CREATIVE MUSICAL INSTRUMENT DESIGN:

A report on experimental approaches, unusual creations and new concepts in the world of musical and sound instruments.

A thesis submitted to the **SAE Institute, London**, in fulfillment of the requirements for the degree in Recording Arts, awarded by Middlesex University.

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Abstract

The following document presents the results of an investigation into the current reality of creative musical-instrument and sound-instrument design.
The focus of this research is on acoustic and electro-acoustic devices only, sound sources involving oscillators, synthesis and sampling, be it analogue or digital, have therefore been excluded.
Also, even though occasional reference will be made to historical and 'ethnical' instruments, they will not be treated as a core issue, the attention being primarily centered on contemporary creations.

The study includes an overview of the most relevant "sonic creations" encountered in the research and chosen as representative examples to discuss the following aspects:

- Interaction between body and instrument.
- Sonic Space
- Tuning and layout of pitches
- Shapes, materials and elements
- Sonic objects, noise and inharmonic sources
- Aesthetics: sound instruments as art objects
- Amplification and transducer technologies

These where chosen to provide some degree of methodology during the research process and a coherent framework to the analysis of a subject which, due to its nature and to the scarcity of relevant studies, has unclear boundaries and a variety of possible interdisciplinary connections.

The final part consists of a discussion on the relevance of creative and innovative acoustic designs, based on the analysis of the works of artists and developers working in the field with reference to musical, social, and aesthetic factors.

The aim of this research is to create a window onto a relatively unexplored area of organology, a fertile ground for new ideas that might be relevant for the future of music.

The Internet has proved a major source of information in this area of study where very few publications are currently available.
Not only has it provided me with valuable secondary sources, but it has also allowed me to be in direct contact with some of the artists whose work I was analyzing.

This written document is accompanied by a CD of sound samples to demonstrate the instruments described (listing at pag70, Appendix 2).
These sounds are also available at the url:
http://www.contourbuzz.com/soundsbizarre.htm
which will soon host the complete research in the form of an interactive multimedia website with sound samples, illustrations and videos.

A basic knowledge of acoustic, audio technology and music theory is taken for granted.
Where footnotes are not provided, the reader may find basic definitions of terms in the glossary on Appendix 3 (p71).

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Preface

Background

The introduction and development of electronics in music undoubtedly represents the most important innovation of this age as far as musical instrument design is concerned.
At the same time, while the design of traditional acoustic and electroacoustic musical instruments is constantly being refined and bettered (according to musical needs, sound quality, individual artists' needs, comfort and, eventually trends) no substantial major innovation seems to have become popular, or standardized following the introduction of modern instruments.

The avant-gardes and experimentations of the 20th century have changed the way many instruments are played and also the way in which we perceive music.
One of the main effects has been the reintroduction of non-musical sounds and sources in the musical equation, a process in current expansion and consolidation.

The reality of creative instrument design analyzed here shows several important bonds with such evolution. It is a fertile universe of ideas where the traditional art of musical instrument building meets with daring aesthetic research. It also raises interesting issues with regards to the functions and values of music in society.

Purposes of the study:

- To investigate and discuss less known aspect of contemporary acoustic musical instruments
- To create a window on the reality of creative musical instrument design
- To identify elements and topics that could help structure further research in this area of study
- To present new concepts and perspectives encountered in the course of the research
- To create a solid platform of knowledge upon which it will be possible to build:
    - A coherent online resource in the form of a multimedia website and
    - A video documentary
- To stimulate new ideas for a healthy development of instrument and music making.

Acknowledgements:

I would like to thank Bart Hopkin for the inspiration and guidance his work has provided to my project. Also I am profoundly grateful to Ela Lamblin, Leah Mann, Ellen Fullman and Robert Grawi for their support and the precious information they have provided me with in our 'electronic' contacts.

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Interface and movement: On the interaction between body and instrument.

"much of the diversity, the character, the color and the life in music comes from the nature of the instruments, and, in particular, from the ways in which people play them – the interaction of the human body with the physical instrument." Bart Hopkin.

The layout of traditional Western instruments has, over the centuries, reached a very high standard of functionality allowing composers and musicians to master technique and expression and bring music to the artistic heights where it stands.
The process is an ongoing one and improvements are continually being implemented on traditional instruments to refine them.

Following the major innovations of the nineteenth century, when technology had become available to develop modern instruments (such as pianos, brass valves, tuneable percussions etc.), the path of musical instrument design has gone through two very important development stages in the twentieth century with the introduction of electric instruments first and, not much later, of electronic ones.

While the former mostly meant rethinking the traditional instrumental layouts to make the most of the potential offered by transducers and amplifiers, the latter, with the use of synthesis,

sequencers and later of computers and data interchange protocols like M.I.D.I., provided the grounds for interesting experiments, and the creation of truly new approaches to the very act of playing an instrument.
Examples of this are the Theremin and some recent control interfaces, usually in the form of joysticks, positional sensors and contact surfaces that allow for different physical approaches in controlling the generation of sounds.

Other innovative approaches were introduced by the musical avant-gardes of the 20th century, especially in the way instruments were played. Compositions begun to include bowed cymbals, prepared pianos and a variety of electronic devices combined with the traditional orchestral instrumentation. Yet the great majority of music is still performed on instruments using traditional layouts and, among these, the piano-style keyboards are favored by large.

As Simon Emmerson[1] and Andrew Deakin[2] have observed with regard to electronic music: now that we have affordable and 'realtime' computer-based systems there is really only one remaining area needing development - interface and /or instrument design[3].

The statement, as we will see, is also valid for non-electronic instruments and a great deal of research is done in this direction within the curious world explored during the course of this research.

[1] Simon Emmerson : electroacoustic composer and lecturer in music at London City University.
[2] Andrew Deakin: BA and MA Sonic Arts programme leader at Middlesex University, London
3 http://www.mdx.ac.uk/www/sonic/research/andrewlive.html

The ‘physical approach’ is probably the single most important aspect when designing a new instrument. If sound quality, comfort and aesthetics are the primary focuses, a deeper analysis shows that they are all deeply interconnected with the physical interaction that generates between the instrument’s layout and the player approaching it.

This interaction makes an instrument unique and creates a special feeling between performer and his or her instrument.

Most of the artisans-musicians behind the creations presented here do in fact make a strong point of the importance of the physical approach to the instrument and a number of them design their objects with specific approaches in mind.

By approach I mean the way the player stands with the instrument, the movements required to play it and the way notes or sounds are arranged within the instrument.

In particular, the next paragraphs will investigate the areas listed below with the help of the most representative examples encountered during the research process:

- Movement, dance and elements of ritual
- Large instrumental layouts and sonic-spaces
- Meditative approaches

Movement, Dance and alternative approaches.

The great majority of conventional instruments can or must be played in a fairly static fashion, whereby movements are mostly limited to fingers, hands, arms and feet. Of course performers naturally extends the movement to the whole body in their own way as they fully integrate with the music.

Alternative approaches are however possible, and some of the inventions encountered suggest interesting uses of larger bodily movements to produce and control sounds.

Particularly attractive is the extension of such movements into a coordinated dance that can be performed by a single player, but more often sees several players in action at once.

Les Phones with their stilophones and other inventions

The "stiltophones". *(Sample #1)*

Invented by Belgian ensemble "Les Phônes", these are effectively musical stilts: with every movement a pneumatic system drives air through special flutes attached vertically to the stilts and reaching up to nine feet in height. The strength of the player's movement determines loudness and pitch, according to the harmonic series of the pipe itself so that higher pitches are generated by heavier steps and sound slightly louder than lower ones. With this very imaginative solution the performance becomes a choreographic game of balance and rhythmical movements.

The underlying philosophy of the group is that music should only be controlled and planned to a certain extent and that the performer should adapt

his movements to the music rather then the other way around.

This "chance" factor in musical compositions, formally introduced by Cage in the last century, is really much more of a natural and pleasant aspect of music than one would assume. By limiting the range of sonic and rhythmical variables, the *stiltophones* effectively increase the player's freedom, who is then allowed to be led by the magic of sound and movement. Thanks to these restrictions, the result of this freedom is a naturally pleasant and coherent musical form rather than a random batch of sounds or a 'conceptually predetermined aural entropy'[4].

The concept of 'limitation' is taken even further by the group with the introduction, in most recent models, of valves that allow the performer to mute the sound of the flutes at will. This permits, with a metaphor used by member Franck Pilonetto[5], to work on the sound elements like a sculptor does with stone, by carving out rather than adding material, in a form of subtractive music.

Lelavision.

Lelavision is a Seattle based performance company formed by composer-inventor Ela Lamblin and choreographer Leah Mann.

This is their description of the idea: *Physical Music is the complete integration of music and movement: the choreography, instead of being performed to a musical score, as is traditionally the case, arises entirely from the performers playing*

[4] structured sonic chaos!!!

[5] Hopkin, B. (1998) orbitones, spoon harps & bellowphones . New York: Ellipsis Arts, pp.46

Lelavision in action on the Sine Stone (above) and on the Longwave (below)

the instruments , which are designed specifically to evoke such movement. Performances consist of several shorter works, similar to movements in a musical composition, centered around themes of invention, discovery and play[6]*.*

In the illustrations (left) show Lamblin and Mann performing different sequences on the *Sine Stone* or *Stone-dance, (sample #2)* a giant vertical instrument made with 100 river stones suspended by wire of different lengths to a wooden resonator. The length of the strings determines the tuning. Half of the instrument is tuned to a major or minor scale and the other has adjacent strings tuned to minor third intervals, allowing the performer to play chords with both hands. By delicately rubbing the strings with rosin[7] gloves, performers extract sequences of related harmonics as they move on a suspended arch shaped bar. The instrument uses the principle of longitudinal string vibration whereupon the movement is not transversal but follows the direction of the string.

In the *Longwave*, *(sample #3)* an horizontal harp, rosined strings are stroked, rather then plucked, by a number of performers ranging from two to six. Hands and body are used to hit the strings and movements often create a burlesque dance.

The *Stamenphone, (sample #4)* is an upright plant-like structure with 16 piano strings stretching from the top down to a stainless steel spherical resonator containing water.

[6] http://www.lelavision.com/
[7] rosin: translucent resin derived from pine trees.

Ela playing the Stamenphone

Leah and I have had to struggle with the sacrifices each has to make to bring two or three disciplines together. As a dancer it is limiting to Leah to have to hold and play an instrument; as a musician, it is difficult for me to play while trying to move (gracefully and with intention)
Ela Lamblin.

Strings are played in harmonics by bowing with one hand and touching key points[8] with the other. In some performances the *stamenphone* and the players (Ela and Leah) are separately suspended. Music arises from encounters of the three suspended bodies on their swinging trajectories, or in joint orbital dances. When the instrument is free to move, water within the resonator creates randomly shifting resonances that add changing tone colors to the sound. The *stamenphone* generates meditative sounds with a natural long decay that allows for layers of notes to linger in time and space and form chords.

The majority of Lamblin's works, of which there are too many to include here[9], are substantially conceived in the three-dimensional world of sound, movement and aesthetics. The objects often derive from a vision but are not made to be simply looked at or listened to but rather to be experimented with and to stimulate musical and sensory interaction.

There are several other forms of composition-choreographies where instruments determine movements and vice versa: notably Ellen Fullman's work on the Long String Instrument, the stage work of musical theatre group Stomp, where performers use dance and space on stage to create musical patterns with objects and the interesting *'whirlies'* ensembles guided by Sarah Hopkins.
All of these will be discussed in more detail in following sections of this work.

[8] natural nodes of the vibrating string according to the Pythagorean (Just) theory. Tone bending techniques, like those used in Indian classical music, apply to this instrument which can thus produce a full chromatic scale over a range of five octaves.
[9] for further information visit www.lelavision.com

Large instrumental layouts and sonic-spaces

Any "large" instrument is bound to have a considerable impact on both audience and player even prior to its sonic qualities.
Firstly, it is likely that both audience and player have to reach the location of the instrument in order to hear it or play it. Secondly, the setting and the layout of the instrument are likely to become an integral part of the performance and a "stage presence" so to speak, forcing the player to make specific movements or becoming a visual attraction in itself, for the way it is designed and operates. These aspects often introduce an element of ritual within a performance and may also call for dance-like approaches like the ones seen in the previous section. (This section is closely related to the previous one in many aspects but here the focus is mostly on the physical environment.)

