3-1-1983

Sounds in clay: a study of vibrating ceramic sculpture

Ward Hartenstein

Follow this and additional works at: http://scholarworks.rit.edu/theses

Recommended Citation

This Thesis is brought to you for free and open access by the Thesis/Dissertation Collections at RIT Scholar Works. It has been accepted for inclusion in Theses by an authorized administrator of RIT Scholar Works. For more information, please contact ritscholarworks@rit.edu.
ROCHESTER INSTITUTE OF TECHNOLOGY

A Thesis Submitted to the Faculty of
The College of Fine and Applied Arts
in Candidacy for the Degree of

MASTER OF FINE ARTS

SOUNDS IN CLAY
(A Study of Vibrating Ceramic Structures)

by

Ward Hartenstein

March, 1983
THEESIS PROPOSAL

The purpose of this thesis is to derive a synthesis of the sculptural aspects of form and structure and the physical principles of musical acoustics. Specifically I wish to deal with three types of vibrating systems: free-end vibrating bars; fixed-end vibrating bars; and three-dimensional vibrating bodies, each of which possesses a unique set of technical constraints within which the aesthetic requirements of form and structure may be addressed.

My objective is to conduct research leading to the design and construction of a group of objects which, through the involvement and participation of the viewer, communicate both a visual and an aural statement. This concept is to be manifested primarily through the medium of clay, although glass, metal, fibers, and wood may be employed where needed to meet certain acoustic, structural, or aesthetic needs.
APPROVALS

Robert D. Slit
Advisor:
Date:  May 10, 1983

Franklin H. Schiraneflugil
Advisor:
Date:  May 10, 1983

Fred Meyers
Graduate Academic Council Representative:
Date:  5/13/83

Robert H. Johnston Ph.D
Dean, College of Fine & Applied Arts:
Date:  5/16/1983

I, Ward Hartenstein, hereby grant permission to the Wallace Memorial Library, of R.I.T., to reproduce my thesis in whole or in part. Any reproduction will not be for commercial use or profit.

Date:  March, 1983

Ward Hartenstein
I see the creative act as a constructive process — the discovery of similarities, connections between disparate ideas, new combinations of familiar things, unifying concepts which enable us to better understand our world and ourselves. The product of this creative act should provide an insight to some aspect of our world and should stimulate and encourage the continuation of this discovery process.

This postulation could perhaps serve as a definition for both art and science, pointing out some of the basic concepts the two have in common. It also defines the conceptual framework within which I choose to operate as an object-maker. The contemporary craftsman must wear many hats to fulfill the demands of his craft: artist, scientist, philosopher, inventor, technician, problem-solver. It is the interrelation of these diverse skills that stimulates the creative process, and it is the objective of the craftsman to execute a tangible product as physical evidence of this process. Most importantly, the product is not an end in itself, but a new beginning; it should communicate the seed of an idea which may then grow and develop through the involvement of object and user. Craft is art that functions.
## TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I    THE INSTRUMENTS OF MUSIC</td>
<td>2</td>
</tr>
<tr>
<td>II   HISTORICAL EXAMPLES</td>
<td>5</td>
</tr>
<tr>
<td>III  THE PHYSICS OF MUSIC</td>
<td>12</td>
</tr>
<tr>
<td>IV   AESTHETICS</td>
<td>17</td>
</tr>
<tr>
<td>V    THE WORK</td>
<td>22</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>28</td>
</tr>
<tr>
<td>AFTERWORD</td>
<td>29</td>
</tr>
<tr>
<td>BIBLIOGRAPHY</td>
<td>31</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>PAGE</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>FREE-END BAR INSTRUMENTS</td>
<td>6</td>
</tr>
<tr>
<td>FIXED-END BAR INSTRUMENTS</td>
<td>8</td>
</tr>
<tr>
<td>VESSEL-FORM INSTRUMENTS</td>
<td>10</td>
</tr>
<tr>
<td>MODES OF VIBRATION</td>
<td>14</td>
</tr>
<tr>
<td>CLAY MARIMBA</td>
<td>23</td>
</tr>
<tr>
<td>PETAL DRUM.</td>
<td>25</td>
</tr>
<tr>
<td>GRAVITY CHIME</td>
<td>27</td>
</tr>
</tbody>
</table>
LIST OF PLATES

PLATES

1. Clay Marimba: "Dance of the Skeletons"
2. Clay Marimba: "Kung Fugue"
3. Petal Drum: "Rutabaga Waltz"
4. Petal Drum: "Musik für Metaforen"
5. Gravity Chime: "Rondo a la Turk"
7. Fountain Chime: "Toccata in BB"
INTRODUCTION

