TOWER AS COMMUNICATION

by

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Abstract

Towers are a part of social, religious, and cultural development. Man's praise to his gods and himself have caused him to build structures to live and govern by. The anchoring of rites and rituals of man into a permanent relationship with natural and man made phenomena often yielded forms such as towers. The form of tower, consistently reproduced over time, holds great significance as a tectonic form and as a vessel to convey communication. Through my work, which fuses art and technology, I have come to appreciate the leverage that this form has yielded in my technical and aesthetic understanding. The thesis provides a context for my present and future work in the area of Art and the Environment.

Thesis Supervisor: Otto Piene
Title: Director, Center for Advanced Visual Studies

Dedication

To my two grandfathers, a blacksmith and a carpenter.

Thanks to the family of friends at the Center for Advanced Visual Studies, MIT and the Visual Arts Center of Alaska.

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Chapter 1

Introduction

As a part of the social, religious, or cultural organism, man has built towers. From ancient times to the present these towers have become symbols of the ruling body or hierarchy of scientific development. Building of towers has occured during times of war and peace, prosperity and depression. Towers have occupied a prominent place in the World Fair expositions as an important cultural exchange between nations.

Today the examples we have to study provide historical data about engineering, astronomy, astrology, the arts and navigation. A great deal of insight into the motivating factor of whole populations, employed to build those structures, can thus be gleaned.

In my research, I have found that both the formation of sub-cultures arising from the planning, construction, and utility of structures, in addition to material technology, are most consistently repeated through the tower image. Much like a bridge, the tower image can be associated with the rationale of a highly sophisticated mathematical (yet imaginative) process, which is manifested through the art of doing. Eiffel once said that he needed to be artist, static's expert, scientist, economist, and organizer as well as inventor.

The tower as image and its significance for communication are deserving of further exploration. Man's search for his identity within the cosmos is often first manifested by his building efforts, and only later by his literary endeavors. Man's development of god mythologies also precedes the development of man as myth. The tower parallels the interaction of man's "inner" dialogue with himself and his "outer" dialogue with the world at large. In this context, I intend to describe the building of towers and tower images of my own within the context of art and the environment.

Chapter 2

Creative Structures to Live and Govern By

"Tower" is defined in Webster's Seventh New Collegiate Dictionary as:

1. a building or structure typically higher than its diameter and high relative to its surroundings that may stand apart (as a campanile) or be attached (as a church belfry) to a larger structure, and that may be of skeleton framework (as an observation or transmission tower) 2. a towering citadel : fortress ; adj. towered and TOWER (v.): to reach or rise to a great height: soar also : overshadow

The tower images referred to here may represent a metaphor, i.e. column, dome, pyramid, that speaks about the ideas of verticality, and scale and their use in articulating enclosed volumes. The enclosed volume can be a physical space articulated by real materials and built with a given geometry, or it can be an idea of vertical space as associated with light sound or other cosmic phenomena that also have a geometry. The tower may then be part of the whole or it may be the whole itself.

Towers have different sizes and shapes. Floor plans can have a circular, square, rectangular, triangular, hexagonal, octagonal, or other polygonal shapes. Floor plans may have a combination of any of these as well. The boundaries of these plans vary according to the site and the intended use of the building. The earth below will also suggest the use of one system over another, as will the choice of material. Elevation can range from low height to many hundreds of feet. The exterior walls can be parallel, can converge inward or outward like a cone, or can bulge about the length of the tower. The tower can be thought of as free standing or incorporated into other systems. The tower's size and shape may be partially or fully concealed by the other systems.

The single and most influential part of tower design is the structural frame engineering. The exterior image and the interior space will always be affected by the choice of structural system. A structural frame that was common from the ancient times to the late 1700s was developed around "stacking" one piece of block upon another. Brick, adobe, quarried stone, and timber were the most common materials. Forged metal in standardized units allowed for predictable schemes for towers and bridges in the 1800's. Since then, steel has completely replaced masonry with the exception of concrete, which is steel reinforced. The Romans had invented concrete as an infill between "stacked" faces. This methodology did not survive into the Gothic period. Not until the late 1800's did concrete become visible in standard building procedure.

The tower exterior may appear solid and heavy or light and transparent, depending on the system used. Chimneys are constructed without openings. Smoke is evacuated high above the living and working centers for health reasons. The radio station tower is light and wind transparent. The placing of a transmitter or receiver at a high elevation is the main objective. The frame will usually be of light weight, modular steel components. The weight of the receiver and transmitter and their support frame are the only weight considerations. Wind load will be minimal on an open frame communications tower, but must always be considered as a force factor. Throughout the tower's history, the exterior massing of solids had gradually opened up, as in the communications tower or space frame. These examples are the most transparent, with the tower interior becoming only a volume of moving air and light, largely unaffected by the exterior skin.

The interior appearance of a tower is as important as the exterior. The interior is faced using a variety of materials affixed to the exterior frame. One objective is to illuminate the interior in a controlled aesthetic way with natural and artificial light. Doors, windows, window walls, skylights, light, and electricity are the common elements. Light reflectancy can be modified through electrical apparati, the color of paint, guilded leaf, or other surface treatments on the exposed structural frame, dividing walls, and veneer finishes.

The interior encompasses the working and living environments. Air, like light, is manipulated through mechanical systems that branch out throughout the tower. There are codes/standards that control the quality of air and light for all interior activities. The choice of materials in tower construction is influenced by the availability of indigenous resources.

Towers, like towns, were located near the building resource. If this was not true the planners usually imported materials using over the land carriers, or by floating the materials on rivers. The "brick", as we know it today, has been used for at least 6000 years. It is composed of clay and then fired to a bisque finish. The firing gives it a greater compressive strength and resisitance to exterior weathering. Mud bricks which are dried in the sun will not have the same compressive strength as fired clay bricks. Babylonian records tell of the building of ziggurats with sun dried brick. After structural failures occured, this brick was quickly replaced with the baked brick.

In parts of Italy, a natural clay block called *Tufa* is quarried. It is naturally damp but dries when exposed to the sun. It is approximately 12 times larger than brick. The use of brick or clay block did not enable high towers to last long. It is through quarrying of igneous, metamorphic, and some types of sedimentary stone that towers of greater height and longevity have become possible.

From ancient times to the high gothic period, there are examples of quarried stone construction. The first major deviation from this form of construction occured in the 1800s with the casting of iron and steel.

For thousands of years the tower's exterior and interior surface reflected the character of the stone or brick used. There is evidence of interior wall finish in the Egyptian pyramidal chambers and ante-chambers where walls were sometimes painted with frescoe-like designs, but the natural stone itself often provided the finish.

In the advent of iron and steel, masonry forms and filigree were reproduced through the casting method and later a skin of stone was placed on a steel frame to give the appearance of a masonry building, a technique highly used today. Reinforced concrete, which is about five times less expensive than steel frame, has also been skinned with everything from stone sheets, lead sheets, glass, and direct painting, to brick and plastic members. Granite's dense crystalline sturcture offers a highly inpenetrable surface when polished. Its mirror-like surface goes well with glass, an amorphous solid made from silica (formula: SiO_2). Pliny and the ancient Romans considered glass a man-made stone. These basic tower-building materials are still evolving.

Chapter 3

Man's Eulogy to His Gods

The development of the tower up to the late Roman period has proven useful in the articulation of successive organized spaces with the tower at one end of the scale. In the tower's construction there are significant, yet minor, decorative elements that distinguish regional character and influence. In the religious art and architecture of Byzantium through the High Gothic period, the tower became the vessel of high decorative relief and a carrier of art that communicated man's eulogy to his gods, paralleled by his higher sense of engineering.

"Byzantium, renamed Constantinople after Constantine the Great, its Imperial founder, and also called 'New Rome,' was inaugurated as capital of the Roman Empire in 330. It stood at the junction of the Bosphorus and the Sea of Marmora, where Europe and Asia are divided by only a narrow strip of water. This gave it a commanding and central position for the government of the easternmost and most valuable part of the Roman Empire. It was also at the intersection of two great highways of commerce, the water highway between the Black Sea and Mediterranean, and the trade route between Europe and Asia; thus it controlled the corn trade from the northern shores of the Euxine. The natural harbour of the Golden Horn possesses unusual advantages for commerce; it is four miles in length, unaffected by tides, and of sufficient depth to render its quays accessible to ships of deep draught. Byzantine art pervaded all parts of the Eastern Roman Empire and was carried by traders to Greece, Serbia, Russia, Asia Minor, North Africa and further west, where it is found in Venice, Ravenna, and Periguex, and it had considerable influence on the architecture of these districts. Venice, by her situation, was a connecting link between the Byzantine and Frankish Empires, and a depot for merchandise from both East and West." [Fletcher 75]

Local craft in Constantinople depended on the import of marble from coastal fissures and islands that had exposed marble stratae. At the time, Constantinople was the major center of marble working, supplying all parts of the Roman Empire. Byzantine architecture was therefore influenced by the accessability of monolithic size block that could be tooled to make large columns and lintels. These monolithic blocks, which no longer exist today, allowed engineering practices to go beyond known practices of the time.

The building of large towering structures in Constantinople paralleled the regional shift of power in A.D. 330 from Rome to Byzantium. The new Imperial city and its buildings communicated wealth, political position, and above all, the glorification of early Christendom, through the building of Santa Sophia.

The forum of Constantine had a large marble column that became a landmark for the merchants of that time. The marble column consisted of feldspar crystals embedded in a dark red and purple ground mass. Its beauty became a symbol of commercial life, and a reference point for the gathering and sale of marketable goods.

The building of aqueducts and the storage of water in enormous underground cisterns with roofs upheld by many hundreds of columns,were monumental efforts achieved through the availability of marble. The Great Wall with its famous military gates had many towers and was built by Theodosius II (c. 413). In its plan, the wall scribed a circle of land and water used as fortifications against the attacks of Huns and Goths.

The character of Byzantine architecture, dating from the fifth century, is determined by the development of the setting a spherical dome on a square chamber. The domical roof construction is in strong contrast to the early Christian timber trusses and stone vaults. " It may be stated that the basilican type of plan belongs to Early Christian architecture and the domed, centralized type of plan to the Byzantine. At the same time, during the first few centuries of the Byzantine Empire one may find domical constructions in Italy and basilican plans in the Eastern Empire." [Fletcher 75]

The decorative character of external facades depended largely on the arrangement of the facing bricks, which were not always laid horizontally, but sometimes obliquely, sometimes in the form of the meander fret, sometimes in the chevron or herring-bone pattern. An attempt was also made to ornament the rough brick exteriors by the use of stone bands, decorative arches, and adjoining towers and turrets.

In Santa Sophia, we see the perfect expression of the Byzantine style: the columns supported the galleries rather than being only ornamental, with the semicircular arches resting directly on the column.

The monumental dome gave an impression of one vast open interior. The articulation of its enclosure was quite intricate, yet straightforward with obvious use of well planned progressions of basic units. Scale was obtained by the gradation of these basic units as they formed the two story arcades with the dome resting on top. "The dome is constructed of bricks about 27 inches square in the lower part and 24 inches square at the crown, and 2 inches thick, with mortar joints of nearly the same thickness. The joints do not radiate from the center of the dome, but have a flatter inclination, in order to diminish the thrust. The walls and piers are sheeted with marbles of Phrygian white, Laconian green, Libyan blue, Celtic black, besides Thessalian and Bosphorus marbles, all fixed by metal clips." [Fletcher 75]

To support the goined vaults 107 columns of marble are used constructively under the galleries, and moulded bronze rings encircle the column shafts at their junction with capitals and bases, while the outward pressure of the arches is counteracted by tie-rods. The lower stories of the aisles north and south of the central space are supported by four columns of dark-green marble, while the upper stories have six columns of the same marble. Each of the four exedrae has two large columns of dark-red porphyry, and six smaller columns in the gallery. The lighting is partly effected by forty small windows in the lower part of the dome and by twelve windows grouped in the spandrel walls north and south under the great arches which support the dome. Many of the windows are small and spanned by semicircular arches; others are more elaborate, with large semicircular-headed openings divided into six by columns of two heights, between which marble lattice screens admit light through glazed openings about 7 inches square.

"The lofty minarets were added by the Turks after the capture of Constantinople (c. 1453), and they frame in the subsidiary buildings of the Turkish period. Santa Sophia is the supreme monument of Byzantine architecture, and provided the model for many of the great mosques which were built after the Turkish capture. The building is now a museum." [Fletcher 75]

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3.1 Islamic Architecture and Towers

"Islamic architecture, insofar as it can be defined, is not the product of any one place or people. It is the product of a major historic event -- the rapid conquest of diverse territories by a people with no architectural tradition, and the consequent synthesis of styles under one philosophy but in many different circumstances." [Fletcher 75]

The majority of Islamic buildings are fundamentally related to a principal axis. This axis (and secondary axes) frequently extended into a formal landscape which is an integral part of the design. While the prime axis was the kibla, the general concept was derived from the line of balance and symmetry implicit in the concept of perfect creation. This was the basis of the formal disposition of gardens, buildings, parts of buildings, and of articles as small as rugs.

Islamic architecture communicated universal religious truths, as held in the Islamic religion, having space designed within certain guidelines. The mosque is the center of contemplation and prayer - totally removed from the exterior world. It was not designed to invoke a sense of exaltation nor to draw attention to any part of the structure.

The mosque serves as a space for the human need. It is a building of meditation and refuge for the tired and traveled. It serves the function of transport for the human well being and allows a "right to space" in an uninterrupted flow of good will. It can be used as a school and a place of transaction as well as a prayer house.

The mosque was a novel conception, of which the first example was the courtyard of the Prophet's house at Medina. The earliest consist of open courts surrounded by arcades (as in Syria) or by trabeated timber colonnades with flat roofs. An early innovation was the minaret, a tower from whose top the Muezzin gave the call to prayer (a form of summons adopted in deliberate distinction to the clapper used by early Christians).

Ancient Greek and Roman columns were often reused by Moslems, and thus became models for new work, particularly in Turkey. Fluted columns were not employed, but tapering circular shafts, with entasis, were common, except in parts of Persia where Sassanian influence continued, and in India, where a square form occurs derived from Jain models. Decoration of Moslem towers was extensive and made use of the following techniques: carving in bas-relief, stone inlay, stone mosaic, structural assembly of contrasting stone, patterned brickwork, carved stucco, ceramic facing, ceramic mosaic, glass mosaic, painting, timber inlay, and pietra dura. Motifs were derived from calligraphy, floral abstraction, and geometric interlacement.

"Among precise architectural features, the following are the most frequently recurrent and characteristic: arcading, both timber and masonry; the pointed arch; the true dome; columns, similar in proportion to Greco-Roman models or their derivatives; squinches, stalactite corbelling and pendentives. Of structural and decorative techniques those of which Moslems make the most significant use are: banded or striated masonry (including brick and stone coursing); decorative bonding for brickwork; interlocked and inlaid stone masonry; metal or timber ties to arches; bas-relief carving in stone, timber and plater; ceramic cladding and facing; interlocking panelled geometric timber construction; screens or pierced grills in marble, metal, or timber for window openings, internal window lights in stained glass set in plaster, colonettes, particularly at quoins; stalactite decoration. ... The stalactite, is peculiar to countries dominated by Islam. It can be used as a corbel to close an opening, as a frieze, as a pendentive and to reduce a square to a camfer on an arris or capital. Inverted, it is occasionally used to transpose a circular or multi-faceted shaft to a square base. A similar purpose is served by the 'Turkish Triangle,' an arrangement of slender triangles, interlocked and with their planes at variance. The use of stalactites (also known as muqarnas), which is something between a decorative and a structural technique, requires description. The construction is a form of corbelling in which the corbel is set at an angle to the main wall, the arris of the corbel being the furthest projection. This supports in turn similar corbels placed above the first and on either side of it, so that their line of junction continues the arris of the first corbel. When repeated successively, this process produced a continuous corbelling which can be elabroated and decorated to an astonishing degree. It has provided Islamic artists with a device capable of application to many materials, on the largest and smallest scale. It has been used to display the virtuosity of the artist and the wealth of his patron and in the process has become more peculiarly identified with Islam than any other feature." [Fletcher 75]

An example of an Islamic fortress and palace combined is the ruin at Ukhaidir, Iraq (c. 780). It stands by a small Wadi on the eastern fringe of the Arabian Desert and appears to be associated with two other isolated ruins of similar character, the tower Minar Mujdeh and the brick-built Khan At'Shan. "Its subdivision into courtyards includes a court of public reception and a mosque." The interior structure is entirely rough rubble, with elliptical and pointed vaults built without centering and the whole building was faced in a coarse stucco. While its impressive massing derives from its function, much of the internal quality demonstrates a vigorous architectural style that is of Sassanian inspiration, no doubt reflecting contemporary Baghdad." [Fletcher 75]

Another example of towers in Islamic culture can be found in the Great Mosque of Kairouan. The mosque is the ancestor of all mosques in western Islamic lands. The mosque gained its present stature in 695 when its was rebuilt upon its original foundation. Renovations were carried out in 836, 862, and 875.

The exterior is simple and clear with a massive square minaret to call the faithful to prayer. The minaret and the adjoining walls, entry, and court communicate a luminous clarity of the ideals and way of life of early Islam.

Early Islamic puritanism, inherent in the view of the Orthodox caliphs that nothing should divert attention from the act of prayer, is symbolized by the purity and simplicity of its architecture forms.

The minaret's construction was based mainly on "stacking." Aside from square plans there are spiral and circular plans. Most minarets favored a flexible system that permitted enlargement and addition with minimum effort. One might say that the minaret communicated structural flexibility in adapting to growth.

> An example of this flexibility is the mosque of Cordoba which was begun in 784 and enlarged several times during the ninth and tenth centuries. The additions followed the original style and arrangement of columns and arches, and the builders were able to maintain a unified style for the entire building. The 36 piers and 514 columns were originally topped by a system of doubled tiered arches that carried a wooded roof, which are now replaced by vaults. [Hayes 78]

The genius of Arabic science covered mathematics, trigonometry, and calculus with strong emphasis on astrological theory. A common 8-point plan on octagonal division of the circle found its way into the Middle Ages of Europ through Latin translations of various Arabic treatise. The octagonal plan in the mid 1400s became symbol for Italian Renaissance cities and tower plans. An example is in the "Filarete" or "Sforzinda," the star-shaped city plan with its radial road pattern. Sixteen main streets radiate from the central piazza to the eight city gates and the eight corner towers. Midway, each street crosses an open square, eight of which have a church in the center. This plan developed betwen a Tuscan architect (Antonio Filarete) and a Renaissance prince named Francesco Sforza. Sforzinda was described thoroughly from the prince's palace and the cathedral down to the quarters to be alloted to merchants and artisans. The outside walls would form a sixteen-sided figure with their height to be four times their depth. The streets would lead to the center square which ought to be twice as long as it is wide. In the middle of the square would be a town high enough to overlook the whole surrounding district.

Moreover, the central tower would become the Bell tower for calling the faithful to prayer much like that of the Islamic minarets and their "clappers." The tower communicated strength and wealth of the ruling families and a focus within the religous domain. [Gardner 75]

* * * *

3.2 Romanesque to Gothic.

From the 11th century through the late Gothic period, the tower was represented in religious structures in quantity and form never before conceived by man. The prevalent religious zeal, aided by the unification of Europe through the temporal and spiritual hold of Rome, provided focus for intense building. Monasticism provided centers that fostered art and learning , producing a grand series of Romanesque buildings beginning in France.

The cathedral of St. Serinin in Aquitaine (c. 1100) is cruciform with nave, double isles and transepts. The nave has a round arched barrel vault, with plain square ribs, supporting the roofing slabs directly. The high triforum chamber has external windows which light the nave. There is no clerestorey. The central octagonal tower (1250) with a spire (1478), 66 m (215 ft) high, belongs to the Gothic period. This was the first genuine Medieval architectural example. The structural system failed in the requirement of lighting because at this time the masonry vault system that admits light had not been fully developed.

The cathedral of Speyer (c. 1050), in the German Rhineland region of Lombardy, was the fist fully vaulted church. It was built in the Ottonian tradition of balanced tower groupings, which added to the articulation of wall surfaces.

The cathedral of St. Ambrogio in Milan (c. 1100) set a type for Lombard churches which included the metrical chanting of the Mass. Here, Saint Augustine was baptized, the Emperor Theodosius was excommunicated, and Lombard kings and Germanic emperors were crowned. The plan includes the only existing atrium among Lombard churches, a narthex flanked by square towers that reflect the crossing towers of German churches. A vaulted nave and isles with an octagon over the crossing, triforium gallery, raised choir over the crypt, and an apse.

The Abbaye-Aux-Hommes, Caen (c. 1068-1115), known as St. Etienne, is a major source of information on the evolution of Gothic architecture. It may have been modeled on the Romanesque Cathedral of Speyer. The western facade is flanked by two square towers, crowned by octagonal spires which with angle pinnacles, added in the thirteenth century was a prototype of late Gothic facades. The triple division of the towers above their buttresses allowed a greater piercing of their walls from the tower to the upper stages. A total of nine spires appear for the first time in any known cathedral. Vaulting in the choir of the abby shows cracks in the webbing caused by outward displacement of the wall, which has little effect on the overall vault behavior.

The church of St. Denis (c. 1140) near Paris was built out of a dialogue between Bernard, a theologian at the time, and Abbott Suger. It is of great interest because it communicates the spirit of the French kings who are buried there. Bernard held the view that faith was mystical and intuitive, rather than rational. Bernard's influence reflected his theology, stressing purity of outline, simplicity, and a form and light peculiarity conducive to meditation. In this aspect, his architectural views were very similar to those of the Islamic architectural tradition. Abbot Suger's description in designing the new choir talked about a string of chapels with luminous windows that would eventually proclaim a new style. He wished the entry volume to shine with wonderful and uninterrupted light. It was the "scienta" theory of light that led Suger to the invention of the earliest truly Gothic structure. Typically Gothic are the deep embrasures of the doors and windows, and the open structure of the tower. The church communicated the principle of reduction of sheer mass by its replacement with intricately framed voids.

The Cathedral of Laon (c. 1160-1225) is planned after the Latin Cross and was built in the early French Gothic style. It has a pair of towers flanking each arm of the transept (only two completed) and a lantern tower over the crossing, which, with the two western towers gives a total of seven, the perfect mystic number.

The Gothic cathedral of Chartes (rebuilt c. 1194-1260) was considered the first High Gothic Cathedral of Europe. The flying buttresses that were normally concealed under the roof of the isles were now exposed. The unified look of exposed buttressing is reminiscent of process, as if it were scaffolding left in place. The exposed buttresses allowed the upper wall of the nave to be opened up and therefore created more window space. There is a north tower with spire (c. 1507-14) which is thought to be most beautiful of all Europe. It forms an interesting contrast with the spire of the South tower (c. 1145-70). Chartre was the first example of a cathedral that changed the bays from a square plan to a rectangle. Although Chartes made a major aesthetic contribution by becoming the model for the great High Gothic buildings that followed it, where technical matters are concerned the cathedral's design was far less revolutionary than has been claimed. Its full significance was not appreciated until late in the Gothic era, when its steep sloping buttresses reappeared in several large churches, including the choir of the parish church of St. Elienne at Beauvias, and the nave of Bath Cathedral. (E.G.S. p. 47)

The High Gothic Cathedral of Amiens (c. 1220-88) is often compared to Hagia Sophia because of the similarity of light quality. The structure has a complete Gothic vocabulary, which consists of a rectanglar bay system, four-paneled nib vault, and a buttressing system. Amiens is a true self-sustaining skeletal structure. The upper part of the west front and the west towers followed after an interval (c. 1366-1420) and gave an overall light quality to the massive masonry facade.

The High Gothic Cathedral of Cologne has the longest building history, spanning five centuries (c. 1248) reconvened in 1824, and finished in 1880. It is the largest Gothic church in Northern Europe, covering 91,000 square feet. Its twin towers stand 500 feet high.

The tower of Pisa (circa 1175) is an out-of-line campanile of the Romanesque Period. It follows the Ravenna pattern, enclosed by six galleries of marble columns. It is grouped with the baptistry and Cathedral of Pisa, and stands 179 feet in height. Its skewed trajection of 14 feet off perpendicular is the result of an unstable foundation (consisting of a 62 foot deep pile of treetrunks and stone). The visual image of a crooked tower contrasts our conditioned thought about mass and its placement in obtaining verticality. Galileo is believed to have used the tower in his studies of falling bodies.

In view of the monumental efforts of church builders during the Romanesque and Gothic period, man had reckoned with a variety of structural systems. Some failed and some were successful. Each fell into a sequential and critical order dependent on or in support of the next. Towers and spires, being elements of structure and decoration, became highly evolved. In my opinion they are unsurpassed in beauty, grace, and artistic intention even today.

The builders of the Gothic Cathedral well understood the facts of size and scale upon which their plans were carried out. There are numerous accounts of cities competing in this respect. The master builder knew his attempts were often unprecedented, therefore the image he created would be new and awesome in the minds of the local and surrounding communities.

The cathedrals of Europe can be considered pure art, in that the "art of geometry" applied used both the "scienta" theory, and "ars" the technical knowledge and practical skills that were needed. There must have been numerous discussions on the philosophy of art and its meaning to the secular and non-secular communities to create these unprecedented structures that penetrated the atmosphere with an upward thrust.. The religious zeal that motivated these monumental efforts was scientific in foundation and dependant upon the widest vision, the best talent, and the hardest-working laborers of the time.

