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COUNTERPOINT: UNDERSTANDING FORCES, REACTIONS, AND MOVEMENT

by

Dan Winfred Burkett III

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

Master of Architecture

APPROVED, THESIS COMMITTEE:

David Guthrie, Assistant Professor

Brian Heiss, Visiting Lecturer

Jessica Young, Director: Publications and Exhibition

HOUSTON, TEXAS

MAY 2005

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ABSTRACT

Counterpoint

by

DAN BURKETT

Counterpoint is an exploration into the relationship between forces and reactions as translated by the material properties of wood, and exploring these relationships within a dynamic system. This relationship is created by an individual or group of individuals' movement through the system. As a person moves through the space, forces are applied by the movement of the body across the floor plane. The force applied by the person or persons is translated into the bending of the wood. The bending reflects the movement and provides a counterpoint to the movement of the body. The system also allows for a misrepresentation of movement by shifting variables in the system. This allows for a multiple of readings of the same type of movement. This project attempts to take a mundane activity (walking) as the program and amplifies the almost imperceptible consequences of this action, and heightens our awareness to our action, thus turning it into a performance.

ACKNOWLEDGMENTS

I would like to express my deepest thanks to everyone that helped in making this project possible.

Susanna - for bringing a little extra craziness to my life.

My Brother Tom - for doing the unbelievable, being able to think clearly and quickly when my brain refused to work, and for just being there.

Melissa - I don't think anyone can make me laugh as much as you can.

Zeynep - for breathing with me.

Justus - for the talks, the smokes, and the banjo.

To all of you who helped me in the final days, hours, minutes:
Anton, Sky, Eric, Quyen, Graham, and Tom. You all helped out more than I could have hoped for.

To my committee for believing in me when I couldn't see what was right before me.

To my Mom, my greatest teacher, my biggest influence, and the most patient and loving person I've ever known. I love you.

And most of all to the one that I love, Kari, I could never have gotten through this without all your love, support, and encouragement when I couldn't believe in myself or what I was doing.

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Opening Position

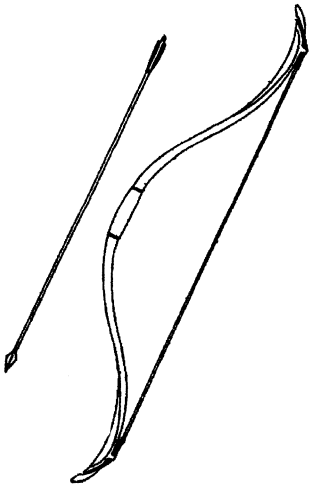
Wood is one of the most common building materials used in architecture. Yet, the potential within the properties of wood are infrequently realized. The variety of spaces and objects made of wood most commonly express only the physically static and aesthetic properties while other properties of wood such as bending and elasticity go unrealized.

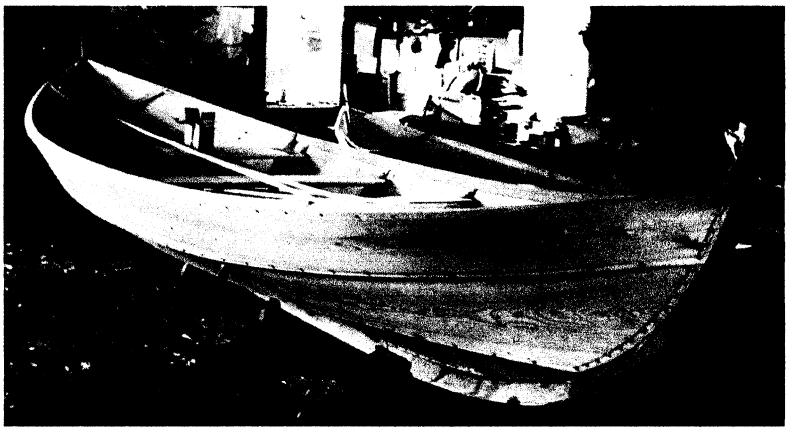
My experience working with wood and understanding its inherent properties began with a piece of bent wood furniture that I built early in my career and has continued through the experimentation and production of various bent and molded furniture and objects. Through these projects I have developed a greater appreciation and understanding of the physical properties of wood.

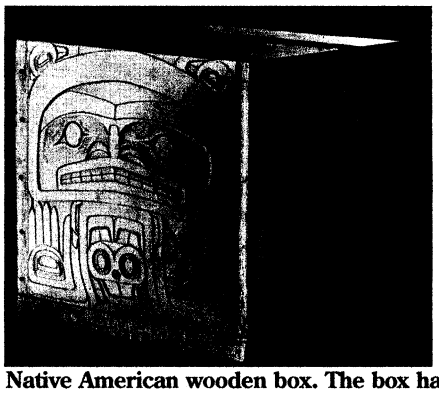
The work of this thesis explores the potentials of these inherent properties of wood; bending, elasticity, and the reactions and translations of forces. It also seeks to exploit these properties by exploring the ways in which an individual can interact with the material. It also illustrates how this interaction with the material, when applied in a way that exploits its physical properties, can changes a persons perception of the material and their interaction with it. In addition this thesis looks at residual spaces such as corridors, walkways, and pedestrian bridges. It suggests an alternative to these mundane spaces and the activities that occur within them by attempting to find new ways of articulating these spaces. By making both the space and the activity more engaging, an individual's awareness and consciousness of their movements is heightened.

History

One of the first uses of wood bending can be dated back to Viking boat building. Vikings soaked wood in salt water to keep the moisture content high and allowing for greater amounts of flexibility. Making a temporary frame out of a solid piece of wood, the Vikings would then bend the salt water soaked wood on the temporary frame to create a permanent frame and the hull of the boat. Native American tribes in the Pacific Northwest used some of the first methods of steam bending to make bows, arrows, and wooden boxes. By using green wood (wood that has not been dried) the Native Americans would bend the wood over a fire heating up the water contained in the wood. This allowed the wood to be easily bent and rapidly dried and fixed in place. Mass production of bentwood objects started around World War II when the military used the technique to produce airplane parts. Today bent wood objects are found everywhere from tennis racket to furniture. We encounter bent wood even on a more experiential level when we walk up a set of creaking stairs or a boat dock where the rolling tide and planks of wood that give slightly under our feet and heighten our sense of balance and awareness.

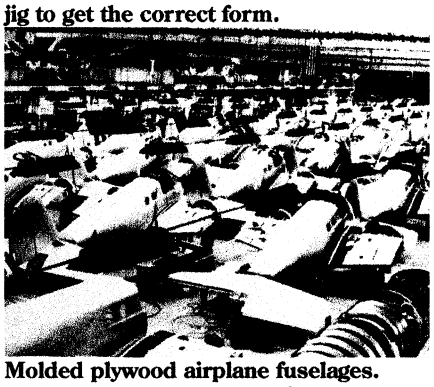






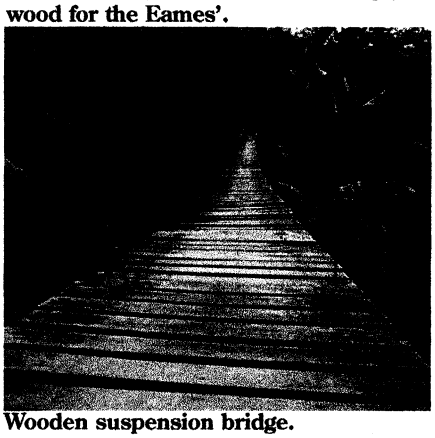
Native American wooden box. The box has been steamed and bent at the corners.

Man steam bending. Once out of the box the steamed piece is bent around a jig to get the correct form.

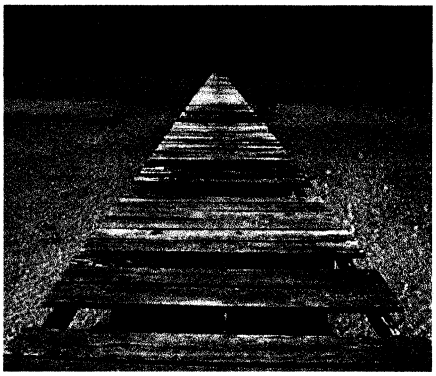


Molded plywood airplane fuselages. These airplane parts were formed using mechanical presses.

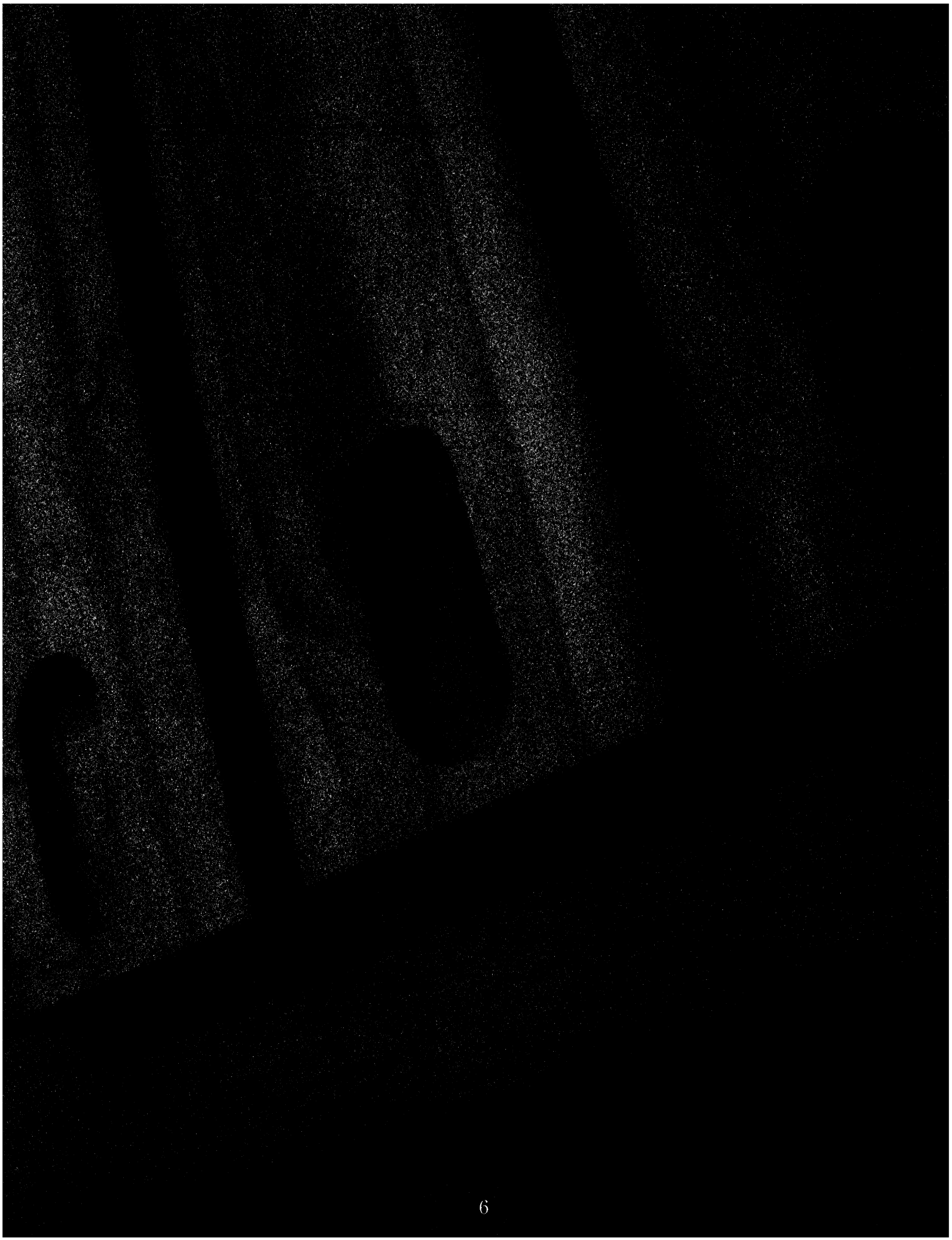
Eames molded plywood sculpture. One of the first experiments in molded plywood for the Eames'.



