

**Mediating Between the Physical and the Virtual Worlds:
A Lecture Hall for the UC Berkeley Campus**

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Submitted to the Department of Architecture on January 19, 1996 in partial fulfillment of the requirements for the degree of Master of Architecture.

Abstract

Cyberspace, Virtual Reality, the Internet: these are the buzz words of the 90's. They represent a layer of non-spatial bits that exists in addition to the known world. These technologies have condensed our physical world by allowing us to communicate independent of space and time. The consequences of these changes are now beginning to impact the built environment. How do we create digitally mediated environments? The virtual world isolates itself easily from the physical world because current virtual reality technology only allows for single user experiences without any possibility for group experiences or face-to-face interaction. How can architecture mediate between the internalized isolation of the digital world and the exterior physical world?

The physical world is characterized by

gravity, limits, tactility, kinesthetic, and orthogonality while the virtual world is characterized by weightlessness, boundlessness, programmability, fluidity, and non-linear time. How might these two worlds coexist? Should they coexist as realms which overlap or where one is contained within the other? Should the physical setting for the virtual play up its weightlessness and boundlessness or should it reveal the very hardware by which such qualities are achieved? If the virtual is ideal and the physical real, to what degree should attributes such as rain, heat, and locale be seen as factors in the design of a virtual environment?

Using a lecture hall on the UC Berkeley campus as a vehicle for exploration, this thesis investigates a mediation between the physical and the virtual worlds. The lecture hall is to

function both for conventional academic lectures and for digital 3D representations. The virtual is placeless but the role of architecture is to make places. This disparity is resolved by employing a strategy of a double-skinned shell where the inside is configured to allow for a seamless and idealized representation of a virtual world, while the outside is layered and distorted according to immediate physical circumstances of the site and the physical environment. In addition to dealing with the very different programmatic requirements of the interior virtual and the exterior physical worlds, the double-skinned shell also accommodates movement of digital screens allowing for an in-between mode where the two worlds can be simultaneously present.

Thesis Advisor: Ellen Dunham-Jones
Title: Assistant Professor of Architecture

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and finally,
in memory of Pommie, wherever you may be.

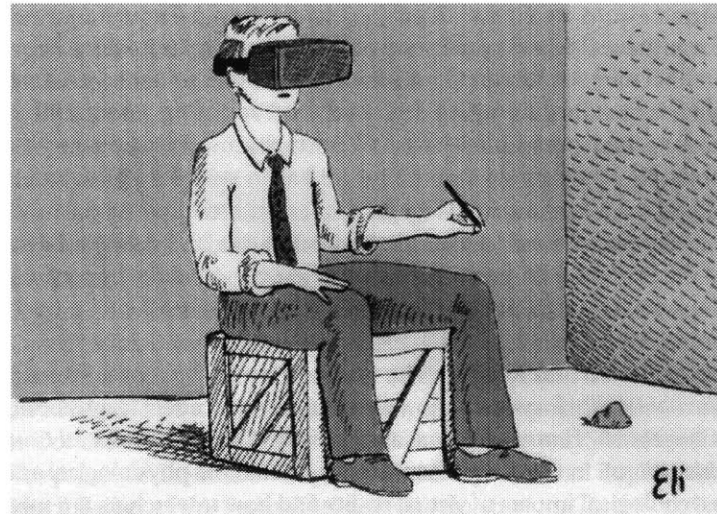
Table of Contents

Introduction	7
Virtual Technologies	11
Virtual Interior	17
Plans and Sections	35
Physical Exterior	41
Appendix A: Criticism and Suggestions	51
Appendix B: Design Process	55
Two Lecture Hall Scheme	57
Eye Shaped Scheme	59
Theater Overlay Scheme	61
Mastercard Scheme	63
Transforming Egg Scheme	65
Dome-in-a-Box Scheme	67
Illustration Credits	71
Bibliography	73

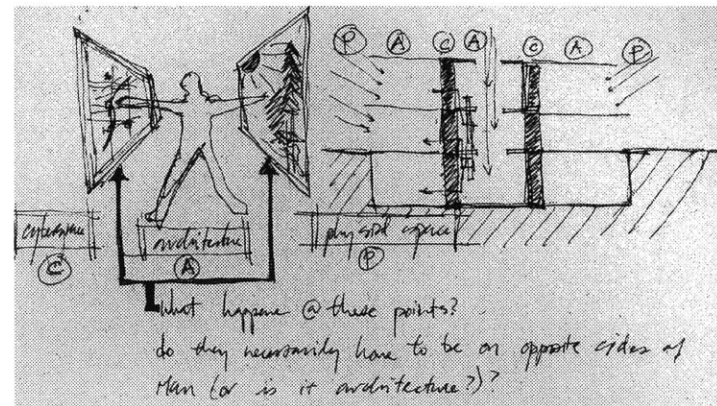
Introduction

The emergence of new forms in communication has begun to change the way we live and work. Technologies such as virtual reality, digital telecommunications, the Internet and the Information Superhighway are creating a new world that allows mankind to communicate without being confined by physical space. This new world of non-spatial bits is beginning to affect more than just communications. The implications of the technology are now beginning to impact the physical world that we inhabit; our perception of the built environment will begin to change (fig. 1). How will architecture change in the new context of an emerging digital virtual world?

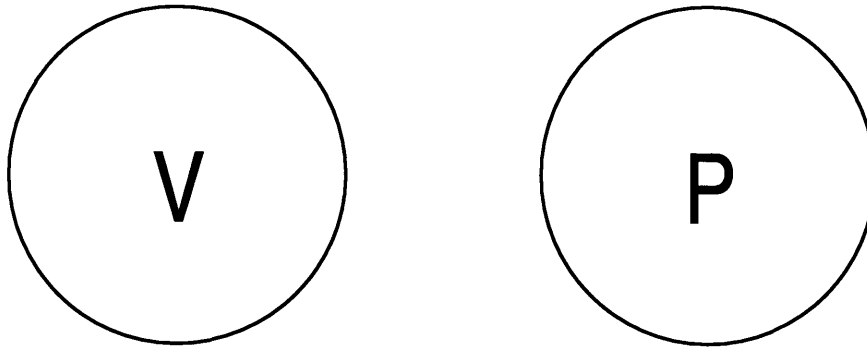
This virtual world is characterized by weightlessness, boundlessness, fluidity, programmability, non-linear time and black light, whereas the physical world is characterized by gravity, limits, orthogonality, kinesthetics, tactility, and white light. In both the virtual and physical worlds, light is a phenomenological characteristic. The virtual black light reveals materials through the emission of light, while the physical white light reveals materials through the reflection of light. A television screen, for example, is



1. The virtual office?

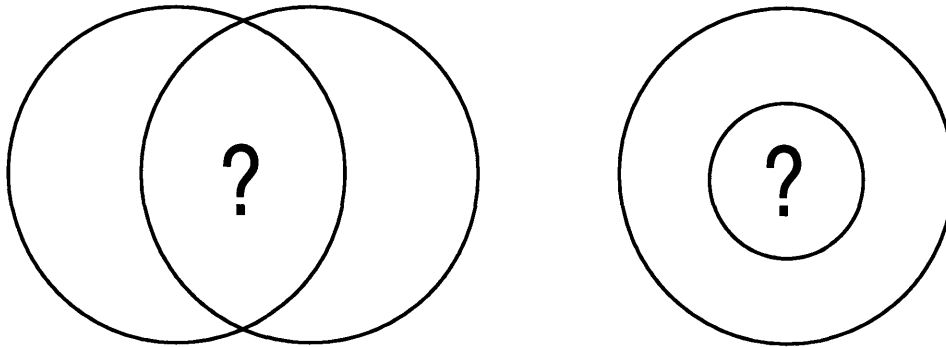


2. Initial sketch establishing a relationship between the virtual, man and the physical.



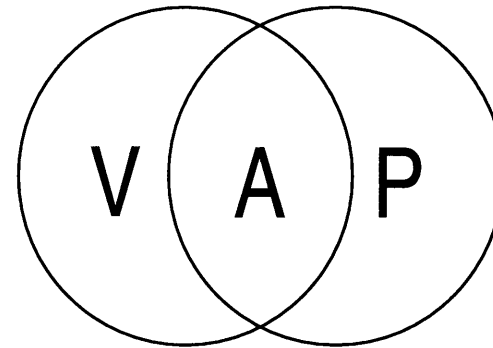
3. The virtual world and the physical world are separate.

black light whereas natural sunlight is white light. By the nature of their characteristics, the two worlds are opposites and consequently, they are currently treated as two completely separate and isolated worlds; the virtual is self-contained and makes no reference to the physical (fig. 3). However, the new technologies are combining the two worlds and blurring the boundary between them. If the two worlds are no longer distinct separate entities, how should they relate to each other? Should they overlap or should one be contained inside the other (fig. 4)?

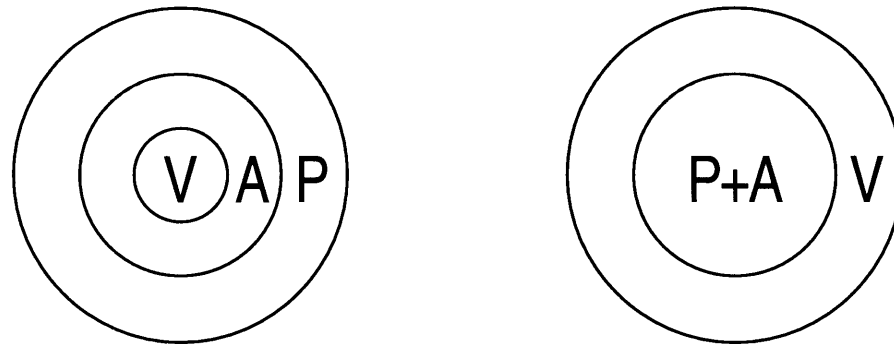


4. Should the two worlds overlap or should one contain the other?

Since the virtual world and the physical world are already merging together, the challenge is to create an environment that is neither dominated by the “black box” technology of the virtual or the phenomenological elements of the physical, but to create a new world that has a mutual symbiotic relationship between the physical and the virtual. I propose that architecture will be used as a means of mediating between the two worlds (fig. 5). But within this mediation, the virtual will be contained within the physical because of the opposing characteristics inherent to each world. The architecture then mediates between the inside and the outside (fig. 6).



5. The VAP Diagram. When the virtual and physical worlds merge, architecture will be used to mediate between the two worlds.



6. From the perspective of the physical world, the virtual will be contained within architecture which is contained within the physical because of their inherently opposing characteristics (left). But from the virtual perspective, the architecture and physical disappear into the virtual (right).

Virtual Technologies

There are many different ways one can experience the virtual world. The most common means is through the Internet via keyboard and screen (fig. 7). Millions of people are hooking up through the use of computers. “The best aspect of the Internet has nothing to do with technology. It’s us. Getting in touch is more fun than the coolest computer game or the hottest information” (Levy 27). Although we may be getting in touch more often, the quality of the contacts has diminished. “The more that the use of computers is demanded of us, the more we shall be taken away from truly deep human experiences” (Brook 124). “The more you interact not with something natural and alive, but with something electronic, it takes the sense of the earth away from you...” (Brook 126). Although the computer allows people to communicate across great distances, the quality of the communication is only a simulation of an embodied experience.

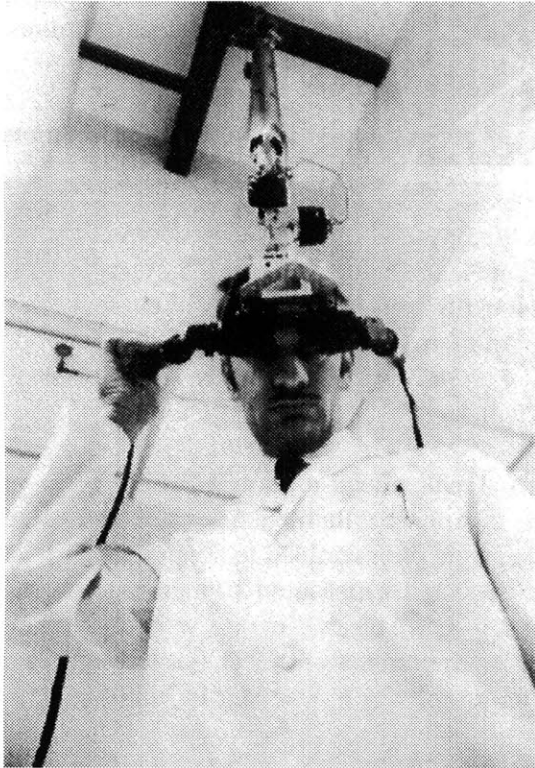
Another popular means of experiencing the virtual world is through virtual reality technology. Virtual reality is a way for humans to visualize, manipulate, and interact with computers. The computer controls what you sense and you in turn



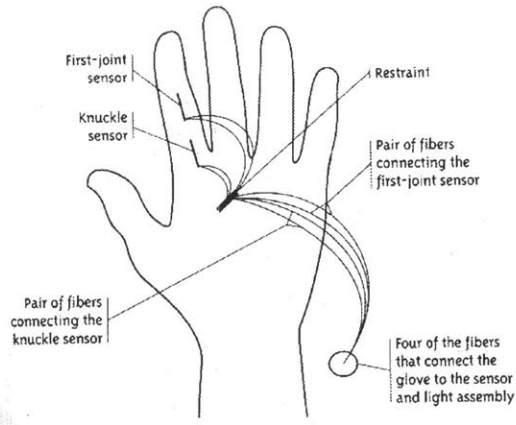
7. A typical cluster of computer terminals.

8. W Industries' Visette. One of the most widely available headmounted device.

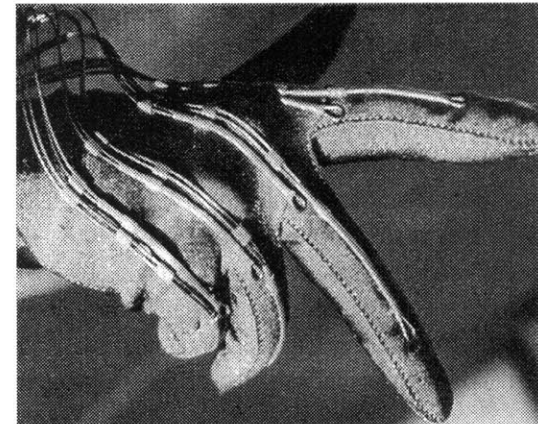
9. Sutherland's Sword of Damocles. A headmounted device with a mechanical position tracker.



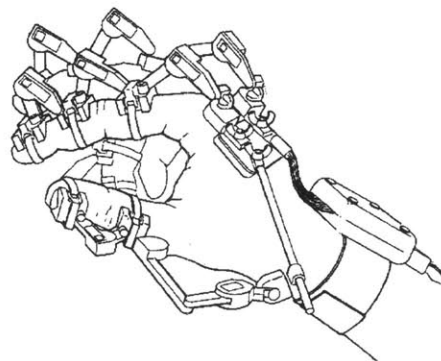
control the computer (Aukstakalnis 7). The most common virtual reality equipments are head mounted devices (HMD), DataGloves, DataSuits, Cave Automatic Virtual Environments (CAVE), electronic wands and force feed-back mechanisms. The HMD's are helmets that track your movement to allow you to see and hear the virtual world (figs. 8,9). The first HMD's were heavy and cumbersome but with recent improvements in the technology, the helmets have become lighter and the realism of the virtual experience has increased. However, one still needs to wear some form of head gear in order to experience the virtual world. DataGloves are gloves lined with sensors which tell the computer where your hand is located and how it is moving (figs. 10-12). The gloves allow you to see and grab objects in the virtual world but you can not experience the sensation of grabbing the ball unless there is a force-feed back mechanism attached to the glove. Such combinations are few since the force feed-back mechanism is large and cumbersome (fig. 13). The DataSuit employs the same technology as the DataGlove except the sensors cover your entire body so that your every movement can be tracked by the



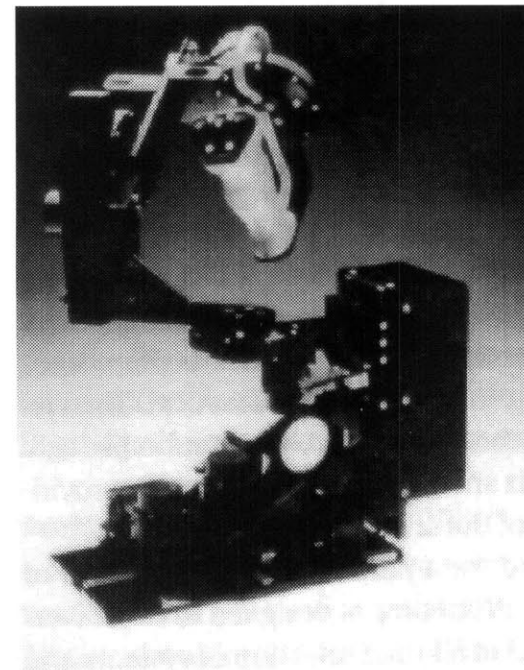
10. A Dataglove exploded view.



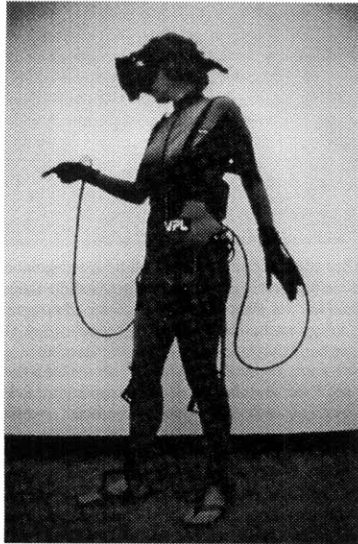
11. A DataGlove showing the wired sensors.



12. Functional diagram of the Dexterous Hand Master.



13. The PER-Force Handcontroller.



14. A Datasuit

15. Sometimes the interfaces are combined to heighten the virtual experience. Here, a head-coupled stereoscopic display is used in conjunction with a DataGlove.

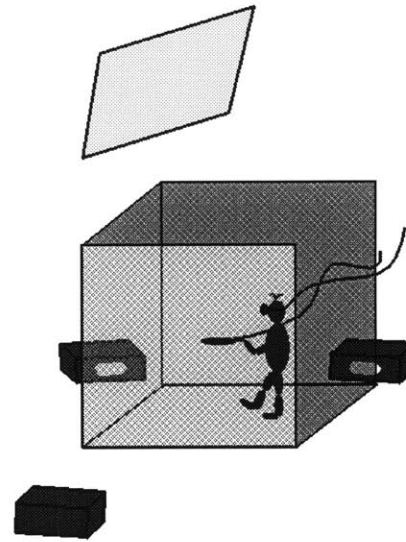


computer (fig. 14). CAVE's are small cubicles which have stereoptic images projected onto five of the six sides of a cube. The user wears stereoscopic glasses and uses an electronic wand to maneuver through the virtual world (fig. 16,17).

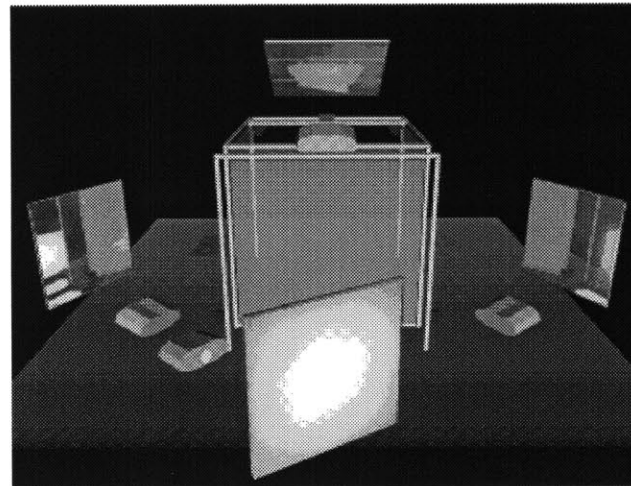
Each of these devices allows the user to experience and interface with the virtual world but they lack two criteria. First, there is no face-to-face interaction and second, there is no possibility for a group experience. The lack of face-to-face human interaction is one of the downfalls of the technology. "What happens is that you get more and more inhuman relationships" (Brook 125). The value in being able to talk to a person face-to-face and to see the expressions on their face or to read their body language is lost when a user has to put on prosthetic devices, such as helmets, gloves or suits, in order to enter into the virtual world. These geared up humans are interacting with machines and not other humans. "...Virtual technologies are pernicious when their simulacra of relationships are deployed societywide as substitutes for face-to-face interactions, which are inherently richer than mediated interactions" (Brook vii). The other problem

with these technologies is that the user is restricted to have an isolated physical experience. None of the technologies allow for a multi-user experience. If you are using a HMD, you will not be able to communicate with a person standing next to you unless they also had a HMD as well, in which case they would still be communicating through a computer as opposed to face-to-face.

These devices also cause a unique form of motion sickness commonly referred to as visually induced motion sickness (VIMS) which is almost exactly the opposite in cause from normal motion sickness. VIMS occurs because the user is unable to orient themselves between the physical and the virtual worlds; the visual cues tell you that you are moving but the motion sensors in your inner ear tell you otherwise (Aukstakalnis 263). The lack of face-to-face interaction and group experience, the need for prosthetic devices, and the disorientation amount to an unsatisfactory means of experiencing the virtual world.



