Glass instruments – From Pitch to Timbre

Ivar Frounberg,[♮] Kjell Tore Innervik[♮]
[♮]Norwegian Academy of Music
Slemdalsveien 11, 0302 Oslo, Norway
{ivar.frounberg, kjell.t.innervik}@nmh.no

Alexander Refsum Jensenius[♮♯]
[♯]University of Oslo, Department of Musicology
PB 1017 Blindern, 0315 Oslo, Norway
a.r.jensenius@imv.uio.no

ABSTRACT

The paper reports on the development of prototypes of glass instruments. The focus has been on developing acoustic instruments specifically designed for electronic treatment, and where timbral qualities have had priority over pitch. The paper starts with a brief historical overview of glass instruments and their artistic use. Then follows an overview of the glass blowing process. Finally the musical use of the instruments is discussed.

Keywords

glass instruments, performance practice, nime

1. INTRODUCTION

The NIME project at the Norwegian Academy of Music focuses on the development and artistic use of new acoustic and electronic instruments.[1] We have approached this from several different perspectives over the years, including:

- Extending traditional instruments acoustically
- Extending traditional instruments electronically
- Developing purely electronic instruments

All the authors have been involved in the development and musical exploration of various types of purely electronic instruments, both for solo performance and in ensemble settings (e.g. OLO – Oslo Laptop Orchestra).

When it comes to exploring the extension of traditional instruments, the second author has developed and performed with a *quarter tone marimba*[2] with which he could explore microtonality on a strongly pitched instrument. This opened for a new approach to performing the marimba, but more so when it came to pitch than timbre. Thus many of the pieces developed for the quarter tone marimba used electronic treatment of the sound, e.g. the piece *Waves and Velocities* by the first author, in which realtime audio analysis of the sound from the marimba is used to control various types of sound processing in a dynamic and changing way throughout the piece.

After working with extending traditional acoustic instruments for several years, we became interested in developing some new acoustic instruments specifically designed for the use with electronics. On one side we wanted to use acoustic instruments to get the spectral richness and complex sonic behaviour found in the physical body of the instrument. On the other side we were interested in enhancing this richness through electronic processing.

As such, our aim when developing these acoustic instruments have been quite the opposite of a traditional design process. Usually, acoustic instruments are designed with acoustic properties in mind, e.g. that they should sound loud enough for being audible at a distance. In our case this has not been a challenge, since we already from the beginning knew that we would use microphones close to the instruments. Another challenge has been to find a balance between a sonic response that sounds good in itself, and a sonic response that could be interesting to use for further electronic treatment.

Finally, we were interested in developing instruments that call for a clean stage set-up. Our experience with electronics is that the technology often takes too much visual focus on stage, typically in the form of cables, microphones, controllers, computers, etc. We are interested in developing instruments that are visually pleasing, so that they can be an attraction in themselves on stage.

So far we have been developing instruments made of wood, glass and stone. In this paper we will present some of the glass instruments, and reflect upon their use in various musical contexts.

2. BACKGROUND

2.1 Glass instruments

Glass instruments are referred to as *crystallophones* in organology [14], and there are reports that bells and bowls made of glass were played in Persia. In Europe the use of glass for musical purposes was reported in Franchinus Gaffurius' *Theorica Musicae* from 1492 [15]. Here glasses filled with water where hit by sticks, and used to conduct tuning experiments. From 1596 an *Instrument von Glaswerch* is known in the collection at Schloss Ambras in today's Austria [12]. Here a number of glass bowls were tuned with water and played by the friction of a finger.

Among the first known performers on glass instruments is Christoph W. Gluck, who in 1746 played a concert on 26 water-tuned glasses accompanied by a chamber orchestra [7]. Another performer, Edmund Delaval, was heard by Benjamin Franklin who in 1762 proposed substantial improvements to the instrument he then called a *glass armonica* [9]. A number of well-known composers have written for the glass armonica, including Mozart, Beethoven and Strauss [3]. Arthur Honegger wrote in 1918 for *bouteillophone* (tuned bottles) in his orchestral piece *Les Dit des Jeux du Monde* [2, p.397].

[1] http://www.nmh.no/nime
[2] http://www.quartertonemarimba.com

More recently the American composer Harry Partch tuned cloud-chamber bowls to create an instrument accommodating certain ratios in his 43-temperament tuning system [11, p.298]. Since 1945 composers like Crumb, Schwantner, Mayazumi, Kagel, Haubenstock-Ramati and Staebler have used glasses in their works [1, p.381].

