SPATIAL EFFECTS AND EXPERIENCE THROUGH REFLECTIVITY

by

Frederick Kim

Bachelor of Science in Art and Design
Massachusetts Institute of Technology, 2011

SUBMITTED TO THE DEPARTMENT OF ARCHITECTURE IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ART AND DESIGN AT THE MASSACUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2011

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Submitted to the Department of Architecture and Planning on May 20, 2011 in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Art and Design

ABSTRACT

Architectural discourse on transparency has centered on the idea of layering spaces, light construction, and perceptions of different spatial relationships and has a long history from modernism to the present. This thesis proposes to question received notions of glass as a transparent material and instead focus on its possibilities as a reflective material. The thesis is an exploration of a specific material property, reflectivity, and the effects it has on architecture in terms of experiencing a space and defining a space and redefining perceptions of one's self within space.

Architectural projects often draw from materials and their specific properties to create certain forms or types of spaces. Reflectivity as a material property operates on the extreme end of the spectrum of transparency. Transparency is a way of introducing layers of space and juxtaposing spaces on top of one another. Reflectivity, on the other hand, has the special property of recreating an image almost exactly but one that is dependent as an effect on the actual eye of the viewer. The location of the viewer in relation to a space and a mirrored surface becomes a relationship that can be highly controlled to create a specific effect or experience. The geometry of the mirrored surface and the geometry of the space being reflected can also be carefully controlled and designed to produce particular effects.

Mirrors are unique in that they provide an opportunity where spatial relationships may not be as solidly defined as what is normally experienced. The architecture latent within the reflected image of a mirrored surface can appear to operate under its own laws of physics. There can be an ambiguous quality to a space that detracts from the more concrete materialization of the architecture. Normally, we can readily define our position within a space but the mirror distorts our perception of space beyond cognition addressing the psychological aspects of experiencing a spatial architecture.

Thesis Supervisor : Joel Lamere
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THANKS TO ...

Joel Lamere for his unending enthusiasm and for keeping me going.

Liam O'Brien for his insight and advice.

Ashley Schafer for all her help and expertise during thesis prep.

My parents for their love and support.

Kayla Manning for being next to me.

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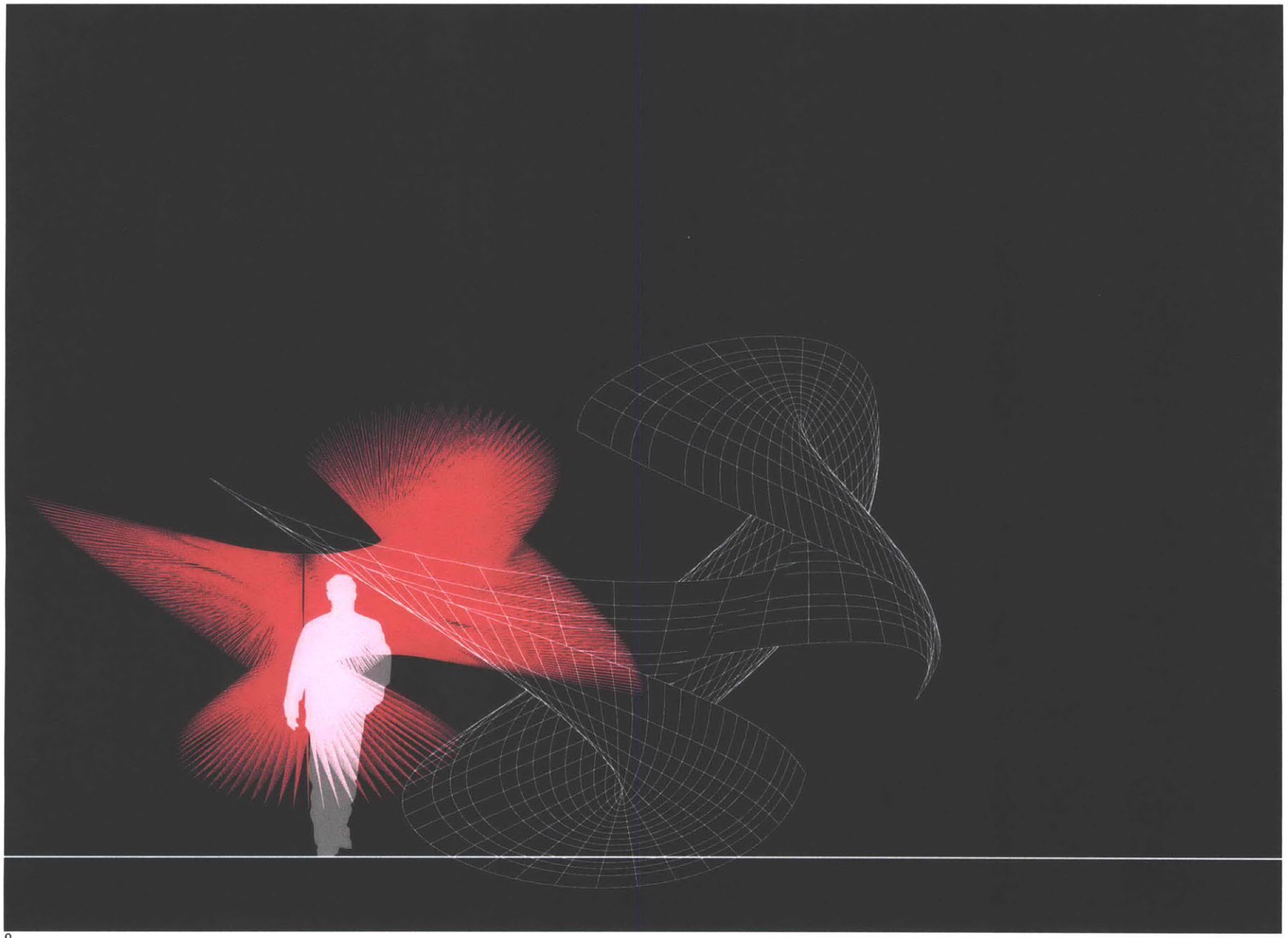


INTRODUCTION

Architectural discourse on transparency has centered on the idea of layering spaces, light construction, and perceptions of different spatial relationships. This thesis proposes to question received notions of glass as a transparent material and instead focus on its possibilities as a reflective material. The thesis is an exploration of a specific material property, reflectivity, and the effects it has on architecture in terms of experiencing a space and defining a space.

Reflective phenomena have the effect of suggesting space or another dimension of space beyond the physical world. This exploration introduces a new language of architecture and a consequent catalog of effects through reflectivity. In a similar way that transparency creates different spatial layerings, reflectivity and mirror phenomena create different perceptional and illusional effects of space.

Reflectivity also explores the idea of seeing an object indirectly through another object. Opportunities of manipulating the intermediary material can therefore be used to alter the perception of the original object. The original object can therefore be presented to the viewer having gone through a form of filter, changing the way the viewer perceives the object.

The first part of this thesis is a research of mirrored geometries and their spatial and distortional effects. A series of different geometric surfaces are documented ranging from planar surfaces to developable surfaces to non-developable surfaces.

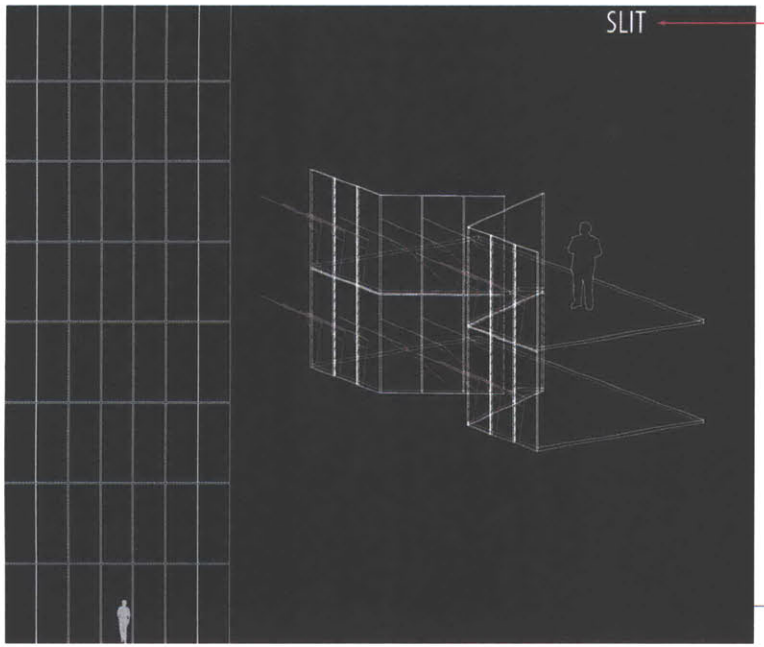
In response to the first research study of documenting distortions and spatial effects, two scripts were developed. The first is used to control and predict the distortions that occur in a reflected image so that specific effects can be created in the reflected image. The second three-dimensionalizes the spatial effects found in the reflected image of a space. The spatial distortions therefore become physical and occupiable.

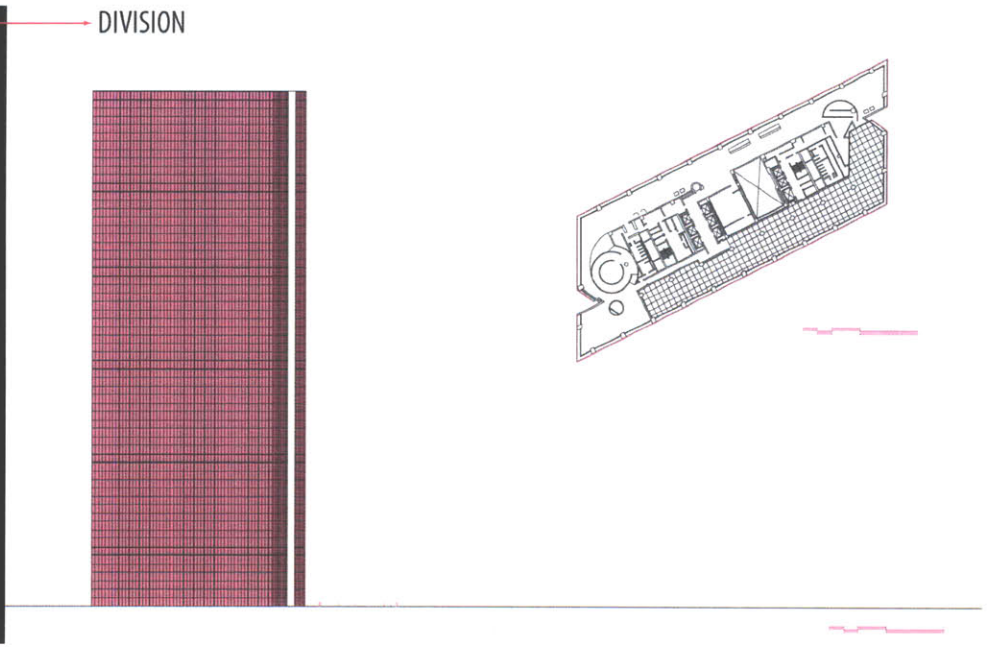
Beyond the research, fabrication techniques for these mirrored surfaces were also explored with considerations of practicality and cost. A mock-up surface was fabricated to completion and involved CNC milling, vacuum forming, and vaccuum metalizing.

The cumulataive design project of the thesis explores the possibility of designing a space with indeterminate boundaries through the use of reflective surfaces. The small non-site specific, building project utilizes the scripting technique of three-dimensionalizing the reflected image on a mirrored surface to create a binary unit offering two identical views. One view is of a reflection off of a mirrored surface and the other is of the physical space constructed from the reflected image. The project explores perceptions of space and illusions of physical versus mirrored.

PRECEDENT STUDIES

A series of precedents was chosen that operate at different scales from urban to pavilion to installation. At the urban scale buildings and their facades where studied for the reflective effects being generated. Smaller installations such as Dan Graham's glass pavilions document the effects of reflectivity at an occupiable scale. Dan Graham's work also explores the spatial effects and illusions of space using different types of reflective glass in combination to create complex spatial layers.