16. Diagram of a CAVE system.

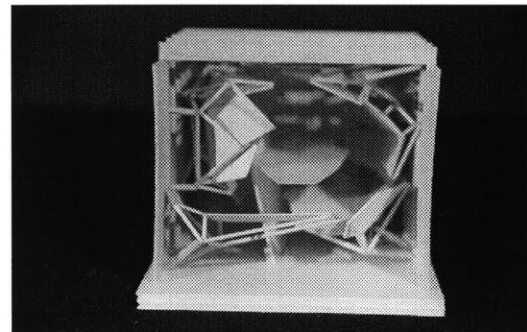
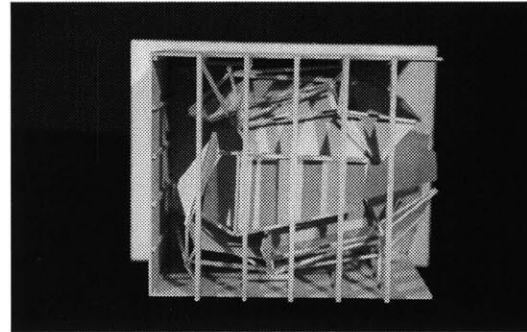
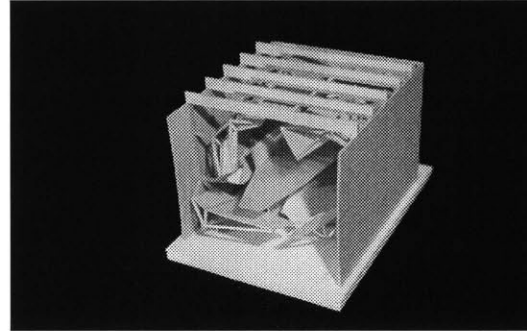


17. Perspective view of a CAVE system.

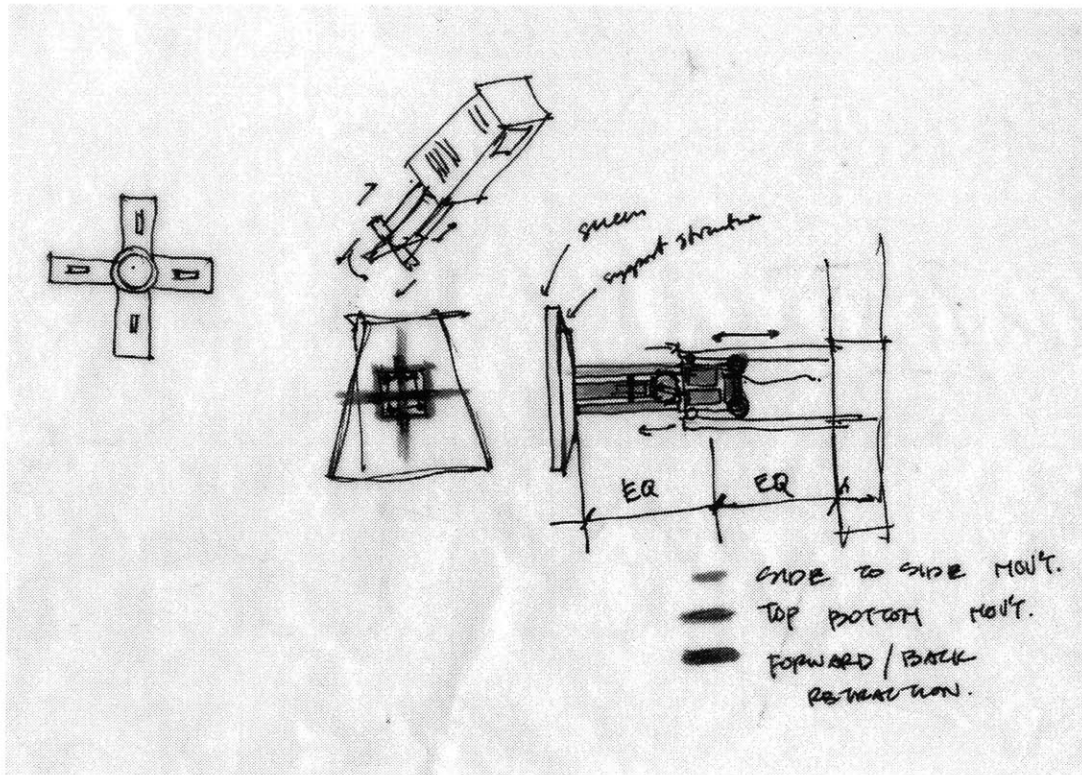
Virtual Interior

How can one experience the virtual world without the use of prosthetics? How can one maintain the valuable face-to-face interactions yet still be part of the virtual world? How does one provide for a way to experience the virtual and yet be orientated to the physical world in which the user is bound to? These questions started the investigation of how architecture can mediate between the two worlds.

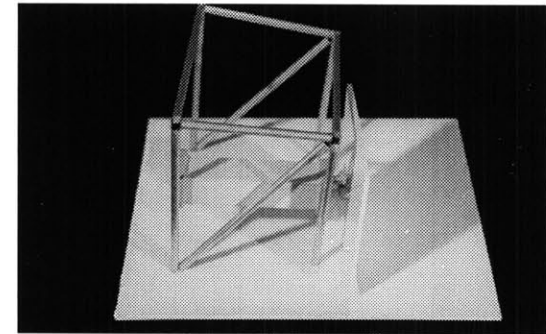
An initial concept model was made to visualize the intent of the design (fig. 18). The imagery used was that of a surf board surfing its way through a wave of moving screens. The model displays a central platform surrounded by screens of varying sizes in varying positions and combinations. The idea is that the people on the platform would have screens flying around them. In this case, instead of the users wearing prosthetic equipment, it is the environment that changes into the virtual.



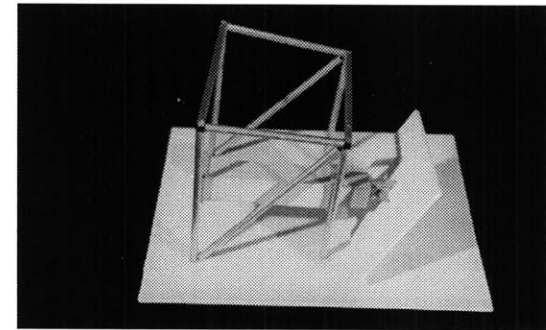
18. Photos of initial conceptual model.



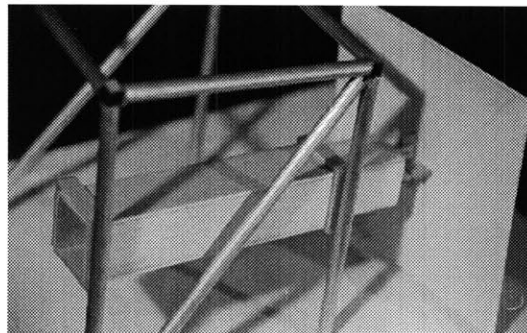
19. Sketch of screen mechanisms.



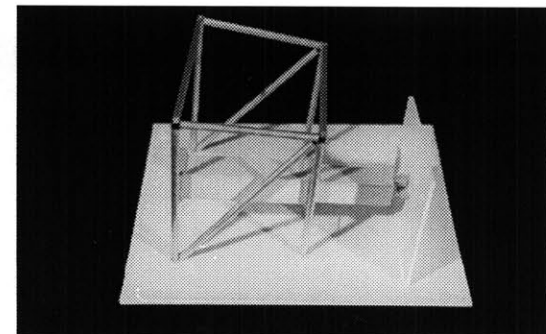
21. Study model of screen mechanism, fully retracted.



22. Study model of screen mechanism, screen tilted.



20. Study model, close up.

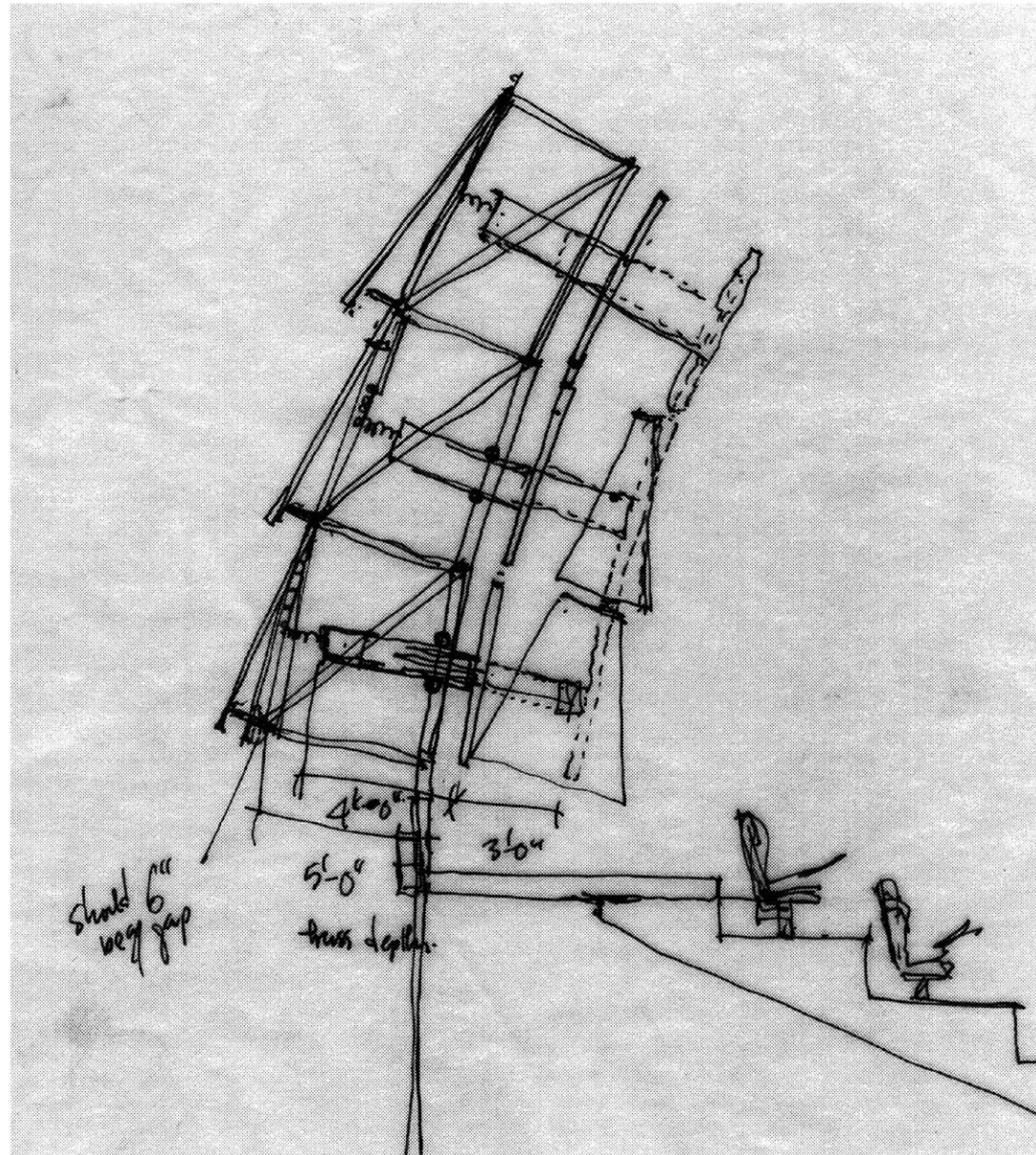


23. Study model of screen mechanism, fully extended.

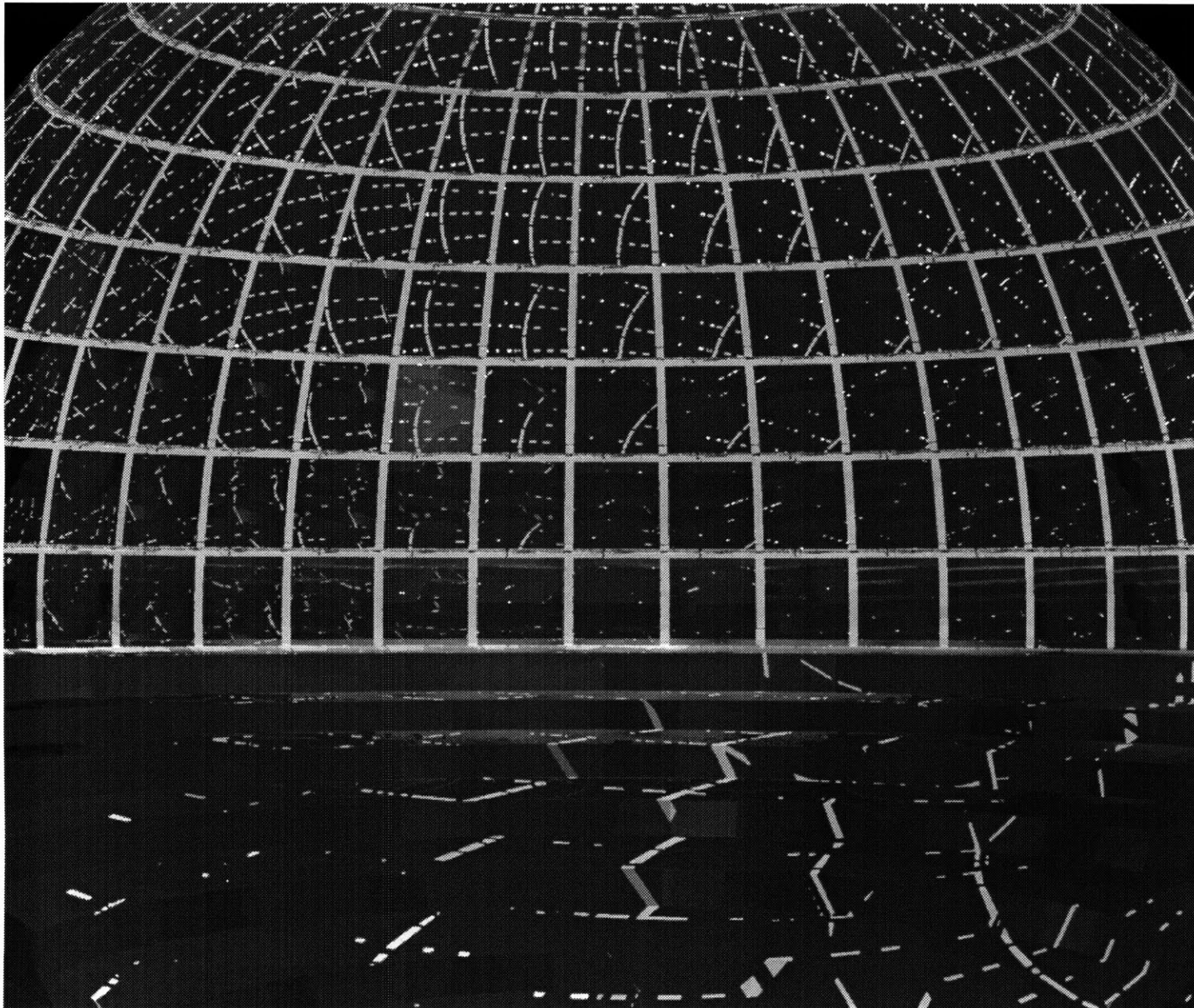
The final scheme for the lecture hall is a circular arena covered by a series of trapezoidal LCD screens arranged to create a dome. There are eight basic trapezoidal shapes which are repeated forty times around to enclose the dome thus making a total of 320 individual screens. The dome symbolically represents the existence of the virtual world (figs. 39-42).

Behind each screen is a mechanism that moves the screen in and out as well as allowing it to tilt up, down, left and right. This gives each screen three degrees of freedom in its movement (figs. 20-23). The movement of the screens addresses the fluidity and programmability characteristics of the virtual, as well as acting as a means to orient the user to their new environment by controlling the amount of light that enters the lecture hall.

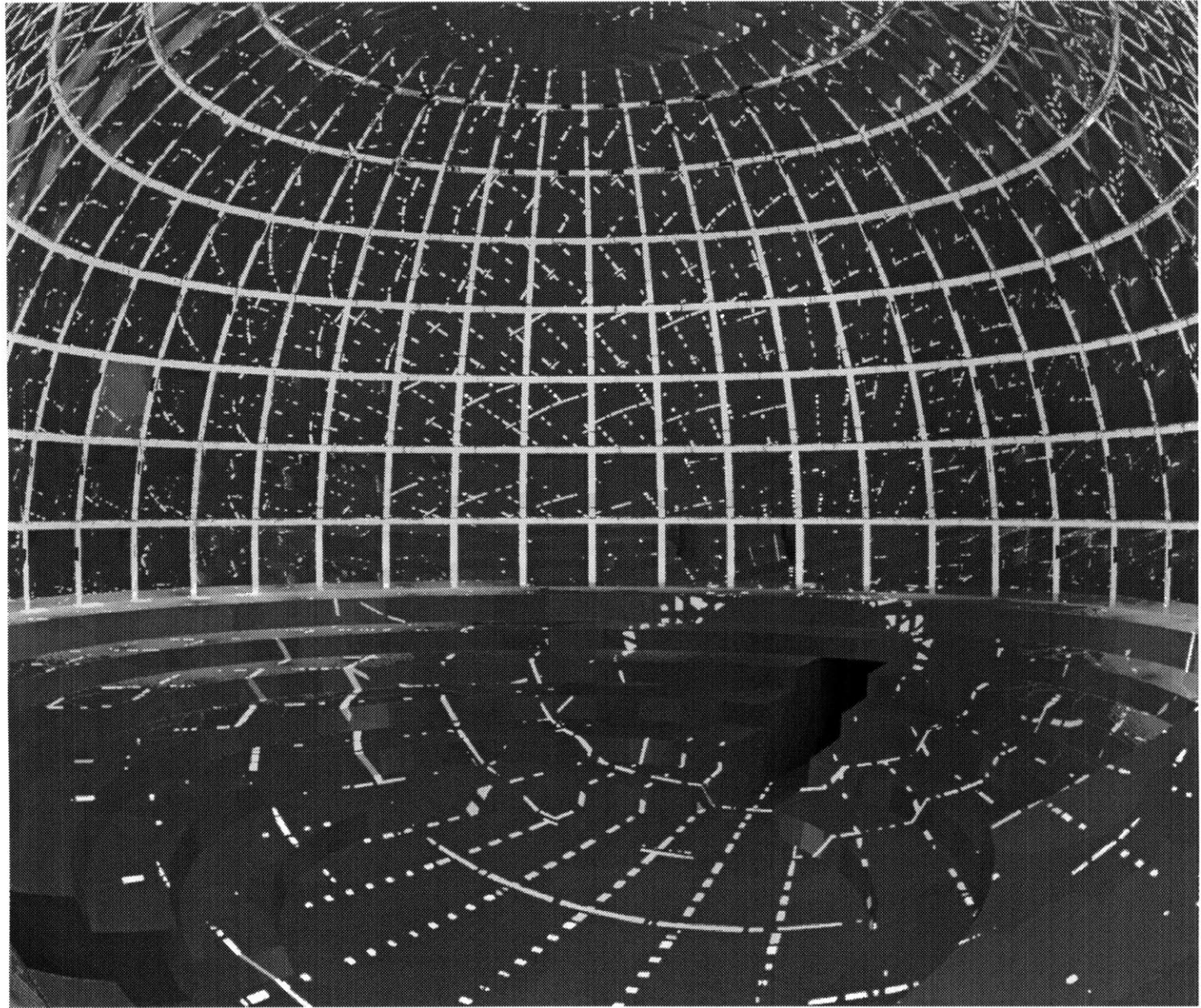
Upon entering the lecture hall, the screens are fully retracted which allows filtered natural light to illuminate the hall. When the lecture begins, the screens move inward, consequently sealing the inside from the outside. Therefore, the people inside the hall become aware of the transition between the two worlds; the natural physical white light becomes replaced with artificial virtual



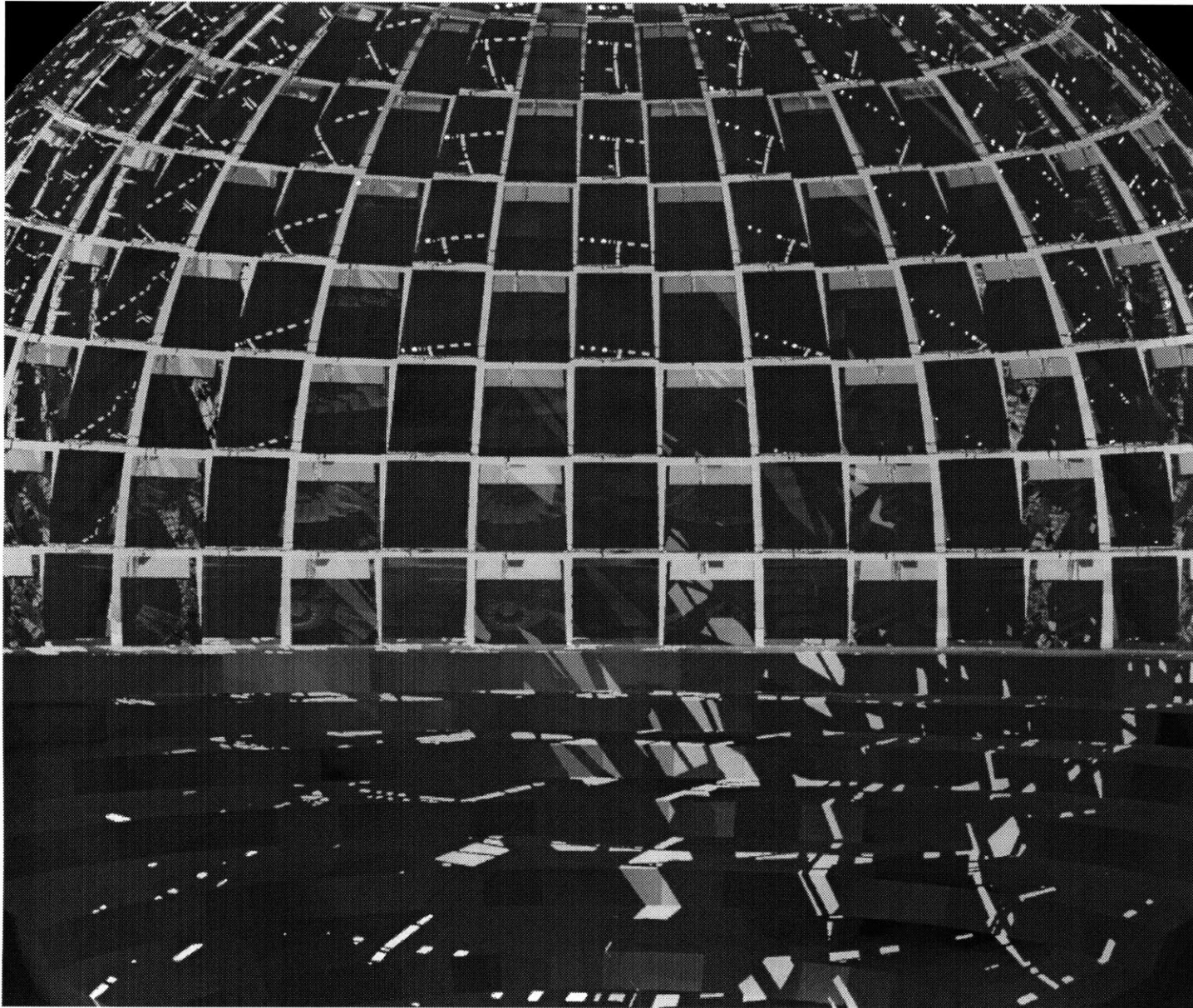
24. Section sketch of screen mechanisms, structure and seating.