Wooden suspension bridge.



Wooden dock.



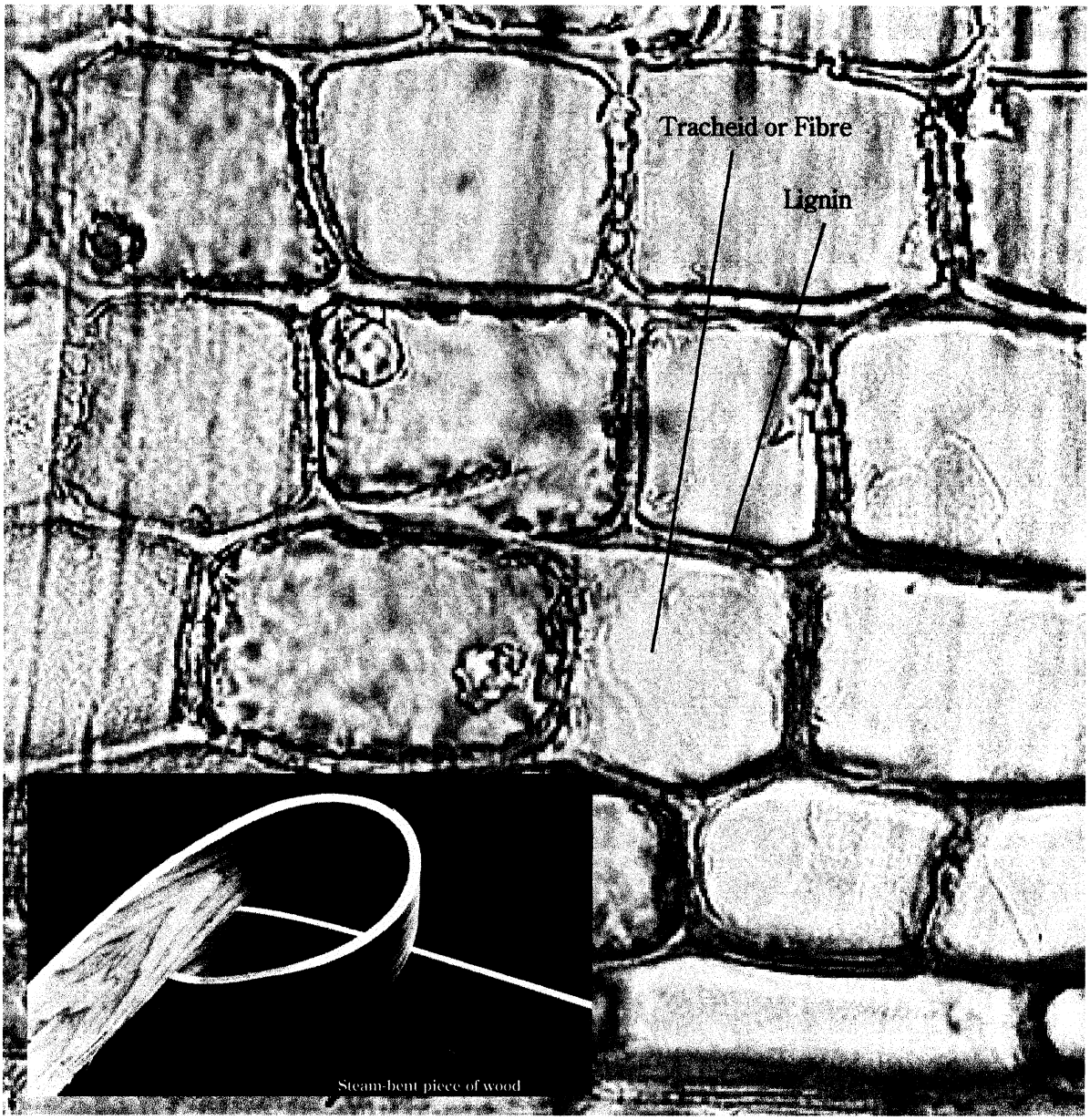
Early Explorations

Lamination is a process in which the wood is cut into thin layers and glued together in a cross grained pattern. This method provides a great deal of strength for the bent piece, is more precise, and has relatively little spring back. However, this method also produces a large amount of waste, and requires a great deal of set-up and clamp time. Kerfing or cutting groves into the wood on the inside of the radius helps to relieve compression in the wood at the bend. The radius of the curve is determined by the spacing of the kerfs. The closer the spacing the tighter the radius. This method is relatively quick and easy but it greatly reduces the strength of the wood at the bend, and can not be done in compound bends or molds.

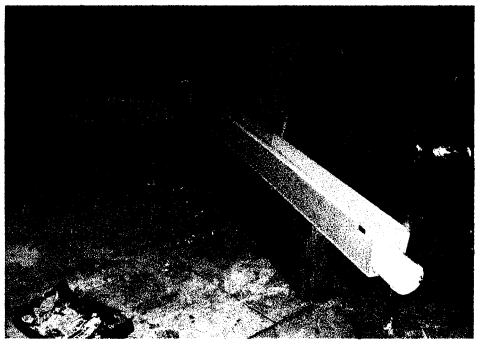
Finished laminated piece.

Vacuum press for lamination.

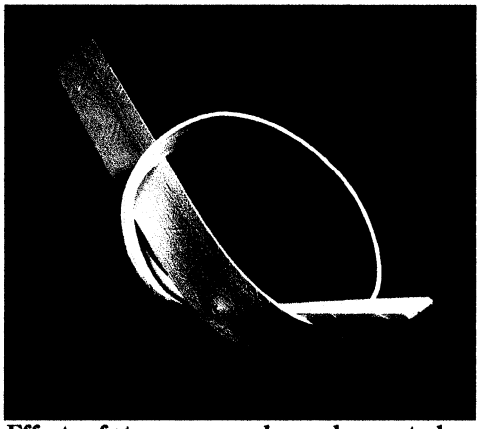
Steam bending is a more complex process than lamination and kerf bending and requires a significant amount of set-up time. However, it produces very strong continuous pieces in the end. Steam bending uses an understanding of the cellular structure of wood to produce bent pieces. The use of moisture and heat cause the lignin (the material that binds the fibers together) to soften and placticizes the wood. The fibers in the wood are then allowed to slide past one another for a short period of time. Once cooled and dried, the wood retains its bent form.



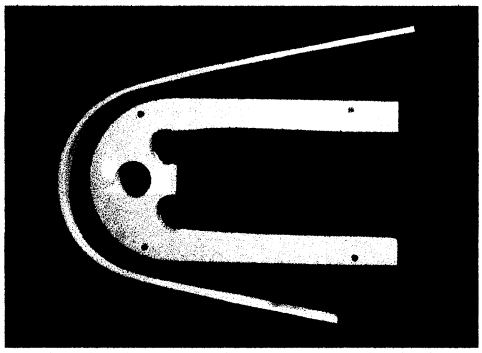
Cross section of a piece of wood showing the basic structure of wood.



Home made steamer. Made out 4" dia. PVC pipe.



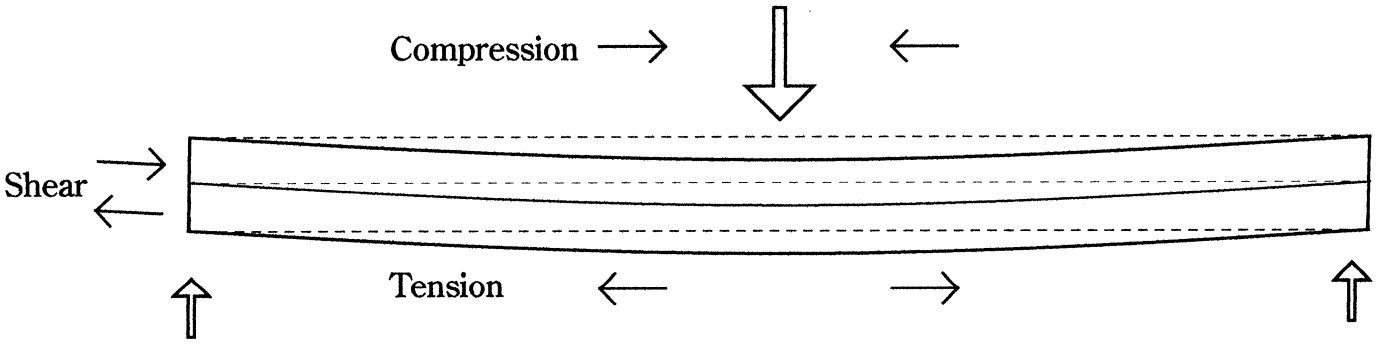
Effects of steam on wood, wooden pretzel



Spring back results from the woods desire to return to its natural form.

Static Bending

Static bending in wood creates a complex series of forces as a result of the bending. Tension, compression, and shear are the forces that result from bending and each has its own effect on the material. In general, wood is strongest in compression and weakest in tension. But different species of wood deal differently with those forces.



Static Bending Properties of some Common woods

Hickory (shagbark)	2.16 E
Birch, Yellow	2.01 E
Douglas Fir	1.95 E
Oak, Southern Red	1.49 E
Bass wood	1.46 E
Spruce, Engelman	1.28 E
Ponderosa, Pine	1.26 E
Cedar, Incense	1.04 E

Hooke's Law

Hooke's Law states that the ratio of stress to strain is proportional within the elastic range. When a load is placed on a piece of wood the amount of deformation is equal to that load. If the load does not go beyond the proportional limit the deformation will return to normal (fig 2). If it goes beyond the limit the deformation will be permanent (fig 2a). This ratio is known as the modulus of elasticity. The modulus of rupture is similar in concept but deals more with static bending of wood (fig 3).