PROJECT
JOHN HANCOCK TOWER

PROGRAM
COMMERICAL OFFICE BUILDING

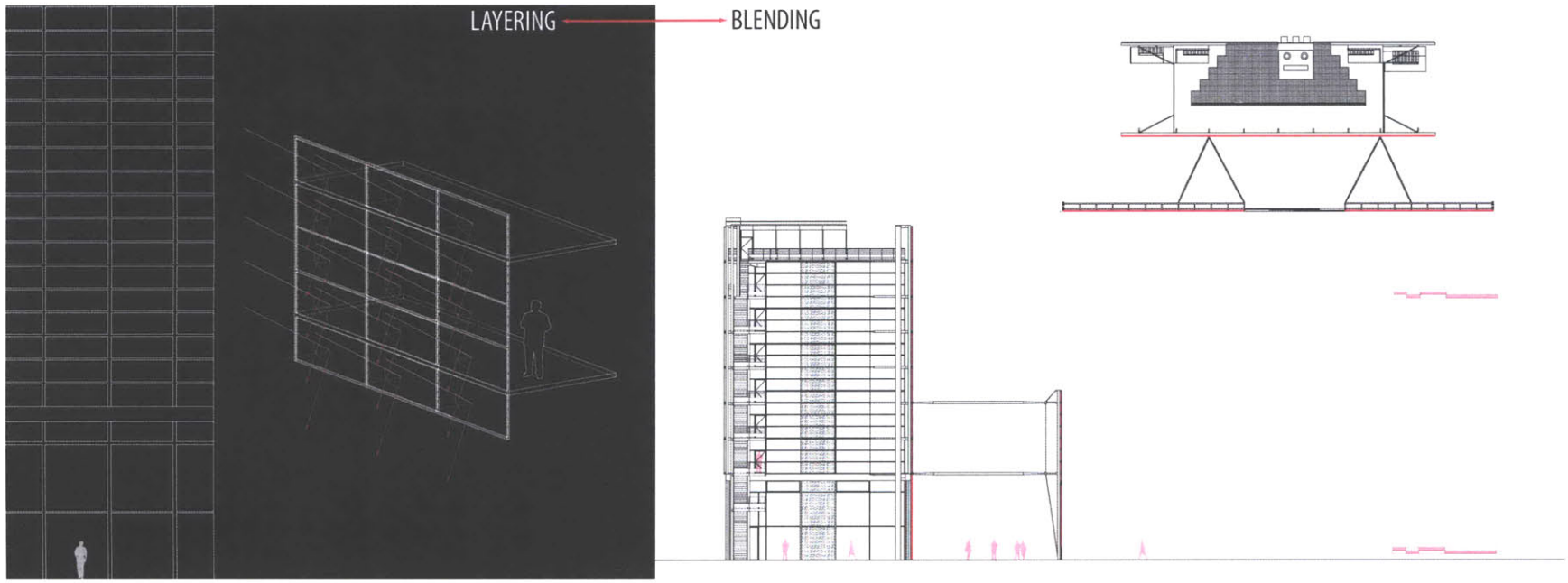
LOCATION
BOSTON - MASSACHUSETTS

ARCHITECT
I.M. Pei

GLASS TYPE
FLAT

METHOD
SLIT

EFFECT
DIVISION



PROJECT
CARTIER FOUNDATION CONTEMPORARY ART MUSEUM

PROGRAM
MUSEUM

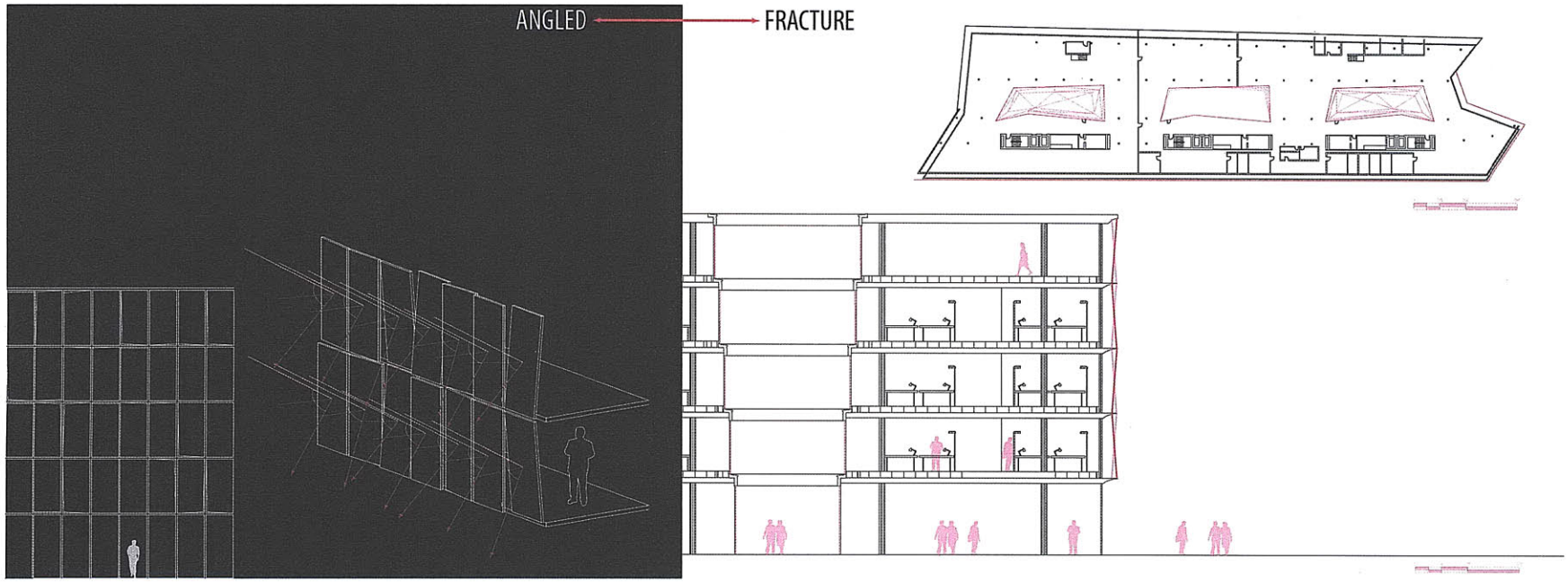
LOCATION
PARIS - FRANCE

ARCHITECT
Jean Nouvel

GLASS TYPE
FLAT

METHOD
LAYERING

EFFECT
BLENDING



PROJECT
BUREAUX ELSASSERTOR II

PROGRAM
OFFICE BUILDING

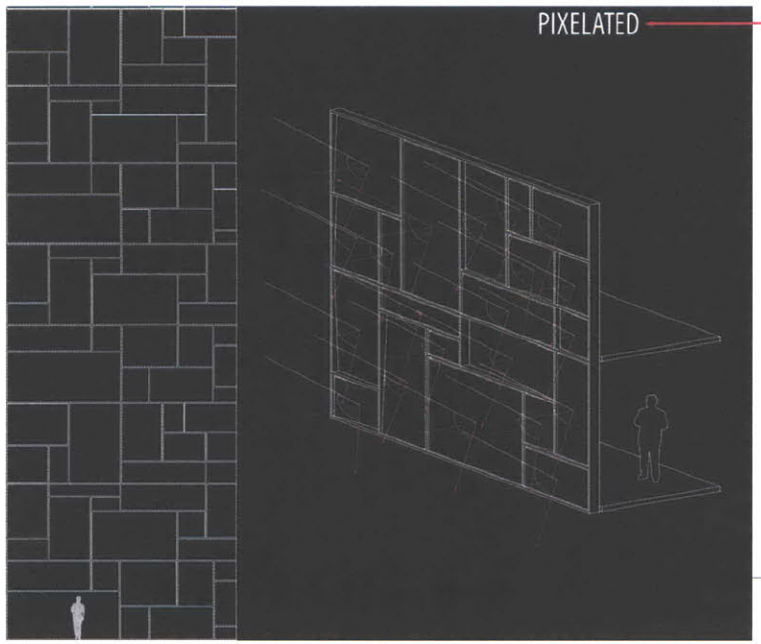
LOCATION
BASEL - SWITZERLAND

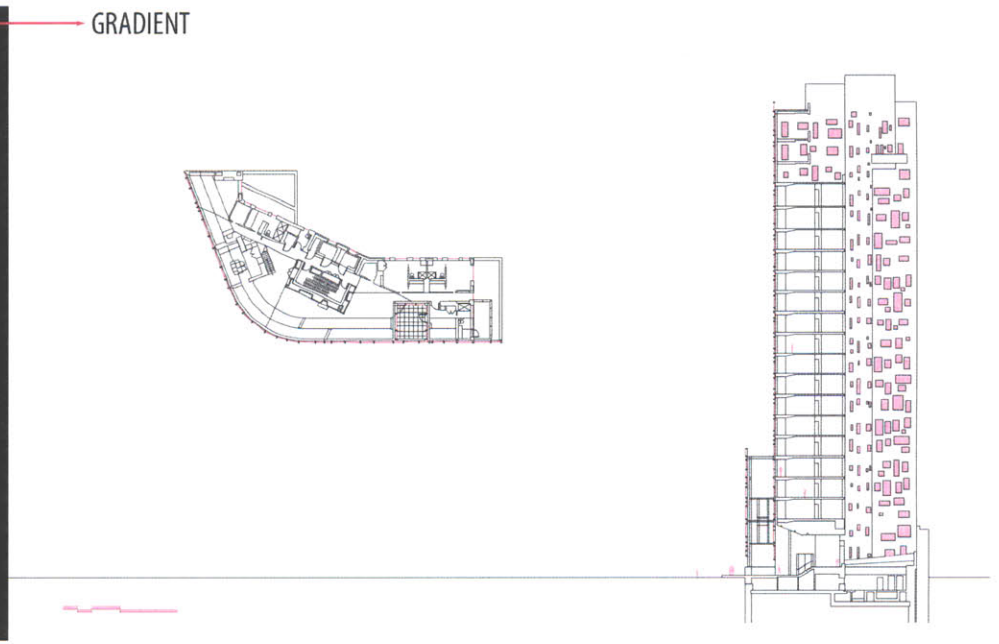
ARCHITECT
Herzog & de Meuron

GLASS TYPE
FLAT

METHOD
ANGLED

EFFECT
FRACTURE





PROJECT
100 11TH AVENUE

PROGRAM
RESIDENCE BUILDING

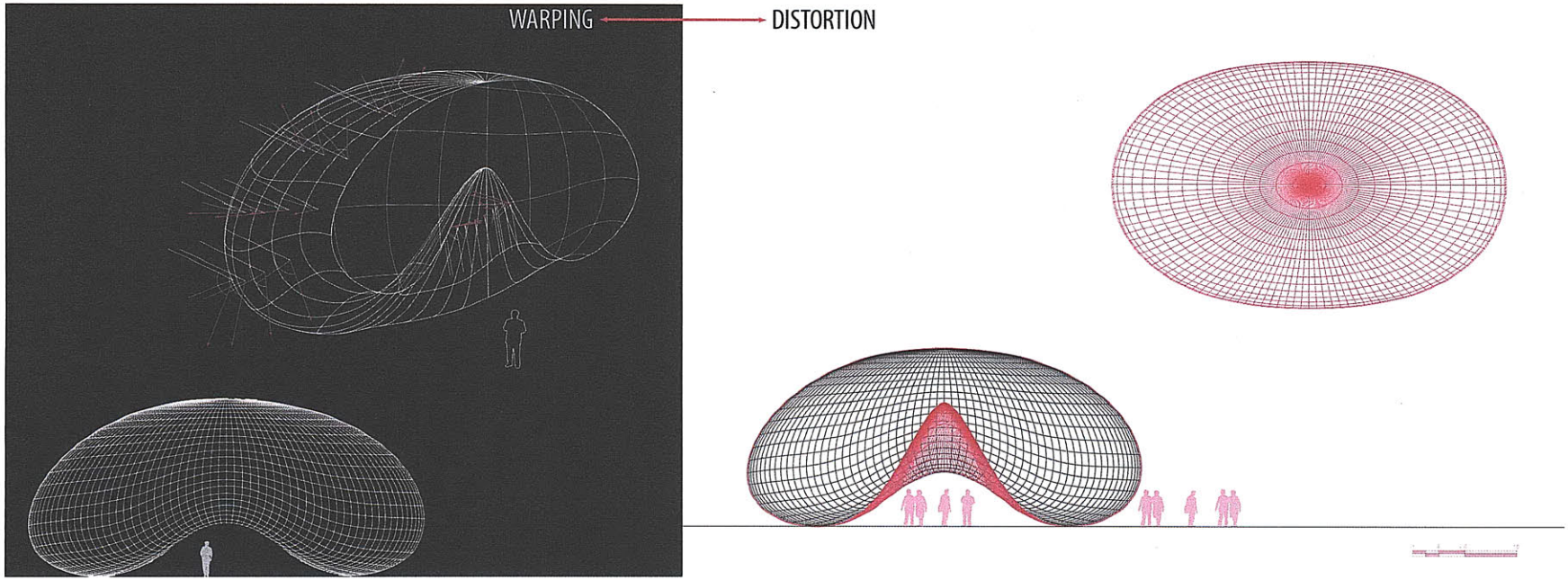
LOCATION
NEW YORK CITY, NEW YORK

ARCHITECT
Jean Nouvel

GLASS TYPE
Flat

METHOD
PIXELATED

Effect
GRADIENT



PROJECT
CLOUD GATE

PROGRAM
PUBLIC SCULPTURE

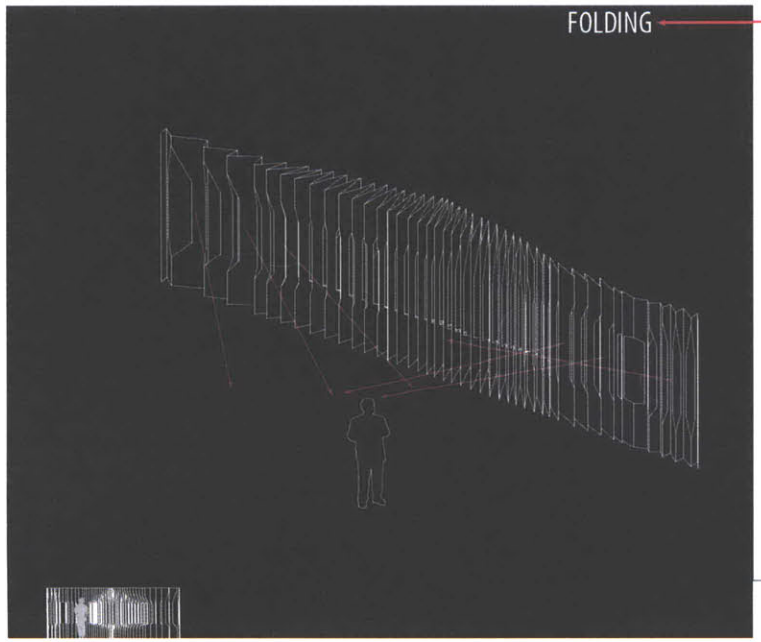
LOCATION
CHICAGO - ILLINOIS

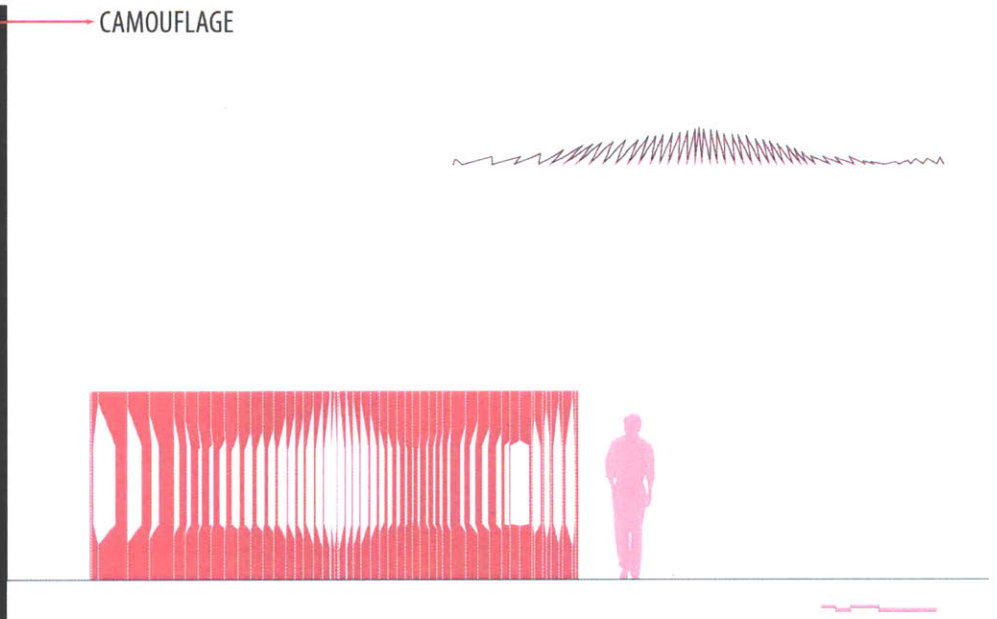
ARCHITECT
Anish Kapoor

GLASS TYPE
MIRROR

METHOD
WARPING

EFFECT
DISTORTION





PROJECT
CAMOUFLAGE VIEW

PROGRAM
Installation

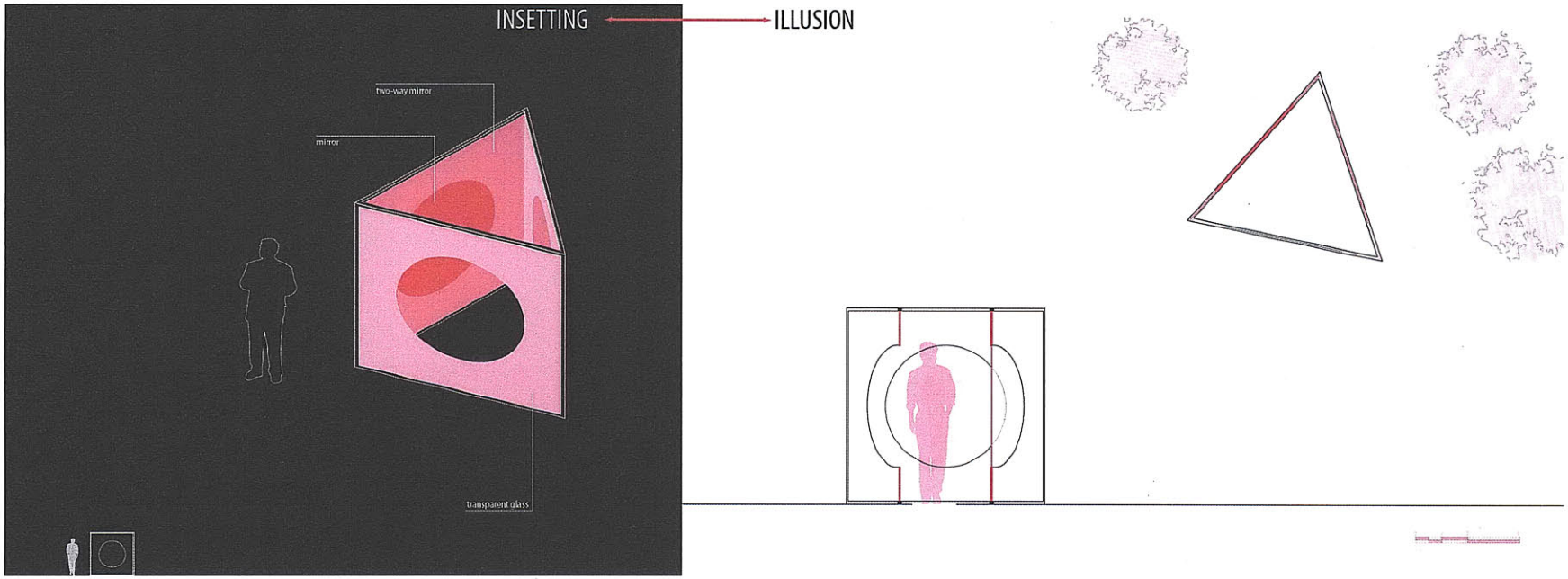
LOCATION
METIS - CANADA

ARCHITECT
ARANDA \ LASCH

GLASS TYPE
APERTURE

METHOD
FOLDING

EFFECT
CAMOUFLAGE



PROJECT
TRIANGULAR SOLIDS with CIRCULAR INSERTS

PROGRAM
INSTALLATION

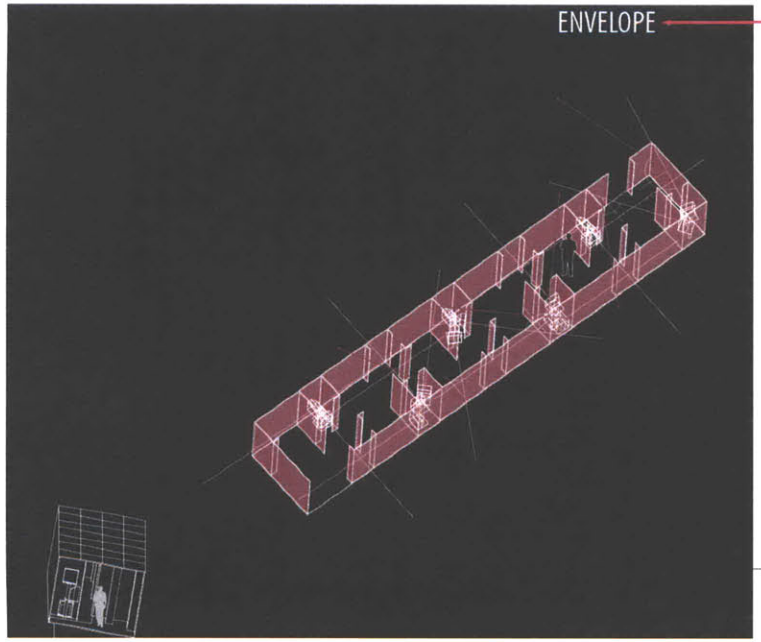
LOCATION
VENICE - ITALY

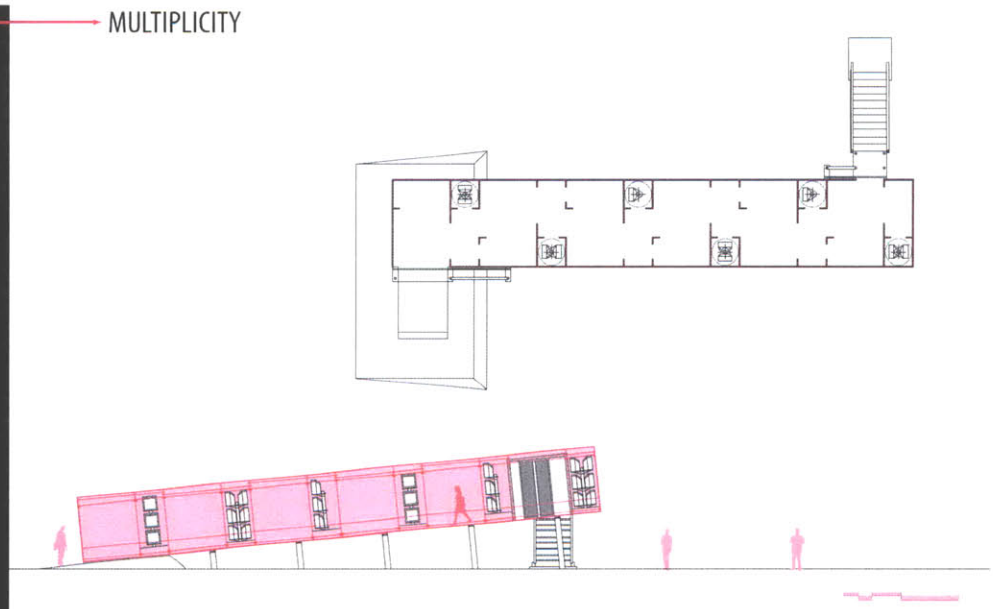
ARCHITECT
Dan Graham

GLASS TYPE
TWO-WAY MIRROR

METHOD
INSETTING

EFFECT
ILLUSION





PROJECT
GLASS VIDEO GALLERY

PROGRAM
EXPOSITION PAVILION

LOCATION
GRONINGEN, NETHERLANDS

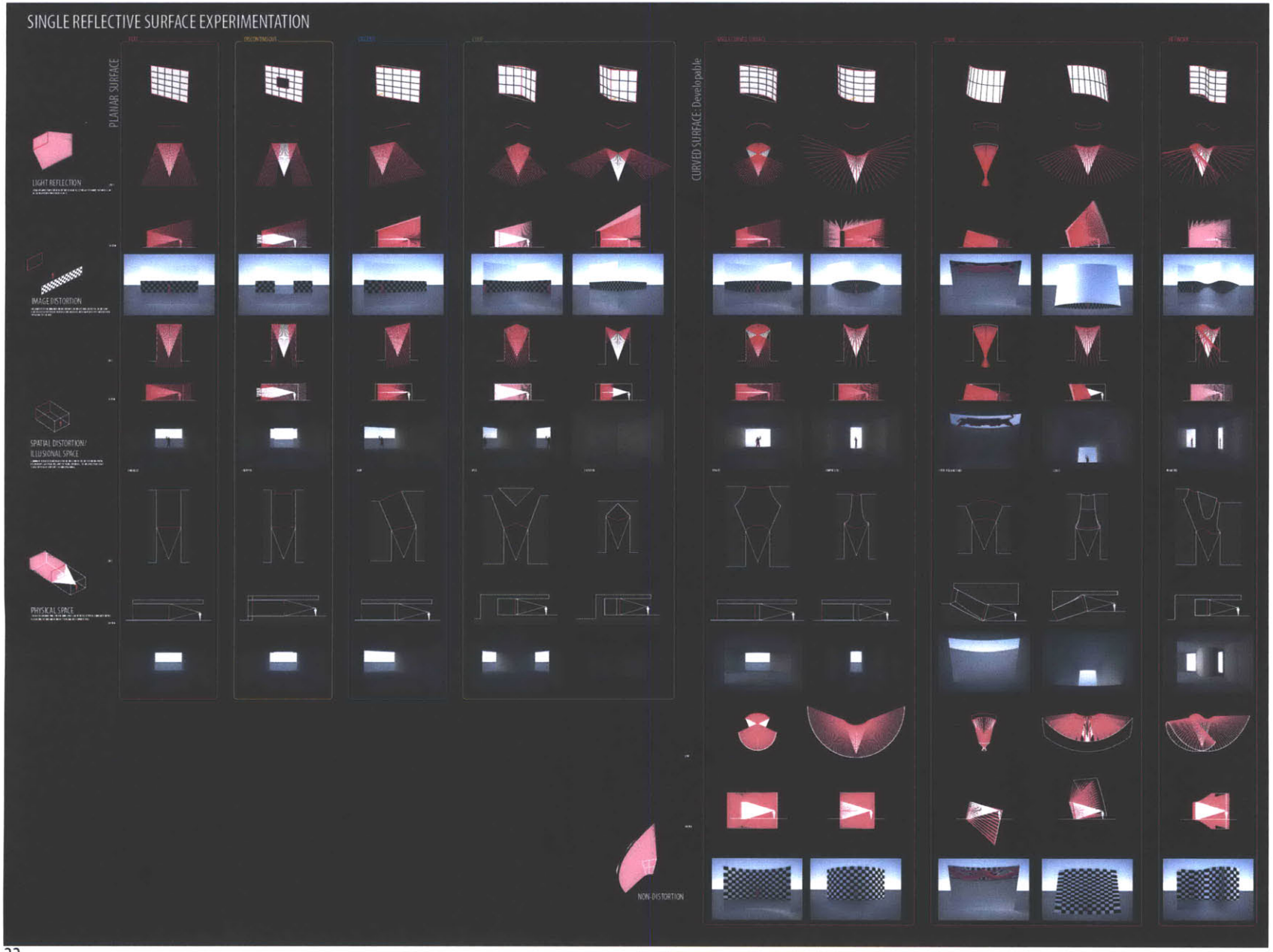
ARCHITECT
Bernard Tschumi

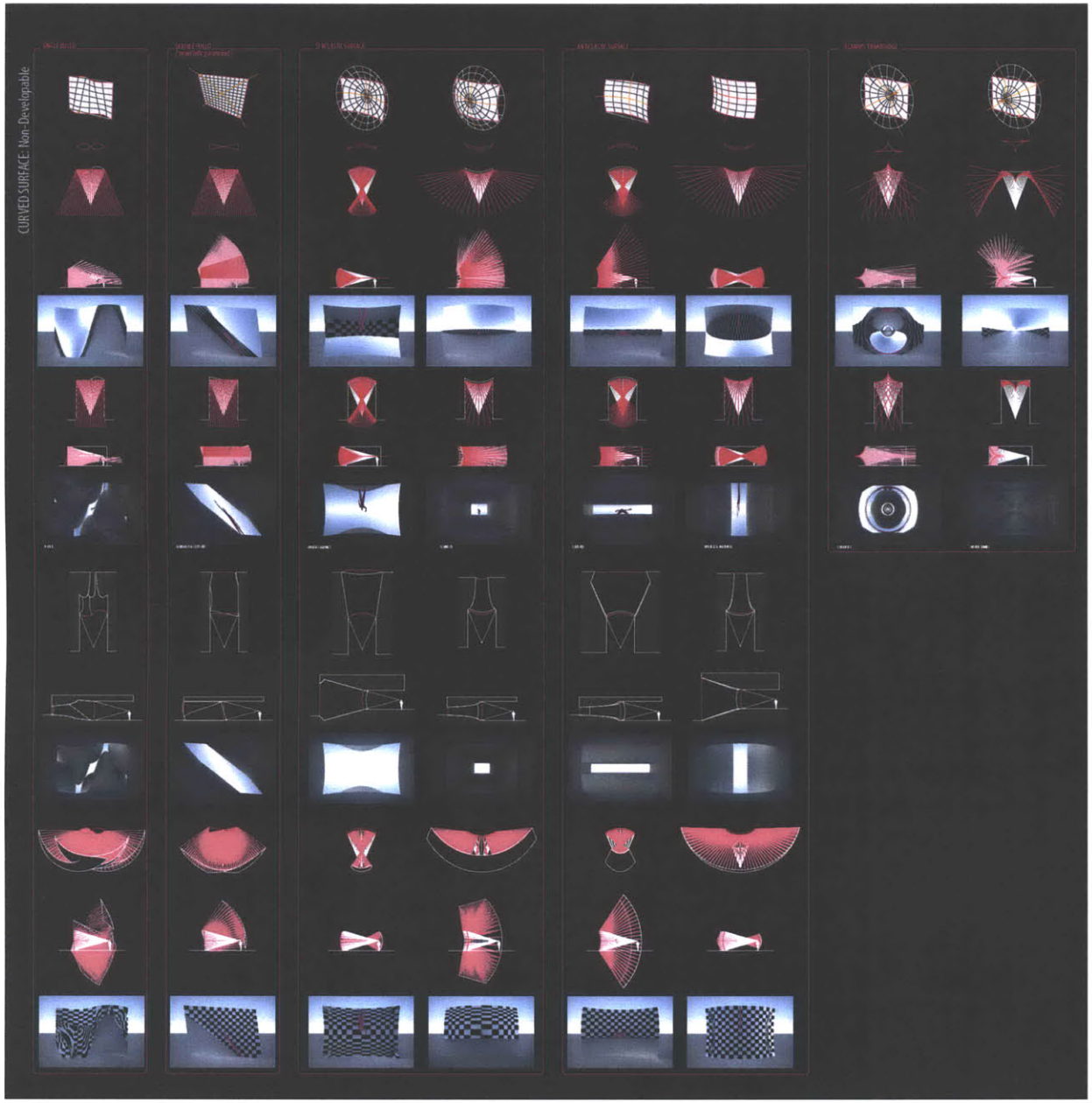
GLASS TYPE
FLAT

METHOD
ENVELOPE

EFFECT
MULTIPLICITY

REFLECTIVE SURFACE RESEARCH

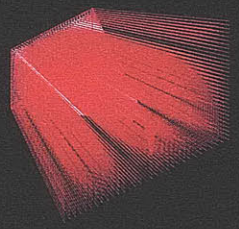

SINGLE REFLECTIVE SURFACE EXPERIMENTATION
PLANAR SURFACE
CURVED SURFACE: Developable
LIGHT REFLECTION
IMAGE DISTORTION
SPATIAL DISTORTION/
ILLUSIONAL SPACE
PHYSICAL SPACE
NON-DISTORTION



A series of geometric surfaces was studied for their reflective properties and effects. Maxwell software was used as a rendering tool to document different distortions. Distortional effects were measured by means of reflecting a patterned image in each mirrored surface. Spatial effects were also studied by placing each mirrored surface within a space. The reflection of light rays is used to specifically calculate the mathematical relationship between mirror and reflected image.

LIGHT REFLECTION

FROM ANY GIVEN POINTS THE INCIDENT RAYS OF LIGHT REFLECTING OFF OF A MIRRORED SURFACE CAN BE CALCULATED AND PROJECTED INTO SPACE.



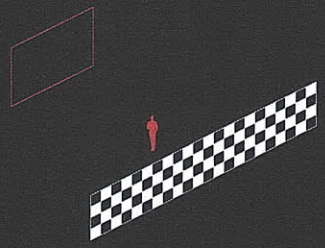
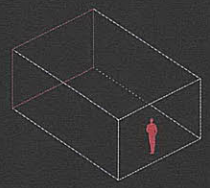


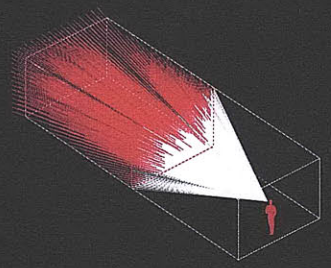
IMAGE DISTORTION

THE GEOMETRY OF THE MIRRORED SURFACE DISTORTS THE OBJECTS BEING REFLECTED. IN THIS STUDY A GRID IS USED SO THAT THE DISTORTIONS CAN BE MEASURED MATHEMATICALLY AND COMPARED FROM ONE SURFACE TO THE NEXT.



SPATIAL DISTORTION/ILLUSIONAL SPACE

WHEN A MIRRORED SURFACE BECOMES PART OF THE ARCHITECTURE OF A SPACE, IT CHANGES SPATIAL RELATIONSHIPS, LIGHT QUALITIES, AND EXPERIENCE OF THE SPACE. THE ARCHITECUTURAL SPACE IS ALSO EXTENDED BY THE ILLUSION OF THE MIRRORED IMAGE



PHYSICAL SPACE

FROM A SPECIFIC VIEWPOINT, THE ILLUSIONAL SPACE SEEN IN THE REFLECTION OF A MIRRORED SURFACE CAN BE CONSTRUCTED THREE-DIMENSIONALLY TO BECOME A PHYSICALLY MATERIALIZED SPACE

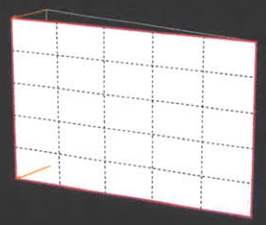
NON-DISTORTION OF MIRRORED IMAGE

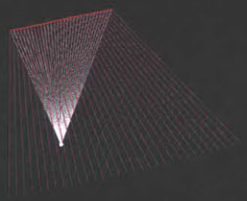
A SECONDARY SURFACE CAN BE GENERATED FROM THE GEOMETRY OF THE MIRRORED SURFACE SO THAT WHEN REFLECTED IN THE MIRRORED SURFACE THE SECONDARY SURFACE APPEARS ORTHOGONAL OR NON-DISTORTED

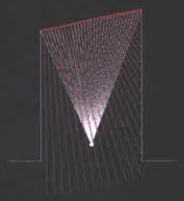

FLAT
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE
PHYSICAL SPACE

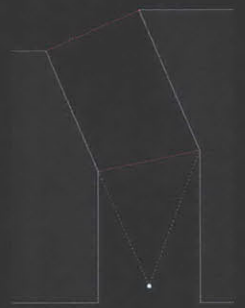

DISCONTINUOUS
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE
PHYSICAL SPACE

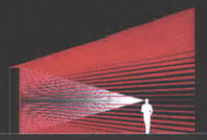
OBLIQUE

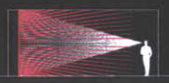












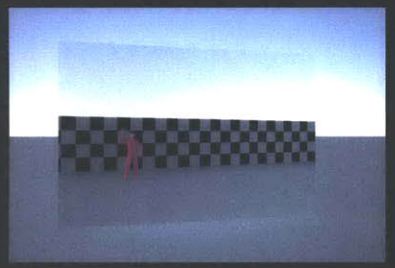
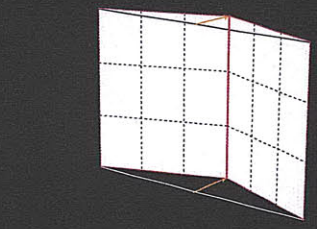


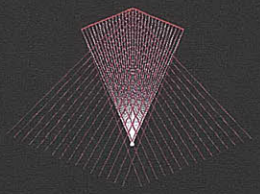
IMAGE DISTORTION

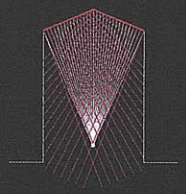
SPATIAL DISTORTION/ILLUSIONAL SPACE

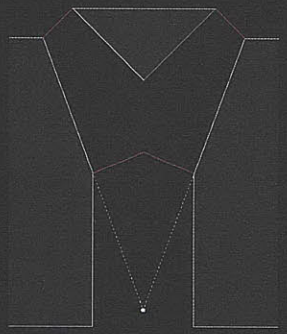
PHYSICAL SPACE

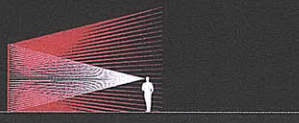
CUSP [ACUTE]











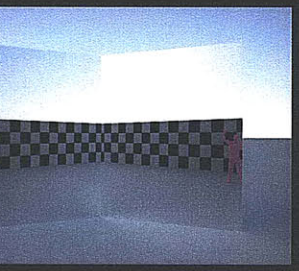


IMAGE DISTORTION

SPATIAL DISTORTION/ILLUSIONAL SPACE

PHYSICAL SPACE

[OBTUSE]

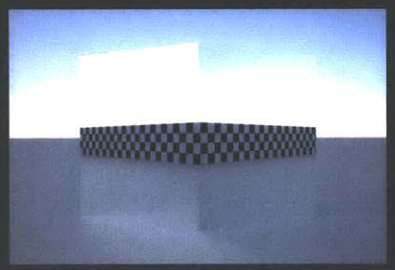


IMAGE DISTORTION

SPATIAL DISTORTION/ILLUSIONAL SPACE

PHYSICAL SPACE

SINGLE CURVED SURFACE [CONCAVE]

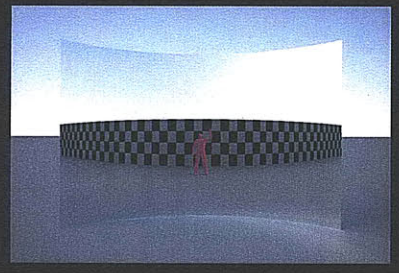
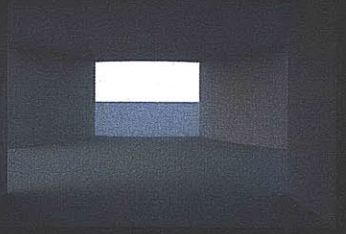
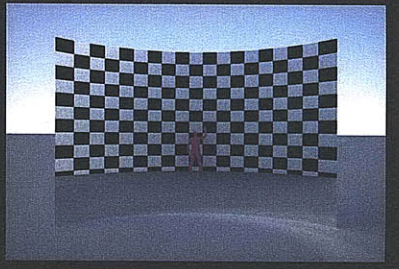


IMAGE DISTORTION

SPATIAL DISTORTION/ILLUSIONAL SPACE



PHYSICAL SPACE



NON-DISTORTION OF MIRRORED IMAGE

[CONVEX]

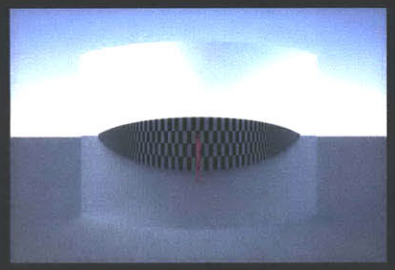
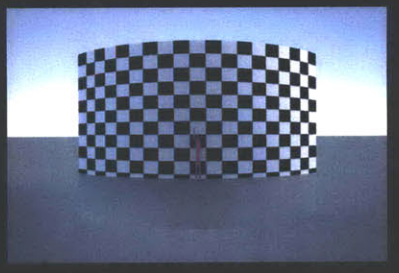