Examples from the contemporary scene include projects like *Glasotronic*,[3] the *Glass percussion project* [10] and *Aquarions*.[4] Our approach to glass instruments differs slightly from all of these, in that we focus more on sonic and timbral qualities than pitch.

2.2 From pitch to sound

Percussion instruments were liberated from the role of being supportive and 'exotic' in the history of so-called classical music during the 1920s. This came across as composers like Darius Milhaud and Edgar Varèse wrote pieces in which the percussion-parts grew into an independent musical expression. Some of these early pieces did not even include pitched instruments at all, cf. Varèse's *Ionisation* from 1931.

Looking at the field of instrumental music in the same period, the organization of pitch was *serialized* in the dodecaphonic theory of the composers from Vienna: Arnold Schoenberg, Alban Berg and Anton Webern. Later, in the restoration of the European composed music after the Second World War, serialisation was extended to other parameters. This included duration, dynamics and articulation, as suggested by Olivier Messiaen in his *Mode des valeurs et d'intensités* from 1949. Similar experimentation were carried out in the US in pieces by Milton Babbitt [5, p.232].

During the 1960s the idea of controlling parameters turned towards extended playing techniques. Serialisation gradually became substituted by a spectromorphological view following the thoughts of Pierre Schaeffer [13]. For composers such as Julio Estrada,[5] Helmuth Lachenmann [8, p.1ff], and Salvatore Sciarrino [4], pitch was downgraded as the carrier of expression and substituted by the 'small' sounds arising from the physical body of the instrument.

3. DEVELOPMENT OF GLASS INSTRUMENTS

In this section we give an overview of the development process of our glass instruments. Please refer to the web page accompanying the paper for more details, including pictures, sound material and further descriptions.[6]

3.1 Working with glass makers

Collaborating with the glass-artists Lars Kværne[7] and Pål Roland Janssen,[8] we have explored the creation of instruments with various types of construction, shape, and coating techniques. There are several ways of developing a glass object, the two most common being *cast* or *blown*. We found the latter method more promising, since we wanted to create objects having a more organic appearance.

The development process has been the combination of two different and separate worlds. Our musical ambition has been to create instruments that are acoustically complex and open for a wide variety of musical explorations. Second, the instruments should also be durable enough to withstand professional musical practice and concert use. These ambitions had to be adjusted in meeting with the possibilities of glass as a material and the artistic ideas of the glass makers.

A challenge working with glassblowing is that every object is created in a single process, not unlike how we are used to think during a musical performance. So the glass artists' improvisation in response to situations arising during the 'performance' is something we could identify with. For this project the glass artists worked with ecological lead-free crystal, in a temperature of approximately 1320°C. The sand used for surface treatment is called *silica sand* and has a grain size between 0.5–1.0 mm. A blowtorch was used to keep the working temperature of the glass-mass, and to glue stems to the objects. After the blowing-process was finished, an annealer was used to slowly cool down the glass from a temperature of 500°C, in order to avoid unwanted stress and friction in the composite object.

So far we have been developing three different types of shapes: bowls, shapes with a stem (i.e. 'wine glass'), and rods (see Figure 1). For each of these types, various construction techniques and surfaces have been explored. The following sections will present these in more detail.

Figure 1: Examples of glass instruments and tools, from left: rods, bowl and shapes with a stem.

3.2 Bowls

Six different bowls have been constructed, and their features are summarized in Table 1. They range from small to fairly large (Ø33 cm)), with the upper size being limited by the size of the glory-hole of the glass makers' furnace.

Two different construction techniques were used: one piece and composite. The first bowls (A and B) were constructed as archetypical bowls blown in one piece. This is a normal technique for glassblowers, and the result were two 'plain' circular bowls. Both have a circular shape and the surfaces are coated with silica sand. The difference is that they differ in size and shape. Bowl A is 'closed,' meaning that the rim is broader than the shoulder, while bowl B is 'open.' Since these two bowls resemble commercially available bowls, we have included one industrially made bowl (C) in the table, which we we will use for comparison in future studies.

The second development phase consisted of creating composite bowls (D to G), all resting on a small base. Different techniques were explored: i) glue a thickened band around the bowl; ii) glue different layers on top of each other; iii) deform the bowl in an asymmetrical shape.

Bowl D has a closed circular rim, and a 'ribbon' was attached on the outside to thicken the shoulder of the bowl (Figure 2). The surface of the fundamental bowl structure is coated with silica sand.