The far-reaching verticality in perceptual schemata identified a new scale and rearranged the existing succession of organized spaces. The development of man's mind and his perception of space had changed, beyond the structural engineering practices. The practice of coupling art with technology was the main influence in this psychological re-evaluation of space. Very few of the texts used for research speak of this phenomenon of art when analyzing the cathedrals. But then it is difficult for people to conceive how past cultures may have reacted to newly-created images. The science of psychological and physiological phenomenon associated with the use of space tells us most specifically how or why we react the way we do, but the science of psychology is barely 75 years old. One must think that monumental achievements such as the Gothic Cathedral building era did not depend on the analysis of each step by a psychologist or an M.D.. What we might assume, is that man's psyche was driven by the thirst for more height, more light, more technology, and in the secular forum, a closer place to God.

The elaborate ornamentation assocated with the Byzantine , Romanesque and Gothic styles are evidence of the attention to detail beyond the main structure. The depth of character in a well-lighted structural void can generate a mood even more sweeping emotionally than the vast clear open vaulted space.

The articulated smaller void holds real information on systems coming together. A merging of forces. A canopy meeting a tower, a canopy meeting a column, a vault resting upon a series of arches, or simply your eye resting momentarily upon the joint where these elements come together all express the merging of individual systems into a unified whole. Where they meet, elaborate decoration, sculpture, and openings for windows are created. In the spirit of the overall system's performance, every detail counts. The art of working solid masonry reveals itself in the context of strength, stability, and permanence. It offers the viewer more than a moment of ponderance. It is the sight of well-crafted, articulated, solids coming together that attracts rather than repels. For the countless hours that masons spent figuring out weights, spans, and erection procedures, the integrity of their art has proven attractive and long-lived. Not unlike early totem makers who carved totems using available means, yet had a general reverence for the material, the Gothic masons knew every inch of the stone, its carving capabilities and performance under compression in a given pattern.

The making of ornamentation the human scale leaves behind a direct expression of the hand. Pieces of stone that are manipulated to become permanently visible. They are the trademarks of the craftsman, made permanent in time.

In review of the tower images mentioned in this chapter from the Byzantine to the High Gothic I would like to mention the two most important elements that appeal to my nature and to that of my own work. Through time the structural envelope had progressed through the use of more pieces and the associated art of craft that places those pieces in intricate patterns within newly-developed structural systems. The evolution of Artistic expression through the building of physical towers' structure cements all known practices of the time into a capsule. With the finality of the flying buttress becoming exposed and the clear story wall becoming more penetrable, more light could illuminate the interior. Structural expressionism and light are the two elements. The use of light as a building block, to sustain a uniformly lit chamber in character with natural light of the passing sun, depends on the structure or apparati created. Casting beams and arcs, into or though or onto or across, in some way traverse or intersect with other structures.

Portraiture and natural gesture of character were important aesthetic concerns in the 13th Century. The Naturalism of the 13th Century led to more Humanistic values in the 14th century. Ornamental effect and courtly convention created a move towards more formally integrated structural systems to parallel the more formal social structure. The use of light interplay within structures, courtly building conventions, and systematized ornamental effects helped to accomplish the formalization of built structures. This structure and light obsession became the ideal for Renaissance art and architecture.

The unity of man's emotional and intellectual position was enhanced by clear logical component parts that were used to articulate self-sufficient systems. Beginning with Alberti (1407-72), and his treatise on architecture, the classic builders rediscovered the text of the ancient Roman architect and theoretician Vitruvius.

> The Vitruvius text became the subject of exhaustive studies and interpretations. Brunelleschis' invention of perspective, and Piero's treatise on the same subject provided the Renaissance artist's opportunity to demonstrate the scientific basis of the visual arts. It is interesting, with respect to the treatise on perspective, that a device that had been used by artists for decades was only in the econd half of the 15$^{\underline{th}}$ Century explained in learned treatises. Thus, as often happens, theory followed practice. [Gardner 75]

The cathedrals of Europe through the High Gothic Period had thus become symbols of man's praise to God and the Royal Court. Portals in the facade's interior and exterior niches held statues of religious figures and royalty. In development of holy and profound space, the art and architectural features were the incarnation of the image of physical and psychic suffering. Depiction of religious figures, especially that of the life of Jesus Christ as the symbol of salvation, introduced motion in portal sculpture which was percieved as emotion. The active, or emotional, human face brought attention to the other dimensions implied in the art. Like the building process, which then derived from three-dimensional constructs expressed as two-dimensional drawn plans, the portal sculpture also communicated an evolved attitude in articulating space.

In the 12^{th} century, a more humanistic world view came into focus, with the elements of suffering and anguish depicted in the arts. The division created by monasticism and monastic art was the expression of the difference between man building on Church teachings in a macrocosmic sense, and the worldly concerns of the Crusaders. The Crusaders were only interested in the microcosmic sense of world conversion.

Chapter 4

Man's Eulogy to Himself

The consolidation of the tower image over time is not difficult to understand from the standpoint of the tower's physical characteristics. There are motivating elements in man's psyche that generate myth and mythos in a culture building images. The tower has played a role as image of hierarchy in a single society, and as an image of hierarchy between societies. The tower, when singled out from other structures can shed light on those divisions of itself and in society, for man and by man.

By seperating functions of society, and thus establishing order, the tower gains its own vocabulary, a vocabulary dealing primarily with articulated perceptual schemata. Our impressions of class distinction, government and human environment are often articulated though the tower image. High on the hill is an enclave of residential homes, some of which have turrets. Downtown there are the municipal or state buildings with their towers in effigy to the celebrated pioneers of local government. The tower image in these places is a part of the order of social structure. Since towers in general are individually high or are placed on high buildings, we perceive them at one end of the scale in a symmetrically organized succession of spaces. Through its constancy as a phenomenon, the tower image is anchored in experience not only as a *form*, but also as the division it represents. The division is an aid in establishing order from one hierarchy of space to the next. We encounter these spaces daily. In a biased or unbiased manner we use these spaces. The spaces will never change unless man or nature changes them.

Tracing the natural evolution of cultures will bring to mind the non-established order of towers. Here the tower is a more direct response to man's environment, an outcome of man's need to identify with his surroundings and shelter himself from the natural elements.

Transient, episodical and periodic cultures often used totems as a mode of expression. The totem, as a tower form, took on zoological and botanical characteristics. The carving of natural rock, wood, and bone, and the use of earthen pigments transformed a local image into an image of communication. Men used simple devices to build their totems. Hand-made stone objects for rubbing, scraping, gouging, and hammering allowed them to shape and form images that were well-articulated, symmetrical, and bold in character. The totem height was restricted by the strength of a small number of men using conventional lifting devices of the time. The totem's communicative intent was manifested through its symbolism and placed upright in the domain of occupancy. Near the home, the hunting ground, or celebratory spaces the totem purported to communicate with the spirit of the place as well the peaceful or non-peaceful individual or group approaching that space. Because of its elevated height and permanence, the totem as a tower made it's location known at a distance. In some regions, totems from early cultures have survived decay. They have provided us with pertinent data for our understanding of the evolution of man's social and physic spheres. It is important to recognize the evolutionary process of symbolism as highlighted by Claude Levi-Strauss:

> As medial classifier (and therefore the one with the greatest yield and the most frequently employed) the species level can widen its net upwards, that is, in the direction of elements, categories, and numbers, or contract downwards, in the direction of proper names. This last aspect will be considered in detail in the next cahpter. The network to which this twofold movement gives rise is itself cross-cut at every level, for there are a great many different manners in which these levels and their ramifications can be signified: nomenclature, differences of clothing, bodily paintings or tattoos, ways of being or behaviour, privileges and prohibitions. Each system is therefore defined with reference to two axes, one horizontal and one vertical, which correspond up to a point with Saussure's distinction between syntagmatic and associative relations. But 'totemic' thought, unlike speech, has this in common with mythical and poetical thought that, as Jakobson has established for the latter, the principle of equivalence acts on both planes. The social group can code the message without any alteration in its context by means of different lexical elements: as a categoric opposition: high/low, or as an elemental one: sky/earth, or again as a specific one: eagle/bear. And equally it has the choice of several syntactic procedures to assure the transmission of the message: nomenclature, emblems, modes of behaviour, prohibitions, etc., used either alone or together.
>
> Were the task not so immense, a classification of these systems could be undertaken. Systems would be distinguished according to the number of catgories they employ -- ranging from two to several dozen -- and according to the number and choice of elements

> and dimensions. They would then be distinguished into macro- and micro-classifications, the former being characterized by the admission of a large number of animal and plant species to the status of totems (the Aranda recognize more than four hundred) and the latter by having totems all, as it were, inscribed withing the limits of the same species. The Banyoro and Bahima in Africa provide an instance of this. Clans are named after particular types or parts of cows: striped cow, brown cow, cow in full milk, etc., cow's tongue, tripe heart, kidneys, etc. The systems may equally be distinguished by the number of their dimensions. Some are purely animal, some purely plant, others appeal to manufactured articles, and yet others juxtapose a variable number of dimensions. They can be simple (one name or one totem per clan) or multiple as in the case of the Melanesian tribes who define each clan by a plurality of totems: a bird, a tree, a mammal, and a fish. Finally, the systems can be homogeneous like that of the Kavirondo where the totemic lists are composed of elements of the same type: crocodile, hyena, leopard, baboon, vulture, crow, python, mongoose, frog, etc. Or they can be heterogeneous, as the totemic lists of the Bateso illustrate: sheep, sugar cane, boiled bones of meat, mushroom antelope(common to several clans), sight of the forbidden antelope, shaved skull, or again, those of certain north-east Australian tribes: sexual passion, adolescence, various diseases, named places, swimming, copulation, the making of a spear, vomiting, various colours, various physical states, heat, cold, corpse, ghost, various accessories of ritual, various manufactured objects, sleep, diarrhoea, dysentery, etc.

Outside the botanical and zoological symbols there are other periods and activities that portray man's myth of self. Man as myth has developed around sexualism, birth, adolescence, and death. In an article, Dolores Hayden describes the skyscaper as a cultural artifact reflecting the economic developments, personal-social mobility, and personal sexualty within the past century. Hayden uses the metaphor of "rape" suggested by the "strong phallic form of the skyscraper that illuminates the process by which American urban residents and workers have, at times, resigned themselves to an oppressive architectural form." In addition, "the skyscraper architect added the office tower to the procession of phallic monuments in history." Poles, obelisks, spires, columns, and watchtowers are included, with very few designers asking what the effects would be to insist that ordinary people inhabit such extaordinary, tall, erect structures. [Hayden 77]

A general assumption among most people, a notable example being Dolores Hayden, is that the tower is a sexually phallic symbol. For practical purposes in the science of psychology many human attributes associated to human activity or man-made artifacts certainly express man as myth, manifested though ritual and ritualistic objects of which some are phallic indeed. Some critics have paralleled sexuality and sexism with the tower image, yet the memories of such tower builders as Le Corbusier and Louis Sullivan go beyond the fixed notion of "phallic permanency" in towers.

The seasonal tower, and the evolution of culture around it, can be discussed in either of two ways. First in the nomadic sense and second through the activity of a periodic or temporary culture trying to become more permanent. The seasonal tower, two examples being the tepee and seasonal lodges of the North American Plains Indians were common among the nomadic peoples. The territory of a single tribe, being thousands of square miles, was contoured by seasonal movement. The Indian was dependent upon the wild animal (bison), and therefore regulated his movement according to the habits of the animal. As the animal in turn migrated due to seasonal changes, so in turn, did the Indian. The tepees could be dismantled, packed and moved in a short time. Tepees were made of buffalo hide, stretched over young saplings arranged in a cone shape. The tepee communicated individual privacy, and allowed for patterns of harmonious clustering of dwellings with a river's edge or a meadow's embankment. Whereas the tepee is a symbol of true adaptability to seasonal environment, towering images, such as Easter Island Monoliths and Egyptian Obelisks, were symbols to seasonal rites and ritual, often incorporating seasonal light patterns.

A periodic or temporary culture created monoliths to express a myth of the land, sky, water,or sun, in order to communicate a presence of order with man at its center. The monoliths were quarried in one piece from a barrow. Barrows could be near the intended erection site or a great distance away.

Seasonal laboring by man and seasonal laboring by natural weather at these barrows were combined to harvest the stone. The splitting of stone was sometimes assisted by frost wedging or intense heat. Through this process man used nature in a seasonal way returning to the barrow each year until the project was complete. To achieve his goals man communicated a feeling of permanence towards his residence, either of his free will or through subjugation by others. Again, the towering image, upon placement, communicates the will not only of the power control center, but also of a division of communication between the labor and the control of labor. The monoliths harvested reflected the power center's understanding of earthen and cosmic order. Monoliths harvested by the labor force set up the periodic movements of the populus which communicated a sense of order through purpose. Workers were educated through the process of building . As influence from a single tower, the education gained would prove to be regionalistic in origin and provide future builders with proven technology from a specific geography. By communicating time and alluding to a physical center of man's known universe, circular and spiral arrangements of stone illuminated his sense of being.

In the Olmec traditions of Classical Ancient Mexico man sacrificed man each day upon the powering pyramid of the sun in the belief that the sun would not appear each morning unless the sacrifice was made. The towering pyramid was made as close to the sun as possible and communicated mystery and power through the priests who were closest to the sun god.

Other monoliths that communicate a homo-centric sense of cosmic order are the spires of cliff stone in the Havasupai Canyon, a finger canyon off the grand canyon in Arizona. Unlike quarried monoliths, these towers of sandstone have been carved out of the cliffs through wind erosion. With the stratum clearing defined the towers appear to be individually stacked boulders. Rising from a base 20 feet in diameter, these rock towers stand apart form the canyon wall. They look fragile and ancient. The Havasu speak reverently about the wind spirit that carved these towers since it is the same spirit that carved the canyon into which their forefathers descended to escape warring tribes of the mesa above. The Havasu believe their world will cease to exist if the towers topple from quake, wind, or man. Havasupai Canyon tower spires communicate a time element relating the "ancient ones" to their own unknown future. Located in a naturally sacred place, the mythical Supai Towers are spared from the insurgence of the technological world.

Rites and rituals find cultural permanence manifested through the building of towers and towering images or the eulogizing of natural phenomenona. The development of permanence paralleled the development and use of technology. Without the stonecutter's tools, there is no stone to build with. Without the rope and horse's harness, there is no way to pull heavy loads. Continuing development of technology has brought man closer to and further away from his ideal at the same time. Increased technology enables more permanence. More permanence suggests less development time or more development time, depending on the user and the part of man or man's domain being developed. Rites and rituals are as much a part semi-permanent and permanent cultures as is the technology needed for their expression yet the scale of expression has grown beyond manageable size. There are the human scale and the larger-than-human scale. Each has its characteristics of motivation, human desire, aspirations, and impulse. Propelling the larger-than-human scale enivronment is a set of non-human values,which are often easily mistaken in the context of humanistic qualities. We have learned from the primitive cultures that the building of towers and towering images emanated from the human scale, and therefore from the human impulse for human communication. Towers in permanent cultures can be dated from the Great pyramids and the Tower of Babel. We may consider the U.S.A. to be a semi-permanent society, because it is relatively young. Sheltered from human instincts, impulses, and desires, the towers of man today reflect pure manifestation of technology or ego, rather than human interaction. The tower as hierarchy in image represenation, and its division along an axis of symmetrically organized successions of spaces, has become permanent today through the economics of building technology and building maintenance. Today, we rarely see tower images that grow out of human rite and ritual. Instead, the tower offers a space for these happenings in a subjective context.

Immigration to the United States was symbolized by the Statue of Liberty. It is a towering statue designed and built by Eiffel that communicated a land of the free; life, liberty and the pursuit of happiness at a time when social and religious subjugation prevailed in Europe. Our forefathers looked elsewhere and to America they came. The old world of our fathers is no longer very different from the new world in modern times. Along the East Coast, it is not uncommon to see a family locked into a tenant slum tower for five generations, with no appreciable change in the family's well being. Through the economics and impulses of a synthetic technological society, habitat options paralleling those of the 17th and 18th have emerged.

The tower, in its role representing hierarchal spaces and divisions between societies became important through the cultivation, expansion, and protection of man's achievements. As man's technological achievement allowed permanency of ritual to become tradition within a culture, the tower image grew in size, scale, and meaning -- both physically and psychically.

A man, or a group of men, at the center of power over a socially organized region, had the right to form armies, centers of education and new materials and methods for art and architecture. Man could develop these functions of society only as fast as his technology allowed. With alternate perspectives from neighboring regions man could move beyond his edifices and traditions. If the invitation to share was unclear, then man either yielded to his own lack of resources and ingenuity, or considered an invitation to war.

During its 600 year reign, the Roman Empire built towers of defense in almost every region that came under its control. *Porta Ostiensis* (Porta san Paolo, c. 275 A.D.) was constructed as the new entry to Rome, in Rome's own defense, shortly before Rome fell. It was an integral part of the Aurelian Wall that had 300 towers and 13 other gates.

The fusing of cultural traditions from one region to the next was often communicated through the towers' architectural or sculptural detail. Influences of the Medes upon the

Syrians is visible in the plan of the palace at Persepolis, c. 500 B.C., where the median square plan was used over earlier rectangular plans. Thirty-six 40-foot columns formed a square main hall which overlooked the sunset to the west. The monumental processional gate was flanked with crenelated towers that conformed to the type of gates found earlier in Babylonian and Assyrian architecture.

The Hellenic period of Greek architecture (323-30 B.C.) owes much to the Mycenaen builders, as can be seen from a triangulated relief void in their lion gate of the fortress at Mycenae (c. 14th century B.C.) The Hellenic period with the Doric, Ionic, and Corinthian orders, all of which used the column and beam system to articulate the central archetype was often referred to as "carpentry in marble." The earliest columns were of timber, with terra-cotta decorations in the upper trabeation, but were converted into stone in the period about 600 B.C..

From the original two "orders of architecture," Doric and Ionic, evolved simultaneously by the two main branches of the Greek race, there at length arose a third, the Corinthian. The Corinthian a purely decorative variant, which although invented by the Hellenic Greeks was only to attain its full identity in the hands of the Romans. The Etruscans developed the Tuscan style, which was inspired by the Doric but was a simpler and cruder version of it. The last to appear was the "composite," a Roman contribution which did not differ greatly from the Corinthian, and which like it, was an offshoot from the Ionic. These were the "five orders of architecture" of classical times. An "order" consists of the upright column or support, including the capital, and base, if any, and the horizontal entablature or part supported. The entablature is divided into architrave, or lower part, frieze or middle part, and cornice, or upper part. The proportions of the column and entablature vary in the different "orders," as do their mouldings and ornaments.

In the Hellenic period, due to the conquests of Alexander, Greek culture was diffused over many Near-Eastern lands and the strong-holds of Asia Minor. Rome had been developing its own shape throughout this time, and it was Greek Hellenistic architecture that provided much of the decorative inspiration for the Romans as well as embryos of a number of Roman buildings that were using the elements of dome, vault, and arch. The classical orders are worth mentioning here with respect to towers, because they are the building blocks of the later Byzantine, Romanesque, and Gothic styles. These styles utilize towers as a structural or decorative element.

Amidst the journeys of large armies, or along the trails of pilgrimages to and from one region to the next, we can see an obvious sharing of engineering, and thus a building upon what had come before; from dwelling to religious symbol. The tower form was first seen by the approaching body like the mountain in the distance. The Roman Empire under Trajan reached the greatest expansion into Hungary and Romania on the other side of the Danube(c. 90 A.D.). The Persians had accomplished a similarly wide range of influence from Egypt to the Danube only 600 years earlier.

The Trajan column as a commemorative monumental tower (c. 113 A.D.) was designed by an architect and military engineer, Apollodorus of Damascus. It was often copied. Once it was copied for the victories of Napoleon, and erected in Place Vendome in Paris, and another time by Marcus Aurelius(c. 180 A.D.). The Trajan column and its marble reliefs depict a continuous record of successful campaigns agains the Dacians, told in 150 episodes with thousands of figures, buildings, rivers, and opposing armies. The 625 foot band that winds the height of the column increases in width as it moves toward the top from 36 inches to 50 inches. The carvings are of low relief in order to reduce shadow and constitute a significant reduction in illusionistic depth. "The narrative puts emphasis on military architecture, fortifications and bridges. In the botton two bands appear the famous pontoon bridge built across the danube by Apollodorus, with the Danube as a river god looking on in amazement at the achievement." [Gardner 75] In the square base of the column, Trajan's ashes had been placed in a gold urn (c. 117 A.D.).

> The column of Trajan embodies some features of great importance for the art of the Middle Ages. One was the flattening of the relief for better visibility. Another was the desire for completeness of narrative description, requiring a great number of actions to be shown in a limited space. Thus narrative fact rather than visual fact is required, and truth to appearance ("illusionism," "realism") can be sacrificed to greater or less degree. [Gardner 75]

Here, the sacrifice is in the representation of space. The figures are not represented as standing or moving on the same ground line as the presumed observer who occupies an imagined line on the same level. The figures in Trajan's Column are placed in rows one above the other, a device altogether different from the approximate perspective of illusionism. From a perspective viewpoint, the figures and architecture are entirely haphazard in their arrangement; from the point of view of the narrative, they occur where the story demands. Proportions are sacrificed as well. Soldiers appear as large as their horses, or the walls they stand in front of. It is possible to say that conventions of Medieval art already existed in Trajan's column.

Another important element of Trajan's column lies in the sculptural relief that effectively opens up or pierces the outer skin of the column over the entire length, so as to make the massive cylindrical stone appear lighter. Considering the entire columnar form and the weight associated with stone, the treatment of every square inch with a series of curves and straight undulations achieves a relatively light, penetrating texture. In comparison, a column used solely to support an infrastructure would not have such a quality of lightness. It is in these undulated divisions that an intelligent articulation of space occurs.

The same element, articulating a towering lightness of mass, can be found in the structure of the Roman Pantheon (c. 120 A.D.). Although earlier than Trajan's column, the Pantheon exhibits a shaped space where the feeling of weight is not present in the enclosed interior. The architecture of its space is determined by the placement of its solids, which do not so much shape it, as interrupt it. It is the Roman architects who initially conceived of architecture in terms of units of space (periodic) than can be shaped by enclosures. The interior of the Pantheon, in keeping with this interest, is a single, unified, self-sufficient whole, uninterrupted by supporting solids.

> It is a whole that encloses the visitor without imprisoning him, a small cosmos that opens through the oculus to the drifting clouds, the blue sky, the sun, the universal nature, and the gods. [Gardner 75]

In contrast; the treatment of solids prominently used in Egyptian and Mesopotamian architecture (i.e., pyramids, obelisks, ziggurats) are the positives we see, with the space in between as the negative that simply happens. The Romans, with the use of the arch, vault, dome, and applied properties of solids and statics of inert masses, moved away from the order of "stacking" and use of monolithic structure. They learned to articulate space with a variety of structural elements allowing experimentation with skeletal or sculptural architecture. The experimentation with the positive and the negative as common in the design process, is an "interpreted" process rather than a process relying on "sight" or "just seeing." It is the difference of degree between ordinary perception, the filing of impressions in our mind, and the interpretation due "to projection." With the development of a "choice" in building blocks, the Roman perspective could become more organic in its internal and external spaces.

It is interesting to note that concrete was invented by the ancient Romans. Loose rubble with a gypsum-type liquid mixture was used to fill large voids between base tier elements. The base could sustain heavy compressive loads, the same if it were blocked with solid masonry. The result of this Roman invention may have affected the massive number of walls, arches, and towers constructed throughout the Empire. This technology did not transfer into the Middle Ages and on to the building of Romanesque and Gothic structures. Not until the late 1800's, in New York City, did concrete reappear -- in the making of subway tunnels. The re-evaluation of concrete's economy and strength within industry may have been due to a need to cover slab-type features or to create elongated vaulting underground. We do know that in the 1800's, with the casting of iron and steel into precise incremental units, the building industry had metal reinforcement available for the liquid slurry that would eventually become the 20th century's revolutionary building material.

The first examples of concrete towers were grain silos, which could be found in mid-western cities with large grain terminals, as well as on farms. Often grain silos were slip formed in a group of six to sixteen with connecting walls. Two methods developed for the placing of concrete were the "form work" type and the "slip form" method. The "form work" type was built in place and is a direct descendant of ancient methods used by sculptors in bronze casting. A mold consisted of base, sides, and an opening to pour the slurry in. Upon hardening the form work is removed. the second "slip form" was a later invention in the industry. Some designers consider the process as more cost efficient than "form work" yet its application depends on the environmental conditions and intended use of the design. Since the slip form mechanism is used best in a circular shape, the circle has been reproduced more than the square or some other polygonal geometries (many of which closely resemble diatoms). The slip form allows the execution of all operations forming a technological sequence, without the use of any scaffolding. It ascends continually to the height of the tower at a previously fixed rate, and after it has moved up, the walls require only some easy corrections, which can be made from hanging scaffolding or working platforms.

With the advent of oil exploration the slip from for off shore drilling and storage began in 1972. The first was the EKOFISK tank tower which had a capacity of 160,000 tons and a height of 90 meters. It was made out of nine cells. More diatom-like floor plans of the slip form tower came later with the Howard Doris type of tower, which had 55 cells. The outer 36 enclosed a flowering bulbous hexagonal which enclosed a truly scribed hexagonal which in turn concealed the inner chamber shaped like the "Star of David," with a circle in the middle. Tower types to be included in the history of slip forming are:

- cooling towers
- chimneys
- water towers
- radio towers
- television towers
- panoramic towers
- oil exploration platforms
- some light houses.

