via telephone and radio networks as well as tape and disc recordings, it was W.C. Sabine who was able to lay a solid foundation for targeted acoustic design and layout of auditory rooms to best adapt them to the perception of speech and music.

However, reduction of undesired sounds by technical means was increasingly recognized as an important discipline too, indispensable even for progressive mechanization of our world. Significantly interested circles thus were sure in the early 20th century already that noise abatement was a public duty, being claimed for instance by the first German noise abatement society founded in 1908.

Physical and technical acoustics tried to meet the respective requirements by successful research activities as well as by new findings and development results. Apart from complementing and completing the far-sighted frameworks of Helmholtz and Rayleigh, this led to increasingly systematic investigations of sound generating, sound transmitting and sound controlling mechanisms. Exemplary examples were

- Berger's mass law (1910)
- Derivation and validation of practical approximation formulas
- Introduction of "dB" (1920s)
- Introduction of loudness characterization in "phon" (1926)
- Derivation and experimental verification of coincidence effect by Cremer and Eisenberg (1942/48)
- Development and provision of versatile measurement technology
- Development and provision (by literature) of theoretically and empirically well-founded state-of-the-art reports for the most important disciplines of technical acoustics.

In total, in the middle of the last century, technical acoustics may be described as a discipline which felt committed to the fascination of new technical possibilities (electro acoustics) and quality-conscious hearing requirements (room acoustics) but also to the (still) weak social awareness of detrimental noise effects (noise control). By orienting successive insight along the requirements of increasing mechanization, acoustics had been able to recommend itself as an important instrument of prudential engineering activities: Technical acoustics was to become engineering acoustics.

At the time, one of the leading protagonists of technical acoustics was Lothar Cremer who - together with his teacher Erwin Meyer at the Technical University and Heinrich-Hertz-Institute in Berlin - had essentially contributed to state-of-the-art acoustics then. But the destructions of war had displaced both from Berlin: Erwin Meyer soon followed (1949) an appointment to the university of Göttingen and Lothar Cremer (also in 1949) started teaching at both, the Technical and the General (Ludwig Maximilian, LMU) University in Munich, where he later was appointed adjunct professor (1951-1953). Also, by license of the US occupation authority, Lothar Cremer had set up a small lab for acoustic research and consulting ("Akustisches Laboratorium") in his private house in Munich. There, he followed up previous research work and - as reputable professor - private contracts for various acoustic consulting services.

By these two activities, Lothar Cremer set the basis for two institutions which both had a strong and lasting impact on the development of technical and engineering acoustics in the second half of 20th century: the Institute of Technical Acoustics (ITA) at TU Berlin ([3]) and the acoustic engineering consultancy Müller-BBM in Munich.

3. ACOUSTIC CONSULTANCIES OF LOTHAR CREMER AND HELMUT MÜLLER

3.1 Office Development

Among the successful attendees of his demanding lectures, Lothar Cremer discovered two attentive students with obvious talents, Helmut Müller and Manfred Heckl. He soon (1951) engaged them as student assistants in his lab to support him in measurements and calculations, evaluations and technical drawings.

Helmut Müller was born in 1929 in Neuburg an der Donau where he graduated from high school - together with his close school friend Manfred Heckl. During his school days, he was already pursuing his wide-ranging technical and physical interests which he put into practice with ambitious developments leading to useful, sometimes even successfully marketed results. Although he was temporarily interested in developing and manufacturing radio sets, he finally started - again together with his friend Manfred Heckl - studying physics at the Ludwig Maximilian University in Munich in 1949. His second main interest, music, took him and Manfred Heckl to the challenging acoustics course given by the private lecturer Lothar Cremer. He and his presentation held a strong fascination for both of them and attracted them permanently to this specialist field.

While working with Lothar Cremer in his lab, they started to follow different working preferences: Helmut Müller strongly involved himself in developing, testing and measuring solutions for the newly built concert hall "Herkulessaal" in the reconstructed Munich royal residence while Manfred Heckl focused on more theoretical and structure-borne sound problems. This difference of their topics was found in their diploma theses (1954) again, where Helmut Müller had put together his results of many detailed in-depth analyses for the acoustic design of Herkulessaal and Manfred Heckl had investigated sound bridges at floating floors.

