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The North German Organ Research Project at the School of Music and Musicology, University of Göteborg

By Hans Davidsson

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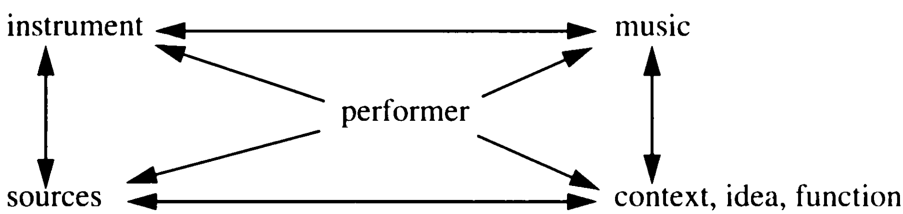
I. Background and aim

The School of Music and the Department of Musicology at the University of Göteborg merged into a single institution in 1985. This union has broken ground for new research focused on performance and has resulted in the development of a new program in the so-called artistic-creative research education. Jan Ling, professor of musicology at the University of Göteborg, has been responsible for this research program, which puts musicology at the service of the performer, focusing research that will illuminate the relationships between performers and the sources of historical or contemporary repertoires, and finally the relevant instruments that helped form them both. The interaction can be described with the following sketch:



The first dissertations to take this approach were presented in 1991 and one of the main subjects of the research has been the North German organ culture of the Baroque.[1]

1. Hans Davidsson, *Matthias Weckmann: the Interpretation of his Organ Music,* Volume One (text), Volume Two (edition), Volume Three (Double CD recording of the Complete Organ Works). Skrifter från musikvetenskapliga institutionen vid Göteborgs universitet nr 22, Ph D diss. (Stockholm: Gehrmans, 1991); Gunno Klingfors, *Bach går igen - källkritiska studier i J S Bachs uppförandepraxis*. Skrifter från Musikvetenskapliga institutionen vid Göteborgs universitet nr 23 (Göteborg: Ph D diss. 1991); Anders Wiklund, *Eduard Brendlers opera Ryno.* Skrifter från musikvetenskapliga institutionen vid Göteborgs universitet nr 25. (Göteborg: Ph D diss. 1991).

The historical instruments themselves are the most important sources for such research. Therefore, the availability of an instrument of similar quality and tonal aesthetics is a necessity for the future development of this research. Already in the spring of 1989 we had the idea of reconstructing a Hanseatic City Baroque organ. It soon became clear that a reconstruction of such an instrument would only be possible on a scientific basis with a interdisciplinary-oriented group of organ builders involved. Professor Harald Vogel, Bremen, as a consultant, and the organbuilder Henk van Eeken, the Netherlands, were involved in the preparatory studies. In 1990 examination of metal samples from 17th-century organ pipes began at the SIMS-laboratory at Chalmers University of Technology, Göteborg. Four explorative tours to Germany and the Netherlands with a varying number of organbuilders, scientists and musicians have been made. In 1991, a joint-venture group of organ builders, who will carry out the applied part of the research and actually build the instrument, and a reference group for the project were formed. The aim is not only to reconstruct a 17th-century Hanseatic organ but also to reconstruct the historical methods of making such an instrument. These goals require a greater awareness of the different perceptions of the organ in northern Europe in the 17th and 20th centuries.

The 17th Century Perception of the Organ

The organ was considered the queen and the heart of all instruments in the 17th century, and the North German organs were especially renowned for their superior standards. They were, of course, also important symbols of the prosperity and power of the free Hanseatic cities. The organ itself was considered to be a symbol of the congregation, Christian life and even the Creation, and was often used allegorically as a subject for sermons and writings.

Such texts describe the human being metaphorically as an organ and the Holy Ghost as the Heavenly Organist. The mouth and the tongue of man are symbolized by the mouth of a flue pipe and the tongue of a reed pipe. The Word of God is compared to the bellows that influence and drive the wind which in turn stands for the human temperament and disposition; the Heavenly Organist controls the instrument from the console, the manuals are the heart and the registers are the different *Affekten*, so that the human being in thought and deed achieves a "Harmony and Resonance" with the divine will.

The organist was a highly esteemed person. The most talented musicians wanted to become city organists, both for the quality of the instruments and for the social status offered by this position. At that time, the Hanseatic cities were foreign and beautiful birds in a landscape of absolutism. In these cities a musician could work with much more freedom than at a court, having the possibility to function as a composer, a capellmeister and an instrumentalist in one person, in other words a *musicus perfectus*.

The organ was thought to materialize and embody the highest standards of art, science, and technology of the time and was regularly admired publicly in services and concerts by people of all ages and social ranks. Only a few people, however, really knew how the sound was produced, how the harmony was created, and what was hidden behind the façade.

The builder was thus a respected and educated person, a combination of scientist, craftsman and artist. The organ building of the time could be described from our point of view as an applied science and art, employing mathematical and geometrical models at the highest level of engineering in construction and design and, at the same time, integrating the latest aesthetical and mechanical concepts.