When the size of the instrument increases to the point where player and audience are eventually contained within the instrument itself or, in more general terms, within the sonic space created, then the psychological and aesthetic impact moves into an ever more interesting dimension. Enlarging the space does not necessarily mean abandoning the familiar concept of musical instrument, a spatially contained object usually playable with controlled movements of hands and feet. It does, however, require some flexibility on our part.
It is not, after all, an entirely new concept, nor a revolutionary one at that. The old church pipe organ could, in a way, fall under the "category" discussed here. Those instruments were in fact

closely associated with the cathedral or church they were built in, and the final sonic result of the instrument was largely dependant on the features of the building itself, which acted effectively as the resonant body for the air-pipe vibration in much the same way the body of the guitar does for its vibrating strings.

The Long String Instrument. *(sample #5)*

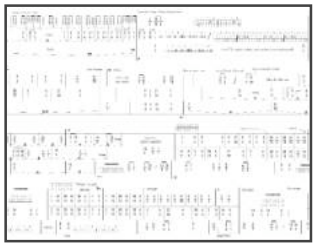
Ellen Fullman's Long String Instrument ©Todd Wolfson

Ellen Fullman began developing the Long String Instrument in 1981, inspired by Alvin Lucier's 'Music on a long thin wire' (1979)[10]. In its more recent arrangement, it consists of 3 separate sets of 20 musical strings each. Strings are 85 feet long and anchored at waist height to soundboards at the far walls of the space. Two of these sets are divided into two parts by means of double-sided soundboards. This arrangement provides a total of 5 sets with 100 segments of playable strings. Tuning, based on just intonation[11], is adjusted by

[10] composition where the vibrations of a suspended string activate a series of oscillators.
[11] See appendix 3 p71

changing the length of the vibrating portion of the string by means of c-clamps attached at the desired points. The longest of the string-sets is the bass section of the instrument, which has now an extension of three octaves (55Hz to 440Hz). The L.S.I, like Lamblin's Sine stones, is based on the principle of the longitudinal vibration mode whereby strings are rubbed lengthwise (better with rosin gloves or hand-lotion) rather than transversely. This action creates waves of compression and decompression along the string, which generate continuously variable tones based on the harmonic series of the string.

In full operation the L.S.I. requires three players, two facing each other on the shorter sets and one on the bass.



Detail of the score for: 'Change of direction' and reference lines on the floor of the installation (below)

Playing involves entering the instrument's space and walking alongside the strings. The result is "a continuous cascade of shifting pitches and overtones resonating within the instrument's space[12]". These shifting sonic layers may reach a high degree of tonal complexity but never result in dissonance as simple and carefully chosen harmonic intervals regulate the system[13]. Fullman has also developed a notation system for the instrument, based on movement/time relationships. Performers can actually follow specifically designed scores, in the form of graphic maps, and reproduce specific patterns of movements using a system of numbered lines painted on the floor at metric intervals.

Bart Hopkin describes it as follows: "It is, by its nature, a walking instrument: an integral part of

[12] adapted from Martin, E. (1995). Architecture as a translation of music (Pamphlet Architecture #16). Princeton: Princeton Architectural Press, pp47

[13] Ibid. pp.48

the music is the choreography of the players' movements along the strings."[14]

Fullman has performed with the LSI in America and Europe, collaborating with the Pauline Oliveros Foundation, the Kronos Quartet and many others. While the main potential of the instrument is that of creating hypnotic and meditative sound environments of changing tones, drones and colors, Fullman's more recent work reportedly displays research towards the possibilities of more rhythmical and melodic approaches.

An interesting aspect of the LSI is that, even though it is one-of-a-kind, it does have a solid underlying concept and a methodically organized structure and approach that could make it a potential signpost for a next generation of large size instruments based on similar principles.

Stalacpipe Organ, (1954 Luray Caverns, Virginia) and the rubber mallet hitting the stalactites.

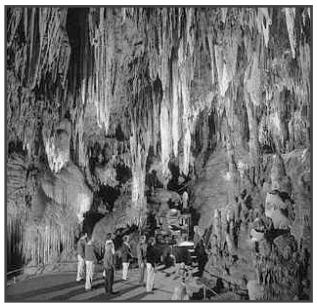
The Great Stalacpipe Organ *(sample #6)*

Built inside Luray Caverns in Virginia, this, due to the 3 $_{1/2}$ acres of caverns it covers, was recognized by the Guinness Book of World records in 1988 as the largest instrument in the world.

The organ was invented in 1954 by Mr.LeIand W. Sprinkle[15], after 3 years of researching the cavern for stalactites that had the right "pitch" when struck. He then assembled a system of rubber-tipped mallets electronically wired and controlled via a traditional four-manual organ console, set in Luray's main cave, appropriately named "the cathedral".

[14] Hopkin, B. (1998) orbitones, spoon harps & bellowphones . New York: Ellipsis Arts, pp 78

[15] a mathematician working for the Pentagon



Stalacpipe Organ, (1954 Luray Caverns, Virginia)

The sonic experience is reported to be quite impressive. The stalactites have, in the words of Laurel Dalrymple from The Washington Post[16], a dulcet sound. The mellow and somewhat marimba-like percussive sound resonates within the chambers with considerable fullness, warmth and clarity.

The place is, sadly, considered almost solely a fascinating and bizarre tourist attraction and occasionally used for weddings! The sonic potential does not seem to be fully exploited and there is apparently one single CD, *(Monte Maxwell's Midnight in the Caverns)* only available at the Luray Cavern shop.

With some flexibility in our conception of musical instrument we can move even further and consider as a valid some approaches to making sounds and music, that are usually found outside musical contexts and, particularly, in the field of architecture and installations.

Dasonics-piano

Phil Dadson's[17] " Dasonics-piano" for example is a "floor-foley instrument" that originally consists of a 14 X 8 meter floor gallery area[18] divided into sections covered with different materials such as pebble, gravel, and shells (representing New Zealand). Within the gallery space, sound is captured by eight overhead condenser microphones and amplified through four loudspeakers hung from the ceiling. In the original installation, sound was

[16] http://www.washingtonpost.com/wp-dyn/articles/A11278-2004May8.html
[17] Phil Dadson is an Auckland (NZ) based composer who worked in London with Cornelius Cardew in the late 1960's, more on his work in the following chapters.
[18] 1st exhibition held at the Robert McDougall Contemporary Art Annex, Christchurch NZ. Oct 6 to Nov 5, 2000

also being transmitted via the floor's natural vibration to the basement gallery beneath.
This is how the artist has described the instrument in a recent interview[19]:
"making sounds with the feet as part of a performance, foot-stepping on different surfaces, can conjure up associations with location in the listeners; atmospheres so potent you can almost taste and smell them in the sound. The floor of 'piano' operates in this sense like a large instrument, a 'foley' floor instrument, activated through walking; with the materials for it evoking locations and experiences of textures that sound underfoot."

In the world of contemporary music, from concert-hall to mainstream electronica[20], where noises and non-musical sonic elements are increasingly used and appreciated, this seems an extremely interesting approach, once again involving larger physical movements and interaction of players with each other and with the surrounding space.

Le Cylindre Sonore

Le Cylindre sonore.

Built within the modern landscape of the Parc de la Villette in Paris, "Le Cylindre Sonore"[21] in fact, a sound space, more that an actual instrument.
Two concentric concrete cylinders 5 meters high with an inside diameter of 10 meters act as an acoustic container for changing sound patterns, derived from microphones distributed in the surrounding bamboo forest and radiating from a

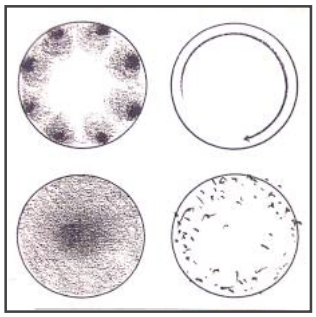
[19] interview with Wystan Curnow. http://www.fromscratch.auckland.ac.nz/
[20] Bjiork Vespertine tour included performers stepping on sand, gravel etc.
[21] Architect: Bernhard Leitner, 1987

total of 24 speakers concealed behind 8 perforated panels on the inner wall.

Each panel also hosts a narrow vertical "water column" designed as an "acoustical fine tuning device[22]" for sound coming from the resonating space between the cylinders.

Natural sounds are thus amplified and eventually distributed within the space according to prearranged diffusion patterns (left) by the loudspeakers and the resonating space creating a unique sensory field.

Nature plays the instrument and the listening experience is guided by the physical space. Steps lead in fact the visitor down into the sound space, sunk below ground level and then up again at the opposite end of the structure.



Notation sketches for experimental sound diffusion patterns within the Cylindre sonore.

We find, once again, elements of chance involved in this concept and, more importantly, an emphasis on perception that may be linked to modern musical approaches such as those suggested by John Cage and Edgard Varese and, more in general, with the creation of sonic textures rather than structured compositions.

Playable or musical sonic spaces are indeed a concept to be explored further. Its musical possibilities are immense and the social implications involved with the idea of performers being also audience within the sonic space definitely deserves attention.

[22] Martin, E. (1995) Architecture as a translation of music (Pamphlet Architecture #16). Princeton: Princeton Architectural Press pp.28

… And on a smaller scale

The above examples have taken us through increasing sizes of instrumental layouts and possibly further away from the traditional definition of a musical instrument.
Yet even among creations of a smaller scale we are bound to find interesting and equally unusual new approaches.
The original idea behind a new instrument may have a variety of origins. Some inventors are inspired by traditional, folkloristic or ethnic instruments and develop new designs with the technologies and materials available to them. Some others may create out of the sheer urge to invent something new, something unique and very personal, be that for practical, aesthetic, conceptual reasons, for matters of ambition, research or necessity.

A meditative approach can have a strong influence on instrumental designs. By meditative I mean that the instrument is mostly, though not solely, oriented towards individual, personal performances without audiences.
In this case the relationship between musician and instrument consists of a private discovery of sensory and psychological states and the development of playing techniques.
The design of the instrument can enhance this aspect.

Huaca *(sample #7)*

Sharon Rowell's Huaca

Sharon Rowell suggests a similar approach in her *huaca,* a triple chambered vessel flute[23] made of clay, resembling a big and bizarre ocarina. The sound-holes of each chamber direct the sound towards the player's ears thus creating and enveloping and dynamic sound field around the performer.

This meditative approach to an instrument, and to music making in general, has its origins in ancient times and is still highly valued in certain oriental cultures. Western, African and South American traditions have overall, apart from some notable exceptions, been more keen on the social and expressive component of music. Traditional instrument design displays this tendency with an output of instruments that are fit for ensemble performance, musical and social interaction or, if conceived as solo instruments also, they allow for the greatest possible frequency range, dynamic range, virtuosity and expression in general.

Symbolic shapes: heaven and earth are represented in the curved sound board of the guquin, a traditional Chinese meditative instrument.

A meditative approach can result in minimal designs or symbolic shapes, like in the traditional Chinese meditation instrument 'guqin' (left) as well as more complex and personalized layouts aimed at making the playing experience a reflective act, where the process of discovery of the instrument's sonic capabilities is part of a personal exploration and not necessarily part of an established ritual or performance.

[23] Vessel flutes are similar to tubular (standard) flutes but are fatter in shape and generally have a rounder sound

The guitar family

This research has shown that one of the most popular forms of instrumental 'personalization', redesign and customization, takes place among the wide family of plucked and bowed stringed instruments.

Despite its popularity the guitar is in fact a limited instrument and, browsing through experimental designs one comes across a very large number of guitar prototypes and hybrids with added strings, added necks, sitar and harp-like implementations, demonstrating a continuous research to expand the instrument's potential.
Here are some of the most relevant cases encountered:

Linda Manzer

Linda Manzer is a luthier who, apart from producing beautiful "standard" guitars, has specialized in (equally beautiful) custom designs for her clients, which include guitar legends Pat Metheney and Bruce Cockburn. Her most famous work is possibly Metheney's Pikasso® Guitar. *(sample #8)*

Pikasso® by Linda Manzer
© Brian Pickell, Mark Brickell, L.Manzer.

"In 1984", she says[24], " Pat Metheny asked me to design and build a guitar with " as many strings as possible". The result was a massive Rosewood, Spruce Mahogany construction with 4 necks, two soundholes, 42 strings and a custom pickup system including an exaphonic pickup for MIDI triggering.
This layout allows Metheney to extract sound with several different playing techniques (tapping,

[24]http://www.manzer.com/more.tmpl?cmd=search&db=lmodels.db&var2=lmodels.db&var3=Custom%20Design&wfskudata=2931-15

Harpsitarguitar by Linda Manzer, for Shunuchi Sawada. © Brian Pickell, Mark Brickell, L.Manzer.