After their diploma in physics, they went unplanned separate ways. Although Lothar Cremer had started successful consultancy business, he was ready to give up his office in 1954 and to follow his preferred research passion by accepting his appointment to become a full professor and director of the new Institute of Technical Acoustics in Berlin. He asked both his assistants to follow him to Berlin as doctoral research assistants, Manfred Heckl immediately and Helmut Müller a little later after closing down Cremer's Munich business.

Helmut Müller failed in getting this done. The successful work of the lab created new and prominent business, the acoustical consultancy for the reconstruction of Munich's opera house ("Nationaltheater" and "Cuvilléstheater") and for the construction of a new concert hall in Stuttgart ("Liederhalle"). Lothar Cremer and Helmut Müller both were sure that such prestigious projects by no means could be rejected and it turned out that this definitely paved the way for Helmut Müller's life-long consultancy career.

Helmut Müller was a born consultant. By combining his in-depth physical understanding and curiosity with his experience, his remarkable ability to intuitively forefeel dependencies and solutions and his reliable sense for manageable risks, he was the right man on the right job. This was all the more true in that in cases of great uncertainty, he could simply consult his friend and his teacher, Manfred Heckl and Lothar Cremer.

Although sharing responsibility for the new projects, Lothar Cremer, as time went on, focused on his new duties in Berlin, thus leaving his Munich lab more and more on its own. Consequently, the lab soon was handed over to Helmut Müller who bought it from Lothar Cremer in 1958 and then renamed it "Schalltechnisches Beratungsbüro Helmut A. Müller".

The growing number of orders soon forced Helmut Müller to rely on substantial support by qualified acousticians and engineers to be employed. This was the beginning of an extremely fruitful spin off period from ITA Berlin, providing proven skills and innovative know-how to the young consultancy. Lothar Cremer, who still gave substantial technical advice, recommended and arranged the employment of his best students and assistants in the Munich lab, the first being Achim Böhm in 1960.

However, the growth rate was limited by available capital and thus couldn't follow the need given by the growing volume of orders. It was a nice coincidence then that at the International Congress on Acoustics (ICA) being held in Stuttgart in 1959, Lothar Cremer introduced Helmut Müller to Leo Beranek, a highly respected acoustician from Cambridge, USA. Leo Beranek, co-founder (in 1948) of the widely known engineering consultancy BBN (Bolt, Beranek and Newman), was impressed by the activities of the young Munich team and offered - by stating that "money is no problem" – financial participation of BBN. This idea was further explored when Manfred Heckl had a working stay with BBN in the US and finally led to the foundation of the "Schalltechnisches Beratungsbüro" Müller-BBN in 1962. The founding shareholders were Helmut Müller, Lothar Cremer, Manfred Heckl, Ludwig Schreiber (the latter two having obtained their doctorate degree at ITA recently) and BBN represented by Leo Beranek. The financial participation of BBN from the US was seen to be of mutual benefit, serving both companies to promote foreign business.

Figure 1. Notarial inaugural meeting of Müller-BBN GmbH (Sitting from left: 1. Lothar Cremer, 3. Leo Beranek, 4. Ludwig Schreiber, 5. Helmut Müller)

The shareholders appointed Helmut Müller to be managing director of the company and Leo Beranek to represent, as director, the shareholders' interest. By formally taking over the previous consultancy, the new company could be run in full continuity to its predecessor with respect to both, staff members and running projects.

Figure 2. Early staff of Müller-BBN (from left: H. Müller, M. Heckl, L. Schreiber, A. Böhm)

3.2 Projects and Technical Activities

Although born out of a distress (due to war and devastation) rather, the consultancy of highly regarded L. Cremer ideally met the needs of the time. Being one of the first private consulting offices which was able to apply engineering approaches to acoustic problems in due time and with full liability, it only needed successive proofs of competence to become widely known and to be frequently contracted.