IMAGE DISTORTION

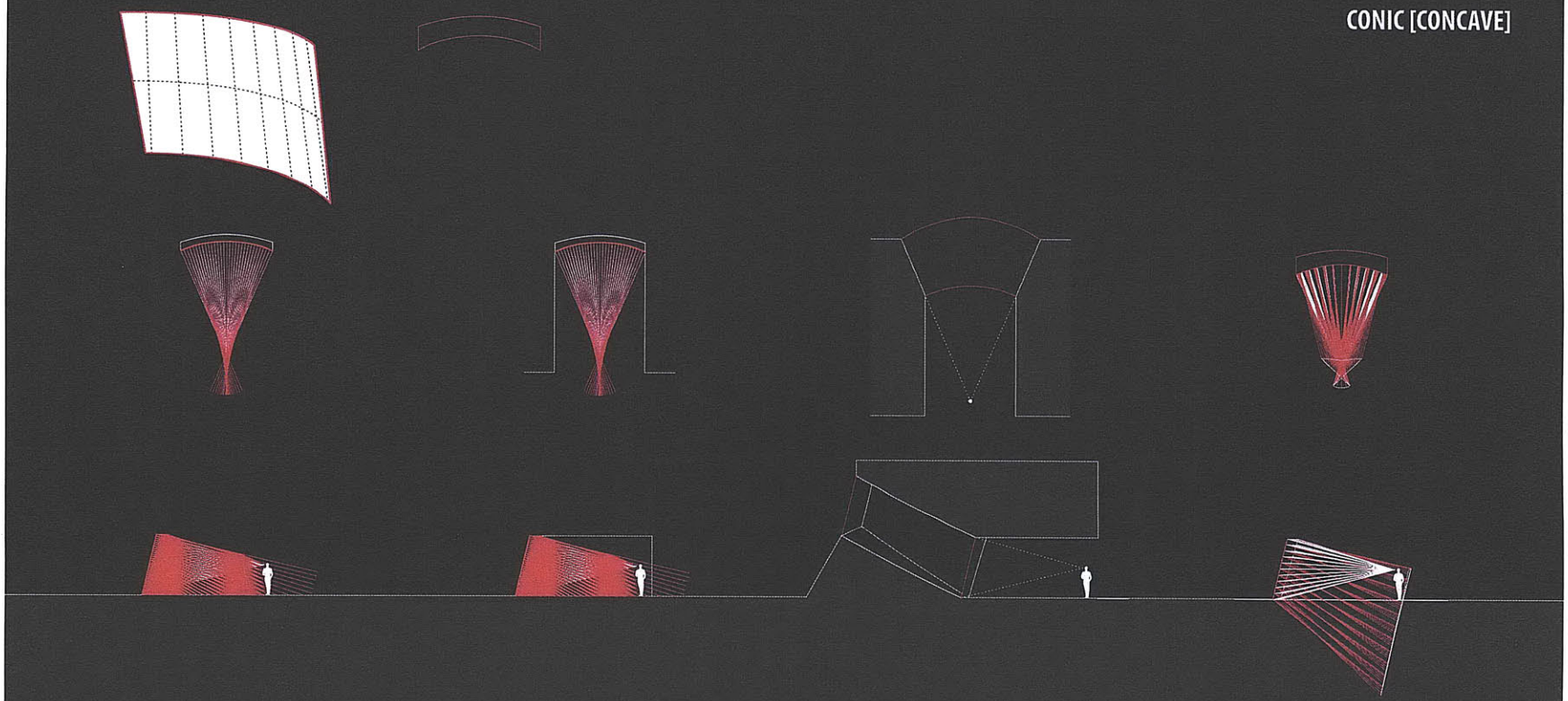
SPATIAL DISTORTION/ILLUSIONAL SPACE

PHYSICAL SPACE



NON-DISTORTION OF MIRRORED IMAGE

CONIC [CONCAVE]



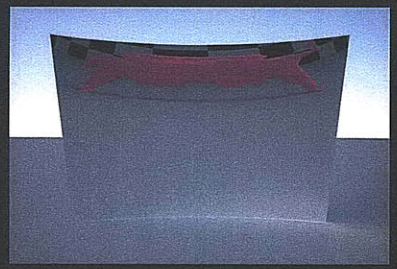
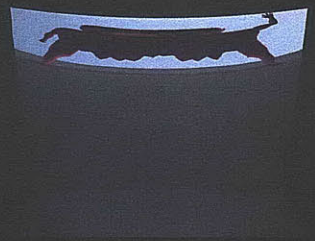
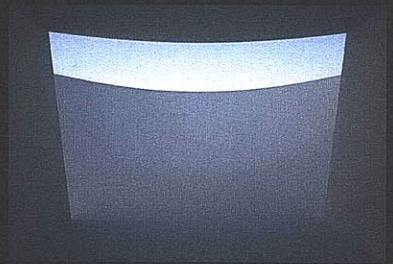


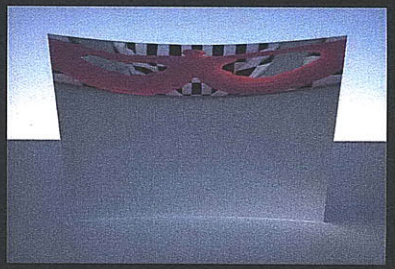
IMAGE DISTORTION



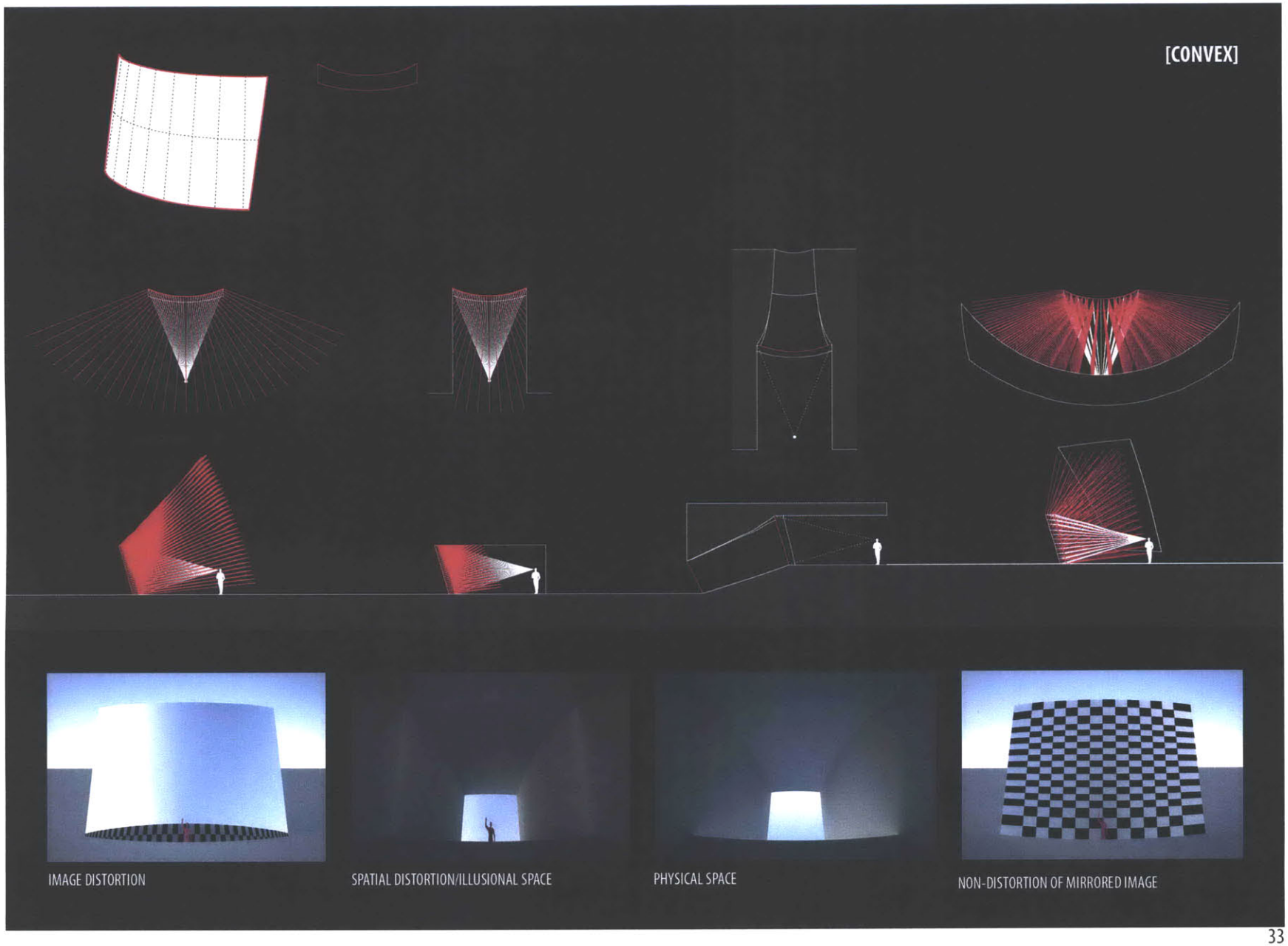
SPATIAL DISTORTION/ILLUSIONAL SPACE



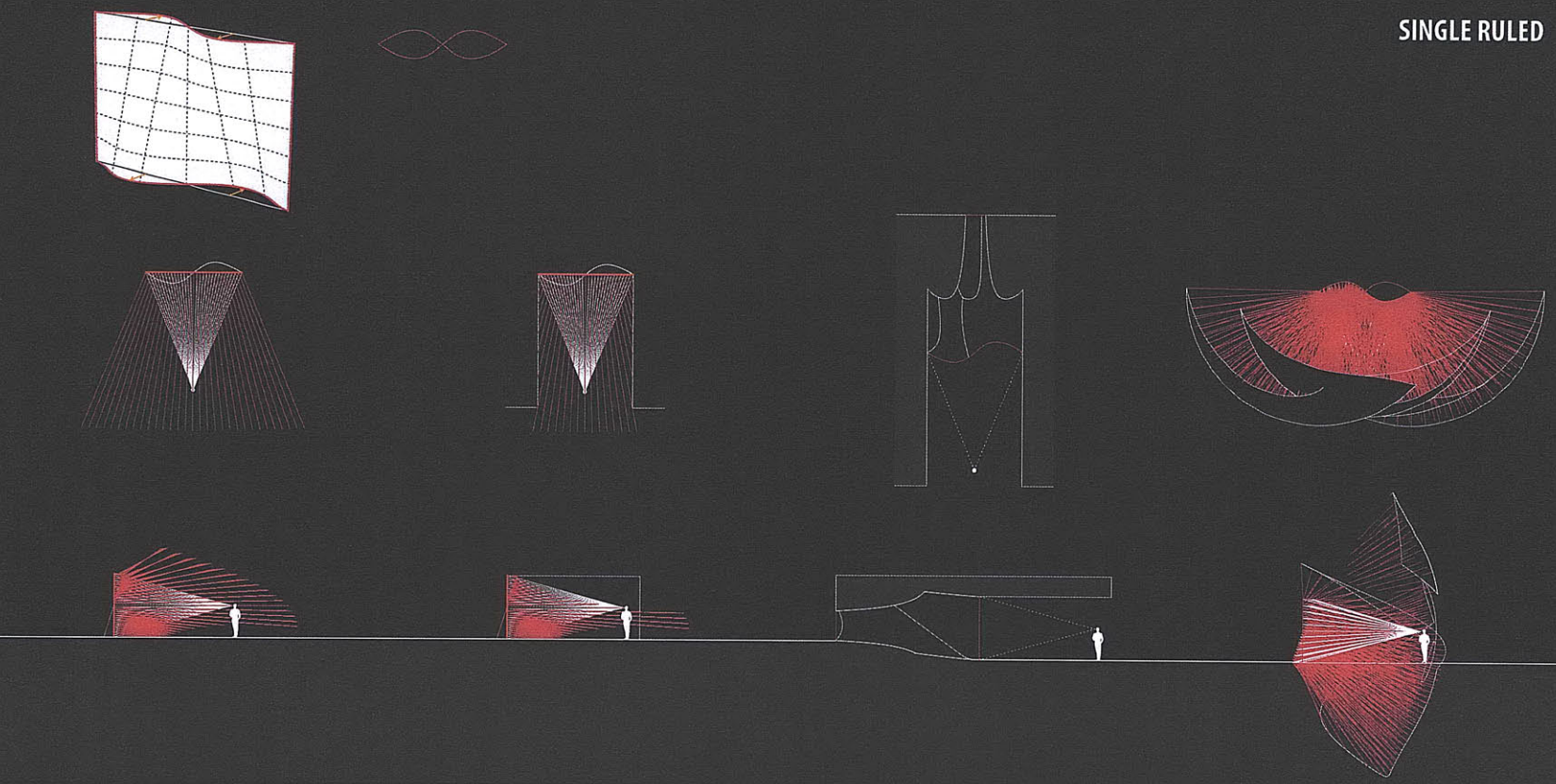
PHYSICAL SPACE



NON-DISTORTION OF MIRRORED IMAGE


[CONVEX]
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE
PHYSICAL SPACE
NON-DISTORTION OF MIRRORED IMAGE

SINGLE RULED



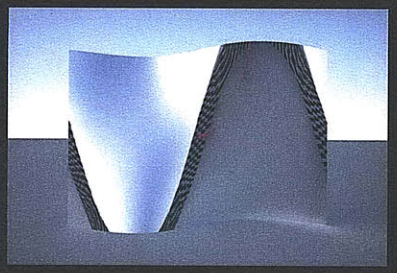
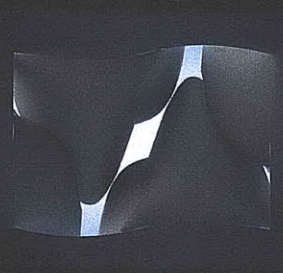
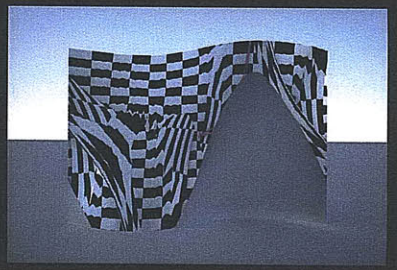


IMAGE DISTORTION

SPATIAL DISTORTION/ILLUSIONAL SPACE

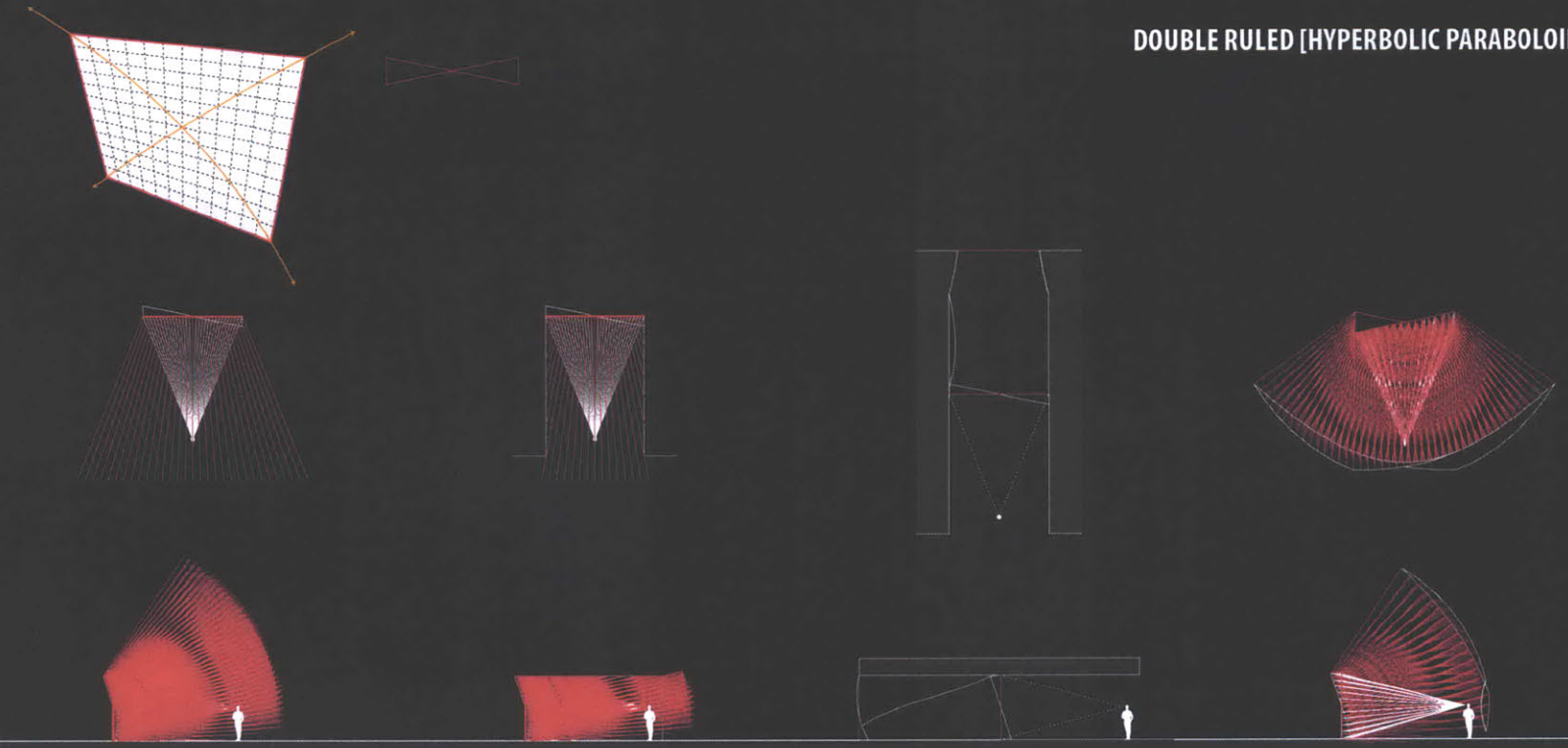


PHYSICAL SPACE



NON-DISTORTION OF MIRRORED IMAGE

DOUBLE RULED [HYPERBOLIC PARABOLOID]



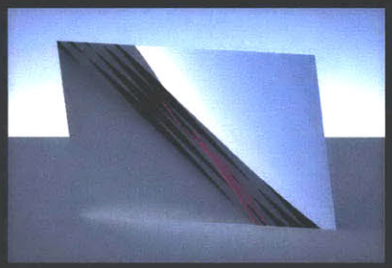
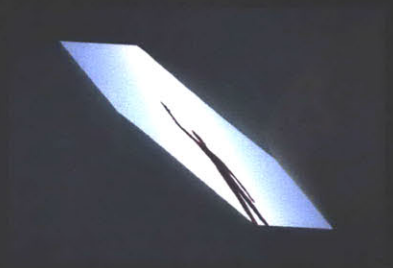
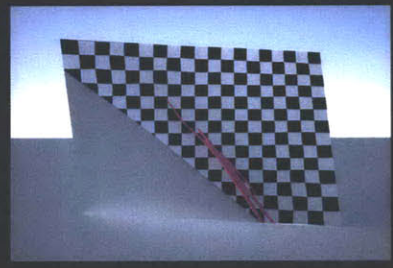


IMAGE DISTORTION



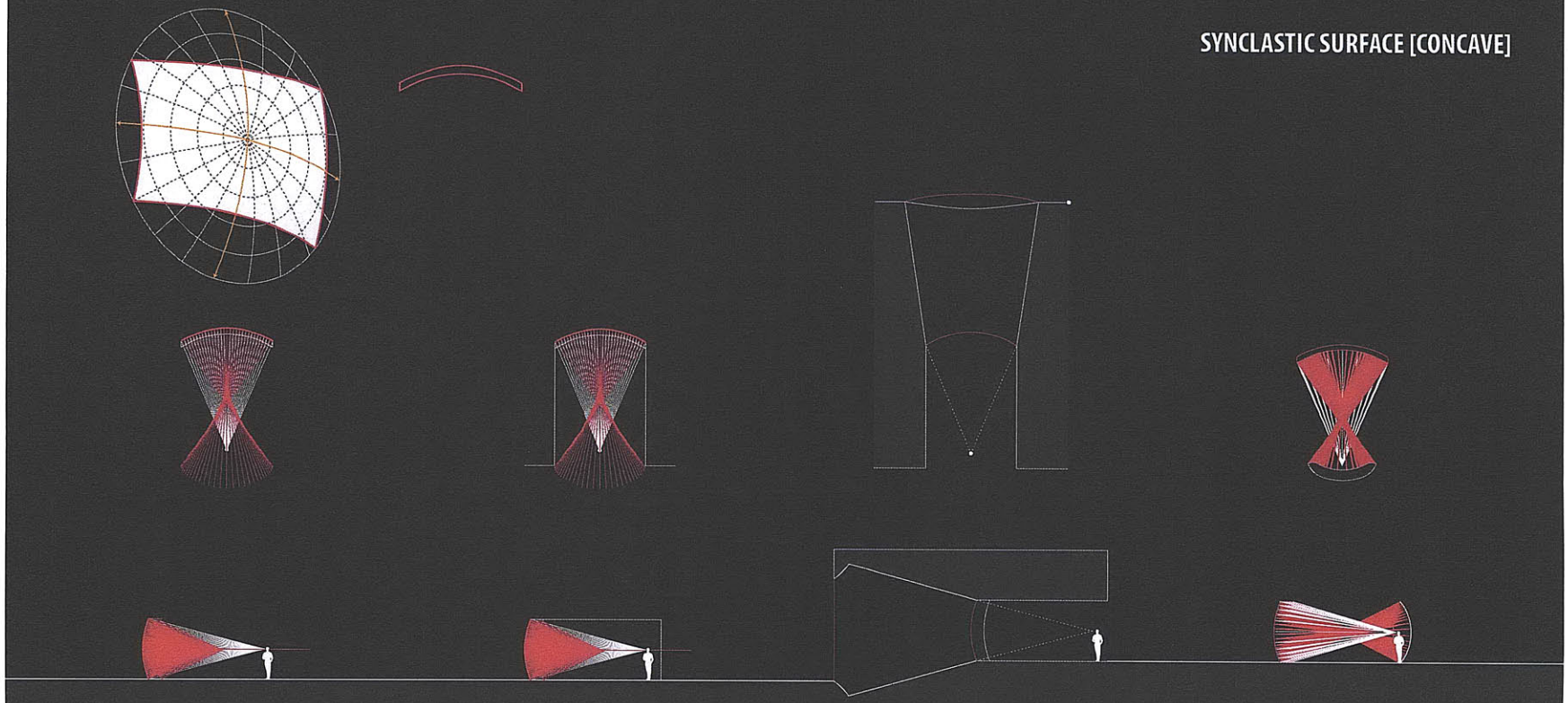
SPATIAL DISTORTION/ILLUSIONAL SPACE

PHYSICAL SPACE



NON-DISTORTION OF MIRRORED IMAGE

SYNCLASTIC SURFACE [CONCAVE]



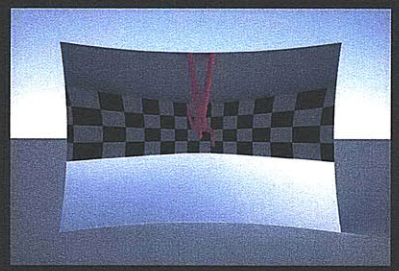
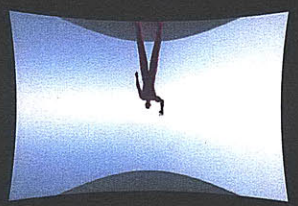
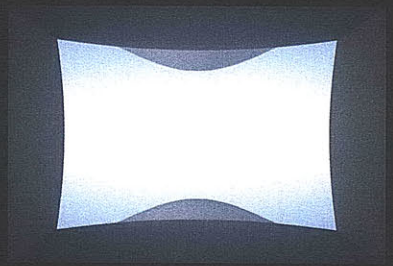