Bowl E has an oval shape, and an irregular rim. Here the rim was broken and glued back together during the development process. The surface of the thickened band around the shoulder is coated with silica sand.

Bowl F was created by adding three layers on top of each other, leaving different textures in the material (Figure 3).

[3] http://www.glasotronik.de/allgemein.html
[4] http://www.tidewater.net/~xylojim/edglass.html
[5] http://www.julioestrada.net
[6] http://www.nmh.no/nime
[7] http://www.larsglass.com
[8] http://www.glassmagi.com

Table 1: An overview of the main features of the different bowls

Bowl	A	B	C	D	E	F	G	Wobbly
Form	circular	circular	circular	circular	oval	circular	oval	oval
Aperture	closed	open	open	closed	irregular	open	deformed	open
Surface	silica sand	silica sand	–	silica sand	silica sand	–	–	optic moulded
Surface part	all	all	–	lower part	at shoulder	–	–	–
Height	20.5	13.0	18.0	15.0	15.5	17.2	9.6 - 17.3	5.6 - 6.3
Dia. rim	29.5	40.7	36.1	19.7	25.3 - 27.2	–	17.8 - 27.5	6.0 - 6.8
Dia. shoulder	33.0	35.5	–	24.5	18.2	–	–	–

Figure 2: Adding a ribbon with structure around the surface of the bowl

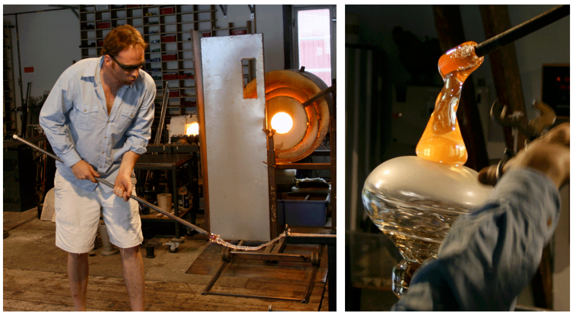

Figure 3: Making an intertwined stick (left), adding a layer on top of the inner surface (right)

The bottom layer (h=7.0 cm) is coated by silica sand, while the next layer (h=5.4 cm) was originally blown in a mould to create a modulated surface. This surface did not, unfortunately, survive the development process.

Bowl G is an oval with a big variation in height, and was extensively deformed during the blowing process.

3.3 Shapes with a stem

Two different types of objects with a stem have been developed: i) wineglass-like and ii) flattened glass-bell with handle instead of a stem. The manufacturing of these objects started out in the same way as the bowls, and then the stem or the handle was glued on later.

Several different types of wineglass-like objects were developed, with different sizes and shapes. For these the structure of the surface came from a mould used while blowing the object.

One small wobbly object was manufactured as the wineglasses but without gluing a stem on it, and has therefore been included in Table 1. This object has a balance point off centre, and is often used in conjunction with bowl A in musical performance.

The manufacturing of the flattened bell objects is more complicated than for the bowls. It typically starts out as the blowing of glasses, followed by various types of deformation of the structure. As for surface structure, we have tested coating the rim with silica sand, and also turning the glass inside out so that the coating ends on the inside. Unfortunately, many of these objects did not survive very long, but two objects of this type are still in use.

3.4 Rods and stick objects

We have manufactured two types of rods: i) glass-chimes and ii) stick objects. The glass-chimes are long cylindrical objects with a small diameter in relation to the length. They have been manufactured with an 'eye' in one end, to facilitate suspension. Many different types of techniques have been explored, e.g. intertwining two strings of glass in the blowing process, which resulted in a screwed surface. The individual objects differ in length, diameter (both cylindrical and slightly conic shapes) and surface roughness.

The stick objects were developed for making sound on the other objects. Most of them are formed as drop shapes, either straight or slightly bend (Figure 3.4). All these objects are coated with silica sand, to be able to cause friction when used on the other instruments.

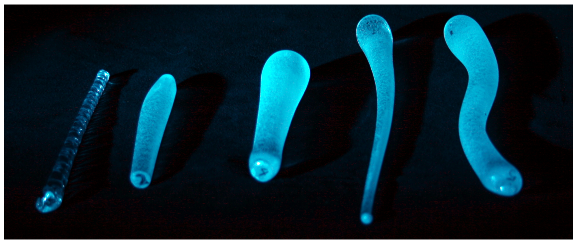

Figure 4: Various types of stick objects

3.5 Surface

Several different types of surface techniques have been tested: i) smooth glass; ii) optic moulding; iii) intertwined threads of glass; iv) silica sand, v) adding a 'ribbon,' vi) attaching bigger glass-parts. The latter was entirely unsuccessful, as the glass pieces melted during the blowing process and left little trace on the surface.