The 20th Century Perception of the Organ

In the 20th century, the organ as an instrument has played a background role in musical life in general. People have been fascinated, however, by the size of the instrument and the amount of sound that it can produce, thus taking a quantitative rather than a qualitative approach. From the composers' point of view, the main focus has been on new sonorities, and a fascination with the number of sounds and effects a single person can control. Generally speaking, the organ has been considered a product of simple handicraft or a fixture of a building rather than a work of art or a manifestation of science.

When industrialization, or semi-mass production, became predominant at the beginning of this century, a paradigmatic shift took place in organ building. The main aim was no longer to attain the highest quality possible; instead, factors such as capacity and profit became predominant. The instruments were often made in large workshops with a high degree of specialization among the employees. The view of the instrument as a whole was lost. The ideas of the time also supported an emphasis on quantity and loudness instead of quality and beauty. Quality organ builders were forced to surrender for financial reasons. Piece by piece, the accumulated experience of the skilled craftsmen disappeared. Thus the end result came to be determined more by the production process itself than by aesthetical or stylistic aims. The organists themselves were catalysts in this process because of their general attitude that the organ should be large and full of technical devices.

The first reaction to this came with the "organ revival movement" which picked up certain elements from the historical organs, mixed them into a new style and integrated them in the semi-mass production process of organ building. This new style, although it purported to be a revival of something old, was much more a reaction against 19th century aesthetical values, than a recovery of any of the important qualities of the historical instruments.

In the late 1940s a new understanding of the value of the antique organs arose, partly induced by the early music revival. Recordings of historical instruments set new standards. Instruments were restored, and sometimes new organs were designed with a certain awareness of historical practice. A kind of underground organ-building movement, parallel to that of other so-called early instruments, was born. The *International Summer Academy* in Haarlem, the Netherlands, centered around the fabulous Müller organ (restored by Marcussen in 1961), and the *Norddeutsche Orgelakademie*, founded and conducted by Professor Harald Vogel, focused around the historical organs in *Ostfriesland* restored by the organbuilders Ahrend and Brunzema, both played a very important role in this development. A relatively small number of organ builders in Europe and the United States studied the antique organs and tried to recreate their standards. Factors such as the following were emphasized and reevaluated: scalings of pipes, tracker action, suspended action, solid materials, organ case, pipe-metal alloy, tuning and temperament, wind chest layout, wind supply, pipe construction and, more recently, acoustical behavior of pipes.

The Problem

All these factors turned out to be important for the quality of the instruments. But the overall result of the instruments built was not satisfactory when compared to the antique organs. Among the many reasons for this situation, there are five in particular that I would like to mention:[2]

1. The 20th-century view often promotes a focus of attention on isolated factors, while deterring an investigation of how these factors interact with one another in an organic whole. A resulting mistake was the assumption that there was a "universal key" that would solve all the problems. The idea of such a universal secret came to determine much individual research carried out especially by organ consultants, thereby establishing themselves as specialists.[3]
2. The general preconception that the 20th century is superior to earlier times prevented an objective approach and generated an automatic tendency to "improve" historical solutions without sufficient evaluation of their qualities.
3. Builders and experts have not shared experience, results and ideas with each other sufficiently. Organ builders still work in the spirit of the guild system, keeping

2. Professor Harald Vogel, Norddeutsche Orgelakademie, Bunde, Germany, has given me many valuable aspects on this matter.
3. See for example Herbert Schulze, Karl Theodor Kühn: *Orgel-Projekte 1942–1978*. (Berlin : Karl H. Heusser Verlag, 1979). My thanks to Harald Vogel who drew my attention to this work.

their knowledge for themselves, and organ specialists follow the 19th-century ideal of the artist and scientist as necessarily independent and self-sufficient.

4. There has not been enough input of scientific research into the development of organ building. Studies have focused on technical problems while ignoring the musical perspective. Important factors of construction have not been observed and their interaction has been disregarded.
5. The application of modern semi-mass production on the process of making organs is in many ways contrary to the production of high quality equal to that of the antiques.

The development in 20th-century organ building has gradually brought us to an awareness that the average quality of antique organs was much higher than that of modern instruments. This is the departure point for the North German organ project. Our central hypothesis is this: if we create the instrument using exclusively historical building methods and practices, we shall attain a level of quality that will be comparable to that of the 17th-century instruments. The project thus has two main goals:

1. To reconstruct an organ that will enable us to experience the North German organ repertoire in the aesthetic environment, both tonal and physical, that inspired this literature in the first place.
2. To reconstruct the 17th-century building process of these organs.