Historically, clay has been valued as a medium for creative expression. The qualities of the material which make it suitable as an artistic medium are its ability to assume an infinite variety of shapes and forms imposed on it by the artist, its durability and strength in the fired state, and the range of treatments which may be employed to exploit the possibilities of color, texture, and pattern of its surface. I propose to reveal another characteristic of the material which I believe may also have applications for creative expression. This heretofore unexploited property of clay is its ability, in the fired state, to generate and transmit sound. The subject of this study is to derive a synthesis of the sculptural aspects of form and structure and the physical principles of musical acoustics. My objective is to conduct research leading to the design and construction of a group of objects which embody this concept, communicating to the viewer both a visual and an aural statement.

Specifically, this study will examine certain aspects of the history and physics of musical instruments with particular emphasis on three types of structures which appear to have the greatest potential for realizing my objectives. These are the free-end vibrating bar, the fixed-end vibrating bar, and the vessel-form or three-dimensional vibrating body. I will examine the historical use of these structures in musical instruments and the physical principles which explain why and how they work. Then I will describe my own approach in evolving an aesthetic framework within which to apply this knowledge to the actual design and construction of objects which express the creative potential of "Sounds In Clay".
I. THE INSTRUMENTS OF MUSIC

Musical instruments are as old as man himself; they existed before ever tonality was known, or the reproduction of a melody. These early musical instruments produced a sound of a certain quality with no regard to pitch, and yet even at this stage of development, when the instruments were an end in themselves, considerable qualitative and quantitative differences were achieved (3:3).†

Man's first musical instrument was his own body; he used his vocal chords, his tongue, his mouth, his hands, his feet, his chest, and even his head to produce sounds. The next step was probably the discovery of certain devices or objects which could be used to enhance or modify man's bodily produced sounds. An example would be an amplification device such as an animal horn or a shell into which he could sing or produce vocal sounds. Children today still delight in the sounds they can make tooting through a cardboard tube, and certain vocal performers in China actually sing into one another's mouths to employ the principles of resonance and amplification.

The notion of an object devised specifically to produce sound probably came about through man's observations of everyday objects such as a hunting bow, a storage vessel sealed with an animal skin, or a few animal bones left to dry in the sun. Their ability to produce sound was noticed by accident in the course of their use as a tool or a utilitarian object, and as man's sense of musical expression became more sophisticated he began to experiment with these objects in order to modify and refine their musical properties. This was the beginning of

†Numbers in parentheses refer to numbered references in Bibliography; those after the colon are page numbers).
the history of the development of musical instruments which has brought about the fascinating diversity of sound-producing forms with which we are familiar today.

At this point I think it would be useful to attempt to define specific types of musical instruments according to the mechanism by which the sound is produced. Most instruments fit into one of three categories: strings, winds, and idiophones. The first of these is characterized by sound generated by the vibration of a string, wire, strip, or membrane on which a tensile force is exerted to alter or regulate the vibrating frequency. The stretched member may be plucked, bowed, or struck to set it into motion and is usually attached to a support structure of some sort which often acts as a resonator, amplifying or enhancing the initial vibration. The piano, the violin, and the tympani are modern examples of instruments in this category.

Wind instruments are characterized by the vibration of a column or enclosed cavity of air. The air column may be set into motion by the fluttering of a stream of air across an opening, or the buzzing of a reed or the lips or other source of vibration in proximity to the enclosed cavity. The pitch is usually controlled by varying the effective length of the air column. The oboe, the French horn, and the pipe organ are modern examples of wind instruments.

An idiophone, as the etymology of the name implies, is "self-sounding". This means not that the instrument plays itself, but that the sound comes directly from the material from which the instrument itself is made. The vibrating structure may be in the form of a bar, a disc, a tube, or any sort of three-dimensional form which is set into motion in most cases by some sort of percussive action. The factors
which influence the pitch and quality of the tones produced include the nature of the material, its size and configuration, and the type of structure on which it may be mounted to provide support or acoustic resonance. Modern examples of idiophones are the xylophone, cymbals, and carrillon bells.