The above-mentioned Herkulessaal project remained an ongoing challenge for Lothar Cremer and his young assistants in his Munich office. By imposing high demands on versatile usability (multi-purpose music hall allowing studio recordings) whilst maintaining strict shape and design requirements (flat audience area and wall hanging tapestry), this hall required innovative solutions of best possible predictive accuracy.

Specific tasks to be accomplished were to,

- find a seating with pretty much the same absorptive effect as the one caused by the audience, to
- find methods of sufficient accuracy to predict the absorptive effect of huge tapestry, to
- find solutions how to supply distant audience areas with sufficient sound energy and to
- guarantee effective sound isolation against exterior noise to enable high quality studio recordings.

The first two problems could be solved by experimentally developing appropriate measurement procedures and using their result to specify design criteria whereas the third problem led to the worldwide first use of curved perspex reflectors above the stage. Because of other prescribed characteristics of the hall and its ceiling, this was necessary to direct enough sound energy to the rear seat area. Together with appropriate measures against exterior noise, the hall finally succeeded in being a long-term home for Bavarian Radio Symphony Orchestra and Deutsche Grammophon recordings. All measures taken are proven expertise today but needed novel ideas and approaches at the time.

Another example to illustrate the inventiveness required at that time is found by reviewing the measures taken in the late fifties for a thermal power station in the inner city of Munich (coincidentally in 'Müller'strasse). It needed a large degree of courage and self-confidence to accept the condition that this power station should be inaudible, not increasing the existing background noise level. And it needed a lot of ingenuity to find ways how to meet this requirement.

Having quantified the requirement by long-term background noise measurements to 45 dB(A), Helmut Müller had to specify the noise sources (machinery) and the requirements for various constructions of the building to be able to make reliable predictions. All this was new ground: no standards, no databases, no guidelines, no concrete experiences. The first thing to do thus was to put great effort in a series of measurements in other plants to characterize the many machinery noise sources within the power station. Then practicable ways had to be found how to design and predict the attenuation of facade constructions and - finally - how to make sure that all transmission paths including vibration transmission had been considered. All this pioneering work was rewarded by the combined effect of all measures taken: the criterion to be inaudible, although hardly expected by neighbouring residents, was fulfilled and the well-targeted procedure to get there was acknowledged as a first, successful step towards the acceptance of industrial plants in residential areas.

4. MÜLLER-BBN - EARLY ACTIVITIES

4.1 Company Structure

In retrospect, Müller-BBN GmbH was a spin off of a scientific/technical elite of young, highly qualified and excellently trained acoustical engineers. By choosing the - at that time and for that business - unusual legal form of a limited liability company, the company was well prepared to make its employees personally liable shareholders. This model was (and still is today) consequently implemented by mechanisms to ensure that new shares could be provided for employees and to prevent that shares could be sold out of the company. Apart from the participation of BBN, the company should be owned by itself, by its employees.

The company grew rapidly, from 7 employees in the end of 1962 to 32 employees ten years later. It grew with its projects, its challenges, its experience and its success. And it made progress in finding an internal structure and governance which best fitted the self-responsibility and the motivation of its members.

Helmut Müller together with Manfred Heckl (who soon had returned to Germany again) and their early partners aimed at and succeeded in establishing an open, trusting cooperation of quasi self-employed, self-responsible colleagues. Apart from autonomous acquisition, processing and completion of orders, this cooperation and team spirit were promoted by flat hierarchies, fair offers of initial shares and open exchange of technical experiences and problems. As far as possible, the company was not only to be owned but also to be led by its mostly technical employees.

This unique staff member participation model was able to set the right frame for a long lasting and successful cooperation of many highly motivated colleagues. Due to high consensus in all relevant decisions, the model of so many fully influential co-owners worked for up to 200 shareholders even, and it took until 2009 that the model was converted into a stock company.