Their plan dimensions are selected to withstand gravitational loads, wind forces, and seismic movement.

Some examples are the television tower in San Antonio, Texas, at a height of 225 meters. Executed in 1968, it was the highest tower in the U.S. at the time. The television tower at Emley Moor, Great Britain has a tapered part made of reinforced concrete to a height of 275 meters. It has a 55 meter high metal antenna.

The Canadian National Panoramic Tower in Toronto is 547.5 meters high and stands today as the tallest structure in the world.

The process of slip forming is a kinematic one. Hydraulic pins are placed in horizontal positions to give stability for compartmental voids. Hydraulic rams provide the lift in the forms upward motion. Kinematics is a branch of dynamics that deals with aspects of motion apart from considerations of mass and force.

The slip form process in making towers has translated across the field of engineering into bridge making. In Italy, 1986, two equal parts of a bridge, each being on the opposite side of a river's gourge were casted vertically to an equal height. Upon curing each wing of the bridge was let down, through the use of a pivot joint at the base. The remaining gap of only several feet was filled with concrete to make one uniform gently curved but long slab, 500 feet in length. From this curvature columnar abutments of equal height were cast vertically, forming equal divisions along the slip formed slab. They were capped and connected by the straight roadway above them.

Other towers that have personal interest for me are those that have been built near the water's edge atop high elevations, for World Fair Expositions, or simply designed to work with the natural elements, i.e. wind, water, air, and light. Some people have dismantled and transported entire towers over thousands of miles because of their cultural and aesthetic qualities.

An example of towers that have been transported from their original locale would be the "needles of Cleopatra", which were obelisks originally carved as monolithic forms from the quarries in heliopolis circa 1500 B.C. . They were part of a large group of 200 gold-gilded obelisks positioned to create certain light and shadow effects in Heliopolis. Julius Ceasar brought the obelisks to Alexandria in 30 B.C., where they stood at the waterside entry to the city in honor of Cleopatra. In 1880, the city of New York bought and transported one of the "needles" and placed it on the east central edge of Central Park, next to the Metropolitan Museum of Fine Art. The other Needle of Cleopatra had been purchased by the city of London and placed along the Thames River across from the government center, where it stands today.

The old masonry and wooden (circa 1600) London Bridge, on the River Thames had been the home of over 100 towers turrets and spires that decorated the buildings which sat upon the bridge and its 19 main arches. The new masonry bridge (circa 1831) was a replacement for the old one, and was built only 100 feet upstream. It had 5 arches and no buildings on it. The first known bridge erected across the narrowest part of the Thames was a pontoon bridge built by the Romans in A.D. 49, at the same location. The entry to London was marked by this bridge. In 1968 the old London Bridge was purchased by Lake Havasu City, Arizona for the sum of $2,248,000 . It was shipped to Long Beach, California in 3 loads. In 1971, Lake Havasu City dedicated the bridge. The bridge spans 954 feet across a body of water essentially created by the Colorado River. The same body of water is connected to the Hanasupai Canyon and River some 200 miles upstream. The light towers upon the Havasu/London Bridge total 12, with two lamps each. They are 15 feet high, and are made from cannons manufactured during the Napoleonic Wars. At night the beacons of light illuminate the waterway and surrounding area. The presence of the bridge in the middle of the desert on an entirely different continent from the one that originated it, communicates again the transport of culture from one hemisphere to the next; a historical timeclock, now being bathed by waters of a different source.

The "tower of the winds" in Athens (circa 50 B.C.) is 39 feet high and is interesing from a social historical viewpoint. Built in the old Roman marketplace, its name comes from the reliefs that decorate the upper part of the octagonal band below the roof. According to legend, it had a weather vane atop its roof and pointed, according to the direction of the wind, to the respective god. There was also a sundial outside and a water clock inside.

In Frombork, Poland, a small Medieval port town, there is a four story rectangular tower that was used by Nicholas Copernicus. He carried out his astronomical observations there for three cdecades in the years following 1512.

The Gdansk Crane Gate (circa A.D. 1411), built on the banks of the Motlava river, had several functions. In addition to defense, the Crane Gate was used for unloading the ships. It has two semi-circular storage towers that project at the corners. They were surrounded by a high wooden center section, which was the treadmill. The tower is now part of a sea museum.

The Lobauer Berg observation tower, built on a 1444 foot peak in Upper Lusatia is the only remaining cast iron observation tower in Europe. Erected in 1854, it stands 82 feet high. The minaret-like tower has ornate relief characteristics that derive from traditional stonemasonry.

The Eiffel Tower of Paris was built by Gustave Eiffel for the World Exposition of 1889. The then new material, steel, was an advance in materials technology allowing new forms and shapes to be explored. The tower offers a viewing distance of over 90 miles from its 1000 foot height. It has a 50 foot mast and serves as a television relay tower as well as an observation tower. It is the symbol of Paris, and has communicated the artistry and technical craft of the Industrial Revolution period. Its form is uplifting and transparent in feeling. The structure has a unique way of using wind and light.

Visual lightness is inspired not only by its design, but also by the inherent character of the material and articulation of joints. The upward movement transcends its monumental weight and pierces the atmosphere.

Chapter 5

The Narrative Tower

The Greeks created statuary to sit upon the precipice of time. The sculpted body communicated a vision of worldly value unified within a universal form. The eyes which looked out over the land were non-pierced. The eyes were expressionless in character and symbolized the internal focus of the psyche. "Greek narration was concerned not only with the "what", but also with the "how" of mythical events." [Gombrich 69] The character of portal sculpture during the High Gothic (See section 3.2, page 24) began to use the emotion of man in portraiture. The psychic suffering that characterized secular icons translated man's inner world into visual motion. The story of man and God unified under multiple centuries-long excursions in removing the darkness of day and night increased the quality of perception toward higher ideals. The elements of narrative art depict man's interaction with his environment, creating exact standards for the rendering of universal beliefs. Any distinction between the "what" and the "how" is not easily discussed. For example, in the painting of the *Creation* by Michaelangelo we are told:

> "in the beginning God created the heaven and the Earth". Whether he wants to or not, the artist has to include unintended information about the way God proceeded and, indeed what God and the world "looked like" on the day of Creation. The Christian Church has been dealing with the idea of illustration since the beginning of Biblical times. It may have been the same difficulty that restrained earlier cultures from embarking on pictorial narratives of sacred themes. But when the poet was given license to vary and embroider the myth and to dwell on the "how" in the recital of epic events, the way was open for the visual artist to do likewise. [Gombrich 69]

In the Renaissance period a treatise by Alberti dealing with a branch of projective geometry called perspective, was set forth as an aid in developing the narrative. As the square picture plane was better understood, so was the projection of light into that space. For the first time the imaginable plane of active information was to be depicted with a geometrical science. The artist/scientist contemplated his universe through real life and a series of temporal projections. Beyond his macrocosmic world, he anchored visions into a framework of imaginable perspective. Questioning the universe , i.e. sun, moon, and earth, was still within the context of secular scrutiny. Yet, the act was evidence of searching for answers unfound in the science of the time. The secular orders permitted this ponderance under "a God-given realization".

A few centuries later, Rodin was a forerunner of "Narrative Art" outside the eulogy to God. Thematic work consisted of man's attention to man demonstrating emotion or state of mind as movement. The best example of this is Rodin's *Burghers of Calais*. "In the movements and facial expressions given to the six burghers, rodin personifies one of the various stages of a deliberation which began in despair and ended in stoic resolution." [Taillanier 78] Rodin's compositions relied on the dimensions of time and space percieved by the observer moving about his work. Through a succession of viewpoints to be interpreted by the viewer as motion about the figure, the work marked a beginning point for society's overt self-assessment through Art. In 1893, Rodin executed a monument to labor where he deemphasized the use of the figure. Instead Rodin used an architectural form; a tower. The tower was a spiral that was composed of eight tiers. A figure was situated to the right of the base, and another was located at the top. From this work one may assume that Rodin had great respect for labor and the implications of the tower for laborers. This respect for labor's effect on the monumental built object was manifested at a time when great feats such as tower building were monumental in scale. Rodin must have compromised his stature as a figurative sculptor to choose a social statement that deals with man in motion (i.e. labor) in a universal context in lieu of somethiong more figurative and usual. His image was one man's homage to a universal state of Man.

The success of the narrative aspect in Rodin's tower is largely due to the spiral form. The spiral, as metaphor for the narrative, has both linear and centralizing tendencies. It travels infinitely towards and away from a never reached, yet never evaded center. Perhaps Rodin's view of man's multi-dimensional physical and psychic efforts of labor prompted him to use the spiral form.

Rodin's monument, *Tower to Labor*, has a light penetrating quality. The opening of the cylinder is modeled through skewed rectangular windows along the spiral incline. It is articulated by hexagonal divisions about the perimeter with the use of vertical columns.

In the context of a socio-political narrative, Tatlin's tower, *Monument to the Third International* (1919 - 1920) communicated the merging of Constructivist ideals and social commitment. The tower was conceived to exceed the height of the Eiffel Tower in Paris, but was never built. The model was built from a double spiral plan. The spirals were a formal device, not a structural device. Vertical and horizontal struts were used to prop up the spirals and counteract the spring-like quality of compression about the spirals. The inclined path of the double spiral relative to the earth and the sky in its winding upward motion, is much like that of a figure engaged in a dynamic forward thrusting movement.

> It was consistent with the analogy between two great arches which lead off from the spire and leading legs recalling the ancient sculptured tradition of the striding figure revived by Rodin and more recently by Umberto Boccioni. In interpreting the tower, it is reasonable to suggest that it signifies a forward stride in political party idealism at that time. [Milner 53]

The author,Milner, had diagrammed the relation of Tatlin's tower to the earth and stars, directed at the pole-star with global functions, as earth itself, being the first of its "hall's" division. Tatlin's design was still bound to earth, yet after much critical assay, is said to have gone further than Tsiolkovsky's model "Utopia". "By having the tower's lowest division be seen as a terrestrial sphere, Tatlin is provided with his vehicle in time and space." [Milner 53] Here time is the fourth dimension, the first through third dimensions are represented in the physical structure and the alternation of its form between some concepts of light. This interaction yields what I consider "the fifth dimension".

Measure, scale and the incision of space, time, and light are equated with the development of towers as I view them. The incision of space is the redefining of space over a succession of perceptual images that are spatially aligned. The event of time (4^{th} element) stretches to its own dimension. The experience of "aftermath", the memory and dialogue of a given event or physical image, must move through the Artist, with the artist being both transmitter and receiver. [See Formulation of Aesthetic p. 109] The association of dimensional time with creative art occurs when the real time in between transmission and reception of idea is made known via feedback from the participants, to include the artist. The dimension, time, can therefore be realized at a moment unattained before, during, or after, the event, through the measure of the moment itself. Through the use of projection in the context of temporal value the event need never have physically taken place, existing only in the mind's eye.

The reconstruction of Tatlin's tower is an example of a moment stretched through the temporal dimension. In 1971, eighteen years after Tatlin's death, his tower was built for the exhibition "Art in Revolution" in London. Although the tower was not built full scale, its steel construction is evidence of the impact it had, and the importance it bears for the future of art and technology. It embraces commitment to the dimension of time and establishes a scaled segment of our historical building of narrative art and tower images.

Chapter 6

Technological and Aesthetic Inspiration

6.1 Technological Inspirations

A recontre of principles in the standardization, rationalization, and instruction of art and architecture were a part of new social and political beginnings in Northern Europe and Russia in the early 1900's. The forming of the Bauhaus in Wiemar, Germany came at a time when " formalistic imitation and snobbery dislocated the fundamental truth and simplicity on which this renascence was based." [Gropius 65] Gropius continues to point out that the change in spatial concept had much to do with the availability of new materials, such as steel, concrete, and glass. Similarly to the Gothic builders experiencing "new light" due to the ribbed vault and flying butresses, the builders of towers in the 20th century could articulate walls almost entirely of glass. Due to the physical characteristics, tension and compression and thus spanning, this was possible.

> The Bauhaus, however, deliberately concentrated primarily on what has now become a work of paramount urgency: to avert mankind's enslavement by the machine by giving its producys a content of reality and significance, and so saving the home from mechanistic anarchy. This meant evolving goods specifically designed for mass-production. Our object was to eliminate every drawback of the machine without sacrificing any one of its real advantages. We aimed at realizing standards of excellence, not creating transient novelties. [Gropius 65]

To regain the dynamic equilibrium between the mind and body, or between the intellectual and the practical, was a message from the Bauhaus people. Like the "scientia" and "ars" discussion in the development of the Gothic building style, we have increased responsibility in the face of modern technological experience. [See page 21] The influence of the Bauhaus principles on the making of a new architectonic art was cast from domestic furnishings to homes, apartments, and towers. "They did not teach on any preconceived ideas of form, but sought the vital spark behind life's everchanging forms. " [Gropius 65]

Gropius has mentioned certain values that were commonly attributed to previously mentioned examples, such as the Eiffel tower and Tatlin's tower in which, although pre-Bauhaus, the union of light quality and structural simplicity prevailed. I understand the Bauhaus to project values onto the process in building that bring the theory and practice together. It is important for me to have looked at the Bauhaus' history as a dedication towards craft concept and ultimate product accessability to the public by means of systemization.

Newspapers carry headlines reporting the latest increases in "Greenhouse effect" gases, tropical rainforest deforestation, and the now-famous "hole" in the stratospheric ozone layer over the South Pole. These are the major environmental issues of today, 1989. How can the environment persist in helping serve man in his quest for a better quality of life when the current industrial trends have brought yet another element of time to question? Is this an irreversible trend leading to less time for the human race? Have the concerns for humankind's future gone beyond the fundamentals of basic needs? How do I respond as an individual, as an artist, as one who breathes, moves, and assigns basic values to need-making and want-giving, as do most people.

A sense of people-doing with a sense of technology-making is moulded in a sense of building. The precepts of man respond and are rewarded by the act which is carried out in ethical humanistic ways. This gives joy. The sight of natural phenomena are found and manipulated into a sustained form. This creates light. A form of building block is derived directly from nature. From the biologists point of view, the virus, its components are raw and geometrically pure in form. His views are challenged by the mystery cavern, far beyond the normal vision of man. He peers into the darkness and hollows out the cavern untill a speck of light weakens the hold of the unanswered.

Technology usually forcasts the mode of perception in the visual world of object users. The consumer world is linked directly to response mechanisms built into a product by the industry. Beyond the sheer need of object, industry makes a profit from the consumer, based on advertising hype. Where human emotion is played on to generate profit, the value of creating that technology is ethically questionable. Commonly the artist and scientist each chooses to use technology in his process with no concern for imagery that speaks of hype and fast-moving glimpses of spectra before him. Working with sustained images, he helps regulate the quality of life, rather than the quantity of carelessly made images.

Gropius, in his article *Reorientation* states " the satisfaction of the human psyche resulting from beauty is more important for a full civilized life than the fulfillment of our material comfort requirements." [Kepes 56]

6.2 Aesthetic Inspirations

Technological inspiration has come to me from a variety of people using art and technology, as a base in their search for new art forms. From their work and my dialogue with them I have integrated a procession of images, upon which I have absorbed and given other images in return. My fascination with light and sound remain the least present in my work, at least with respect to illumination and amplification through electrical sources. I have explored the theory of light and sound, and exposed their theoretical structure somewhat through what I consider a usable form that speaks of structural amplitude, with special attention to measure, scale, and optical magnification.

In the work of Thomas Wilfred, I see the genius of an artist/mechanic, integrating form, color, and movement as a seperate art.

> Wilfred defined the basic ingredients of lumia as form, color, and motion in a dark space. Of the three, he considered form and motion the most important elements. Lumia, like dance and drama, is an integral space/time art. [Stein 71]

Wilfred advanced the use of optical systems and merged the arts of sight and sound. A blend of art and technology came forth in his designs of the clavilux (1919). The clavilux was a keyboard operated machine that could modulate sound and optical components alternatingly or in unison. The coupling of the clavilux and lumia was a creation unifying art and science. His largest work was a 21 x 210 foot projected mural done in 1929. His experiments in using light-created phenomena in vertical and horizontal movements grew as his audience increased in the 1920's and 1930's. His compositions became more complex in unifying patterns of "light" movement. Wilfred conceived of a "tower of a tall building surmounted by a clavilux silent visual carillon" in 1928. He listed the qualities of his tower thusly:

- Playing ever-changing synchromies in pure color or great intensity upon four curved steel surfaces which from a top unit of great strength as well as beauty.
- When played upon by the clavilux projectors, will appear as a huge dome of opalescent glass made in a single piece.
- The clavilux carillon can be operated continuously by an automatic paper roll player or it can be played by an artist from a keyboard.
- The exposed glass surfaces are limited to four wire glass skylights, easily cleaned.
- A compelling display of beauty, visible for miles.

[Stein 71]

Wilfred's tower of light melody, to be placed high upon another type of tower for visual effect, was a direct ascension of tower form upon tower form. It was also meant to project light data, which in Wilfred's isolated struggle, held greater content toward the explanation of natural phenomena, to be observed over dimensional time by an audience. His work projected "cosmic links" to our own environmental switching of light from the outer to the inner, as the fascination of his own inner world created a need to embrace a sustained public interest. Wilfred travelled into the public forum with hundreds of performances in major cities and universities. It was a type of ephemeral or transient display of art and artifact, that links a celebratory event with an evolving myth in technology.

To go beyond the dimension of what we call an "applied normalcy of consciousness", the casting of towering light images allows us to see different associations of form, shape, and nuance that may not have been previously brought to mind. The limitlessness of phenomenology is expressed best through light , since light is the purest of phenomena that conveys basic information to our senses. Otto Piene quotes Thomas Wilfred in a 1956 statement titled "Musing on the Spheres":

> In the space dimension our concept of the universe is contained between the smallest particle our electron microscope can detect, and the farthest galaxy our radiotelescope can locate. In the time dimension it is limited to the finite because we are unable to conceive of eternity, of phenomena and transitions having neither beginning nor end. [Alexenberg 88]

In my own development, I have had to make conscious decisions in dividing my time between the physical process and the temporal projection. The systemization of towering data requires time to receive as well as transmit. The association of input with output goes hand in hand with the conscious and subcinscious modeling of that universe, yet the division is neccessary. Each mode is real and the mode can be lost without the conscious division of time. My love of material and process needs grooming as time moves forward. I look to other transports of image making vis a vis the towering displays of light. a frame unbound by physical structure. Otto Piene explains the following:

> Coins are sun symbols; *Roi Soleil* is a preferred ruler image reflecting enlightenment; the clock is the sun image of the Renaissance portable and not. Towers, cathedrals, bullets, and rockets appear to be shaped after the drawings of lens schemata turned vertical. Architectural forms are "frozen light beams," incorporating "light and further animated through" light. A hole in the roof, a window in the wall make us "see the light." [Alexenberg 88]

Crescents of form division loom high overhead, enacted through group celebration, launching a tower of helium. Light string, light ribbon, and light canopy, were experienced along the way ... in first meeting the artist Otto Piene. In celebration of earthen and cosmic phenomena where man transforms (Man as Myth) in the context of Alaskan "Summer Light" territory, I thank you, *Sky Art Alaska* 1986. The elements of polyethylene tube, the inert gas, helium, bodies, hands, valve stems, steel pins, nylon cord, and sunlight put in motion a theater of three parts.

Light String: Where celebrants become anchor to a solar point between one arched wave of volume and eons of time impaled particles concentrated about that volume. The volume becomes a median of metaphor as a star much furthur away, as an intersecting reference point toward realizing origin.

Light Ribbon: The earthen side of the median flashes in cosmic sequence. The wind from the Knik Arm distributing a load over the median, transforming it to a prismatic shell section with amplitude made visual. High-ward, one point upward in fan formation, singular waving cylindrical volume speaking.

Light Canopy: The field of seven such medians scaling a broader gust. A pneumatically formed canopy. I connect their sides by walking south across the field. Reflections ascending on the cosmic side, reflections of light transferred and descending on the terrestial side. I entered the conical light that directs my hands and feet up the towering light ladder.

"The gestalt was out of a timeless festival each person believes he is responsible for discovering" [Blaine 86] Sky artist, light artist, Dale Eldred builds light towers; directing beams, arcs and lines of light "communication". His assemblages hold large viewing window-size panels in sequence upward on scaffolds, hillsides, mountainsides, and tower sides. Wasatch Spectrum, 1986 had seven reflective panels over what appeared to be a height of 80 feet. Elizabeth Goldring writes:

> Dale Eldred installed "Mountain Desert Beam" two thirds of the way up Mt. Whitney. The mid-day suncought the bronze-coated, acrylic sheets sendind a flash of "gold" the length of the distance between the main site and Mt. Whitney. The 32 mirrors,each 2 feet by 4 feet and set a few feet apart, ran a length of 180 feet to create Eldred's intended 'Light Line' of 4 1/2 miles. The Light Line was calibrated to the sun's declination between the hours of 11am and 1pm on June 13th-14th and 15th, 1986 [Goldring 87]

As written in *Desert Sun/Desert Moon* by Elizabeth Goldring [Goldring 87]

> In 1982 I was living in Phoenix, Arizona. Passing by the Phoenix Art Museum one day I noticed an installation of high mettalic reflective strips about 16 feet long and standing upright along side and in front of the museum. I didn't count, but my estimate was 300 [strips] at a width of 4 inches each. The art section of the Sunday Phoenix newspaper told me that the artist Dale Eldred, was presently in the North Mountain area of Phoenix. That he was dividing up the mountain with arcs of light that would be reflected towards the museum installation.

Mountains have a special meaning to me. As a backdrop or metaphor used by artists the mountain embraces a universal truth. (See page 57.) In image recognition from earliest times the mountain has been the largest terrestial verticle tower.

I travelled the towering mesa of the Navajo Indian and became engulfed by the niche in the cliff wall. There sat a "wise one" in harmonic praise to the cosmos beyond. The inner view of the outer light shined upon his face. He was exercizing a myth about the land, in spirt, never intending to own it. Not to own the physical land but to temporally project its beauty on the soaring winds of the eagle. And we as people, own not the land but the essense if we will, and to gauge the essence is to recognize science and art as one culture. Each is represented in its own sphere of cultural enterprise, yet to experience one without the other is to not experience the essence.

> Regarded in terms of its essence, art is a consecration and a refuge in which the real bestows its long-hidden splendor upon man ever anew, that in such light he may see more purely and hear more clearly what addresses itself to his essence.
>
> Science is no more a cultural activity of man than is art. Science is one way, and indeed one decisive way, in which all that is, presents itself to us. [Heidegger 77]
>
> Light is the essence of as many religions as we have time to read and explore - just as we cannot read or explore without light. [Alexenberg 88]

6.3 Tower Melody

In the building of my towers I have been looking for a well crafted form -- a form that speaks of life, of an organism that is alive in the dark and by day rests comfortably in the rays of sunlight. A form that is larger than man, yet like the human body, has joints bespeaking continuity from one part to the next. I envision movement and sound. Perhaps it is due to the site, the people, or the users whom it serves. To attract rather than repel a moment of passing, it coexists with people circulating about their daily path or temporal projection. A projection of self is possible into a warm generous space that is cheerful, not solemn or blazing with signs and multicolored awnings. The aperature of silence it may be, for there are static moments in its frame, wishing and potentially yes, responding to the wind and rain. Creaking sounds and moans resound through chambers hidden away in the structure. Like a well-tied 16 foot wall of rebar steel begging to be immersed in concrete, it sings in the wind, steel bar meshing steel bar, and creaks like the old wooden rocking chair as it lulls a rhythm of cyclical force. The static can be amplified to make its position known; on its limitations stretched to a modulus of spring quality. Onward, forward, backward, its movements are energized, skewed across the web of braces joints and pins. Searching for a resting place in descent, the thrust sets off a vibration of a hidden melody played once before. Up from the earth are the moments of resistance, colliding with those from above; the earth sphere foundation grasping with the tower. Piles, piers, and beds of concrete lodged within the earth sphere act like a sounding board in a piano.

When physically disturbed, all materials produce vibrations, like those of a stretched cord, creating waves of air compression transmitting the sound of a musical tone to the ear. It is a normal characteristic of particles of an elastic body or medium to move in alternately opposite directions from the point of equilibrium.

To create a volume... that allows working with phenomena... such as light... towers have been proponent of structural order as segment to the whole. ...towers share a structural bond with the cosmos... their position among other structures has provided many vantage points in perspective... and offered man counless events of trial and error in building high... tower walls contain inventions of aperature... emmiting projection of light and sound.

Elizabeth Goldring writes:

> In *Desert Sun/ Desert Moon* a series of temporary events and installations utilizing the temporal landscape of sky and space to evoke at the same time mythical and immaterial dimensions of that sky and space. [Goldring 87]

Desert Sun/ Desert Moon took place in Lone Pine, California, June, 1986.

Segments of light and sound ascending through technological and cosmic means are transformed into a "tower ballet" by the artists, Otto Piene and Charlotte Moorman.