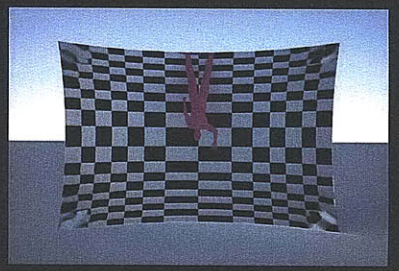
IMAGE DISTORTION



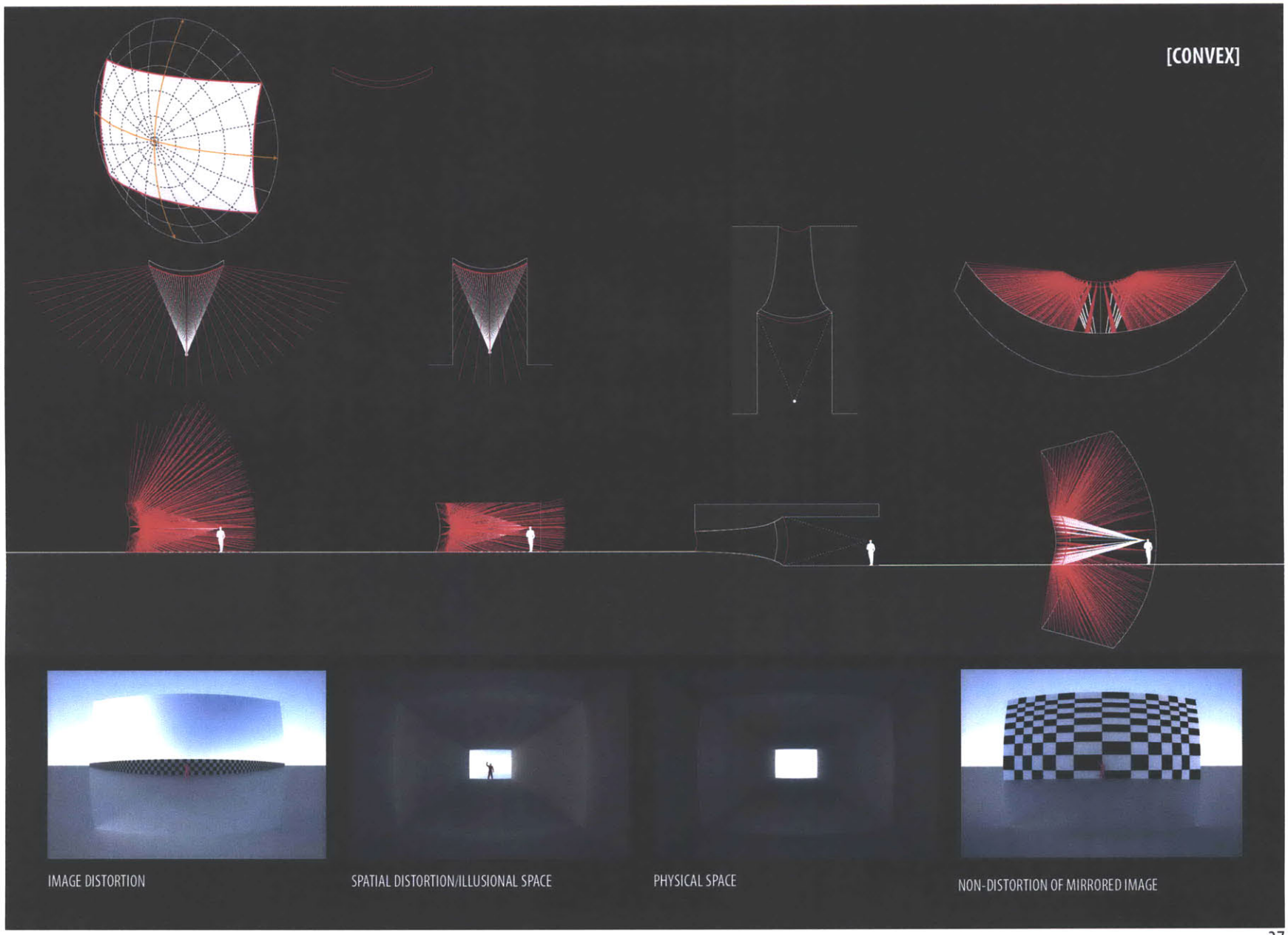
SPATIAL DISTORTION/ILLUSIONAL SPACE



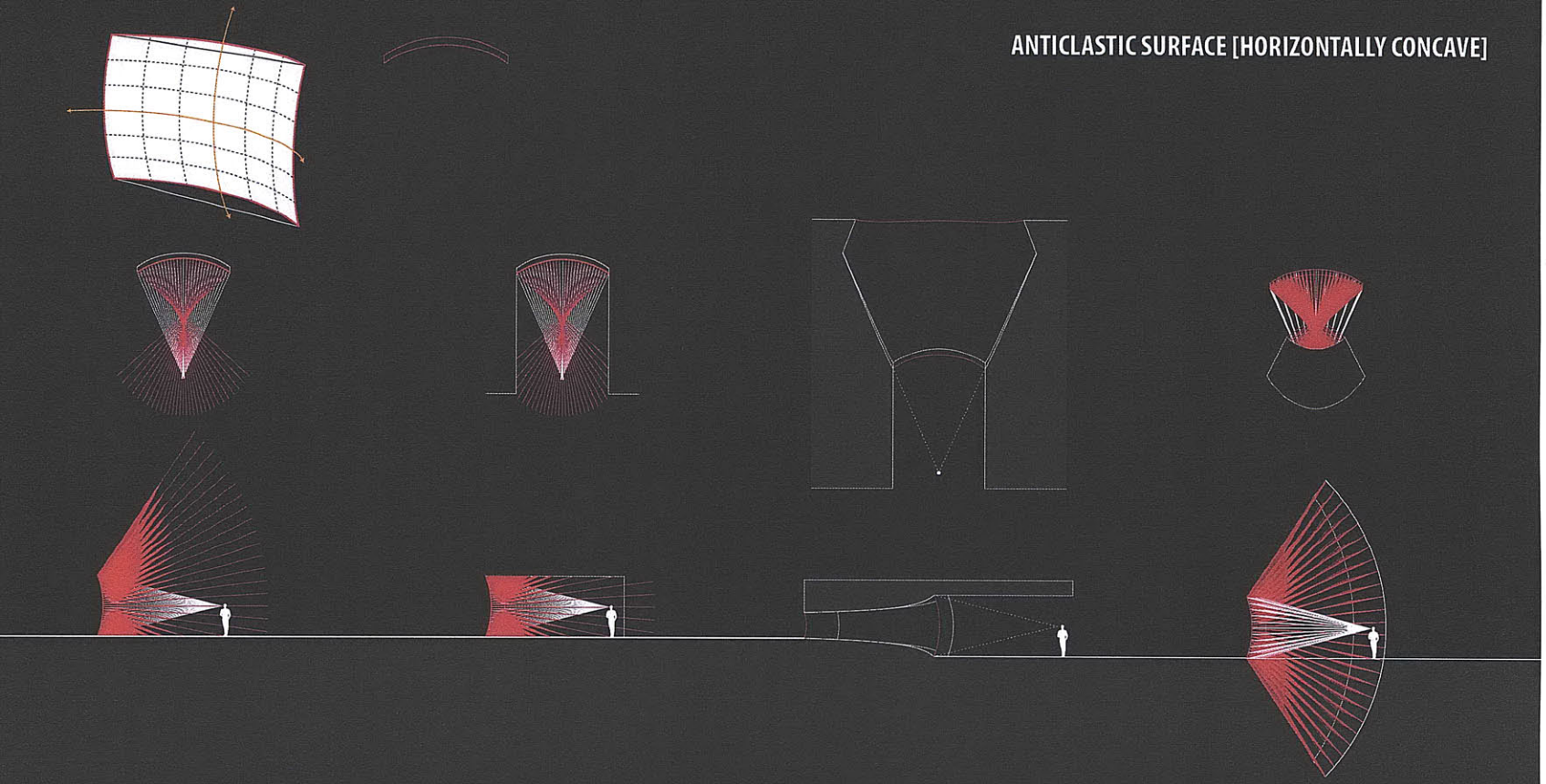
PHYSICAL SPACE



NON-DISTORTION OF MIRRORED IMAGE


[CONVEX]
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE
PHYSICAL SPACE
NON-DISTORTION OF MIRRORED IMAGE

ANTICLASTIC SURFACE [HORIZONTALLY CONCAVE]



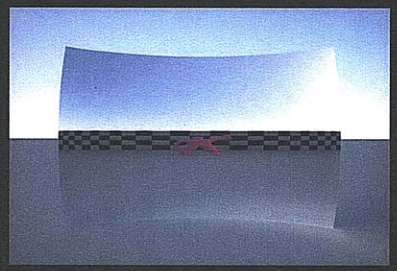
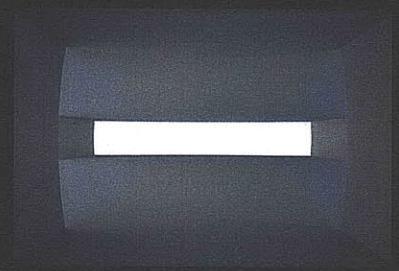
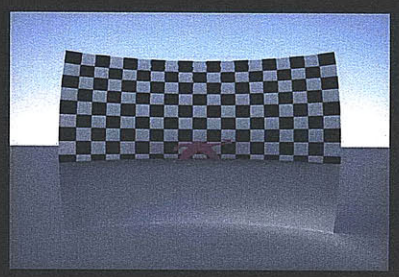


IMAGE DISTORTION

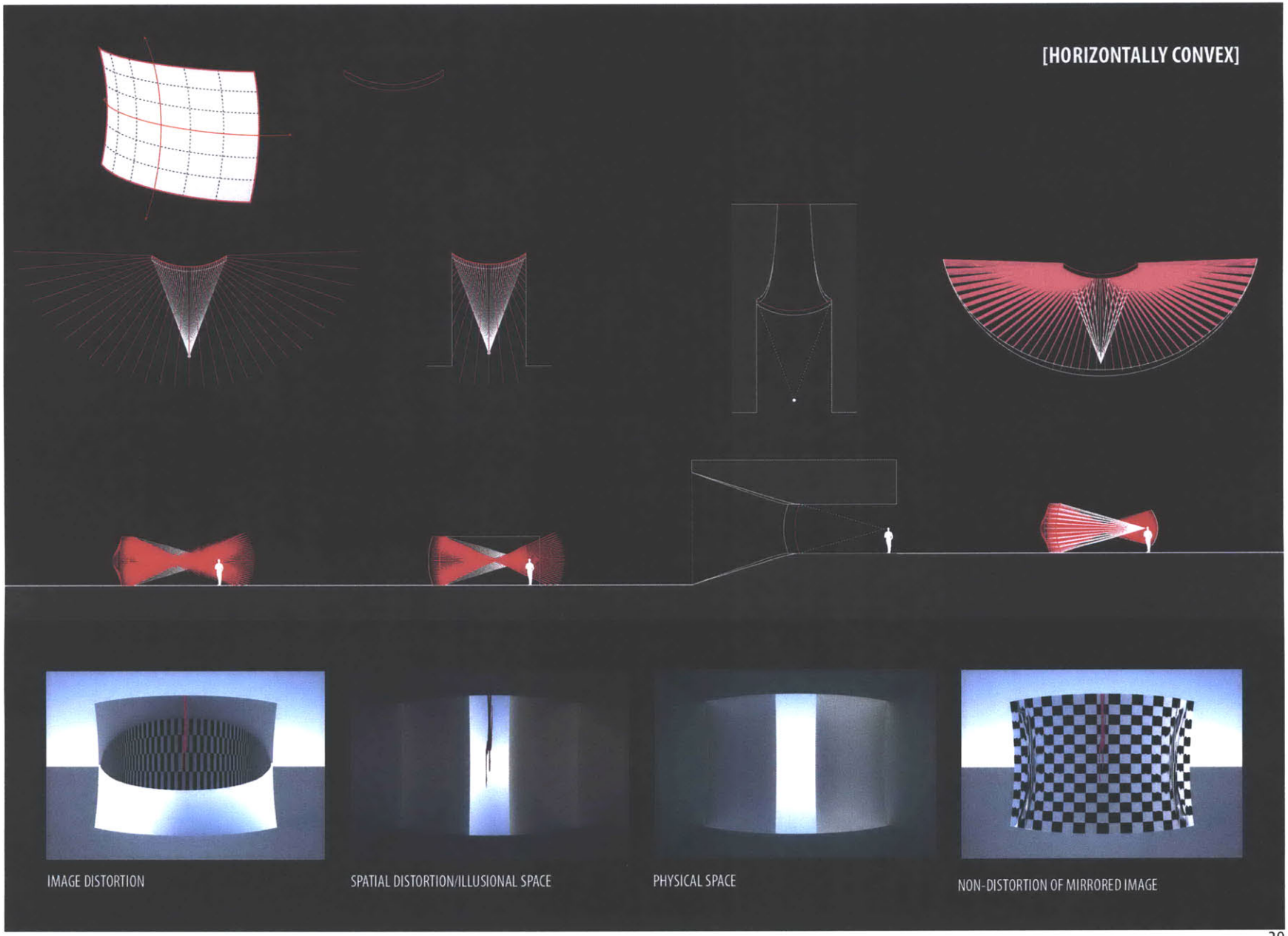
SPATIAL DISTORTION/ILLUSIONAL SPACE

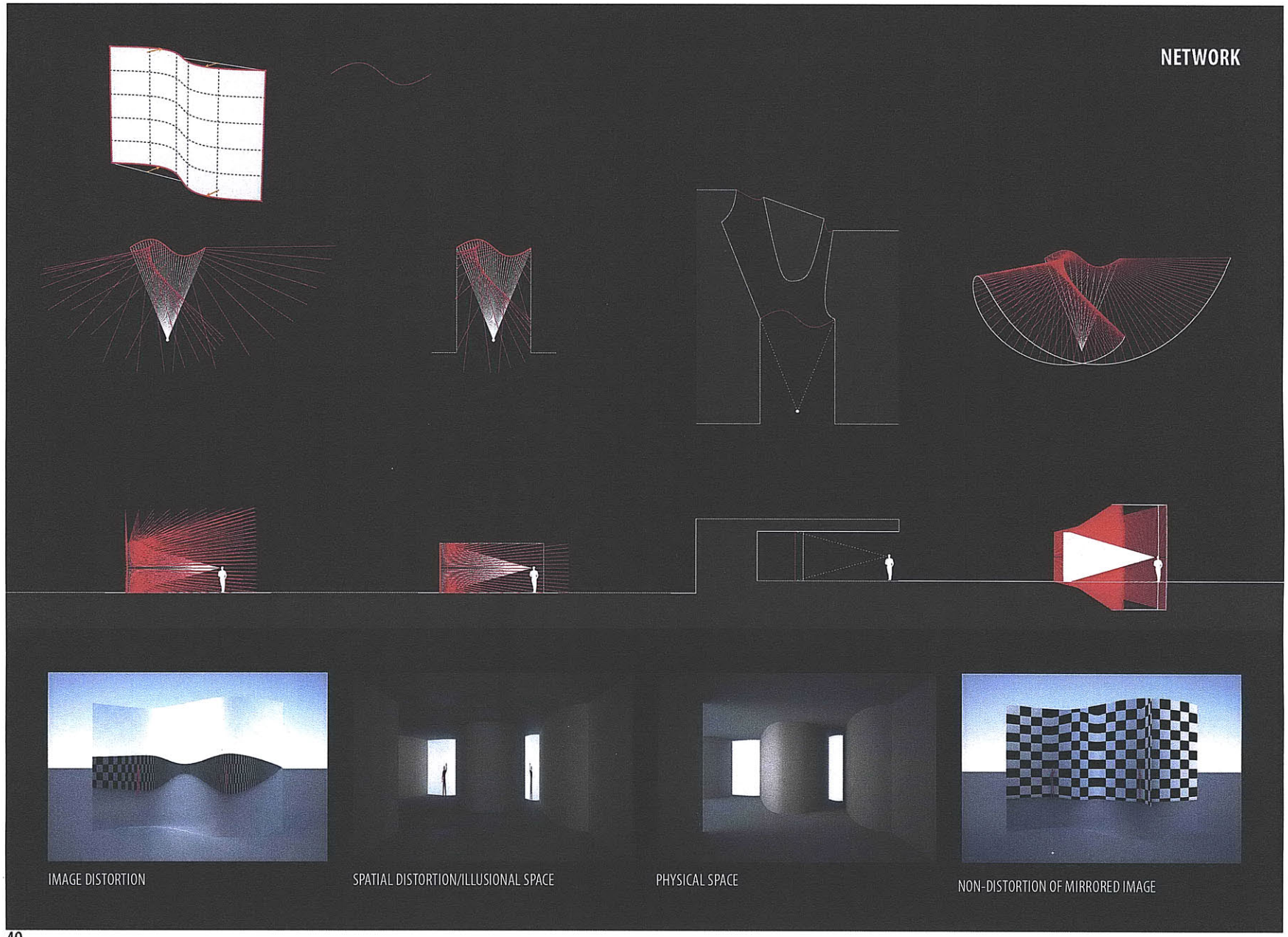


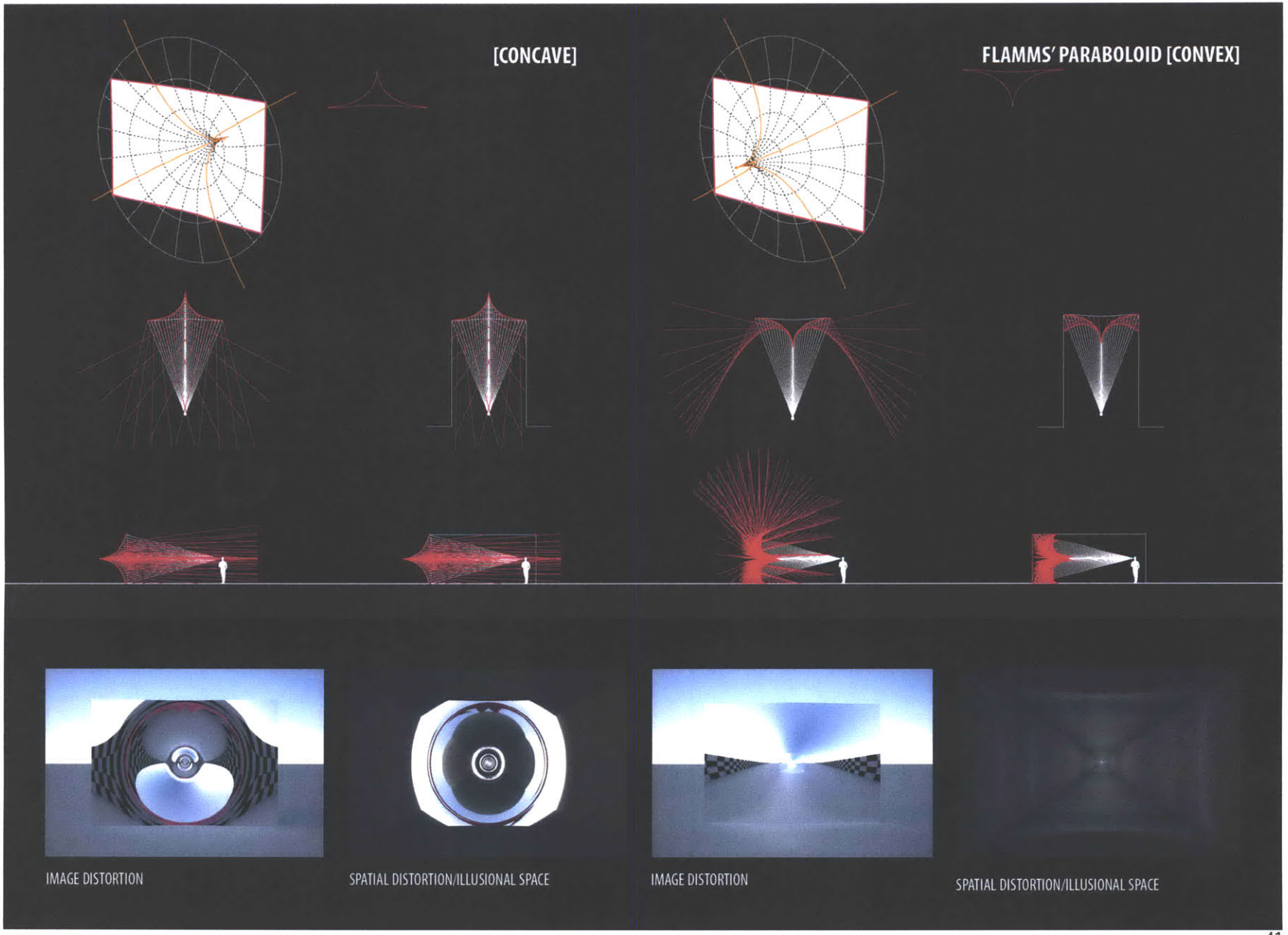
PHYSICAL SPACE



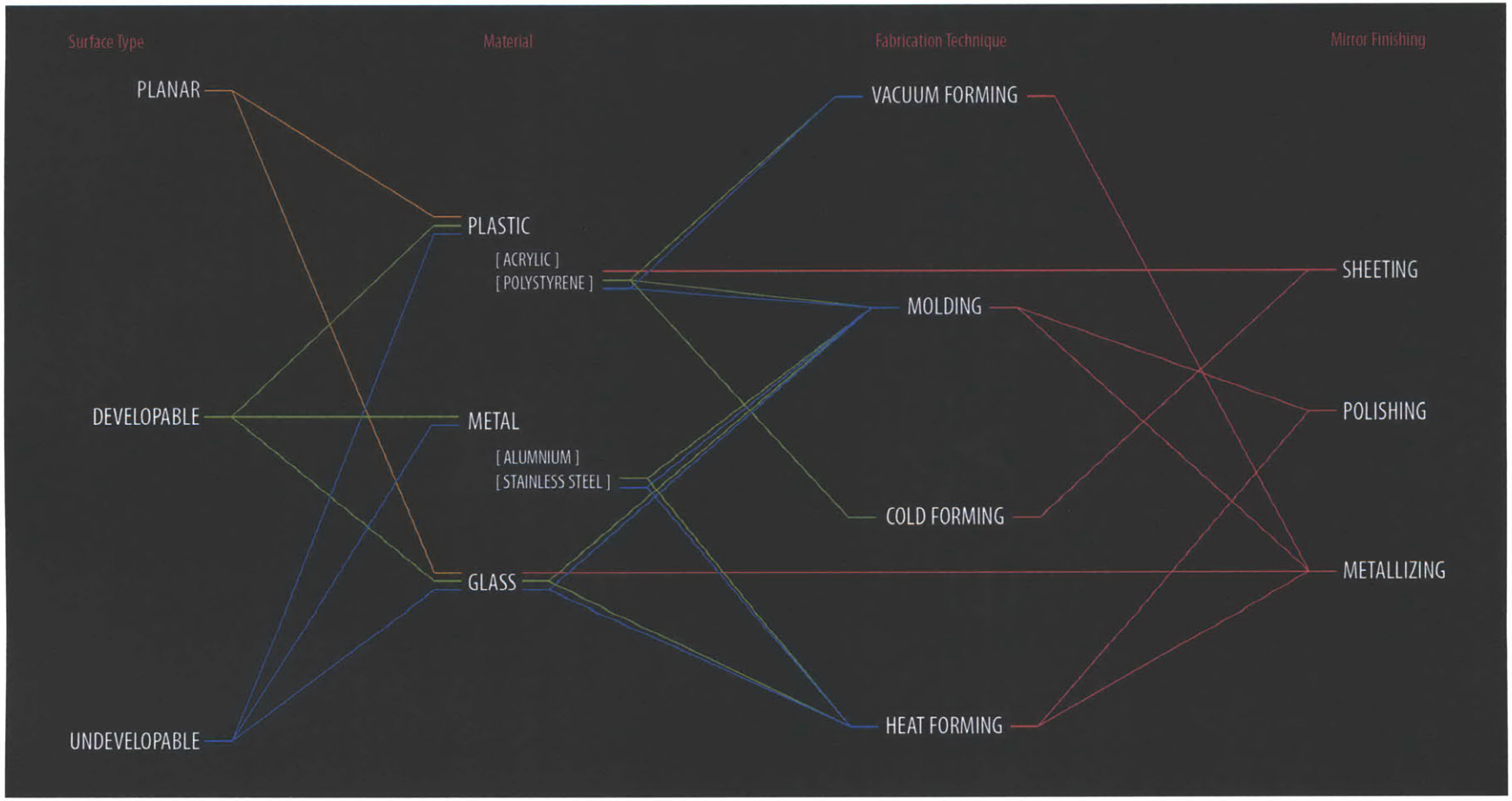
NON-DISTORTION OF MIRRORED IMAGE


[HORIZONTALLY CONVEX]
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE
PHYSICAL SPACE
NON-DISTORTION OF MIRRORED IMAGE


NETWORK
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE
PHYSICAL SPACE
NON-DISTORTION OF MIRRORED IMAGE


[CONCAVE]
FLAMMS' PARABOLOID [CONVEX]
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE
IMAGE DISTORTION
SPATIAL DISTORTION/ILLUSIONAL SPACE

FABRICATION



CONSTRUCTION METHOD & MATERIAL MAP

The fabrication for a complex mirrored surface involves several steps and methods. The complexity of the geometry of the mirrored surface suggests different materials and fabrication techniques. Materials considered include plastics, metals, and glass. Each material also lends itself to particular fabrication methods and mirror finishes. Metals for example can be molded or heat formed and polished to a mirror finish. Other factors of size limits on fabrication machinery and cost also determine the fabrication technique for each type of surface. For large surfaces the mirror must be broken down into smaller pieces that are then seemed together to create a complete surface. Mirror finishes include sheeting, which will distort under heat, polishing, and vac uum metalizing, which can be applied to any geometry.

CNC MILLING

As a mock-up installation one of the research surfaces was chosen for fabrication. The complexity of the surface demanded certain fabrication methods. The first step in fabrication was to CNC mill the surface out of MDF. The limit on the depth that could be milled was 2 inches and therefore the surface was milled in three sections that were then glued together.

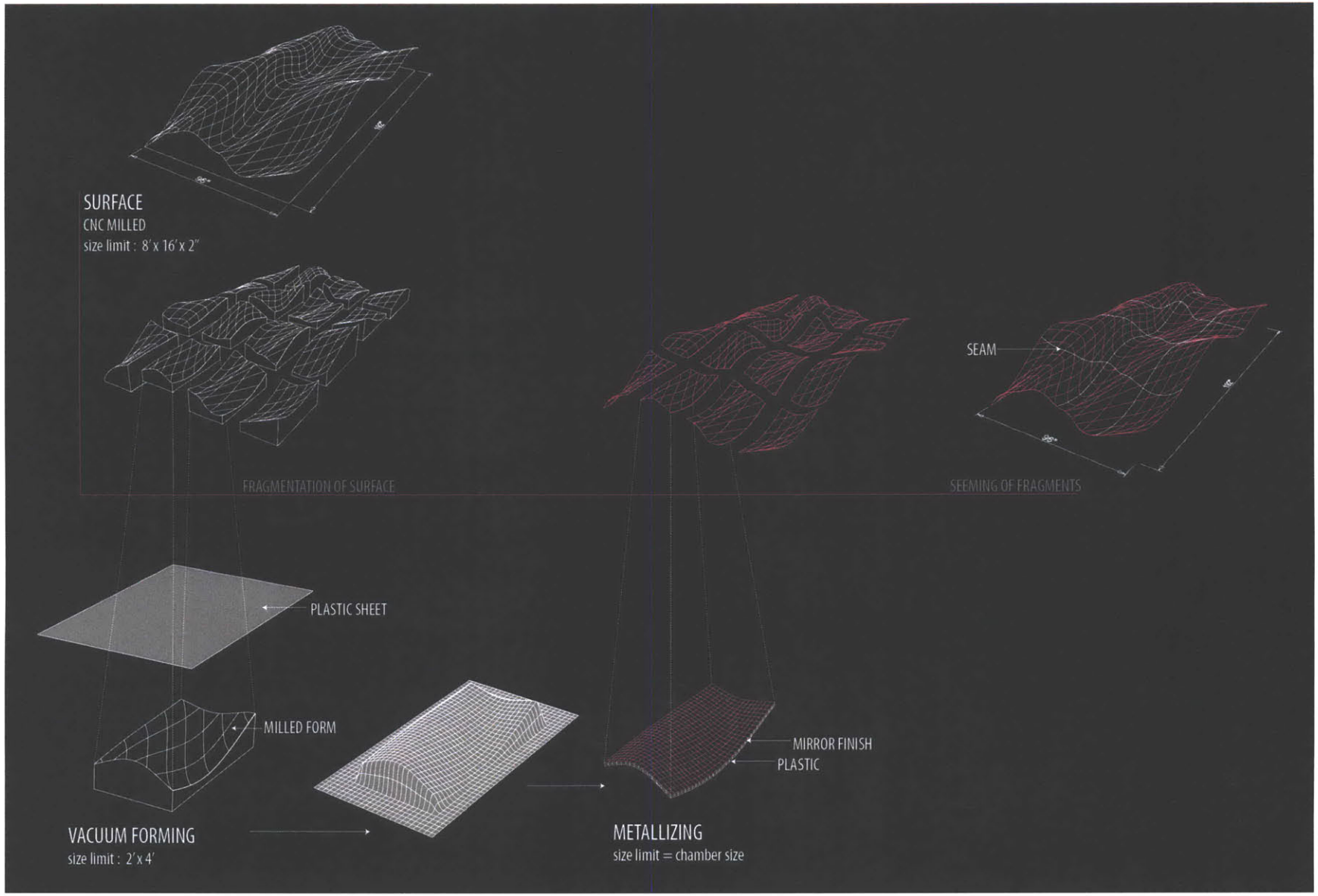
MOCK-UP INSTALLATION

PLASTIC VACCUUM FORMING

The final milled product was then used as a mold for vacuum forming acrylic plastic to the shape of the desired surface. MDF as a porous material works well as a mold for vacuum forming. Acrylic as a material can be brittle after the vacuum forming process and therefore is not ideal but it is very economical. The size limit on the vacumm former was 2' x 2'.