II. Standpoint of the Research

The 20th-century perspective on the organ outlined above can be traced in a majority of the studies made so far. This main-stream view is characterized in an article on material science from 1987 as follows:

> Bau und Funktion einer Orgel unterliegen sehr unterschiedlichen Anforderungen:
> – Der Musiker wünscht sich ein möglichst vielseitiges (sehr großes) Instrument mit strahlend hellem Klang, auf dem er die dem momentanen Geschmack entsprechende Orgellitteratur spielen kann.
> – Der Auftraggeber möchte eine möglichst große, aber preiswerte Orgel, die schön aussieht und möglichst silbern glänzende Orgelpfeifen besitzt, die sich nicht verändern.
> – Der Orgelbauer möchte eine seiner Tradition verhaftete Orgel entwerfen und aufstellen, die in Größe, Form und Klang den räumlichen Gegebenheiten angepaßt ist.[4]

4. Klaar, Burchard, “Über die Mikrostruktur historischer und neuzeitlicher Zinn-Blei-Orgelpfeifenlegierungen.” (1987), 245.

1. Musicians´ Point of View

The main-stream opinion is that the organist wants as large an instrument as possible which will be versatile enough to serve equally well for all repertoires.

During the last few decades, however, there has been a fundamental change in awareness of quality of sound, stylistic orientation, and the relationship between repertory and instrument. The superior functioning of the historical instruments in liturgical settings has also been pointed out, and basic “sound concepts” of modern instruments have finally been called into question.

This ongoing paradigmatic shift in the art of organ building and playing is still a fluid thing, not yet having firmly established a new set of ideas about what “sound quality” is and what the new accepted comprehensive view of the instrument will be. Some of the factors that may have impeded such a development have been mentioned above. Frequently one encounters either the opinion that the highest quality can be achieved if only the voicer is good enough (the “mystery” of voicing) or the opinion that the sound *must be* good, if the instrument is carefully copied in all measurable respects. Recent studies and practice dispute such ideas, which are influenced by the outlook of the nineteenth century.

2. Organ Builders´ Point of View – Stability and Construction

During the post-war period discussions and studies were limited to measurable factors, such as the proportion of tin in pipe metal-alloys, the stability of pipes, the cost of production, the delay in electric and pneumatic actions compared to mechanical ones,[5] the touch of the tracker organs compared to that of the piano (heavy or easy)

5. Caddy and Pollard (1957): The resulting oscillograms show significant differences in the initial transients: the mechanically operated pallet produces an neatly rounded figure of the initial transient, in contrast to the ragged irregular appearance of the electrically operated pallet. Moreover, independent listening tests favoured the sound of the mechanical action. Another experiment, in which the “electric” pallet was operated slowly by hand gave a result fairly similar to that of the mechanical action. From this the authors conclude that the difference in initial sound should be ascribed solely to the difference in pallet valve opening speed whereas the existence of a note channel in the mechanical system is of negligible importance. This latter conclusion is questioned by Finch and Nolle (1968). In his study “Time Delay Effects in the Operation of an Organ Pipe” (1968), Pollard has carried out experiments on real organs with different action systems (mechanical, Barker, electro-pneumatical and electric) instead of specially constructed laboratory devices. The aim is to conlude what degree of delay may be regarded as acceptable to the performer (defined as initial delay, rising time and total starting time). Two different mechanical organs have been used for the measurements, called “old mechanical” and “new mechanical” respectively. Unfortunately no other information is given as to their age. A systematic method to measure and describe the characteristics of different mechanical systems has to be developed. This can also be seen in a recent study by Kostek/ Bozena (1992), in which mechanical and electrical actions are examined in order to build up an equivalent electrical circuit of an organ action. It is stated that one can conceive a computer modelling system with a kind of electronically controlled keyboard, ensuring the quality of sound similar to organs with the mechanical actions.

and the consequence of the concept compared to the established Neo-Baroque style in terms of specification, the so-called “Werkprinzip” and the absence of nicking in the voicing technique.[6] Research on organ pipes has focused on the fear of collapse and the wish to use cheaper material.[7] Only rarely are factors of sound taken into consideration.This focus can clearly be detected in articles written up until today. Most of the articles written on the topic of organs discuss problems not from an aesthetical point of departure but from the perspective of the semi-mass production.

Consequently, tin-rich alloys dominate in the metallurgical studies, and the eutectic alloy is considered to be the ideal. In practice, tin-rich alloys were considered to be superior to others; this idea might also emanate from the implicit assumption that more expensive materials would give a superior quality.

> Nowadays most organists will tell you that tin is good, lead is not, and zinc is something one tries not to talk about! …the popular assumption that the more expensive metal produces the better sound.[8]

From the 1970s and onwards some studies refer occasionally to historical construction methods. With the help of material science it is shown, for example, that points of great stress occur on the sides of the mouth area of the pipe,[9] which could be overcome with historically inspired simple methods of construction, such as varying the thickness of the metal from the mouth to the top and thereby reducing the amount of tin drastically.