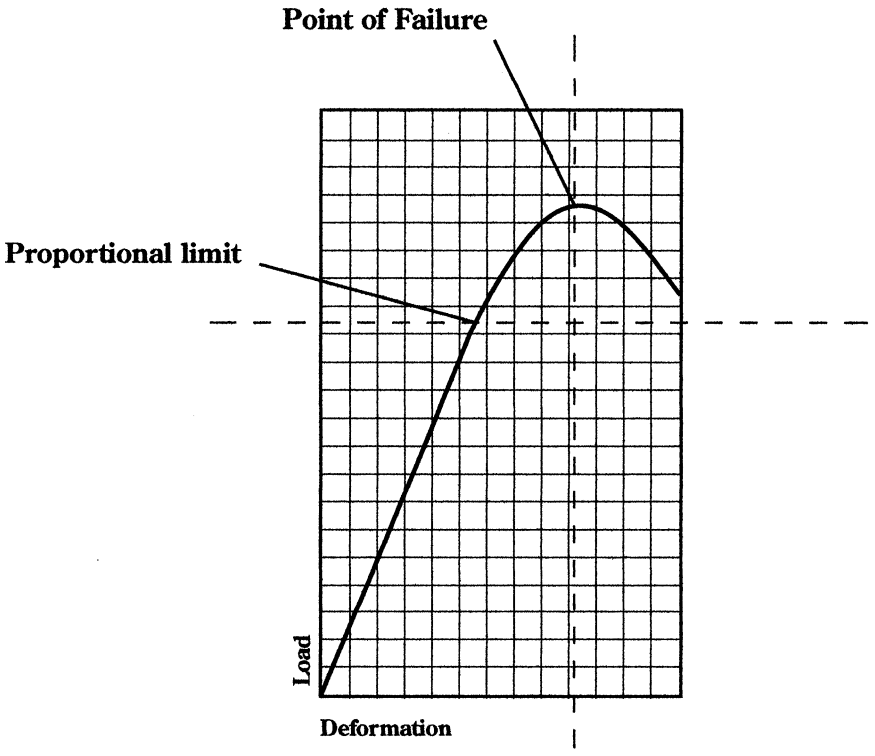


Fig 1. - Modulus of Elasticity

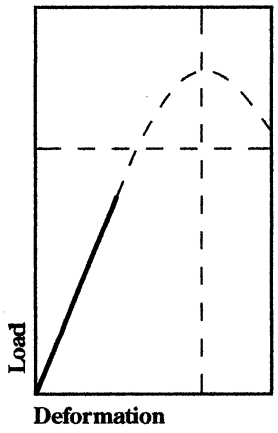


Fig 2

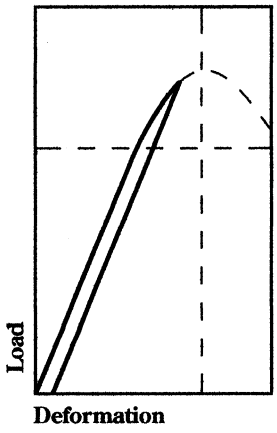


Fig 2a

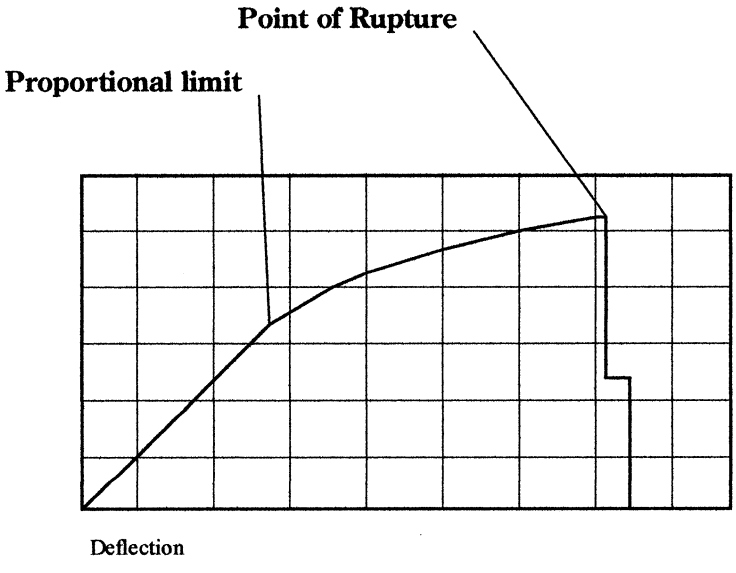
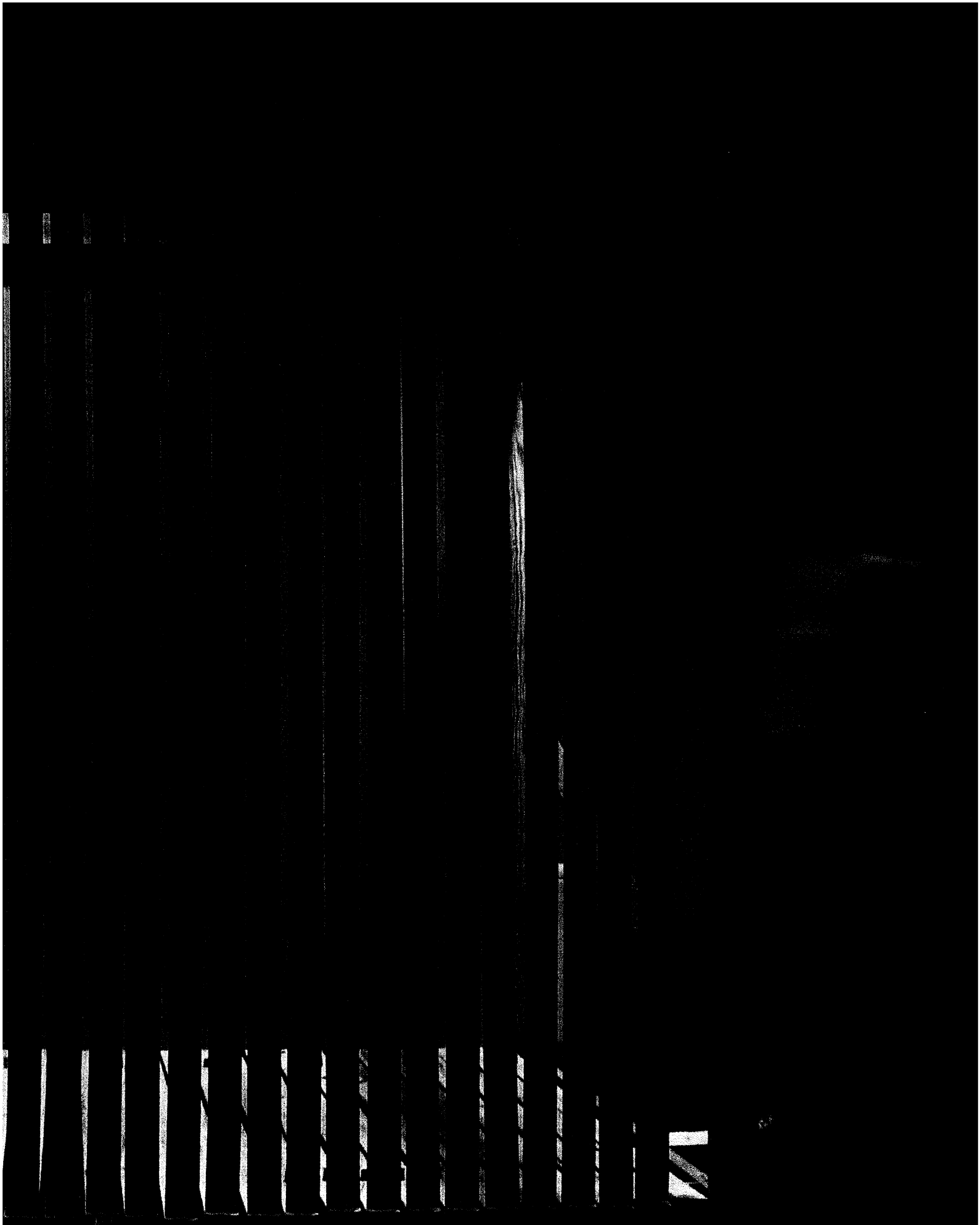
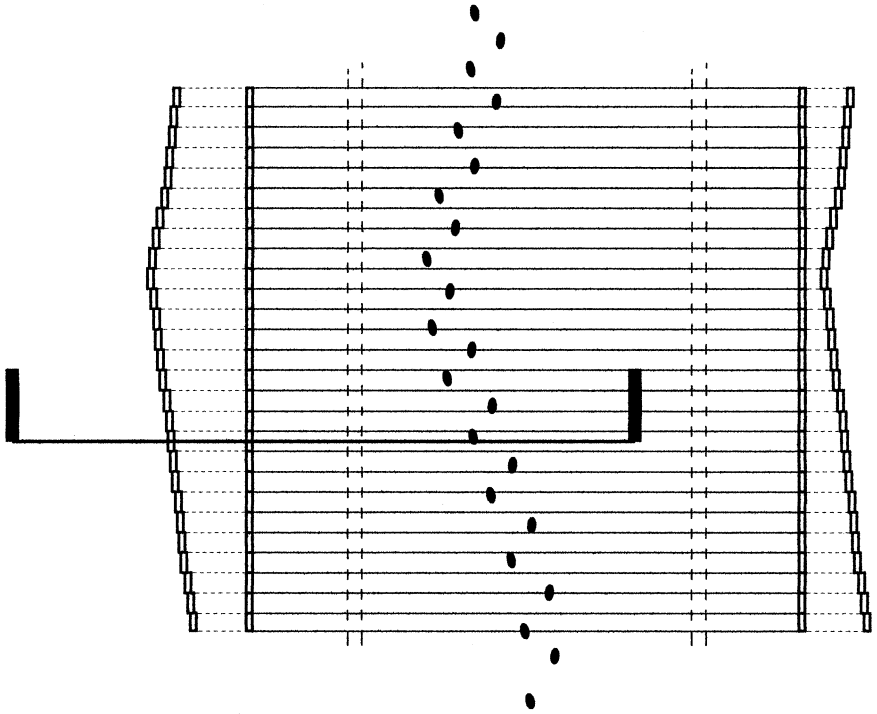


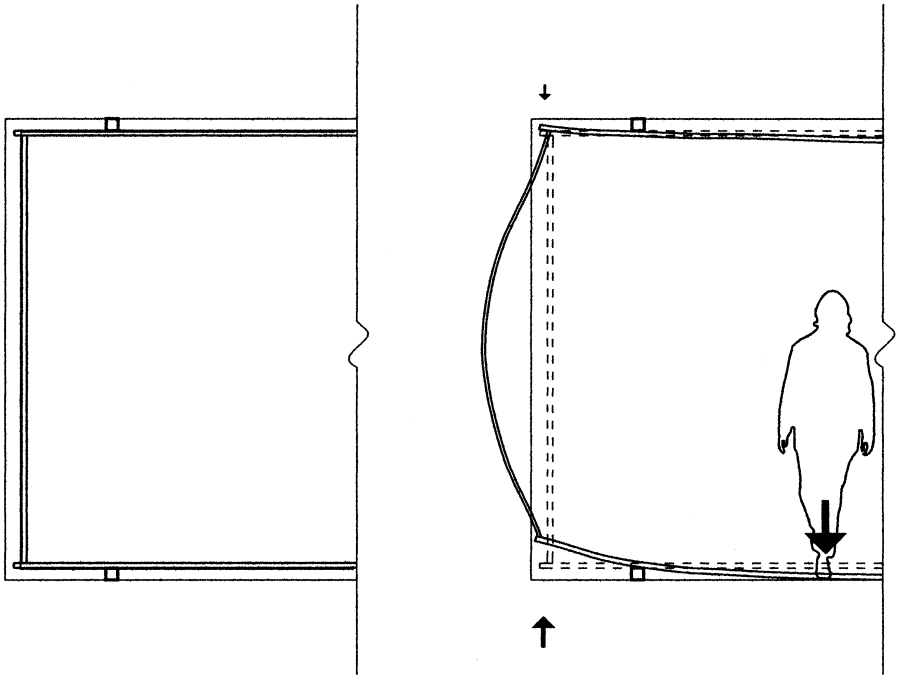
Fig 3. - Modulus of Rupture



Basic Form

In its simplest form, this system explores how wood responds to external forces and uses its inherent properties to transfer those forces. Its construction is intended to respond to and reflect an individual's, or a group of individuals' movement through the space.