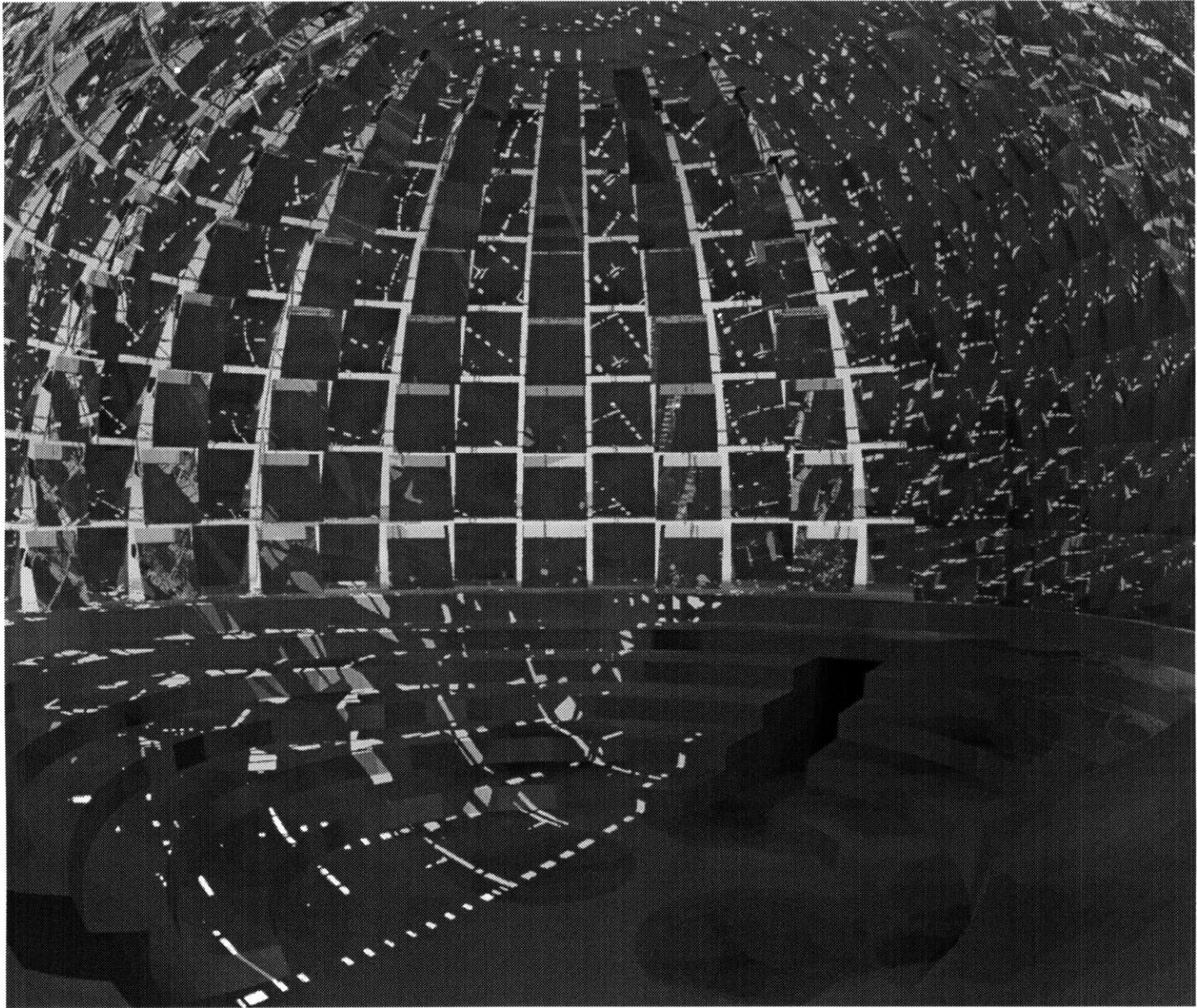
25. Interior perspective of Lecture Hall from the lectern with screens fully retracted.



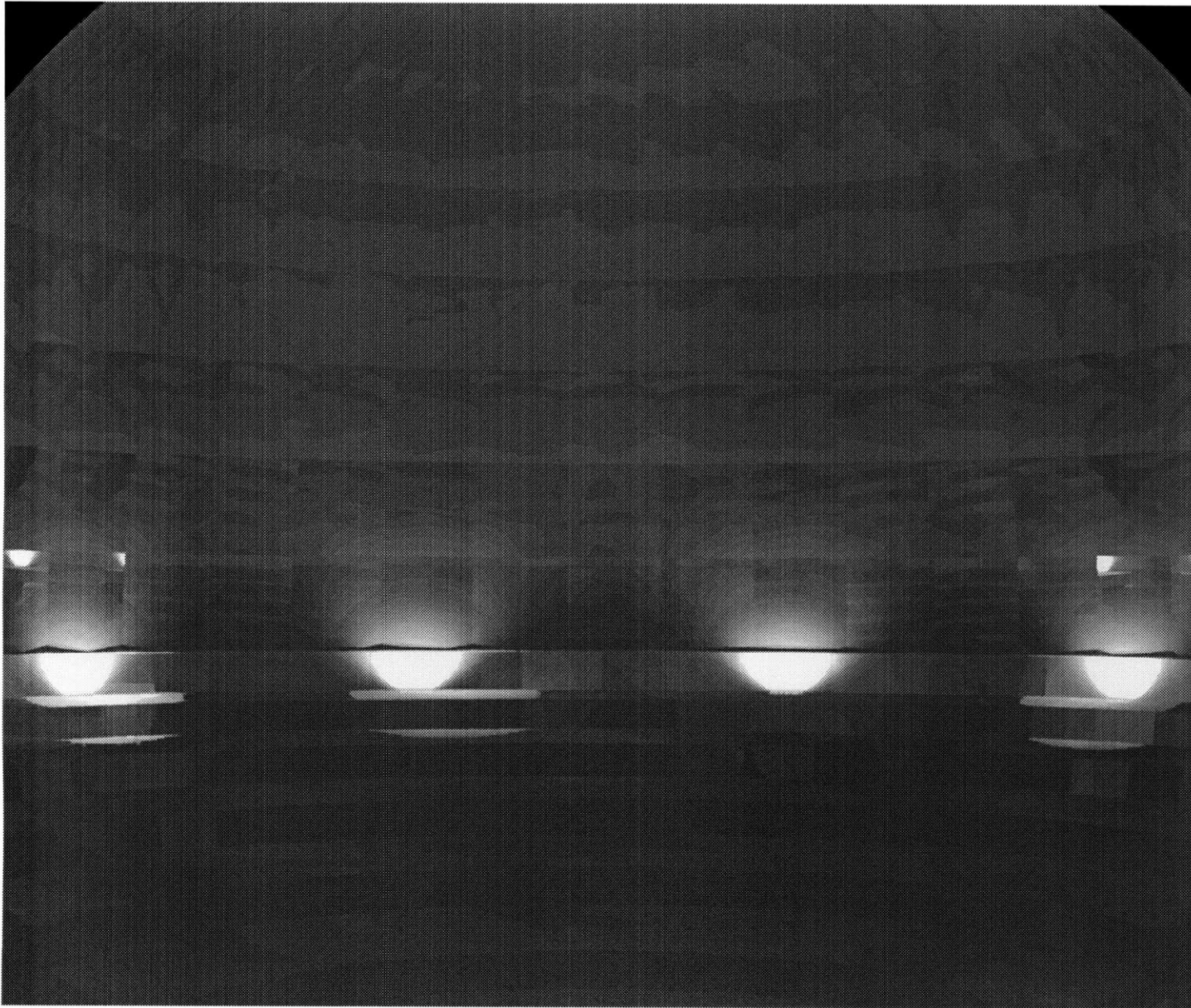
26. Interior perspective of Lecture Hall from upper seats with screens fully retracted.



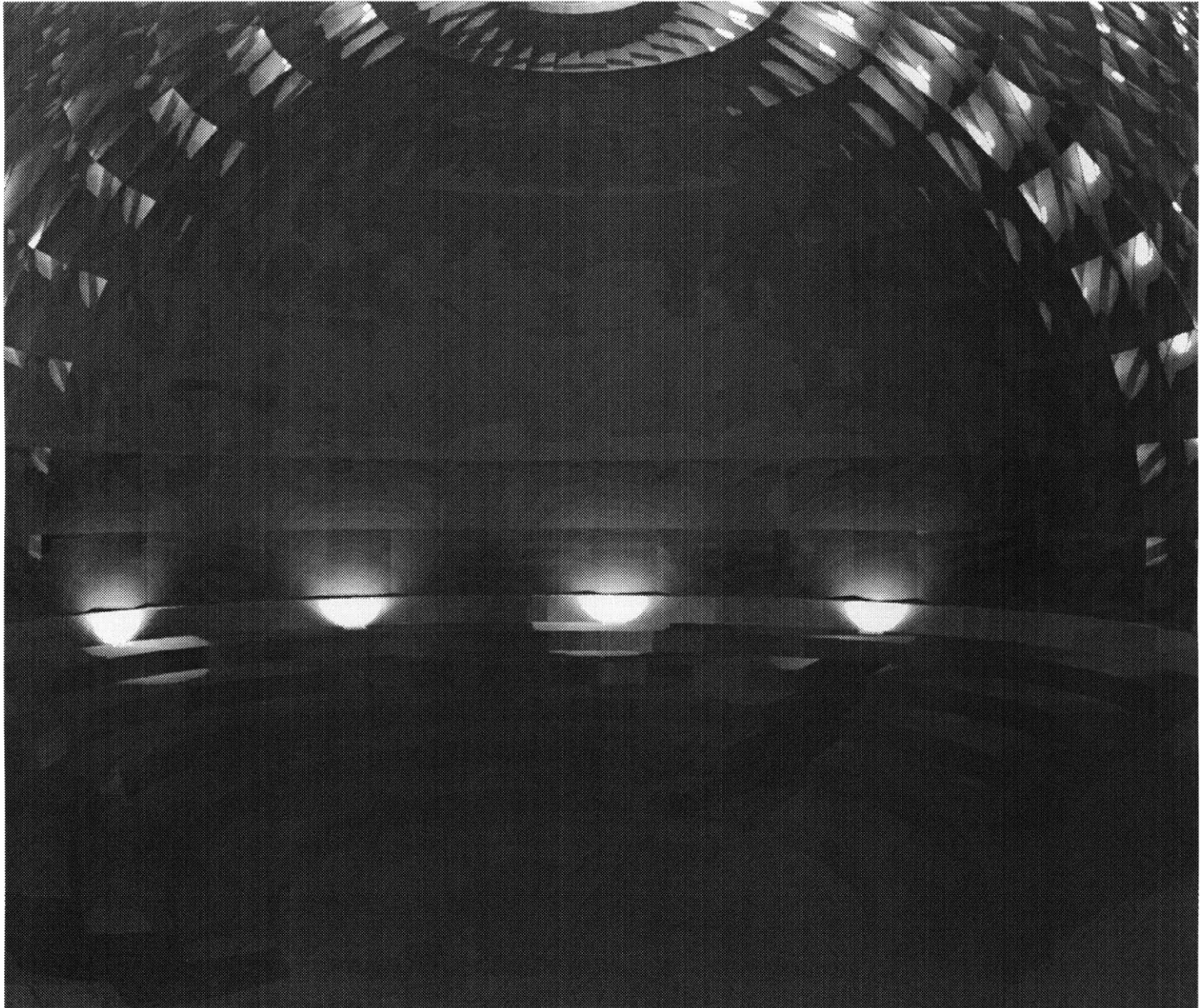
27. Interior perspective of Lecture Hall from the lectern with screens half open to allow natural light to filter through the space.



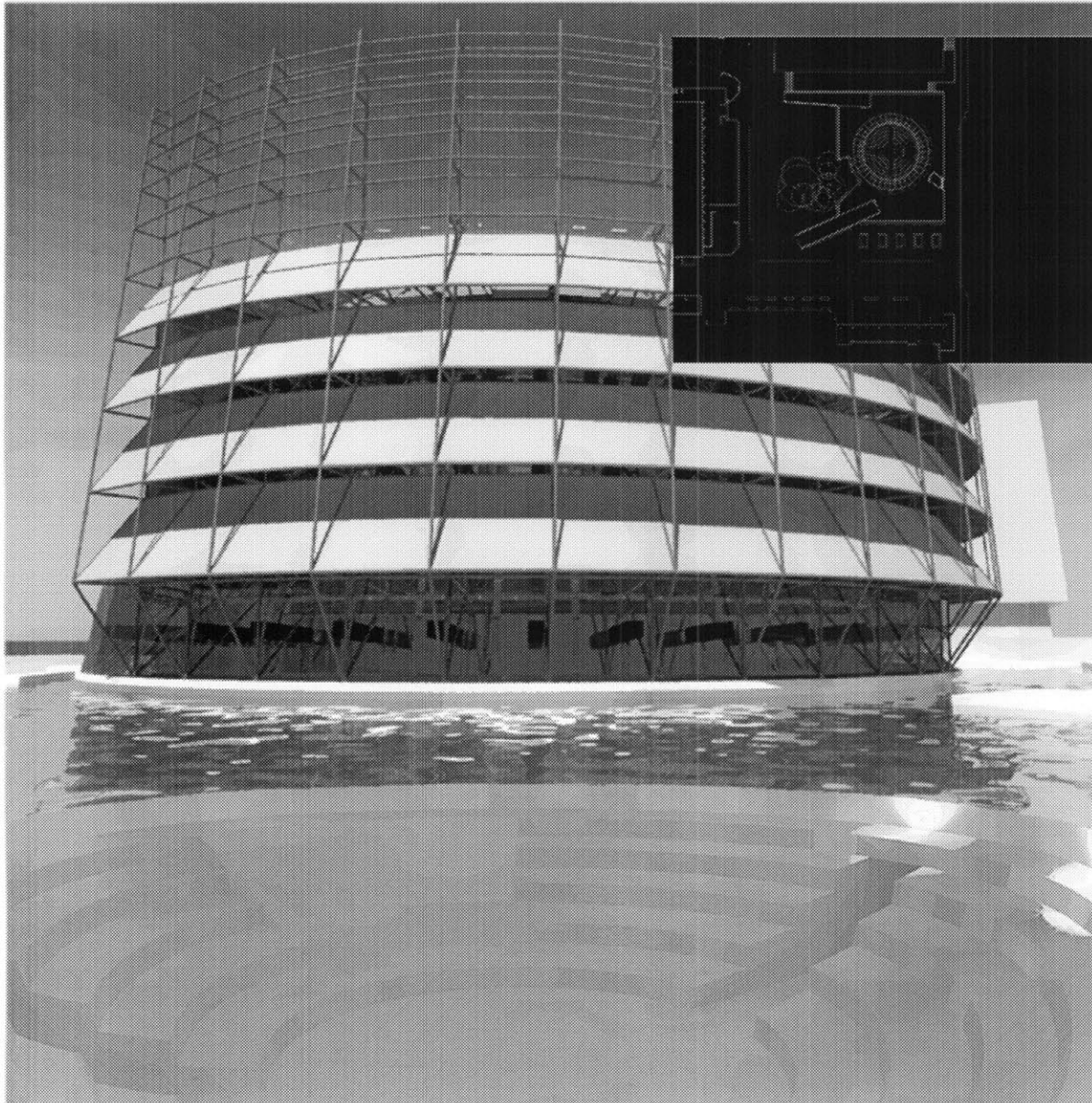
28. Interior perspective of Lecture Hall from upper seats with screens half opened to allow light to filter through the space.



29. Interior perspective of Lecture Hall from the lectern with screens closed.



30. Interior perspective of Lecture Hall from upper seats with screens closed.



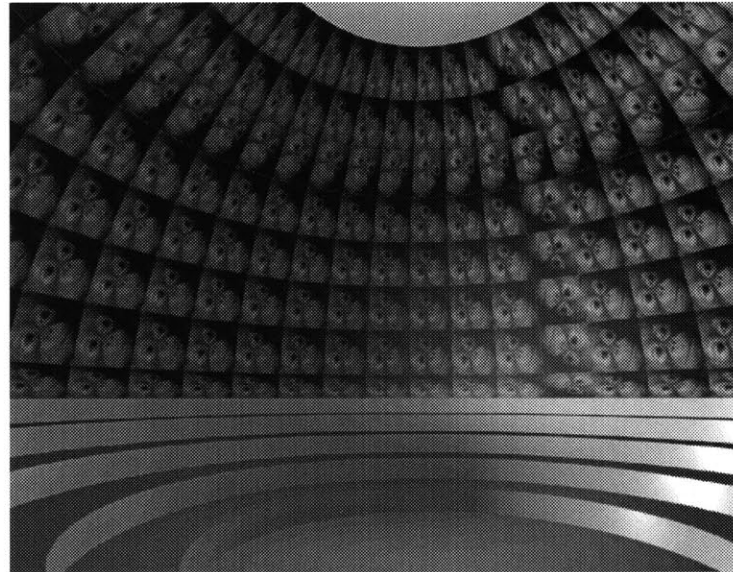
31. Interior perspective of Lecture Hall with seamless image of the building exterior with a window of a plan view displayed on the screens.

black light (figs. 25-30). The screens can also be programmed to allow natural light to filter through one section of the dome allowing the other side to be used for displays.

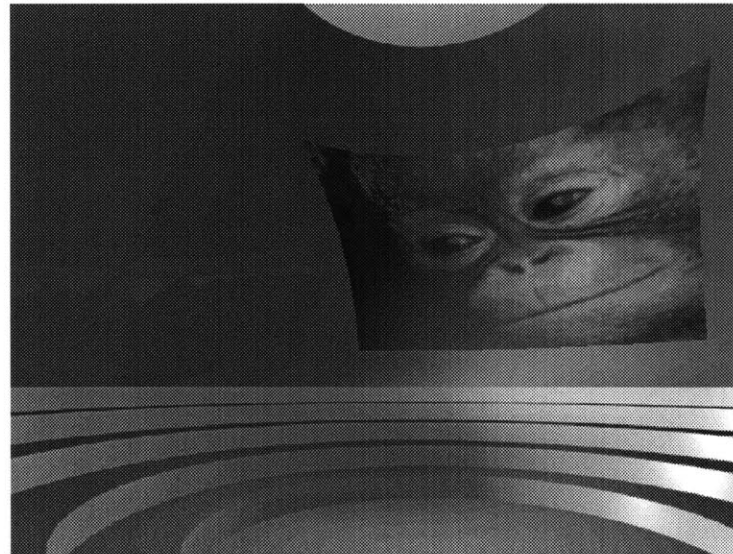
The lecture hall is used for any type of lecture that requires the use of a virtual environment. It is assumed the primary purpose of the lecture hall is to be used for virtual walk-throughs of architectural spaces, but it can also be used to display molecular models, mathematical models, or used to visualize a virtual wind tunnel. The screens can be programmed to be used individually or together in various combinations to produce larger images (figs. 31-33).

Along the base of the dome is a ring which forms a horizon line between the dome and the seating area. This horizon line contains all the necessary equipment such as acoustical paneling, speakers, sensors and lights necessary to supplement the virtual experience. It also serves as a visual cue to orientate the user since the same horizon line is experienced upon entering and leaving the lecture hall (figs. 34-36).