In attempting to design and construct musical instruments out of clay, I have chosen to deal predominantly with idiophones in order to best make use of the qualities inherent in the material itself. Since the type of sound produced by an idiophone is determined largely by the quality of the material, the size and shape it is made to assume, and the manner in which it is coupled to a resonating support structure, these then become the major design elements in the creation of new or different musical objects.
II. HISTORICAL EXAMPLES

The three types of idiophones I have chosen to focus on can be described by the nature of their vibrating structures. They are the free-end bar, the fixed-end bar, and the three-dimensional or vessel form. All have historical precedents which encompass a wide range of cultures, materials, and musical traditions.

The first group includes all those instruments in which a solid bar of some material is suspended or supported in such a way as to allow it to vibrate freely when struck. An early African instrument of this type is the leg xylophone which consisted of a player who sat on the ground with two or three rough slabs of wood laid across his outstretched legs and upon which he would beat with a stick. Variations on this idea include the log xylophone in which the bars are laid loosely across two parallel logs, the pit xylophone in which wooden slabs are laid across the edges of a hole dug in the ground, the bail xylophone in which bars are attached to a frame which is hung at the player's waist, suspended by a strap over his neck and held away from his body by a semi-circular hoop, and a gourd xylophone in which gourds are used in conjunction with the wooden bars to act as resonators. These are all African instruments believed to have been derived from Malaysian archetypes (13:54).

There are many examples of this type of instrument originating in Asia as well. Javanese instruments based on the free-end bar principle include the "gambang" in which wood slabs rest on the edges of a long trough or cradle, the "saron" in which bronze slabs are mounted on a wooden box, and the "gender" in which bronze slabs are slung on cords across a trough containing tuned bamboo resonators. In China, the "chu"
GOURD XYLOPHONE  
(Africa)  
- wood bars  
- gourd resonators

GAMBANG  
(Java)  
- wood bars  
- trough resonator

GENDER  
(Bali)  
- bronze bars  
- tube resonators
employs a system of hammers which pivot to strike the undersides of the bars (2:12).

Central America produced the Guatemalan marimba in which up to 137 chromatic wood bars are mounted over gourd resonators having small openings covered by a thin membrane of pig gut. More modern European and American examples include the glockenspiel (Dutch) in which steel slabs are supported on a table-like frame, the celesta (French) in which steel bars mounted on tuned resonant boxes are struck by hammers connected to a keyboard, and the vibraphone (American) in which three and one half octaves of chromatically tuned steel bars are mounted over resonating tubes containing rotating discs to produce a vibrato effect. I could find no historical examples of any marimba-type instruments employing clay bars or other ceramic components.

The second type of idiophone structure I have chosen to deal with is characterized by one or more vibrating bars, rods, or strips which are securely fixed at one end to a support structure which usually doubles as a resonator. In Africa, the "sansa" or "kalimba" is a traditional fixed-end instrument consisting of a wooden box or hollow gourd onto which flexible steel or bamboo strips are mounted to be plucked at their free ends by the thumbs or, in the case of the "marimbula" and the "rjon", struck with mallets (1:75). Also in Africa as well as in Central America the slit drum was developed and later evolved into more sophisticated fixed-end idiophones. It consisted of a hollowed log closed at the ends into which a longitudinal slit was cut. When the edges of the slit were struck, a resonant percussive sound was produced. Later the single slit was modified into a long H-shaped slit which created two separate fixed-end bars capable of
SANSA
(Africa)
- steel tongues
- gourd resonator

TEPONAZTLI
(Mexico)
- wood tongues
- log resonator

TONGUE DRUM
(American)
- wood tongues
- box resonator
producing distinct tonal sounds when struck. The Mayan "teponaztli" was such an instrument in which the two bars were shaved in order to tune them. In North America during this century, an instrument known as the tongue drum has emerged as sort of a cross between the marimbula and the slit drum. It consists of a wooden box whose upper face is cut into as many as twelve or more tongue-shaped bars of differing lengths to produce a range of tones when struck. As with the marimbula and the slit drum, the enclosed air cavity acts as a resonating chamber. Again, wood and metal instruments predominate in this category, with a noticeable lack of historical references to the use of ceramic materials for fixed-end idiophones.

Nearly all other idiophones can be grouped into a third category of three-dimensional vibrating bodies, characterized by a structure of widely varying form which is suspended or supported in such a way as to allow the entire object to vibrate freely, usually without the aid of resonating structures.

Historical examples include such unusual instruments as the Chinese lithophone which consists of a series of irregular stone slabs suspended from a frame and struck with mallets, the West Indian steel drum and other gong-like instruments in which a hammered metal disc, constricted at its edges, is set into vibration by percussive action, and the 18th century orchestral instrument known as a glass harmonica in which the rims of tuned glass bowls are rubbed with moistened fingers to produce resonant hum tones (6:129).