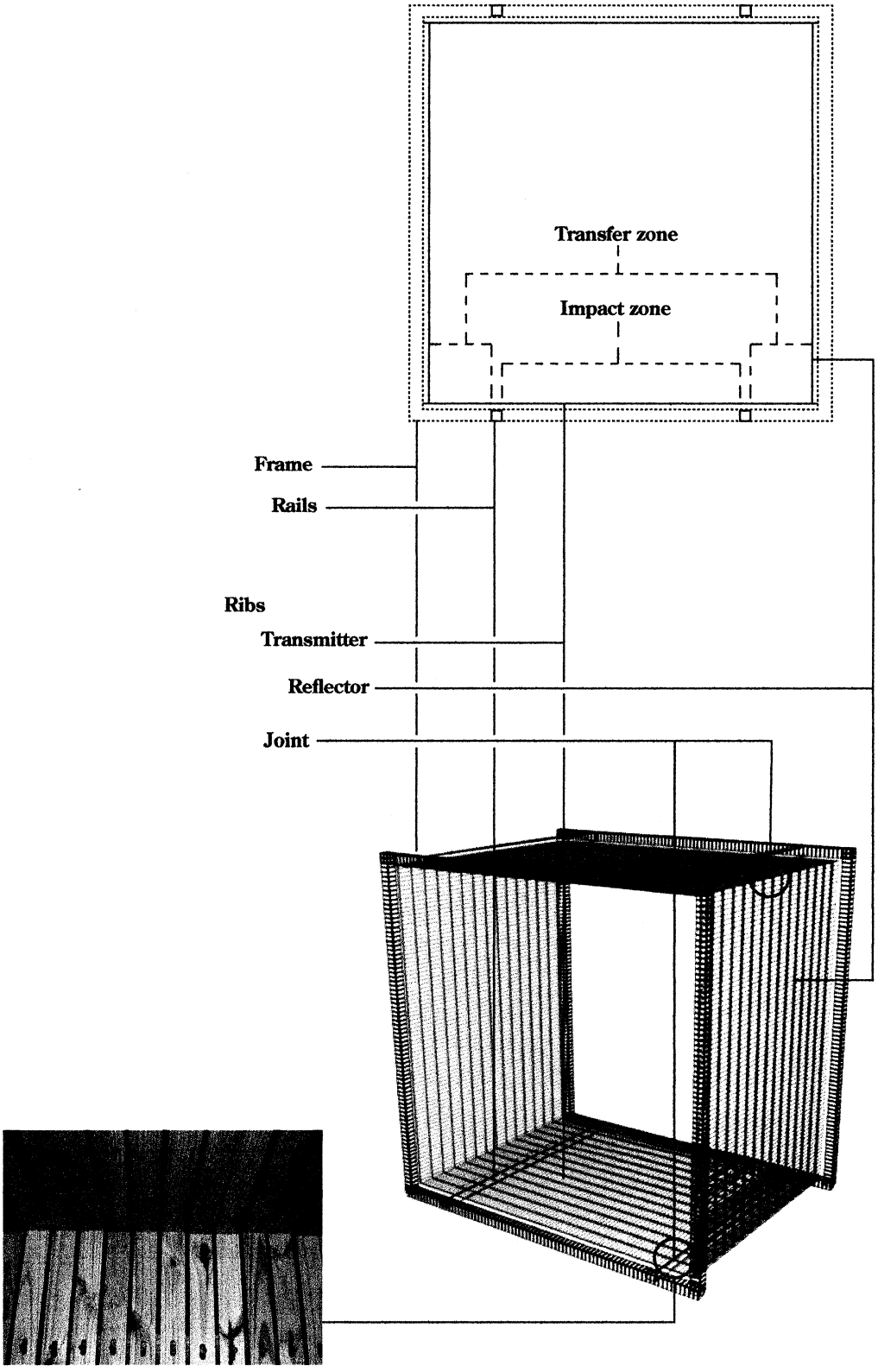


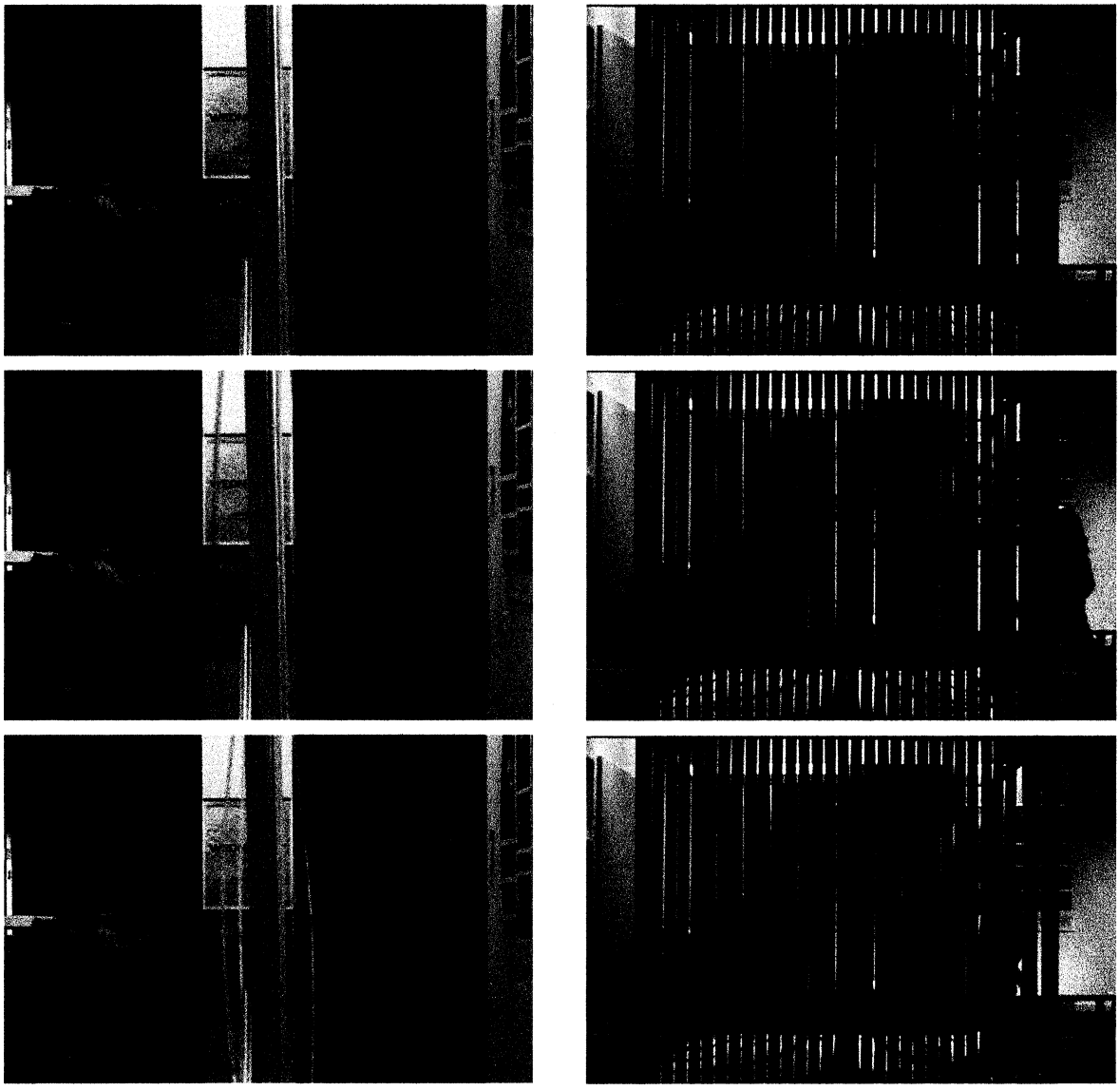


Reflected Movement

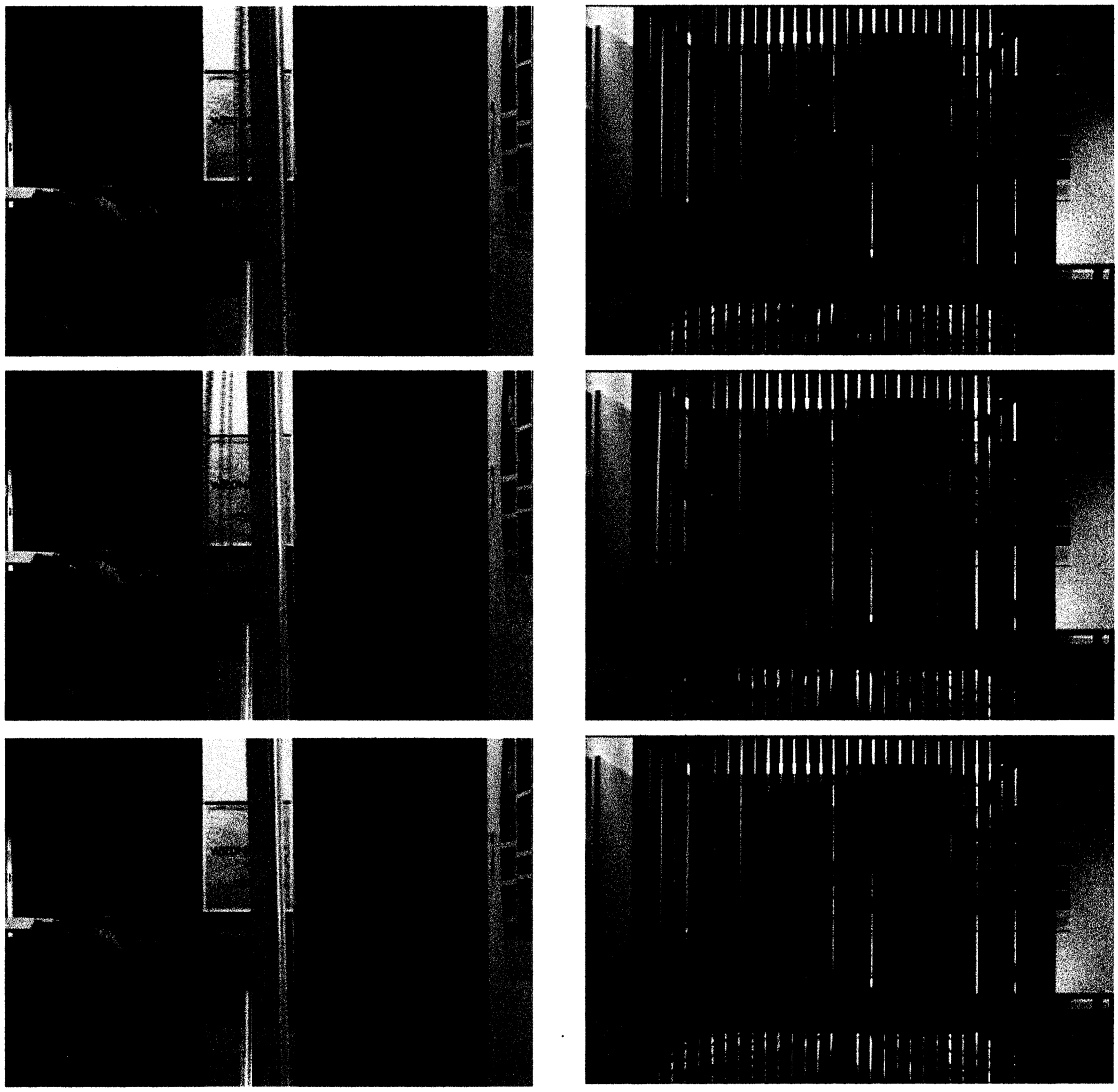
The basic forces at work within the system are tension, compression, and the relationship of stress to strain. Stress is defined as the amount of force on an area. Strain is the resultant amount of deformation that occurs due to the amount of stress on an area. It is this understanding that allows the system to work. When an individual applies an amount of force to the transmitters, they are put into stress. The resultant strain is then transferred to the reflectors as they bend under the stress from the transmitters.

The frame work of the system consists of three primary components that work to allow the system to respond to movement. These components are the rails, transmitters, and reflectors. The rails work to provide the transmitters with a counterpoint to the force being applied by an individual. The force is applied to an area of the floor called the impact zone, located between the rails. The force is then translated into a counter-action and transferred through the transfer zone to the reflectors. The reflectors respond by bending under the force.


Transfer zone
Impact zone
Frame
Rails
Ribs
Transmitter
Reflector
Joint



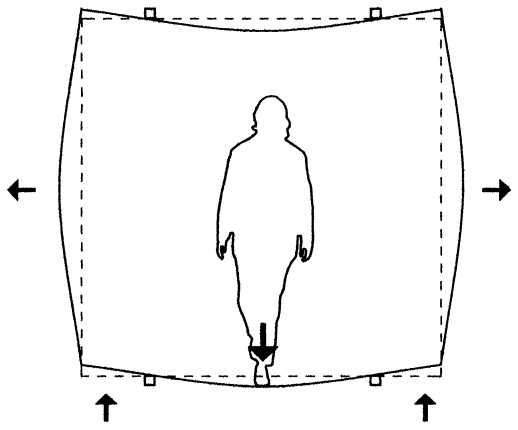
Sequence showing typical reaction to force (walking). Left hand column shows deflection of side members. Right hand column shows corresponding position of person.