The knowledge gained is that the surface of the objects is of utmost importance for the musical possibilities. Particularly the appliance of silica sand on the objects opens for many interesting sonic results. Unfortunately, the life span of such objects are limited since the sand gradually falls off during use.

4. MUSICAL PRACTICE

All the objects described above have been tested in various types of musical exploration and performance.

4.1 Creating music with the instruments

We have explored three different types of creating music with the instruments: improvisation, improvisation related to composed material and fully composed material. One approach was to improvise freely with the instruments. Here we have also explored the use of electronics with the instruments, ranging from amplification only to extended use of electronic treatment. This type of exploration has made evident some of the possibilities of the instruments, and has worked as a testbed for both composers and performer.

Improvisational techniques were also applied in the piece *Friction and Transformation* by Ivar Frounberg and Peter Tornquist, written for solo percussionist and orchestra. Here a structured improvisation on the glass instruments (with electronics) were used in conjunction with composed material for the orchestra.

Finally, we have also explored the use of full notation with a high level of specification of musical parameters. This was done in the solo piece *Invitro Modus III* by Ragnhild Berstad for glass instruments with amplification. Here the composer focused on both timbral nuances and microtonal qualities by tuning the bowls and glasses with water. One of the main challenges here, is that of developing adequate notational techniques that allow composers to write pieces for various performers.

4.2 Performing with the instruments

One of the main challenges of the performer has been to gain knowledge and hands-on experience with the new instruments. Here we have drawn on the percussionist's ability to explore, learn and master new instruments quickly. The approach has been to improvise and perform with the instruments in various settings. This includes solo performances, and exploration of the instruments' possibilities in relation to other performers of various genres.

From a percussion point of view, the glass instruments are interesting since they allow for continuous excitation, as opposed to an impulse based playing technique often used in percussion instruments. This possibility of shaping the sound continuously over time opens for new ways of exploring timbral nuances.

We have also been interested in exploring how the instruments work at different scales, everything from small rooms to large concert halls. Our musical aim has been to create closeness to the sound, and convey the richness of the timbral nuances made possible by the instrument. When playing in a small room, even minute details can reach the audience, while large concert halls require more dynamics in both action and sound. Here the glass instruments differ from many other instruments in that their fragility creates a specific musical energy, which we believe is both audible and visible for the audience.

4.3 Integration with electronics and visuals

As mentioned in the introduction, we have developed the glass instruments with the specific intention of being used with electronics. An important question here is that of microphone selection and placement. Here we have explored different setups, including contact microphones attached to the bowl, microphones placed around and over the instruments, and handheld microphones. This has also led to a systematic study of importance of microphone placement around one of the bowls [6].

Besides the sonic impact, there are several challenges related to the use of microphones. One is the visual impact of microphone stands and cables. Another is the performer's ability to move freely around the instrument. We are therefore focusing on developing strategies for amplification that are both practical for the performer, and that also make for a visually pleasing stage setup.

Concerning electronic treatment of the sound, we find that it is necessary to use a compressor to 'lift' the least audible components emanating from the instrument, but not so much that the dynamics are ruined. This is particularly important in larger halls, so that it is possible to keep some of the nuances alive in the final sounding result. In smaller rooms we find it necessary to add artificial reverberation to create a larger 'space' for the timbral nuances.

We are still exploring other types of electronic treatment, but standard techniques such as delay and pitch shifting work well for impulsive sounds, and various types of bandpass filters play well together with continuous sounds from the instruments. Examples of such processing can be heard at the accompanying web site.

5. CONCLUSION

The exploration of glass objects presented in this paper represents the first step towards creating more complex glass instruments. One finding is that the objects which do *not* have a clear pitched sonority are the most musically interesting. This is because they allow for experimentation with more complex timbral and textural nuances. Similarly we find that impulsive excitation of the objects is less interesting than iterative and continuous excitation of the surface.

In addition to the exploration presented here, we have started to undertake systematic studies of various features of the instruments, and how they can be used in composition and performance [6]. Future work includes developing a more articulated language and terminology that can be used in the continued compositional and performance practice with the instruments.

6. ACKNOWLEDGMENTS

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