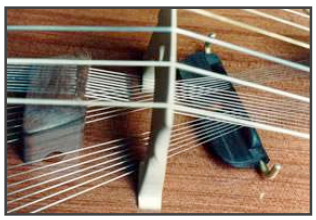
plucked arpeggios etc.) thus working on multiple scales and palettes of tone colors at the same time. The instrument also has its own peculiar resonance due to the sympathetic vibration of untouched strings.

Linda has also implemented a simple but effective innovation in designing the body of the Pikasso. The side closer to the player is thinner than the opposite one for increased visibility and comfort.

This unusual feature, which Manzer trademarked as "The Wedge™" now appears on many other of her instruments and is highly appreciated by several guitarists.

Manzer Guitars also produces some the hybrids mentioned above, under exotic names like: harpsitarguitar and sitarguitar.

Guitarangi da Gamba and bridge detail, by Todd Green. ©Alan Porter



Fred Carlson

Luthier Fred Carlson (Beyond The Trees) is also a master of the latter hybrid kind. His Guitarangi Da Gamba designed for Todd Green, has six string in a viola da gamba arrangement that can be easily bowed or plucked thanks to adjustable nylon frets on the neck. It also boasts 10 sympathetic strings inside the neck and 14 more harp-sympathetic strings cutting across the soundboard. Many more variants can be seen at his online gallery at:www.beyondthetrees.com/gallery.html

Similar designs, combining western and oriental traditions, but also plucked, bowed and sympathetic strings exist in countless variations.

Overall there is notice a tendency towards instruments designed for mixed playing techniques

that allow for a much richer and varied approach to instruments and, generally speaking, provide extended sonic palettes.

A few more interesting innovations in the world of commercially distributed guitar-like instruments are worth mentioning here, noticeably the Chapman Stick, the Novax/Charlie Hunter instruments and the Ashbory Bass. They are relevant here as their innovations directly affect the interaction between musician and instrument apart from other sonic and musical qualities.

The Chapman Stick *(sample #9)*

Tony Levin playing the Chapman Stick. ©Armando Gallo

Developed by L.A. guitarist and bassist Emmett Chapman in the 70, in its standard layout[25] "the Stick" consists of an extended fingerboard (touchboard®) with ten strings arranged as follows: five melody strings tuned in descending fourths, and five bass and chord strings tuned in ascending fifths[26] so that the lower strings are in the central section of the board.

As seen in the picture the instrument is played in an upright position with the fingers of both hands perpendicular to the strings. Notes are tapped by both hands onto the fingerboard thus combining guitar, bass and, notably, piano and percussive techniques in one single instrument.

This unique tapping method occurred to Chapman in the late sixties while experimenting with different guitar approaches and, having realized its potential, he spent the following years developing

[25] there are also 8 and 12 string models
[26] http://www.stick.com/articles/evolution/

an instrument that would make the technique effective and practical.

In this case the technique is clearly the driving force behind the design for a new instrumental concept.

Novax/Charlie Hunter *(sample #10)*

A tapping technique is also involved in the music of guitarist Charlie Hunter who approached Ralph Novak of Novax guitars to design an 8 string guitar bass hybrid. Hunter taps bass lines onto the lower strings whilst playing melodies with standard techniques on the higher ones.

Charlie Hunter with his Novax model

The Novax/Charlie Hunter instrument comes in a fairly standard guitar like shape but benefits from Novax "Fanned Fret®" technology whereby fret intervals on higher strings are shorter than ones on lower strings and, subsequently, higher strings are shorter than longer ones (as on harps and pianos) thus allowing for a very natural tone due to a more balanced overall string tension. This apparently awkward layout is reportedly much more effective and natural when playing than the standard parallel fret arrangement, and a number of guitarists are having their standard instruments retrofitted with Novax technology.

DeArmond Ashbory.
Foto by Mike Tavener

Ashbory *(sample #11)*

The last notable commercial example is a peculiar transformation of the bass, the Ashbory™[27]. Designed in the UK by Alun Ashworth-Jones and Nigel Thornbory in 1985 the Ashbory is a short scale bass with silicon rubber strings and specially designed active piezo-electric transducer technology. The silicon rubber strings are extremely thick and produce a deep bass sound even on such an extremely short scale (string length is 5,7 inches).

The "bone-like" shape of the wooden body allows for a variety of playing positions both seated and standing. The short scale of the fretless fingerboard allows, once the technique is mastered, for very fast and complex and stretched passages as harm movement is reduced to a minimum. Its portability and its sound make it a very useful, practical and innovative sonic resource that has encountered the interest of musicians like Tony Levin, Peter Gabriel and Les Claypool.

Portability can certainly be a factor in the design of a new instrument.

A small, practical and portable instrument can be taken along anywhere thus increasing even further the complex emotional relationship that some musicians develop with their instrument. Moreover, easy-to-carry instruments may give rise to music in the most unexpected contexts, from solitary meadows to late night jam session. Part of the success of the guitar is certainly due to its portability.

[27] Now manufactured by the Fender® corporation, was also previously sold under Guild® and DeArmond® brands. The commercial story of this bass is too long and complex to be included here, for further info visit http://www.ashelec.demon.co.uk/ashbory/ and http://www.largesound.com

Exploring the world of creative design may also lead to even more bizarre encounters in the realm of stringed and guitar like musical devices.

These final examples introduce stringed instruments of a kind conceived for a much rougher approach. Here, precision of tuning and refined tone qualities become irrelevant, whilst free creativity, experimentation, sturdiness and simplicity of components are the leading factors. In both cases we find a simplistic street-like quality that can conceal rich and peculiar sonic possibilities.

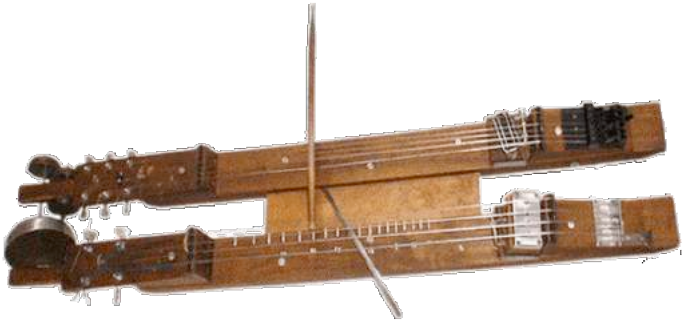
The Skatar

Keith Irish of Californian punk band "Punk as a doornail" plays a skateboard upon which he has installed two sets of strings (bass and guitar) with two independent pickups. Ha calls this creation "skatar" and mostly plays it as a slide guitar (with bottlenecks and bottles) sending two separate feeds to bass and guitar amplifiers.

The Skatar

The Pencilina *(sample #12)*

Slightly more sophisticated is Bradford Reed's "Pencilina", which he defines as: an electric board zither played primarily by striking the strings with sticks; also by plucking and bowing.[28] The pencilina also has two sets of strings (6 guitar and 4 bass strings) and additional bells, the whole being picked up by two electromagnetic pickups and two contact microphones. A rhythmical and percussive sonic tool that Bradford plays as the melodic part of his a drum kit also adding effects, real-time computer programming and voice.



Bradford Reed's Pencilina. It ows its name to the fact that it was initially played with pencils

[28] http://www.pencilina.com/insts.html

tuning and layout of pitches

Tuning is a very delicate and complex issue and a thorough analysis of it is well beyond the purpose of this research. What I would like to highlight here instead is how tuning, alternative layouts of pitches and different tonal systems can influence the design of an instrument.
A number of creations are in fact the result of a research for different solutions in terms of tuning and intervals. In order to use tunings other then the standard Western 'tempered' system one needs in fact to recur to ethnic instruments, variable pitch instruments or, even better, to design one's own.

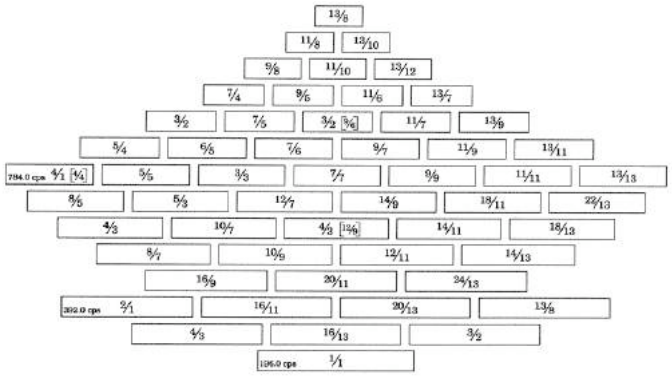
Harry Partch (1901-1974) for example implemented in his instruments a microtonal scale based on just intonation. In his "monophonic fabric", as he called his system, each octave interval contained 43 subdivisions, and no fixed pitch instrument was capable of that.
Just intonation instruments and theory have been also developed by Max F. Meyer (1873–1967) and Ervin M.Wilson but the music community generally recognizes Cris Foster as "the finest ji[29] instrument builder alive[30]".

Cris Forster:
Diamond Marimba
©The Chrysalis Foundation

Perhaps one of the most interesting ji instrumental concepts is the "tonality diamond" and his most well known realization: the diamond marimba.
The diamond marimba, developed separately by Max F. Meyer and Partch is a percussion instrument

[29] just intonation
[30] http://www.microtonal.freeservers.com/mclaren/post166.html

in which the particular arrangement of tuned woodblocks allows to create arpeggios with single strokes of the mallets. The diagram below shows the arrangement used by Forster in his instrument.



Cris Forster: diagram of pitches ratios and layout for his Diamond Marimba.

In this layout diagonal rows ascending left to right produce major tonalities and rows that descend left to right produce minor tonalities. This is a substantial innovation compared to the "linear" layout of most instruments.

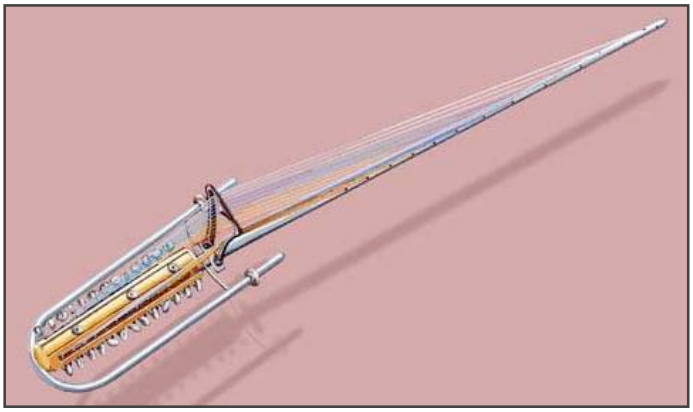
Such a solution is in fact somehow closer (conceptually) to the tonal structures as played on a guitar where a single stroke across the strings can produce a harmonically coherent sequence of notes.

Guitar-like instruments, from this perspective, offer an amazing potential as, regardless of the number of strings, these can be tuned to any sequence of intervals, even microtones if required and thus complex arpeggios can be played. Non-standard tunings associated with an increased number of strings, which as we have seen is one of the most frequent forms of customization of the instrument, can truly expand the potential of the guitar.

The Gravikord *(sample #13)*

Several musicians and instrument makers have experimented with tuning systems other than the tempered one.

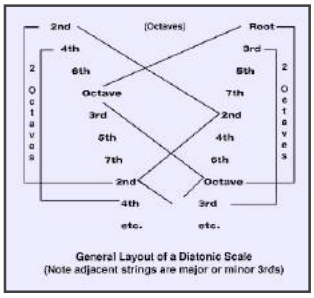
A very interesting design with regards to that is Robert Grawi's Gravikord®, below.



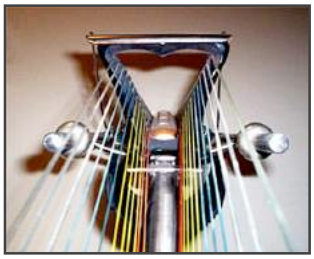
the Gravikord®.
© 1996 White Bear Enterprises/Robert Grawi All Rights Reserved

In its design, Grawi has been inspired by the African Kora, a diatonic instrument with twenty one strings arranged in a non linear fashion between two sets independently playable by each hand. (pitches that are adjacent in the scale may be distributed between the two rows of string). The Gravikord uses in fact a similar layout. While the first models developed in the late seventies resembled koras quite closely, making use of big resonators and bamboo sticks, the latest versions have become something quite new. They are currently made out of lightweight stainless steel tubing, don't have a resonator but rather piezoelectric pickups built in the bridge, the number of strings has increased to 24, the string tuning pattern has been slightly altered to make the instrument more flexible and "the least awkward to approach"[31].