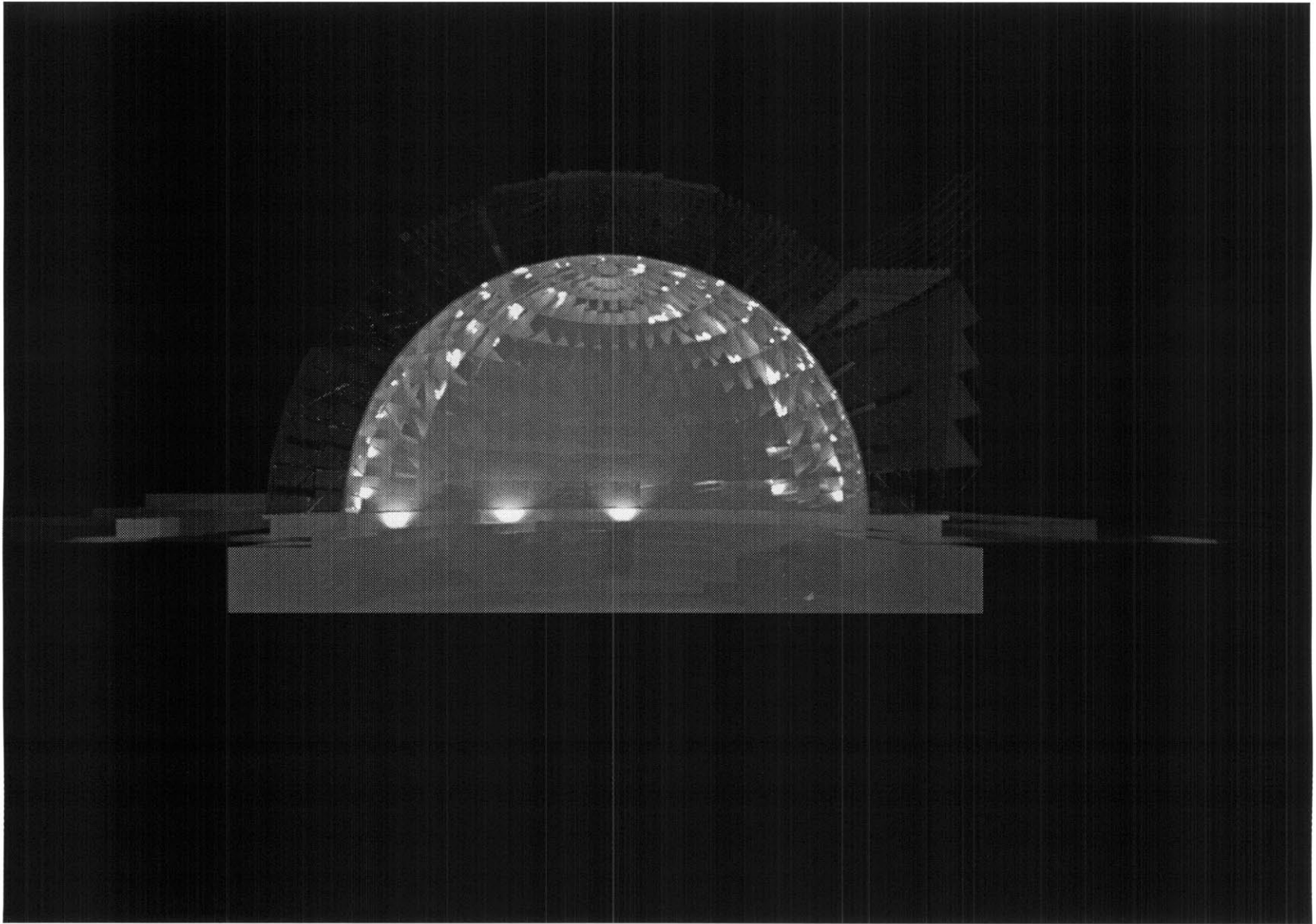
Below the horizon line, the downward stepping seats are arranged in concentric circles to ensure that each person



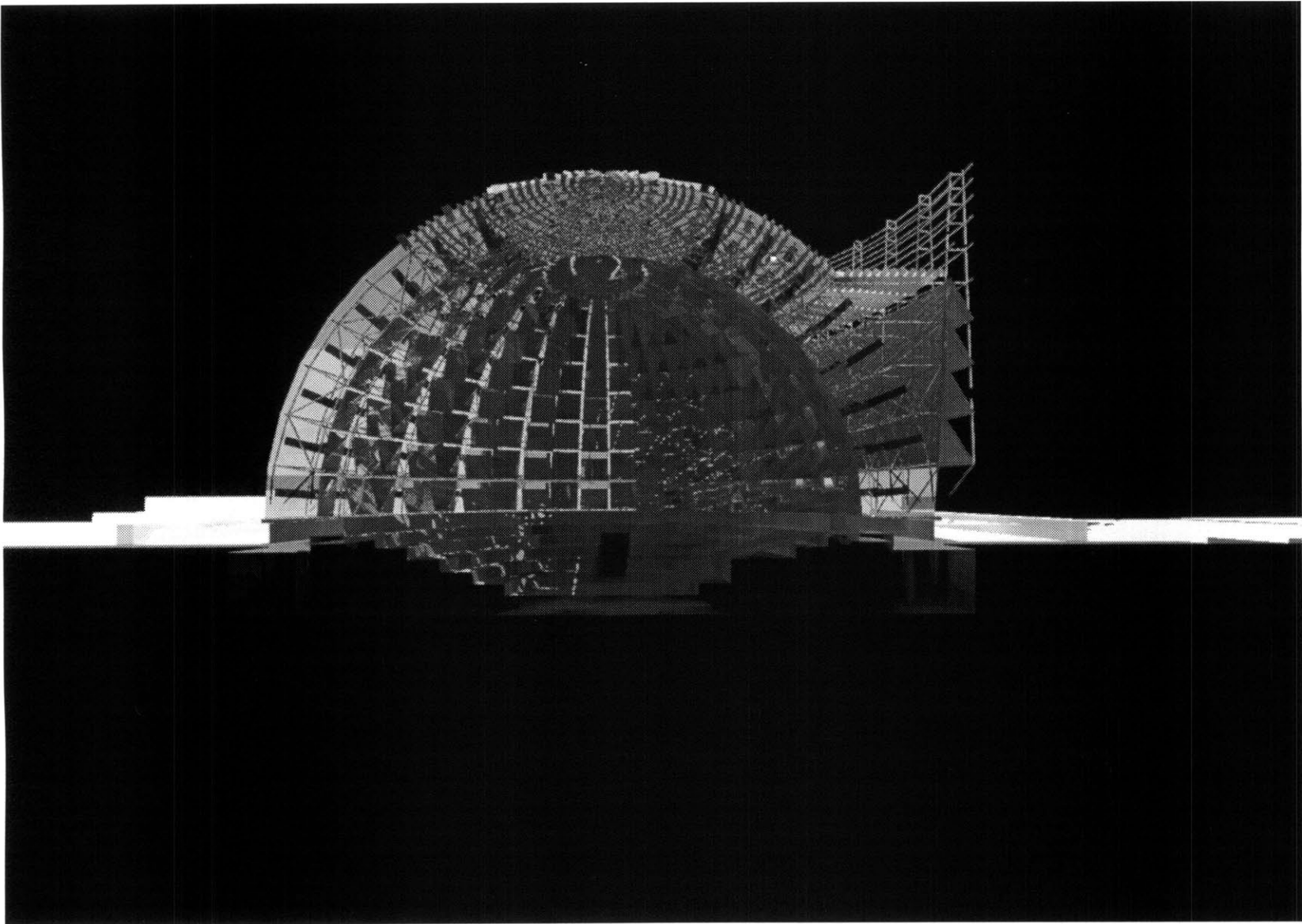
32. Interior perspective study of Lecture Hall with each screen displaying an image.



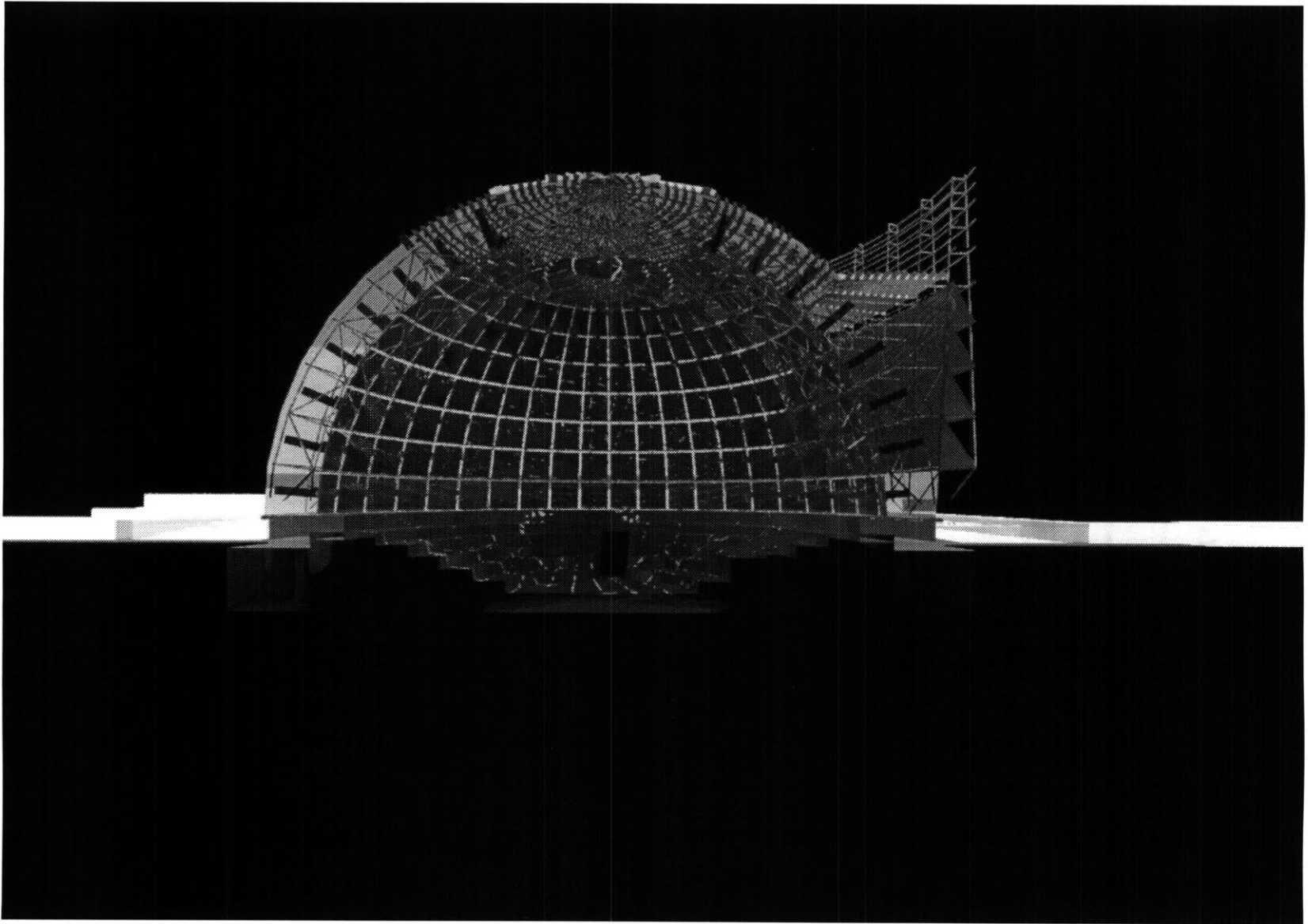
33. Interior perspective study of Lecture Hall with a single image displayed across multiple screens.



34. Section perspective of Lecture Hall with screens closed.



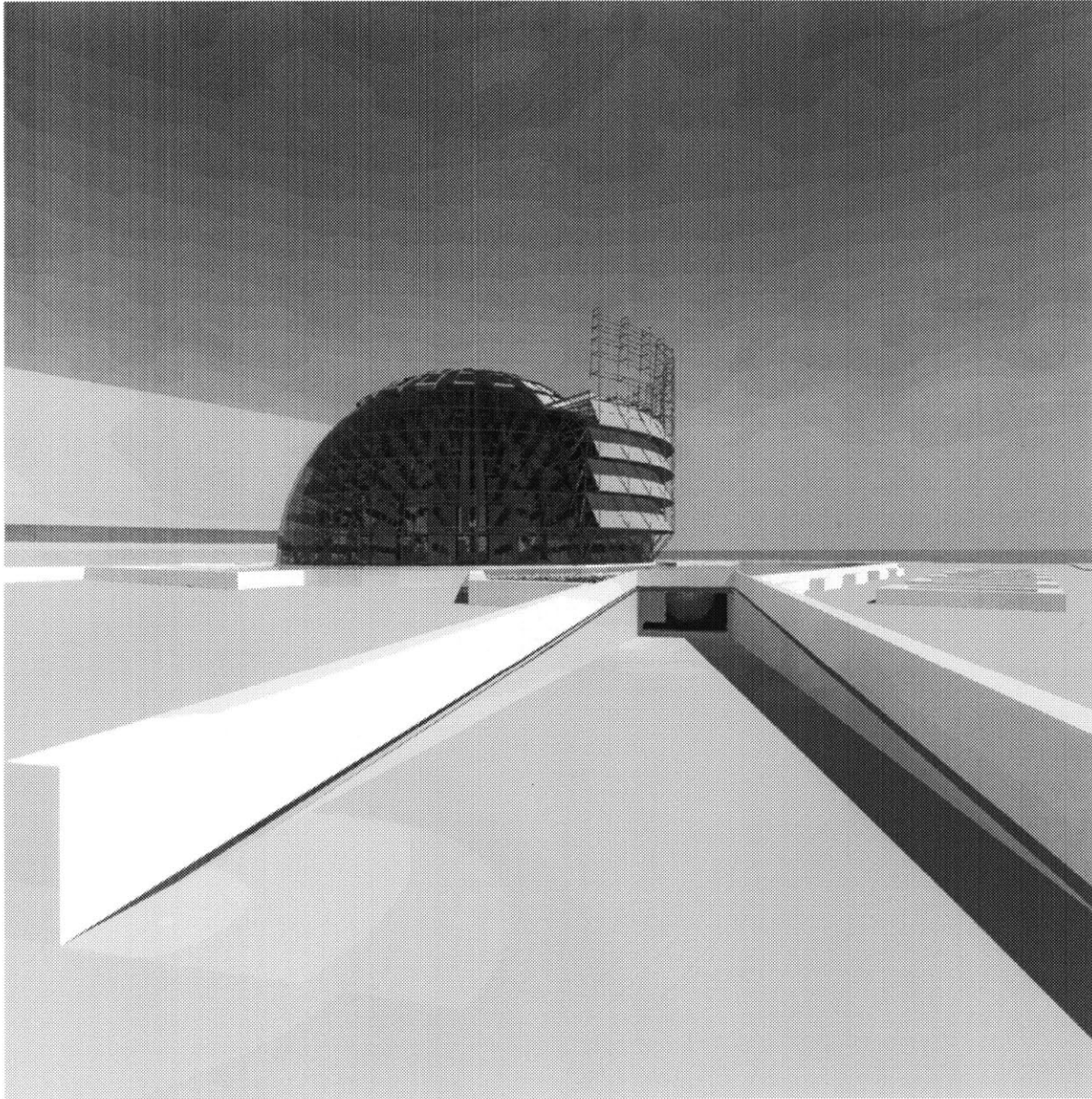
35. Section perspective of Lecture Hall with screens half open.



36. Section perspective of Lecture Hall with screens fully retracted.

will have a clear view of the dome. Unlike the linear seating in the conceptual model, a circular seating arrangement was chosen to emphasize the communal interaction between the members of the audience. Each seat is also equipped with a small screen which can be used to see alternative views of the virtual space. At the bottom center of the lecture hall is the lectern. In order to give the space an orientation of front and back, the lectern is shifted towards the control room allowing for the majority of seats to face it (figs. 39-42).

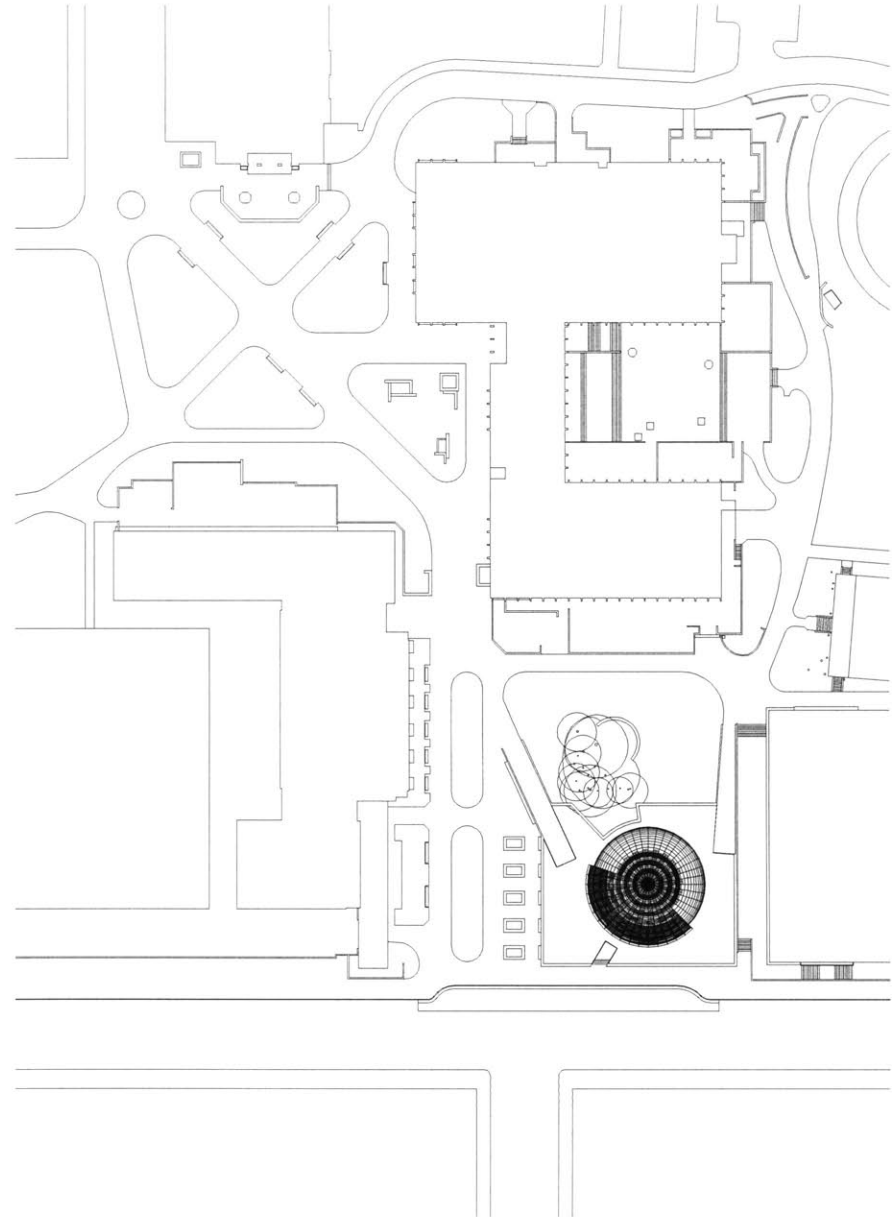
A gentle slope takes you out of the lecture hall into a circulation corridor which runs along the perimeter of the building. The corridor accesses the control room, the restrooms, the mechanical spaces as well as the entry and emergency exit. The outer wall of the corridor is a rough textured concrete retaining wall while the inner walls are a translucent material that glows. This luminescent glow, caused by the lights situated behind the wall, is a reference to the quality of light found in the virtual world. The smooth concrete columns in the middle of the corridor support the dome above and represent a permeable boundary between the virtual and the physical.



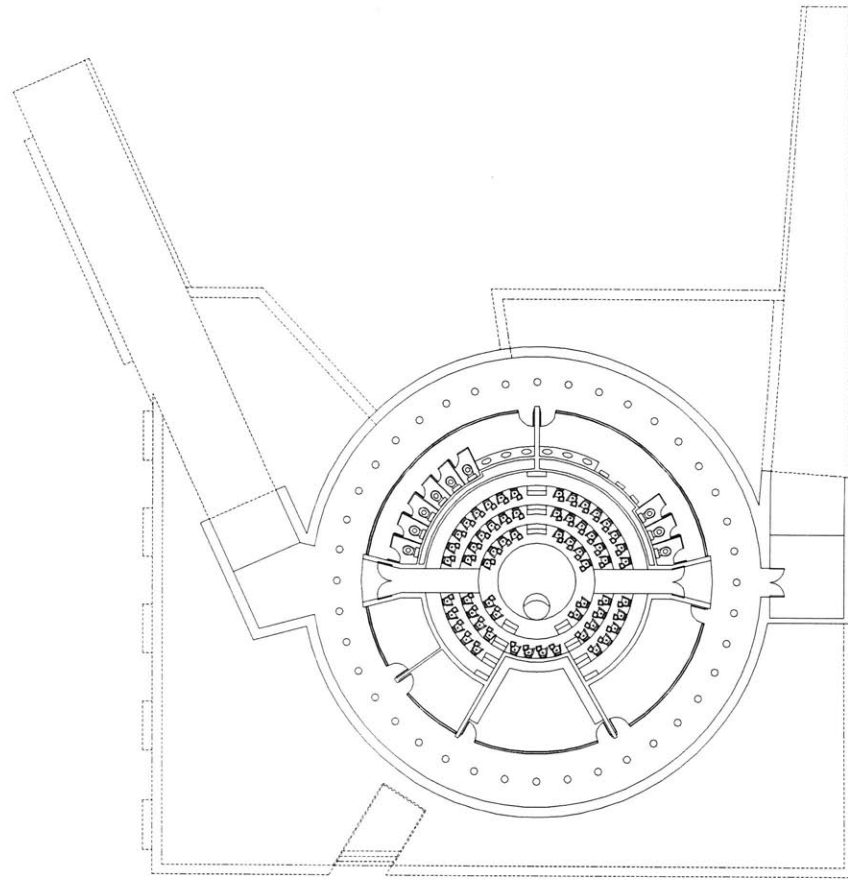
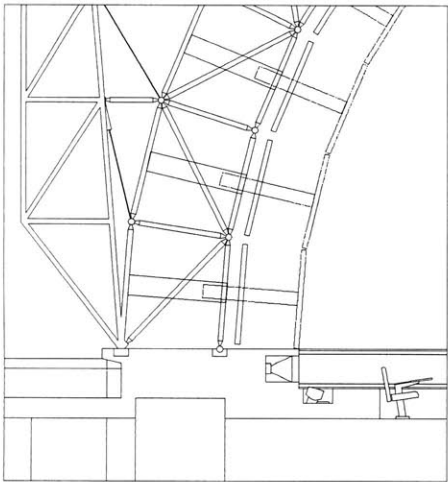
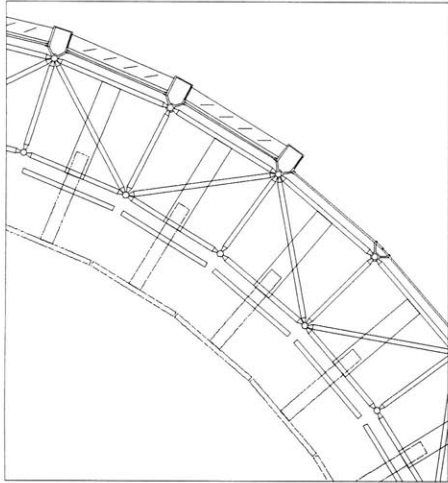
37. Perspective view of the entrance.