4.2 Technical Activities

While keeping continuity in its successful way of working, the improvement of its institutional and financial framework enabled the company to strictly improve its personnel and its spatial and instrumental resources. Due to growing demands for acoustical engineering services, the spectrum of technical competence grew along the application areas. The four talented students of Lothar Cremer, who were with the new company from its very beginning, soon felt forced to focus their professional activities around their specific interests but also around some particular topics being continuously addressed and contracted again and again. Thus, long before formal thematic groups were introduced, a natural allocation of specialist knowledge and experience occurred. This will be shortly highlighted later in section 5.2

Increasing need for involving acoustic expertise grew out of social requirements. Having helped to fulfil basic sound requirements in the fast post-war reconstruction period, acoustics now was requested to ensure acceptable noise exposures within progressive mechanization and industrialization. Being the spirit of the time, this request was picked up by national and international initiatives of legal and professional organizations. In Germany, federal authorities and professional associations (like the commission for noise reduction, KLM, within VDI, the association of German engineers) had started to develop legal requirements and technical guidelines. Thus, technical acoustics was about to change its focus from improving desired sounds and sound environments to suppressing undesired sounds.

5. MÜLLER-BBM EXPANSION AND CONSOLIDATION

5.1 Company Structure and Infrastructure

In 1972, BBN asked the management of Müller-BBN whether the company could overcome the selling of their shares. At that time, the request from existing and potential (internal) shareholders was sufficiently strong and the takeover of the BBN shares was no problem at all, the more so as Leo Beranek also showed interest to personally take over some of the BBN shares. Of course, the leaving of BBN had to be linked to removing it from the name of the company. As by this time the name had become a distinguished trademark, a kind of brand already, the company was lucky to find a slightly different shortcut which nevertheless nearly sounds the same: Müller-BBM. Fortunately, this abbreviation also could be given a sense when interpreted as BeratungsBüro München (Consulting Office Munich).

The now called Müller-BBM went on to grow continuously in size, competence and business: from 32 employees end of 1972 to 211 end of 2000, 112 of them being shareholders.

It may be of interest perhaps that the physicists and engineers working with Müller-BBM soon represented all technical disciplines and that only some 50% of them were recruited as trained acousticians, the many others being recruited as particular specialists to best communicate and work with their trained engineering disciplines. They learned acoustics on the job and this best reflects the interdisciplinary nature of engineering acoustics which needs to understand the methods and processes, the thinking of the disciplines it works with and for.

By its very nature, interdisciplinarity best evolves from direct mutual communication and cooperation between the disciplines and their applications. Being identified as a useful source of mutual inspiration and competitive advantage, this internal communication was the reason for keeping the staff together at one company location. However, this location soon suffered space limitations in Munich and moved, in 1976, to new, expandable grounds and buildings in Planegg, close to Munich. And it took until the end of the century that the ease of electronic internal communication allowed to serve customers from closer geographic proximity by a wide-spread branch network.

5.2 Technical Activities

To illustrate the pioneering character of early engineering acoustics in the first post-war decades of 20th century, this section shortly reviews relevant developments together with some milestones of engineering acoustics and noise control engineering.

5.2.1 Architectural Acoustics and Building Solutions

The most urgent need after the end of war was to provide - as quickly as possible - habitable dwellings. It is clear - and it soon became obvious at that time - that this "quickly" had its price: insufficient acoustic comfort and acoustic annoyance by insufficient sound attenuation. In search of competent guidance how to find out of this dilemma, word got around quickly that the well-known acoustician Lothar Cremer might help - and that's what he did. Having made a name for himself in structure-borne sound and sound radiation problems, he soon became a much-sought-after contact person for current acoustic and noise issues, and he was able to set trends for both, quick pragmatic advice and basic acoustic research.
This equally applied to room acoustics where Lothar Cremer soon could prove himself in small and in prestigious projects like the before mentioned Herkulessaal. By focusing himself on research later, he left his projects to his young assistant and successor Helmut Müller who first was hindered by Liederhalle in Stuttgart and the Munich opera house to follow his teacher to Berlin but then knew to use these opportunities for his business.
Thus, architectural acoustics was the kernel business for both aspects of early applied engineering acoustics: supporting and improving pleasant, enjoyable sounds as well as reducing and protecting from unpleasant, annoying sounds. Having successfully started and maintained this business, architectural acoustics became an important application area for the young consultancy - and a successful one! This can be seen best perhaps from some new approaches which had been introduced first by Lothar Cremer and Helmut Müller to become frequently used standard approaches later.