> Otto Piene inflated his *Berlin Star*--a soft white sculpture, 55 feet in diameter--in the day landscape near the main site. The star became an envelope to house *Cocoon Concert*, a

performance by Charlotte Moorman. For his "Desert Moon" events, Piene alternated *Sky Kiss*, in which an airborne Moorman played her amplified cello, with *Berlin Star*, air-inflated and helium-lifted to 250 feet, lighted by ground lights and complemented by the light of a quarter moon . Moorman's daring performance as the flying woman of *Sky Kiss* set forth a gripping dialogue between the rock landscape and the desert night sky. In dramatic sequences, she touched the ground and left it -- playing her cello in the midst of assembled spectators and rising above their heads as she was released, hanging suspended at 150 feet. Then, pushed by the wind and hauled by Piene's ground ropes, she swooped down upon the craggy terrain and floated up again. [Goldring 87]

As written by **Elizabeth Goldring** in the article Desert Sun/Desert Moon, "Leonardo", Volume 20, Number 4, 1987

Chapter 7

Towers by Jerry McCarty

7.1 Horizon Line

Horizon Line (c. 1986) was an environmental sculpture installation in Anchorage, Alaska. The work was a culmination of eight years of research that embodied an investigation in three parts. The first part conceptually related to the geometry of the tetrahedron and its potential to enclose space with the least amount of effort and material spent. The second consisted of listing categories and developing charts and graphs that recorded natural forms, and man made forms that use the tetrahedron, or other non-orthogonal structures. The use of orthogonal systems (having perpendicular intersections) was found to outnumber the non-orthogonal by a ratio equal to or greater than 99.9 to 1. Sequencing order in a rectilinear or linear pattern is a phenomenon created by man through his endless hours of organizing. When man builds redundant structures for economic reasons, the size and shape of the material's yield will systematically shape his behavior when using it. My need at the time was to go beyond this regularity with some type of form that offered a useable strength in building art work. It wanted to "truss" areas without using a straight line of projection.

I studied harmonics and tried to make their form visual. I studied the moon's light and watched its reflection on any wet surface. I modeled thin shell concrete and tensile sturcture to see how they would stand up under loads. I stacked sand in the desert and observed the patterns created by the wind. I finally took a 2- 3/4", 4' x 8' sheets of plywood and joined them on the 8 foot edge. I scribed an 8 foot diameter circle and applied my charts and graphs for divisional purposes. I postualted all real numbers to be inclusive between zero and one.

I limited any segment of real measure to nineteen. I made the number twenty the point at which the progression returned to zero. I discovered that after nine such progressions there was a rise in elevation or simply interpreted as an un-planned axial shift. I developed an intermediate work which I called "Octet Sprial" realized in Phoenix, Arizona, c. 1983. I would use this work as the lower case spiral in "Horizon Line" three years later.

Part three involves the making of an environmetal art work using the "octet truss", later to be called "octet spiral", that was placed into its first real context. It became physically useful to me and hundreds of people in Anchorage, Alaska during "Sky Art '86", sponsored by the Visual Arts Center of Alaska in cooperation with the Center for Advanced Visual Studies at the Massachusetts Institute of Technology.

Horizon Line consisted of two spirals made of tetrahedrons that interlocked at 180 degrees. The upper case spiral was 9 feet at its diameter and exactly one half scale of the 18 foot lower case spiral. The spirals were welded solid at each joint of its 600 pieces. The upper case used 1/4" round stock x 10" length and the lower was 3/8" round stock . 20" length at each edge. All joints were ground and the steel was painted silver. The base was defined by 99 [2 inch x 16inch] concrete hexagonal patio pavers set into the green grass in a pattern similar to one that is often found in carbon compounds. The concrete pavers extended beyond the 18 foot lower case spiral by eight feet on each of two sides. The path invited participants to enter the work where they would experience becoming part of the work.

Once inside, the participant had an option to look through two telescopes 2x (builders levels on tripods). The telescopes were preset to view two different peaks in the Chugach Mountain range that borders anchorage on its east side. The peaks were Mt. Gorden Lyon at 4000 foot elevation and the wedge at 4660 foot elevation. The peaks were 18 miles apart and each was 18 miles from the third point on the park strip, where my installation had been placed for the celebration of "sky art." The participant used the telescope to see points at an 18 mile distance; reference points to their own activity. By visually triangulating the space between themselves and the mountain range, an equilateral shape occured that resounded throughout the two spirals they were standing in.

In the Art and the Environment context I chose to contrast the city (inner) environment with that of its surrounding (outer) natural habitat. What was evident through observing the participants was the excitement in projection of self to and from a space they helped create. Through the use of optics and a homocentric physical reference point a scale of self was realized beyond normal experience. Images are normally experienced in two ways. The first is experiencing the whole process in a minute way, as opposed to the second, seeing only a segment. What is normal in perception, scale, form, and pattern can be alternatively transformed into different relationships, through the use of optic apparatil (See Figures 8.1 and 8.2).

The elements of "Horizon Line", being the spirals, concrete pavers, telescopes, people and mountains, constitute a work that puts man and mountain in a relationship that speaks of living earth organisms. The mountain can be thought of as man's companion through time. The parts are as many as there are views, near or far, above and below, and inside its chambers of crystallized transformation. Man has created myth and mythos about the mountain's majestic quality. The mountain has inspired man in making images, in fulfilling his need for identity. The most obvious forms that speak of this can be found close to home. On the roof of dwellings we find spires, pinnacles, finneals, coupulas, and other tower forms. The making of home, paralleling the making of permanency had its beginning in the mountain.

7.2 Star Clusters: One Up and One Down

Star Clusters: One Up. One Down., Anchorage Alaska Sky Art, 1987, were twin towers. They were exhibited during Sky Art Alaska, 1987. Also called *Towers, '87*, they were expressive of the connection between microcosm and macrocosm. Microcosm here refers to the idea of man or human nature being the epitome of the world or universe. Macrocosm refers to the great world: Universe. The idea of designing a structure using a geometry patterned on geometries found in the universe's smallest components inspired me. I imagine a cluster of stars descending upon the green lawn of the park strip. The cluster would be accessable to humans with no fear of heat or gaseous consumption. To create the experience of a cosmic geometric order of star formation, I chose the carbon atom and one molecular arrangement as the base geometry for the towers. I wanted to have a type of labyrinth to be explored with the same tower as beginning and ending point. The walking path began at the entrance to the first tower and through either of its two rectangular doors. Upon exiting the second door, the walker entered the five point cluster connecting link leading onward to the second tower. The link ended at the entry door of the second tower, which also acted as an exit door. Once inside the second tower, the participant would return through the five point link and out through the first tower. The participant would pass through a total of six doors during the walk, parallaling the six-sided hexagonal floor plan of each tower, and the amount of base 2x4 foot units displaced in creating the door openings.

The floor plan of each tower was identical, with four feet on each edge of the hexagon, and 9 feet 4 inches across the diameter. The edge measurements were determined by the size of the light diffusion grids used to construct each face of each tower. Discounting the 6 panels that were excluded, to allow for 3 doorways, the total number of panels used was 162. The tower heights were determined by 8' high sections with 2x6 hexagonal compression rings at each end. Where two sections joined, one ring was shared.

The base and tip of each tower had its own ring. In each 8' high section there was a total of 24 panels. The first section of tower one totaled 20 panels because of the two doors. The first section of tower two totalled 22 because of the single door. Tower one was 24 feet in height, and tower two was 32 feet high. Each tower stood erect on its grass and earth foundation. They were erected in one piece by a team of seven men and women, all friends of the Visual Arts Center of Alaska. The towers were stayed with wire ropes at three points each. The wind off the knick arm generally blows at a steady 10 - 20 m. p. h. . The towers withstood any wind force and remained standing for only three days.

Through a variety of photographs and a xerox process I was able to observe clear moire patterns along the entire height of the second tower. The 1/2" wide diffusion grids were transparent enough for light to pass through one segment and reflect off and outward through the adjoining panelled segment (See Figures 8.3 and 8.4).

Chapter 8

Thesis Project: 36 Diatom Tower

I had two main priorities in choosing a tower design. Firstly, I wanted a towering structure that would reflect a pattern in nature. Since I have been working to "idealize" material and process to their most efficient growth capacity, it was important to make use of the sense that combines man and nature. The emphasis would be placed on my own manifestation of terrestial and cosmic links that become products of conscious activity. In order to project this manifestation, I chose to use natural materials, namely wood. The wood parts would be connected with metal, brass, rubber, etc.. I could make other metaphorical statements through the use of non-natural, store-bought objects, but as in all processes of man, the practice of visual metaphor creation requires adherence to some central idea when manipulating material beyond its natural state.

The project may be entirely of wood, but how do I cut the wood? The harborside "ebb and flow" effect upon the sandy beach requires only the ancient architect, the ocean, to shift the sand--an example of nature acting on nature. When "man" acts on nature, his impulse is to transform the natural material to his liking, or his projection. The event of making tools to crudely scratch, gouge, and hone surfaces of natural material, as in totemic cultures, is not at all removed from the use of the table saw, joiner, and planer of today. Through this naturalistic process man's psyche is shaped, formed, and takes on glimpses of projection beyond his former state. Those projections aid in the initial formation of concept.

The saw blade is therefore a ritualistic object, much like the automobile "magneto" (the original spark coil), the windmill, and the waterwheel. Artifacts are created as a natural response to man's desire to effortlessly travel long distances over the land or into the sky, an expression of the nature of human response to the conservation of human energy. This brings to mind a question; Effortless living at what expense? We are at risk of consuming and totally obliterating our natural resources through the projection of effortless living. There are several thousands of plants and animals dissapearing from our planet each day. In addition, totemic peoples have all but disappeared in the wake of Western civilization's "progress".

In the 1950's and 1960's, during the great American Rural development, entire tracts of land and trees were bulldozed over to create sites for the generic home. At what expense? Judge for yourself. I discuss this in chapter 6.

My second major concern was integrating my tower with an existing site without a sense of physical incision. I wanted to blend my work with the site by reflecting the existing natural and man-made architectonic forms and shapes originally scribed by Eero Saarinen, and reinforced by the passage of 30 years of natural and cosmic cycles (See chapter 8 --Site Considerations]

Horticulturists know that the color and size of plants vary from region to region according to the earth's nutrients and climactic conditions. So does man vary in his habits and attitudes from the environment in which he works and lives. Carl Jung describes this type of "spiritus loci" as:

> ...indescribably present as a sort of atmosphere that permeates everything, the look of the people, their speech, clothing, smell, their interest, ideas, politics, philosophy, art, and even their religion. [Jung 58]

The *36 Diatom Tower* was designed with intentions of placing it in the Kresge Oval area. The tower and its placement was intended to provoke communication from the M.I.T. community about towers and their use in our pattern recognition of natural phenomena. It was conceived as a structure having a lightweight appearance, yet possesing a distinct transparent volume that could be visually integrated with Kresge Auditorium and the M.I.T. Chapel.

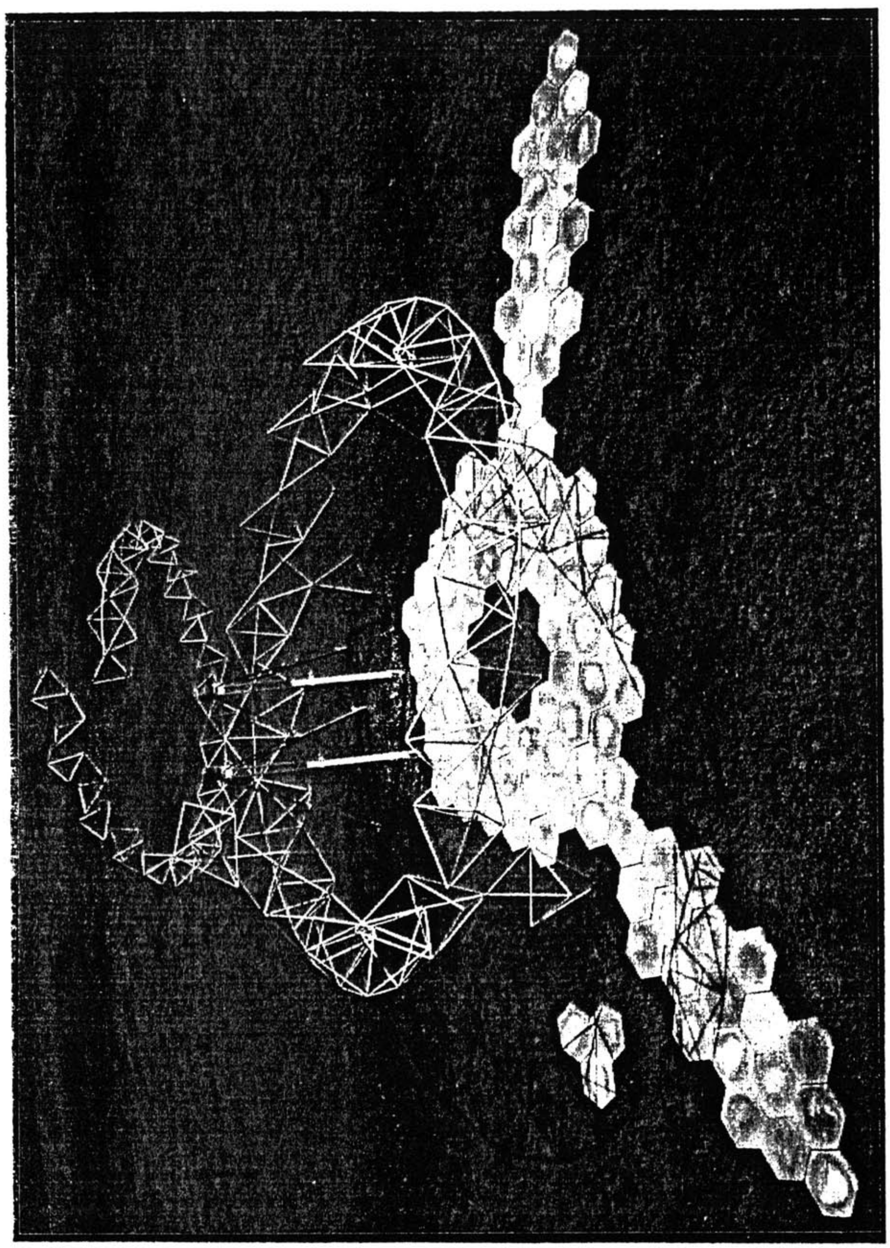
I conceived of the base and spire components as having a natural organic origin in shape. At best, I hoped that the spire would move about its ball joint connection from the effects of the wind. I expected to create light patterns due to cast shadows across the oval grass. I had imagined final data that may lead to good designs for future towers to be built unaffected by shifts in terrestial or other planetary tectonic plates. Working with the concept of rubber cords as a link in structural assembly in a variety of structures, not only towers. I considered the project as an experiment, or work in progress, leading to the development of a flexible truss system. A type of base component, to allow larger generations of form with the least amount of material and handling, was needed. I envision a coil or a spring with a line of projection through the primary structure, either as a member of the primary system or running parallel and attached. Because of its pure generation of "typical" basis units, I can divide non-arbitrary points of intersection into that line. The intersections are meant to be structurally sound up to a particular strength. At the point of intersection, or as some say ,"interception", another "sub" or secondary system may be attached. I am intrigued by systems with the character of diagonal loading interfaced with orthogonal systems. The idea of working with a circular pattern is to give one ultimate control over load-bearing data. I desire to learn Computer Aided Design (CAD) to help me in the fundamental design process, and as a vehicle to enable me to more fully demonstrate the characteristics of these motions.

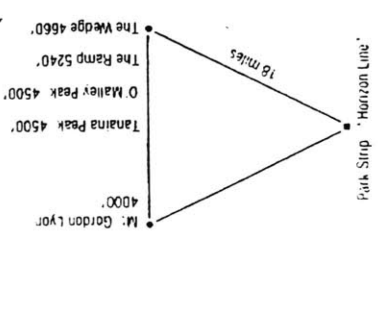
As an environmental artist, I am pleased to have had the communication about my work, as well as about other concepts that I am presently researching such as tower light, tower sound, and tower wind. From these studies, I hope to glean the capacity to develop towers utilizing kinesthetic movement.

The following figures represent the assembly and final image of *36 Diatom Tower* in a variety of perspectives.

In figure 8-40 one can see hypothetical tower "footprints" that had been developed using light projections. Light projections were chosen to demonstrate the fluidity of form and shape, potentially translating directly into a solid structure. The appearance of this "footprint" when pulled up vertically should work well with the wind and light. The problem with this concept is the quantity of research neccessary in order to develop exterior skins, as well as nonorthogonal lit interior.

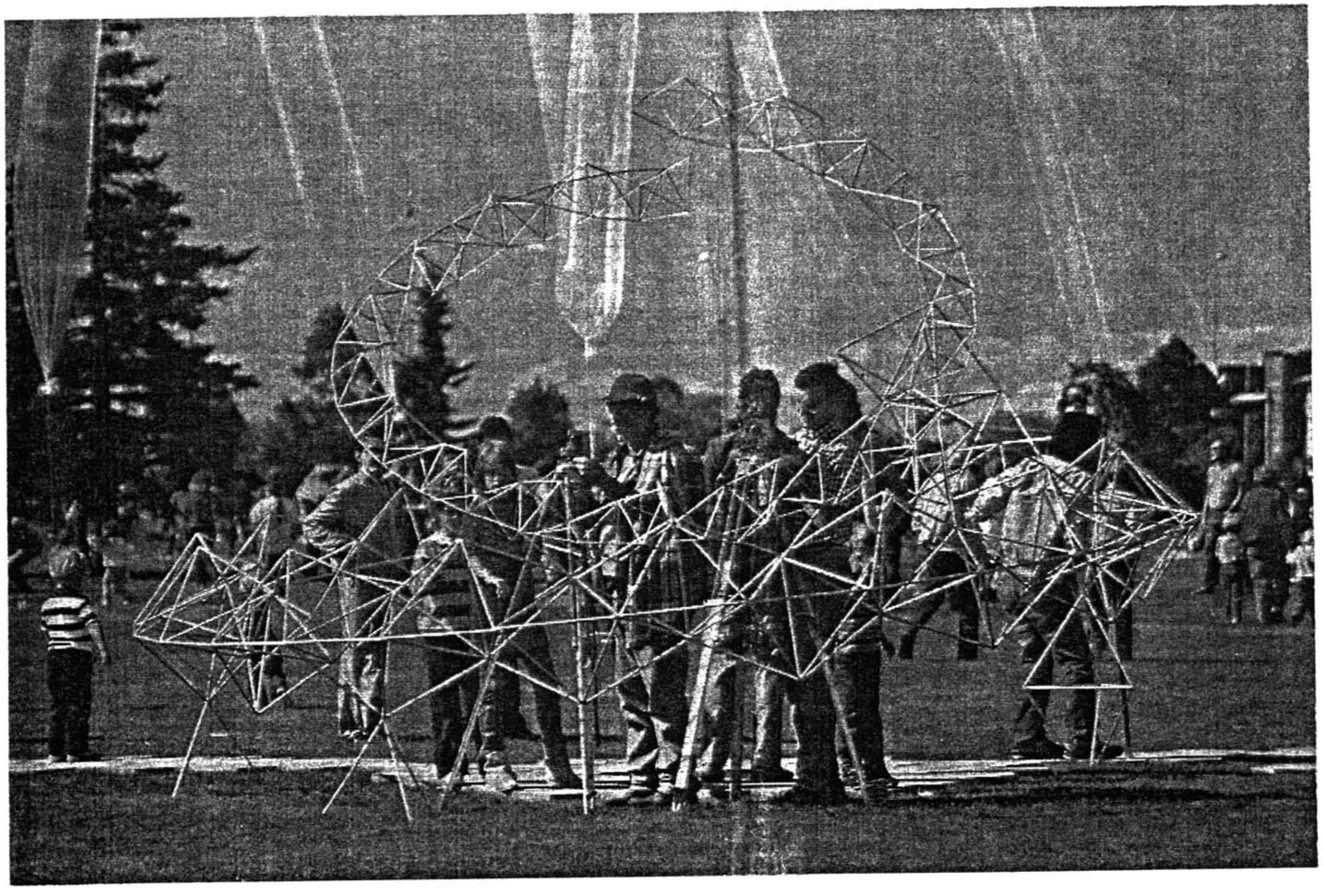
Figure 8-1: Horizon Line 1986





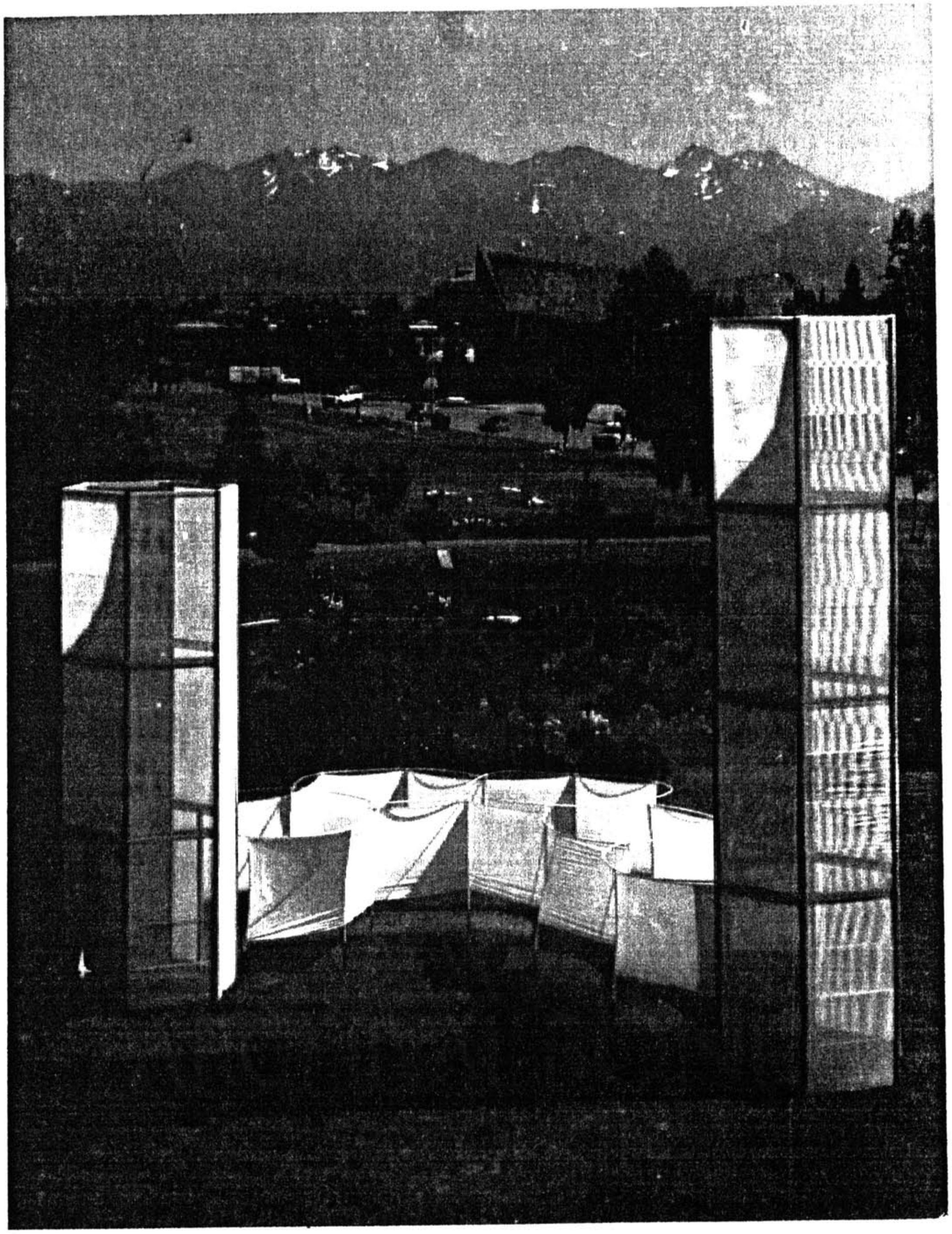
Nine foot and eighteen foot spirals. Steel, concrete and builders' levels.