[31] Hopkin, B. (1998) Gravikords whirlies & pyrophones , New York: Ellipsis Arts, p85



Diatonic Scales in the Gravikord.



Bridge of the Gravikord®.
© 1996 White Bear Enterprises, All Rights Reserved

Pitches are set according to a diatonic scale[32] divided into two sets, one played by each hand, so that each set is a sequence of major and minor thirds.

The instruments, now regularly patented and available from Robert's website[33], allow for interesting polyrhythmic patterns to be played by the two hands thus creating hypnotic melodies that share the sound of the Kora and that of the harp. The Gravikord is in fact also defined as "electric double harp", it can be played sitting or standing and, even though Robert plays it accompanied by flutes and percussions in his Gravikord ensemble, it is highly effective as a meditative solo instrument.

In this particular case the layout is derived from the African tradition but the idea of spreading the notes in a non-linear fashion, (that is to say that the smallest intervals are not necessarily physically adjacent, as seen on the Diamond Marimba also), is an interesting one and it offers ground for further investigation.

Ela lamblin's Stamenphone described on page 7 also employs an interesting layout whereby the strings are divided in four quadrants, each tuned to a different mode depending on the music.

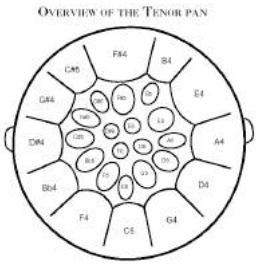
[32] a diatonic scale consists of 5 tones and 2 semitones with no other alterations (like major scale for example where intervals are T-T-S-T-T-T-S)
[33] http://members.aol.com/gravikord/index.html

The Steel Pan

One striking example from a past not too remote is the steel pan. The instrument was created in the mid 1940s in Trinidad, which had a tradition for drumming bands and rowdy carnival parades. The quest for louder instruments to compete with other bands, drove Winston Simon and Ellie Mannette to recycle old 55 gallon oil barrels discarded by the American Army during WWII.

They eventually discovered that by hammering the originally concave surface into convex areas they were able to get different series of tones. By 1947 they had perfected instruments with two octaves of diatonic scales.

Steel pan bands have up to 10 players and up to 300 pans. The instruments and the music became very famous after one performance of the TAPSO (Trinidad all percussion steel orchestra) in London in 1951. Since then the steel pan has increased its popularity worldwide to become one of the most widespread nonwestern instruments and a symbol of freedom and cultural independence.



Above:
A) a tenor steel pan
B) layout of pitches on the tenor pan

The culture behind the pan is in fact very rich and there are several conceptual and ritual issues involved in the approach to the instrument, played with varying degrees of complexity, and perhaps more noticeably, in the traditional art of its tuning.

The Steel Pan is recognized as one of the very few new purely acoustic instruments invented in the twentieth century that have proved so successful. It is also worth remembering that it is certainly the only one that, by virtue of its modularity, loudness and range of frequencies covered, can be used to

form a whole band, which can effectively be looked at as a single instrument with multiple players[34].

As shown in picture B, pitches on the pan are generally[35] laid out in a circular fashion, the lower notes being on the outside. Pitch is increased clockwise following intervals of fifth.

Different ranges of steel pan:

Lead ("tenor") Pan - highest range, single barrel; traditionally plays the melody in steel band arrangements

Double Tenor Pan - next highest range, comprises of two barrels. May play the melody, or a harmonized version of the melody, or may "strum" chords beneath the melody.

Double Seconds Pan - slightly lower than the Double Tenors, also comprises two barrels. Often strums chords, but may play melody, harmony or other parts of an arrangement. This is the instrument favored by many solo (unaccompanied) pan artists such as Robert Greenidge and Len "Boogsie" Sharpe (Mangrove's arranger).

'Cello pan - usually three or four barrels, set in a semicircle, comprise this instrument. These fill a variety of roles in a steel band, ranging from bass lines, to strums, to the melody.

Quadrophonics - a sister instrument to the 'cello pan; however, rather than having the drums arranged side-by-side in a semicircle, two of the drums are set flat in front of the player, while the two remaining barrels are set vertically.

Bass pan - as the name would indicate, the lowest-ranged instrument in the steel band. Due to the size of the notes used on this instrument, there may be as few as three different pitches on each barrel, requiring the use of six, eight, or even more barrels to complete a single instrument. The traditional role of this instrument is bass lines, but arrangers such as Cliff Alexis, Ray Holman, Robert Greenidge, and Len "Boogsie" Sharpe (among others) will often assign the melody or countermelodies in the bass instruments, at some point in their arrangements.

source: http://www.portowebbo.co.uk/nottinghilltv/carnival-steel-pans-history.htm

[34] The Steel Band occasionally incorporates a non-pan percussive section called “the engine room”
[35] there are versions with different layouts, for example with adjacent notes placed in rows.

on shapes, materials and elements

As Bart Hopkins observes[36], *a number of contemporary instrument makers show a special feeling for natural forms and materials, and have developed an underlying aesthetic that seeks an harmonious relationship with the natural world.*

Harry Partch, Gourd Tree 1964

Exotic fruits (calabash and gourds) are used as resonators. Bamboo provides a useful resource as its hollow sticks can be easily manipulated and used as air chambers and percussions. Clay, after centuries, is still among the most popular materials as it can be easily shaped and turned into solid resonating bodies. A bond with nature is present in the work of many musical instrument designers. Partch's creations for example often tend to remind us of nature, with frequent references to trees, but also clusters of rounded objects hanging like fruit or flowers and other complex yet harmonious shapes.
The names he used for them (cloud chamber bowls, chromelodeon, eucal blossom, gourd tree[37]). also contributed a certain natural feeling to these objects.

The quest for visual harmony and the integration of natural elements is tangible in many different contexts.

[36] Hopkin, B. (1998) Gravikords whirlies & pyrophones , New York: Ellipsis Arts pp. 9
[37] for a complete overview of Harry Partch instruments refer to the official Harry Partch Foundation website at www.corporeal.com and also http://www.newband.org/instruments.htm#partch%20instruments An excellent interactive (instruments can be heard and played) online gallery is available at http://musicmavericks.publicradio.org/features/feature_partch.html

The following paragraphs will analyze examples of uses of different materials and interesting conceptualizations of natural elements applied to musical instruments.

The examples are divided by type of material in a way similar to ancient Chinese organology[38].

In the Bayin (eight tone) classification method, which originated in the 23rrd century BC and was used for over three thousand years, musical instruments were divided into eight groups, depending on the material used to produce the sound. This classification was based around ideas of the dependence of the Human race from natural forces and elements and correlated specific psychological and bodily reactions to given sound sources.

Below: Categories in the ancient Chinese organology, the Bayin.

Stone *- A good example is the Pien Ching. It is a set of L-shaped stones, of different quantities and sizes, hanging from a stand and struck with a special hammer. They are played only at court and during religious ceremonies.*

Metal *- Includes Bells, Luo (gongs) and Bo (cymbals).*

Silk *- Refers to stringed instruments. Stringed instruments can be further divided into two categories: the bowed strings (e.g. Erhu) and the plucked strings (e.g Guzheng).*

Bamboo *- the majority of woodwind instruments are made from bamboo. Examples include the dizi (flute), suona (trumpet).*

Wood *- This section includes a large variety of small percussion instruments including wooden blocks, boxes and xylophones with wooden blocks. These were used by Buddhist monks during religious ceremonies.*

Skin *- Drums are often covered with different types of animal skins along the top or head.*

Gourd *- a type of plant. A sheng (mouth organ) is one of the oldest Chinese instruments made out of hollowed-out pumpkin-like vegetables. It consists of a wind-chest and a number of bamboo pipes set in a circle. The sheng imitates the sound of a phoenix.*

Clay *- The ocarina, a small, egg-shaped wind instrument (with six holes for the finger tips) made of clay.*

Source: http://www.chinesemusic.co.uk/english/InstrumentsPage.htm

[38] the study and classification of musical instruments

Earth

The most common uses of elements from the 'earth' are modeled clay and shaped stones.
The latter is generally used in percussive solutions like marimbas and tongue drums but other creative uses are possible as previously seen in |Ela Lamblin's *Sine Stone.*
Shakers and similar percussions also use sand or gravel as a sound source.
Clay on the other hand allows for greater manipulation of shapes and is generally more musical.
The possibility to create resonating cavities and tubular structures, and the ability to easily tune these by reshaping and changing size, makes it a favorite resource among instrument makers.

Barry Hall *(sample #14)*

Barry Hall with some of his ceramic globular horns

Barry Hall, master in the creation of clay instruments, suggests an interesting concept in saying that he is *driven by the desire to explore and expand all of the different sounds that can be created from a single medium – burned earth*[39]*.*
His first instruments were simple sets of flowerpots mounted on wood racks. His love for clay eventually led him to master the art of pottery and to develop a series of percussions and aerophones, which he calls globular horns, for his music and his Burnt earth Ensemble.

[39] Hopkin, B. (1998) Gravikords whirlies & pyrophones , New York: Ellipsis Arts pp. 63

Even though they may appear very basic and primitive in concept, these blown-up ocarina-like instruments are quite unique in terms of size and shape of the resonating section.

Ward Hartenstein *(sample # 15)*

Ward Hartenstein:
Petal Drum
©Erik Mandaville

Ward Hartenstein, another ceramic sound artist, specialized instead in beautiful clay idiophones and defines the tone of ceramic instruments as: "both delicate and earthy, a seeming contradiction in terms that reflects the dual nature of the material itself as well as reminding us of its source.[40]"

This quest for roots and origins is an important element for many developers of new instruments when they are seeking an harmonic integration and reinterpretation of the natural world throughout instruments and their music.

Besides the appearance, most of the time, is the use of a natural element within the instrument to determine its main sonic character.

With clay this often results in a 'truly' earthy and rounded sound.

[40] Hopkin, B. (1998) Gravikords whirlies & pyrophones , New York: Ellipsis Arts pp. 38

Fire

There are currently very few known instruments where fire is involved. Among the sources consulted for this research the only well documented example of pyrophone is Michael Moglia' fire organ. *(sample # 16)*

Micheal Moglia and his fire organ ©N.Serrison

Built in a pyramidal structure with over 250 stainless steel tubes reaching 30 feet high. He uses hand held burners, which he introduces into the pipes from beneath to heat a metallic mass within the tube itself. This generates a fundamental tone that is then harmonically enhanced and enriched by the tube. The sustain lasts for a few seconds after removing the flame as the mass cools down. The pitches bend with changing temperatures. By spectacularly moving around and heating the pipes, usually in effective night-time performances, Moglia creates "unpredictable" sonic patterns. He believes in such a primitive and somehow unregulated approach as, he says, "to accept mystery and the role it plays in our lives is essential"[41].

[41] Hopkin, B. (1998) Gravikords whirlies & pyrophones , New York: Ellipsis Arts, pp 37

Such a dynamic visual and sonic impact is likely to compensate for the (conscious) lack of structure in the music, and must be appreciated as such.
The approach to the instrument can be seen as a wild and somehow primitive ritual dance.

There is some documentation of a previous Pyrophone designed in Paris in 1875 under the name of "Les flames chantantes" by Frédéric Eugène Kastner. His instrument was controlled by a keyboard and used glass pipes.
Contemporary artist Norman Andersen has experimented with pyrophones and there is apparently a fully functional glass model built by the Tokyo Gas Company in Japan.
Apart from this, the use of fire in instruments is very scarcely documented and indeed not very popular for several practical reasons.

Water

Waterphones are instruments where water plays a determinant role in determining the sound quality. One of the most widely used effects is that of creating pitch glides or variable tone patterns in random or controlled fashion.

Richard A.Waters *(Sample #17)*

Richard A.Waters and his Waterphone

One of the most successful water applications is found in Richard A.Waters' Waterphones. These (a range from small to large models is available) have a metallic resonating chamber where water bends the tones generated by tuned metallic rods that can be struck with mallets or played with a bow.
The instrument is generally hand held and tilted to make the water move as the tones decay.
Tom Waits has described the sound as: "A cascading crystal waterfall of light amidst the songs of a whale[42]". The Waterphone, partly inspired by the Tibetan Water Drum, was patented in 1969[43] and has appeared on soundtracks (amongst which Poltergeist and the Matrix) , songs (including Miles Davis's "Aurora" & "Tutu") and has even been used for experiments in communicating with whales[44].

Aqualung

A different approach is taken by Brazilian ensemble Uakti with the Aqualung. Here water streams into a set of two pipes, one larger fixed at the bottom and a smaller one, left free to move inside the former. The resonance of the air above water level in the

[42] http://www.richardawaters.com/waterphone/index.html
[43] US patent # 3896696
[44] by Inter-species communication expert, Jim Nollman

small pipe determines the pitch, which can therefore be adjusted by moving the pipe up and down. The more the pipe is dipped, the shorter the resonating air column gets and thus the higher the pitch.