The horizon line, like the use of light, is another element used to orientate the user to the change in environment from the physical to the virtual. Adjacent to the corridor is the entrance to the lecture hall, a ramp that goes to the outside. This ramp is placed tangentially to the dome so that the two different sides are clearly visible (fig. 37). As one walks up the ramp, one now becomes aware of the horizon line between the earth and the sky; a horizon line like the one inside the lecture hall between the screens and the seats. Similarly, as one walks down the ramp, one moves from above the horizon line to below the horizon line. Upon entering the lecture hall, one notices a similar horizon line dividing the lower half from the upper half of the dome. This continuous horizon line bridges the physical and the virtual.

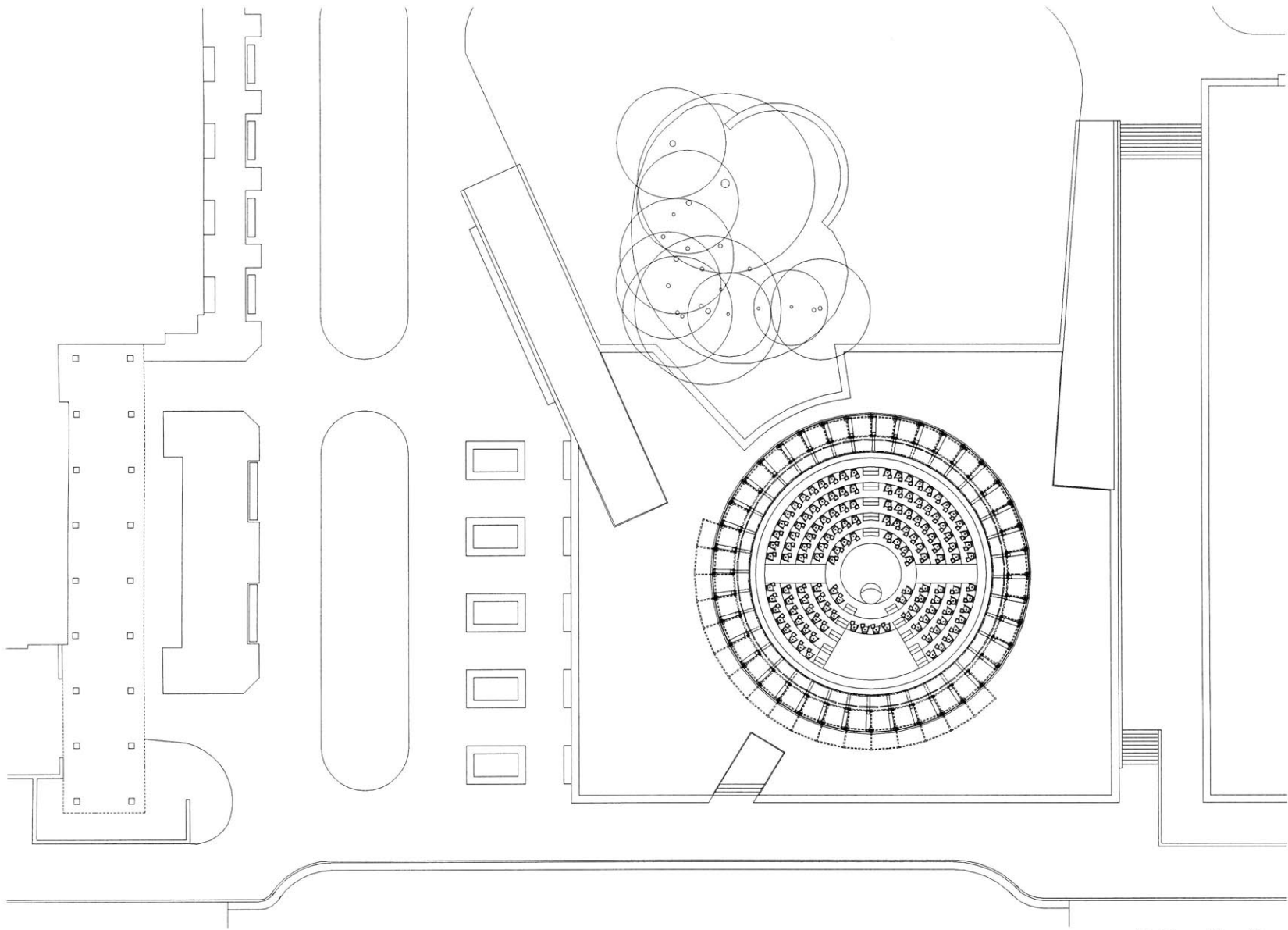
Plans and Sections



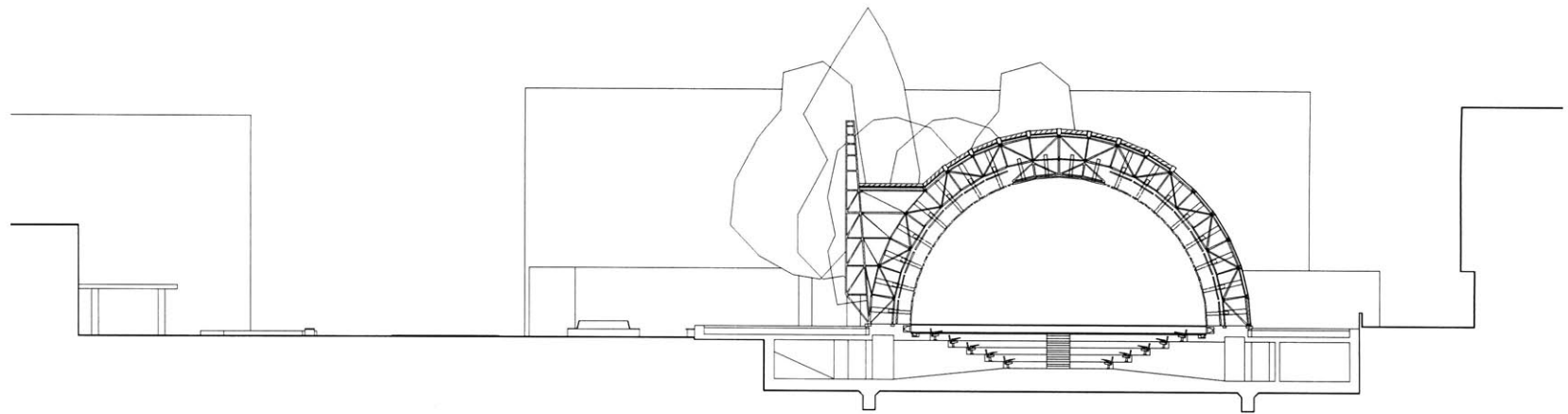
38. Site Plan.



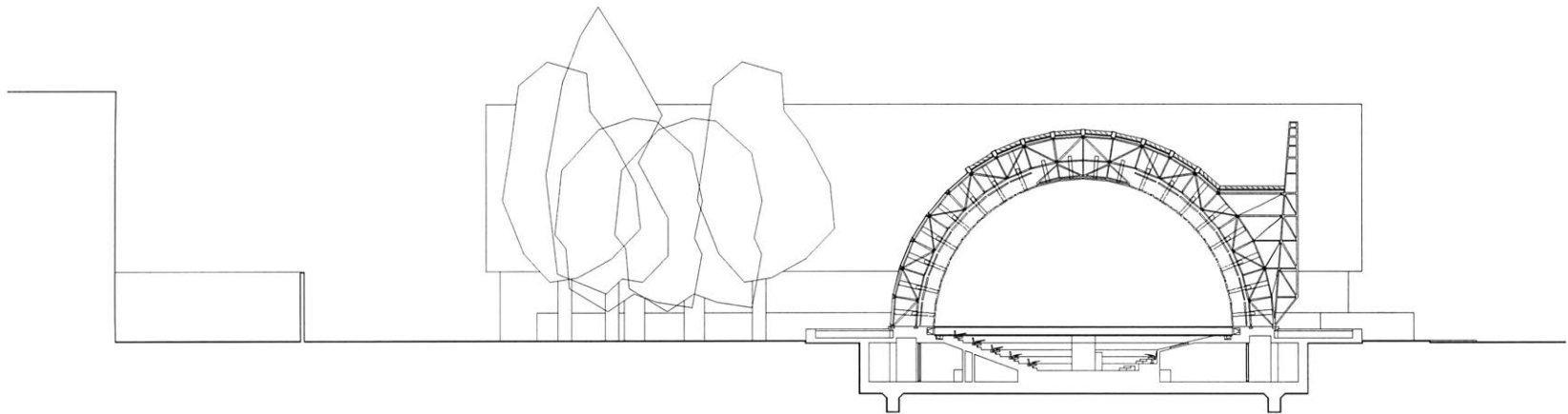
39. Two Section Details and Lower Floor Plan.



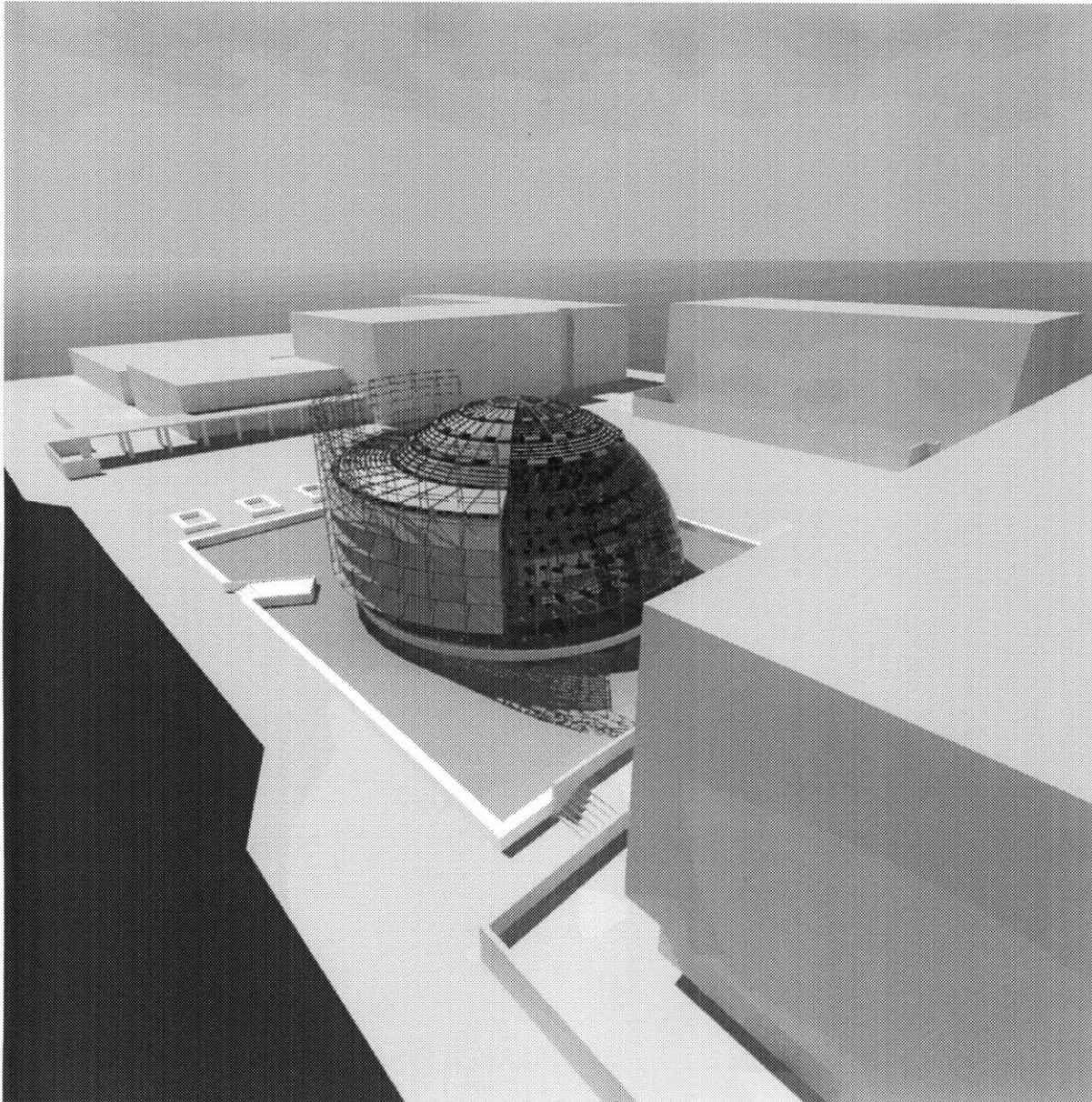
40. Upper Floor Plan.



41. East-West Section looking North.



42. North-South Section looking East.



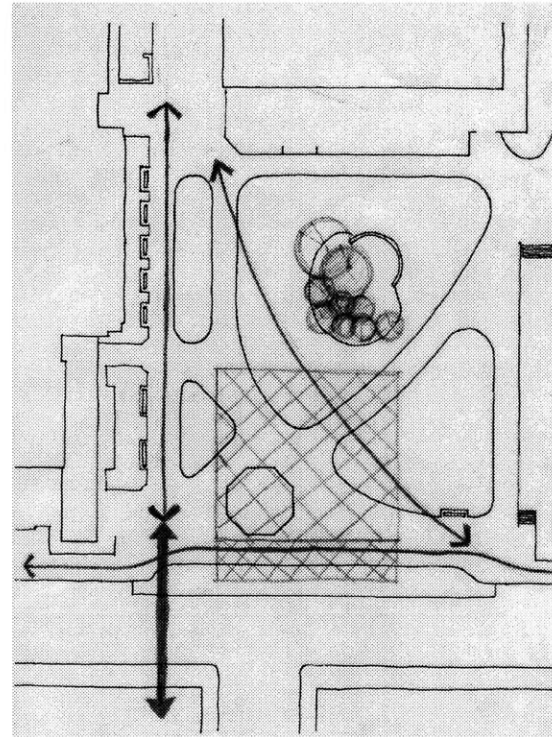
43. Aerial perspective from the southeast.

Physical Exterior

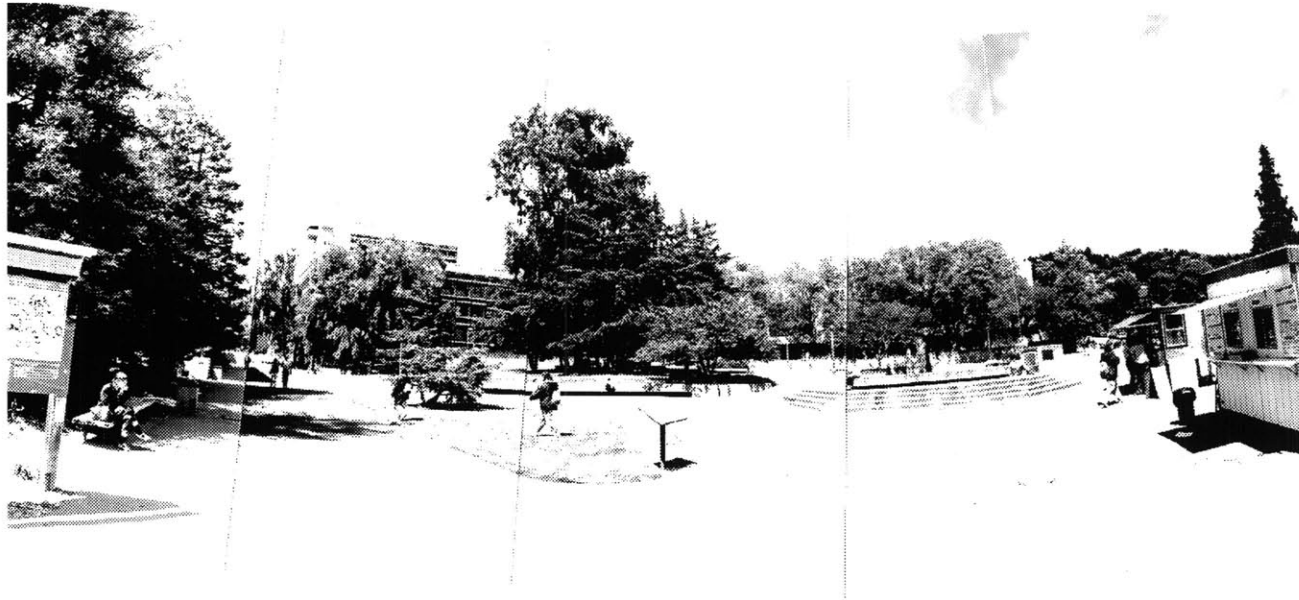
If the interior of the dome creates a new virtual environment, how should the exterior of the dome relate to its physical surroundings? How should the interior relate with the exterior? How do we mediate between the internal virtual and the external physical?

The site for the lecture hall is on the south side of the UC Berkeley campus (figs. 45-48). The building is located in a courtyard between Kroeber, Wurster and Boalt Hall. This courtyard also acts as a secondary gateway onto campus. By situating the lecture hall in the southeast corner of the courtyard, three objectives are met. First, the building provides for exterior seating along the south and west side where there is a heavy flow of people going to and coming from campus. Second, the hundred year old trees near the center of the courtyard are not disturbed. Third, the lecture hall defines the edge of the courtyard as well as the edge of campus (fig. 44).

From the exterior, only the dome of the lecture hall is visible. The dome is situated in a large reflecting pool which collects the run off water when it rains. Water is used to represent the virtual because it is



44. Preliminary site analysis. Arrows show major flow of people. Larger hatch area shows the popular sunny sitting areas while smaller hatch area shows where the food trucks and buses stop.



45. Site photo from the southwest corner.



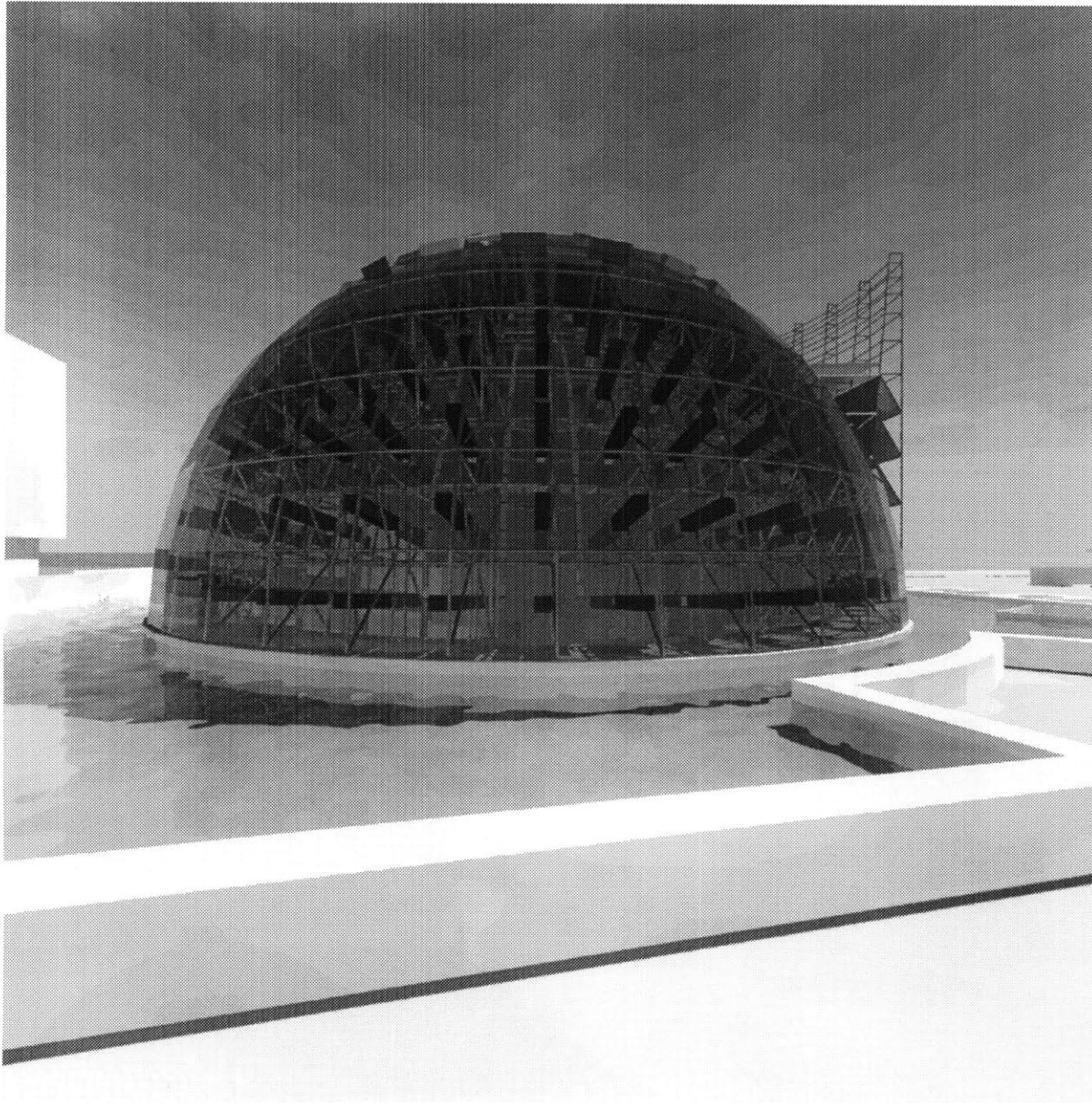
46. Site photo from the south edge.