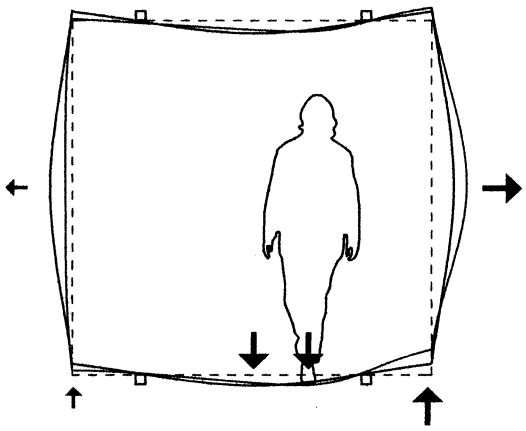
Variable Diagrams

Variables such as length of members, allow for the system to be modified to respond differently to an individual's movement, potentially influencing the way that the individual occupies and perceives the space.

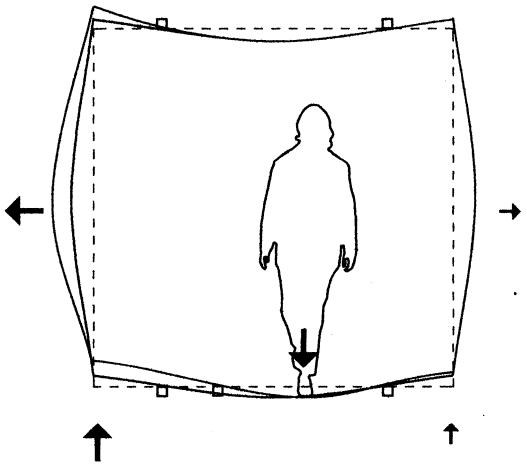
Basic form
No variables are shifted.



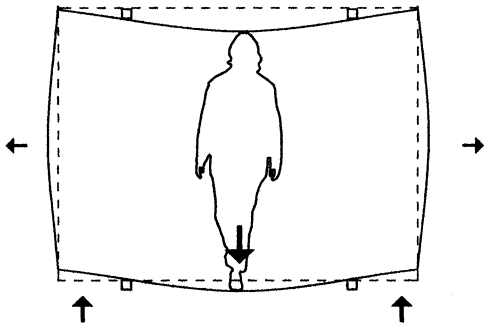
Position of force
The position of the user relative to the rails shifts the amount of force transferred from the transmitters to the reflectors. The closer the user stands to one rail the more force is transferred to that side.



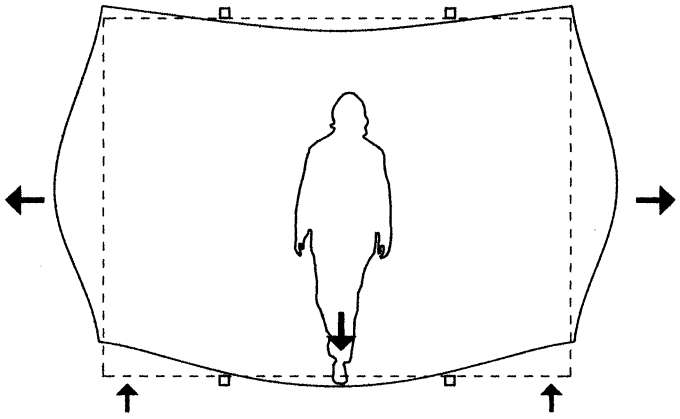
Position of rails
The positioning of the rails allows for a shift in the relationship between the impact zone and the transfer zone. This shift increases or decreases the amount of bending in the reflectors.



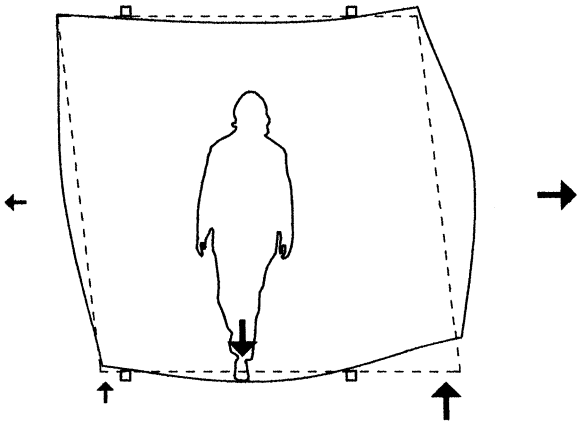
Height of reflectors
A change in the height of the reflectors allows for a change in the amount of bending in the reflectors. The shorter they are the less they bend.



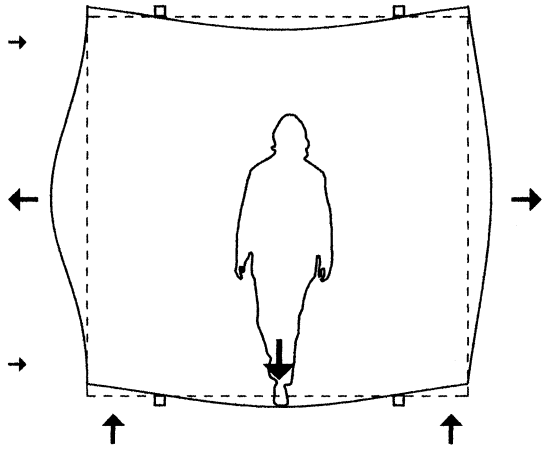
Length of transmitters
Changing the length of the transmitters while maintaining the distance between the rails allows for a shift in the relationship between the impact zone and the transfer zone.



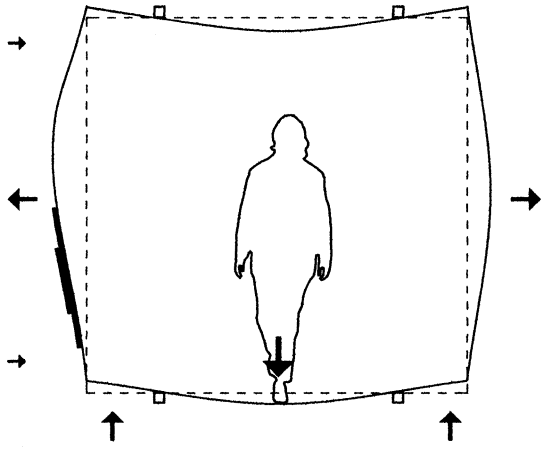
Position of transmitters relative to rails
Similar to the position of the rails, shifting the position of the transmitters allows for a shift in the relationship between the transfer zone and the impact zone.



Joints (rigid or flexible)
The amount of flexibility in the joints changes the sharpness of the curve in the reflector. The more rigid a joint is the sharper the curve.

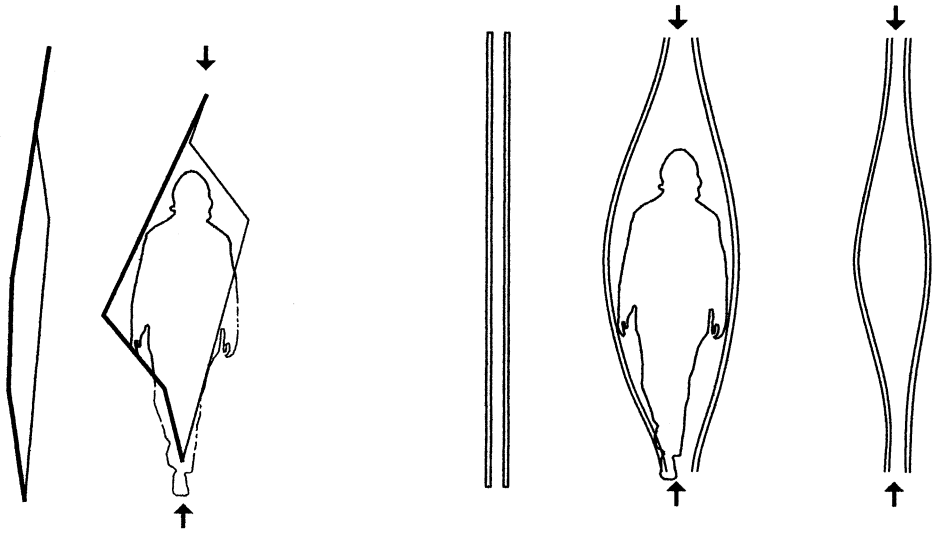


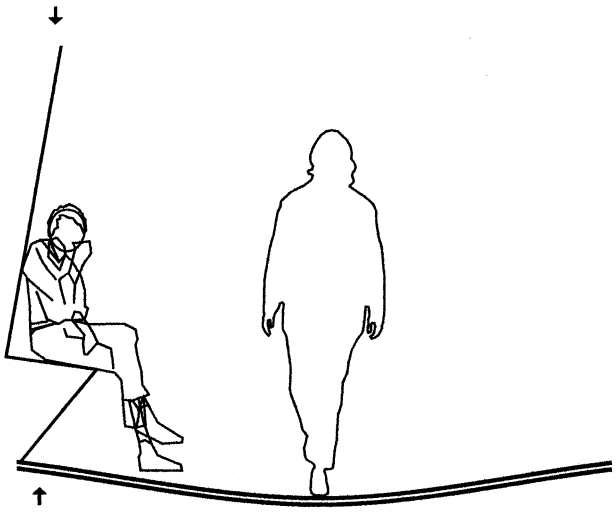
Thickness of members
Changing the thickness within the members allows for a change in the shape of the curve.

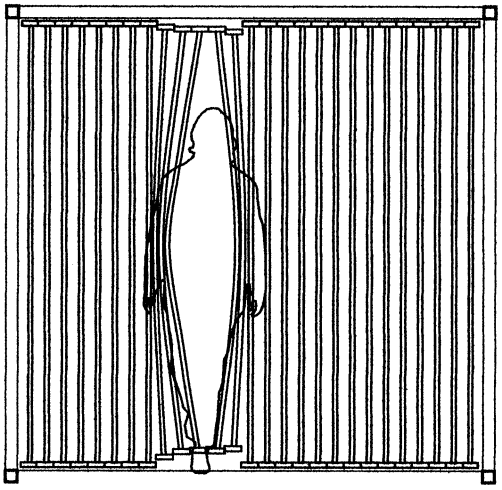


Variable Combinations

Through a shift in the variable, or a combination of shifts, the potential arises for basic programs to emerge based on these combinations. Basic programs are defined as opening, pass-through, horizontal surface, etc...