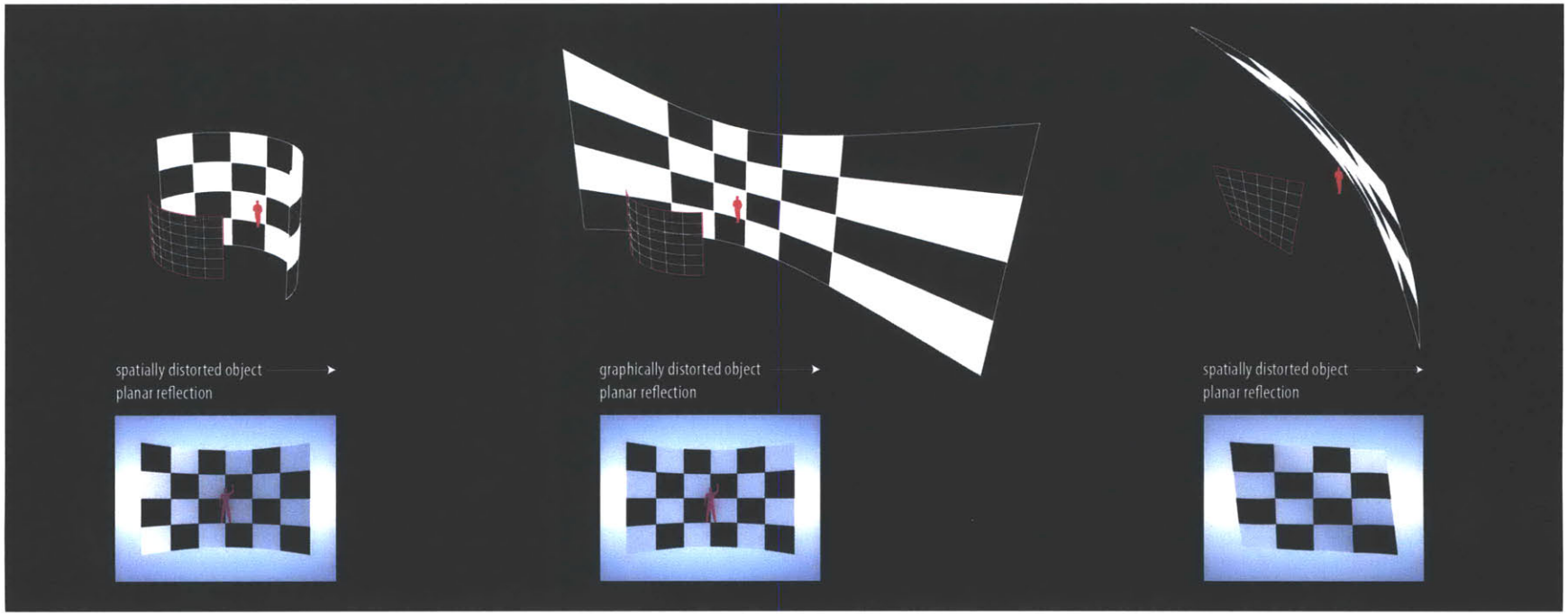
ALUMINUM METALIZING

The vacuum formed plastic was then sent to a company to be vacuum metalized. In vacuum metalizing the plastic or substrate is placed inside a vacuum chamber. Metals (most commonly aluminum) are then evaporated inside the chamber and bonded to the substrate. The result is a uniform metalized layer on the surface of the plastic. The advantage to vacuum metalizing is that the mirror finish is applied to the final geometry of the surface and therefore does not become distorted with the processes of shaping the surface into its final geometry.



FABRICATION PROCESS

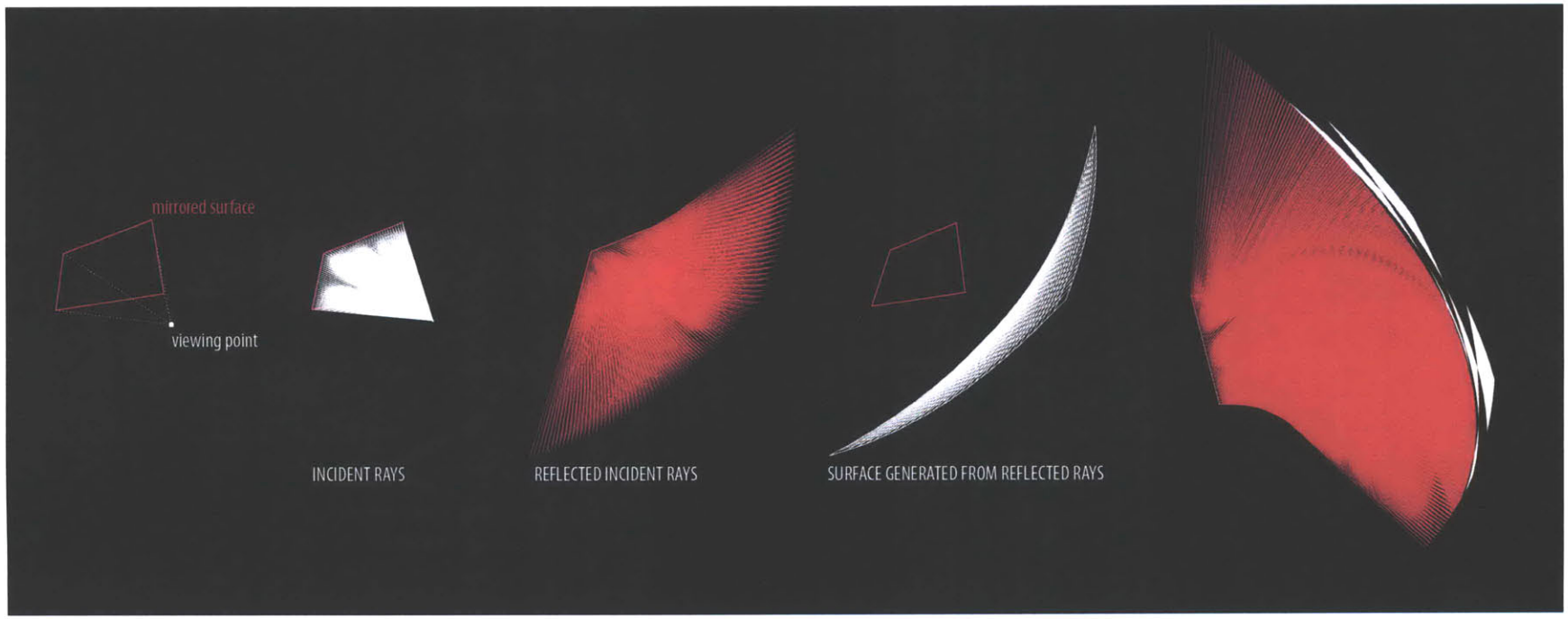
SCRIPTING REFLECTIVITY EFFECTS



NORMALIZING THE MIRRORED IMAGE

2-DIMENSIONAL IMAGE NORMALIZING

One scripting technique generates a secondary surface representative of the area being reflected in the mirrored surface. This area creates a complex surface on which images can be displayed. The images are distorted to fit onto the secondary surface so that when the surface is then reflected back in its generating mirrored surface the images appear non-distorted in the reflected image.

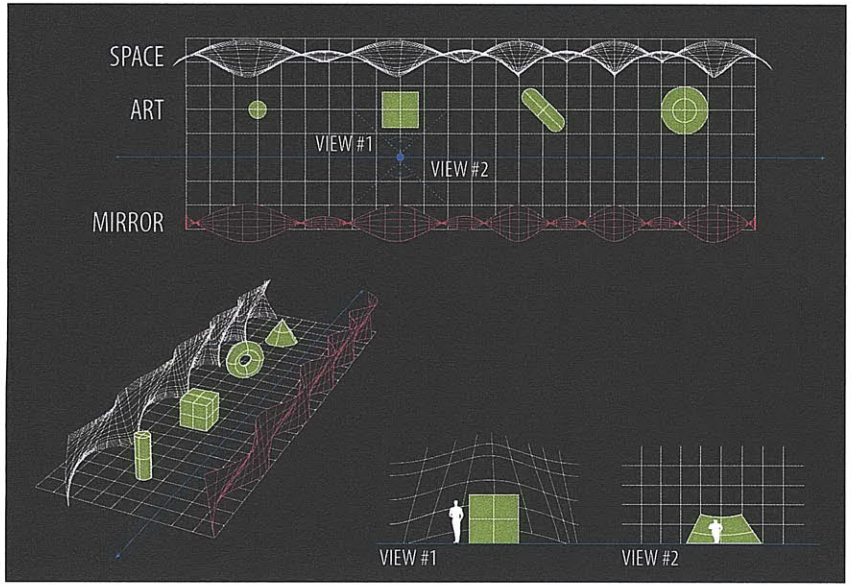


SECONDARY SURFACE GENERATION

The secondary surface is generated from a mirrored surface and a specific viewing point. The rays of light that enter the eye at the specific viewing point are traced back to their incidence on the mirrored surface. The incident rays are then traced further back to their origin by reflecting them off of the surface and extending them into space. The rays will always reflect off of a surface at the same angle as their incidence and therefore their path can be mathematically traced. The endpoints of these reflected rays are representative of the origin of the light rays that enter the eye of the viewer at the specified view point and therefore the network of these points represents the area being reflected and perceived in the mirrored surface at the particular view point. When this network of points is used to create a surface, that surface becomes the secondary surface on which images can be distorted.

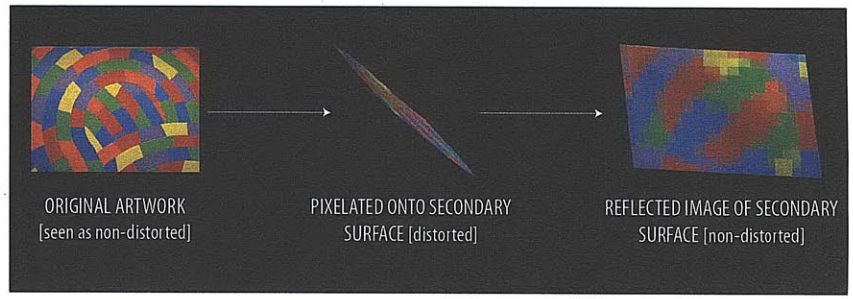
The potentials of this concept suggest an art gallery where the art is distorted onto these secondary surfaces and the experience of the gallery therefore becomes one of moving through a visual labyrinth of distortions in order to find discrete moments of focus.

[ARCHITECUTRAL APPLICATIONS]



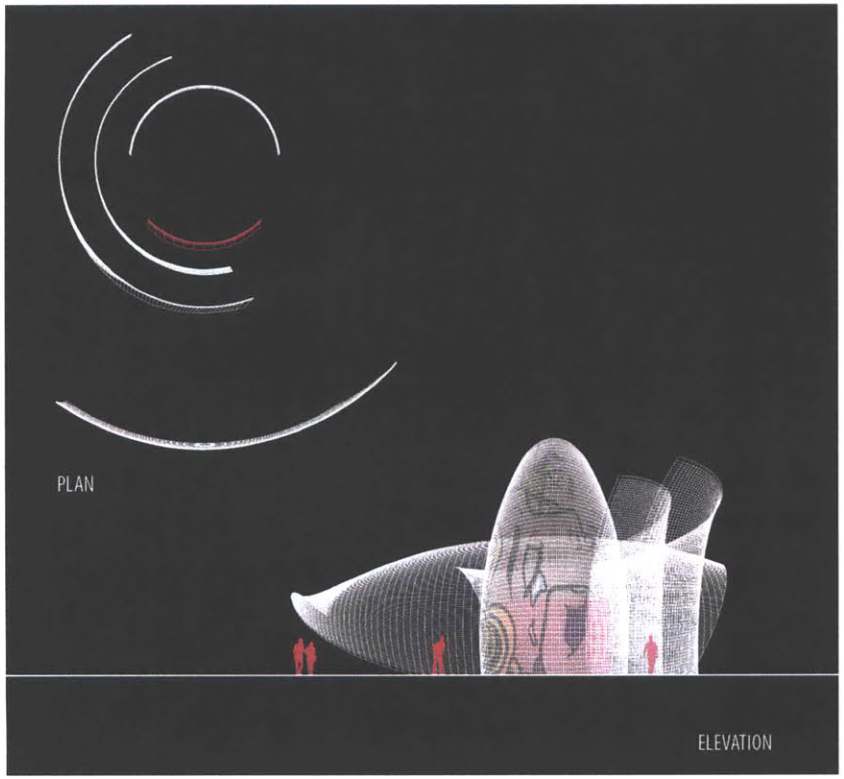
[1] 3-D ART GALLERY

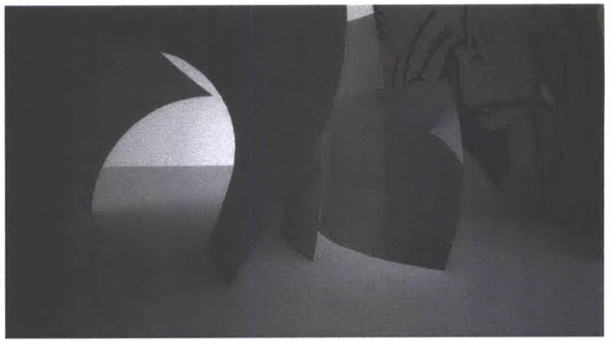
The gallery is composed of three elements: the architecture, sculptures, and mirrored surfaces. The arrangement of the three elements offers two types of views. One view shows the art sculptures with the backdrop of a distorted architecture. The second view is seen in the reflection of the mirrored surface and shows a distorted art sculpture in a normalized architectural space.

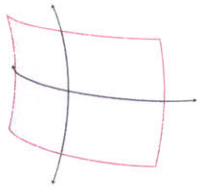


[2] 2-D ART GALLERY

In this case the artwork is distorted onto a new canvas generated from a mirrored surface. The art is then viewed through the mirrored surface as a reflection and due to the geometries of the new canvas the art appears non-distorted in the reflected image.

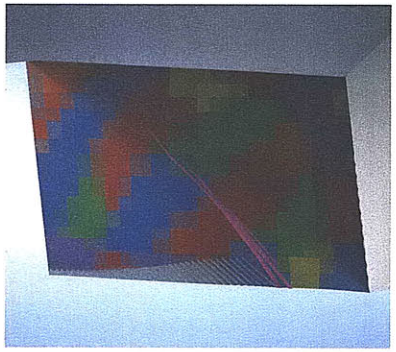




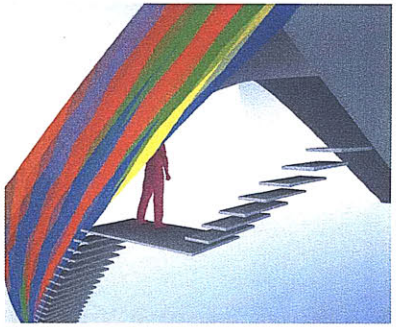


[3] ART EXHIBITION PAVILION

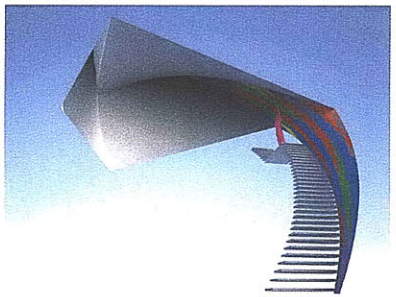
Mirrors can add dynamism to the experience of viewing objects. In an art gallery for example mirrors might be used so that the artwork becomes distorted and merges into the exhibition space yet there is a singular point where the art can be viewed proportionally and in proper alignment through the reflection of the mirror. The use of complex mirrored surfaces imagines a potential gallery space where the mirror prescribes the dimensions of the canvas and the articulation of the walls. There exists also an exploration of the relationship between artist and architect.



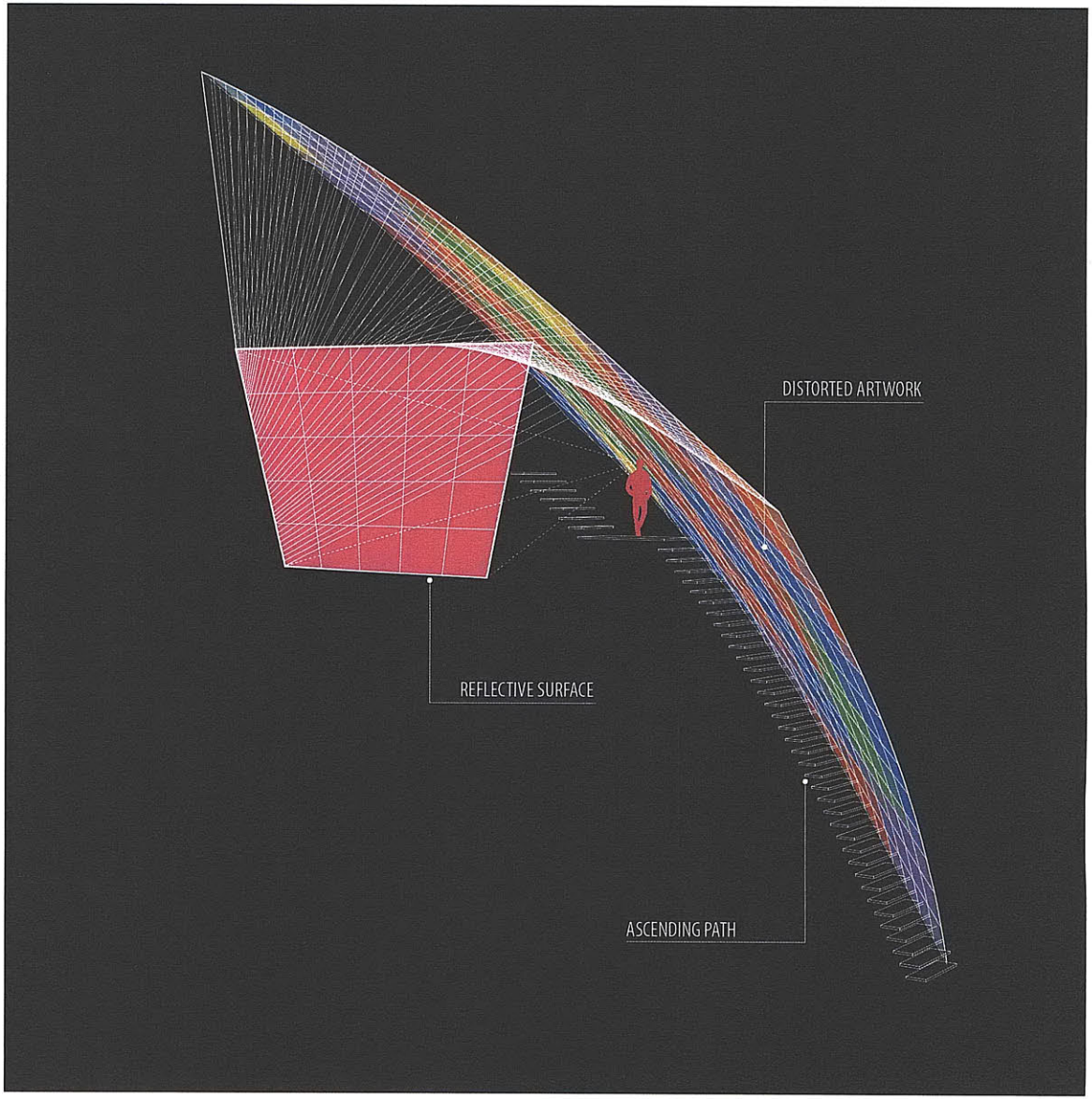
PERCEIVED IMAGE IN REFLECTIVE SURFACE

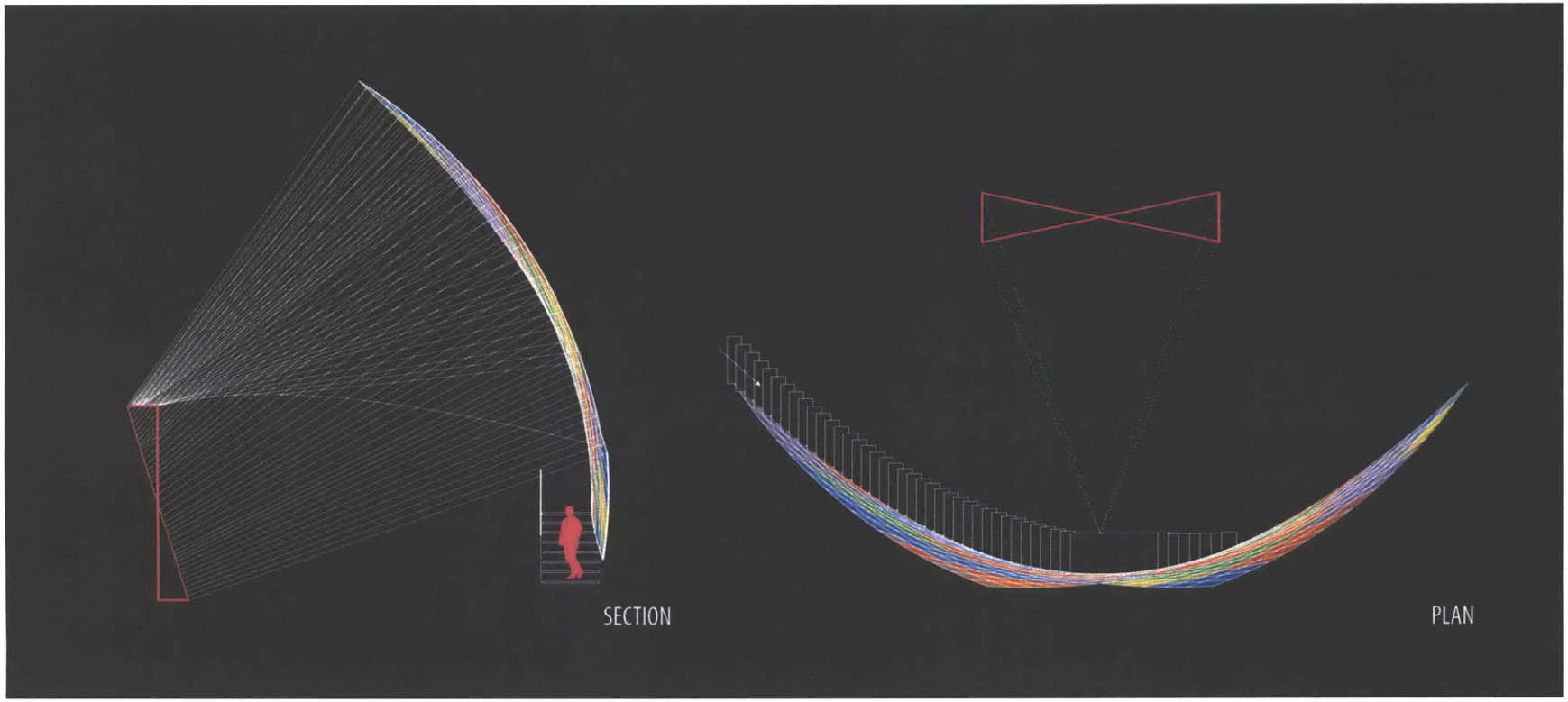


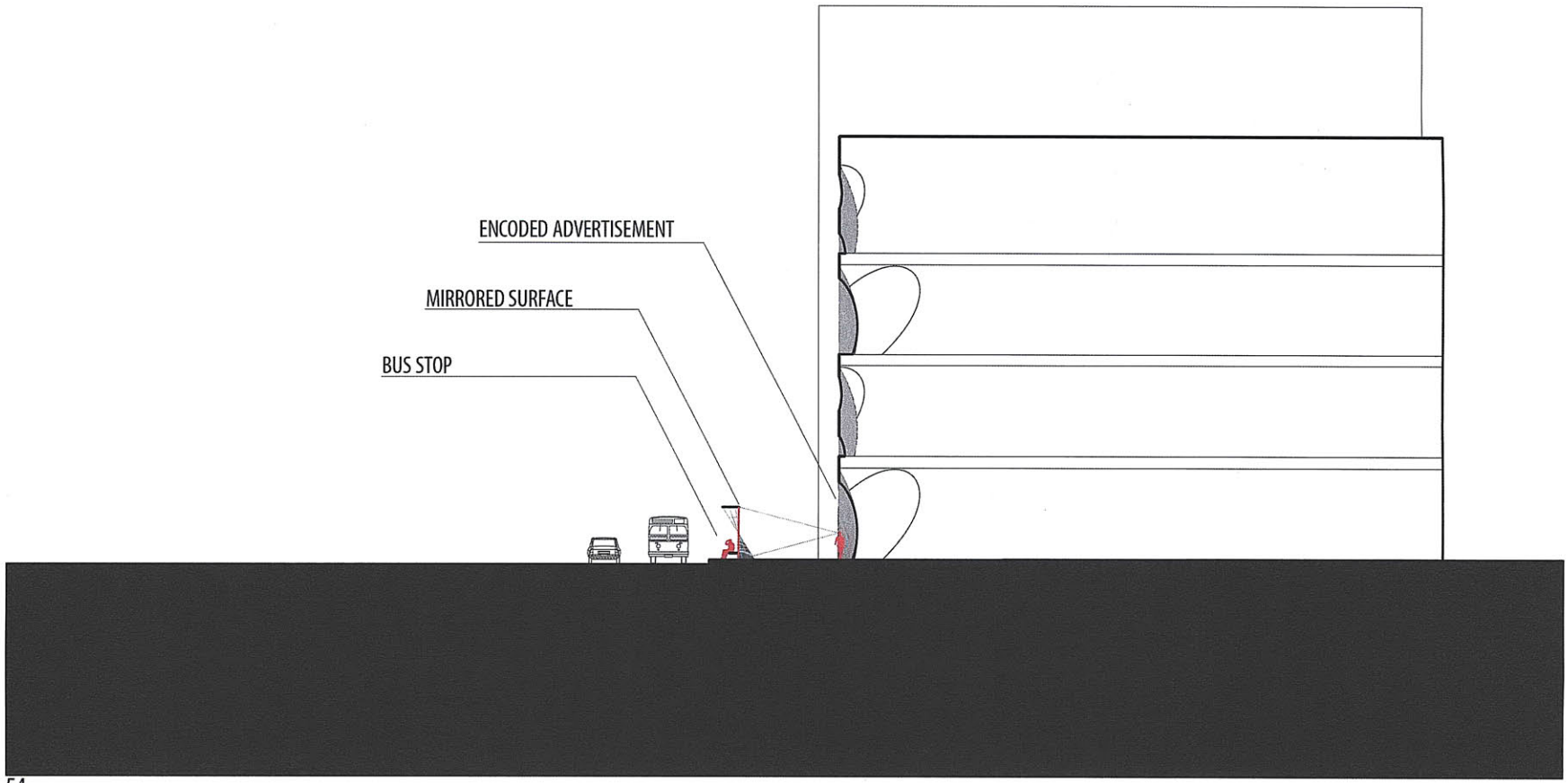
THE PIXELATED ART WORK BECOMES ORTHOGONAL AT A SINGLE POINT AT THE TOP OF THE STAIR