47. Site photo from the northeast corner.



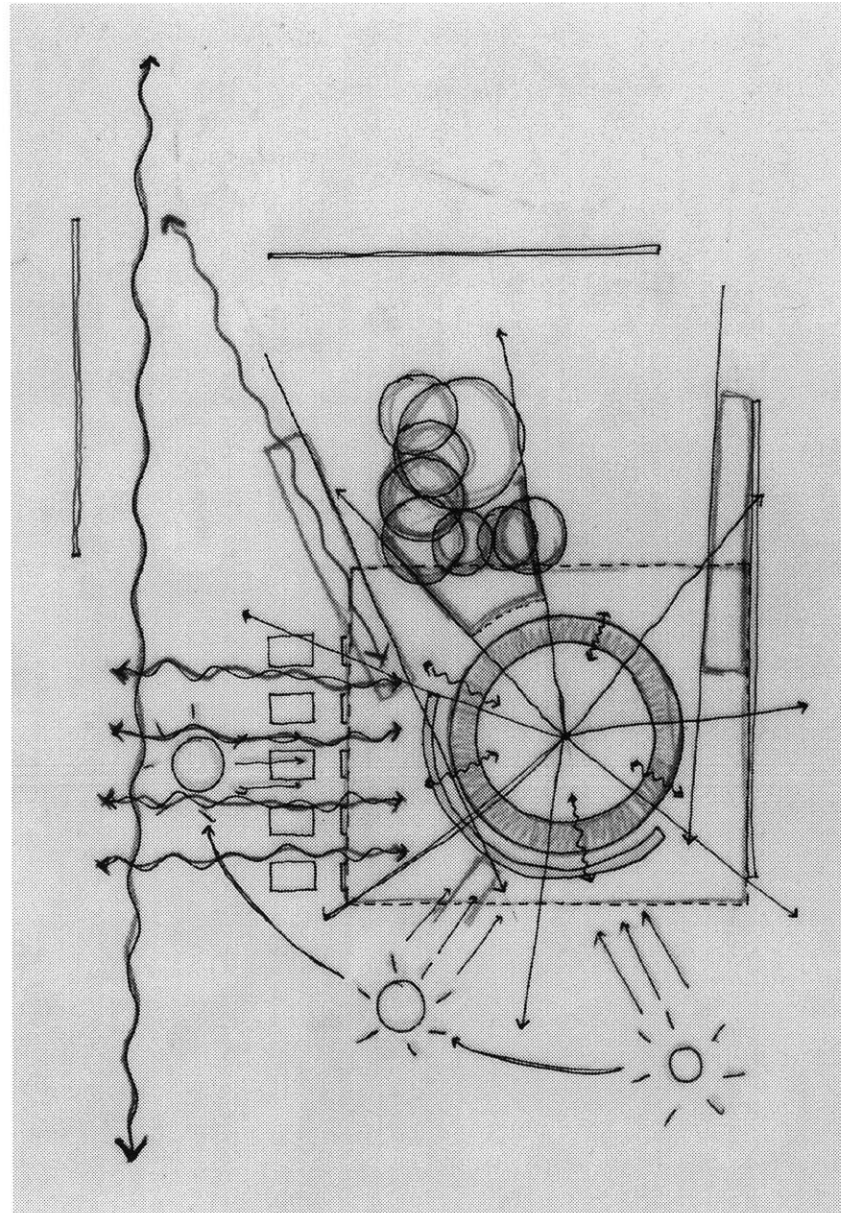
48. Site photo from the northwest corner.



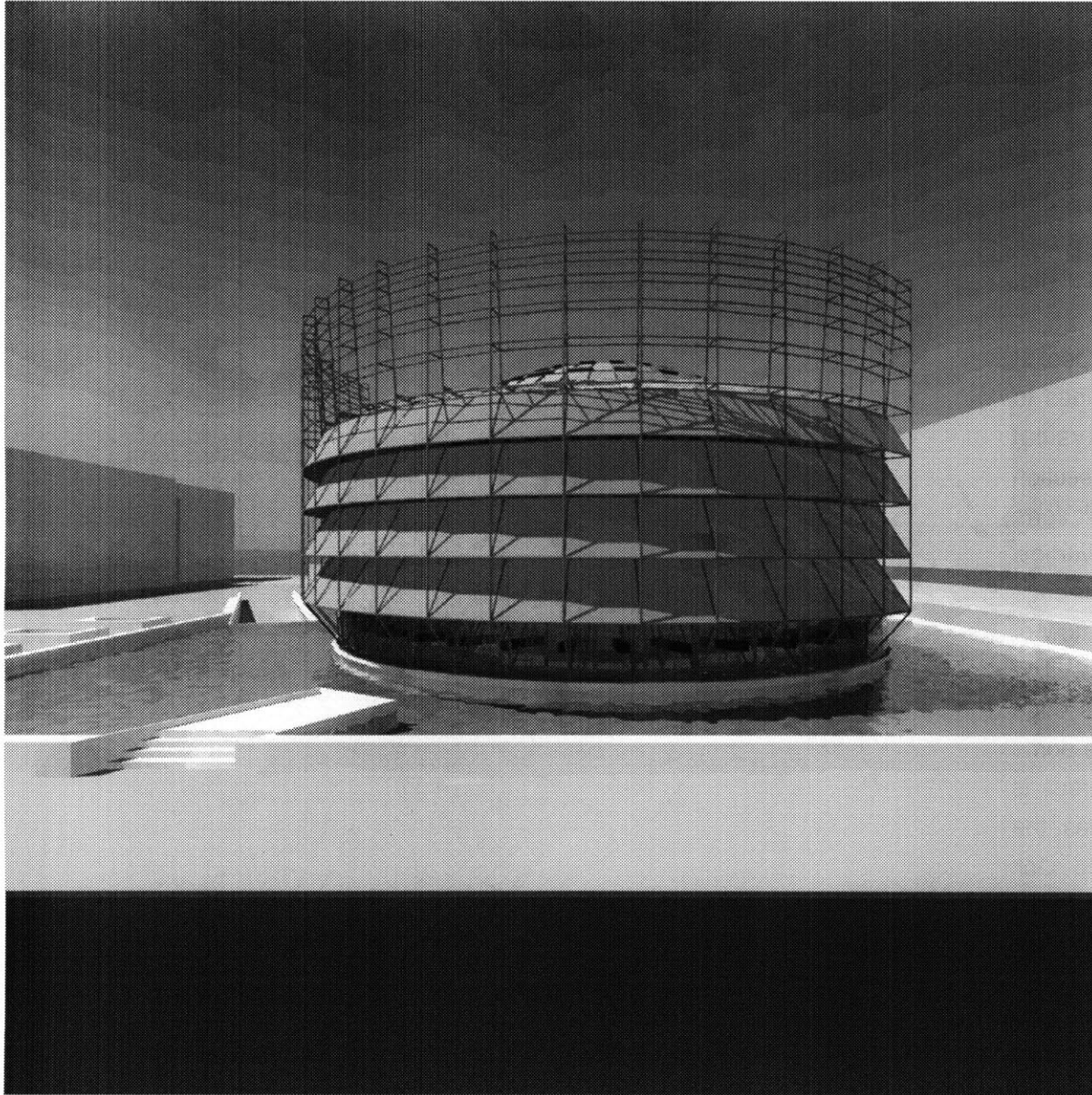
49. Perspective of the Lecture Hall dome from the north.

one of the few elements that is physical yet has characteristics of the virtual such as fluidity and the ability to emit light through reflection. The reflection of the dome in the water, completes the dome to create an image of a sphere which is half physical and half virtual; an ideal symbolic gesture of a world uniting the virtual and the physical (fig. 49).

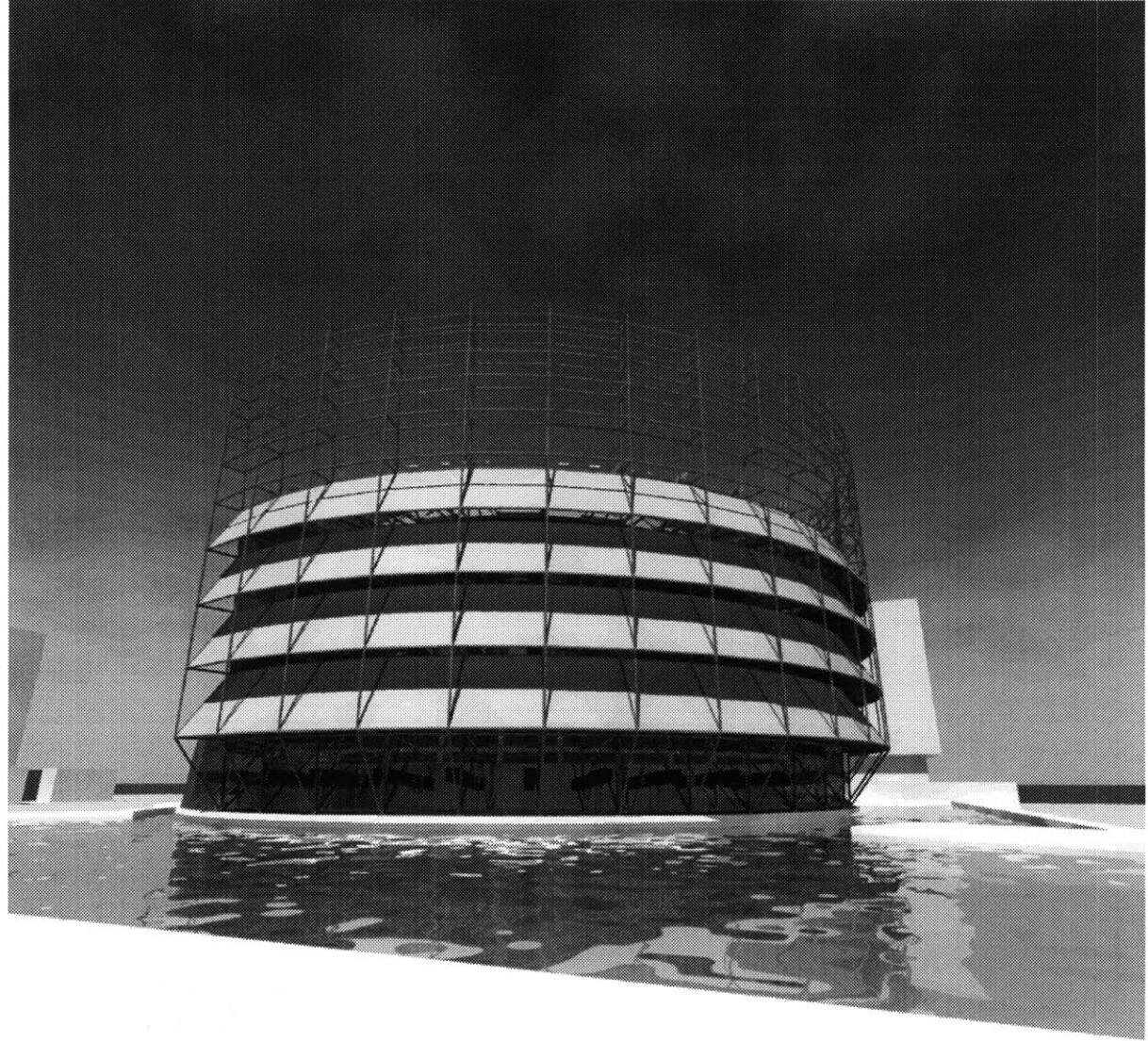
Each side of the rectangular pool of water in which the dome sits, changes to accommodate its immediate physical surrounding (fig. 50). To the south, a section is cut out to provide for a viewing platform which is placed at the middle of the vertical fabric louvers (fig. 51). To the west, this edge of the pool is adjacent to the major flow of people coming and going to campus. The creation of a sitting area along this edge allows people to linger and view the dome (fig. 52). To the north a grove of trees is situated. In recognition of these trees, the edge of the rectangular pool is pulled back towards the dome. This gesture allows the trees to grow closer to the dome; it becomes a juxtaposition of the physical and the virtual. The gesture also allows people to get a closer look at the dome and the mechanisms inside (fig. 49). To the east is the emergency



50. Diagram of the different ways the Lecture Hall responds to the site.



51. Perspective of Lecture Hall from across the street.

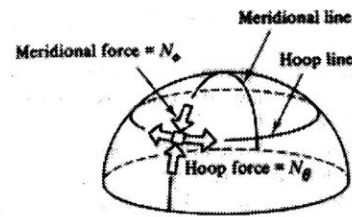


52. Perspective of Lecture Hall from the plaza.

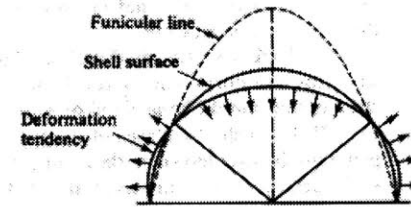
exit which also acts as the cargo entry.

The outer layer of the dome, like the edge of the rectangular pool, also changes to adjust to the site (fig. 50). On the south side, the major concern is the sun. To minimize heat gain, fabric louvers are strategically placed to prevent direct exposure of the dome to the sun. The louvers are placed on a vertical structure which is attached to the curved dome structure (fig. 39). These louvers could have simply been applied to the curvature of the dome but I chose to express a vertical or orthogonal element to relate to the vertical walls already surrounding the edges of the site (fig. 43). On the north side where there is no threat of direct sunlight, the dome is only clad with glass to allow people walking by a clear view of the mechanics inside the dome. The exterior glass of the dome is tinted blue to indicate a layer of the virtual on top of the physical (fig. 49). Louvers and vents are placed at the top of the dome to allow hot air to flow out and, at the same time, allow cool air to circulate through the lecture hall. All the louvers and vents are units that attach to the main structure of the ribbed dome (fig. 39).

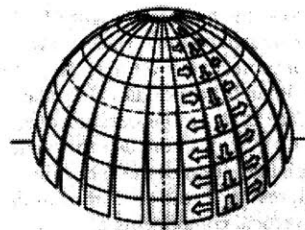
The structure of the dome is a double-skinned shell. The inner shell accommodates the screens, while the outer shell is layered and distorted in response to the physical environment. Between the two shells are the mechanical devices that manipulate the screens and bridge the inner and outer shells. The shells are ribbed domes with steel tube members approximately three inches in diameter. In a ribbed dome structure, the members above the point of inflection (the hoop ring) are in compression while the members below the hoop ring are in tension (fig. 53). Because of this structural performance, the overall size of the tubes remain uniform. In this case, the members at the bottom of the structure are in tension but longer while the members on top are in compression but shorter. The uniformity of the structural members is another ideological representation of a perfect virtual world.



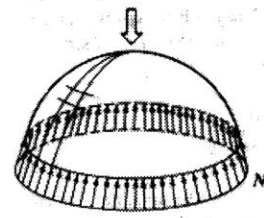
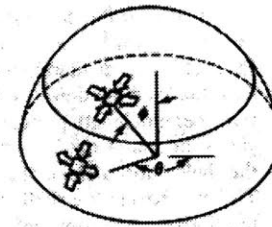
Types of forces developed in a spherical shell.



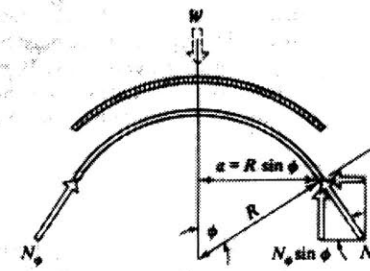
Relationships between the surface line of a spherical shell segment, the deformation tendency of the surface under a uniformly distributed loading, and the funicular line for the same loading.



Hoop forces are compressive in the upper zone of a sphere segment and tensile in the lower zone. Meridional forces are always compressive.



Meridional forces acting in the plane of a shell.



The sum of the vertical components of the in-plane meridional forces developed internally in the shell equals the external vertical live and dead load.

53. Meridional and hoop forces in spherical shells.

Appendix A: Criticism and Suggestions

The following is a synopsis of the discussion during the final presentation. The panel of critics included Ellen Dunham-Jones, William Mitchell, Julie Dorsey, Ken Kao, Robert McCarter, and Jerry Wells. There were three basic points of criticism.

The first point of criticism dealt with the seating arrangements inside the lecture hall. The critics felt that since my dome of screens is such a radical departure from the norm, why were the seating arrangements so “normal”? In fact, why were there even seats? Could the people not be standing? Why create a flexible exterior skin with a fixed interior seating arrangement? Their suggestion was that I create a seating arrangement (if they were to sit) that is as flexible and dynamic as the screens.

One element that was missing from the interior of my dome is the interaction usually associated with virtual reality? Where was the interaction? How do people engage the virtual space? The little screens at each seat were a start at fostering an interaction between the audience and the virtual space. A point was also brought up that the virtual experience inside the lecture hall was more akin to an augmented reality

than a virtual reality.

Another point of criticism focused on the seamless images created in my visuals of the inside of the lecture hall (fig. 31). The critics felt that the images on the screens could not be as seamless as I had portrayed because the spacing between the screens would make a visible black strip. I suggested that the strip could be used for acoustics but they felt that the minor strips were not enough to control the echoing problem of having a perfectly symmetrical dome. Some other means would have to be employed to combat the acoustics.

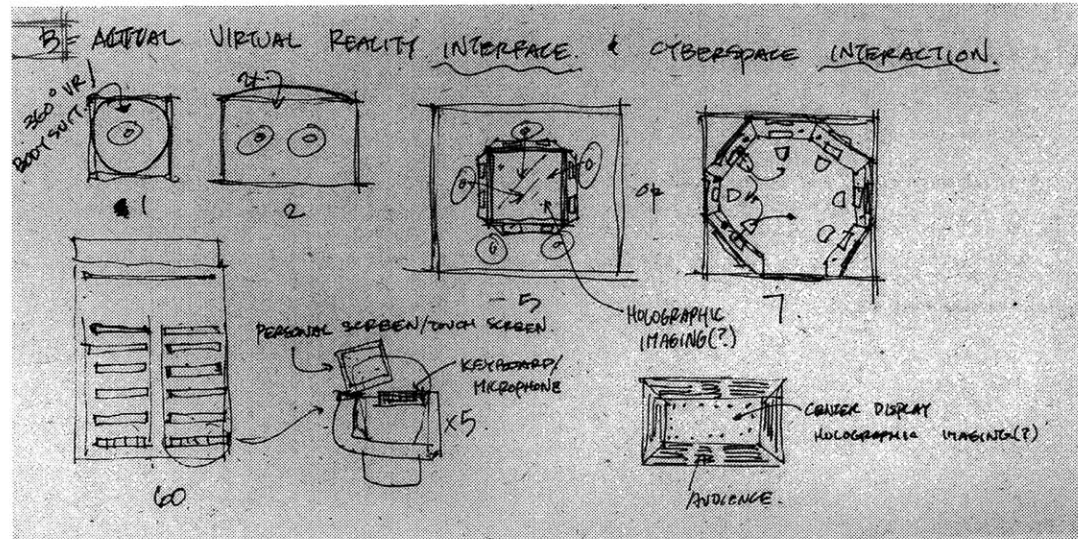
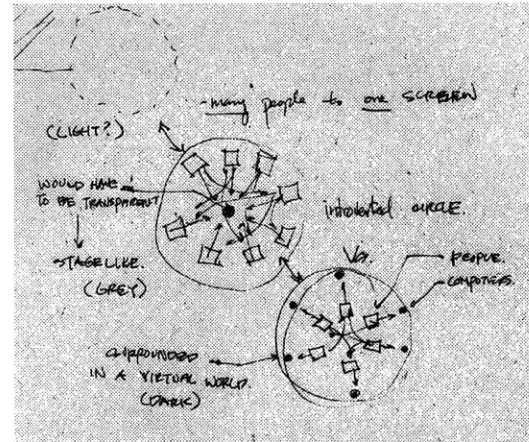
One possible solution to creating a seamless image on the inside of the dome is to use pixels instead of screens. Pixels inherently have a black border around them and if enough of them are used, the black borders disappear much like a monitor or a jumbo-tron. I liked the suggestion but how would one manipulate 320,000 plus pixels to allow light to filter through?

The last major point of criticism was directed towards how the lecture hall fits into the urban fabric. The critics were not convinced that the vertical louvers were enough of a gesture or even an appropriate reference towards the buildings surrounding

the site. In looking at my previous work some of the critics felt that having the dome in a box could have been just as successful, if not more so (see Appendix B, Dome-in-a-Box scheme). I had moved away from that earlier scheme because I wanted to compress and simplify the layering of the skin; the Dome-in-a-Box scheme had too many superfluous layers. The complexity of the layers is more strongly emphasized when they are compressed into one skin as opposed to being dispersed. Although the box would express the four conditions of the site clearly, it would not reveal the dome as a hybrid between the virtual and the physical. The key is to make a building that reflects both the box and the dome. This returns to the original virtual/architecture/physical diagram (fig. 5) which places architecture as that element which is a compromise between the two worlds.