Perhaps the most common and universally fascinating idiophone of this type is the struck bell. It occurs in almost all cultures and in a wide variety of sizes, shapes, and materials (including clay). Origin-
GLASS HARMONICA
(American: Benjamin Franklin)

- glass bowls spun with a treadle wheel and played by rubbing with moistened fingers

CLOUD CHAMBER BOWLS
(American: Harry Partch)

- severed pyrex chemical jars played with soft mallets
ally made from natural materials and found objects such as crab pincers, sea shells, and cocoanut shells, the concept of a musical vessel-form evolved along with the development of metallurgy, ceramics, glassblowing, and other technical advancements which contributed to the production of utilitarian vessels. Some interesting historical examples include the Chinese "ch'ing" which was a heavy bronze basin placed open side up on a cushion and struck on its thick edge with a stick, the Korean "tjangkun" which was an earthenware predecessor to this type of resting bell and was struck with a split bamboo wand, the Japanese bell tree consisting of a series of metal bells of graduated sizes stacked on a vertical support rod, the Indian "jaltarang" consisting of a semi-circular arrangement of eighteen porcelain dishes, varying in size and tuned by partially filling with water, which are played with a bamboo stick, the European carrillon bells which are cast iron or bronze and weigh up to several tons, requiring a sophisticated support structure and a mechanized striker, and 20th century American composer Harry Partch's cloud chamber bowls which consist of an array of severed pyrex chemical jars suspended on a rack and struck with soft mallets (1:175).
III. THE PHYSICS OF MUSIC

A study of the physics of vibrating structures has been a valuable contributing factor to my work. Sound itself is nothing more than a vibrational disturbance of a medium of some sort, which is passed on to the bones of our inner ear where it is converted into an electrical impulse which our brain perceives as sound. Usually the medium through which the vibration is transmitted to our ears is air, and the source of the vibration can be almost anything around us whose motion and accompanying kinetic energy is capable of initiating a disturbance in the adjacent air molecules.

In idiophones there are many factors which influence the type of sound which is produced. The material from which it is made can affect the sound depending on its density, its ability to transmit and absorb vibrations, its elasticity (i.e., its resistance to tension, compression and shear stress) as well as the texture and quality of its surface. The manner in which the sonorous body is suspended or supported and the method used to set it into motion will determine to a great extent how it may sound. Its size, shape and juxtaposition to a resonating chamber will determine the frequencies which will be produced.

A musical tone is actually a complex combination of tones which our ear perceives as having an overall quality or "timbre." This is what enables us to distinguish the sound of a violin from that of a '49 Ford. The most important factor determining timbre is the overtone structure of a particular note. We usually perceive a dominant or "fundamental" frequency which gives us a sense of pitch which we associate with the tone, but in addition to the fundamental there are present in every tone
a range of additional higher frequencies or "overtones" which are not
usually perceived as distinct tones but as a shading or coloring of the
fundamental. The manner in which a structure vibrates will directly
affect the relationship between the fundamental and whatever overtones
are present. In vibrating strings and air columns, overtones are
produced at frequencies which are integral multiples of the fundamental.
If these individual overtones could be played together as a chord on the
piano, the ear will perceive a harmonious blend of tones. In vibrating
bars, plates, or vessel-forms, the overtones may occur at frequencies
which are more complicated mathematical derivatives of the fundamental.
These notes if played together on the piano would most likely sound
harsh and discordant, but since they are heard only faintly compared to
the fundamental, our ear perceives only the subjective effects of these
additional notes on the overall tone quality of a struck bar.

When a string is plucked or a bar of metal is struck, the intervals
between the overtones, their relationship to the fundamental, their
relative intensity and duration, and the degree to which they change
during the attack and decay of the note all combine to produce this
sensation of timbre or tone quality. The way our brain reacts to this
sensation is more of a subjective phenomenon than an acoustic one, so I
have concerned myself in this study more with recognizing and measuring
the overtones of certain vibrating structures than with the subjective
observations of timbre and tone color.