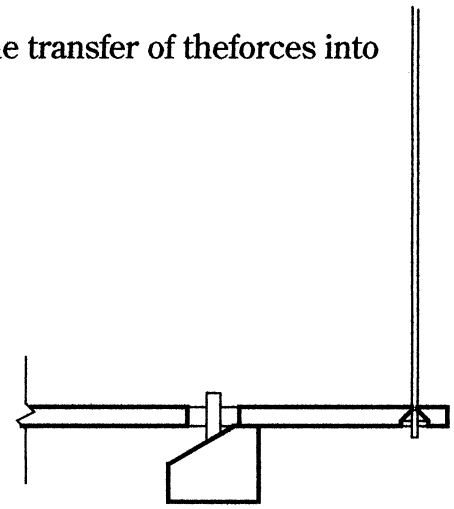


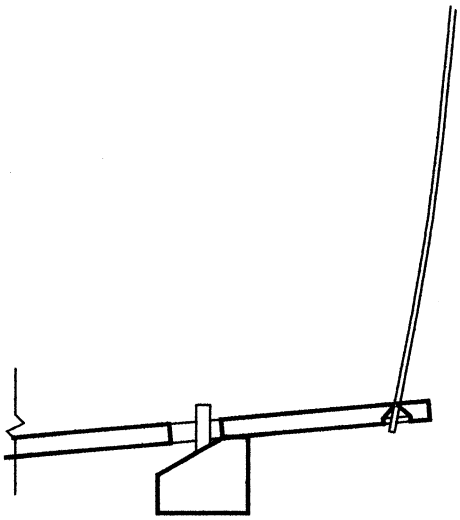


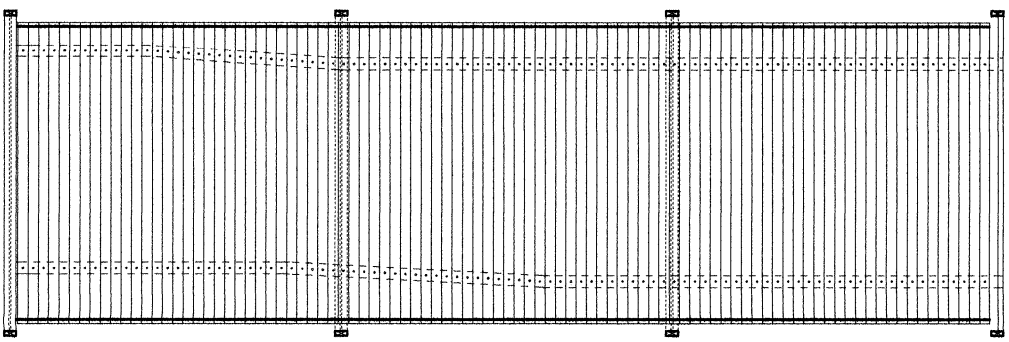


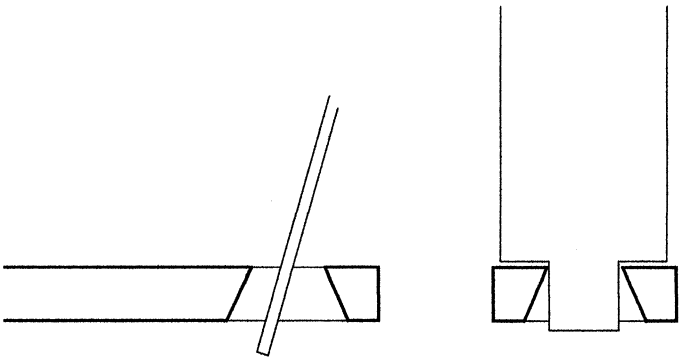
Detail & Connections

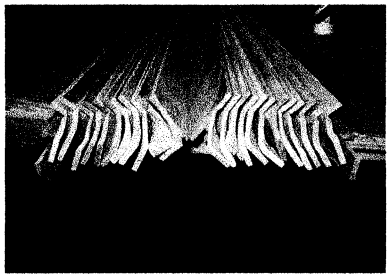
The details and connections have the potential to change the way in which the system is read. At certain points the connections allow for a relief of forces in the system. In others they allow for the transfer of theforces into other parts of the system.

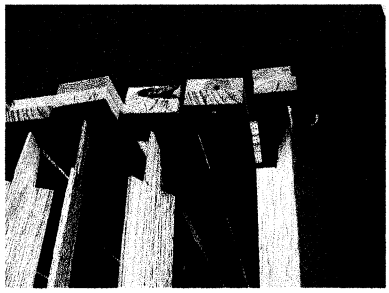


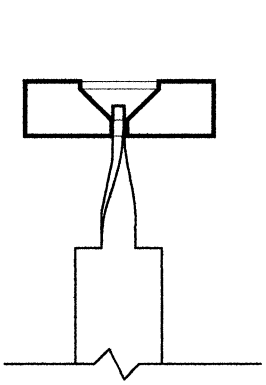


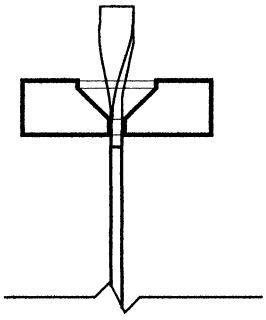


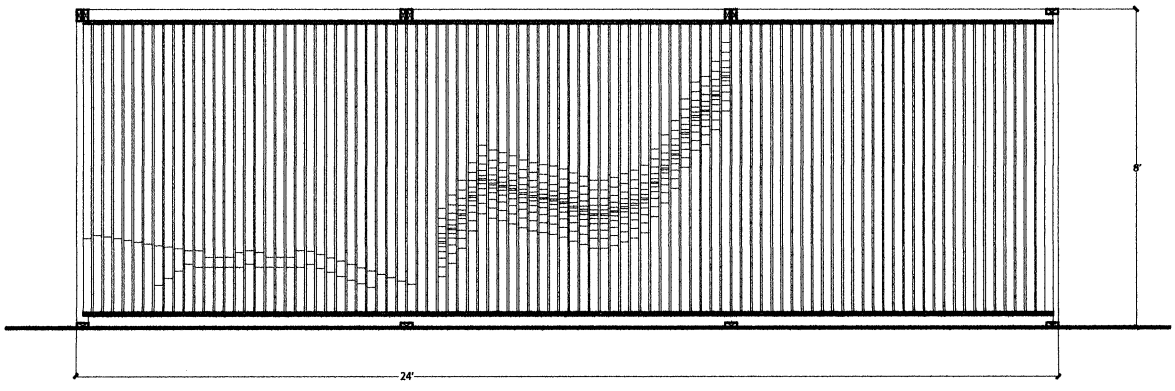








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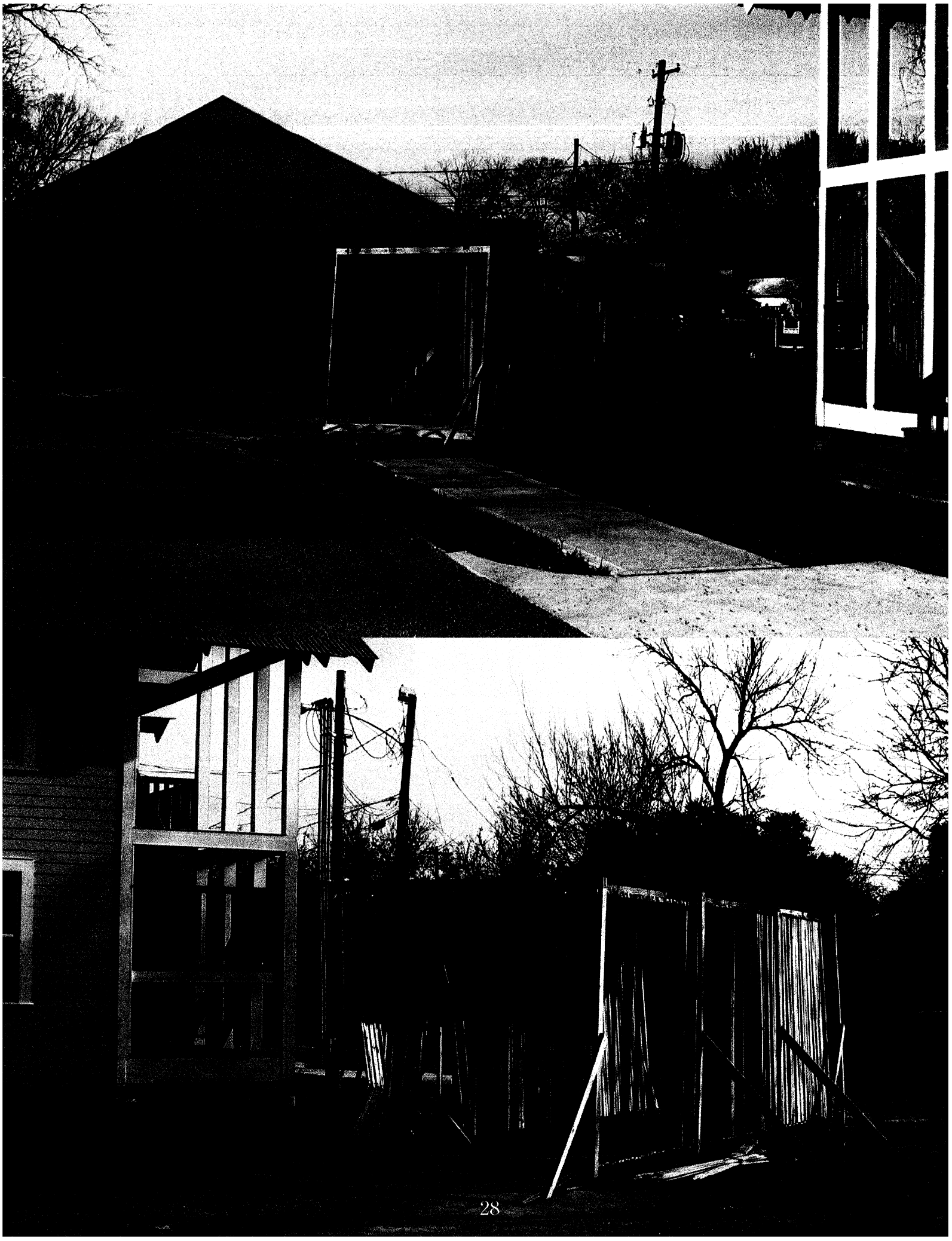
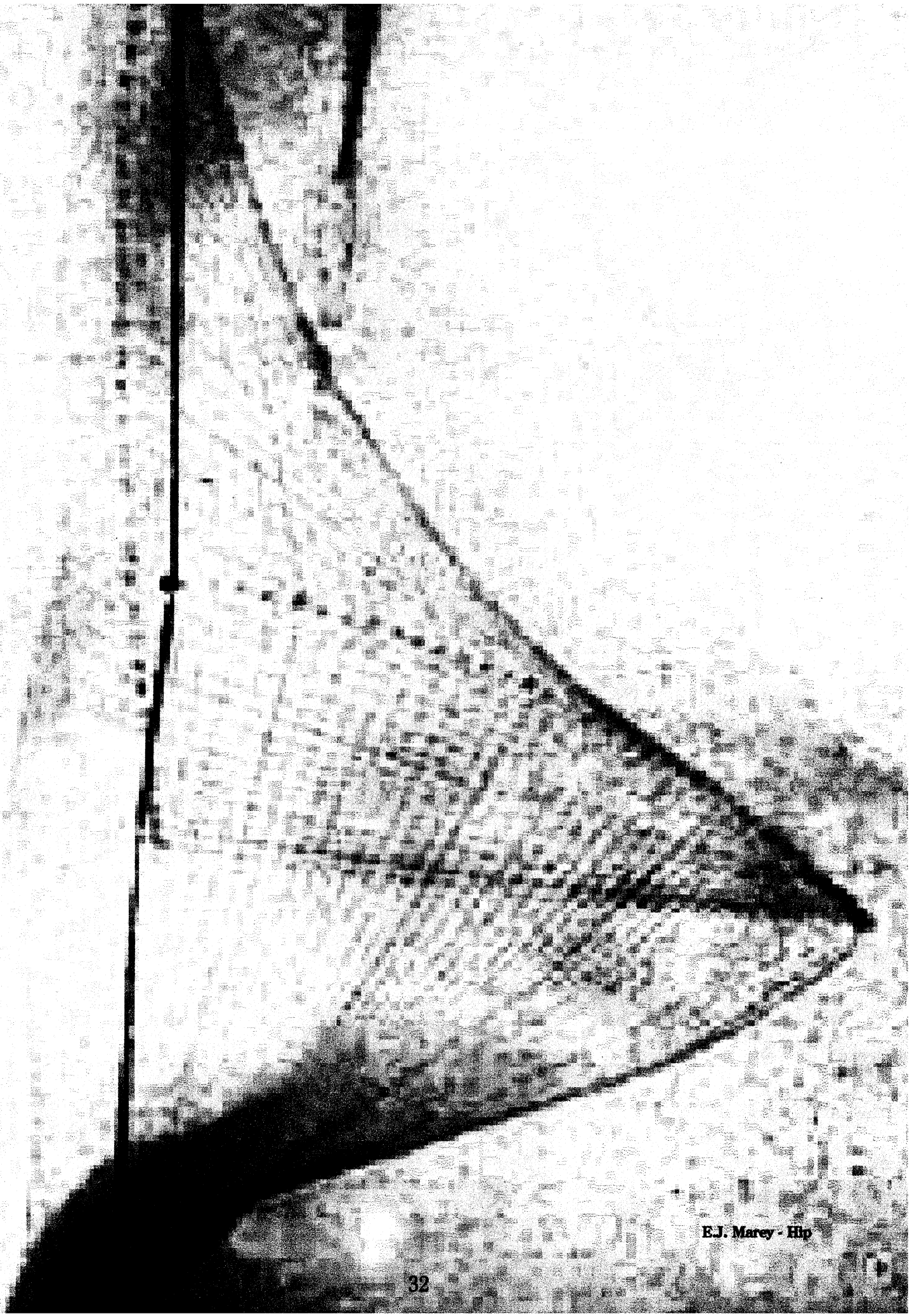
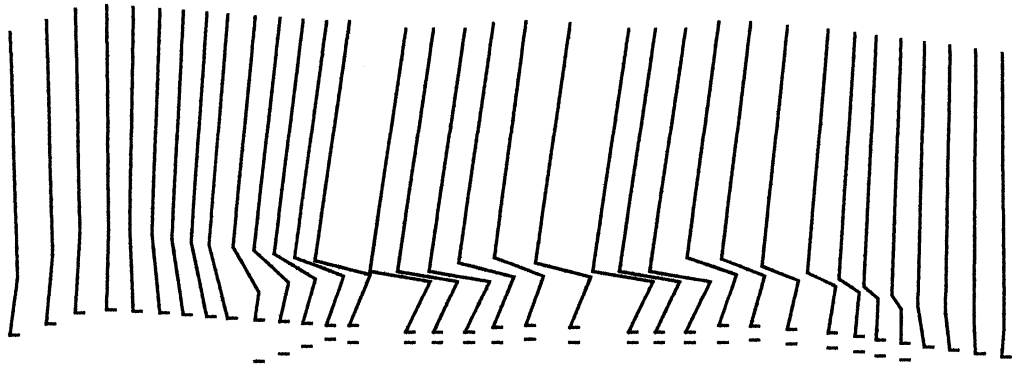