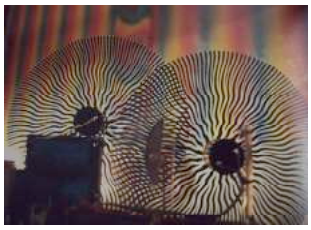
The Aquavina *(sample #18)*

Jaques Dudon playing the Aquavina. ©Pierre Ciot

A master in the creation of water sound instruments is Jaques Dudon.
He has developed a wide range of metal percussive instruments where water is used alternatively as a percussive element or to vary the pitch, for example by dipping the resonating body to varying depths.
His Aquavina is a plucked or bowed string instrument, played horizontally on the lap, wherein a metal bowl floats within a larger container creating a peculiar wah wah resonance.

Water is a rich sonic resource explored by many, including Stomp, Ellen Fullman and Ela Lamblin's. His "Stamenphone" mentioned earlier, has water within its globe-shaped resonator to add shifting tonal resonances to the harmonics generated by the bowed strings.

Light



Jacques Dudon:
'disque photosonique'

In his experimentations Dudon has also made use of Light for music in his "**disque photosonique**" a device where a light sensor cell detects intermittent light and converts it into analogue electric signals, which are then amplified. Dudon now prints concentric opaque patterns on transparent film disks. When performing he shines a hand held light through the rotating disks (one or more to create more elaborate soundwaves or pulses) and modulates the sound by interposing another printed film that allows him to control sound attack, overtones, vibrato etc.
The rotational speed of the disks is constant and the pitch is determined by the radial distance at which the light is positioned from the center, the closer to the center, the lower the pitch.
The patterns on the disks are carefully studied and developed by computer software[45] to achieve the desired sonic quality, somehow similar to that of a synthesizer and yet even more articulate in its structure and totally different in principle.

Other "photophones" have been developed elsewhere. The majority of the ones encountered in the research, however, work in connection with synthesizers, circuit bending devices or other electronic equipment like in the case of Reed Ghazala Video Octavox[46], the LightHarp[47] and the

[45] software developed by J.Dudon, D.Arfib and P.Sanchez
[46] a device reading light patterns from TV screens and generating 8 voice synthetic sounds accordingly
[47] developed by Stuart Favilla ,Robin Whittle and Garry Greenwood.,the LightHarp has 32 sensors acting as virtual strings that trigger a synthesizer, it is designed to play Indian music mostly but the light-string response can be customized to any style.

Optivideotone[48] and have therefore not been included in this work.

Lightwave Systems String Pickups

Lightwave-Systems™ optical pickup

Light is also being used for a new optical pickup technology for string instruments. Company Lightwave-systems[49], based in California, has developed an optical transducer and is currently the only one to provide a similar system. For each string an infrared system is coupled with arrays of photo-detectors. This solution provides a totally flat response, free of hum. The pickup allows for separate gains and even separate outputs for each string and includes an hexaphonic transducer for MIDI.

[48] Created by Professor Scott F. Hall of Cogswell Polytechnical College, Sunnyvale, California, the Optivideotone reacts to images it projects on the ceiling and therefore plays itself triggering a synthesizer.
[49] http://www.lightwave-systems.com/

Glass

On the subject of materials and elements a few lines must be devoted to glass-based musical instruments.

The tradition of glass music is quite old, dating back to 11th century Persia where glass bowls were used as percussion. **Musical glasses**[50] played by friction appeared in Europe from the end of the 15th century and in 1761 American inventor Benjamin Franklin designed his **glass harmonica**, *(sample #19)* a superb instrument where bowls of decreasing sizes are made to revolve around a horizontal spindle.

The Glass Harmonica

The bowls are played by touching the rim with moist fingers: for constant rotational speed the smaller the radius of the bowl the lower the pitch produced.

The sound of the glass harmonica and of glass instruments in general has ethereal and crystalline qualities, the tone sustain is very long due to the density of the element and the harmonics generated are extremely rich and complex. W.A.Mozart was fascinated by glass music and wrote some, also inspired by his fellow freemason[51] and hypnotist Dr.Franz Anton Mesmer, who used magnetism and glass music to throw his patients into a condition of hypnotic trance (hence the word "mesmerized"). After a century of great popularity the glass harmonica and glass music in general went out of fashion to be later rediscovered from

Harry Partch, Clud Chamber Bowls
© Steve Hockstein

[50] friction instrument: wine glasses played by rubbing the finger on the rim, different pitches are achieved by filling the glasses with water at different levels.
[51] a member of a worldwide society of men, the Free and Accepted Masons, devoted to the promotion of human harmony and known for its charitable work and for its secret rites.

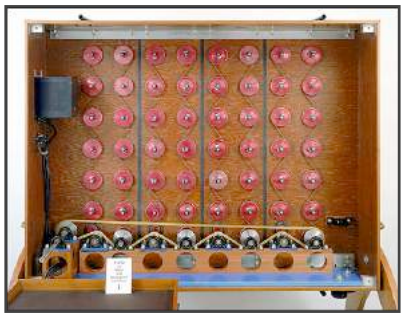
the 1950's by Harry Partch (*cloud chamber bowls*). He was then followed by Frederick Rzewski (amplified glass plate in the group "Musica Electronica Viva" in the 1960s); Meredith Monk (wine glasses acoustically 'beating' with vocal improvisations); Bill Fontana (large glass bottle acting as resonator with a microphone suspended inside to eavesdrop) and Annea Lockwood (concerts of live and tape-manipulated glass sounds since the mid 1960s)[52].

This tradition continues and the most popular glass instruments are still Franklin's harmonica, glass marimbas, musical wine glasses and several percussive solutions using different sizes and shapes and soft mallets.

While in traditional wine glasses the pitch is determined by the amount of liquid contained in the glass itself other solutions are possible as described below.

The Glassdance

The Chrysalis Foundation produced the Glassdance, an instrument inspired by the glass harmonica, in which 48 glasses of the same size, but trimmed at different heights to achieve 3 octaves of pitches, are laid out in a vertical arrangement and set in rotation by a motor.



Cris Forster: Glassdance and detail of the inside mechanism.

©Will Gullette

[52] Adapted from http://www.vex.net/~rixax/GlassO/GOhistory.html#history

Above:
the Glass Orchestra

Below:
Les Trasparences Ensemble

Other notable examples are to be found in the work of the Canadian-based "**Glass Orchestra**" *(sample #20)*, founded in 1977 and of "**Les Trasparences Ensemble**" *(sample #21)* led by instrument maker Jean-Claude Chapuis in France.

Both groups perform solely on glass instruments that they design or assemble. The former group, led by Eric Cadeski, has toured the world and their instruments have earned an entry in the New Grove Dictionary of Musical Instruments.

These designers have studied the properties of glass thoroughly in order to be able to blow their own shapes to the required size and thickness and control, even shape the sound itself.

Glass music is occasionally found in performances by street artists. There are, however, very few commercially available recordings. Allegedly one of the reasons for this is that the magic and ethereal quality of the sound, due to the frequency content extremely rich of high and complex harmonics, translates with difficulty onto the recording medium. Accurate techniques and sophisticated equipment are required on both recording and playback ends. This suggests an interesting specialized sector of sound engineering that, with the help of the latest technologies, could call for further investigation.

Sound-Objects and Noise

If the 18th and 19th century can be seen as the climax for refined and traditional musical instruments the 20th has seen the re-introduction of noise, first through machines and then through everyday-life objects in the musical world. I say re-introduction because music in its most primitive form was made with common objects and eventually tools, originally designed for other purposes.

In our technologically advanced society there is a growing tendency towards that primitive vision of music evolving in parallel (as Russolo suggested in his 1913 Manifesto on the Art of Noises) with our increased familiarity with machines. We refer here to distributed works that are exposed to large numbers of people because this shows a general and curious evolution in taste and trends rather then focusing on the experimental work of avant-garde groups or isolated cases and visionary artists.

The experimentations of the avant-garde and experimental groups of the 20th century (Russolo, Partch, Cage but also Einstürzende Neubauten and Throbbing Gristle for example) and a combination of many other cultural factors have paved the way and opened the global musical horizons to noise and object-music by forcefully educating the ears and suggesting a new sensitivity.

Technically speaking one could also say that inharmonic sound sources, ones where the harmonic overtones are inconsistent with respect to the fundamental, were made popular in Western music by means of this process.

The process is of course still ongoing and what used to be a natural and primitive form is now becoming a genre and a form of trend.

Stomp, UK cast

This is proved by the success of musical theatre shows like "Stomp", "Les Tambours Du Bronx[53]" and "Scrap Arts Music[54]" where objects like oil barrels, brooms, water tanks, sticks, lighters, are taken out of their original practical context and reconsidered under a new light, for their sonic properties. And if the audiences are getting accustomed to the idea, the insiders are already treating the objects like musical instruments that require practice and technique and allow for the development of a personal style[55].

Electronic duo Matmos playing amplified bycilcle wheel with e-bow

Also, an increasing number of commercial musical works include rhythmic sequences and melodies produced with objects. Examples of this are in recent CD releases by pop artists Bjork (*Vespertine*[56]), and Mum (*Finally we are no one*). Finally, the recent success of musical feature and animation films like "Belleville Rendezvous[57]", where a refrigerator, a vacuum cleaner and an old newspaper become invaluable sound instruments and Lars Von Trier's "Dancer In the Dark", where industrial machinery becomes the rhythm session for the themes, is a further proof of an overall acceptance and appreciation of object/noise as a musical element.

Les Triplettes de Belleville, from Belleville Rendezvous ©Sony Pictures Entertainment

[53] French experimental industrial percussion group
[54] Vancouver based ensemble led by composer and inventor Gregory Kozak
[55] from a recent conversation I had with James from the current UK Stomp cast.
[56] Produced by San Francisco duo Matmos experts in electronics & live noise applications.
[57] Director:Sylvain Chomet

Tom Waits says: "… the hardware store has developed more pull for me than the music store. I always bring a couple of mallets and a violin bow with me – I get to hear things I've never seen before. All hardware items must be admired for their sonic properties…they're all waiting to be played[58]". And all his music, not just the most experimental projects (where he uses close and contact miking on squeaking old rocking chairs and such solutions. *see p55*), reflects this attitude as Waits achieves beautifully musical results.

The Musical Saw *(sample #22)*

Marlene Dietrich playing the musical saw

The musical saw is possibly one of the most interesting and simple evolutions of a work tool into a fantastic musical instrument. It is an improved carpenter's saw where thickness and material are optimized for sound. It is played while sitting, between knees and bent into an s- shaped curve with one hand while the other strikes the non dented edge vertically with a bow. The sound has something of the violin and something of the theremin. Different pitches can be achieved by degrees of bending of the blade and thus curious glissando effects are possible. Longer blades extend the range of the saw downwards. There is very little documentation on the origin of the musical saw but it became very popular in the 1920's and 30's. Mussehl&Westphal, the most famous manufacturer of dedicated saws reached sales of 30.000 pieces a year before the Depression and WWII.

[58] Waits.T.,Hopkin, B. (1998) Gravikords whirlies & pyrophones , New York: Ellipsis Arts pp. 6

The saw is just representative of an idea explored by many artists in many ways, in most cases achieving a fully melodic musical instrument is not as important as creating a "sound instrument" with specific sonic qualities.

Among several experiment encountered the most widespread tendency is that of using objects from urban life and landscape or even waste material and creating sound objects in which the sound properties are generally more relevant than accuracy or degrees of complexity in the tuning.

Ken Butler

Ken Butler: Object Opera and hybrid string instruments ©Ken Butler

Ken Butler is one such artist. He has developed an amazing amount of instruments, mostly stringed ones, choosing objects that would fit the musical purpose but also the ergonomics of the player. Bikewheels, fans, vynils, sky poles, toy guns are integrated to become playable musical instruments. Some of them are even mechanically activated by remote keyboards like in his Object Opera, created in 1995. In the latter, a two octave keyboard controls a network of electrical connections activating over a hundred items. These include sirens, TV sets, rotating disks that strum or bow guitar and viola-like instruments.