There are certain physical patterns or "modes" of vibration in any
given structure which determine the exact frequencies of its overtones,
and I will examine these firstly in a free-end bar. As the bar flexes
during vibration in the fundamental mode there are two stationary points
called "nodes". The points of maximum displacement are called "anti-
<table>
<thead>
<tr>
<th>MODES OF TRANSVERSE VIBRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN BARS WITH A UNIFORM DENSITY AND RECTANGULAR CROSS-SECTION</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>f, f₁, f₂, ...</th>
<th>indicates fundamental and successive overtones</th>
</tr>
</thead>
<tbody>
<tr>
<td>f, f₁, f₂, ...</td>
<td>indicates flexing patterns</td>
</tr>
<tr>
<td></td>
<td>indicates nodal points</td>
</tr>
</tbody>
</table>

**EXAMPLE OF A VIBRATIONAL PATTERN OF A VESSEL-FORM BELL**

---

<table>
<thead>
<tr>
<th>free-end bar</th>
<th>relative frequencies</th>
<th>fixed-end bar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>f₁</td>
<td>6.25</td>
</tr>
<tr>
<td>2.76</td>
<td>f₂</td>
<td>17.5</td>
</tr>
<tr>
<td>5.40</td>
<td>f₃</td>
<td>34.4</td>
</tr>
<tr>
<td>8.93</td>
<td>f₄</td>
<td>56.5</td>
</tr>
</tbody>
</table>

---

indicates nodal lines
nodes", and the number and position of these change for each overtone because the bar vibrates in a different pattern for each overtone. The strongest vibration will usually be in the fundamental mode with the vibrational pattern for each successive overtone superimposed on the fundamental pattern.

Since the bar in this example is considered to be floating in space, it is important to consider how the means of supporting or suspending it will affect the vibrational pattern. If it is supported at its midpoint, for example, it will be prevented from vibrating freely in its inherent fundamental mode because the midpoint is an antinode in this mode. However, since the midpoint is a mode for the first overtone, the bar may vibrate more freely in this mode. In most cases, the truest or clearest and most resonant tone will be produced when the bar is supported in two locations — those corresponding to the nodal points of the fundamental. The upper partials will still be present in lesser intensities to provide tone color.

A fixed-end bar will always have a node at its point of attachment, and as with a free-end bar, there is an additional node added with each successive overtone. It can be noted, however, that the frequency of successive overtones increases more rapidly than with the free-end bar, and thus the overall harmonic structure and the resulting tone quality are quite different. It is interesting that the relative width of the bar is not a practical factor in determining the frequency of the fundamental, but an increase in the width may introduce additional overtones due to a torsional flexing of the bar. This is true in free-end bars as well. The point or manner of striking may affect the resulting sound by encouraging or discouraging certain frequencies in the overtone structure. Generally the percussive blow of a mallet or
striker will generate an initial response over a broad band of frequencies. The energy of the blow is then channeled almost instantly into the inherent vibrational modes of the structure.

A given three-dimensional structure will also possess certain built-in modes or patterns of vibration which will determine the relationship of the overtones to the fundamental thereby affecting the timbre or quality of the tones produced. A bell or vessel-form will vibrate in a system of modes in which the midpoint or base is always a node, and the lip or rim is always an antinode. Nodal lines may occur as concentric circles radiating out from the center and as meridians bisecting the form through its midpoint. When such a form is mounted on a support structure, it is important, as with free-end bars, that it is suspended or supported at a nodal point or at points along a nodal line so as not to inhibit the vibration.

A practical approach to the tuning of musical instruments can be formed with an understanding of these principles. The fundamental frequency of a given free-end bar may be lowered by increasing its length, decreasing its thickness, increasing the mass distribution near its ends, or decreasing its mass in the middle. The pitch of a fixed-end bar may be lowered by increasing its length, decreasing its thickness, increasing the mass at the free end, or decreasing the mass at the fixed end. Bells and vessel-forms may have their frequencies lowered by increasing their diameter, decreasing their thickness, increasing their mass at the lip, or decreasing their mass near the center. The opposites of these procedures will, of course, raise the pitch. It should be noted, however, that some of these tuning methods will alter not only the fundamental, but the intervals between overtones as well, thus subtly changing the tone color as well as the pitch.
IV. AESTHETICS

Before describing how I have applied these principles of musical acoustics and how I have evolved my own designs for sound-producing forms guided by historical precedents, I will outline my personal aesthetic objectives in pursuing this course. As I stated at the beginning of this paper, my purpose is to derive a synthesis of art and technology. I also wish to make objects which embody the spirit and the classical ideas of creative expression in sculptural form while incorporating into my list of design constraints the following concepts: an awareness of the physical requirements of musical acoustics; an attitude toward materials and processes which stresses the virtues of simplicity and integrity, and a concern for the accessibility of these concepts on the part of the viewer.