- first freely suspended stage reflectors in concert halls (Herkulessaal)
- first consequent design of stepped audience blocks (vineyard steps, in Liederhalle Stuttgart)
- first movable ceiling above the orchestra (Staatstheater Karlsruhe)
- formulation and application of the first wavefront law
- consequent refinement of measurement methods to determine the absorptive behavior of materials and constructions.

Based on its achievements, acoustic concert hall design projects involving Müller-BBM soon spread out internationally. Today, the expertise of more than 70 years is substantiated in numerous, sometimes spectacular concert hall projects all over the world.

5.2.2 Industrial Noise control

Next to architectural acoustics, industrial noise control soon appeared to be another dominant driving force for further developing the toolbox of practical engineering acoustics. The rigorous acoustic treatment of the thermal power station in Müllerstrasse had shown that sound emission of large plants could be estimated by simple energy considerations which then allowed to meet achievable limit values. This was a key prerequisite for setting mandatory acoustic requirements for technical plants and installations because the predictable only can be planned. The resulting competitive lead gained by these unique experiences brought many follow-up orders and soon resulted in a market leadership: whenever and wherever a power plant was to be planned and built, Müller-BBM almost always was involved.
But there was another branch of industrial plants which needed completely different approaches of noise control: petrochemical plants, typically spread over large areas in open air due to risks of explosion. It was not possible therefore to build enclosures around the plant or parts of it. The predominant opinion of the time was that noise emitted by so many complicated sources and mechanisms was not predictable and control measures therefore only applicable in retrospect, after commissioning. It took many arguments and demonstrations to convince the operating companies that thorough determination of the sound power emitted by the great number of single aggregates would allow to predict the noise impact in the neighborhood. And it needed many basic investigations and measurements to provide all necessary data and influencing parameters.
In the early seventies, stringent but balanced control measures at all relevant sound sources (e.g. primary

measures at valves and fans) but also at appropriate sound transmission paths (e.g. secondary measures like encapsulation, blow-out or inline silencers) altogether were able to reduce the radiated sound power of petrochemical plants - in spite of increased plant performance - by some 15 dB(A). This means that the area exposed to a particular sound level could be reduced by more than 90% - an impressive demonstration of the potential of consequent noise control. Such pilot projects provided evidence that even large industrial installations could be operated in an environmentally compatible way in densely populated countries.

Figure 3. Balloon measurement of vertical radiation patterns within petrochemical plants (around 1970)

5.2.3 Vehicle Acoustics and Traffic Noise Control

The first vehicles being dealt with systematically at Müller-BBM were ships and it definitely was surprising to see that happen in Munich, far away from any sea. This may be traced back to previous contacts of Lothar Cremer, particularly to his early works for British Navy. In any case, being involved in the acoustics of ships forced the young consultancy to early investigations of structural dynamics and structure-borne sound which later helped to apply this progressive knowhow to other applications.
Looking back today, it seems strange that first acoustic analyses of seagoing vessels were done that far (1000 km) away from any German coast, but as said before, the team philosophy of Müller-BBM was to provide intensive exchange of ideas and experiences by keeping the team together in Munich - until new communication technology was introduced at least.

Among the many contributions to vehicle acoustics and traffic noise control, early pioneering work was applied to provide predictive estimates of traffic noise for roads and rails. As with the before-mentioned thermal power station, any tools for predictions such as in noise maps were not available, they still had to be developed. It took decades to complete, implement and provide, step by step, the large toolbox of clear standards, guidelines and extensive software packages we are used to have today.
An example of such an early step is shown in fig. 4 where a noise map has been calculated and drawn by hand from plausible estimates of sound propagation losses in a given landscape. Again, such calculations were the basis for clear and binding rules as fixed in relevant regulations, guidelines and software packages later.