Luigi Russolo

The idea is somehow reminiscent of the work of Futurist Luigi Russolo[59] with his noise tuning devices (intonarumori or "noise intoners" that

[59] Luigi Russolo (1885-1947)

Intonarumori

included busters, cracklers, howlers etc) and the first "noise orchestra". Russolo's instruments were devices that could mechanically reproduce selected noises at different pitches (an ancestor of the modern sampler) by means of horns, drumheads, springs, strings and levers. With no formal training in acoustics, instrument building nor musicianship Russolo managed to create an influential body of inventions that attracted the interest of composers such as Stravinsky, Ravel and Varese. His inventions and his music, now largely lost, were also supported by a conceptual manifesto, the Art of Noises (1913), promoting the new concept of noises as musical elements in a natural evolution of the musical arts. This body of works has given Russolo a central role in preparing and stimulating a new musical sensitivity, ours, inclined to accept and enjoy musical noise.

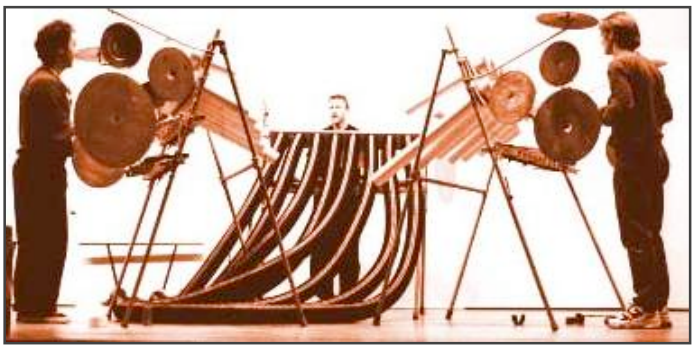
Lirio Salvador: Sandata ng lolo ni tatay

Many more artists work with objects taking them as they are or elaborating them into something new. Harry Partch was known for using scrap objects in his designs, both as part of his revolution against the standard western system and as a conceptual representation of the civilization around him. Peter Whitehead among uncountable others, creates folk instruments out of domestic objects in the attempt to express his own, authentic voice and to continue an ancient tradition of instrument making[60]. Ela Lamblin makes frequent use of bicycle wheels and other elements in his playable sound sculptures.

[60] Hopkin, B. (1998) orbitones, spoon harps & bellowphones . New York: Ellipsis Arts, pp.48-51

Lirio Salvador, native of the Philippines, creates astonishing sound instruments out of steel kitchenware, bike parts and pipes.

From Scratch Ensemble *(sample # 23)*



Phil Dadson's From Scratch ensemble with their 'percussion stations'

Phil Dadson's[61] ensemble From Scratch (above), for example, employ a stunning stage setting for their percussion stations.

The centerpieces of these are sets of fourteen common plastic pipes up to 10 feet long arranged on two layers and hit at one open end with a rubber club.

The group believes in a fusion of visual and sonic elements further enriched by symbolic concepts. The whole performance space becomes an instrument where performers engage in a rhythmical dialogue and interaction (the group calls this hocketing)

[61] Phil Dadson is an Auckland (NZ) based composer who worked in London with Cornelius Cardew in the late 1960's.

Whirlies *(sample #24)*

Harmonic Whirlies® - Sarah Hopkins

Even the simplest object can become an amazingly rich sound resource. A Whirly for example, is noting but a flexible corrugated plastic hose in which air resonates when it is made to spin. Different speeds of rotation generate different tones (approximately six) according to the harmonic series of the tube. Tubes of different lengths can produce different tone sequences and thus ensembles of whirlies can produce complex musical structures.

Australian composer Sarah Hopkins has refined the instruments (the Harmonic Whirlies®) and created such an ensemble. She writes inspiring music and meditative soundscapes for it and offers whirly music workshops[62].

There are 16 different instruments: 8 low range, plus 8 matching higher range instruments from C5 (middle C) to B6 an octave above[63].

Educational and fun, tables, chests and benches from 'musical furnishing'

Musical Furniture

To end this section I would like to introduce a slightly different approach, suggested by Tor Clausen and his American based company "Musical Furnishing", in the business of producing musical coffee tables, chest, drawers and benches. His designs are actually fully functional in their original conception as tables, chest and so forth but they include playable parts, mostly consisting of marimba-like tuned wooden or metallic elements.

The idea is aimed mainly at musical individuals and kids but also at anyone wanting a curious object to spark a conversation.

[62] http://www.harmonicwhirlies.com/index.html
[63] http://www.harmonicwhirlies.com/harm.html

Aesthetics: sound instruments as art objects

Throughout history musical instruments have been also valued as objects of beauty, of artistic and aesthetic relevance.

Nowadays the boundaries between arts and crafts are increasingly overlapping and this reflects on the designs of new instruments.

Creative aesthetic approaches throw a new light upon musical instruments by reshaping them and often relocating them within contexts that used to be occupied by visual arts, sculpture and architecture.

The following examples show us how new instruments still retain that ancient magic aura whilst projecting into other, non-musical, contexts and how important design is.

The instruments of Harry Partch

American composer and eclectic artist Harry Partch was one of the most influential creators of curious sound objects. His creations were often made from scrap material, or bamboo and eucalyptus woods and conceived to generate bizarre sonorities and exploit different tuning methods[64] but also with a strong aesthetic underpinning. He started developing his collection of instruments after his departure from the traditional western musical system in the 1930's and, because his parents used to be missionaries, his musical and aesthetic research was then highly influenced by close contact with Asian and Native American cultures. Traditional and oriental elements are definitely

[64] more on Harry Partch' tuning system on page 24

traceable in Parch's work as an inventor and builder of sound instruments.

The Chrysalis Foundation

Cris Forster.
The Chrysalis
©Will Gullette

A similar aesthetic vision can be found in the instruments built by Cris Forster who was in fact curator, archivist, and performer for the Harry Partch Foundation from 1976 to 1980[65].

His instruments, aside from reflecting extensive theoretical investigations on acoustics, tunings and musical mathematics[66], are extremely refined and stunning pieces of art.

His work, organized under his non-profit San Francisco based arts organization Chrysalis Foundation, is not for sale and he does not work on commission either.

He claims his research to be aimed at creating aurally and visually innovative art objects that may serve as signposts to stimulate other people' research and creativity in order to support a musical renaissance for the twenty-first century[67].

Mobius Operandi

Still in the San Fancisco Bay area we find other builders of sound objects of a futuristic visual and sonic appeal. Notably Oliver di Cicco, a sound engineer and producer now devoted to visual arts, who has designed a whole ensemble of instruments for his experimental pop group Mobius Operandi.

The group mostly performs at art institutions, universities, theatres and galleries due to the

[65] http://www.chrysalis-foundation.org/about_cris_forster.htm
[66] extracts from Forster's unpublished documents on acoustics and design, (including his "Musical Mathematics: A Practice in the Mathematics of Tuning Instruments and Analyzing Scales") are available at http://www.chrysalis-foundation.org/Manuscript.htm and http://www.chrysalis-foundation.org/creative_aspects.htm
[67] http://www.chrysalis-foundation.org/about_us.htm

nature of the instruments and the choreography they provide, not necessarily suitable for standard rock venues.

The creations are mostly plucked string type of instruments and percussive, marimba-like ones[68]. They all have an original and futuristic aura, an impression that is further enhanced by the use of aluminum and stainless steel as building materials.

Below & right: Some instruments of the Mobius operandi Ensemble.

Some of the sound instruments and installations presented in the first chapter could also be referred to here purely for their aesthetic qualities.

Performance artist Ela Lamblin for example often creates his instruments starting from a vision, prior to the sound they may produce. His "stamenphone" described earlier, he claims, was derived from the image he had in a dream where he was playing a musical plant[69].

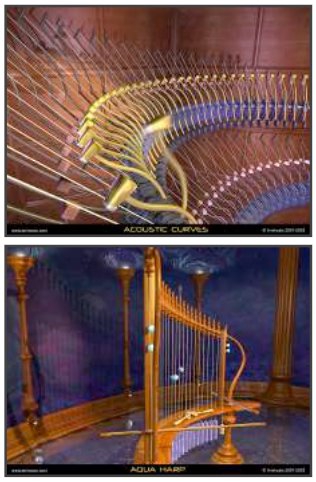
We must indeed bear in mind that all non-ordinary instruments are bound to have a strange visual impact on us because they do not fit in a standard mental frame created by years of tradition and

[68] refer to www.mobiusmusic.com for more details.
[69] Hopkin, B. (1998) orbitones, spoon harps & bellowphones . New York: Ellipsis Arts, pp.85

performances. In other words all new instruments are new to the eye and not to the ear only.

The examples here, however, seem to be willing to show a new way, an interesting mixture of music and visual arts.

These creations may be paving the way for a future generation of instruments. These hypothetical instruments of the future may not even produce any real sound but may trigger computer based systems with the advent of new optical and positional interfaces. Even more interestingly, the instruments may not even really exist but be part of a virtual reality. Graphic and media company "animusic[70]" is already developing this concept and creating stunning virtual models of acoustic instruments.



Acoustic Curves (Top) and Aquaharp, virtual models developed by animusic.

[70] http://www.animusic.com/

Amplification & technology

The following paragraphs will discuss ways in which amplification & technology have and may be applied to experimental instruments and sound sources. Technical literature on traditional methods of amplification and sound capture by means of pickups and microphones is widely available but some specific research on the subject has also been done by Bart Hopkin, Jim Gage and a few others.
The approach taken here is not deeply technical but rather a sound explorer analysis of possible solutions.

Let us start by approaching a random object with the intention of finding its sonic potential. The first step is finding the best way of playing it, which could be by bowing or by means of beaters. Next, one needs to determine the most effective way of holding or placing the object and this includes suspending on shock mounts, resting on inflated balloons as well as clamping to rigid surfaces. Once that is done, one needs to find the area of the object where the most interesting sound radiates, and this is affected by several factors including placement, damping, type of vibration (longitudinal or transversal) and is also especially tricky in the case of small or thin objects that may not project or transmit sound in a very effective way.
Considering all the above elements one can then make a decision as to what may be the best way to amplify the object so that the desired sound is achieved.

As a general rule, equally valid for objects and more traditional instruments, one or more good quality "air" microphones invariably achieve the best result in terms of neutrality of the sonic representation, especially with medium to large sources where the air resonance is crucial to the sound.

There are, however, feedback issues in case of loud levels and, where the source does not radiate very efficiently, the microphone might not be able to capture a sufficient portion of sound.

Where sound emission is fairly directional and especially with some air based instruments (the Didjeridu for example) many seem to appreciate the sound qualities of Pressure Zone Microphones[71] especially when mounted on larger flat reflecting surfaces than the ones provided with commercial models, as they provide an improved bass response.

Pressure Zone microphone (PZM)

Contact microphone

Contact microphones offer an interesting localized method of amplifying sound but they are less neutral and, being mounted on vibrating surfaces, they are extremely prone to feedback. They are nonetheless a valuable resource as they can be easily moved about a source to find its sweet spots and they can enhance unexpected features of a sound. Tom Waits for example has used them on rocking chairs, tables and other objects in his experimentation[72] *(sample #25)*.

Contact microphones can also be creatively applied to any larger vibrating surface, such as a drumhead or a balloon, used as a diaphragm that reacts to

[71] P.Z.M., microphones where the sound bounces on a reflecting surface before being captured by a diaphragm very close to the surface itself.

[72] See Tom Waits, Babbachichuija, Prairie Sun Recording 1998

incoming sound in ways that, far from being accurate, can generate interesting filtered descriptions of sounds and add curious reverbs and decays to sounds that have none.

Wherever there are metallic elements vibrating to produce the sound, a magnetic pickup like the ones used in electric guitars may be used. Occasionally such a metallic element can be applied to non-metallic vibrating bodies, as is occasionally done with woodblocks of marimbas. The add-on element can be anything from a tiny bar to a screw providing it's light enough not to interfere with the vibration.

Another solution is to use piezo-electric pickups either in the form of rigid bars (like the ones used in electro-acoustic guitars), disks or flexible piezo-film transducers. The problem with this solution is that the output will not be descriptive of the overall timbre of the instrument but of a very localized area. This can be used creatively, and used as a form of natural filtering, to achieve particular sounds or to enhance specific areas of an object or instrument. If a more neutral representation is required however, the problem can be compensated with equalization: as a general rule contact applications tend either to miss the warmth of the lower frequencies given by air resonance, addressed by boosting frequencies in the lower range, or to exaggerate the attack and crispness of some sounds if placed at the nodal points of the vibration pattern. This can be solved to some extent by filtering the higher frequency range.