Historically, instruments have been valued as objects of aesthetic beauty, both visual and aural. Much like a decorated funerary urn or an ornately inscribed sword, they carried a visual message designed to enhance or transcend their existence as a strictly functional object. The visual embellishment may have been in a form totally superfluous to the sound production such as the intricate carvings on the African and Central American slit drums depicting religious deities or the decorative inlays of ivory and ebony on a baroque harpsichord communicating the indulgent tastes of the time. On the other hand, the visual embellishment may have come about as an inspired solution to a structural or technical requirement of the sound-producing mechanism. Examples might include the classic reverse curve of the instruments of the violin family designed to allow free movement of the bow, or the
graceful curving and spiraling of the early horns, designed to compact the maximum length of brass tubing into the smallest space.

It is the latter of these two approaches which appeals more to me as a means by which to incorporate a visual statement in the design of a musical object. I tend to follow the philosophy that form follows function, but I would attach to that the stipulation that the artist's conception of form must be permitted to wander a bit through flights of fancy or other inspirational detours in its pursuit of function. Otherwise the creative process disappears from or becomes a strictly mechanical part of the act of making objects.

The notion of combining an aural statement with a visual statement is an important concept in my work and brings up the question of the relative importance of these two aspects. Are the objects intended to be instruments or sculptures? My intent as an object-maker arises solely from neither an instrument nor a sculpture aesthetic, but from an honest attempt at something that includes but goes a step beyond both. I think that people will respond to my work in different ways, some finding more to appreciate in the visual qualities, others responding more to the sounds. And since eliciting a response from the viewer is part of my objective as an object-maker, I am content to let the viewer decide whether the objects seem to him to be more sculptural or instrumental.

I am making musical objects out of a desire to explore the limits of form and structure within a set of chosen constraints. I see this as a design process much like that of the artist/potter who chooses to make tea bowls which are something more than just tea bowls. The musical instrument, like the tea bowl, is a vehicle for creative expression and
can embody all of the aesthetic qualities which we ordinarily associate with sculpture. It also creates a potential for musical expression just as a tea bowl can have an aesthetic potential in the expression of form and style embodied in the tea ceremony.

By allowing the viewer to actively explore this potential I am bringing together the two apparently antithetical concepts of an object as sculpture and an object as musical instrument, and by deriving this synthesis I am trying to express a concept which is more far-reaching than either. The challenge of forging an aesthetic from this synthesis is to retain an essence of the constraints which we associate with "sculpture" and "instrument" while developing a format or conceptual context for the objects to exist within which is indicated by neither set of constraints individually, but only by a true synthesis of the two. Addressing this challenge forms the basis for my artistic intent in this body of work.

One of the keys to the success of these objects, as with any work of art, lies in the perceptual response of the viewer. The object must communicate something or elicit a response of some sort in order to justify its intrusion on our senses. My pieces rely on viewer interaction to facilitate this communication. While I try to design objects which can stand on their own as purely visual statements, I require the viewer to initiate the discovery process which reveals to him the aural aspects of the aesthetic statement. This may entail striking a bar with a mallet or dropping a marble into an opening in a form, and the effort is instantly rewarded with a revelation which elicits a discovery response in the viewer. A basic communicative link has been established, and now the viewer may, if he chooses, continue the interaction
in order to discover all the secrets of sound and structure which are there to be observed. I mentioned previously my concern for "accessibility" in an artwork. I don't want a viewer to have to struggle in order to get my point. In today's environment of readily available stimuli, all offering immediate gratification, he is either going to give up before he reaches an understanding of the message, or if he has to work too hard to get it, he'll probably decide that whatever was being communicated wasn't worth the effort. I consider a work to be successful if it can capture a viewer's imagination and involve him in an ongoing process of discovery and communion.

Another phenomenon associated with this process of viewer interaction is a transformation of the object from inanimate to animate. It is always a challenge to endow a cold, lifeless object with animate qualities, but this is one of the prime objectives of the artist. This is why we use terms such as movement, energy, flow, growth, development, tension, gesture, posture, and strength to describe our perceptions of an aesthetic work. Most of the time these animate qualities are embodied in a visual metaphor, but with the incorporation of elements which go beyond just the static visual, such as kinetics and sound, the pieces actually seem to acquire an animate presence of their own. Artists who work with kinetics, sound, and such other related elements as light, electricity, and locomotion may elect to create this illusion of animation totally without direct viewer interaction — the "plug it in and let it rip" approach to technological art. I find, however, that a much more constructive interaction is likely to take place if the viewer is permitted, encouraged, and actually required to participate with the object in order to bring it to life. Once the communicative
link has been established as the viewer strikes a bar or drops a marble in, a transformation has taken place from inanimate object to animate viewer/ object system. As the viewer comes to grasp his role in this system he can begin to feedback information into the system based on his own responses to the object. The more input he directs toward the object, the more he gets back in return. Thus, the creative process doesn't end with the execution of the piece, and it becomes possible for the viewer to contribute to the piece, making discoveries and finding applications of which even the artist himself was perhaps not aware.
V. THE WORK