Figure 8-2: Sky Art Celebrants



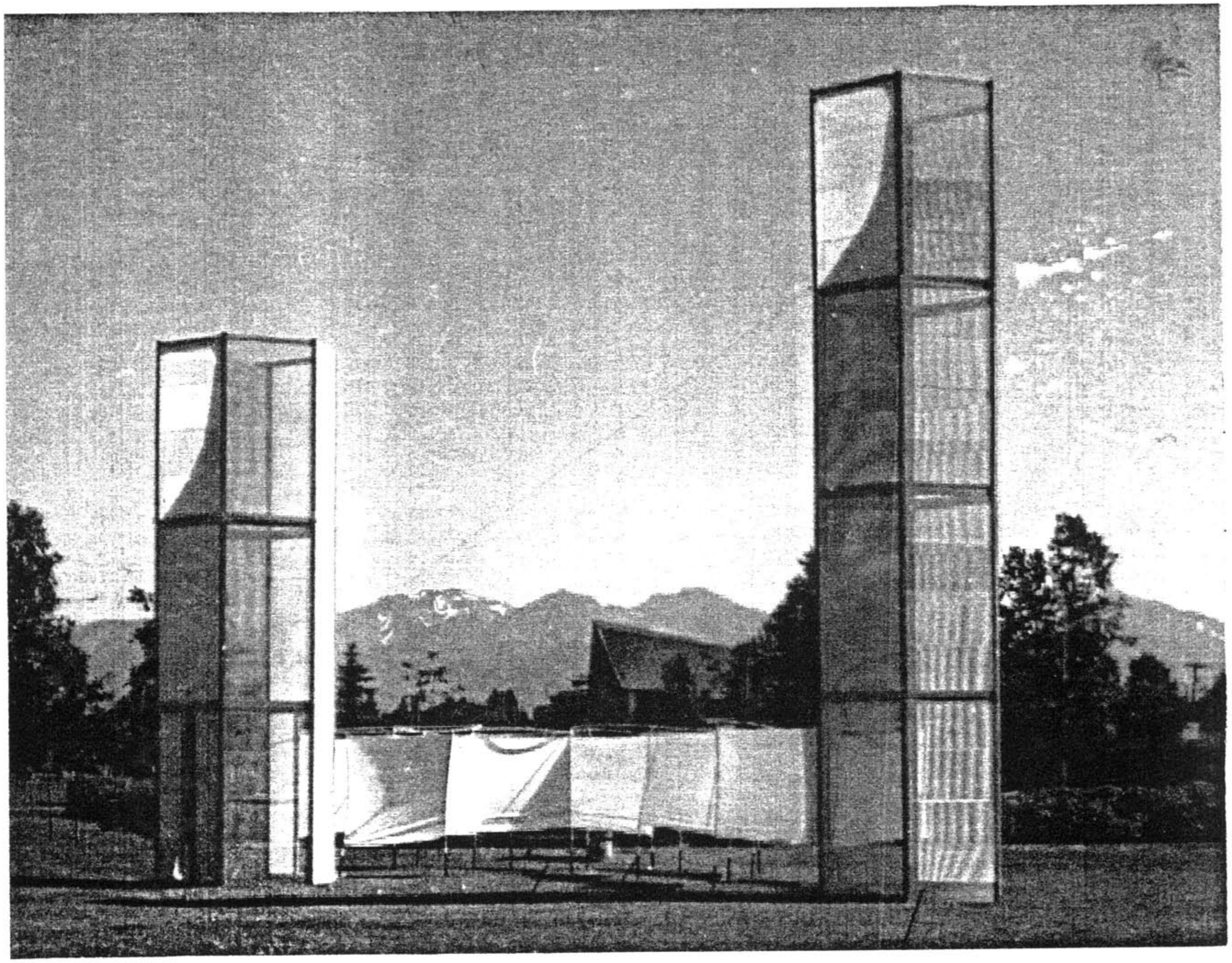
Toward a view of the Chugach Mountain Range, *Horizon Line 1986*

Figure 8-3: Star Clusters: One Up, One Down, 1987



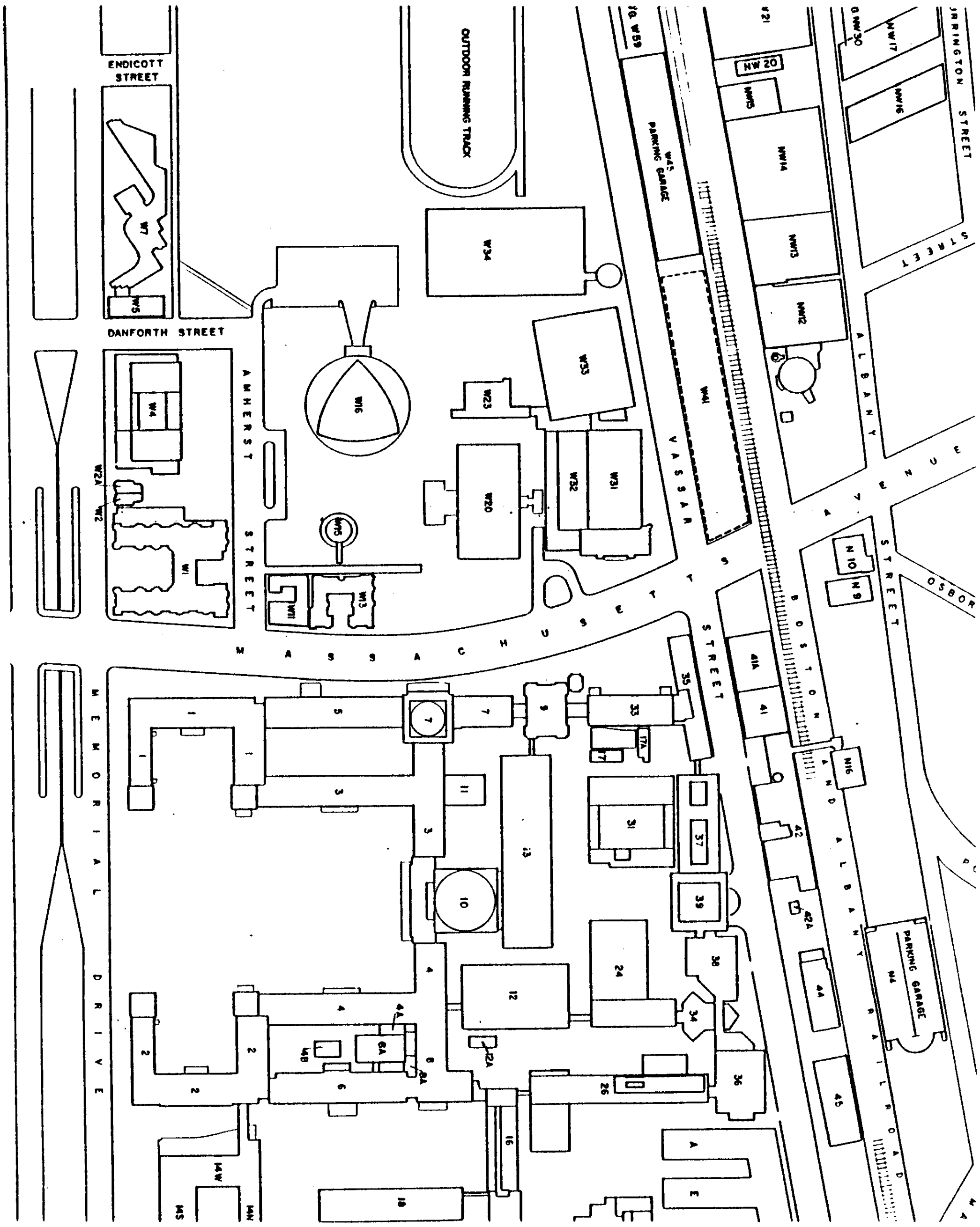
Star Clusters: One Up, One Down 1987. Towers are 24 feet and 32 feet in height.

Figure 8-4: Moire Light Patterns



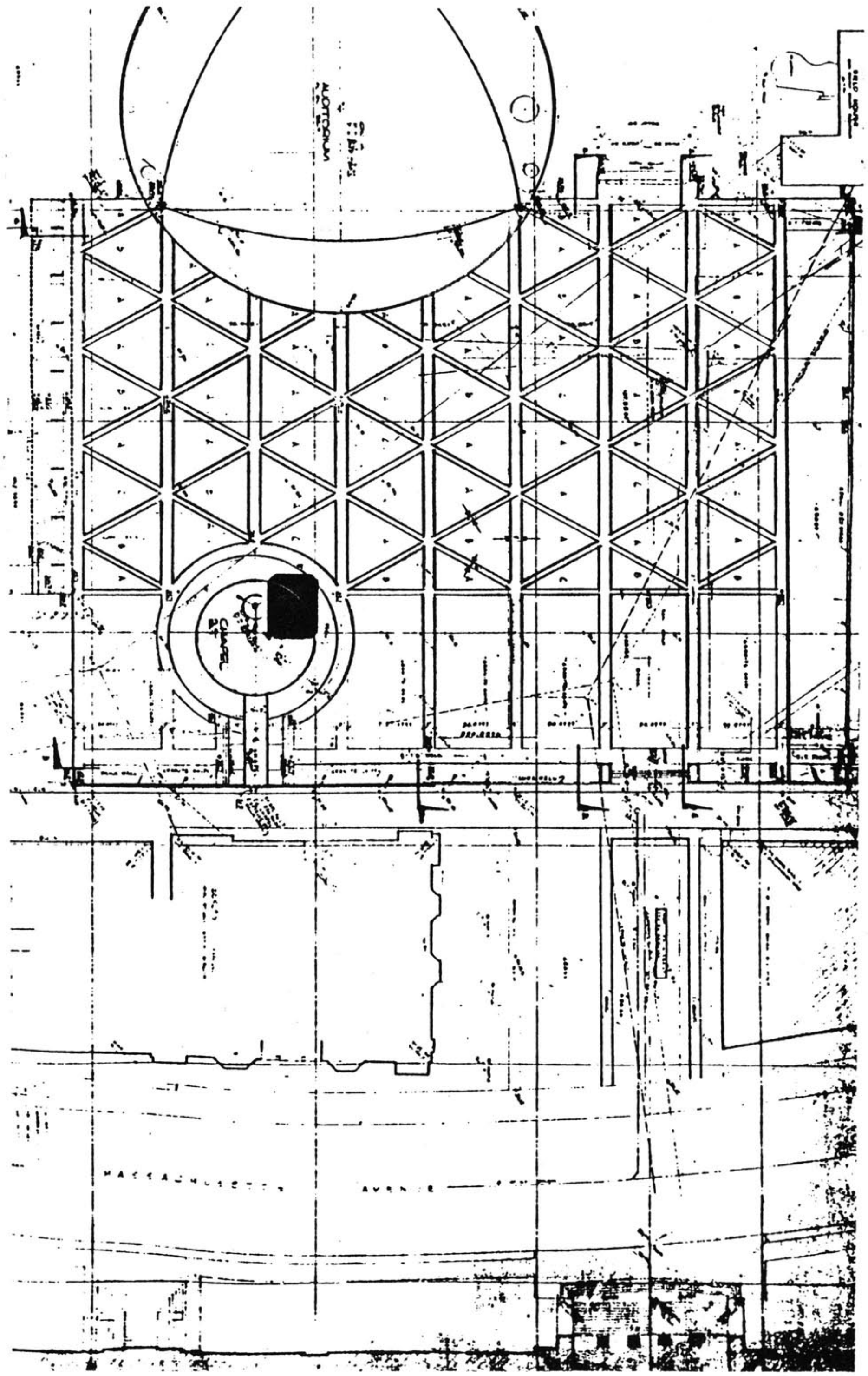
Star Clusters was made of wood plastic and fabric

Figure 8-5: MIT Plot Plan



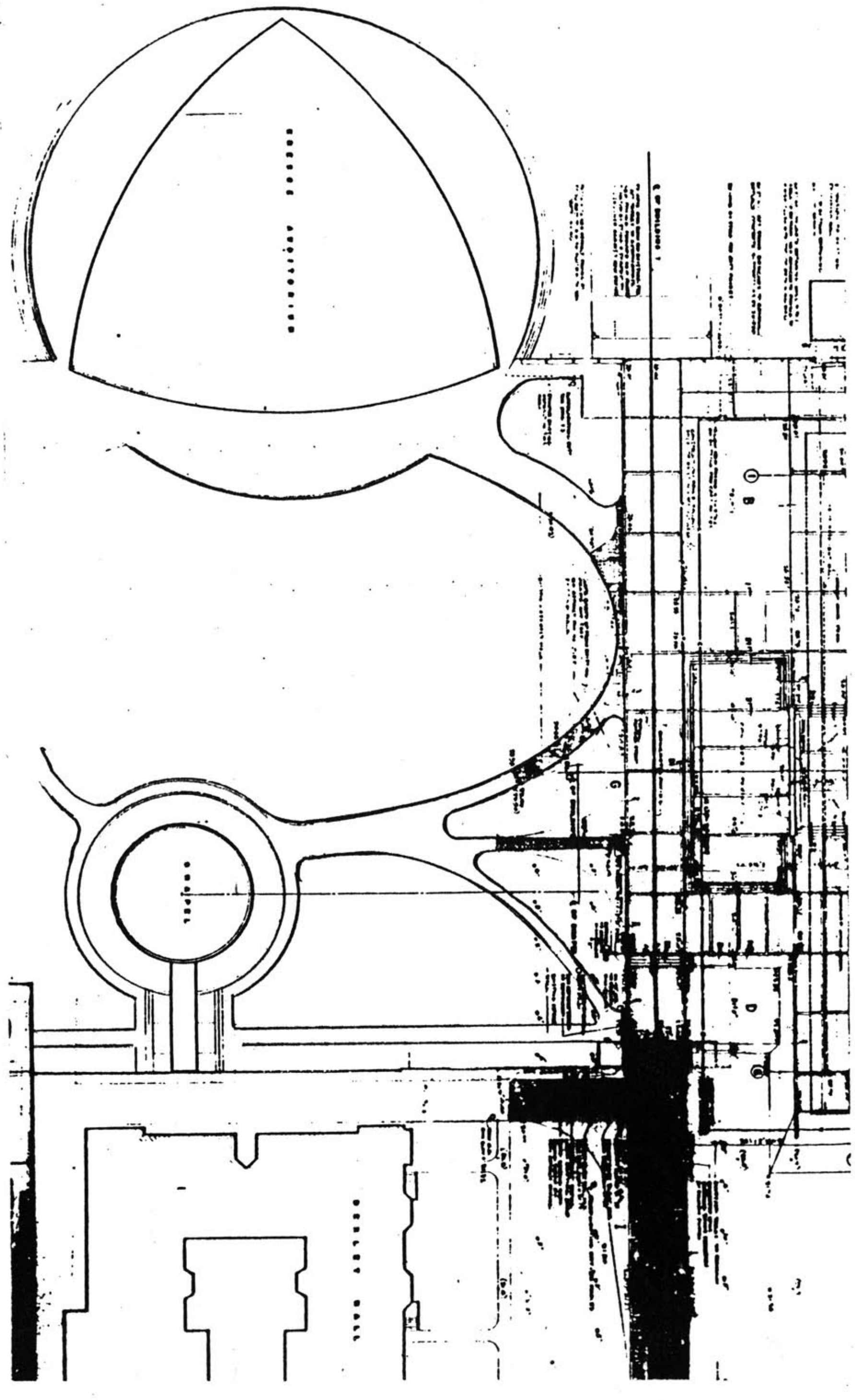
M.I.T. Chapel Bldg. W-15, Kresge Auditorium W-16

Figure 8-6: Eero Saarinan Site Plan



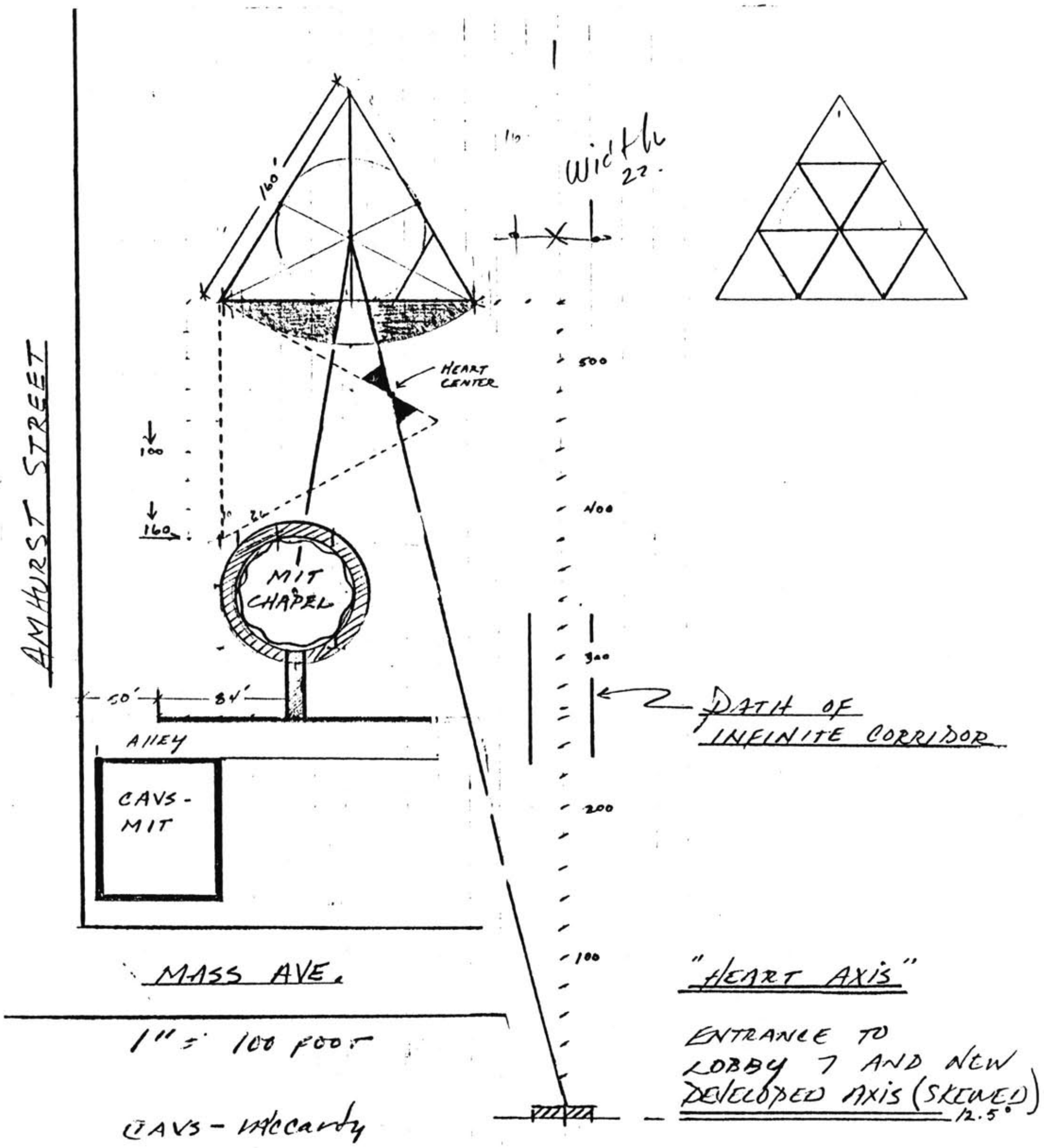
M.I.T. Chapel and Kresge Auditorium with triangulated infill not used