Piezo transducers: Under the bridge bar and flexibler film transducer

Another possibility is to pick up the sound at different locations on the source by means of dual or multiple pickup systems. These can all be of the same type (all piezo, all magnetic etc) or a combination of different technologies as is commonly done on some acoustic guitars where a piezo-electric element is combined with an air microphone inside the body.
In combined systems a simple mixer can then be used to blend the signals together in order to achieve a more natural tone.
As the different signals can be out of phase with each other, due to the distribution of the mechanical vibration being picked, it is best to have phase reversing (if not shifting) options built in for each signal.

the Gram Pan by the Brazilian Uakti ensemble

The design of the instrument can be adapted in order to make it easier to record or amplify the sound. An example of this is found in the latest designs of an instrument called the Gram pan, designed by Brazilian ensemble Uakti. *(sample # 26)* It is a stand-mounted set of tuned pipes played percussively. Flexible extensions attached to the ends of each pipe are made to end inside a resonator box.
If the instrument requires amplification it is certainly advisable to consider this in the initial design as it can make a substantial difference.

Some of the designs described in the previous pages employ customized electronics to fit the characteristics of the instrument.

With the Ashbory, for example, designers Ashworth-Jones and Alun D. had to develop an improved piezo-electric transducer solution (shielded bimorphic transducers[73].) to best capture the vibration of the rubber strings. The entire bridge of the instrument is pressure sensitive and transmits string vibration to a highly reactive piezo electric element beneath.

In other cases the design itself is more important than the technology in translating a good representation of sound.

Rober Grawi says in with regard to the electronics used on his Gravikord:
'I use a Piezo pickup in the bridge. I've found the physical design of the bridge to be more important than the quality of the pickup! For a long time I looked for the ideal pickup before I realized this. The design must be designed to actively focus the vibrations induced in the bridge by the strings to the actual location of the pickup. This is especially true on frame type instruments (instruments without sound resonators). This of course relates to all electro-acoustical instruments, but I believe it's not widely understood. Tone control on the instrument is actually mechanical and has to do with differential dampening[74]'.

Multiple systems (more than one pickup on different parts of the instrument) offer greater

[73] The Ashbory is defined in its patent as an: *Electronic musical instrument with elastomeric strings and shielded bimorphic transducers.* US patent #4,750,397 June 14, 1988. from http://www.largesound.com/ashborydoc/patent/us4750397/
[74] I interviewed Mr Grawi via e-mail on the subject on 03/08/2004

flexibility and are extremely useful in complex instruments where different sounds radiate from different areas of the resonating body.

The Pikasso® guitar uses a network of piezo elements and air microphones and has separate output feeds as does the Novax Charlie Hunter instrument.

Having separate outputs allows for interesting experimentation with sound processing and panning.

Optical pickup systems (like the one described on page 39) push this to the extreme allowing separate outputs for each individual string. This opens up a world of unexplored sonic possibilities for stringed instruments and should be taken into account as a part of the general design concept for a new instrument.

Other aspects & concepts.

A few questions could be raised at the end of this overview of experimental solutions for instrument building: Are they isolated experiments? Where do they exist? To what extent do they affect the contemporary music scene? And how about the economic aspect of such experiments?

It is extremely hard to trace an exhaustive picture of the scenario formed by the plurality of these small creative realities. By their very nature in fact, most of them are hidden from the media interest and thus from the public eye.
Some of them, being either part of larger artistic movements or backed by institutions, foundations and universities, get public exposure in academic and sophisticated forums, showcases, art exhibitions and so forth.
The majority however, belong to a hidden world and is kept within a private, domestic dimension.

The Internet provides an invaluable resource for many developers and artists to display and eventually sell their work.
In many cases though, the economic side seems secondary, as the creators develop their work mostly for personal motivations. The Chrysalis Foundation is for example at the extreme of refusing to produce and sell their instruments and is sustained by donations only, motivated by the philosophy of enriching and stimulating human creativity and advancement.

The resources available on the Worldwide Web are still chaotic and the subject is still relatively unexplored, the knowledge unorganized.

The most exhaustive work in this area has been done by Bart Hopkin, founder of Experimental Musical Instruments (E.M.I.), and by John Pascuzzi, founder of the internet discussion group "Oddmusic.com".

Interestingly, they both operate in California and indeed San Francisco would appear to be the most active center in this field, being also the hometown of the Chrysalis Foundation, the Mobius Operandi ensemble and many others.
Australia and New Zealand follows next in a hypothetical list of productivity.

The output from Europe is comparatively lower, a sign that the centuries-old tradition of acoustic instrument building has given way to electronics and related experimentation on the old continent.
Even in the London scene, which certainly provides the grounds for a fertile experimentation thanks to its many academic centers, organizations and events, the research seems to be primarily (with some notable exceptions[75]) focused on electronic applications, interfaces and multimedia installations.
Also, from the sources consulted in this research, French and Belgian artists and instrument makers would seem to be quite productive and daring while in Italy, which has an historical tradition of luthiers and during the last century contributed great

[75] one of them being Stomp, the brainchild of Luke Cresswell and Steve McNicholas, native to Brighton.

musical innovations with the Futurists and the "Studio di Fonologia Musicale della R.A.I.", the focus of experimentation seems once again to be set around electronics.

Bart Hopkin, apart from being an instrument builder himself, is generally regarded as the greatest "authority" in the field.
He owes this position to the fact that in the early nineties he started a quarterly publication called Experimental Musical Instruments (like his company) where he reviewed the most interesting instrumental experimentations he had come across.
The success of his magazine has been such that "now the most interesting work tends to find its way to his desk, one way or another[76]".
Listening to and reading his work, notably a set of 2 cd compilation/guides published in 1998 by Ellipsis Arts, NY and entitled "Gravikords, Whirlies & Pyrophones" and "Orbitones, Spoon Harps & Bellowphones", it is possible to grasp of the amazing variety and multidisciplinary qualities of the subject.

Even though certainly not definable as a "movement", all this creative activity may well sow the seeds for a new structured discipline, a combination of music, craftsmanship, visual arts, philosophic and social values.

A tendency to oppose mass-produced objects and sounds is evident throughout many of the realities

[76] Adapted from http://www.ink19.com/issues_F/99_02/ink_spots/bart_hopkin_nf.html Bart Hopkin, Experimental, interview by Ian Koss.

explored, and there is a subsequent research for personalized instruments or for ones that employ, recycle and transform mass-produced objects and scrap material in creative and/or functional ways.

Many of the artists and inventors encountered raise, through their work, a number of relevant issues, notably on the relationships 'audience/performer' and 'player/instrument'.

Being mostly free from the constraints of the average commercial music circuits, these individuals and their instruments seem to seek the true value of what sound-making means to mankind.

A large number of new instruments and sound objects do not require complex skills to be played but rather call for a very personal approach, a unique interpretation, a 'fertile interaction[77]' with the instrument, and a different social interplay.

There is, in fact, a diffuse 'reaction against conservatory or concert hall music-making formats[78]' and a tendency towards "music-making gatherings[79]" where instruments can be played as a group activity rather than a performance in the traditional sense.

The audience becomes active in the music-making process, however not in the slightly sophisticated way suggested by Cage in his "four minutes, thirty-three seconds[80]" but rather by a radical and primitive approach.

This suggests an interesting new vision of music as a form of active social interaction that brings individuals to the same level.

[77] Hopkin, B. (1998) Gravikords whirlies & pyrophones , New York: Ellipsis Arts, p11
[78] Ibid. pp10
[79] Ibid. pp10
[80] a provocative piece where the audience is left in front of silent performers for 4 minutes and 33''. The performance is actually in the sound made by the impatient audience.

The work of some of these great artists seems an attempt to bring music closer to us, to make it more tangible, to free it from conceptualism for the sake of well-being and natural beauty.

The reconnection between the act of playing music and that of dancing, and movement in general, (Whirlies, Lamblin's sound sculptures, the Stomp sound-objects and the Stiltophones) is also an important factor that leads us back to the very roots of sound being shaped by man to form rhythms, melodies and harmonies.

The idea of water-music and instruments, a very ancient one in fact, provides a goldmine of sonic resources and could be reevaluated and developed together with Dudon's experiments with light, which also suggest a wide range of possible applications to be investigated.

The prospect of playable sonic spaces is among the most exciting ideas encountered and definitely one that could find a place in a future vision of music, one that could maintain his artistic validity whilst also evolving in its social function.

Finally, the examples provided by the Tonality Diamond, the Gravikord and other instruments, suggest that linear layouts and standard arrangements of notes are definitely not the only possibility. They show a world of options offered by simply arranging the notes in different orders, whether or not one chooses to abandon the standard tempered tonal system.

Conclusions

The overview of instruments and inventions presented here is not exhaustive. It is rather a selection of representative ideas and solutions encountered whilst researching this unusual field.
By its nature therefore, this work is not a comprehensive nor an in-depth evaluation of a specific topic but is rather meant as a window over a very specific and unique reality that, without being necessarily new in itself, is gradually surfacing and gaining new relevance.
Further investigation is certainly required for each individual aspect suggested here, from the choice of materials, to tuning issues, from events and organizations to the activities of individual artists.
There are the grounds for a structured area of study and indeed an extremely varied and complex form of art and I hope that this work has highlighted some aspects that could eventually help or stimulate further research.

Most of these experimental instruments are in fact one-of-a-kind creations, but, in the hope to see the musical world they present grow in importance, I have tried to identify a few elements such as 'playing approach', 'materials', 'social and psychological functions', that may eventually help the exploration, classification and development of this articulated area that combines musicology and organology with visual arts, aesthetics and social sciences.

Finally I hope I have stimulated the readers' curiosity, regardless of their field of interest, and refer them to the 'further readings and links' section to continue on this interesting path.

Future developments of this work.

The material contained in this work will be published in the form of an interactive website with sound samples, pictures and videos within the next few months.
This essay could be seen as the preliminary research work for such an interactive publication.
It is also a sketch of screenplay for a video documentary, which will be developed under the umbrella of contourbuzz productions as soon as the funds become available.

Appendix 1 - Hornbostel-Sachs classification.

Musical instruments are commonly classified according to the system devised by Erich von Hornbostel and Curt Sachs in 1914.
In this system instruments are put into categories according to the way in which sound is produced. There are originally four top level divisions and, for each, many subdivisions and sub-subdivision in a tree structure.
This structure is Based on the Dewey Decimal Classification or DDC (Melvil Dewey 1851–1931) whereby 'catalogue numbers' are in the form xxx.xxx.xxx.
Each series of numbers (xxx) describes a 'quality' and so the system can flexibly and infinitely combine qualities or create new ones to describe new entries.

The chart below outlines the main structure of the system, examples in bold refer to instruments mentioned in the main body of the essay.

1. Idiophones

1.1 11. Struck idiophones

Can be Struck directly *(percussions, xylophones, litophones, metallophones, concussion, bells,* ***gram pa, percussion stations****) or* Struck indirectly *(shakers, rattles, jingles, scraped)*

1.2 12. Plucked idiophones *(jew harp)*

1.3 13. Friction idiophones *(vessels,* ***Glass harmonica****)*

2. Membranophones

2.1 21. Struck drums *(drums and membrane percussion, organized by shape)*

2.2 22. Indirectly struck or Plucked drums *(rattle drums)*

2.3 23. Friction drums *(cuica)*

2.4 24. Singing membranes *(mirlitons, kazoo)*

3. Chordophones

3.1 31. Simple chordophones *(resonator, if any, does not support the strings: piano, zither* ***L.S.I., sine stone)***

3.2 32. Composite chordophones *(where resonator is part of the instrument: guitars, harps, violin, sitar..)*

chordophones are also sometimes divided in:
*bows, lyres, harps (****gravikord****), lutes (****guitars****, violins..), zithers (spinet, clavichord, piano)*

4. Aerophones

4.1 41. Free aerophones *(****Whirlies,*** *bull roarer)*

4.1.1 412.13. Free-reed instruments *(accordion, harmonica, harmonium, melodica,* ***stiltophones****)*
4.1.2 413. Plosive aerophones (*udu)*

4.2 42. Non-free aerophones (wind instruments proper)

4.2.1 421. Edge-blown instruments or flutes *(ocarina, flutes, whistle, pan pipes,* ***huaca****)*

4.2.2 422. Reed instruments
4.2.2.1 422.1 Double reed instruments *(Oboe, bassoon, bagpipes)*
4.2.2.2 422.2 Single reed instruments *(clarinet, saxophone)*

4.2.3 423. Trumpets
4.2.3.1 423.1 Natural trumpets *(didjeridoo, alp horn)*
4.2.3.2 423.2 Chromatic trumpets *(sackbut, trombone, cornett, horn, trumpet, tuba)*

5 5. Electrophones

This division was added in 1940 to include instruments where sound is generated by electrical means, includes:

Electromechanical instruments *(**Disque Photosonique,** mellotron)*
Electroacoustic instruments *(**All instr. amplified by electric means incl le Cylindre Sonore!**)*
Electronic instruments *(theremin, synthesizer, samplers)*

According to the results of this research the addition of the following category would also seem appropriate

6 6. Hydrophones

Waterphone, stamenphone, Aqualung, aquavina.