The actual works in which these ideas are manifested fall into three categories corresponding to the free-end bar, fixed-end bar, and three dimensional vibrating bodies: clay marimbas, petal drums, and gravity chimes.

The marimbas I have made employ unglazed stoneware bars of an oblong shape, about $\frac{1}{8}$" in thickness and varying in width and length. Fine tuning is accomplished by grinding a small amount of material from the underside of the bar. Thinning the bar in the middle will lower its pitch, and thinning it near the ends will raise the pitch. The bars are mounted to a support structure which also acts as a resonator. Rather than construct tuned resonators for each bar, I have used a single large chamber or a row of large chambers which will resonate over a broad range of frequencies. The bars must be mounted over these chambers in such a way so that they are supported only at the nodal points and are held in place loosely enough to permit them to vibrate freely. I have chosen to lash the bars onto two parallel bamboo rods or fiber strands which traverse the entire structure. When struck with a wooden mallet, the clay bars have a bright clear tone which is rich in overtones.

The various elements — bars, resonating chambers, support rods, lashing, and mallets — are combined in such a way as to create a sense of organic unity. I approach this sort of design problem in much the same way as the potter approaches the incorporation of such diverse design elements as vessel, lid, spout, and handle in the construction of a teapot. Each element must fulfill its own unique functional requirement and still contribute to the overall aesthetic of the object as a whole.
CLAY MARIMBA

22"

FINE TUNING:
GRIND BARS AT ENDS TO RAISE PITCH
GRIND BARS IN MIDDLE TO LOWER PITCH

STONEWARE BARS LASHED TO SUPPORT CORDS AT NODAL POINTS

RESONATING CAVITY AND SUPPORT STRUCTURE
My petal drums are extrapolations of the African slit drum and the Mayan teponaztli. The principle of the fixed-end vibrating bar has been incorporated into a handbuilt stoneware form in which clay bars protrude from the edges of a roughly hemispherical chamber. These tongue-shaped bars are struck with soft-tipped mallets to produce low, rich, harmonically complex tones. Because the clay transmits the vibration so well, some of the energy absorbed by an individual bar as it is struck is transmitted through the body of the structure to activate other bars as well as the air enclosed in the cavity. This effect produces a wide range of overtones which gives the sound a very sonorous and full-bodied tone quality.

It is virtually impossible to predict the pitch of a bar before it is fired, but I have found that by cementing small weights to the underside of a bar near its tip I can effectively lower its pitch for purposes of tuning. Since the vibration is transmitted throughout the body of the instrument, it is important that it be supported in such a way as not to interfere with this vibration. I have found that a bamboo stand serves quite well to acoustically isolate the piece.

My approach to form with the tongue drum has been organic — treating the total structure as if it were an organism which had evolved a specialized cellular structure in order to exhibit this particular characteristic of sound-production. The visual effect is influenced by the building technique used. I have constructed the shell from pinched cell-like units which swell in size and evolve into the petal-shaped structures that produce the sounds. This gives an overall appearance of organic growth and development. The added visual aesthetic of the stand contributes to the "specimen-like" quality of the piece.
CONSTRUCTION:
Built and fired upside down
in a shallow support form
with a shrinkage slab

PETAL SHAPED FIXED-END
BARS ARE CANTILEVERED
OVER RESONATING CAVITY

HEMISPHERICAL SUPPORT SHELL
AND RESONATING CHAMBER

SMALL TUNING WEIGHTS
CEMENTED TO UNDERSIDE
OF BAR TO LOWER PITCH

16"
The gravity chimes are the products of an original concept for a sound producing sculpture. Employing a variety of acoustically designed three-dimensional forms which are suspended to allow them to vibrate freely, they are activated by the kinetic energy of a falling pellet, analogous to the aeloian force which activates a wind chime. The two forms which I have found to be most applicable in this type of structure are a bowl or funnel shape, which vibrates much like a vessel-form bell, and a curved tubular segment into which fixed-end bars are carved, which vibrates in part like a tubular bell and in part like a tongue drum. These components must be supported in such a way as to acoustically isolate each from the others and still provide a pathway for the falling marble or pellet to follow as it is driven downward by the force of gravity.