Some American organ builders, however, were aware of the relation of the material to the sound. Charles Fisk described the differences between lead and tin pipes[10] according to their actual quality of tone production. Lead pipes, which had been almost completely ignored in modern organ building, were re-examined, primarily for musical reasons, and employed by a small number of builders, of whom John Brombaugh

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6. New standards for the modern organ building were set by Sybrandt Zachariassen about 1940. His concept was based on slider chests, tracker action and historical scaling, a combination that was considered to guarantee the quality of the instruments. Other factors concerning the pipework, such as flue, cut-up and wind pressure, were not based on historical evidence, or at least not combined in a historically-informed manner.
7. See for example Klaar/Burchard (1987), “Sometimes the mechanical stability of the historic organ-pipes is better than that of the modern pipes…,” 259; Greunke (1984: 108); Kluge (1980), Kluge (1981; this article also takes sound quality into concern), Lewis (1974:772).
8. Fisk, “Some thoughts on pipe metal” (1986).
9. Kluge, “Die statische Festigkeit von Orgelpfeifen.” (1980).
10. Fisk, “Some thoughts on pipe metal,” (1986:124). “Raw lead is a plain-sounding material that imparts no marked overtone structure to the tone of a pipe, whereas tin adds a sheen of overtones which, under the right circumstances, produces a tone of explicit elegance.” Charles Fisk, “How certain...”, (1986:128).

was the pioneer. Experiments with Pb-rich alloys showed that almost pure lead with a certain degree of trace elements is very stable and shows almost no creeping.[11] The possible influence of ageing on the microstructure and the mechanical properties was discussed and heating was proposed as an artificial method for new model pipes. The ancient methods of casting[12] and work hardening were subject for deliberation.[13] A study of the microstructure of historic and modern Sn-Pb organ pipe alloys argues that a conscious choice of metal composition, casting procedure, cooling rate and construction can lead to improved stability.[14]

The historically-oriented organ building brigade managed very well with the technical part of the construction, and the degree of perfection of the woodwork, for example, was higher than the standards of the historical instruments. The copying of the pipework was not always as succesful. The American movement was characterized by a more eclectic approach, which often paid more attention to the sound and touch of the instruments than to the authenticity of materials.

3. The Aspect of Complexity

A general problem with organ pipe studies so far has been that the properties of the pipes examined have not been described in enough detail. Moreover, in almost all cases only modern pipes have been studied. The influence on the sound exerted by details in construction and the mechanical properties of the materials themselves are often not taken into consideration, despite the fact that a relationship between construction material and sound quality was demonstrated as early as 1961.[15] Johan Sundberg´s thesis from the 1960s is one of the earliest of the few studies aware of the difference in behavior between modern and antique pipes.[16] Charles Fisk described

11. In recent years, there has been a growing interest in duplicating the kind of Principal and Flute tone produced by the almost pure lead pipes which were made by Arp Schnitger´s predecessors, and often preserved by him when he rebuilt earlier organs. That kind of tone seems to require high lead-content pipes and to be unobtainable from higher tin alloys. Herman Greunke, "The Structural Stability of Lead-Tin Alloys used in Organ-Pipes." *The Organ Year Book* (1986:108).
12. See: Morgan (1982).
13. See: Kluge (1981) and Pootvliege (1978).
14. See: Klaar/Burchard (1987); No quantification of the elements in the historical alloy is done. The authors do not exclude a possible influence on the sound of the parameters studied. See also: Gifkins (1973).
15. Lottermoser and Meyer, "Über den Einfluß des Materials auf die klanglichen Eigenschaften von Orgelpfeifen" (1962). The influence of material on the sound as an important factor is denied by Yoshikawa in "Energy Dissipations in Underwater and Aerial Organ Pipes" (1985). However, the author does not take into consideration a difference between historical and modern pipes in his calculations.
16. Johan Sundberg, *Metodologiska problem vid analys av orgelklang*, Diss. Uppsala universitet, 1963. See also: Plomp and de Laat, "Comparisons of Organs in a Spectrum Space" (1984), which compares the sound spectra of plenos (principals and mixtures) in 14 different organs from different epoches, from the 17th century to 1950 and, among many other things, shows a striking similarity in the spectra of the three 17th century North German organs, indicating that these organs have common sound characteristics that distinguish them from other 17th century organs as well as from later instruments.

the intimate relation between the pipe and the note channel and stated his awareness of the un-known factors that determine the quality of the organ sound.

> Ah, the note channel – what mysteries lie hidden in that small medieval tunnel! Organ sound is conceived in the note channel, born in the pipe. Half the troubles in an organ seem to originate in the note channel, and yet, so also do a thousand unknowable, dissertation-worthy intricacies that help make of the organ the instrument we find so irresistible.[17]

In 1986 Finch and Nolle stated that oscillations produced by the reflections of air pressure waves in an organ note channel may under certain conditions cause fluctuations in the initial sound output of the pipe.[18] The complex interaction between all the factors influencing the organ sound, which the organ builder in the 17th century knew, is taken into full consideration by Munetaka Yokota in his article on the Chico organ in *The Historical Organ in America* (1992).