Appendix 2 – Cd Samples Listing

All the samples on the cd are also accessible online through the page:
www.contourbuzz.com/soundsbizarre.htm

Trk	Instrument	Composition & Artist ©holders / source	Duration
1	Stiltophones	Les Phones, Excerpt from 'Megalithe', 1995	00:40
2	Sine stones	Ela Lamblin & Leah Mann demo on www.lelavision.com	00:39
3	Longwave	Ela Lamblin & Leah Mann demo on www.lelavision.com	00:27
4	Stamenphone	Ela Lamblin & Leah Mann demo on www.lelavision.com	00:36
5	L.S.I.	Excerpt from 'Change of Direction', Ellen Fullman/BMI 1996	00:44
6	Great Stalacpipe Organ	Sample from http://www.oddmusic.com/gallery/om25450.html	00:36
7	Huaca	Excerpt from 'elegy for The Missing' by Alan Tower	00:22
8	Pikasso®	Excerpt from Pat Metheny live at Umbria Jazz 1997 VHS	00:28
9	Chapman Stick	demo on http://www.stick.com/method/ played by Greg Howard	00:37
10	Novax/Charlie Hunter guitar	Excerpt from Charlie Hunter live at Umbria Jazz 2001 VHS	00:25
11	Ashbory	Excerpt from Swing#1, Andrea Santini/contourbuzz 2004	00:35
12	Pencilina	Excerpt from 'Motivational music for pedestrians' Bradford Reed/BMI 1996	00:26
13	Gravikord	Excerpt from 'piccadilly', Robert Grawi/Take that music 1990	00:25
14	Globular Horns	Barry Hall / Demo sample on http://www.ninestones.com/globhorn.html	00:27
15	Clay percussion	Ward Hartenstein, exc. from 'claycussion' byJohn Beck, Ellipsis arts 1996	00:30
16	Fire organ	Excerpt from 'Chant De l'Orgue á feu'. Michael Moglia 1995	00:39
17	Waterphone	Richard A.Waters demo on http://www.richardawaters.com/waterphone/sounds.html	00:41
18	Aquavina	Excerpt from 'naïades'/CD *musiques de L'eau* . Jaques Dudon 1983	00:29
19	Glass Harmonica	W.A.Mozart, adagio for glass harmonica. From http://www.oddmusic.com/gallery/om14725.html	00:29
20	Glass Orchestra	Demo on http://www.glassorchestra.com/index1.html	00:27
21	Les transparences	Excerpt from 'Luminescence' /CD *'transparences'.* Jean Claude Chapuis/Buda Musique 1994	00:29
22	Musical Saw	Music by Mendelssohn. http://www.datacomm.ch/fesch/musicalsaw.html	00:23
23	Percussion stations	Excerpt from 'Pacific 3-2-1-0'/ Dadson, McGlashan, Laird/ From scratch 1986	00:24
24	Harmonic whirlies	Excerpt from 'Kindred spirit'. Sarah Hopkins/ellipsis music 1996	00:32
25	rockin' chair	Excerpt from 'babbachichuija' . Tom Waits/ASCAP 1998	00:27
26	Gram Pan	Excerpt from 'arrumacao' /CD *'trilobyte'* Dunvagen Music Publishing/Point Music/ASCAP. 1996	00:42

Appendix 3 – Glossary

diatonic scale
the diatonic major scale is a fundamental building block of the Western musical tradition. It contains seven notes to the octave, corresponding to the white keys on a piano, obtained from a chain of six successive fifths

equal temperament or tempered tuning
Equal temperament is a scheme of musical tuning in which the octave is divided into a series of equal steps (equal frequency ratios). The best known example of such a system is *twelve-**t**one **e**qual **t**emperament*, sometimes abbreviated to *12-TET*, which is used in most Western music and divides the octave into 12 steps.

harmonic series
Pitched musical instruments are usually based on some sort of harmonic oscillator, for example a string or a column of air, which can oscillate at a number of frequencies. The integer multiples of the lowest frequency make up the harmonic series.
The lowest of these frequencies is called the *fundamental* or first partial. This is the note created from normal bowing of a stringed instrument or from the lowest octave of a woodwind instrument. All of the other frequencies in the harmonic series are integer multiples of the fundamental. The second partial is twice the frequency of the fundamental, which makes it an octave higher. The third harmonic partial, at three times the frequency of the fundamental, is a perfect fifth above the second harmonic. Similarly, the fourth harmonic partial is four times the frequency of the fundamental; it is a perfect fourth above the third partial (two octaves above the fundamental)

just intonation
Just intonation is any musical tuning in which the frequencies of notes are related by whole number ratios. Any interval tuned in this way is called a *just interval*. Another way of considering just intonation is as being based on members of the *harmonic series.*

elettro-magnetic (pick up)
a device that translates the variations in its magnetic field into an analogue electric signal.
Any metallic body set in vibration within such magnetic field affects the electric output.
Sound generated by a metallic string (like in electric guitars) or a vibrating part of an instrument (i.e. metallophones) can be transformed into an equivalent electrical signal with this device.

piezo-electric (pick up)
Piezoelectricity is the ability of certain crystals to produce a voltage when subjected to mechanical stress. The mechanical vibration of soundboards, strings etc can therefore be translated into electric voltage, and amplified, by means of piezo-electric crystals, commercially available in the form of bars, disks or film strips.

transducer
A device that translates mechanical sound waves into an analogue electric signal

Adapted from http://en.wikipedia.org

Bibliography – books

Ernst, D. (1977). The evolution of electronic music .
New York: MacMillan Publishing Co

Geiringer, K. (1978). Instruments in the history of Western music. London: George Allen&Unwin

Grant, C. (1999). Ring of Steel. London: Macmillan Education

Hopkin, B. (1998). Gravikords, whirlies & Phyrophones.
New York: Ellipsis Arts

Hopkin, B. (1998). Orbitones, Spoon harps & Bellowphones.
New York: Ellipsis Arts

Hopkin, B. (2002). Getting a bigger sound.
Nicasio, CA: Experimental Musical Instruments

Rosenstiel, L. (Ed) (1981). Shirmer history of music.
London: Collier MacMillan Publishers

Sadie, S. (Ed) (1980).*'Chinese Instruments'.* The New Grove Dictionary of Music and Musicians, vol4. London: MacMillan, pp245-249

Sadie, S. (Ed) (1980). '*Musical instruments,Classification'.* The New Grove Dictionary of Music and Musicians, vol9. London: MacMillan, pp237-241

Sturrock, S. (Ed) (1984), Longman Handbook of orchestral Instruments. BurntMill, Essex: Diagram Group/Longman

Unger, C. & Hamilton. (1981) Keyboard Instruments
Oxford: Phaidon Press

Yates. P. (1968) Twentieth century music.
UK: George Allen&Unwin

Bibliography – magazines & other publications

Lachman, G.(2003). 'Ready to Rumble'. Wire, (238), pp30-35

Martin, E. (1995). 'Architecture As a Translation of Music'
Pamphlet Architecture, No 16 Princeton: Princeton Architectural Press.

Bibliography – Electronic sources

All the following links were visited several times between Feb 2004 and Aug 2004
They were last checked for availability on 14/08/2004

General reference, theory and associations

http://www.windworld.com/emi/

http://www.oddmusic.com/

http://www.si.umich.edu/chico/instrument/

http://www.furious.com/

http://www.sas.mdx.ac.uk/SAS.2002-2003/index.html

http://www.sonicartsnetwork.org/

http://www.thewire.co.uk/

http://www.resonancefm.com/

http://www.dotcog.co.uk/cmn/feedback/site2.htm

http://www.city.ac.uk/music/simon1.htm

http://www.audiorama.org/index.html

http://psychevanhetfolk.homestead.com/index.html#anchor_13631

http://www.classicalnotes.net/columns/silence.html

http://www.colander.org/gallimaufry/Instruments.html

Bart Hopkin

http://csunix1.lvc.edu/~snyder/em/hopkin.html

http://www.ink19.com/issues_F/99_02/ink_spots/bart_hopkin_nf.html

http://www.coma.org/article_9.htm
Tuning

http://www.ericweisstein.com/encyclopedias/music/DiatonicScale.html

http://www.chrysalis-foundation.org/Partch-s_Diamond.htm

steelband.toucans.net/pan_tuning.pdf

http://www.microtonal.freeservers.com/mclaren/post166.html

Classification

http://www.music.ed.ac.uk/euchmi/cimcim/iwte.html#Classification

http://www.metmuseum.org/toah/hd/pipa/hd_pipa.htm

http://en.wikipedia.org/wiki/Sachs-Hornbostel

http://en.wikipedia.org/wiki/Musical_instrument_classification

http://en.wikipedia.org/wiki/List_of_musical_instruments_by_Hornbostel-Sachs_number

http://www.chinesemusic.co.uk/english/InstrumentsPage.htm

http://www.music.vt.edu/musicdictionary/appendix/instruments/instrumentmain.html

Chrysalis foundation

http://www.chrysalis-foundation.org

Ellen Fullman

http://www.deepmedia.org/ellenfullman/production/photos.html

http://www.deeplistening.org/dlc/26fullm.html

From scratch

http://www.fromscratch.auckland.ac.nz/

Other instruments

http://www.theremin-saw.com/

http://www.ohek.co.uk/index.htm

http://www.ohek.co.uk/instruments/wtpics.htm

http://www.ohek.co.uk/links/inst-sup.htm

http://www.audiosculpture.co.uk/#audiosculpture

http://www.bassbox.org/

http://www.helixmusic.com.au/index.html

http://www.animusic.com/

http://www.lightwave-systems.com/

http://www.harmonicwhirlies.com/

Gravikord

http://members.aol.com/gravikord/instrument.html

http://members.aol.com/gravikord/index.html

http://members.aol.com/gravikord/bass.html

http://www.sonicgarden.com/sonic-web/artist.cfm?artistid=4930

Glass Music

http://www.vex.net/~rixax/GlassO/

http://www.glassorchestra.com/index1.html

Harry Partch

http://www.corporeal.com/cm_main.html

http://www.harrypartch.com/aboutpartch.htm

http://www.newband.org/instruments.htm#partch%20instruments

http://musicmavericks.publicradio.org/features/feature_partch.html

Le Cylindre sonore

http://www.bernhardleitner.com/de/87paris1.html

http://a.parsons.edu/~mateo/thesis/background.html

Les Phones

http://www.audiorama.org/phongb.html

Musical furnishing

http://www.musicalfurnishings.com/

Noise

Lachman, G.(2003). 'Ready to Rumble'. Wire, (238), pp30-35

http://switch.sjsu.edu/switch/sound/articles/wendt/folder6/ng632.htm

http://luigi.russolo.free.fr/arnoise.html

http://www.irre.toscana.it/futurismo/opere/manifesti/russol.htm

Pyrophones

http://www.windworld.com/emi/articles/pyronw.htm#anderson

Stalacpipe organ

http://www.luraycaverns.com/stalacpipe.htm

http://alber.dyndns.tv/~xaver/pages/send_03_we/send_03_we_04/br_040104_2.htm

http://www.showcaves.com/english/usa/showcaves/Luray.html

http://www.washingtonpost.com/wp-dyn/articles/A11278-2004May8.html

http://www.boloji.com/travels/010.htm

http://www.zentropolis.com/logs_2003_02_13.htm

Steel Pan

http://www.iadb.org/idbamerica/English/MAY01E/may01e2.html

http://www.portowebbo.co.uk/nottinghilltv/carnival-steel-pans-history.htm

The guitar family

http://www.novaxguitars.com/

http://www.guitarp.com

http://www.manzer.com/more.tmpl?cmd=search&db=lmodels.db&var2=lmodels.db&var3=Custom%20Design&wfskudata=2931-15

http://www.manzer.com/more.tmpl?cmd=search&db=lmodels.db&var2=lmodels.db&var3=Custom%20Design&wfskudata=2931-5

http://radio.cbc.ca/programs/asithappens/entertainment/011001_curves.html

http://www.stick.com

http://www.ashelec.demon.co.uk/ashbory/

http://www.largesound.com/ashborydoc/patent/us4750397/

http://www.pencilina.com/

The Musical Saw

http://www.theremin-saw.com/

http://www.musical-saw.com

Waterphones

http://www.richardawaters.com/

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