Figure 8-7: Kresge Oval Site Plan



Current Site

Figure 8-8: Heart Center of *36 Diatom Tower*



12.5 Degree Developed Axis

Figure 8-9: Heart Center Enlarged

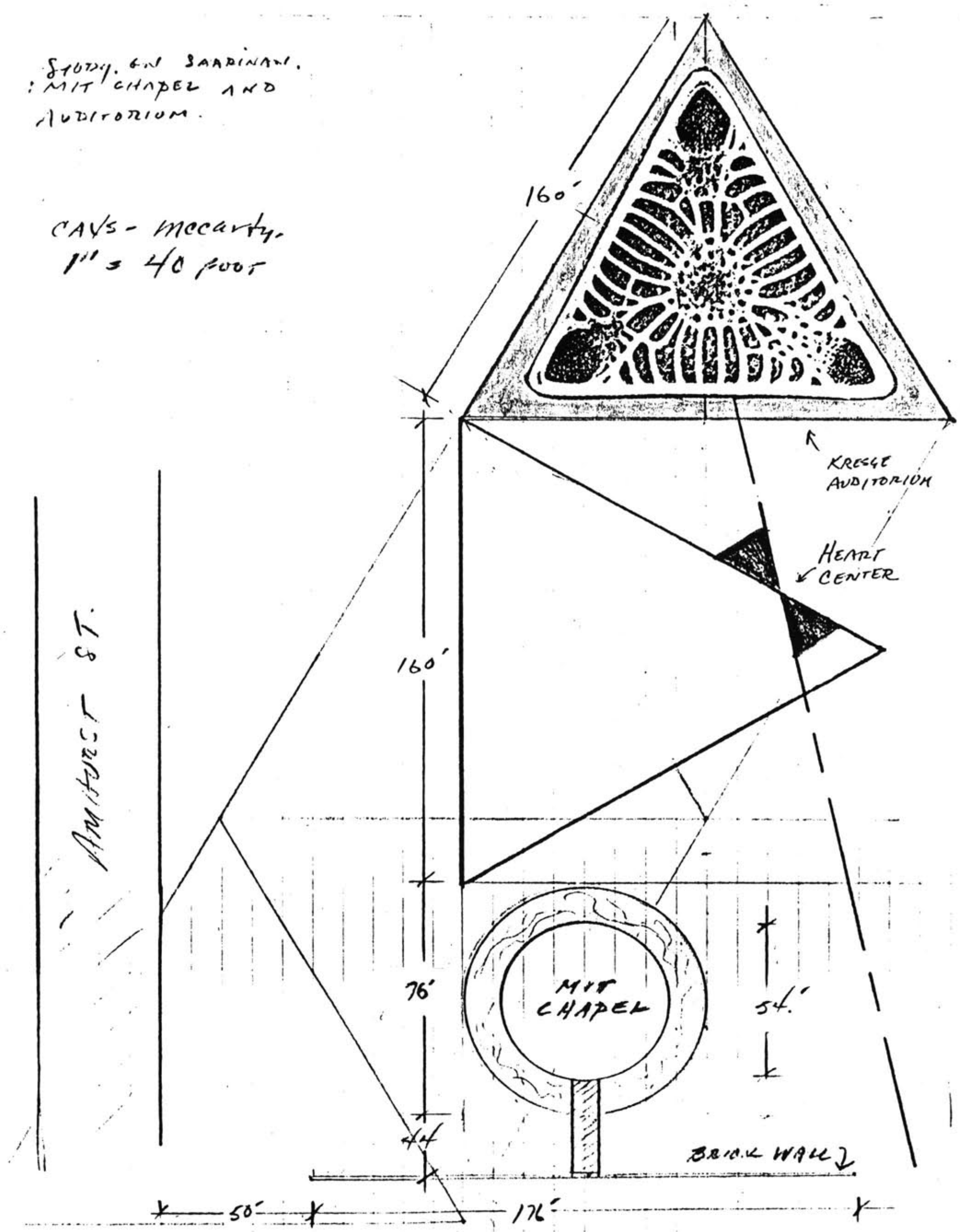


Figure 8-10: *36 Diatom Tower* Plan

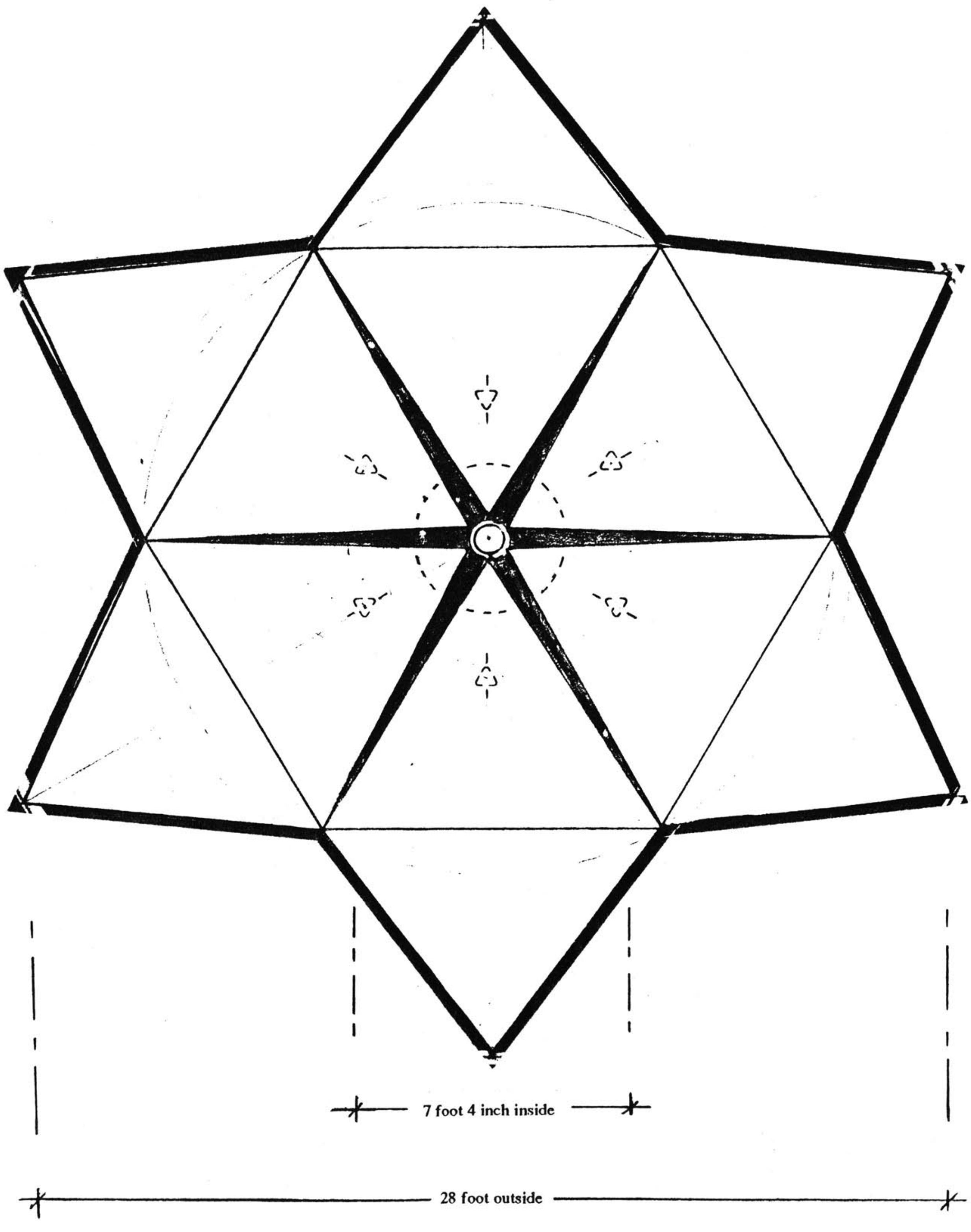
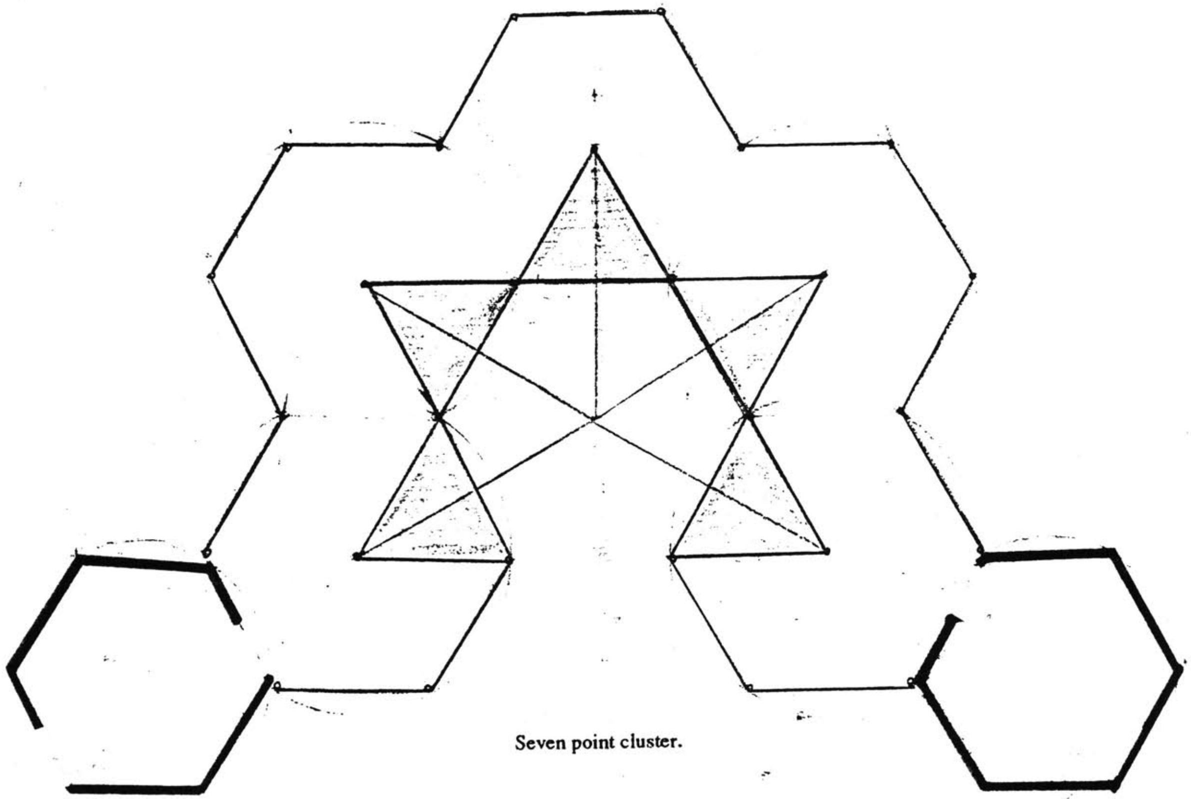
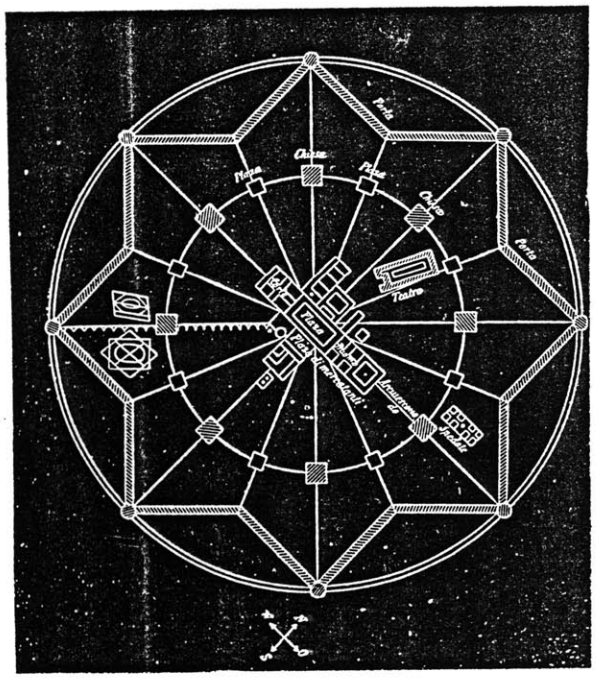


Figure 8-11: Plan - Star Clusters: One Up, One Down



Tower One is 24 feet high, Tower Two is 32 feet high. Labyrinth is made of fabric.

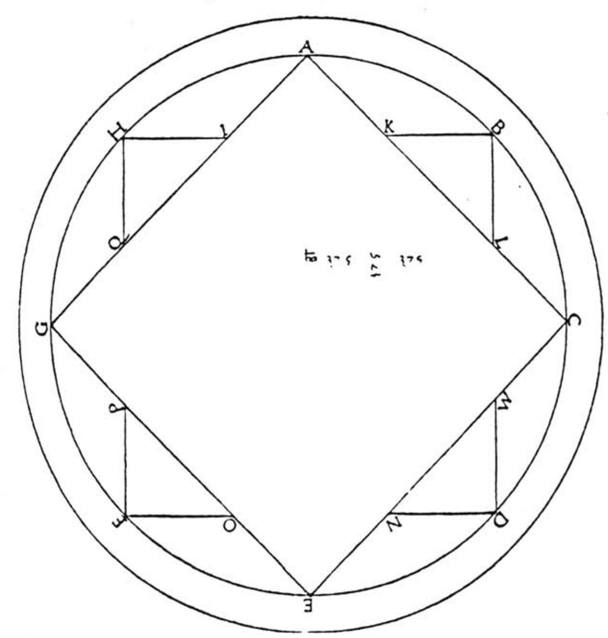
Figure 8-12: Filarete "Sforzinda", The Star-Shaped City



A radial road pattern with sixteen main streets that radiate from the central piazza to the eight city gates.

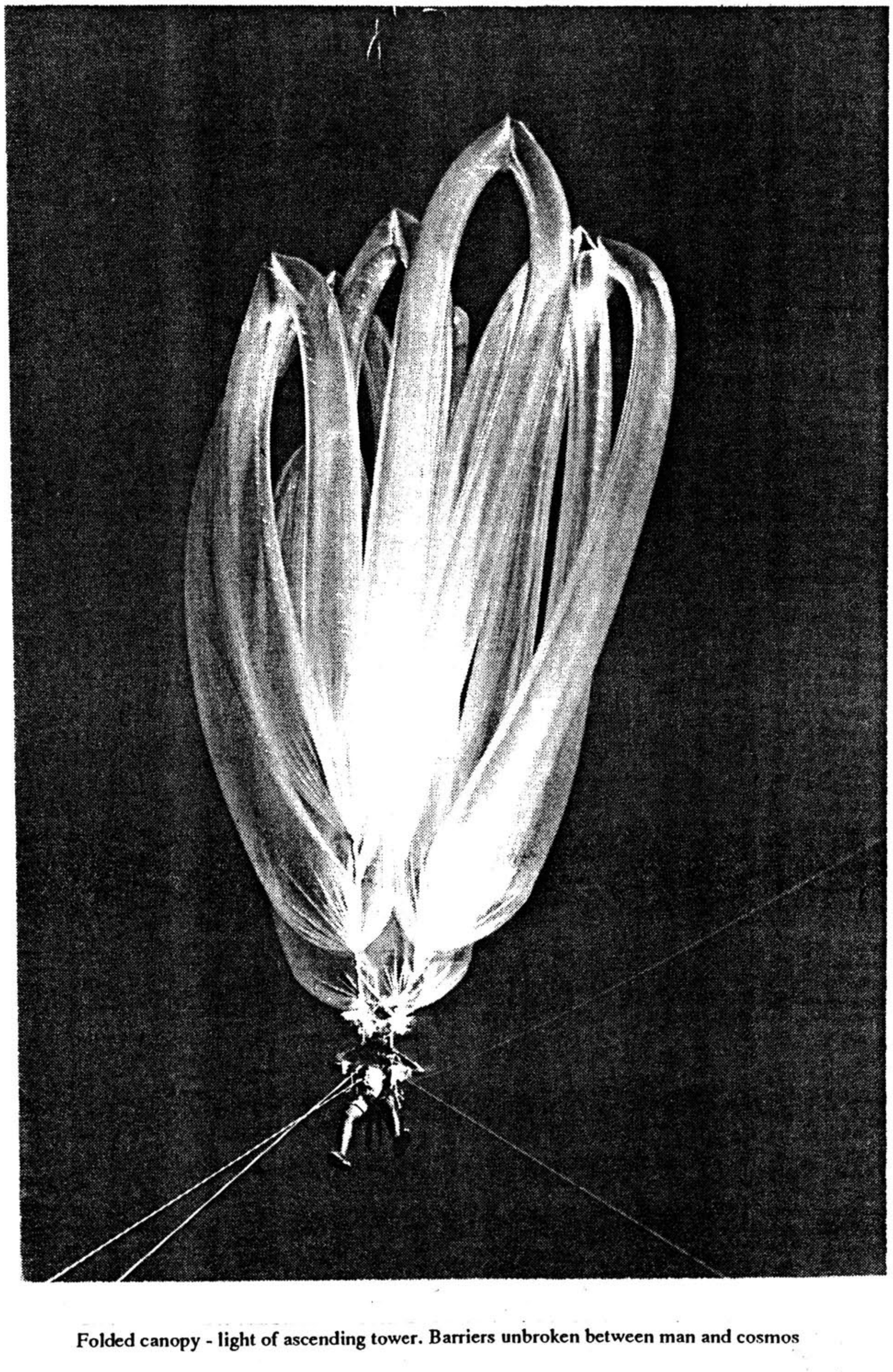
Church and tower are at center.

Italian Renaissance period.



Come io detto lo rimostrero questo plimiamento ilquale e riquadrato in
quadri picholi rugliposteresti intendere grandi & picholi aruo fermo maio
glintendo diquesta misura cioe diquattro stady perischetto quadro che fare
che almodo nostro mezzo miglio pquadro Siche uedendo questo tupuoi sa
pere quanto mene cessere girando per lacuam ouuoi due meglia o uuoi
due stady ouuoi due braccia tu sai quanti stady e uno miglio e sai
quante braccia e lostadio molapridera & saperrai quanto ella circunda
o quanto elle perogni uerso Eo cosi allaragione diqueste misure massime

Figure 8-13: Otto Piene; Man, Light, and Tower, 1987



Folded canopy - light of ascending tower. Barriers unbroken between man and cosmos

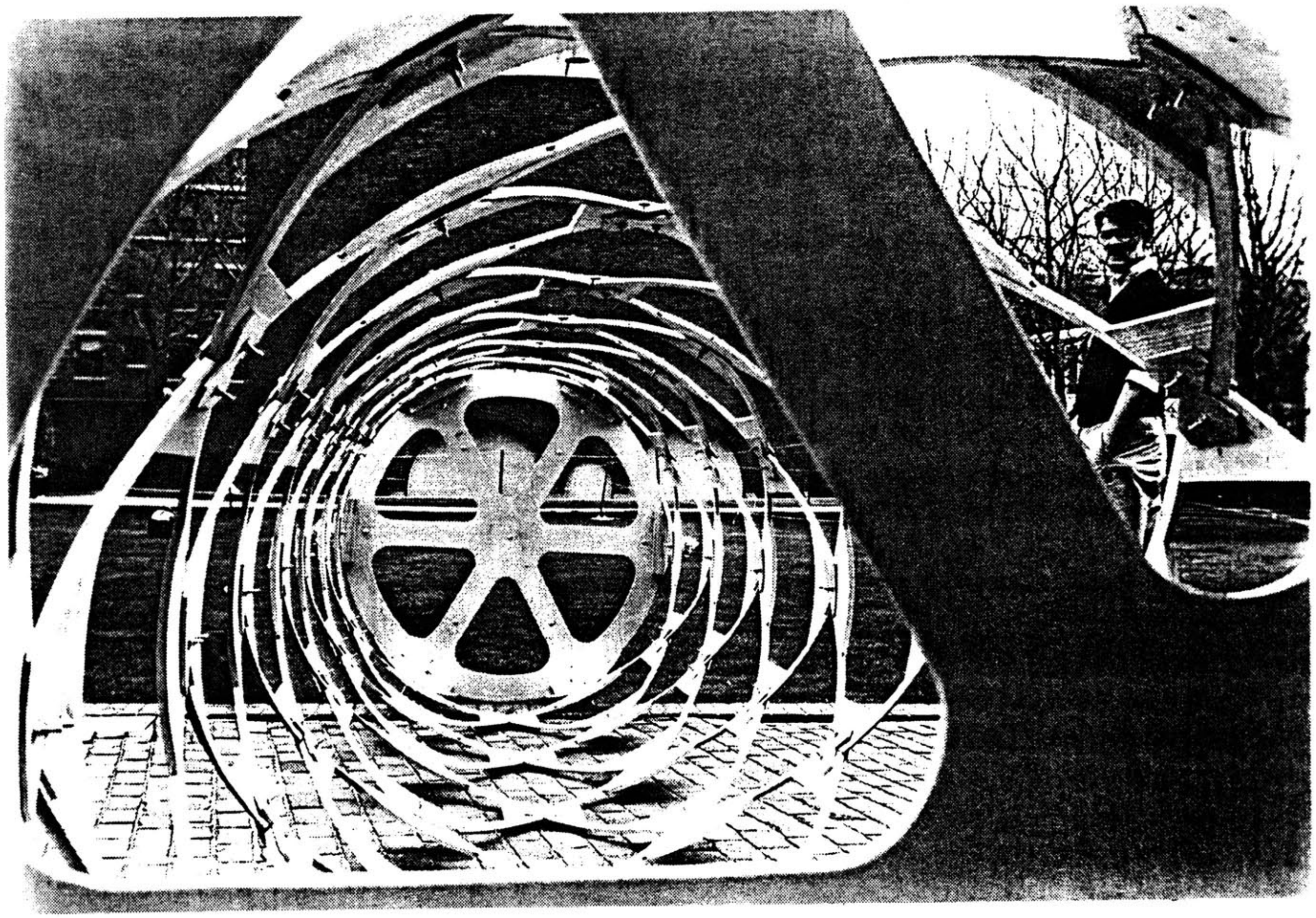
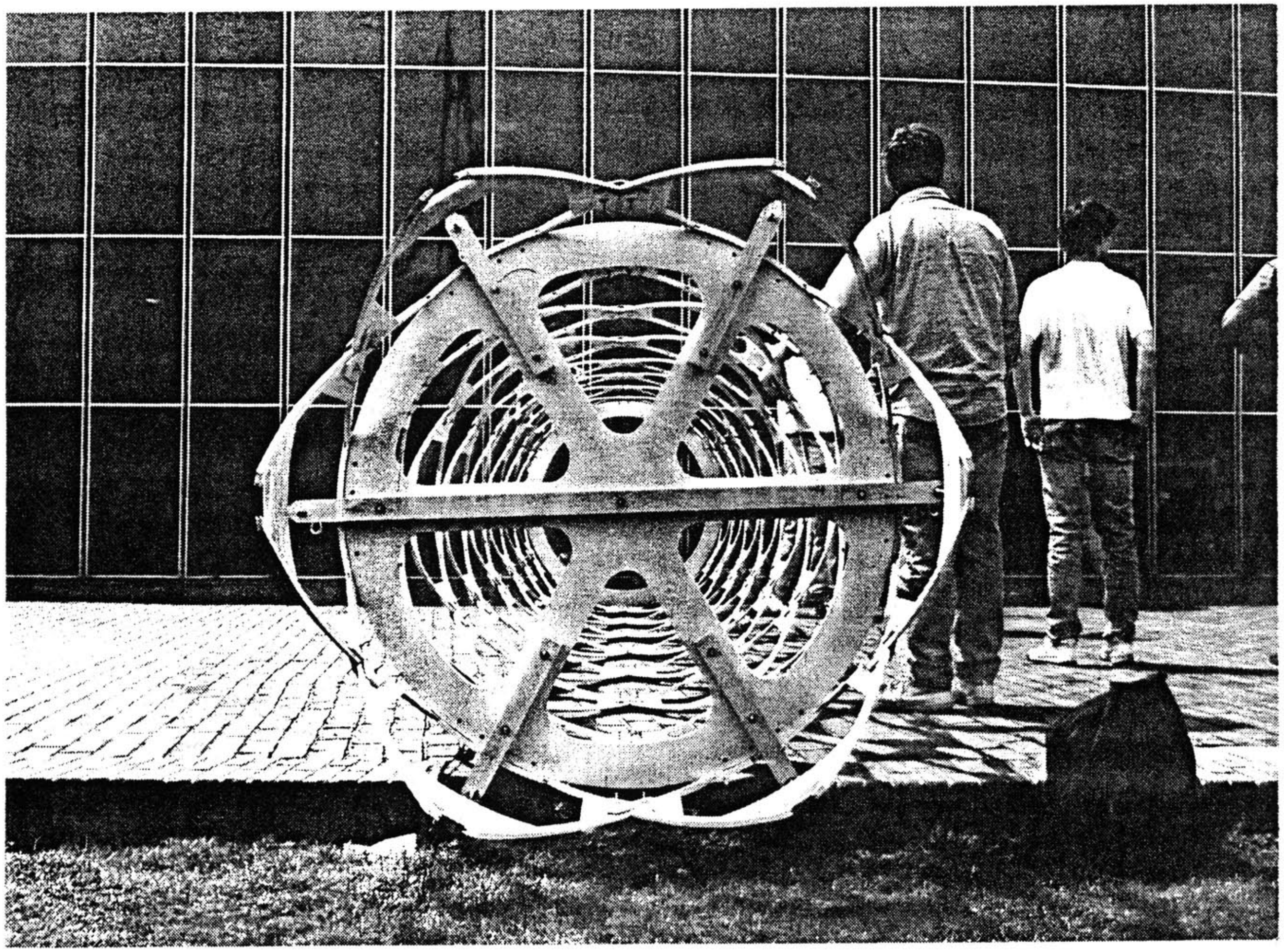


Figure 8-14: Horizontal Spire

point of intersection made visible.