> Some historical records indicate that the voicing of the organ pipes was a much easier job for the old masters and could be done without our modern voicing "tricks" or "aids," and that these old pipes have very natural and musical speech…wide latitude of usable speech even under the various speeds of wind pressure increases.[19]

Through experiments that consider all factors important for the generation of sound, Yokota has observed that the quality and beauty of sound are achieved when the factors are combined in such a way that a "dynamically balanced art is created."[20]

> If materials are chosen on the basis of their acoustical properties and if their inherent nature is respected, the materials themselves will determine the dimensions and construction appropriate to them… style is the result of a subtle but powerful interaction between the craftsman, or builder, and the environment.[21]

When principles of construction from different periods are combined "unharmoniously" or even when one is exaggerated in relation to the others, the organic balance is lost and the end result is inferior. The sound result is uninteresting or in the worst case, the instrument does not even work. Some characteristics of *Silbermann* pipes are pointed out.[22] The tapered and relatively thin material that Silbermann used (thicker

17. Fisk, "How certain..." (1986:132).
18. Finch and Nolle, "Pressure Wave Reflections in an Organ Note Channel" (1986).
19. Yokota, "California State University, Chico, California, Munetaka Yokota, Opus 2, 1990." In *The Historical Organ in America, A Documentary of Recent Organs Based on European & American Models*, edited by Lynn Edwards. Easthampton, Massachusetts: The Westfield Center for Early Keyboard Studies, (1992:102).
20. Yokota, ibid., (1992:101).
21. Yokota, ibid. (1992:101).
22. Silbermann pipes also serve as references in Kluge (1975) and in Klaar/Burchard (1985). In both of the articles a possible influence of factors as construction, material and dimensions on the sound are assumed and the word "beauty" in the sense of a superior quality, is used to describe these pipes.

at the mouth end of the pipe and thinner at rest of the body) and its mechanical properties make the pipe body more resonant. In such a pipe wall vibrations can be observed in the upper part of the body.[23] While holding, tapping, or blowing such a pipe, one experiences that the tone is actually living in the pipe itself. It seems as if there is a certain harmonious relation between the acoustical resonance and the vibration resonances. Such a balance should characterize the whole concept so that

> all pipes speak at their most natural point, they balance and blend superbly and yet express a distinct personality of their own, the performer´s interpretation can be sensitively expressed through touch, sufficient and well-behaved wind create musical "bloom" for each note or chord without quick chattering or choking, every part or the organ assists the pipes acoustically.[24]

A similar balance of compatible elements characterizes a living performance of the music of the time. The extrinsic level of a 17th-century organ composition, such as registration (sonority), tempo, and proportion, has to correlate to the intrinsic level of figures, motives, and ornaments. When the performer finds the optimal balance by the technical means of articulation, phrasing and rhetorical gestures, the performance gains beauty, character, and a continual breath of contrasting elements, on microlevel and macrolevel respectively.[25] Studies of musical performance by computer modeling have shown a similar interdependence of musical means of expression and the texture of the composition.[26]

III. The Göteborg Method of Research

The main part of the research within the project will concentrate on the pipework, the part of the instrument that primarily sounds. The research on organ pipes will focus on the properties, construction, and acoustical behavior of the antique pipes. All the factors that influence the quality of the sound should be studied in their complex interaction within the historical models. Relevant wind-supply systems (and extant parts), wind chests, actions and action components will be measured as well as case work. The measurements will be evaluated and compared with theoretical calculations and model experiments. Such a working method requires an interdisciplinary ap-

23. In Yoshikawa, "Energy Dissipations in Underwater and Aerial Organ Pipes" (1985), wall vibrations and sound radiation from the wall are stated to be negligible factors for the sound generation in an [aerial] organ pipe, irrespective of pipe material. However, the author does not take into consideration a difference between historical and modern pipes in his calculations.
24. Yokota, ibid. (1992:101).
25. Davidsson, ibid., pp. 45-82.
26. J. Sundberg, A. Friberg, L. Frydén: "Common Secret of Musicians and Listeners: An Analysis-by-synthesis Study of Musical Performance." (1991).

proach using the wide-ranging expertise of organbuilders, scientists, scholars, and musicians.

It is plausible to assume that the antique instruments sounded differently in the 17th century from the way they do today. The influence of tuning, restorations and sometimes more or less thorough rebuildings over the centuries has to be taken into consideration. The effect of ageing will be an important subject for the research. The research must concentrate on ancient pipework and other parts of the instrument that seem to be untouched and therefore can be assumed to be authentic. The aim of the project will be to reconstruct a Hanseatic city organ with a sound quality equal to that of the antique and well-preserved instruments of today.