54. Sketch of the introvert/extrovert relationship between a group of people and their machines.

55. Sketch of the possible methods to implement the introvert/extrovert relationships.

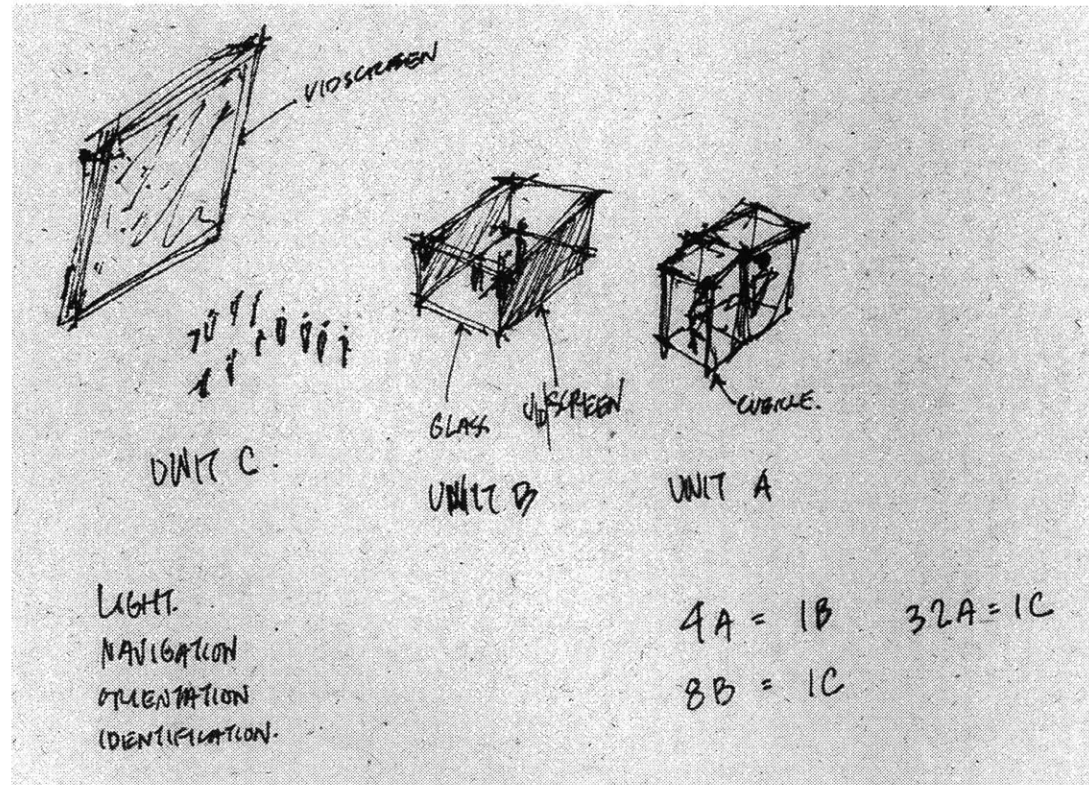


Appendix B: Design Process

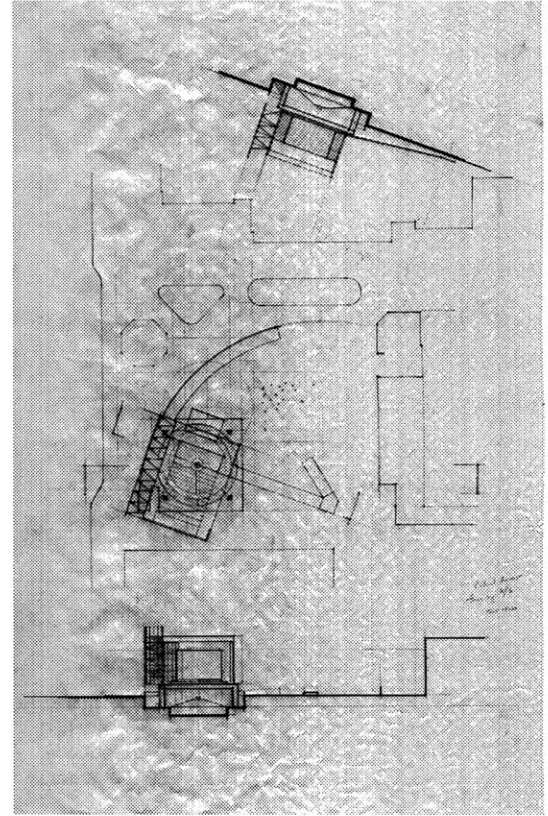
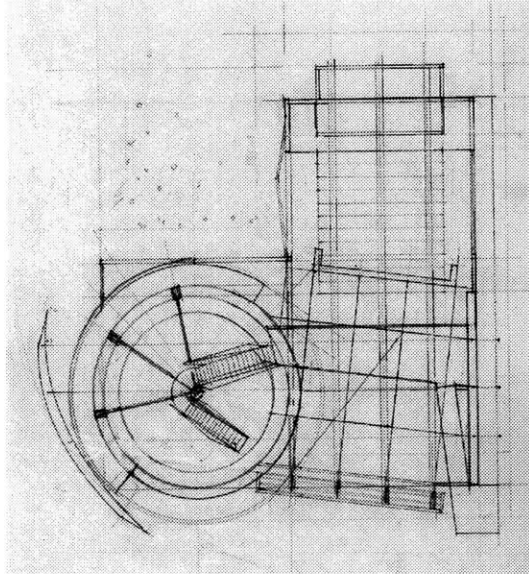
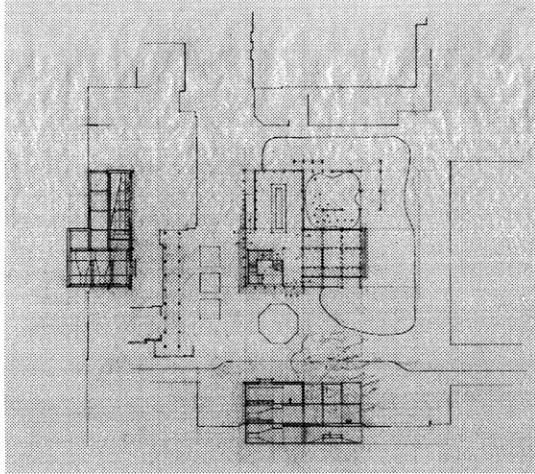
The form and mechanisms of the lecture hall went through many design schemes before arriving at the final form of a dome. The first investigation towards understanding the mediation was directed towards the VR technology. I researched several different types of interfaces and how they allow the user to explore the virtual world. My main interest was establishing a relationship between man, machine and environment. How does mankind relate to each other and to the machine? What formal spaces allow users to experience both the physical presence and the virtual environment (figs. 54-56)?

One of the greatest problems was the dilemma of how to arrange the space so that one could work at their terminal and yet be allowed to communicate face-to-face with the person next to them with no hindrance. The technology is now improving at a rate in which we can build almost anything we want. So, what do we want?

The following pages are descriptions of the various schemes that have evolved throughout the design process.



56. Sketch of the relationship between the number of people and the type of machine required for that group of people to have a virtual experience.



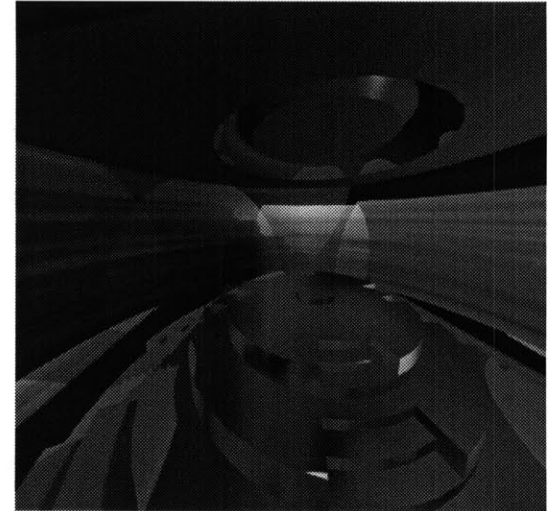
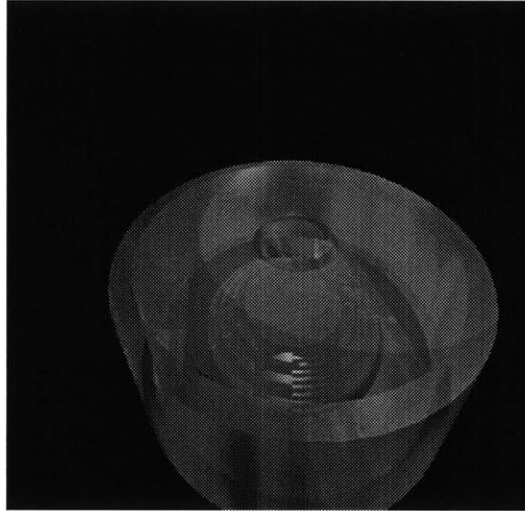
57, 58, 59. Three initial schemes of two lecture halls.

Two Lecture Hall Scheme:

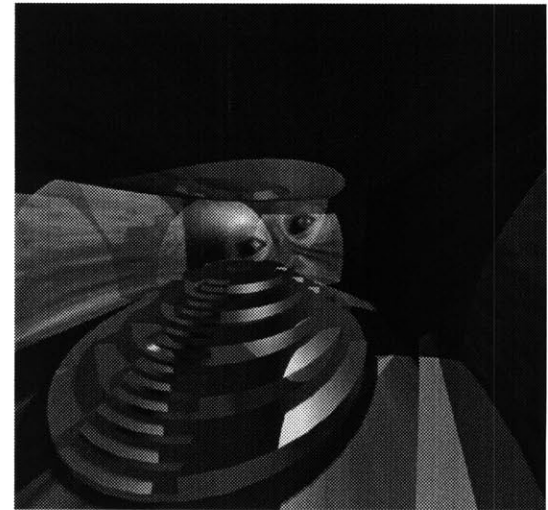
The initial designs dealt with the problem of the virtual and the physical by creating two lecture halls; one which was about the physical world and other was about the virtual world. The problem was establishing an architectural language that exemplified the relationship between the two lecture halls.

Three initial schemes were made (figs. 57-59). Each scheme was a variation on how to establish a relationship between the two lecture halls. After further consideration, it was decided that a lecture hall which incorporated attributes of both worlds would be the better way of addressing the mediation between the virtual and the physical.

There was also an investigation into creating a new virtual space that did not need prosthetics and allowed for group interactions. The biggest problem was how to focus a group of people on one object (the lecturer) and still allow them to explore the virtual space (figs. 60-62).



60, 61, 62. The initial design was a cylindrical space with seats arranged in a circular fashion stepping up to create a cone shape in the middle of the cylinder. The skin of the cylinder would be a layer of curved screens. The audience would site in the center cone and face the screen. The lecturer directs the lecture from the top of the cone.

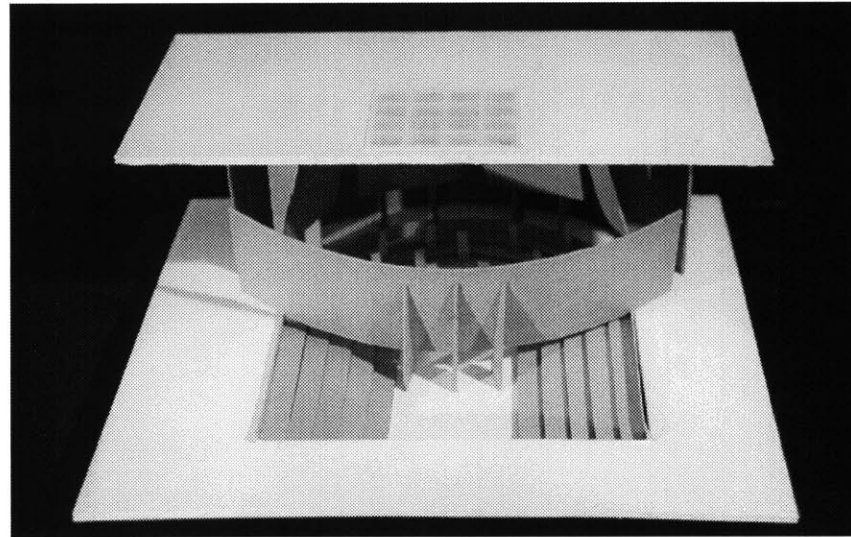


Eye Shaped Scheme:

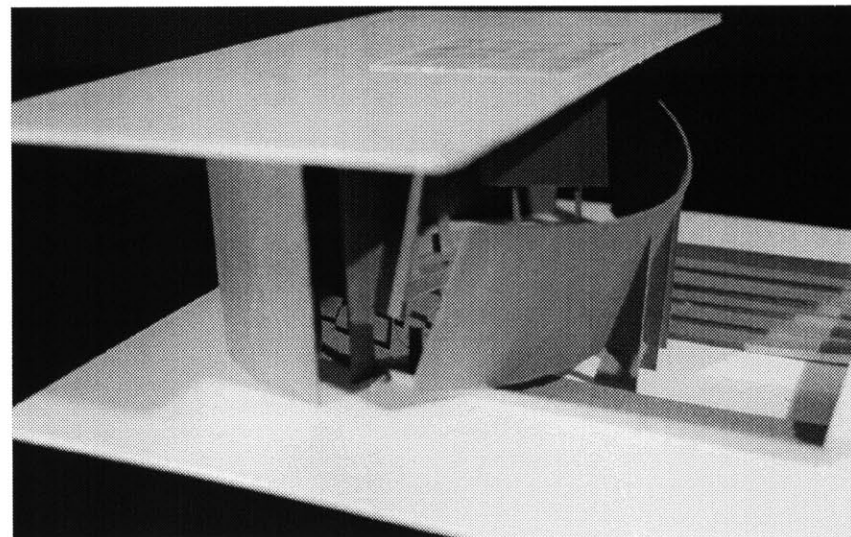
The Eye Shaped Scheme (called so because when viewed from above the study model looks like an eye) was an investigation into alternative methods of creating a virtual reality experience lecture hall.

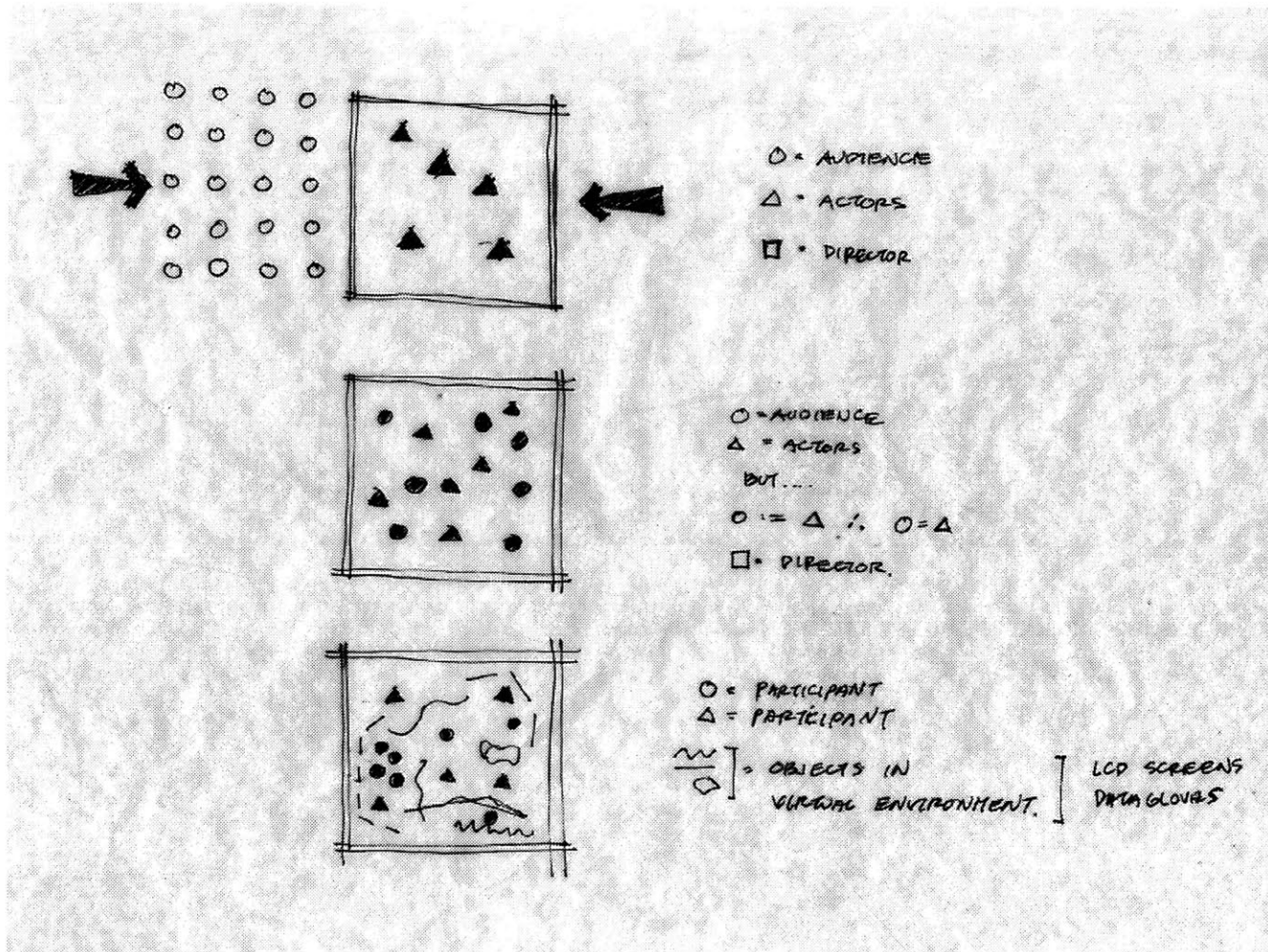
One of the problems with the virtual lecture hall in the Two Lecture Halls scheme is that the lecturer is not directly visible to the audience. To compensate for this, I placed a curved screen, which acts as a digital blackboard, behind the lecturer and arranged the seats in a semi-circle facing the screen. There are also screens behind the audience to supplement the main curved screen (figs. 63, 64).

I felt this scheme was unsuccessful because it was simply the placement of complicated electronic equipment into a standard lecture hall space.



63, 64. Model photos of the Eye Shaped Scheme.



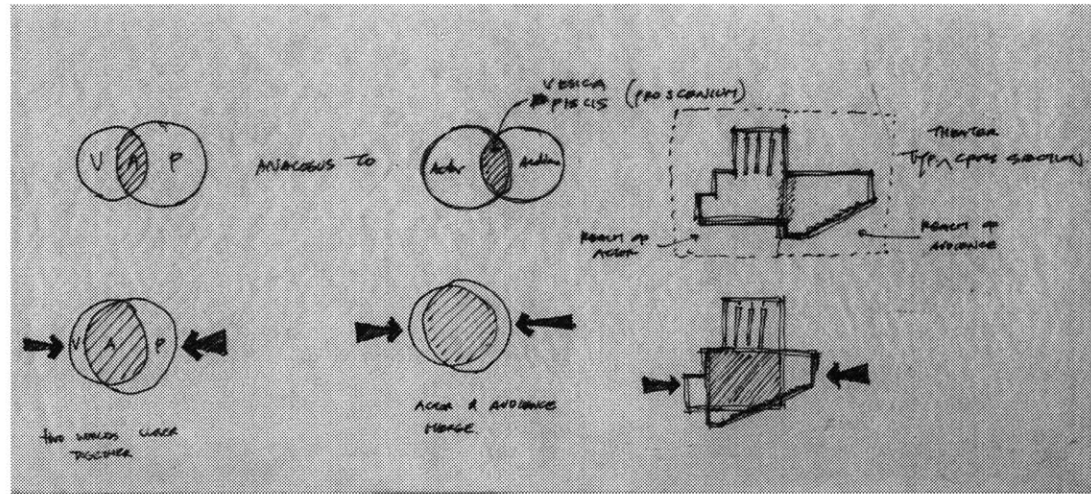


65. Diagram of how the stage and audience merge.

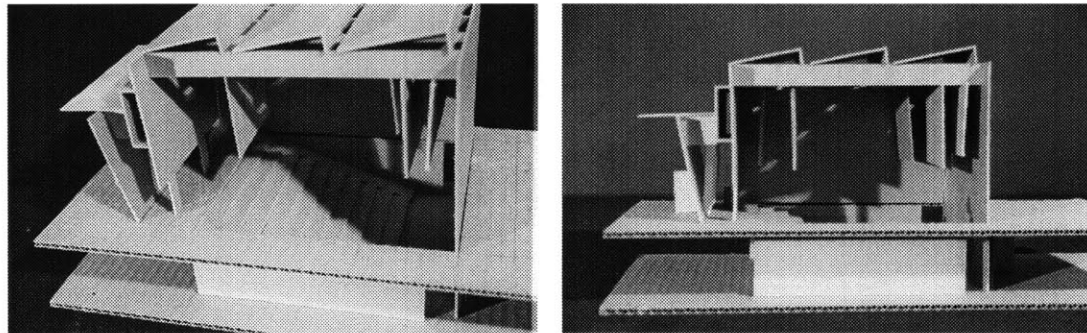
Theater Overlay Scheme:

In the Theater Overlay Scheme, I started to investigate theaters as a possible precedent for my lecture hall since both are similar in function. The diagram of the theater can be divided into 3 parts; the audience, the proscenium and the stage. This diagram is similar to the virtual/ architecture/ physical diagram which shows the virtual merging with the physical. If we made an analogy between the two diagrams, then the theater diagram can be seen as the merging of the audience and the stage (figs. 65, 66). Using this idea, I created a lecture hall in which the seating area and the stage were combined into one (figs. 67, 68). To give the audience a virtual experience, large flat screen televisions from above come down and can be maneuvered into any position to surround the audience.

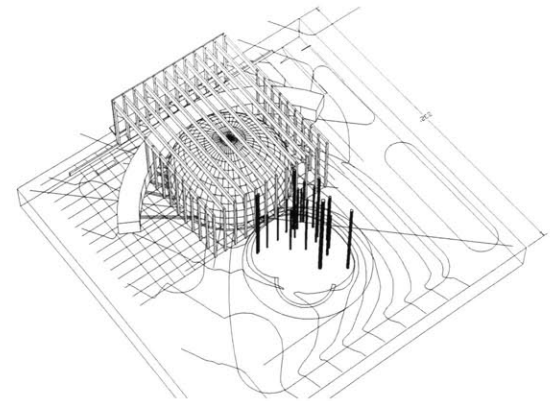
This scheme was a step in the right direction but there were still many problems that went unresolved such as how do you have a lecture in a room full of moving screens? What is the mechanism by which the screens move? How does natural light filter through the space?



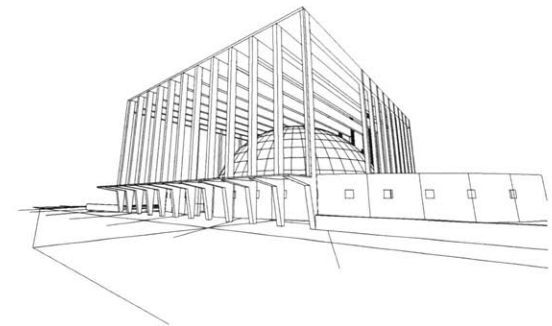
66. Sketch of the analogy between the theater diagram and the VAP diagram.



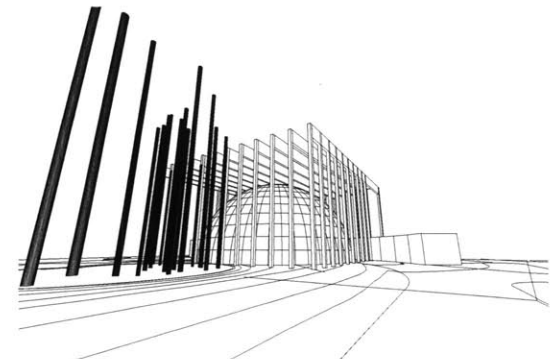
67, 68. Photos of study model, Theater Overlay Scheme.