Figure 8-15: Compression Ring at Spire Top



Four foot diameter

Figure 8-16: Base Diatom With Oval

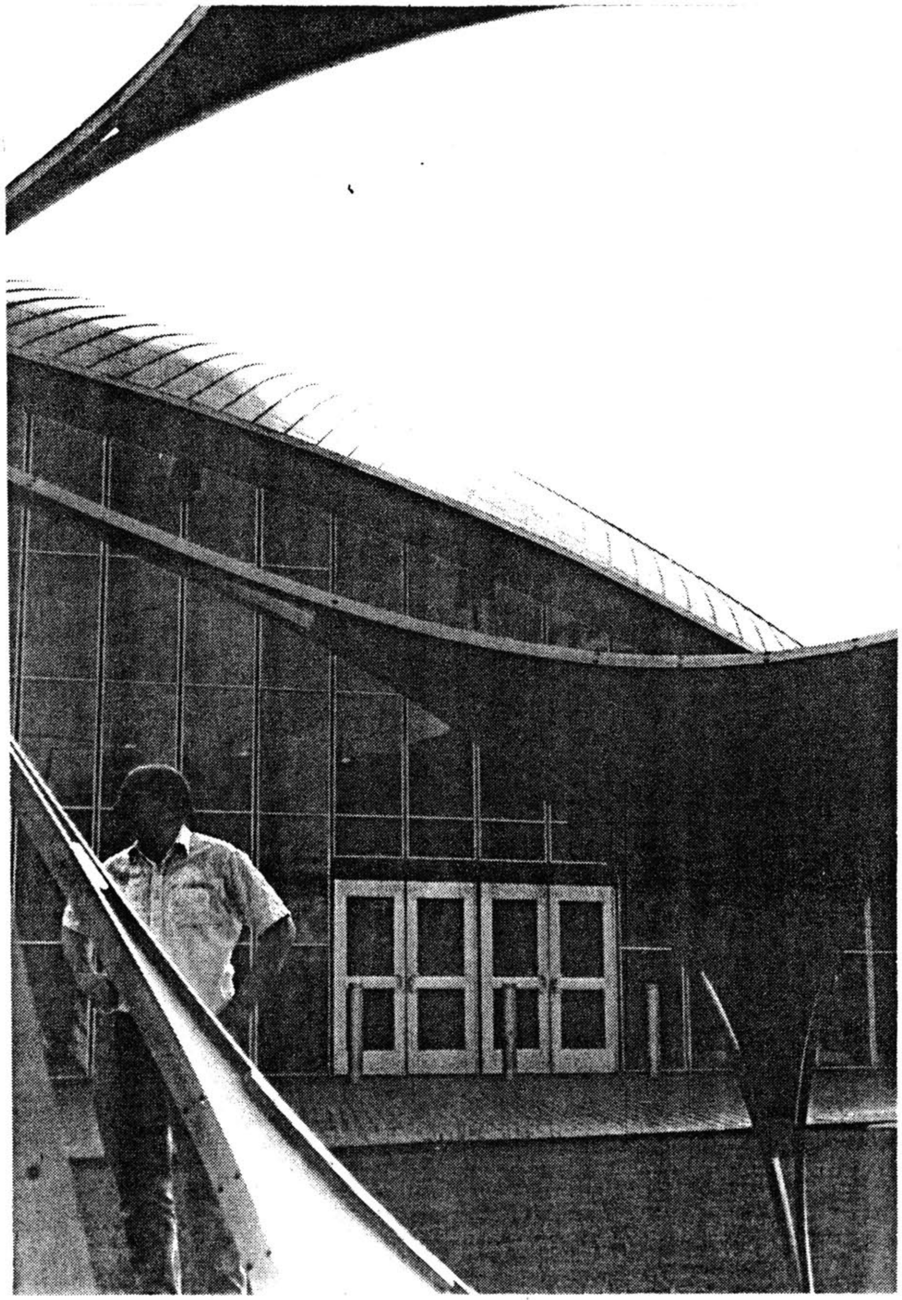


Figure 8-17: Procession of Spire

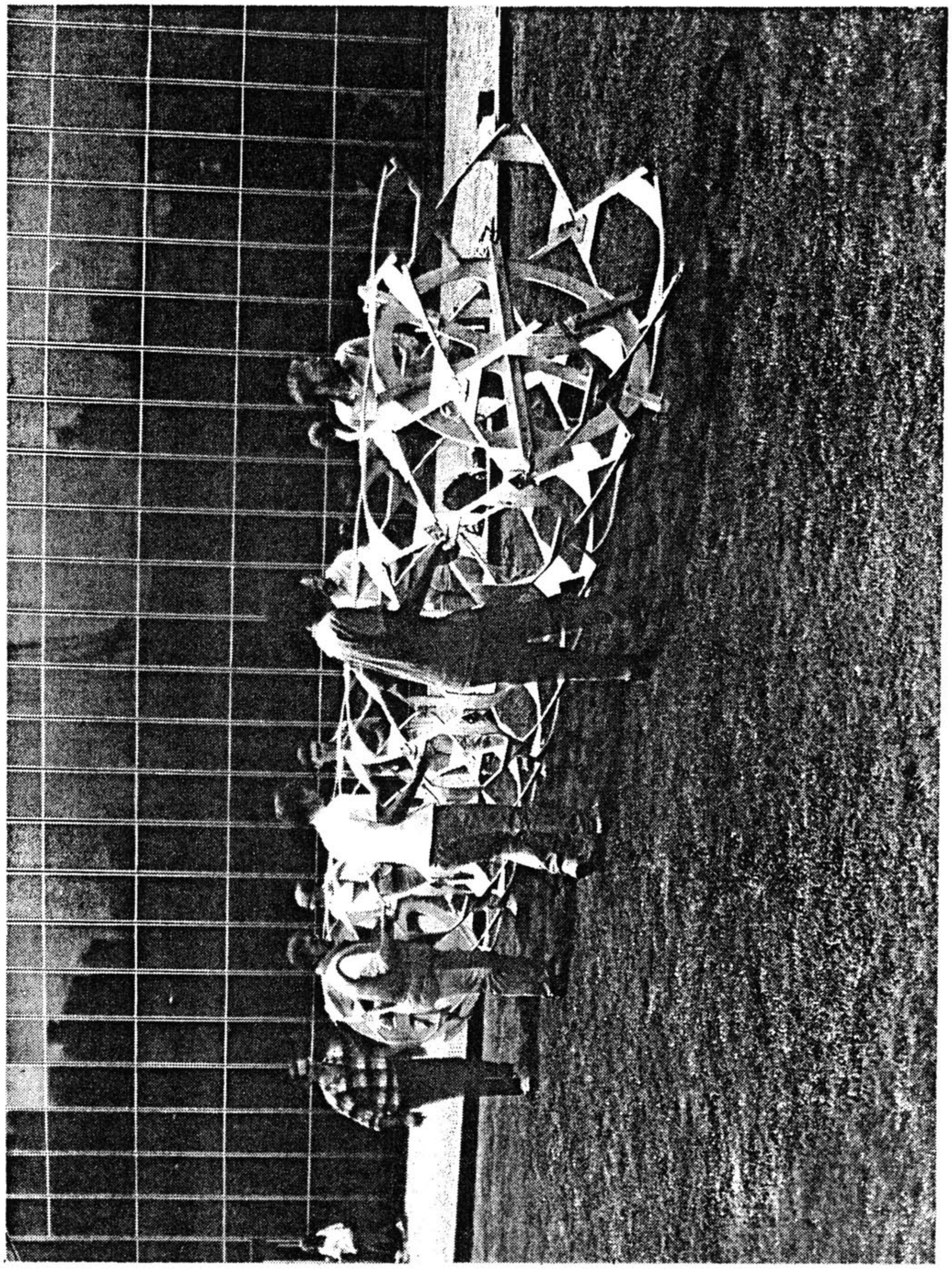


Figure 8-18: Procession : 2nd Movement

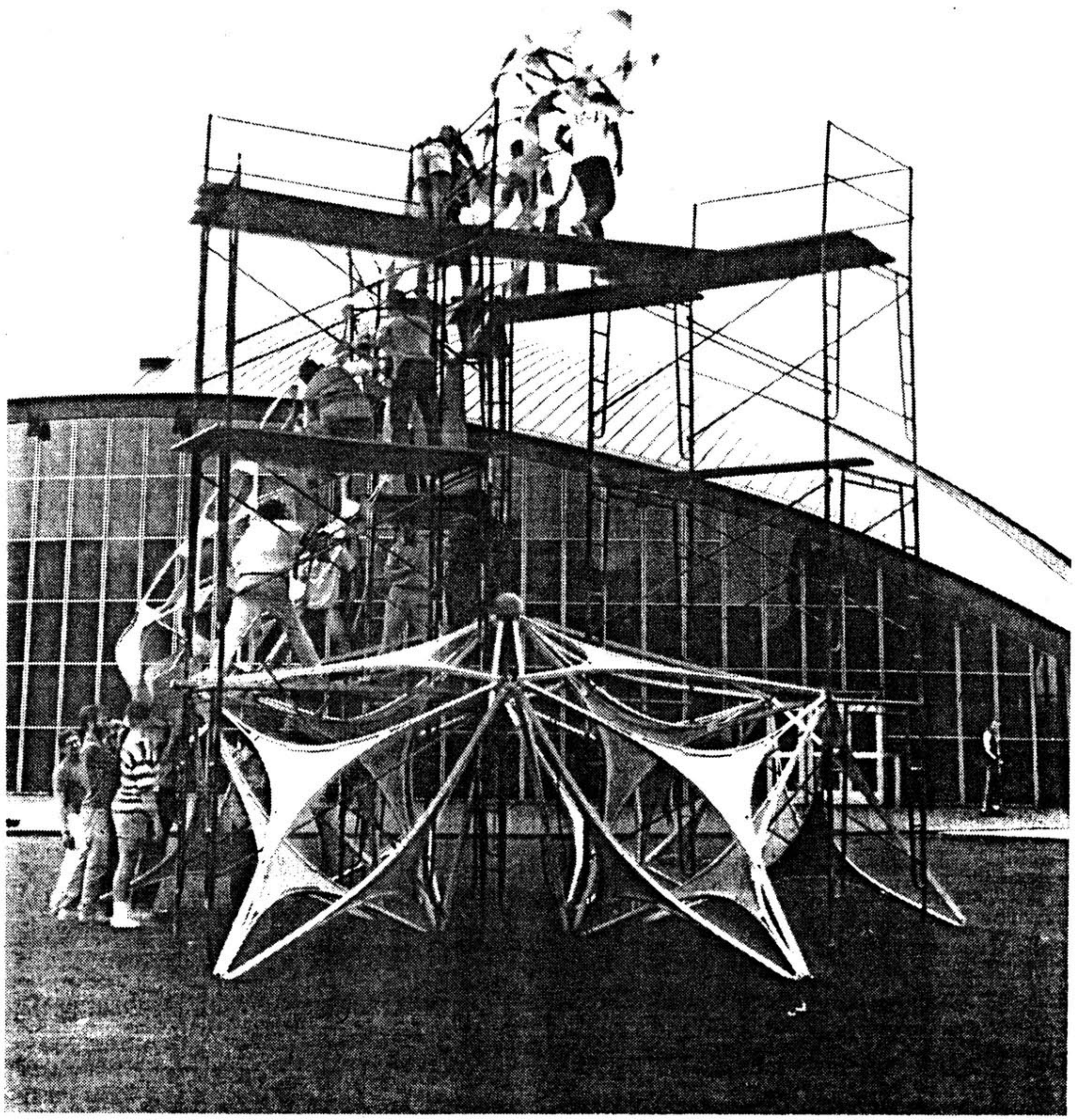


Figure 8-19: Procession: 3rd Movement

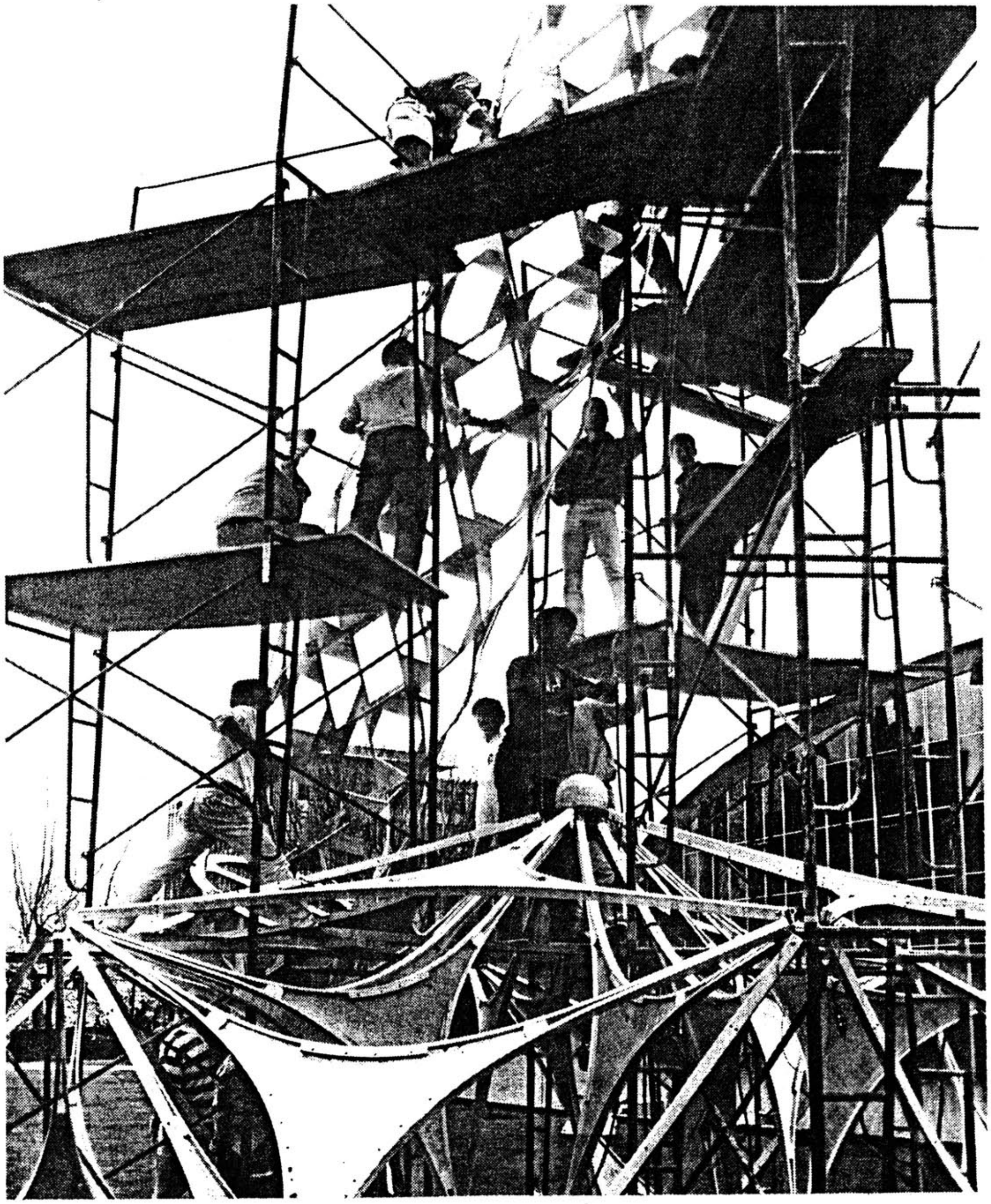


Figure 8-20: Hands and Cup

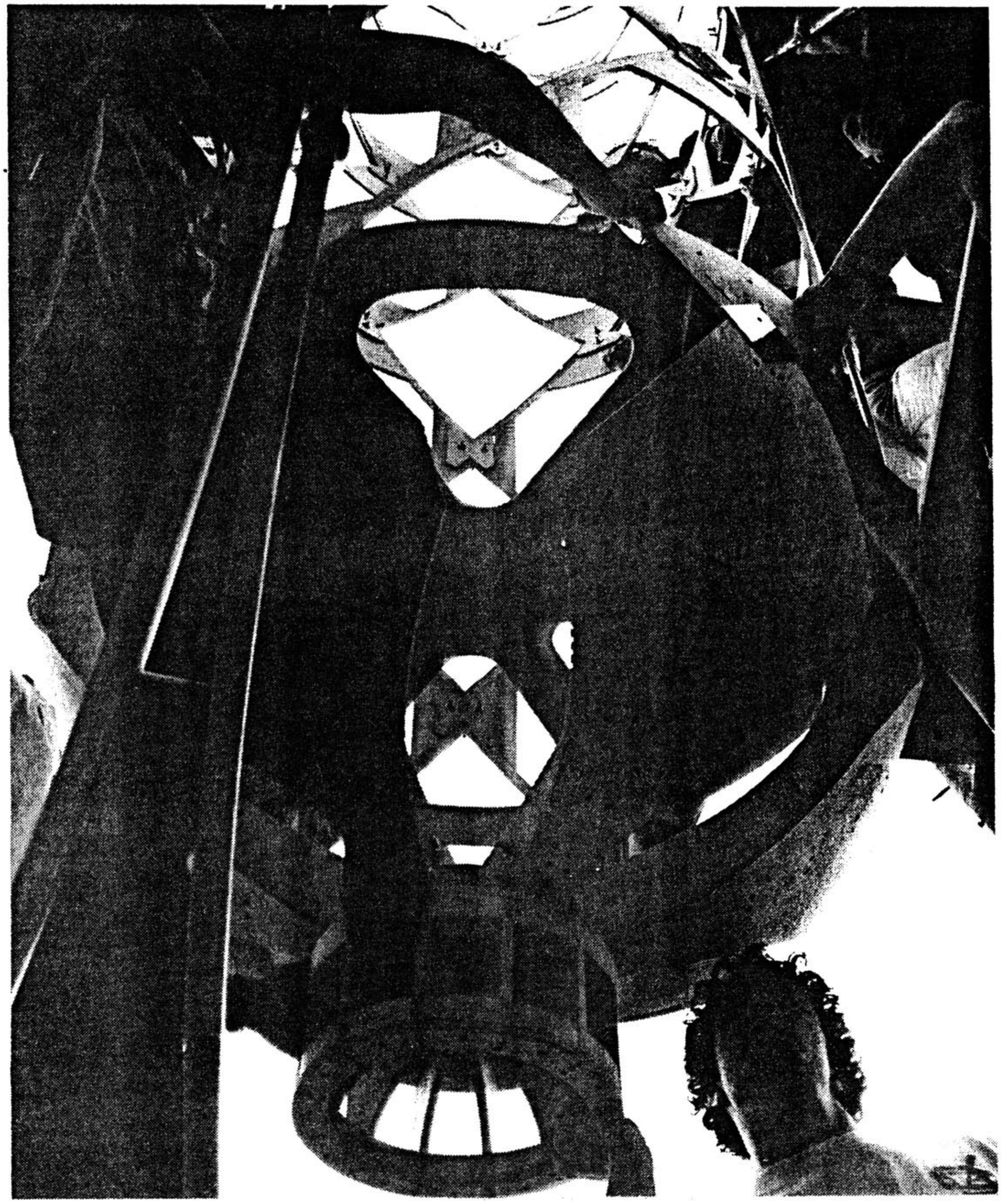


Figure 8-21: Inner Court of Light and Scale

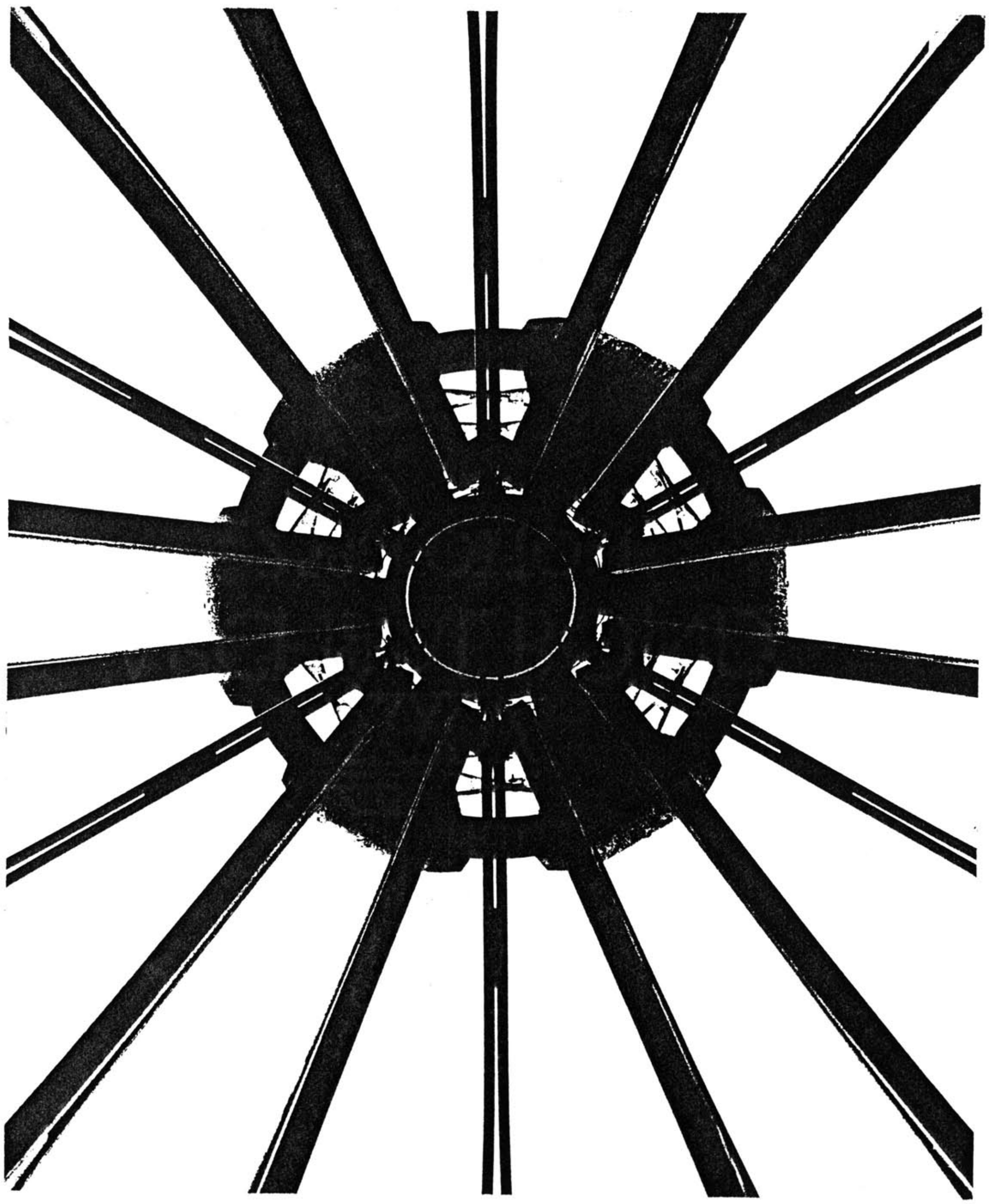
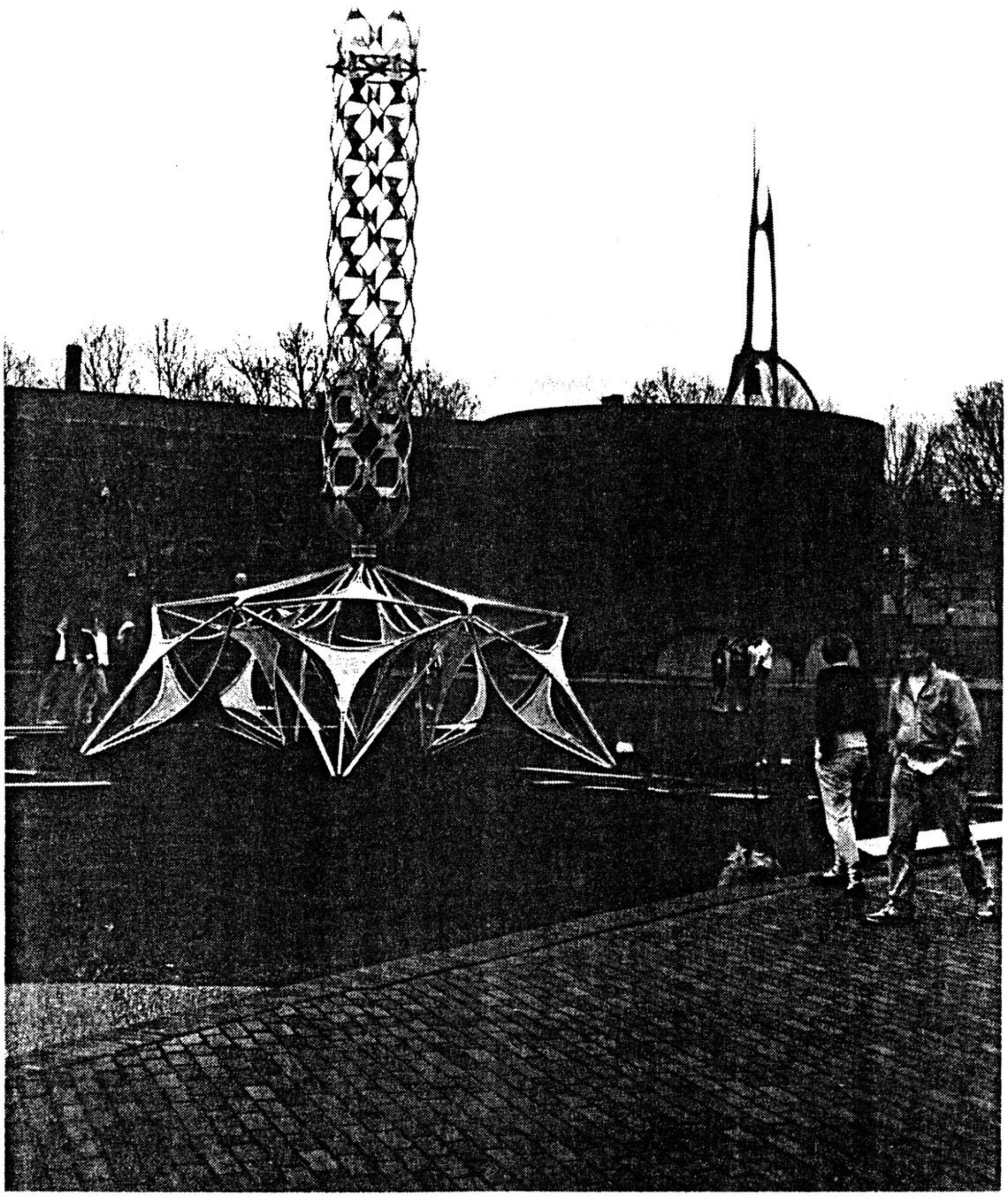
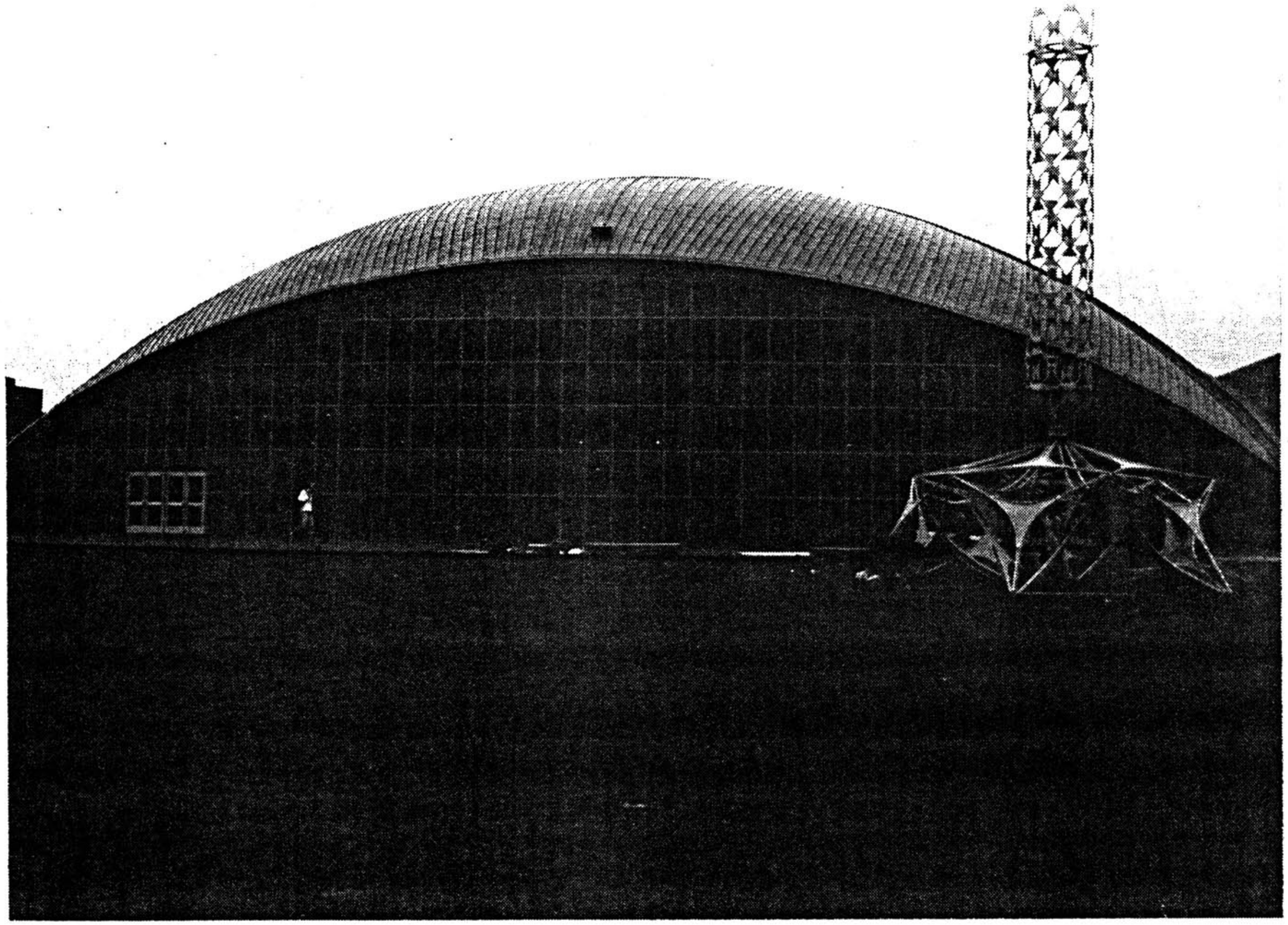


Figure 8-22: West Elevation



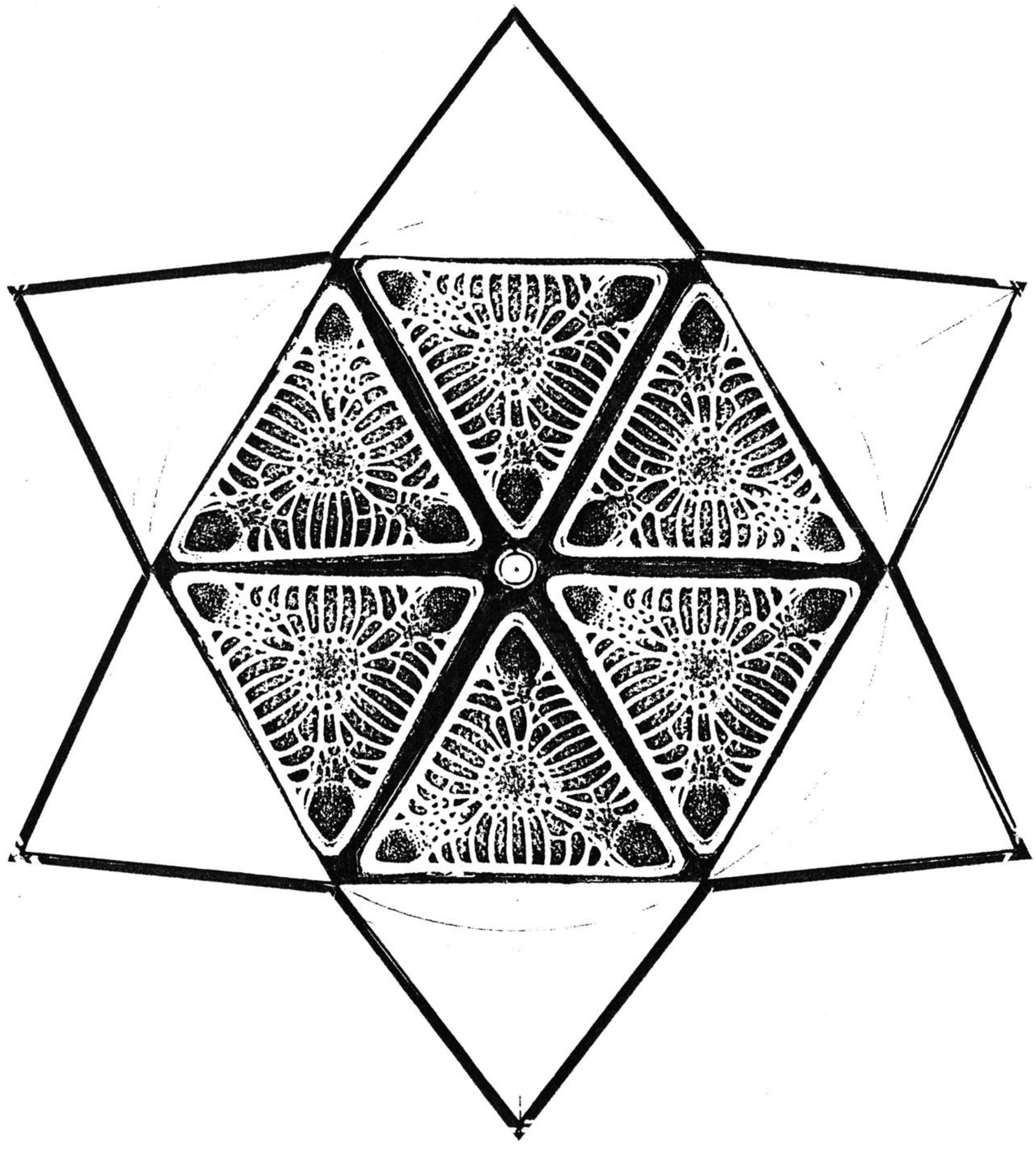
With M.I.T. Chapel

Figure 8-23: East Elevation



With Kresge Auditorium

Figure 8-24: Plan View w/ Marine Diatom



The light, nutrient, and stress transport arteries are quite evident in this diatom cross-section.