Field research

A sufficient number of antique pipes will be examined with a special focus on their acoustical behavior. All standard measurements will be taken (circumference in different positions, mouth width, cut-up, languid thickness, angle, etc); observations of the construction in detail and the acoustical behavior (video recording) of the pipes will be made; careful measuring of the wall-thickness with an ultra-sonic device will be carried out; at the mouth area photos will be taken of the shape of the body and the languid from above and below respectively (with a fiber-optic device). A protocol which coordinates the data will be evaluated and kept as reference.

The extant wind systems will be measured and examined. Initial and reflected impulses will be measured simultaneously and computer model systems will be used to create simulations.

Materials

Mechanical properties of organ pipe alloys and the characteristics of aging will be studied as follows:

1. Microstructures of antique pipe materials will be investigated regarding macroanalysis and microstructure and recasting of alloys followed by microstructural analysis.[27]
2. Microstructural studies of cast modern Pb-Sn alloys with additions of trace elements (nominal compositions and materials cast with modern and ancient methods on different beds; sand, stone, wood etc).

27. The preparation of Pb-rich specimens for microscopic examination has always been a difficult task because of the softness of the material. Dr. Milan Friesel has developed a partly new technique which will be described in an article (in prep). See also: Vilella (1939).

3. Short-time annealing experiments to simulate the natural ageing that has taken place in ancient material (room temperature and elevated temperatures) will be followed by analysis of microstructure and microhardness and compared with the results from new model and ancient material. Aspects of work hardening (scraping, hammering etc.) will be taken into consideration.
4. Ultrasonic measurements will evaluate elastic modulus and internal damping.

One of the main problems with this research is getting access to historical material. Most of the time, only metal samples of a square centimeter are at hand. This is a particular problem for the investigations of microhardness, elasticity, and internal damping. A special research project with the aim of developing a method for measuring the elasticity modulus and internal damping in small samples will be initiated.[28]

Acoustics

This aspect of the research will focus on the acoustical behavior of the antique pipes and the relation between material and sound. An initial study of the relation between elasticity, internal damping, and density will be carried out through computer modeling. Experiments with materials treated in different ways (scraped, hammered,[29] varnished,[30] etc.) will follow. When new pipe models are made, factors like variable wall thickness and the influence of wall vibration will be investigated.

Generally speaking, sound generation in organ pipes is well understood today.[31]

28. So far no study concerning elastic parameters and internal friction in ancient Pb-Sn alloys has been carried out. Cf. Varkey/Padmini (1983).
29. “Frietsche hat schon 1627 beim Orgelneubau in St. Ulrici zu Braunschweig einen eisernen Hammer zum Pfeifenschlagen verlangt” (Flade, E. Gottfried Silbermann. Leipzig: 1953: 171). See also Kluge, “Über den Einfluß des Hämmerns auf die Festigkeit und die Klangqualität von Orgelpfeifen.” *Acta Organologica*, 15 (1981), 180-212. …“Thus the question as to whether, and in what degree, hammering is responsible for different tone quality, could not be definitely answered.”
30. The influence of varnish is not studied so far. Yokota assumes an effect which he relates to increased hardness. See also Yokota, ibid., p.102.
31. See for example: Fletcher, “Transients in the Speech of Organ Flue Pipes — A Theoretical Study” (1976), which gives a theoretical foundation of the nature of the initial transient and the factors that govern it; and Fletcher, “Jet-drive mechanism in organ pipes” (1976), which deals with the deflection of the air jet when it meets the upper lip of the organ pipe. When this happens, the jet switches between a position outside and inside the pipe. This causes an interaction with the pipe modes which produces the harmonic structure of the sound jet stream; Yoshikawa, “Harmonic generation mechanism in organ pipes” (1984); the article is a theoretical study of the physical mechanism producing harmonics (fundamental and overtones) in organ pipes and gives a theoretical foundation for the assumption that the jet offset adjustment is of great musical importance; and Sundberg (1963).

Many of the studies, however, only deal with modern pipes and are not up to date when it comes to measuring methods and technical resources. Much more advanced methods are available today which will reveal subtle differences in both sound spectra and radiation patterns as well as in vibratory patterns and organ tone generation. The speech sound analysis used should be continued and expanded with sonogram methods to study modulation as well as tone build-up and decay properties. Subjective sound quality determination will also be required because no signal analysis technique has the resolution capabilities of hearing.[32]

Special attention will be given to the influence of mouth form, languid angle and thickness and shape, tuned pipe material and parts, shape of the pipe-body, varnishing of the outer pipe surface, dimensions and shape of the note channel, etc.[33] The problems of the case and the acoustics of the case interior are very complex, not to mention the absorbant and resonant properties of the pipes themselves.

Yokota states:

> …if there is a small amount of controlled wall vibration in the pipe wall, it adds charm to the sound…another important advantage…it blends superbly…[tapered] pipes sound a bit softer, they have freer, richer tone…even though single pipes are somewhat softer, the organ sound is enhanced by many such pipes sounding together…the more rigidly pipes are constructed, the more absorbing they become…[34]

These factors are less well understood currently because of lack of research.