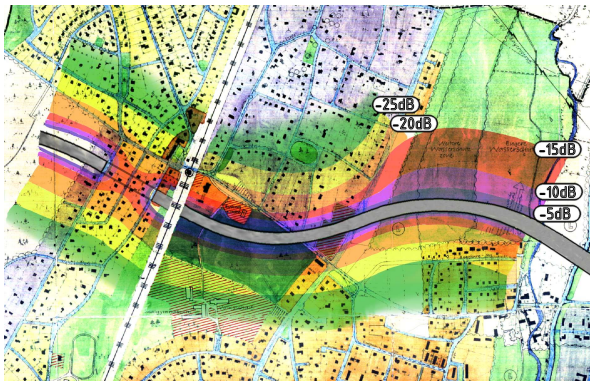

Figure 4. Early hand-drawn noise map (around 1970)

5.2.4 Other Technical Activities

Around its early core activities, architectural acoustics, industrial noise control, ship acoustics and traffic noise control, Müller-BBM from its very beginning was consulted to all technical areas where sound, noise and vibrations had to be considered - and these were all soon, indeed. Thus, the four first working areas and groups soon were complemented by new groups dealing with, among others, railway noise control, automotive acoustics, vibration engineering, structural dynamics, active noise and vibration control, acoustic product testing, software technology and computer-based measurement systems. Also, since the eighties of the last century, Müller-BBM followed growing demands of customers to complete its consulting services by adding new areas of expertise like thermal building physics or air pollution control.
In addition to applying state-of-the-art knowledge, all these activities needed state-of-the-art technology and equipment,

above all latest measuring instrumentation and computer technology. The wide span of using computers may be illustrated by two key points: the installation of the first private terminal in Germany providing time-sharing on-line access via modem to a mainframe computer in the US (in the 60s) and the development and application of high-end computer based multi-channel measurement systems (PAK) and signal-processor based active control algorithms since the 80s of last century.
In addition, it was only due to countless applications of computing power for measurement evaluations (like modal or correlation analysis) or numerical calculations and simulations (like FEM/BEM or SEA) that acoustical problems could be solved at all. But these and some other reviews (e.g. research and teaching activities or work in committees and associations) would definitely go beyond the scope of this paper.

6. OUTLOOK

Development and growth of Müller-BBM steadily continued after the early years described here. Today, Müller-BBM is a widely expanded engineering company with more than 1200 employees in many countries all over the world providing many services, also outside acoustics (see https://www.mbbm.com/). However, although the range of services and specialized products goes far beyond the here described spectrum of the early decades, the unique spirit of high acoustic core competence and self-responsible cooperation could be preserved and still contributes to motivation and commitment.

7. SUMMARY AND CONCLUSION

Fast reconstruction after World War II and upcoming comfort requirements from the following economic miracle rapidly increased the demand for technical acoustic know-how. Lacking any proven engineering tradition before, the involvement of technical acoustics relied on consulting services of specialized acoustic engineers who soon were able to establish themselves as a crucial interdisciplinary discipline. Then, growing comfort-of-life demands, together with increasingly urgent requirements of preservation of our environment, further forced acoustics and acousticians to control sounds. Thus, driven by social demands and driving for new results of scientific research and development, application-oriented engineering acoustics was closely bound into the iterative cycle which has made acoustics a relevant and exciting discipline again, thus essentially contributing to its renaissance in the second half of the 20th century.

Directly continuing and extending earliest post-war activities of Lothar Cremer, Müller-BBM had (and still has today) great formative influence on both, further developing and applying engineering acoustics and establishing it as an important interactive engineering discipline, typically provided by autonomous engineering consultancies. Although in many larger companies indispensable acoustic support today is provided by competent in-house groups with specialized knowledge and experience, the broad cross-application spectrum of acoustic engineering firms and their ongoing contributions to newest insight and technology seem to secure them a solid position in the interactive network of user- and environment-friendly engineering.

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Finally, the author highly appreciates the opportunity to express - by this review article - his admiration and gratitude for the work and guidance he received from the pioneering generation of Müller-BBM. They impressively taught him how to apply acoustic insight to the benefit of sustainable engineering solutions.

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