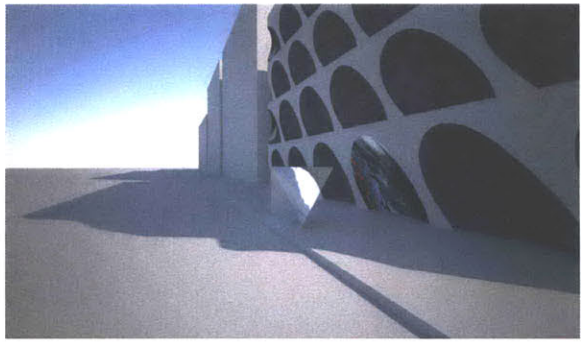


THE REFLECTION OF THE COLORED ARCHITECTURAL WALL IS SLOWLY REVEALED AS PEOPLE ASCEND

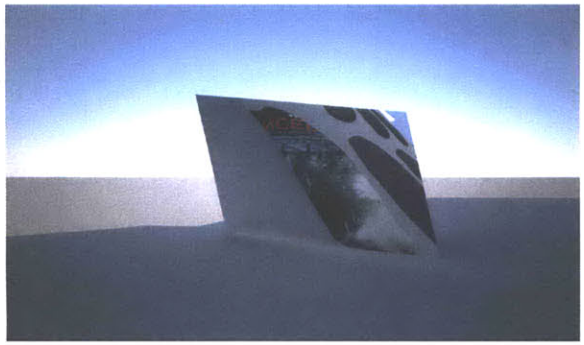



SECTION
PLAN


ENCODED ADVERTISEMENT
MIRRORED SURFACE
BUS STOP



ADVERTISEMENTS COME INTO FOCUS ONLY AT PARTICULAR MOMENTS THROUGH SCULPTURAL MIRRORS

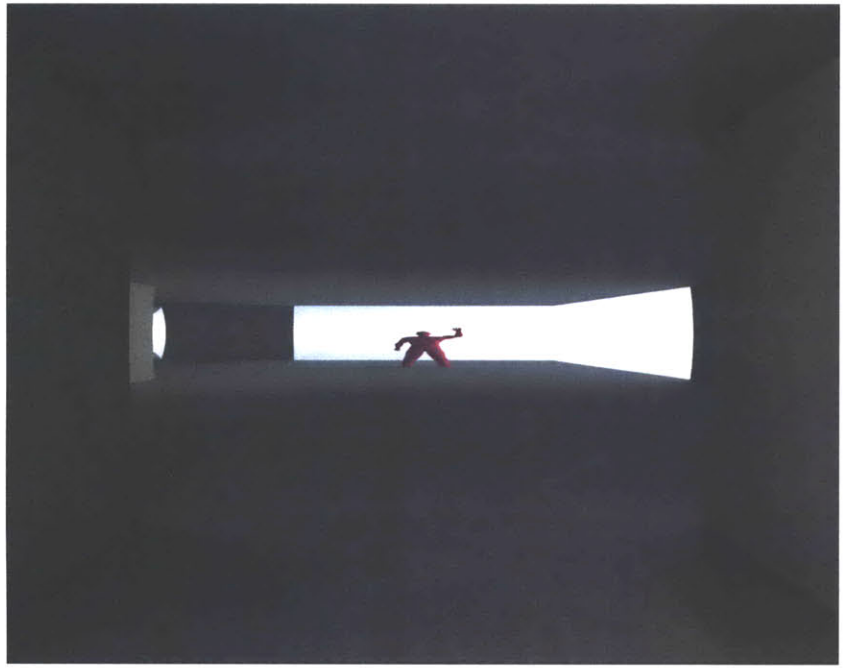


MIRRORED SURFACES BECOME ELEMENTS IN THE URBAN STREET SUCH AS A BUS STOP

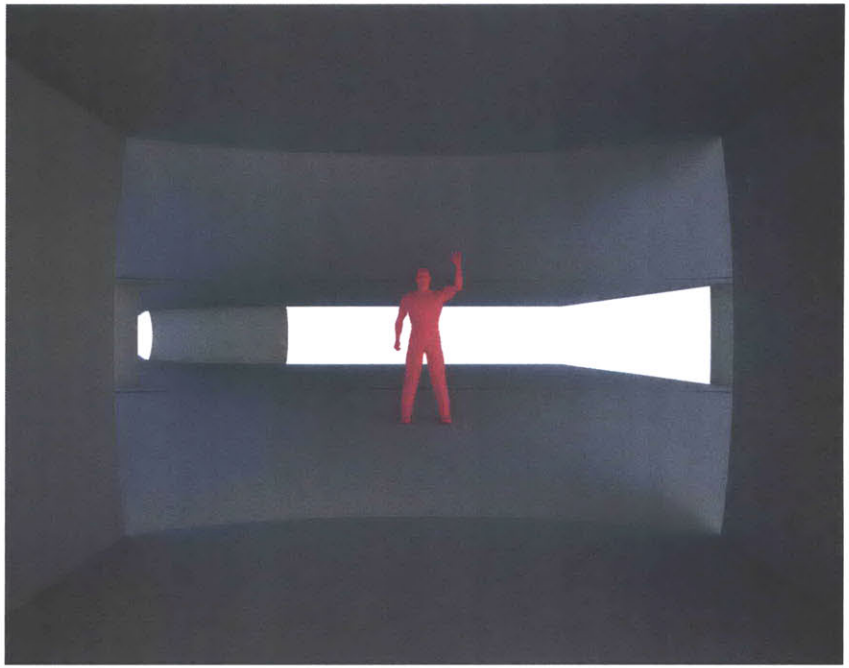
[4] URBAN SCALE / BUILDING FACADE

Another potential use is that the secondary surfaces encoded with images can become part of a building façade and the mirrored surface an element in the urban street. There are therefore moments along the urban street where the information distorted in the building façade is made visible by its reflection in a mirrored surface. The density of billboards and signs on the urban street would therefore become obsolete and would instead be imbedded into the façades of buildings.

Building facades would be encoded with images or advertisements and mirrored surfaces would be used to orchestrate the precise moment where the images or advertisements become clear to passersby.



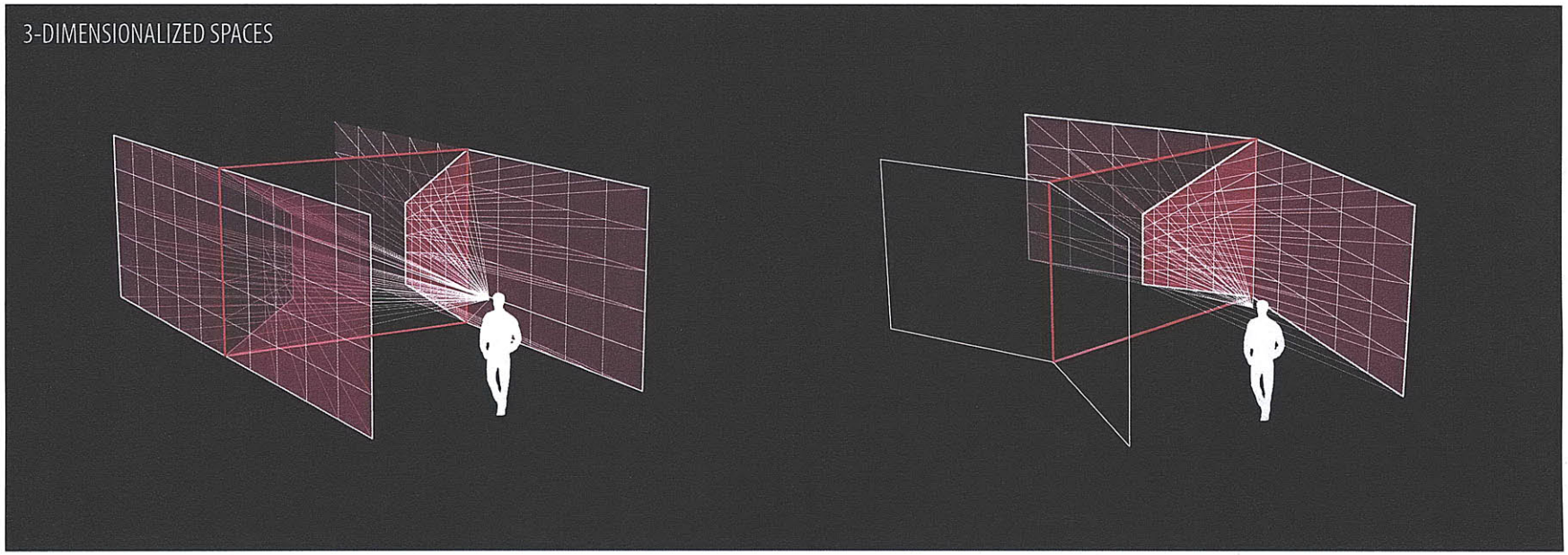
VIEW #1 : REFLECTED IMAGE OF SPACE



VIEW # 2 : PHYSICALLY, OCCUPIABLE SPACE

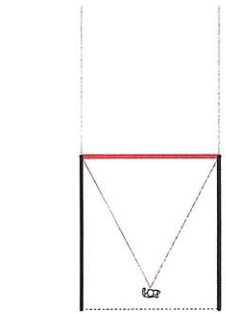
3-DIMENSIONALIZING THE MIRRORED IMAGE

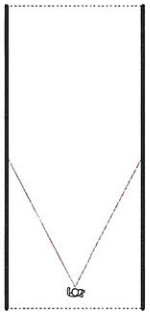
The space perceived on a mirrored surface is created by the reflection of the surrounding space. Another scripting technique that was developed was a means to three-dimensionalize the image seen on the mirrored surface. The script allows every detail of a room from walls and floors to mullions and lights to be reflected through a geometric surface and then reconstructed into a physical space. From a specific viewpoint, the view seen in the mirrored surface and the view seen of the room are precisely identical. One however is a reflected image and therefore will also include a distorted view of the viewer. The other is a three-dimensional space that the viewer can then physically occupy.

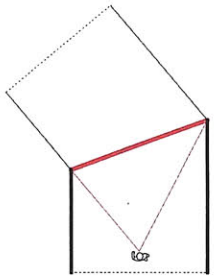


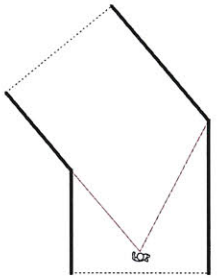
PLANAR

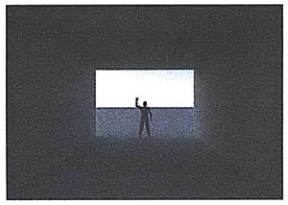
OBLIQUE



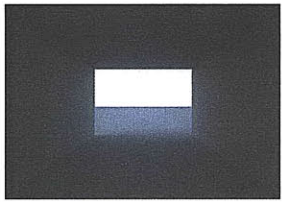








ILLUSIONAL SPACE



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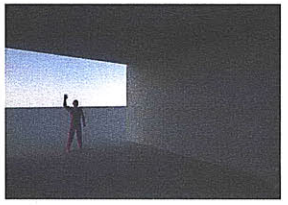

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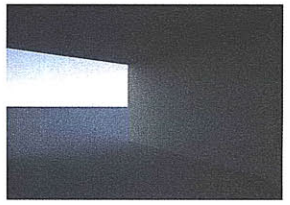

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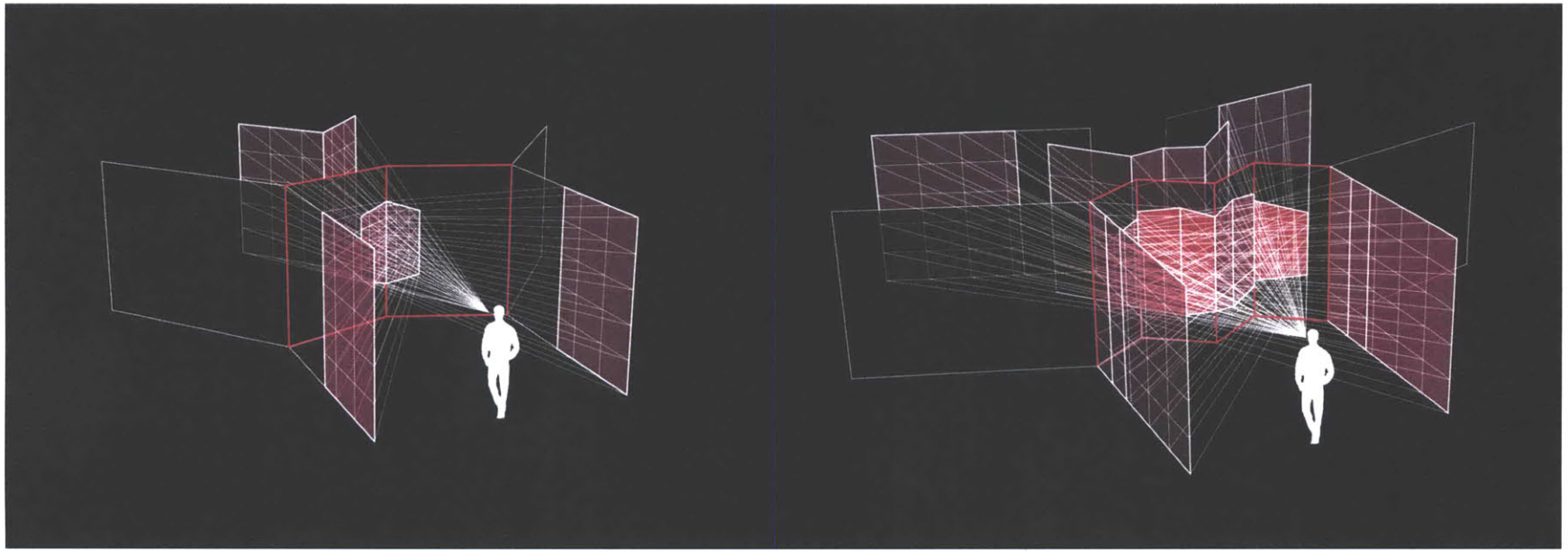

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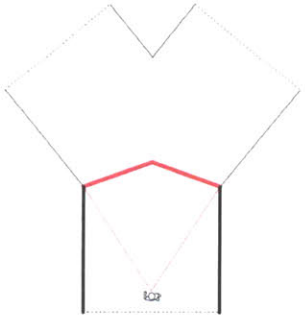

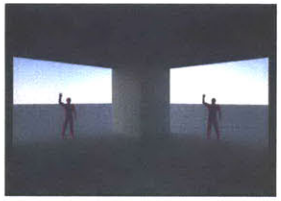

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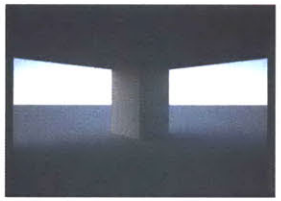
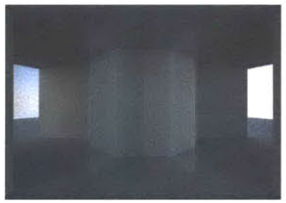


PHYSICAL SPACE

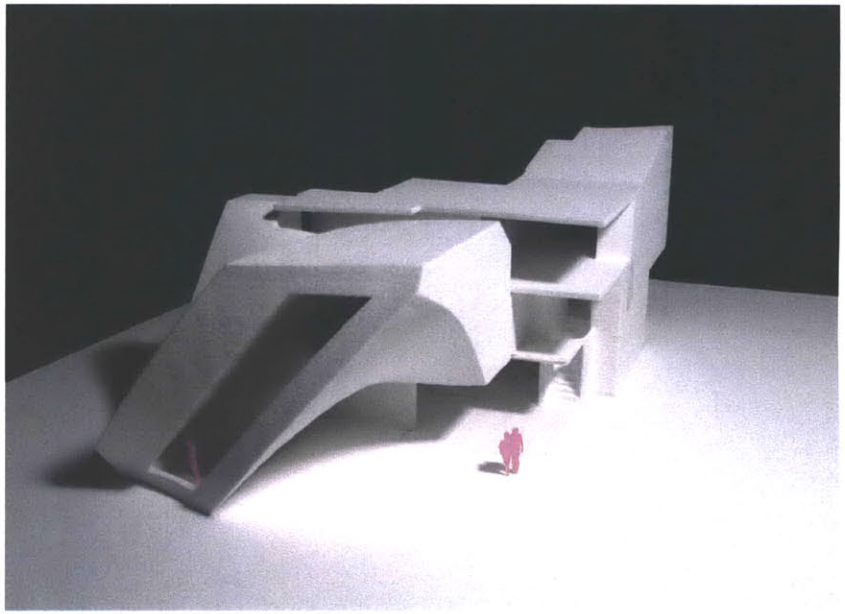
TRIPLE CUSP



ILLUSIONAL SPACE

PHYSICAL SPACE

DESIGN PROJECT



SPATIAL MIRROR GALLERY

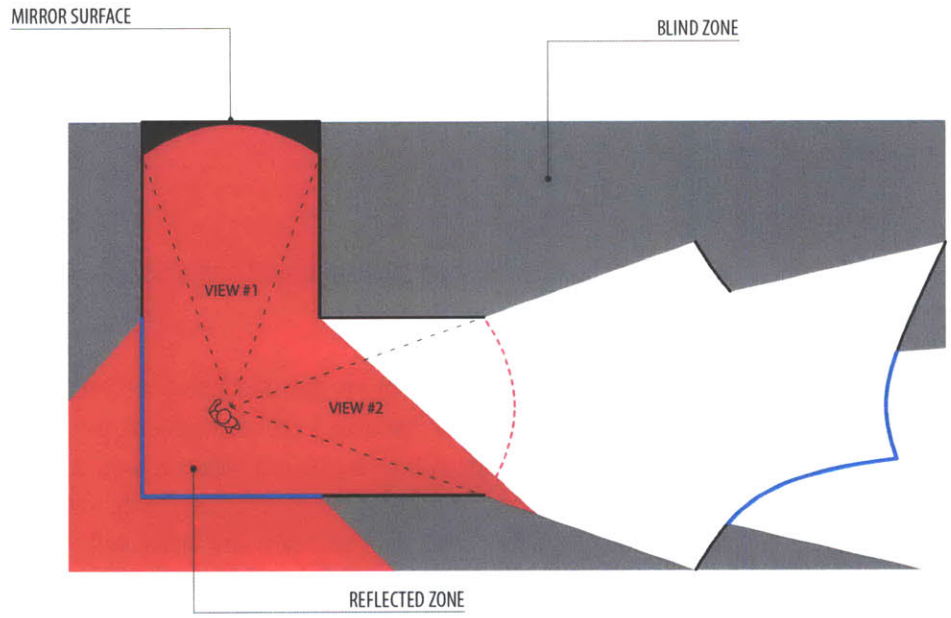
The final project utilizes the research and the scripting techniques to create an experiential museum. The museum is organized by vertically-stacked binary units. The binary units are shaped in an L-form where standing at the vertex visitors see two views. One view looks directly at a complex mirrored surface and the other is a view into the three-dimensional space constructed of the reflected image in the first view. As the sequence of spaces progresses elements of the first spaces begin to affect the sequential space in order to create a complete accuracy to the two views that are being seen. The progression of spaces is therefore generative as the spaces are created.

The details of the spaces are also accounted for so that the vertical mullions of the space being reflected become distorted and curved in the space being generated. Elements such as circulation are also hidden in the blind zones of the mirrored surface. These zones become poshe areas for other elements of the museum to occupy freely. The architecture itself is therefore being carefully constructed around the geometries of these mirrored surfaces and the special moments where visitors are able to see distinctly the two images.

The generative spaces also lend themselves to particular occupancies. One for example might become a double height space where viewers can see the empty being generated from the mirrored surface. Another space might become non-occupiable due to the sloping of the floor or the compression of the space. These spaces invite a different interaction where visitors may crawl on their hands and knees to occupy these spaces and the feeling of how the mirror is distorting the space is more intimately experienced. Another space hides a staircase in the blind zone of the mirror. The top the staircase however must be carefully shaped and articulated so that the effect remains exact.

A series of massing methods explores the stacking of the binary units and the circulation paths through the building. Considerations of the volume that the generated space would occupy both in plan and section as well as considerations of the space being reflected drive the logic of each massing study. The vertical stacking of the spaces allows for a 'clean slate' with each new binary unit. Circulation is also carefully orchestrated so that the entry sequence of each unit does not detract from the effect being created.

The final circulation path is a loop through three, stacked binary units. Each unit offers a binary view of two perfectly exact images. The museum plays with the idea of the illusions of space and materializes the architecture latent within the distortions of a mirrored surface. In the series of galleries the mirrored surfaces and architectural spaces become the exhibition of art. The architecture is shaped by the three mirrored surfaces and visitors are able to perceive how at specific points where the image seen in the reflective surface is identical to what is perceived looking at the architectural space.

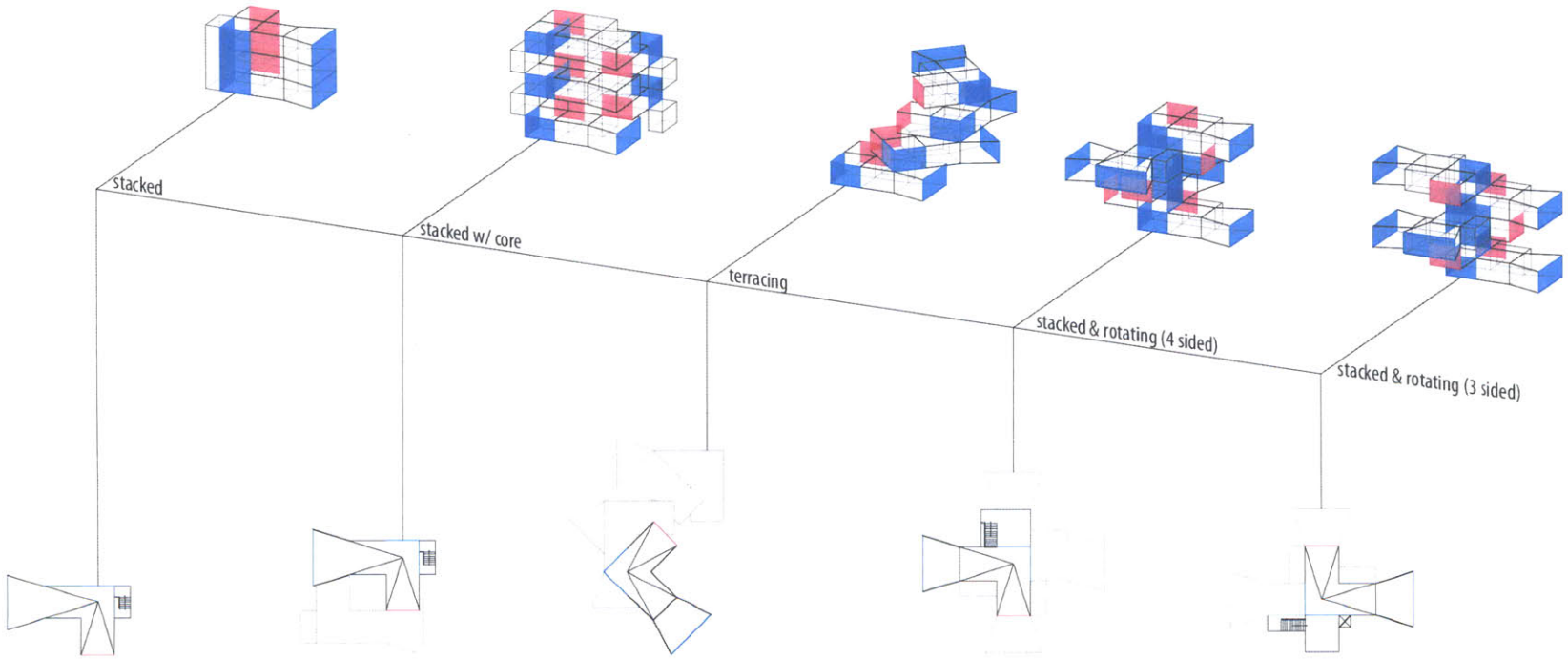


BINARY UNIT SYSTEM

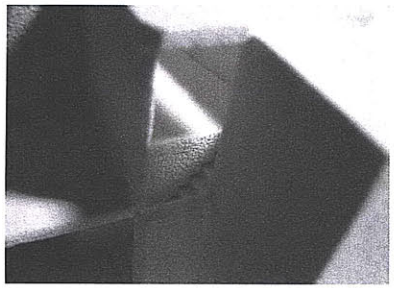
The binary unit provides two views one of which is a view looking directly at a complex mirrored surface. The second view looks into a space constructed of the reflected image seen in the first view.

The area being reflected in the mirrored surface is the area that is then constructed to compose the second view. Blind zones are areas that are either not reflected or not visible from the specific viewpoint. Blind zones become poshe areas where other building elements such as circulation can exist freely without detracting from the effect of the binary views.

A series of vertically stacked massing studies were used to explore different circulation paths and sectional relationships. Factors important to consider included the volume of the three-dimensionalized space and the zone being reflected in the mirrored surface. The location of open windows either being reflected or as part of the three-dimensionalized space also needed to be carefully considered so that the two perceived views are exact and the illusional effect is not lost on the viewers.