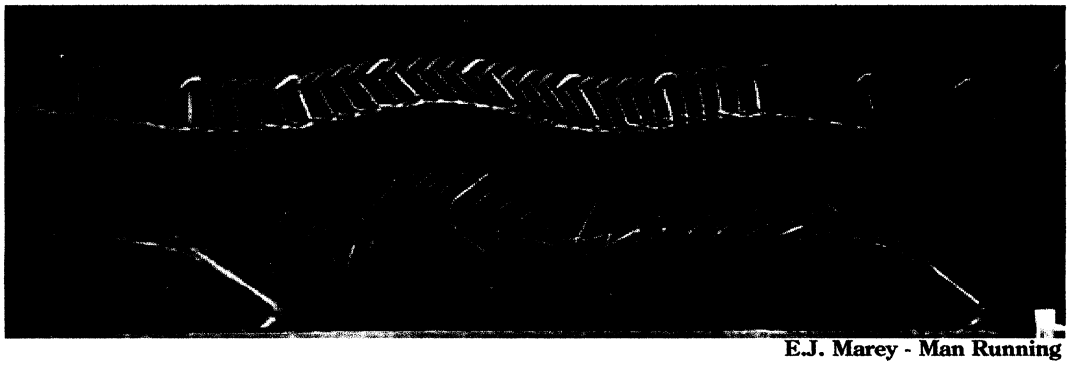


E.J. Marey - Hip

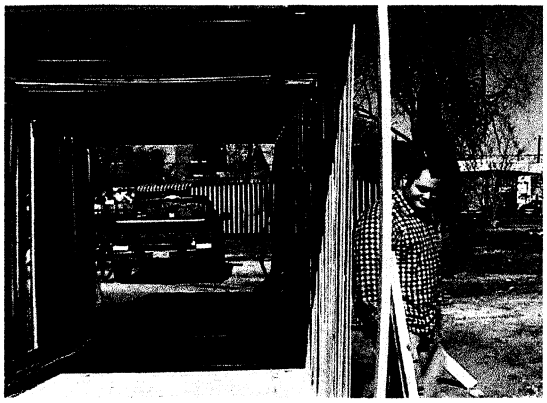
Movement

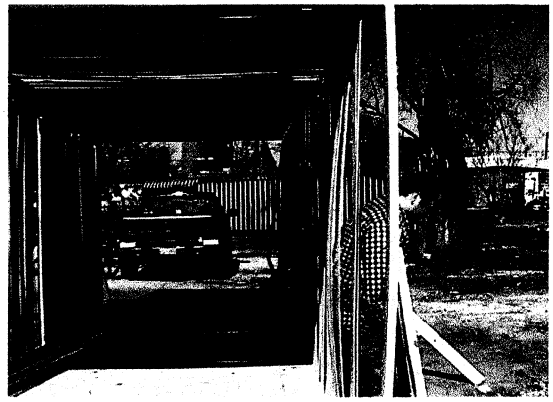
This system was built to respond to and reflect an individual's movement through the space. The system also changes the way in which an individual perceives their own movement, making them intimately conscious of how their feet touch the floor, or how they interact with the wall. This new found perception changes how they interact with the system. It makes them more deliberate in some ways, with how they move in relationship to the system and with others in the space. This encourages different types of interactions and movements within the system and thus produces a variation of responses and reflections of movement.