These pieces definitely move into the field of sculpture as opposed to musical instruments. Their musical versatility is limited due to the automated nature of their operation, but they offer an unlimited potential for new and exciting sculptural compositions which incorporate a strong visual and an aural statement. What I find most exciting about these pieces is the relative absence of visual references to musical instruments. While the clay marimbas and petal drums convey a definite visual impression of "instrument", the gravity chimes and the fountain chime are most often read as "sculpture" upon initial viewing. They portray a sense of some sort of uncertain function which becomes more and more clear as the viewer examines their structure, finally making the discovery of their sound as a marble or pellet is dropped into the inviting openings.
HOLLOW TUBULAR SEGMENTS WITH TONGUES CARVED INTO THEM

MARBLES DROPPED INTO OPEN ENDS OF UPPER SEGMENTS

ATTACHMENT CORDS

BOWL-SHAPED SEGMENTS WITH SMALL OPENING IN BOTTOM

CLOSED BOWL TO CATCH MARBLES

GRAVITY CHIME
CONCLUSION

My research and experimentation with musical clay forms have shown me not only that this is a feasible idea, but that it offers more possibilities for creative designs than I had imagined. I have been able both to draw from historical examples for design ideas and to invent totally new contrivances based on my understanding of the acoustic principles involved in musical instruments. In addition, my observations of viewer interaction with my pieces have proven the success of this aspect of my endeavors. People seem to be irresistibly drawn into participation with the pieces, fascinated at first by the ability of the structure to produce sound and enthused by each new discovery they make about the piece as they experiment with it.

There are two inherent difficulties with these pieces which may hinder their effectiveness as musical instruments per se: the relative fragility of clay as opposed to wood or metal and the difficulty involved in matching the acoustical standards to which we are accustomed in commercially produced instruments. I don't consider either of these problems to be serious obstacles in the visual or sculptural aspects of the work, and I am willing to accept them as design constraints.

Thus, I think my research and my work stand in support of my thesis and demonstrate an understanding of musical instruments in both a technical and a historical context and an application of ceramic processes both practical and aesthetic to form a successful merger of art and technology.
The success of a work of this sort can perhaps also be measured by the doors it opens -- the new questions raised, the new possibilities to explore, the new attitudes about one's work which are generated. My endeavors in producing a body of work to support the thesis have enabled me to achieve a certain level of craftsmanship in the objects I make, both in a technical and an aesthetic sense. These objects, having never before existed, seem to present a new challenge, the implications of which go beyond a simple craft or visual art aesthetic. An important question presents itself: What is the actual potential of these objects to create music, or in another sense, to continue the creative process into new dimensions through their function as visual/aural objects? The answer to this question will take the form of a new and more far-reaching body of work to be built on the groundwork set forth by this thesis.

As I attempt to consider my approach to this challenge, I see a need to broaden my attitude about what I do and why I do it. If I am going to direct my efforts toward realizing the musical potential of these objects, I must forge a new aesthetic -- one which will provide the framework within which I may operate not only as a craftsman or visual artist, but perhaps as a musician, composer, or performance artist. This thesis has given me some of the basic tools for shaping that aesthetic; as a craftsman I have evolved an attitude about materials, processes, and the relationship between form and function. Now I need to consider the implications of the objects I have made in light of their musical capabilities and look for the connections and
unifying constraints which will tie together a craft aesthetic and a music aesthetic. This is the constructive process from which perhaps a new product will emerge — one which will evoke new responses and elicit new answers to questions about ourselves and our world.

If a potter begins to think like a tea master, his tea bowls will become vessels for more than just tea.
BIBLIOGRAPHY


PLATE 1

Clay Marimba
"Dance of the Skeletons"
48x12x14h
PLATE 2

Clay Marimba
"Kung Fugue"
24x18x16h
PLATE 3

Petal Drum
"Rutabaga Waltz"
18x20x20h
PLATE 4

Petal Drum
"Musik für Metaforen"
16x16x46h
PLATE 5

Gravity Chime
"Rondo a la Turk"
50x6x64h
PLATE 6

Gravity Chime
"Suite for Double Helix"
20x20x62h
PLATE 7

Fountain Chime
"Toccata in BB"
18x18x34h