69. Axonometric view of the Mastercard Scheme.



70. Perspective view of the Mastercard Scheme.



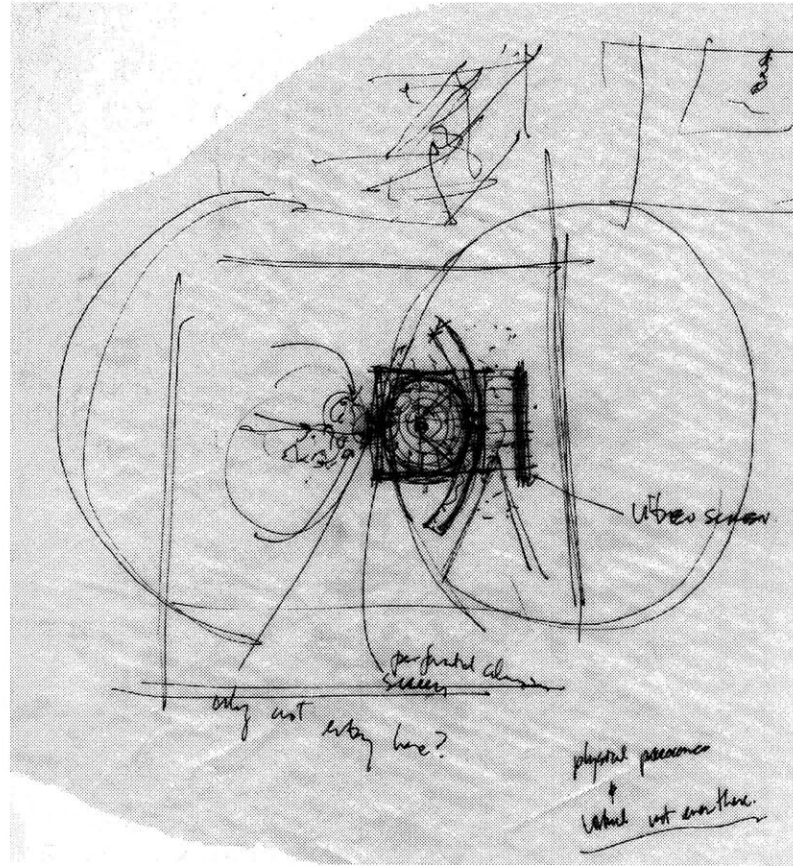
71. Perspective view of the Mastercard Scheme.

Mastercard Scheme:

This scheme was another variation of the virtual/architecture/physical diagram. If the definition of each circle is the realm in which characteristics of each world could occur, then the center eye shape should be the zone that will have characteristics of both.

The central dome is the main lecture hall. The left circle represents the physical world and the right circle represents the virtual world (fig. 72). The solid curve piece is that part of the center eye that is associated with the physical. The vertical wall beyond the curve is a huge jumbo-tron representing the virtual. The building is covered by a box which relates to the verticality of the context of the site (figs. 69-71).

The problem with this scheme is that the architecture is too diagrammatic and there was not enough development of the different parts.



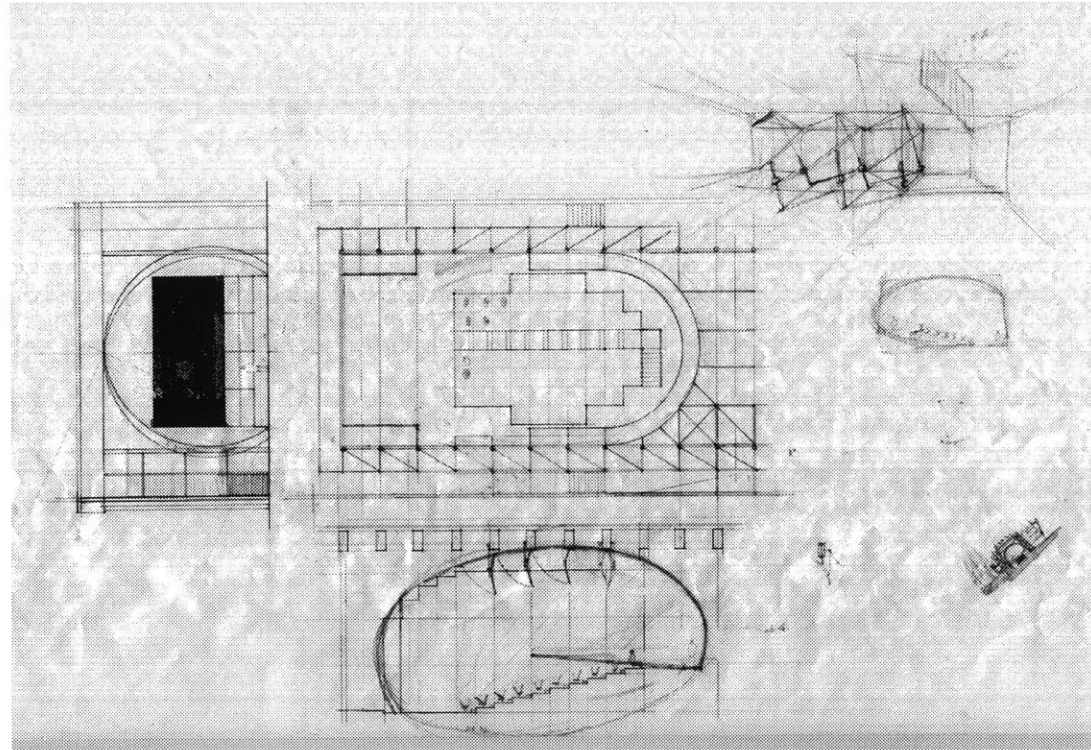
72. Sketch of the Mastercard Scheme.

Transforming Egg Scheme:

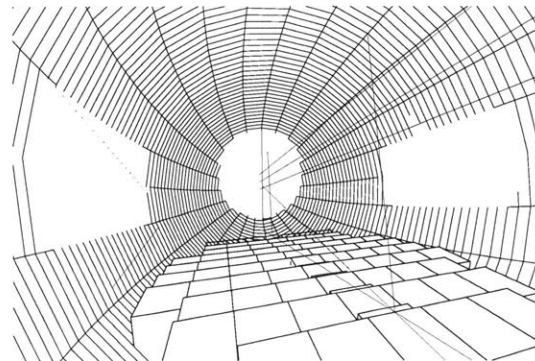
By this stage in the thesis, I decided that the lecture hall had to incorporate some means of transforming from the physical to the virtual and vice versa. The transformation of the skin of the building would be the best, since the changes could be viewed from the outside and the inside.

I started with an egg shaped hall because that was a cross between an ideal spherical virtual environment and a rectangular physical lecture hall. The skin of the egg would change to indicate whether the lecture hall was in virtual mode or physical mode. The screens were designed to flip in and out so that in the physical mode they can be used as acoustical paneling and in the virtual mode, they can be used as a television screen.

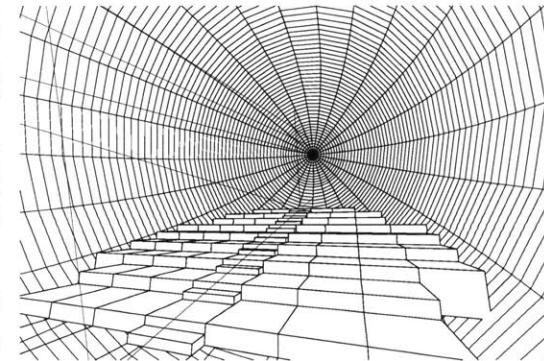
The difficulty in this scheme was the fact that the screens were not uniform which meant that each piece had to be custom made. Also the seating arrangements did not work well when the lecture hall was in the virtual mode due to distance to screens and sight lines. After having explored the egg scheme, I realized that the best form was a dome.



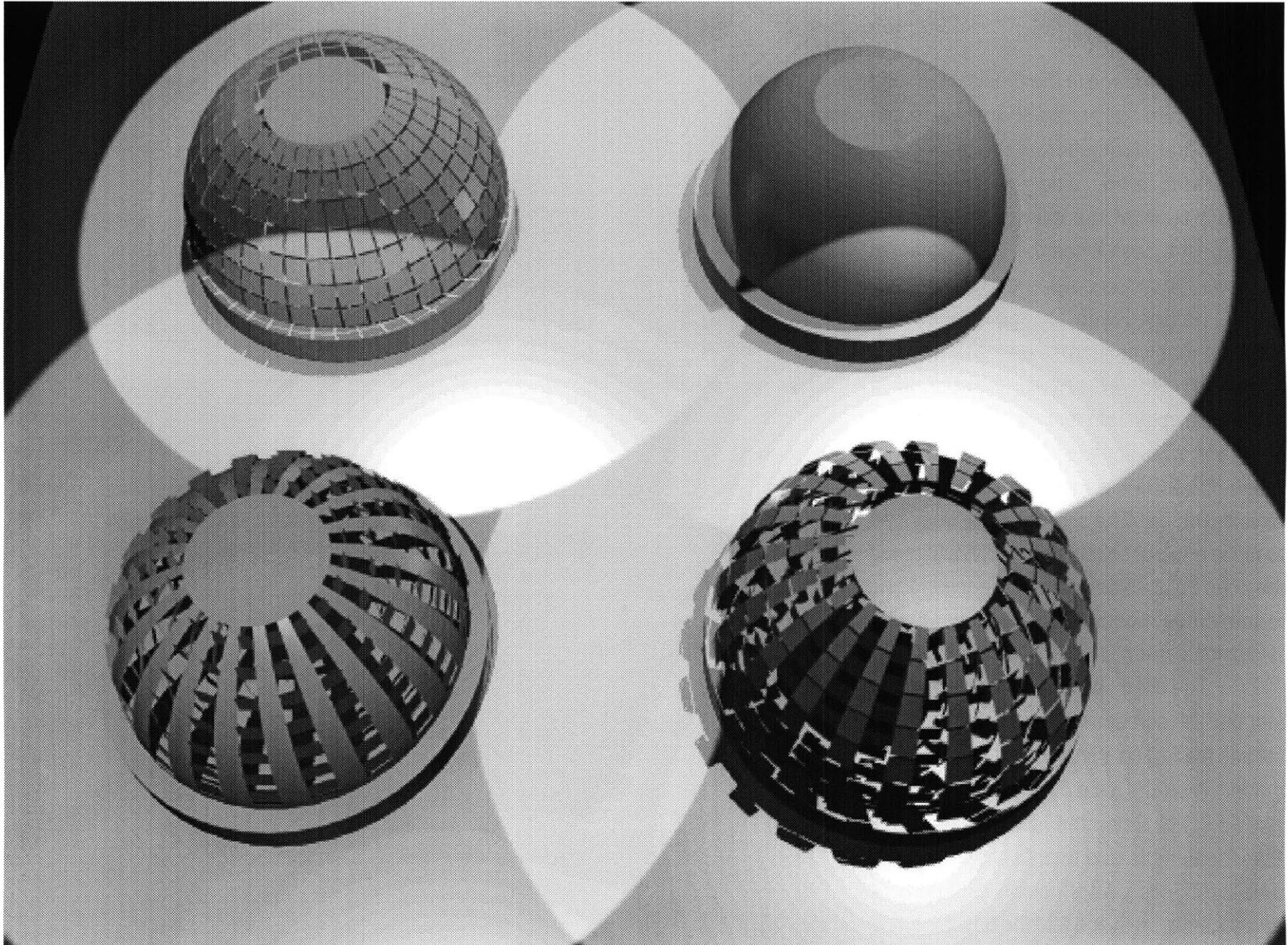
73. Plan and section of the Transforming Egg Scheme. The lower section shows how the screens move.



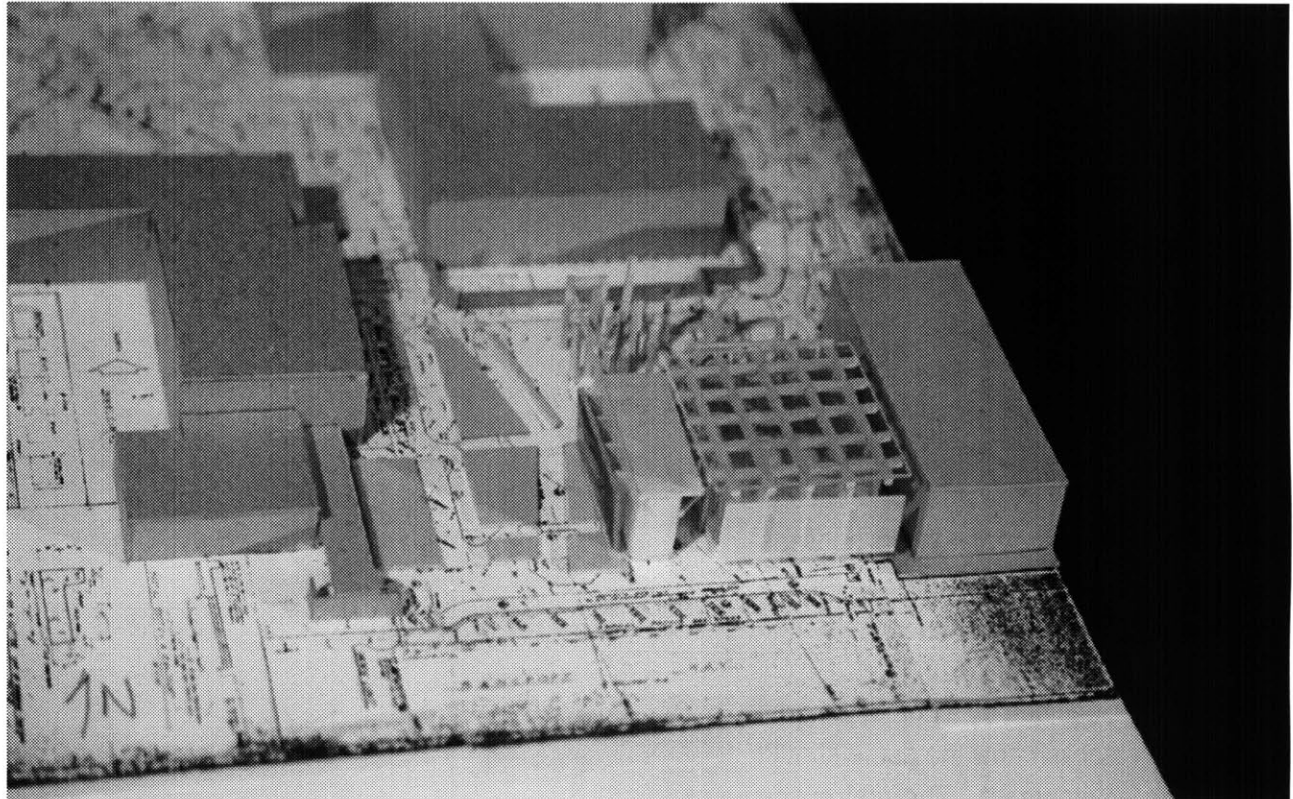
74. Interior perspective looking at the stage.



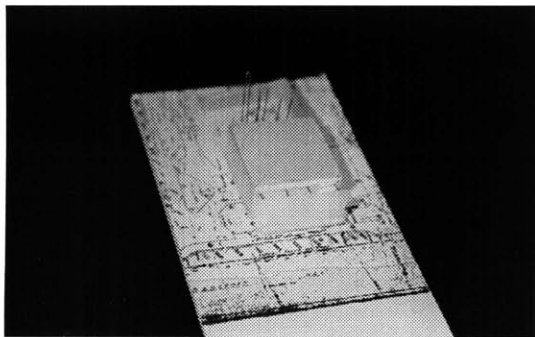
75. Interior perspective from the stage.



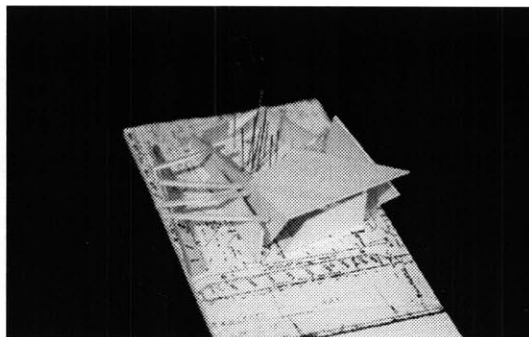
76. Perspective study of the four possible screen movements..



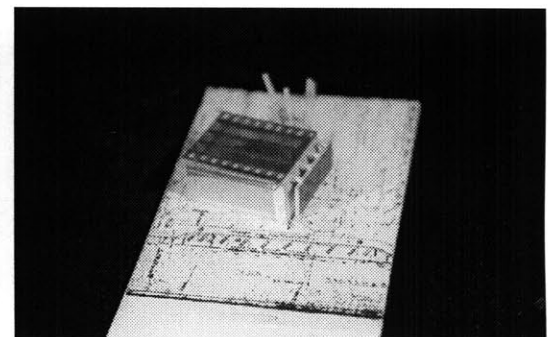
81. Photo of final Dome-in-a-Box study model.



82. Photo of study model #1.



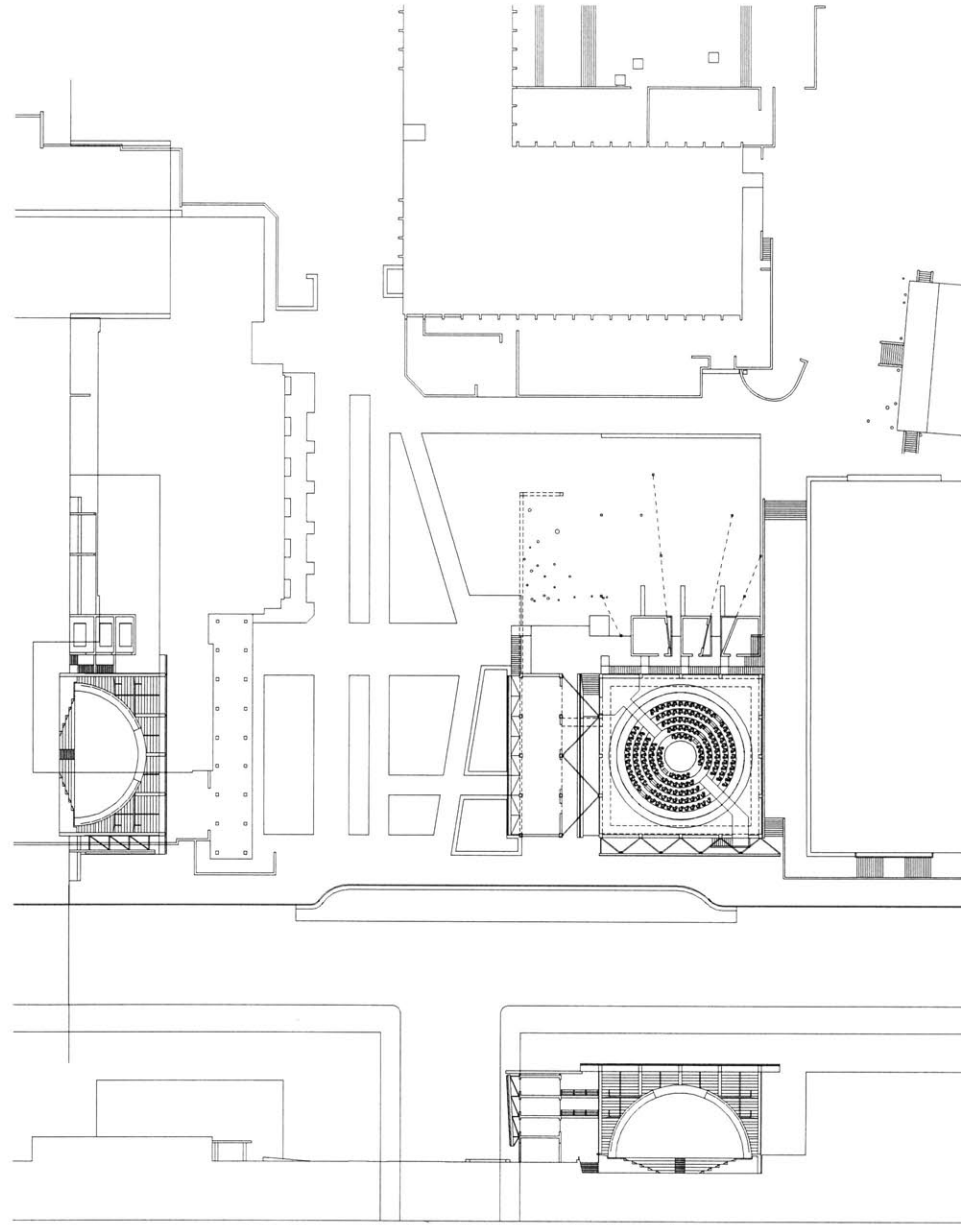
83. Photo of study model #2.



84. Photo of study model #3.

wanted to include a cafe and study area to supplement the lecture hall. These added program elements were attached to the outer layers of the box which created a filter between the virtual dome and the physical exterior (fig. 85).

After the content review, I decided that the box was unnecessary and that a stronger argument could be made if I incorporated the elements I used in the box into the dome. The dome would then truly be a hybrid between the physical and the virtual.



85. Plan and Section of final Dome-in-a-Box Scheme.

Illustration Credits

All illustrations are by the author unless noted otherwise.

1. Aukstakalnis, p. xi
7. Scientific American, p.142
8. Aukstakalnis, color plate 1
9. ibid, p.81
10. ibid, p.161
11. ibid, p.160
12. ibid, p.166
13. ibid, p.148
14. ibid, p.174
15. Laurel, Interface, p.424
16. <http://www.ncsa.uiuc.edu/EVL/docs/html/CAVEGuide.html>
17. <http://www.ncsa.uiuc.edu/EVL/docs/html/CAVE.html>
53. Shodeck, p.411

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