Acoustical scale modelling techniques must be used in the design stage according to the room. A few relevant church acoustic environments will be measured, evaluated, and then related to the room where the instrument is intended to be placed, *Örgryte nya kyrka* in Göteborg.

Similar research programs are planned for the investigation of the wind supply and the action.

The following scientists from *Chalmers University of Technology* are involved in the research:

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32. See for example: Pollard, "Feature Analysis of Musical Sounds" (1988) in which different methods of analysis are discussed. The perception of the initial transient is, according to the author, of a different nature (much faster and focusing on a few outstanding features) than the perception of the steady-state tone.

33. Yokota relates the following acoustical phenomena to these factors: I. the diffusion of the sound source. II the preservation of sound energy (which minimizes sound energy absorption), III. the diversification and control of the pitches of sympathetic resonance. Yokota, ibid., p. 104.

34. Yokota, ibid., p.105.

Materials: Dr. Milan Friesel, Dept. of Physics, Chalmers University of Technology (CTH), Professor Alexander Lodding and Hans Odelius, SIMS-laboratory, Dept. of Physics and Professor Birger Karlsson, Dept. of Engineering Metals, Dr. Öjwind Davidsson, Dept. of Organic Chemistry.

Acoustics: Associate Professor Mendel Kleiner and Dr. Wolfgang Kropp, Dept. of Applied Acoustics, Professor Erik Olsson, Associate Professor Bror-Arne Gustafsson and Dr. Tord Granhäll, Dept. of Thermodynamics.

Responsible for the project are Professor Jan Ling and Associate Professor Hans Davidsson, School of Music and Musicology at the University of Göteborg, and as a consultant, Professor Harald Vogel, Bremen.

IV. Method of Building

A joint-venture research project

The organ must be built by organbuilders who identify themselves with the music and craftsmanship of the 17th-century North German tradition and are used to working with an interdisciplinary research approach. Because of the special character of the enterprise, Professor Harald Vogel, the consultant for this project, has proposed a joint-venture projecture. The following organ builders will be responsible for different parts of the process:

Henk van Eeken: research, design, preliminary scaling, and complete drawing.

Mats Arvidsson: manufacturing of all woodwork (including organ-case, bellows, wind-chests, key and stop action, console and the erection of the instrument).

Munetaka Yokota: research concerning the pipe-work, final scaling, pipe-making, installment of pipes and voicing.

The idea of the project is to reconstruct on a scientific basis a fully developed Baroque organ according to the philosophy of the North German builders of the late 17th century. The instrument will be built in all respects according to this tradition. Data will be assembled and evaluated as a basis for the reconstruction from several *Schnitger* instruments, among them: Hamburg St. Jacobi, Groningen Aa-kerk, Lüdingworth, Steinkirchen, Norden St. Ludgeri, Hamburg Neuenfelde and Zwolle. The design of the organ case will take as its point of departure the Schnitger organ (destroyed during the Second World War) in the cathedral of Lübeck. The result of the research will determine the process of making the instrument.

The following **specification** will be realized:

			Oberwerck (CDEFGA–c''')	**Brustwerck** (CDE–c''')	
Principal (F)	16	Q		Holtz-Principal	8
dena	16	O		Octava	4
va	8			Hohlflöt	4
Spitzflöht	8			Waldflöht	2
Octava	4			Sexquialtera	
Rauschpfeiff	II			Scharff	4–6 fach
SuperOctav	2			Dulcian	8
Mixtur	6-8 fach			Trechter Regal 8	
Trommet	16				

		Pedal (CD–d')	
Principal	8	Principal	16
Quintadena	8	Subbaß	16
Principal	8	Octava	8
Gedact	8	Octava	4
Octava	4	Mixtur	5 fach
Blokflöht	4	Groß Posaune	32
Octava	2	Posaune	16
Sifflet	1 1/2	Dulcian	16
Sexquialtera	II	Trommet	8
Scharff	4-5 fach	Trommet	4
Dulcian	16	Cornett	2
Bahrpfeiffe	8		

Four keyboards, two tremulants, nightingale, *Cimbelstern*
Couplers: Ow/Hw, Bw/Hw
Six wedge bellows

Documentation

The results of the research on the different parts of the project will be published in international scientific journals during the building of the instrument. A complete documentation of the project and of the building process of the instrument, including all the results of the research and detailed drawings of the instrument, will be published when the organ is finished. The instrument is expected to be finished by the fall of 1997, and an international conference and presentation is planned for August 1998.

Applied Research Center

Organ education and research has been emphasized at the School of Music and Musicology in Göteborg. The North German project is part of a plan that includes several instruments representing different styles of the main epochs of the organ art. The following instruments will also be built: a Swedish classical organ (according to the styles of Schiörlin, Wahlberg, Schwan, Gren & Stråhle[35]) and a French symphonic organ, which will be built in all respects according to the philosophy of Aristide Cavaillé-Coll.[36] The North German and French projects are financed by *Knut och Alice Wallenbergs stiftelse, Svenska Handelsbanken* and *Forskningsrådsnämnden för Universitet och Högskolor (FRN)* in Sweden. The initial research has been made possible by financial support from *Kungliga Musikaliska Akademien* (the Swedish Royal Academy of Music) and *Stina och Erik Lundbergs stiftelse*.