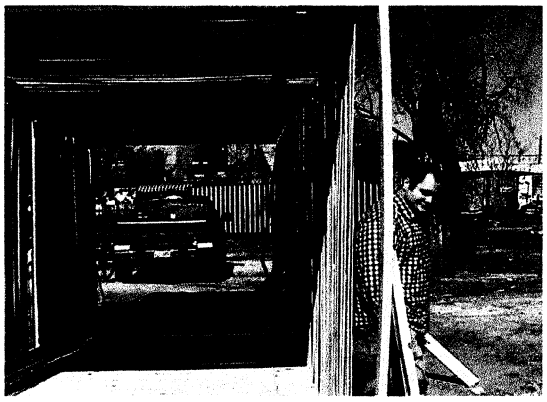


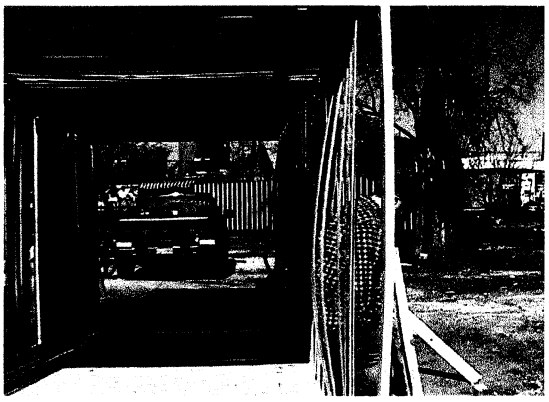


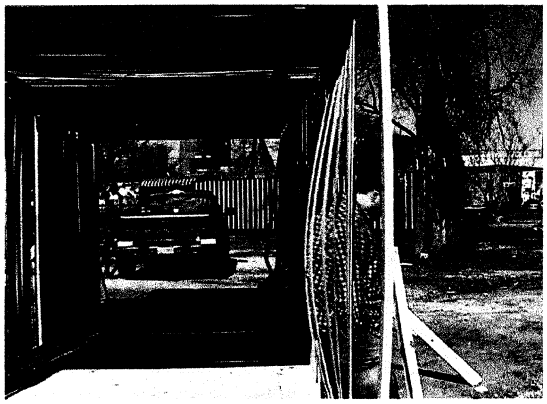
E.J. Marey - Man Running

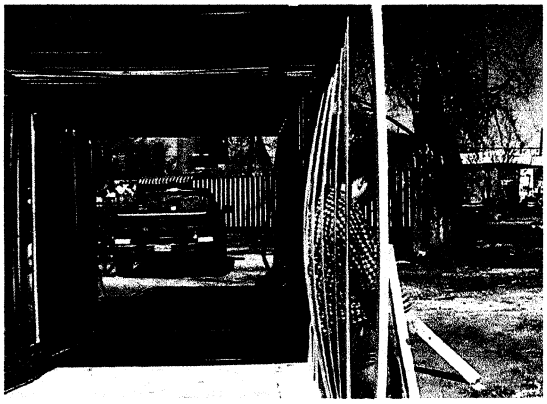


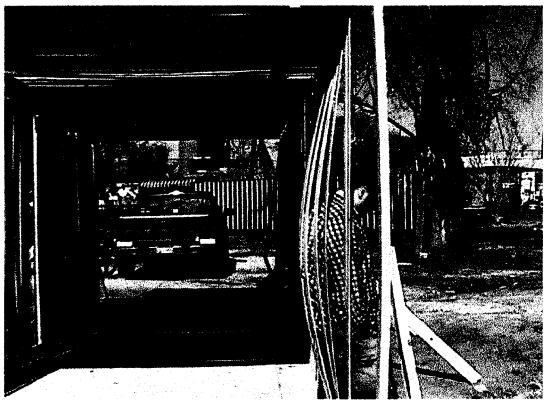


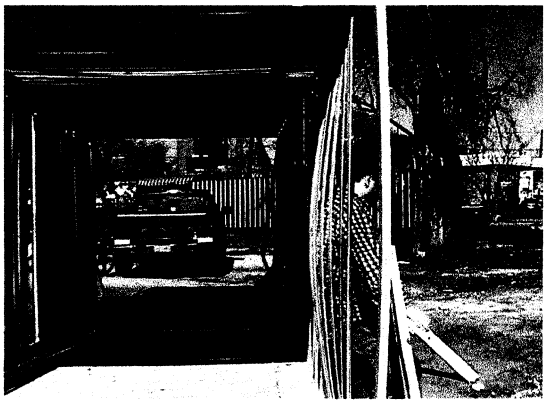


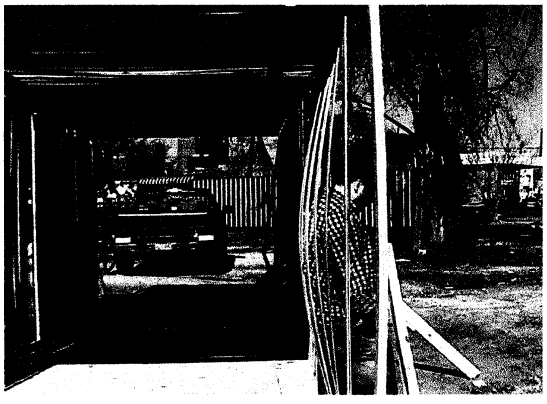


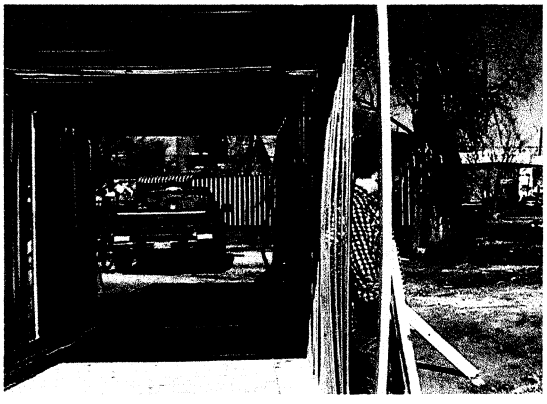


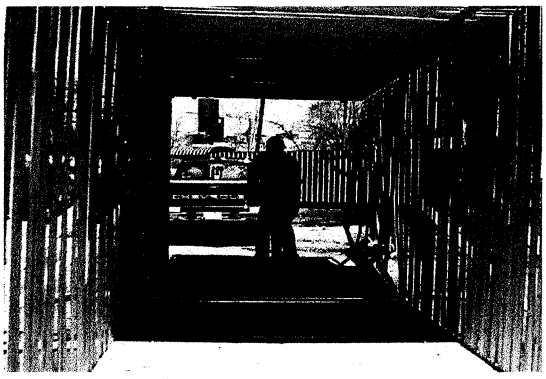


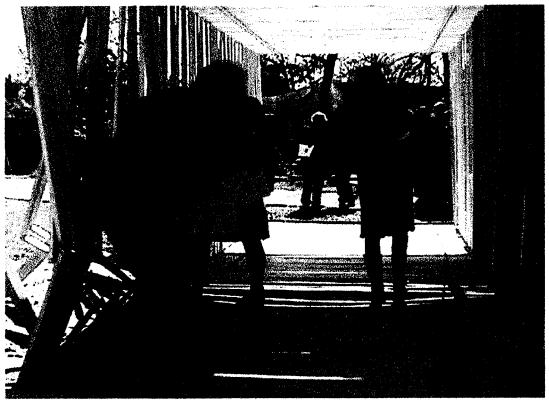


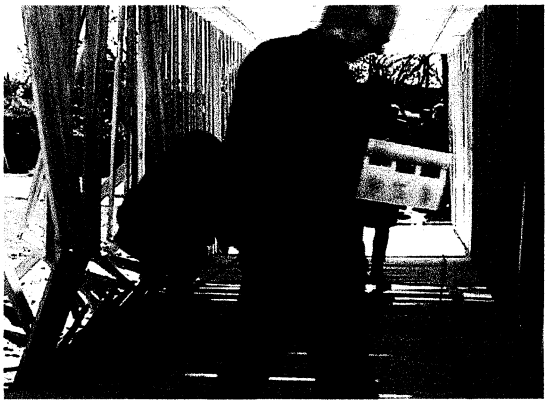






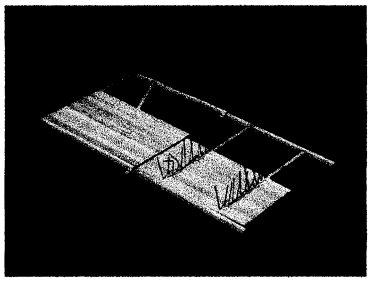


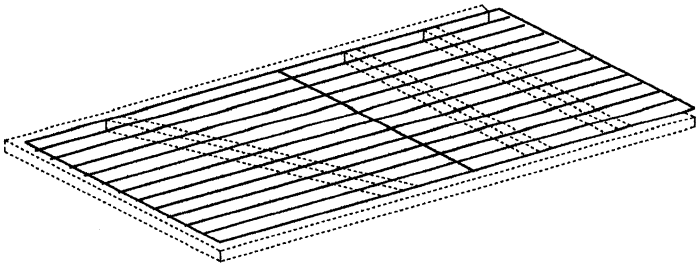


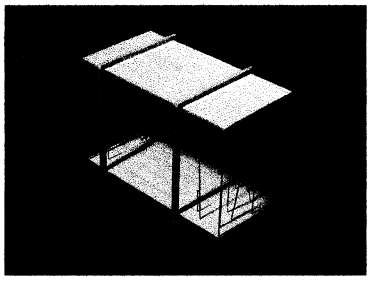


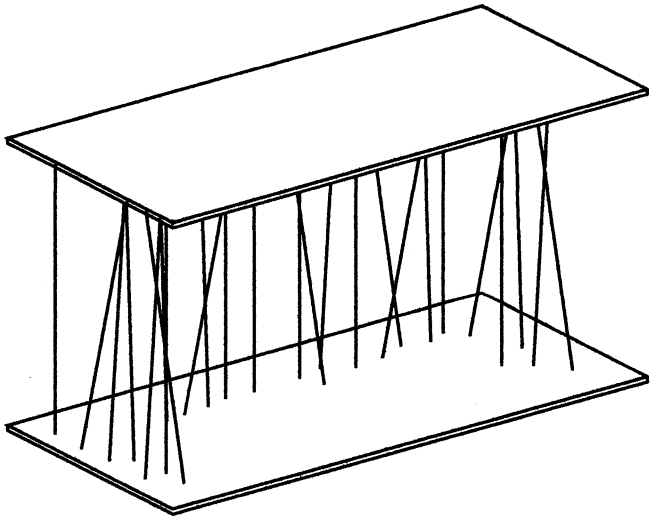
Hybrids

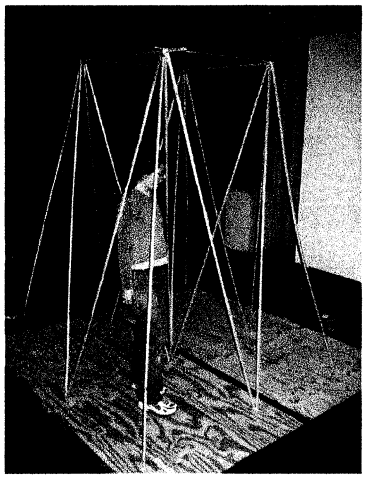
By combining variables and connections, the potential arises to develop new hybrids of the system. These hybrids can perform in very different ways, from producing sound, changing light qualities, and morphing the entire space.

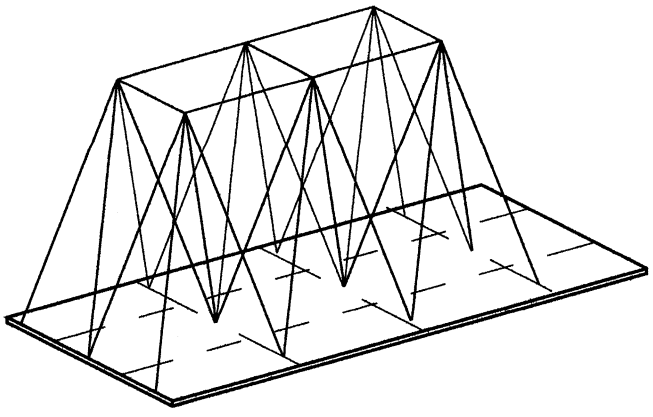








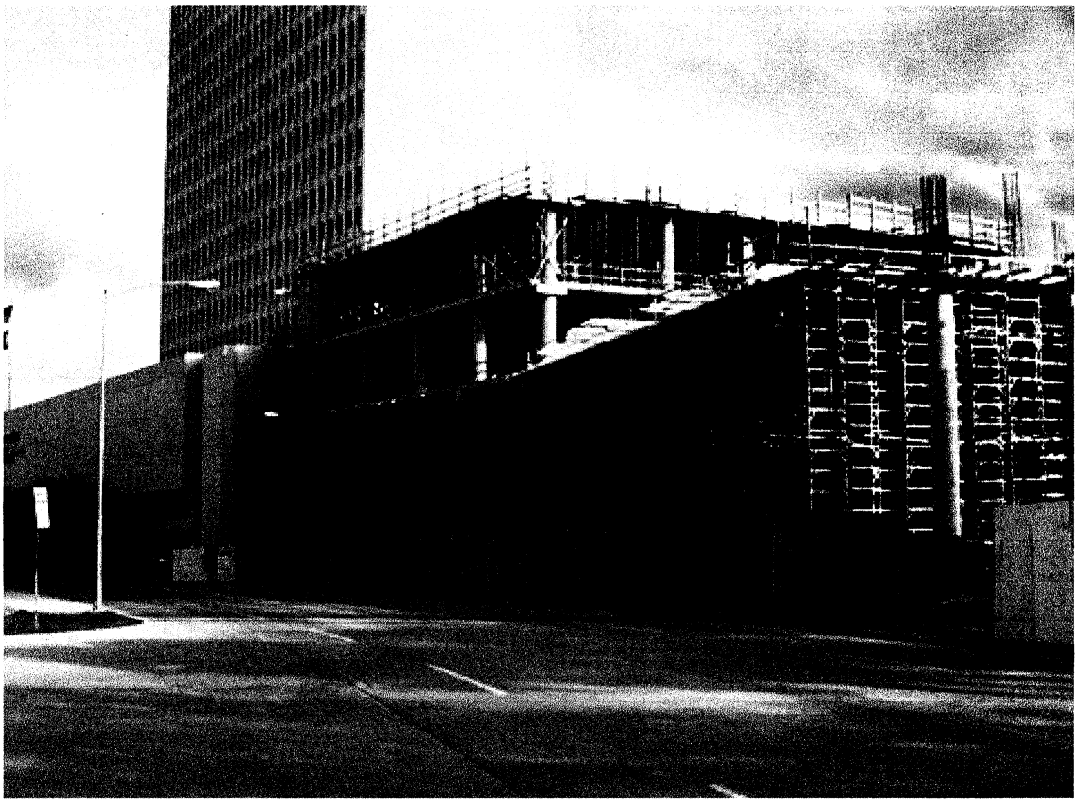


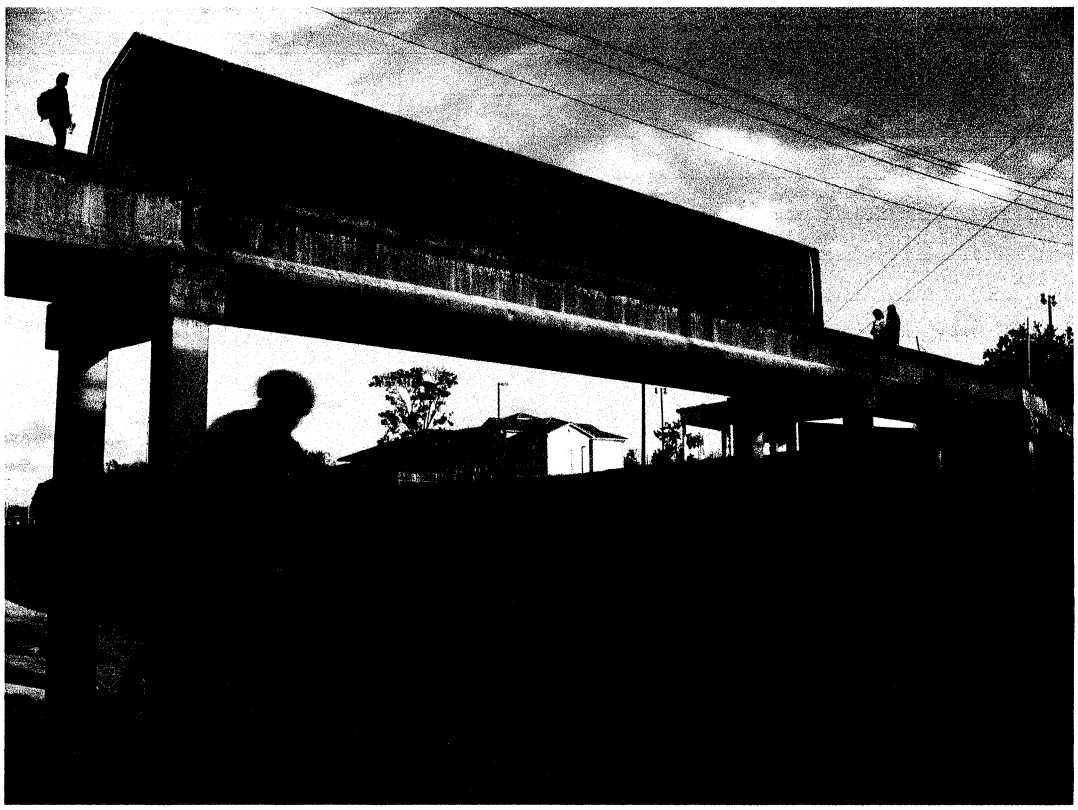


Residual Space

This thesis takes as an important starting point the residual space which is characterized as the space which resists development. These urban and often highly public spaces are frequently separate from the space which is intentionally planned. As such, these spaces had a latent potential and became a source of innovation. By retaining the primary function of these spaces, the identified marginal space of an airport or construction site corridor, or a pedestrian walkway or bridge, are transformed to create a significant shift in our perception and understanding of these spaces.

Furthermore, the system that is developed here provokes an even greater appreciation of these spaces by creating new relationships of interaction between the individuals that use them to themselves, one another and the space. This system is most successfully realized by transforming a space which is so mundane that people pass through it not only indifferently but, without any memory of doing so, into a space which intimately engages an individual's awareness and consciousness.





CROSS ONLY AT CROSS WALKS
S. Dunn
DWEB

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