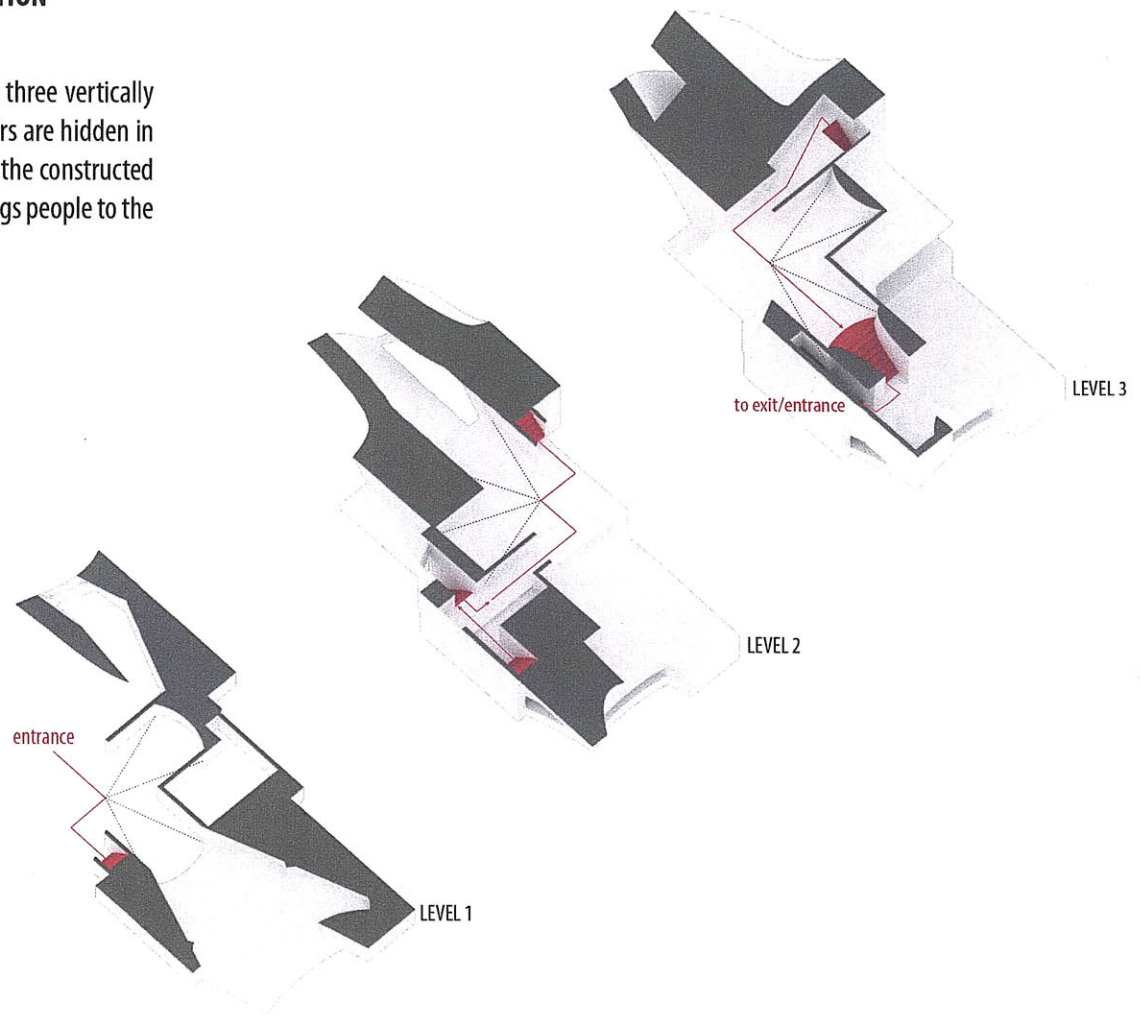


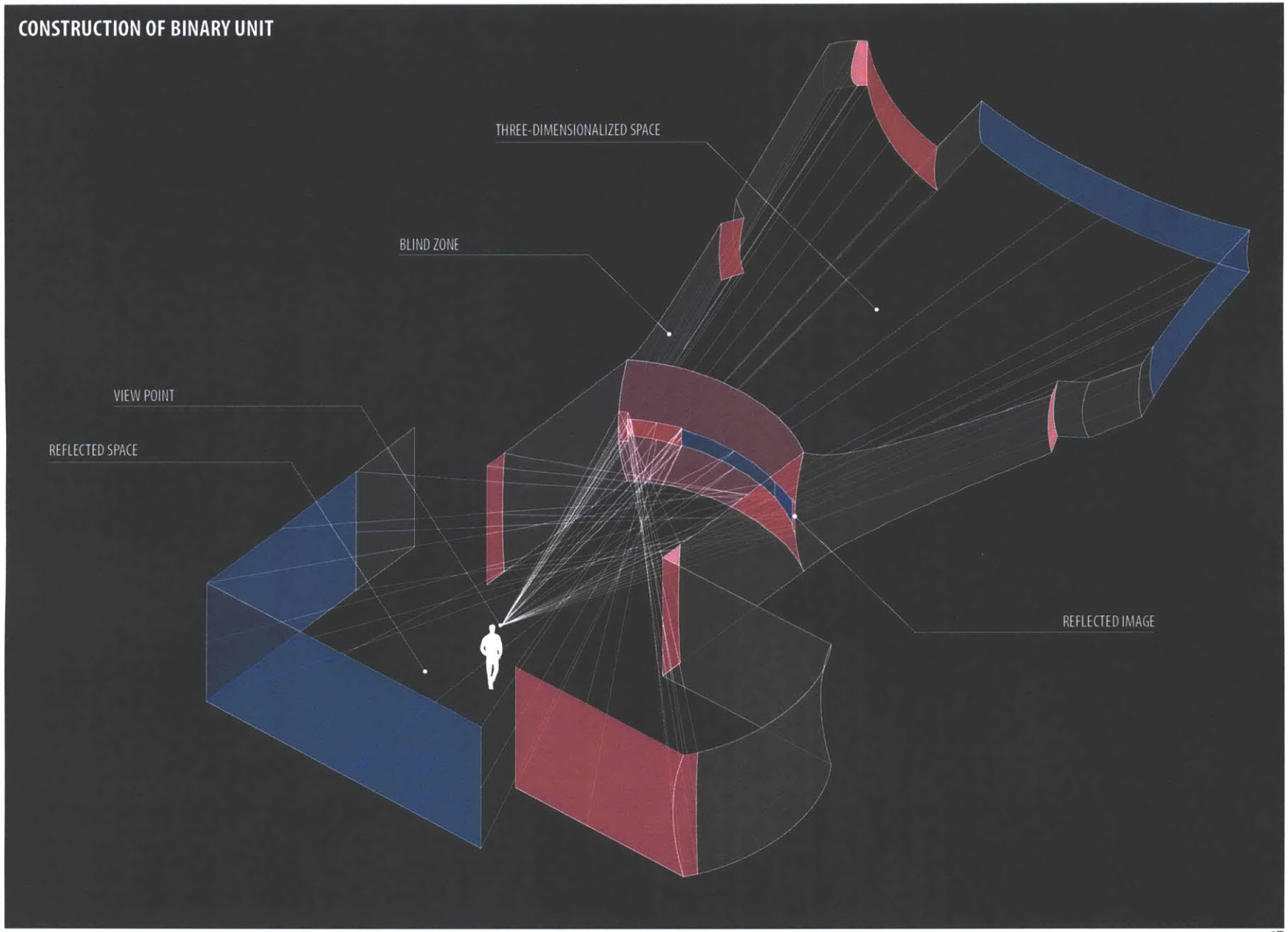
MASSING STUDIES

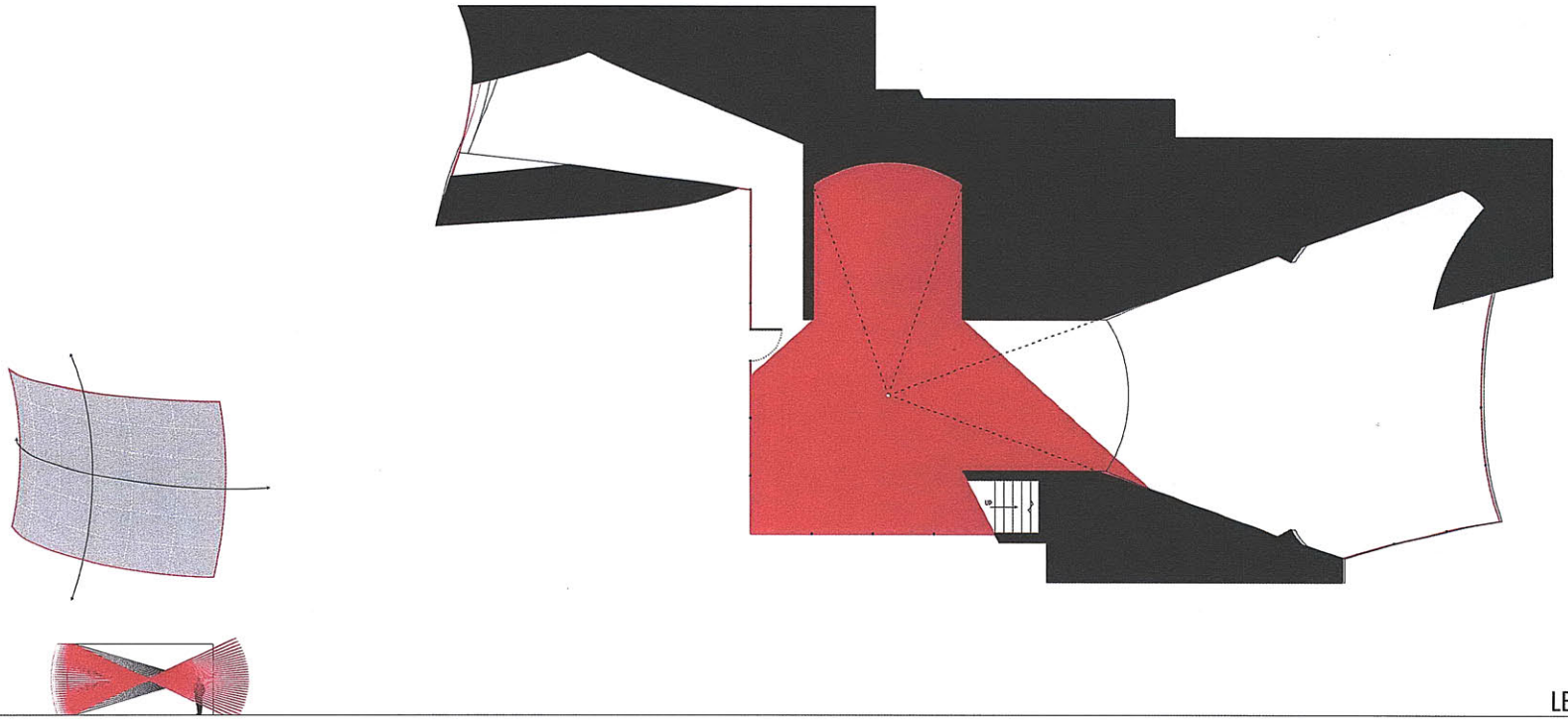


CIRCULATION

The final circulation path creates a loop through three vertically stacked binary units. The vertical circulation stairs are hidden in the blind zones of both the mirrored surface and the constructed architectural spaces. The circulation carefully brings people to the three specific view points of the binary spaces.




CONSTRUCTION OF BINARY UNIT
THREE-DIMENSIONALIZED SPACE
BLIND ZONE
VIEW POINT
REFLECTED SPACE
REFLECTED IMAGE



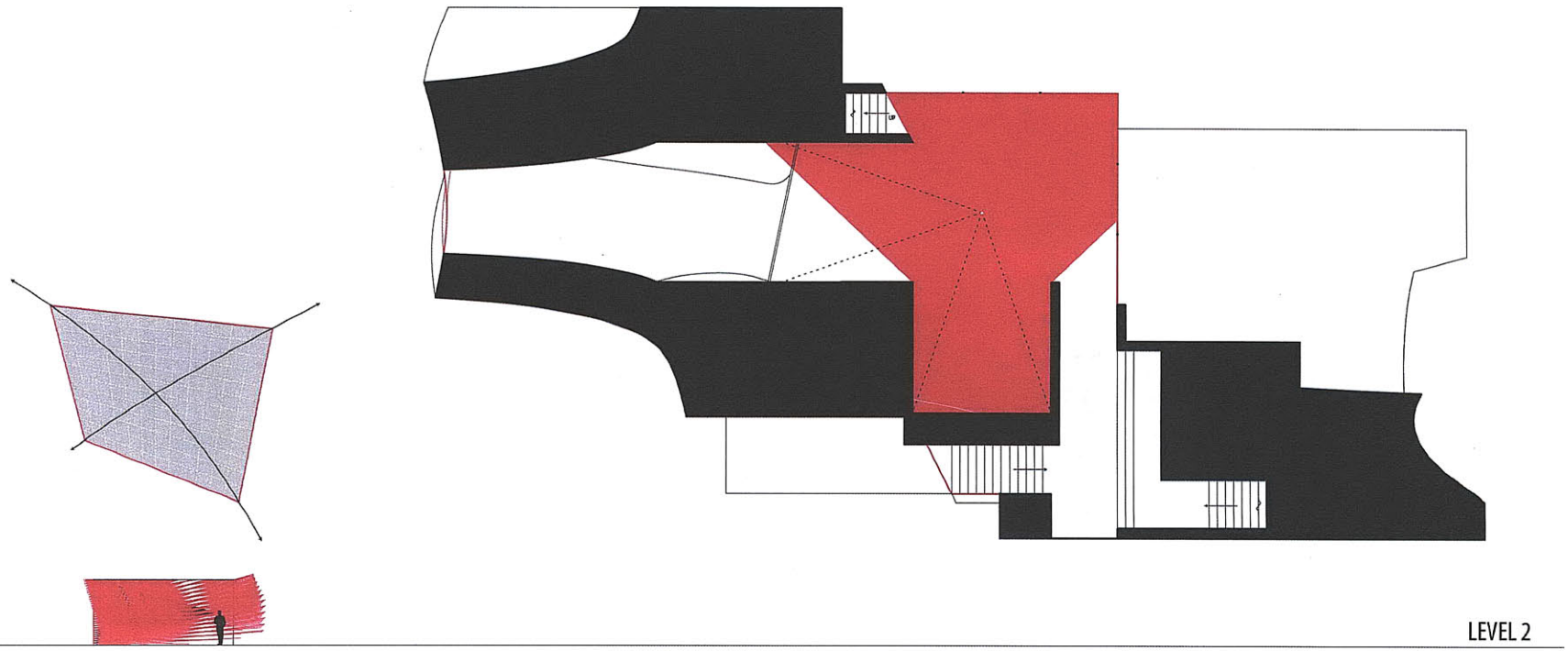
LEVEL 1

On the first level the binary unit is constructed of an anticlastic surface. The resulting three-dimensionalized space is squeezed sectionally to an extremely low floor-to-ceiling height.

Another space is created that is connected sectionally to the three-dimensionalized space of the unit above.

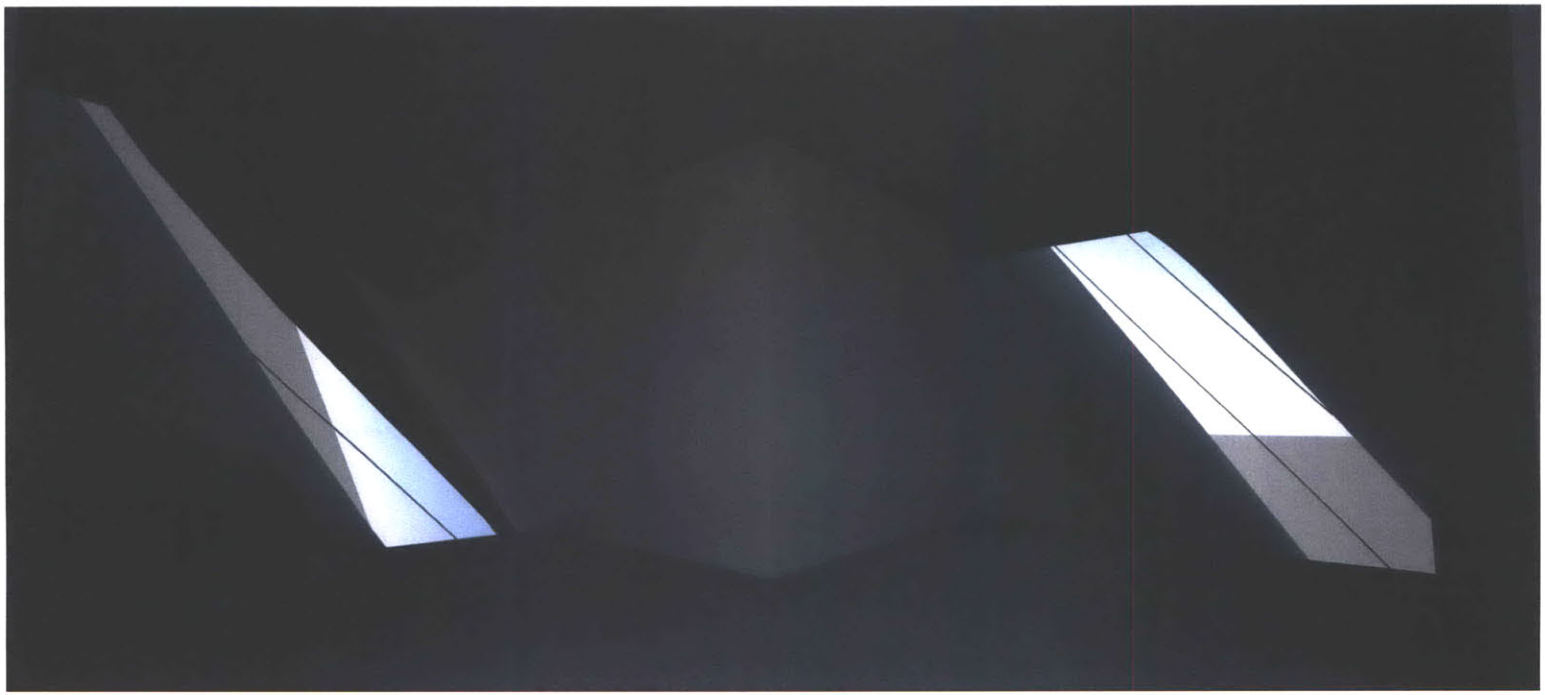
Circulation to the next level is hidden in the blind zone of the mirrored surface.

Visitors are able to perceive themselves in the reflection of the mirrored surface. They see themselves 'occupying' the space which then physically exists to their immediate right. The first view therefore allows a projection of one's self into a distorted space while the other view invites people to actually physically occupy the distorted space and 'feel' the comparison between the two experiences. The way that the distorted space is occupied in the reflected image proves different from the way that the physical space is occupied in reality.

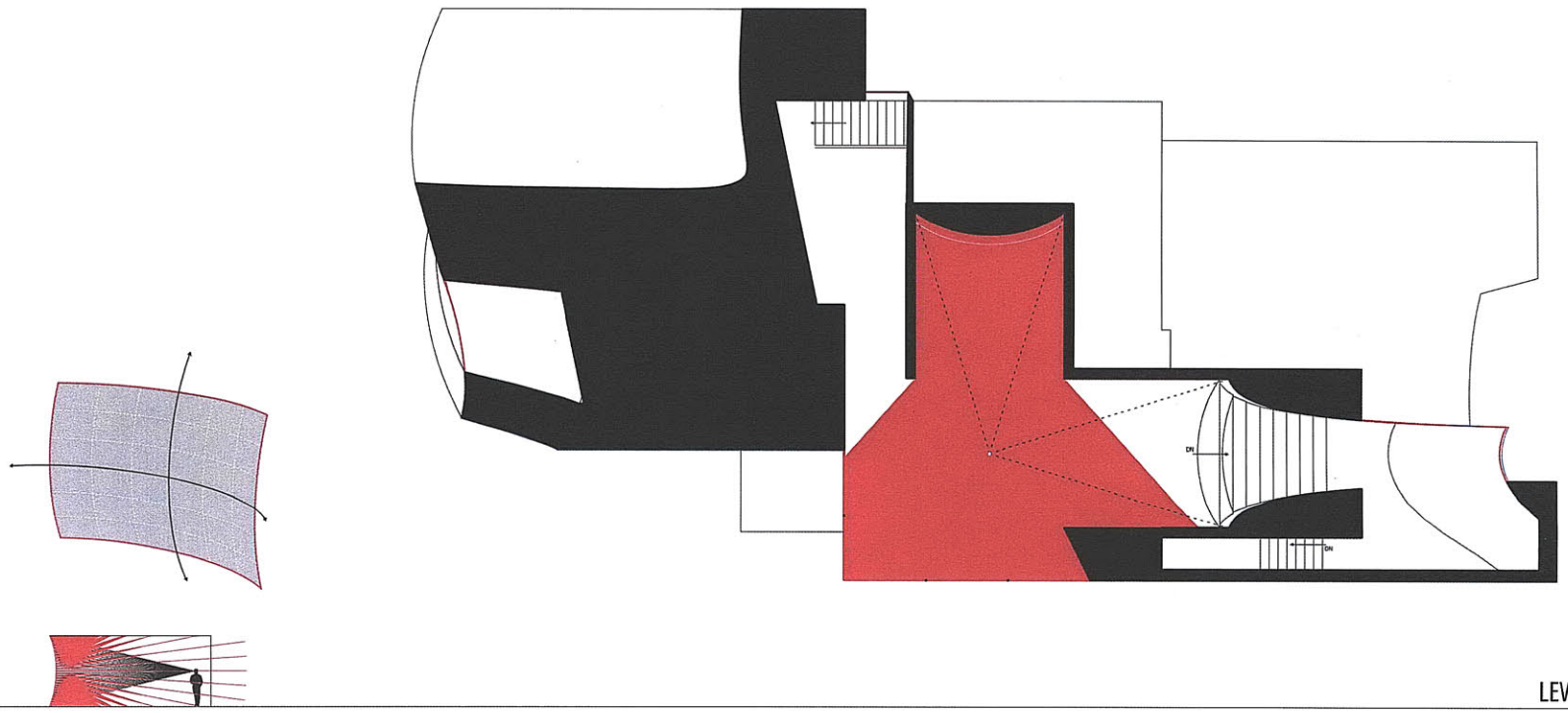


On the second level the binary unit is constructed of a hyperbolic paraboloid surface. The resulting three-dimensionalized space is open to the level below.

Again the circulation to the next level is hidden in the blind zone of the mirrored surface.



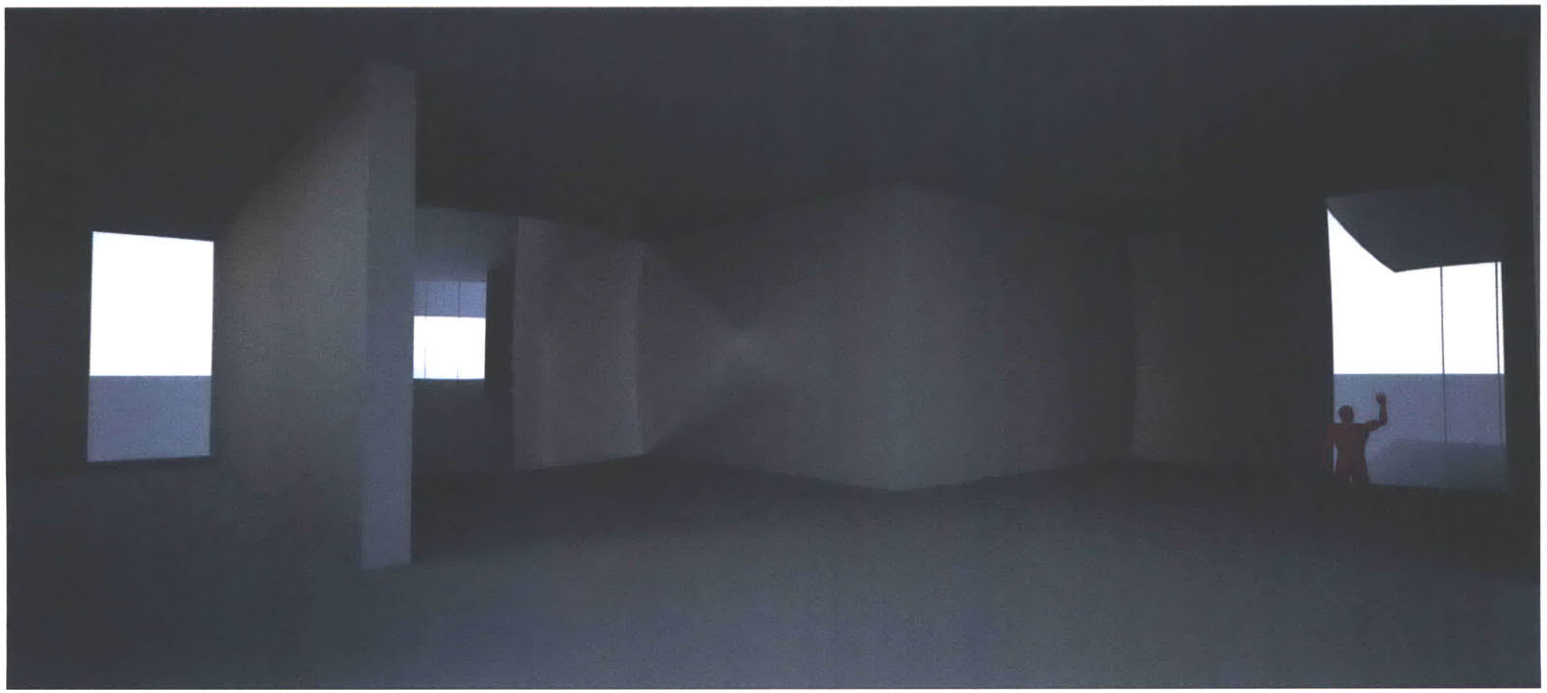
The difference between the two views can be seen in that the horizon line is angled in the reflected image on the left but remains horizontal in the view thru the window on the right.



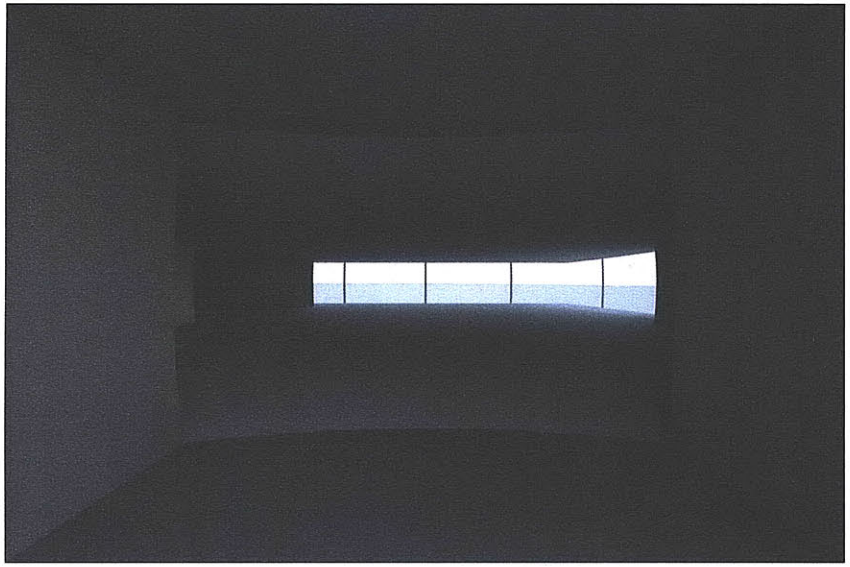
LEVEL 3

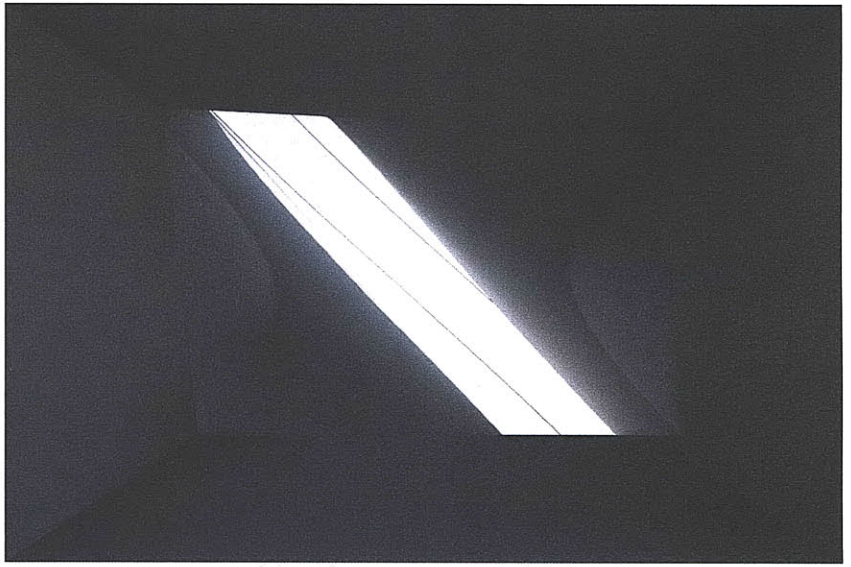
On the third level the binary unit is constructed of another anticlastic surface.