In the future, the University of Göteborg plans to establish an Organ Art Center with an applied research center for organs and other instruments. The focus will be on restoration, reconstruction, and the development of new methods in instrument building.

General Aspects

Several aspects of the North German research project have general application. When mass-production replaced handcraft, a sudden loss of accumulated experience took place, the full extent of which has hardly been realized yet. In the wake of industrialization and urbanization has followed a tendency to emphasize quantity at the cost of quality, or even to redefine "quality" in quantitative terms. In the market economy financial aspects have prevailed and qualitative factors of human life or influence on nature or environment have been more or less neglected. The theme of technological development accelerating out of the hands of the human race is well-known.

The 17th-century organ builder cast the metal sheets to final, and often variable, thickness. A minimum of work was needed to select suitable pieces for particular pipes according to thickness, and the microstructure was not influenced nor weakened by any severe finishing treatment. Hand scraping and/or hammering were sometimes used to treat the surface. In modern practice, sheets that are extremely thick when

35. Schiörlin and Wahlberg belonged to the so-called Linköping school of the Swedish organ building tradition, being apprentices of Wistenius. Olof Schwan belonged to the so-called Stockholm school and worked in the footsteps of Johann Niclas Cahman, whose father, Hans Heinrich, was educated in the workshop of Hans Cristoph Frietsche, his brother-in-law in Hamburg.

36. The dominating builder in France during the 19th century, whose instruments had a major influence on the repertory and were considered to be superior to others of the time.

compared to the final thickness desired are cast and then machine-planed to their final thickness. This process is considered to influence the microstructure substantially and to change the mechanical properties of the metal. Thus, from a qualitative perspective, the general modern method developed from technical and rational points of view seems to be inferior to the historical method and is even an impediment for the accomplishment of certain musical aims. New scientific models are needed, which consider complexity and context to be as important as details.

The Balance of Perfection and Variation

An overall dominating principle of our time is *perfection* and consistency, from both a functional and an aesthetical point of view. No one wants to hear recordings, for example, which are not perfect in the sense that the performer plays the right notes. The contemporary manner of listening over and over again to the same performance implies a shift towards perfection in this sense and also induces the establishment of "universal" and consistent performances. Everyone knows that a live performance is something different from a recording; it allows more spontaneity and risk-taking on the part of the performer. Despite this, the aesthetics of our time and the process of producing and listening to recordings force us to accept the demand for technical perfection.

The 17th-century way of living, handcraft and art always left space for a certain element of *variation*, which from our perspective could be described as inconsistency. Inconsistency can be found in case work, in note channels as well as in the shape and the dimensions of the pipes. A higher degree of perfection can often be noticed when it is important for the function or an aesthetical aim. It seems as if the idea of a dynamically-balanced concept prevented the people in the 17th century from rigid accentuation of perfection. Perhaps this is also the reason why we today admire the art of that time with our minds and souls without having any social or ideological relationship to it. The use of principles based on geometry and natural proportions for the construction rather than on the linear and logarithmic functions of modern times may also contribute to the balance and beauty of the antique organs.

When early fingering is used in performance of Baroque music a certain degree of variation in articulation and accentuation is achieved. Accentuation is known as the most important factor in the interpretation of 17th-century music. The combination of the performer´s intention of perfection and the historical technique results in an appealing balance within the performance.

The historico-sociological aspects of the status of organ art in the 17th century may also provide important knowledge of the time. Why were these instruments brought to birth in times of war, plague, financial crisis, and political upheaval? What transnational cultural currents can be traced or reflected by the propagation of the North German organ art?

It is our hope that the North German organ research project may serve as a model for interdisciplinary small-scale projects, where science, scholarship, humanities, arts and handicraft can meet, inspire and complement each other. This project represents the reconstruction of a piece of art and the manifestation of a lost musical concept both from the prenational period of Europe, when the peoples in the North were in many ways closely interrelated. It is, therefore, also a logical and not insignificant symbol of internationalization and reunion. Its primary purpose is to provide us once again with the splendid musical resources of the 17th century organ art in a monumental musical instrument, to investigate the factors which determine the generation of highly quality organ sound and to recreate the knowledge and experience of the art of organ building. We hope that the project will also contribute to a renaissance of organ building, so that the words of Athanasius Kircher (1650) also can be attributed to the organ art of the 21st century:

> Nothing is to be compared to the Organ and nothing is more similar to the visible world than the Organ…the Organ is a miraculous achievement of art. Who will deny / that the art of organ building has been brought in our time to its pinnacle of perfection.[37]

37. See Also: Davidsson, ibid., p. 18.

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