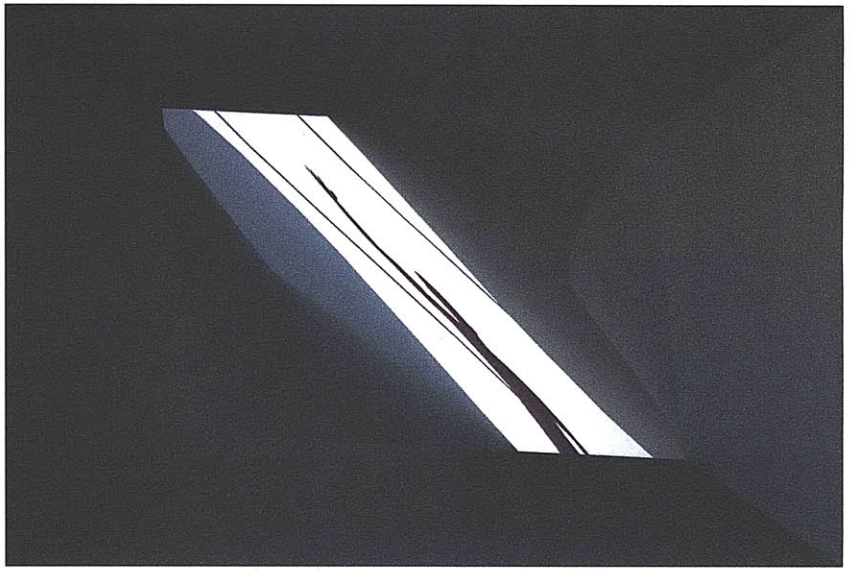
Circulation back down to the ground floor is hidden in the three-dimensionalized space of the unit.



The mirrored surface of this unit inverts the reflected image. The reflection of the horizon line on the left is turned upside down while views out the glazed windows appear normal. The effect of creating two identical images is therefore made imperfect by the reflection of the horizon line. The effect could be made perfect however by eliminating the horizon line and instead reflecting a solid backdrop. The museum in this case would exist as a building within a 'black box' or would have painted surfaces as opposed to open windows so that the surrounding context of the building is not reflected in the mirrored surfaces, distracting from the illusion of the binary units and the two identical views.

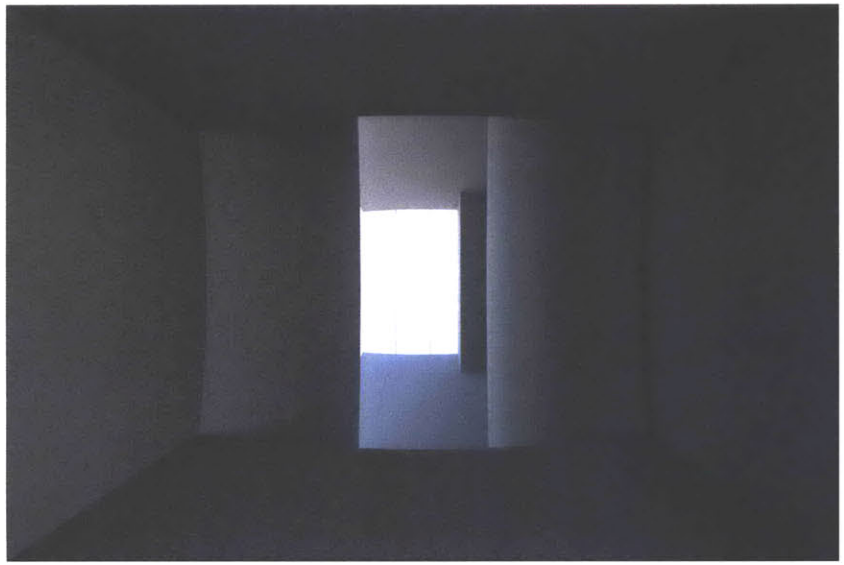


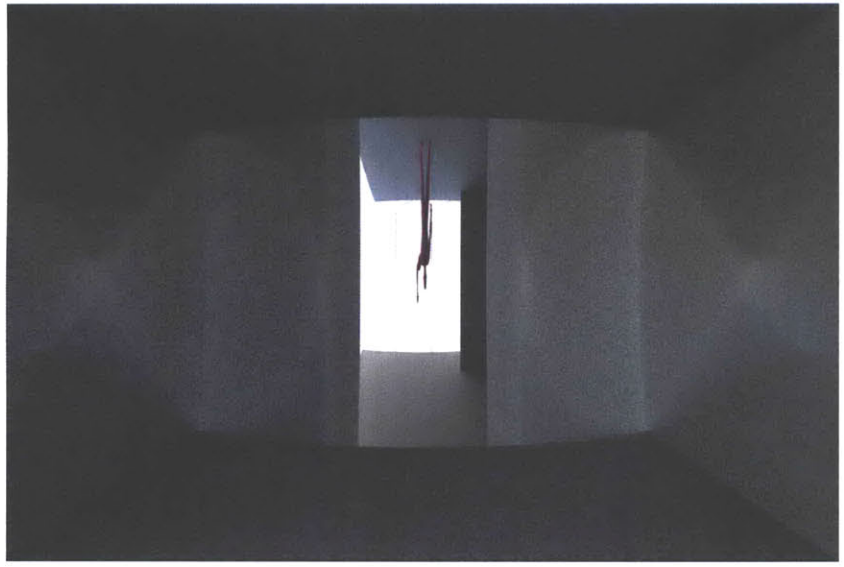




LEVEL 1

LEVEL 2





LEVEL 3

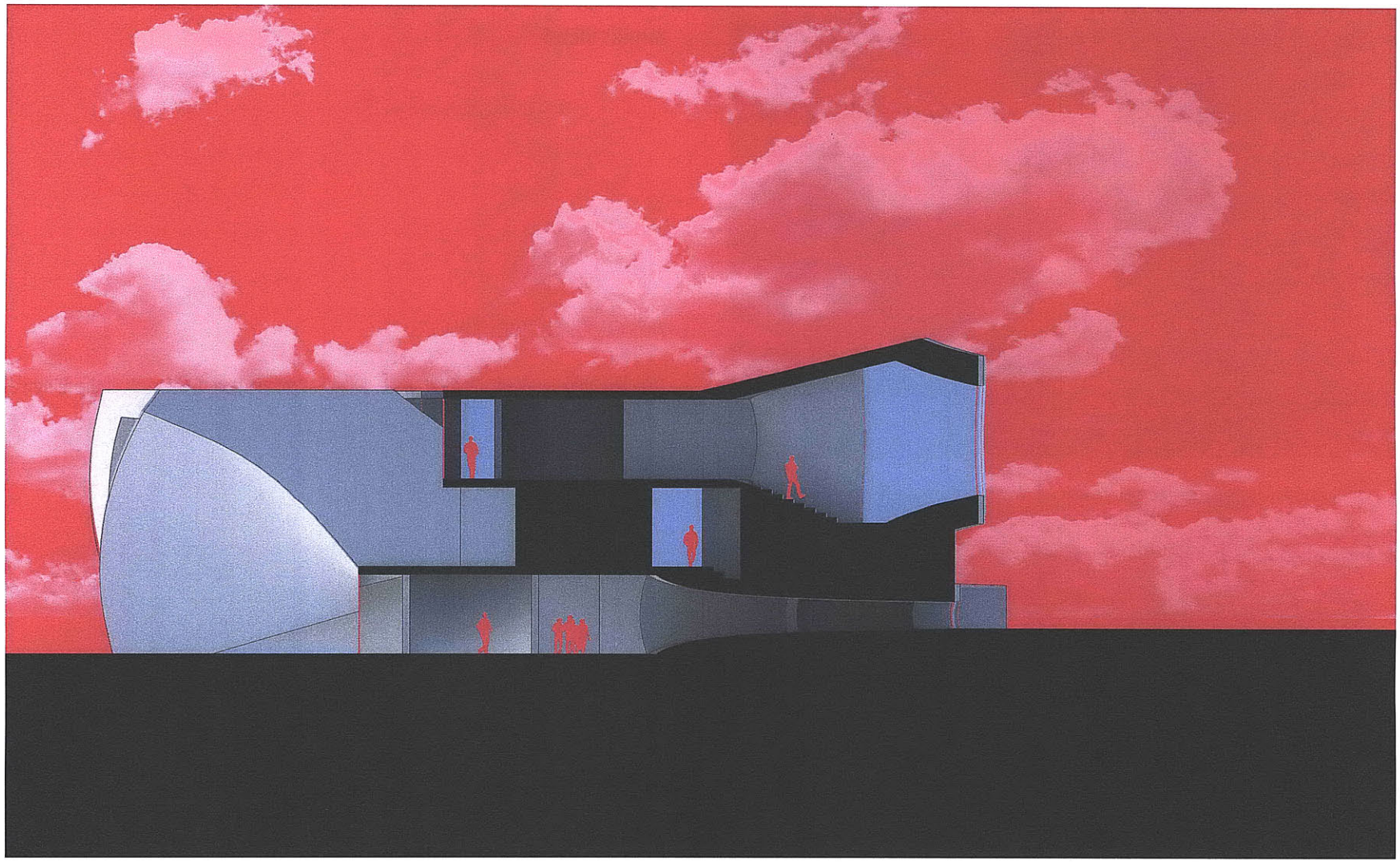
BINARY VIEWS

PHYSICAL, THREE-DIMENSIONALIZED SPACE

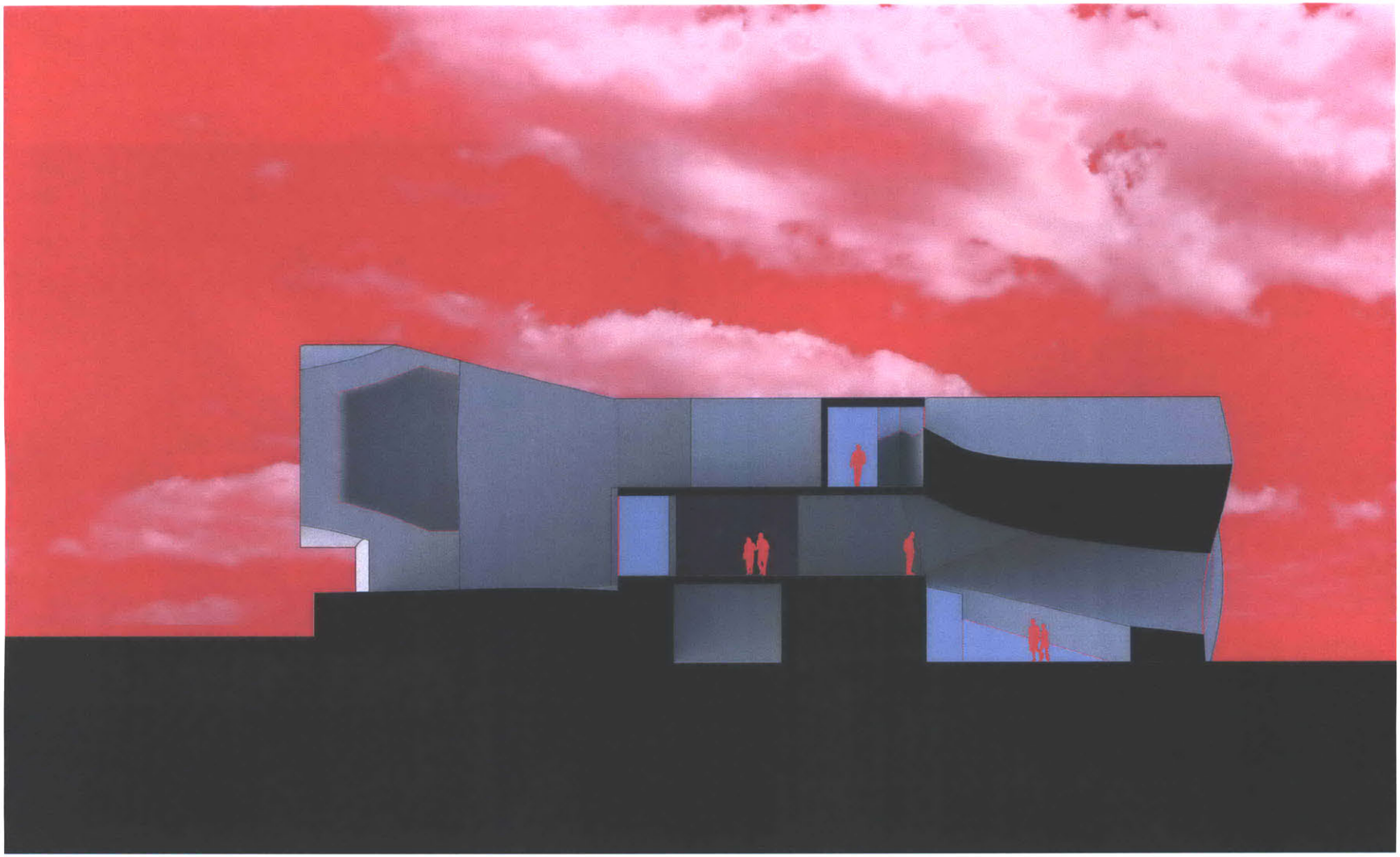
The light qualities of the physical space change in comparison to the view in the mirrored surface.

REFLECTED IMAGE

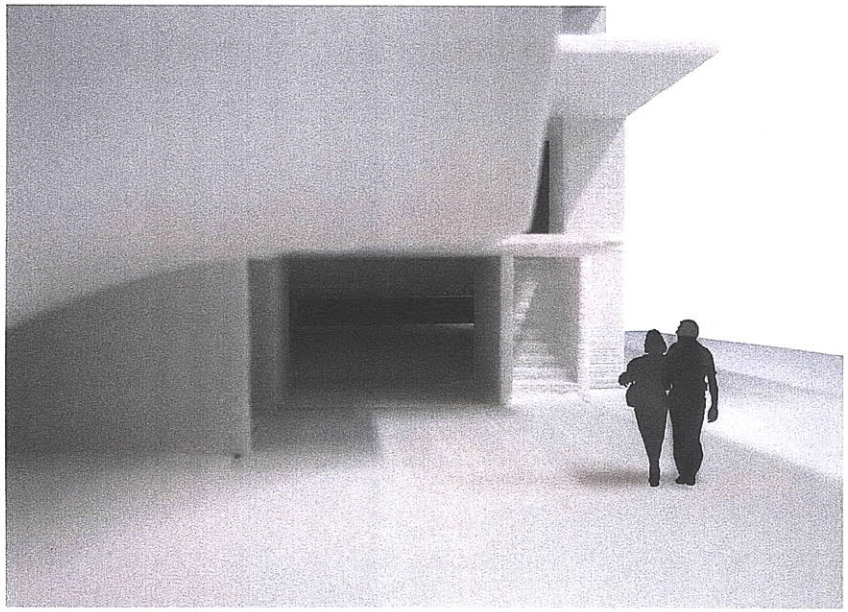
The reflected view shows the distorted image of the viewer within the distorted space.



SECTION 1 : SHOWING FIRST AND THIRD FLOOR THREE-DIMENSIONALIZED SPACES

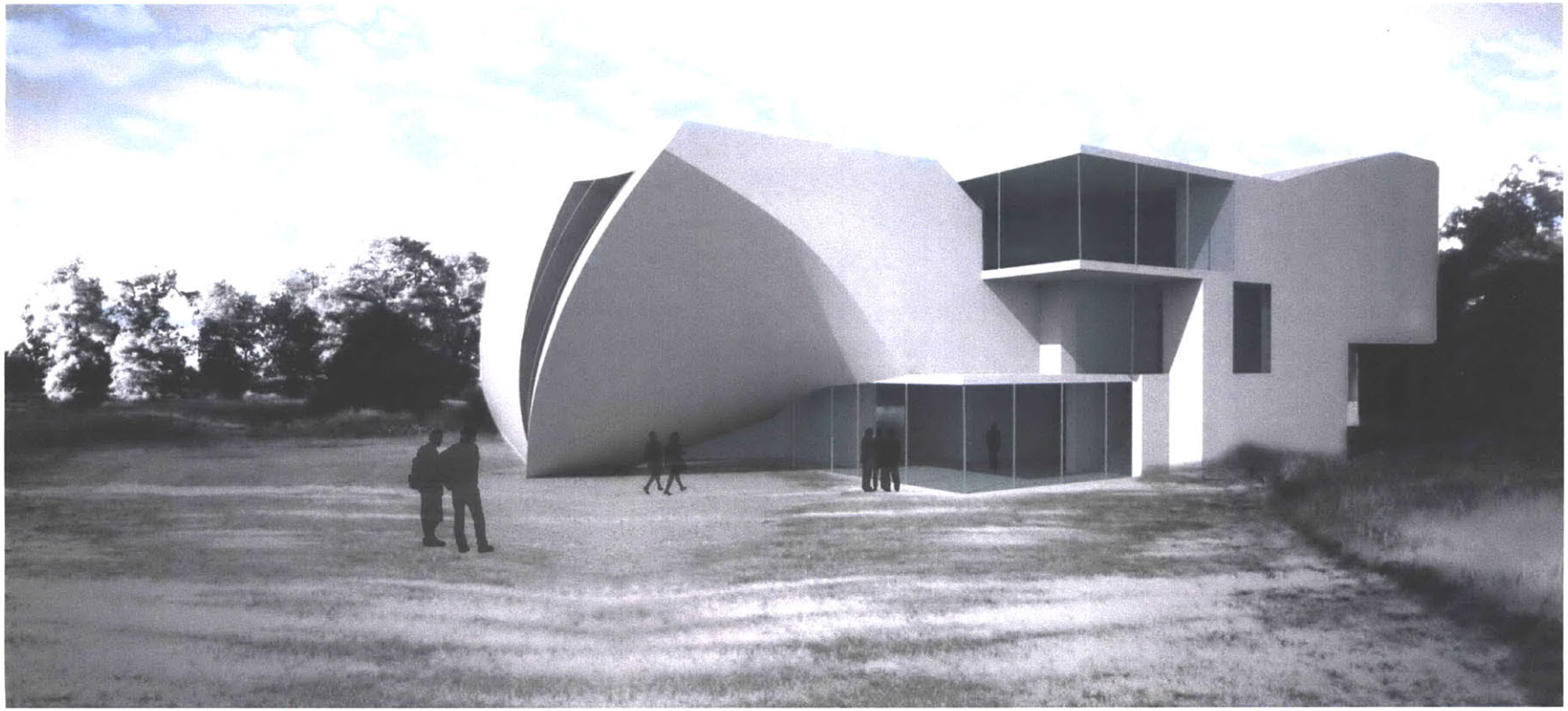


SECTION 2 : SHOWING SECOND FLOOR THREE-DIMENSIONALIZED SPACE

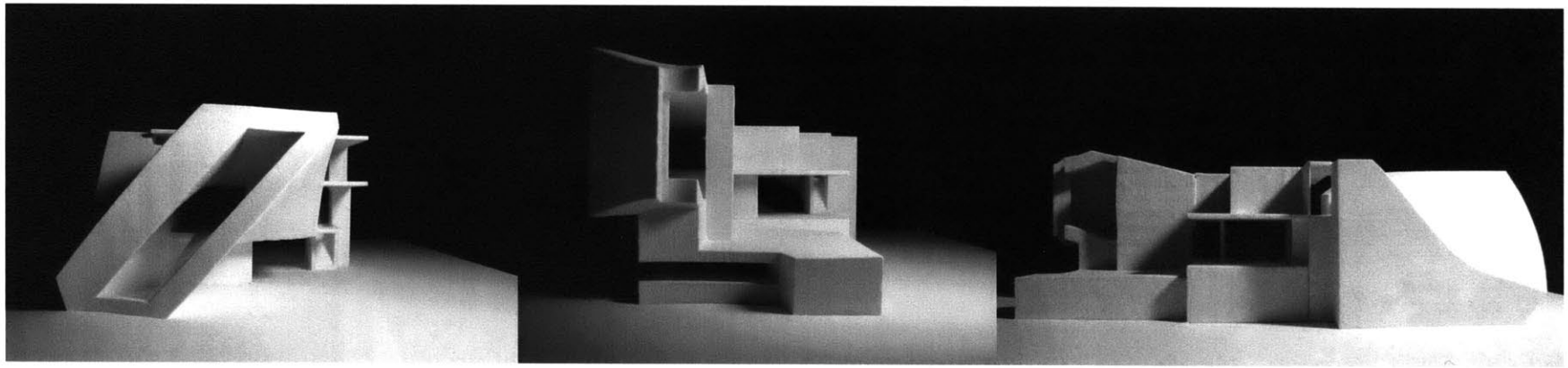


GALLERY ENTRANCE

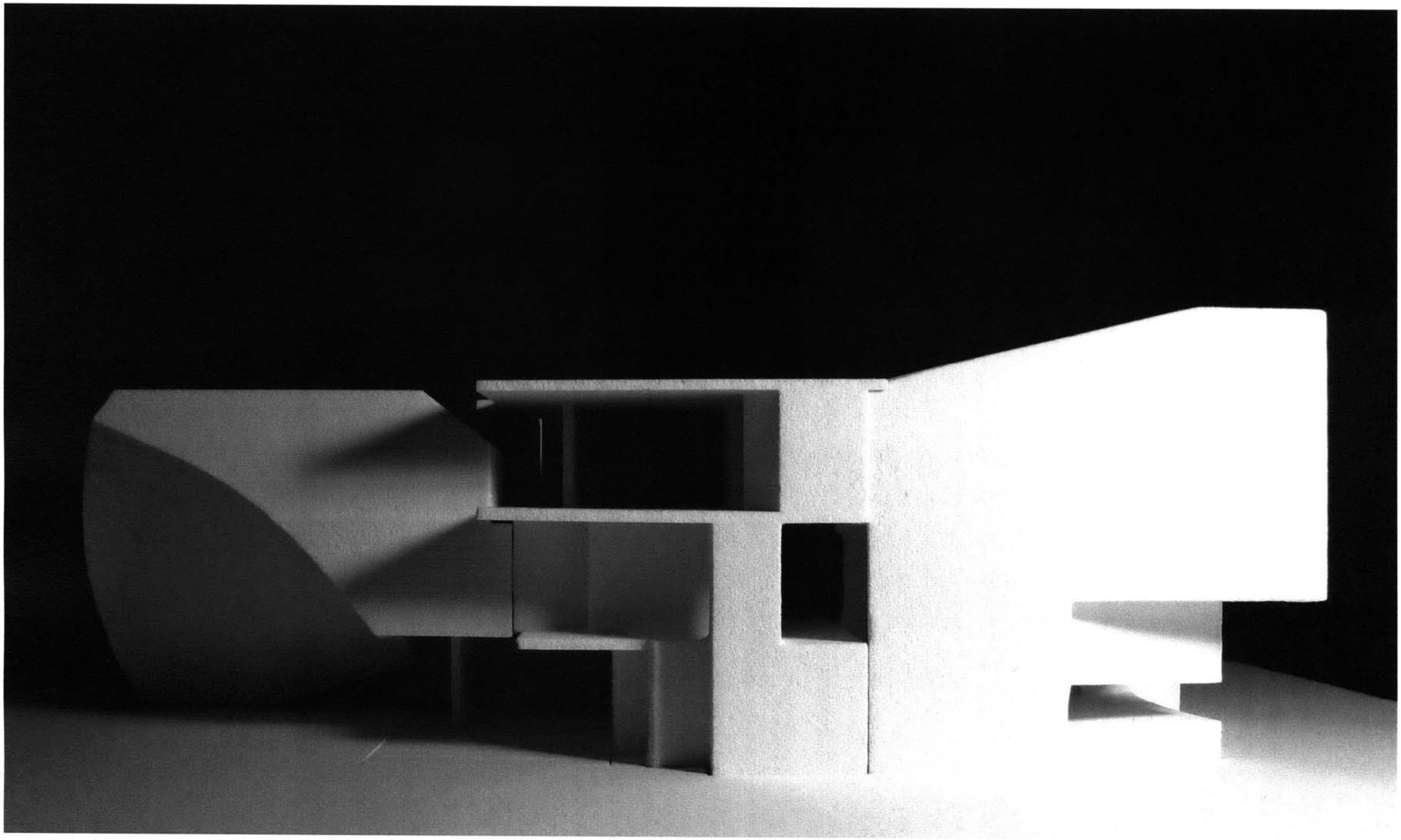
NIGHT VIEW



PERSPECTIVE RENDERING



MODEL IMAGES



BIBLIOGRAPHY

Ateliers Jean Nouvel. Jean Nouvel. November 2010. < http://www.jeannouvel.com/>

Bell, Michael and Jeannie Kim, editors. *Engineered Transparency : The Technical, Visual, and Spatial Effects of Glass*. New York : Princeton Architectural Press, 2009.

Boudet, Dominique and Olivier Touraine. *Verre / Glass Architecture*. Paris: Groupe Moniteur, 2006.

Elkadi, Hisham. *Cultures of Glass Architecture*. Burlington, VT : Ashgate, 2006.

Graham, Dan. *Dan Graham : Architecture*. London : Architectural Association, 1997.

Graham, Dan. *Half Square, Half Crazy*. Milano: Charta, 2005.

Graham, Dan. *Dan Graham : Pavilions*. München : Kunstverein, 1988.

Graham, Dan. *Dan Graham : Works and Collected Writings*. New York, N.Y. : Distributed Art Publishers, 2009.

Herzog & de Meuron, 1978-2002. Tokyo : A+U Pub., 2002.

Mack, Gerhard. *Herzog & de Meuron : das Gesamtwerk / the complete works*. Basel ; Boston : Birkhäuser, 2005.

Mueller Corporation, Vacuum Metalizing. Mueller Corporation. May 2011. <http://www.muellercorp.com/>

Richards, Brent. *New Glass Architecture*. New Haven, CT : Yale University Press, 2006.

Wang, Wilfried. *Herzog & de Meuron*. Basel ; Boston : Birkhäuser, 1998.

Weller, Bernhard. *Glass in Building : Principles, Applications, Examples*. Basel, Switzerland: Birkhäuser, 2009.