Figure 8-25: Section Through Elevation

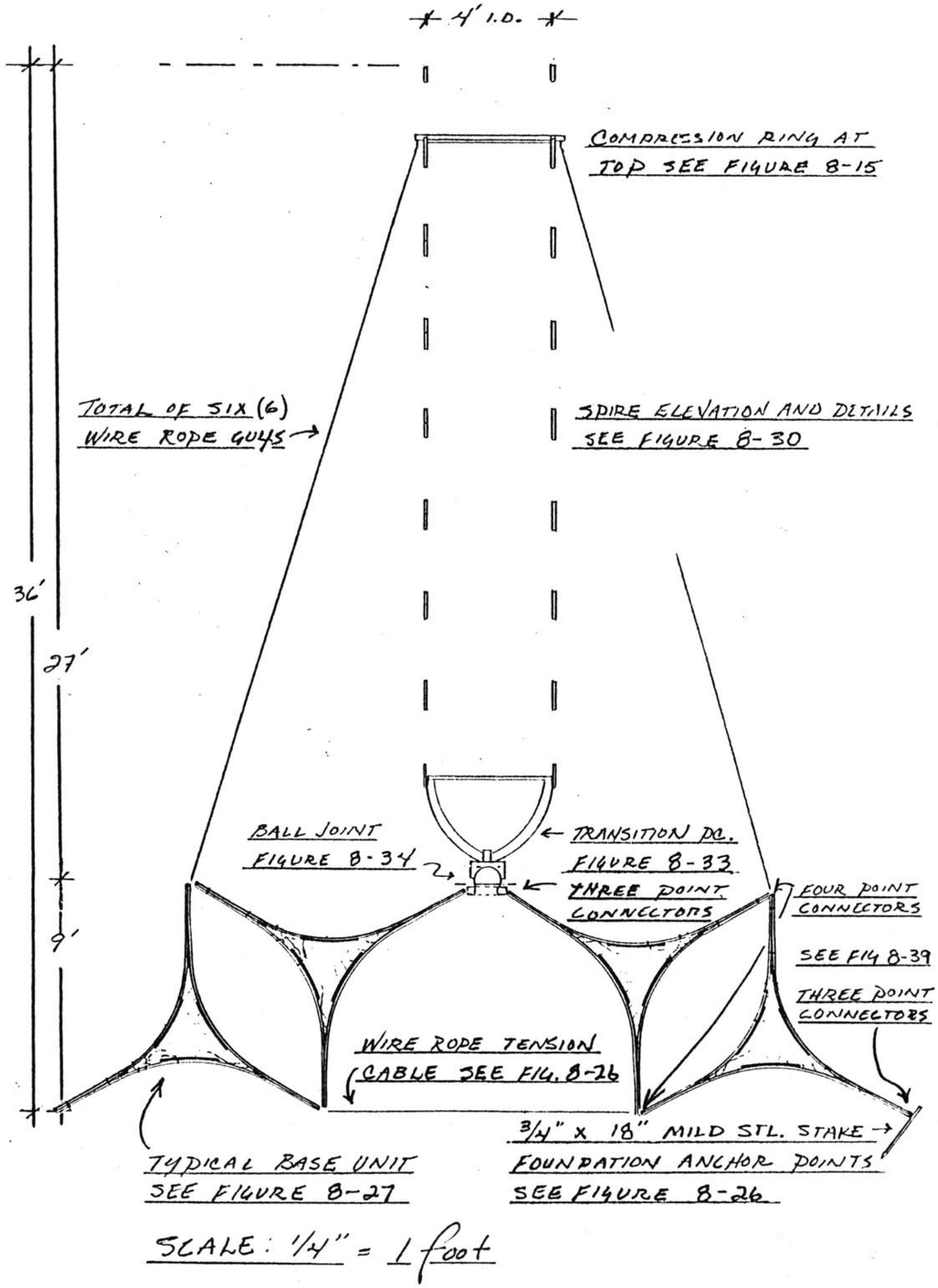
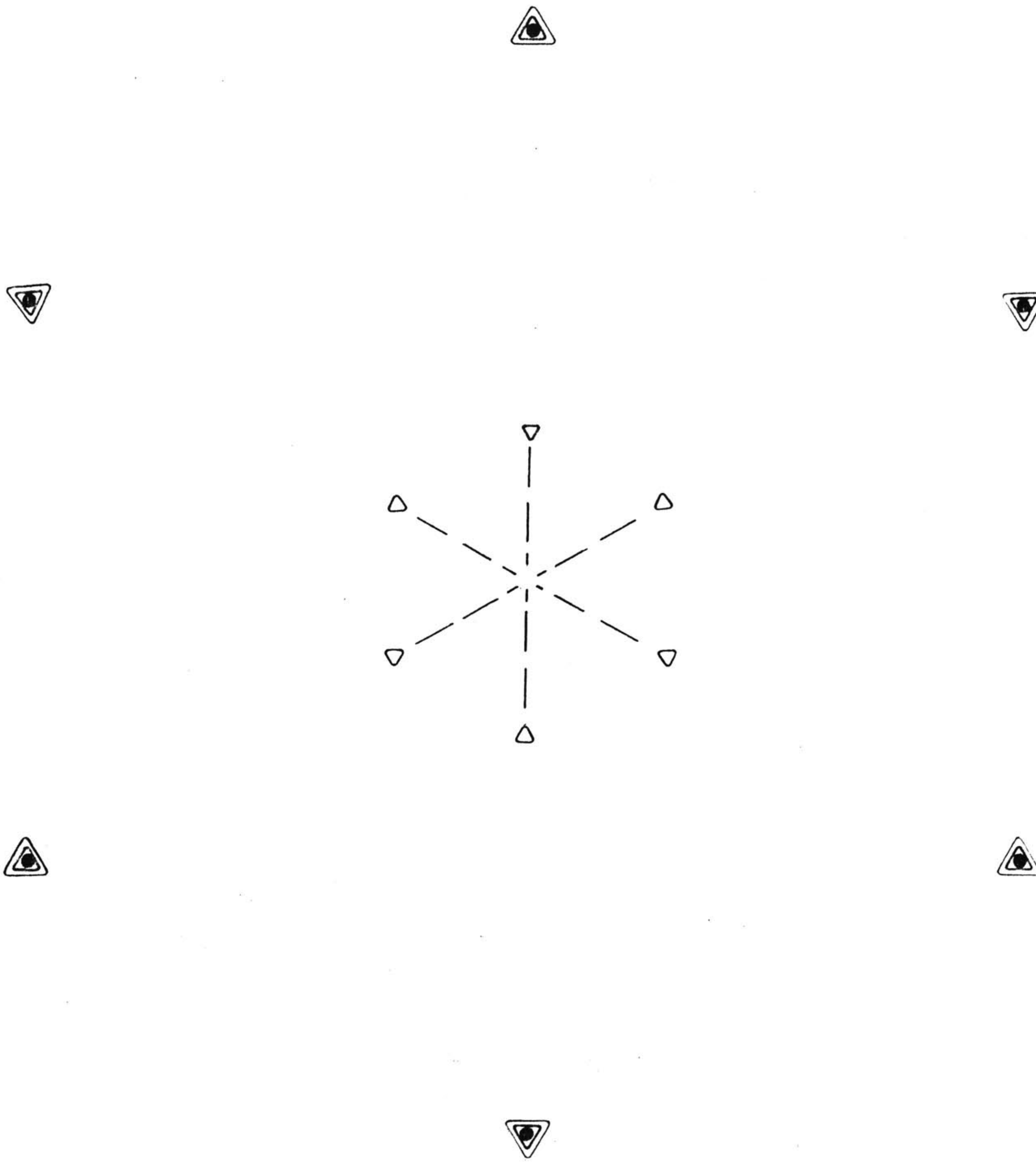
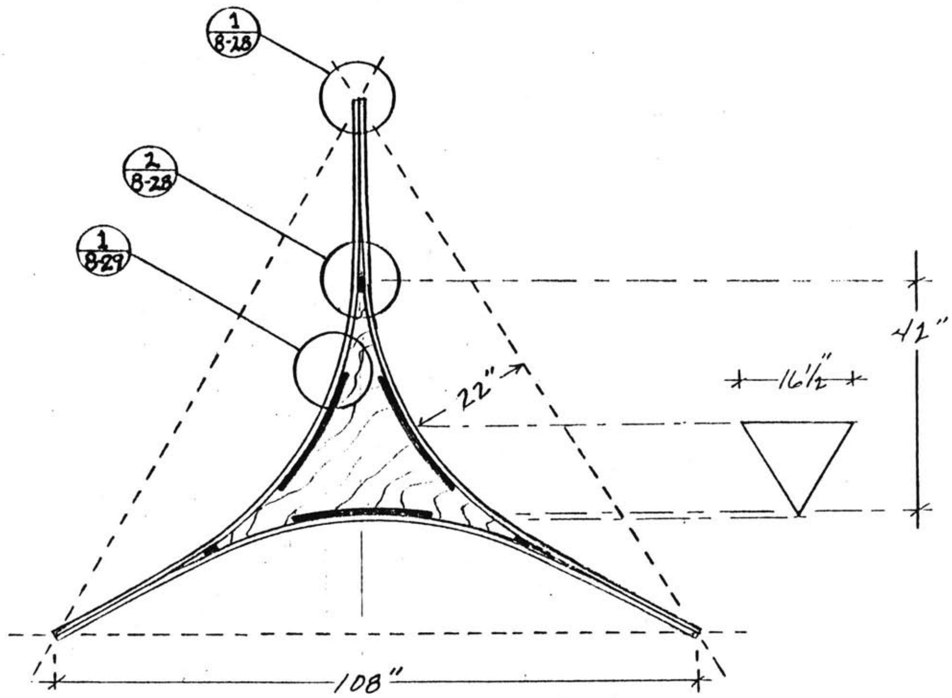


Figure 8-26: Foundation Anchor Points



Refer to Figure 8-10 for Dimensions

Figure 8-27: Tower Base: Typical Unit Plan



PLAN - TYPICAL UNIT (x 36) @ BASE

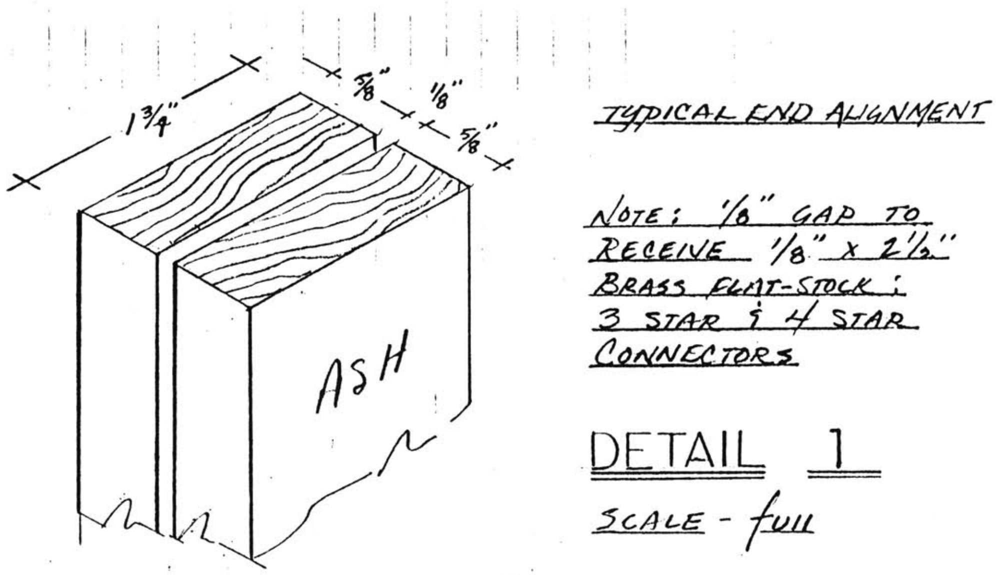
SCALE 1/2" = 1 foot

MATERIAL LIST PER EACH UNIT

3 - pc. 5/8" x 1 3/4" NET x 117 7/8" ASH
6 - pc. 5/8" x 1" NET x 18" POPLAR
3 - pc. 2" x 1 3/4" NET x 3" MAPLE
42 - 1/8" x 1 1/4" TAPERED TECH SCREW
12 - 1/8" x 1 3/4" TAPERED TECH SCREW
1 - pc 3/8" x 45" △ AC - PLYWOOD

NOTE: TWO 1" - 4'x 8' AC-PLYWOOD SHEETS WERE ARRANGED IN A TEE SHAPE TO PROVIDE A SUITABLE WORK SURFACE. THE ASH WAS PRESSURE BENT INTO A 3 POINT MOLD.

Figure 8-28: Details



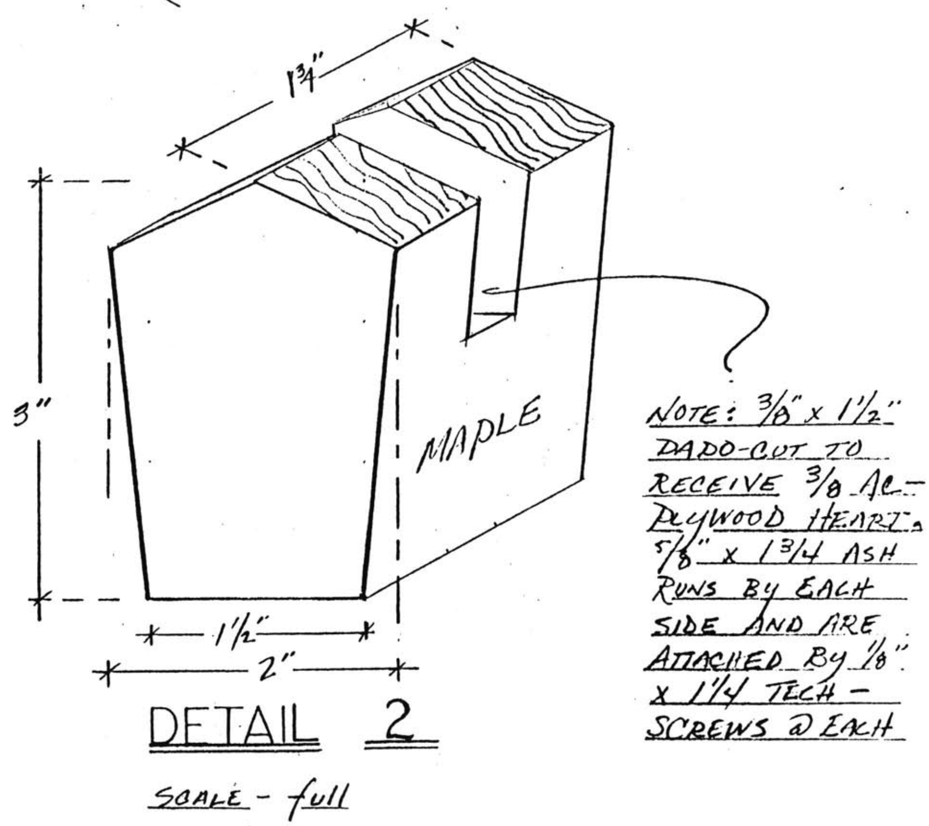


Figure 8-29: Details

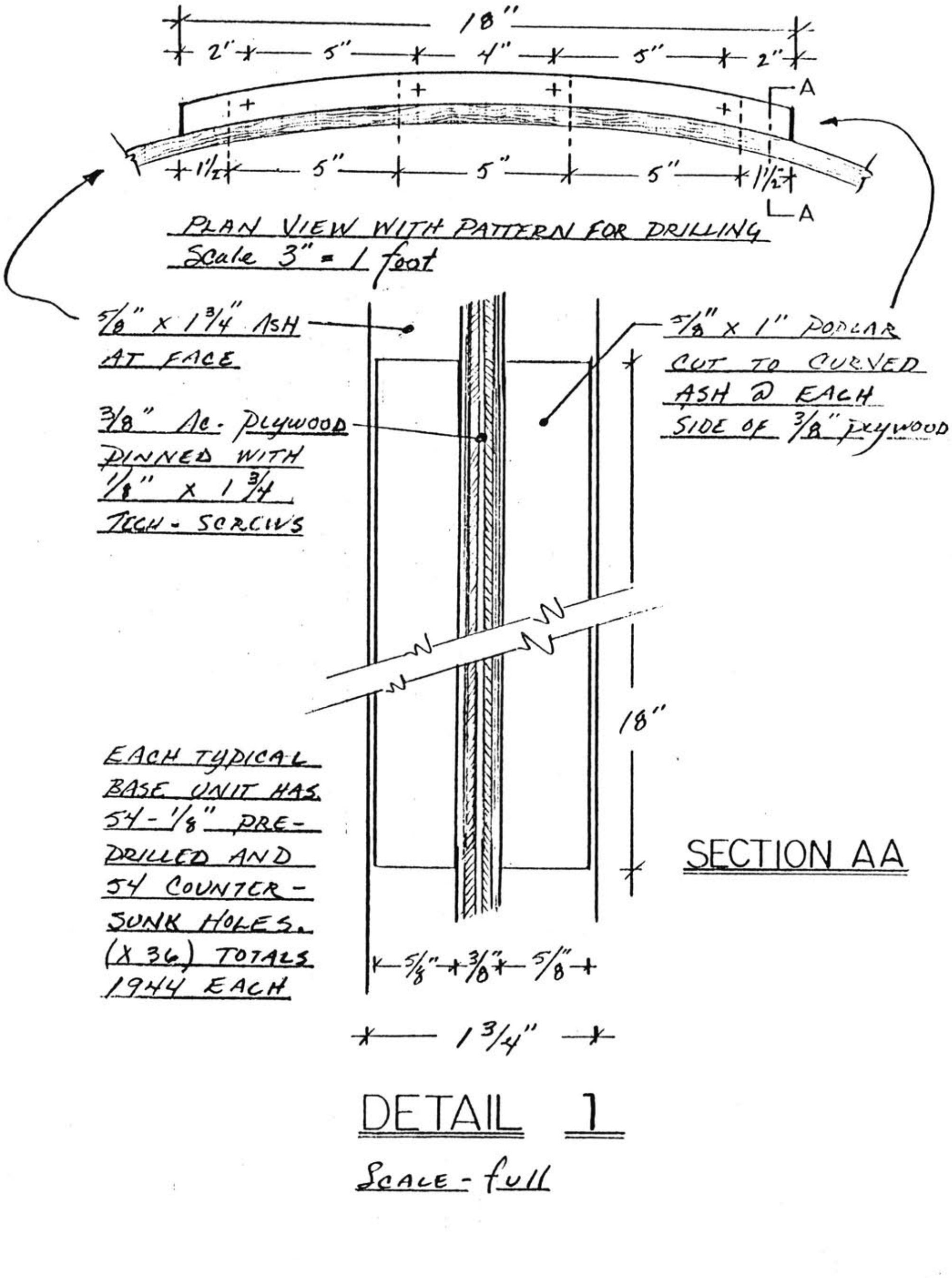


Figure 8-30: Spire Elevation

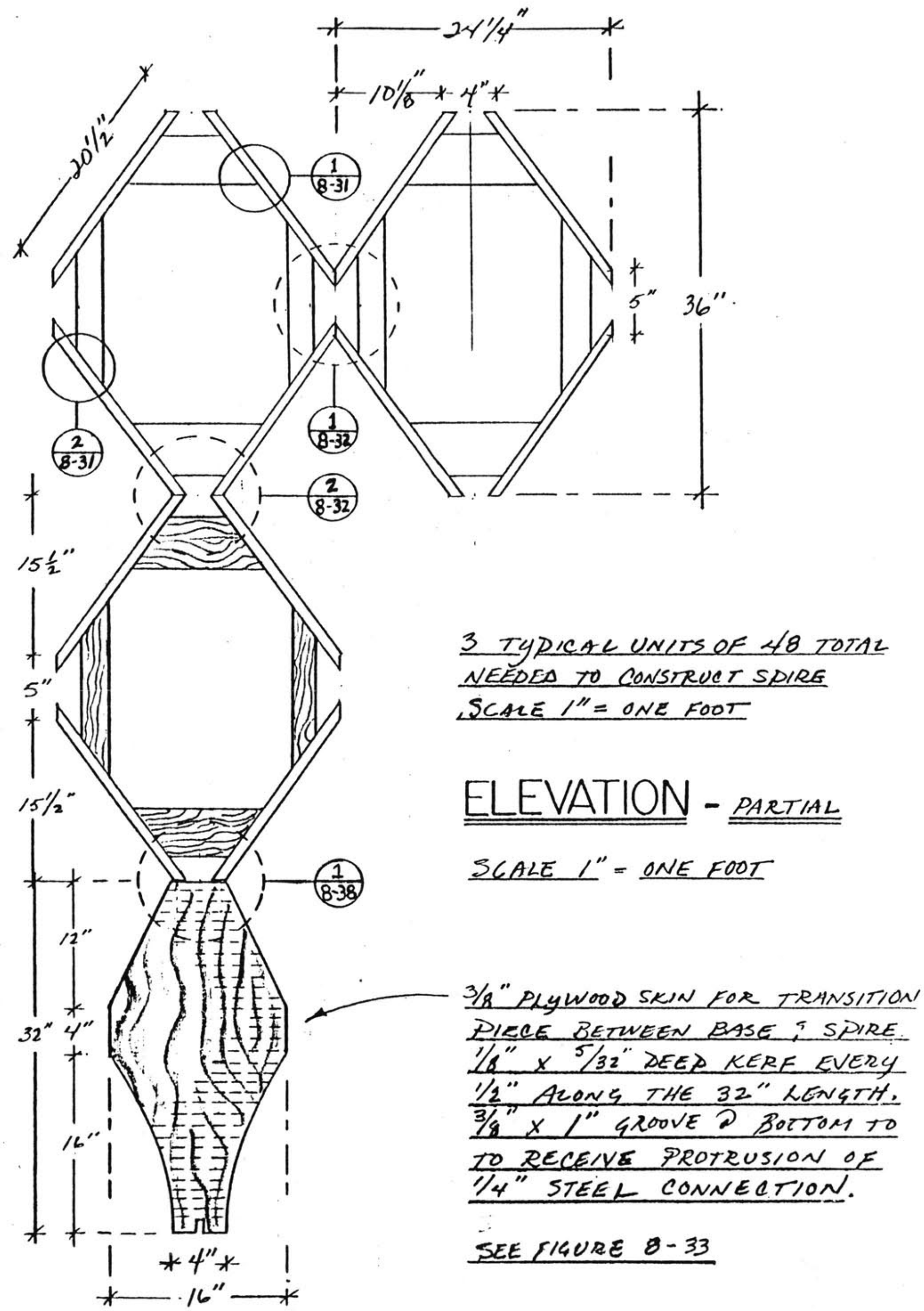


Figure 8-31: Details

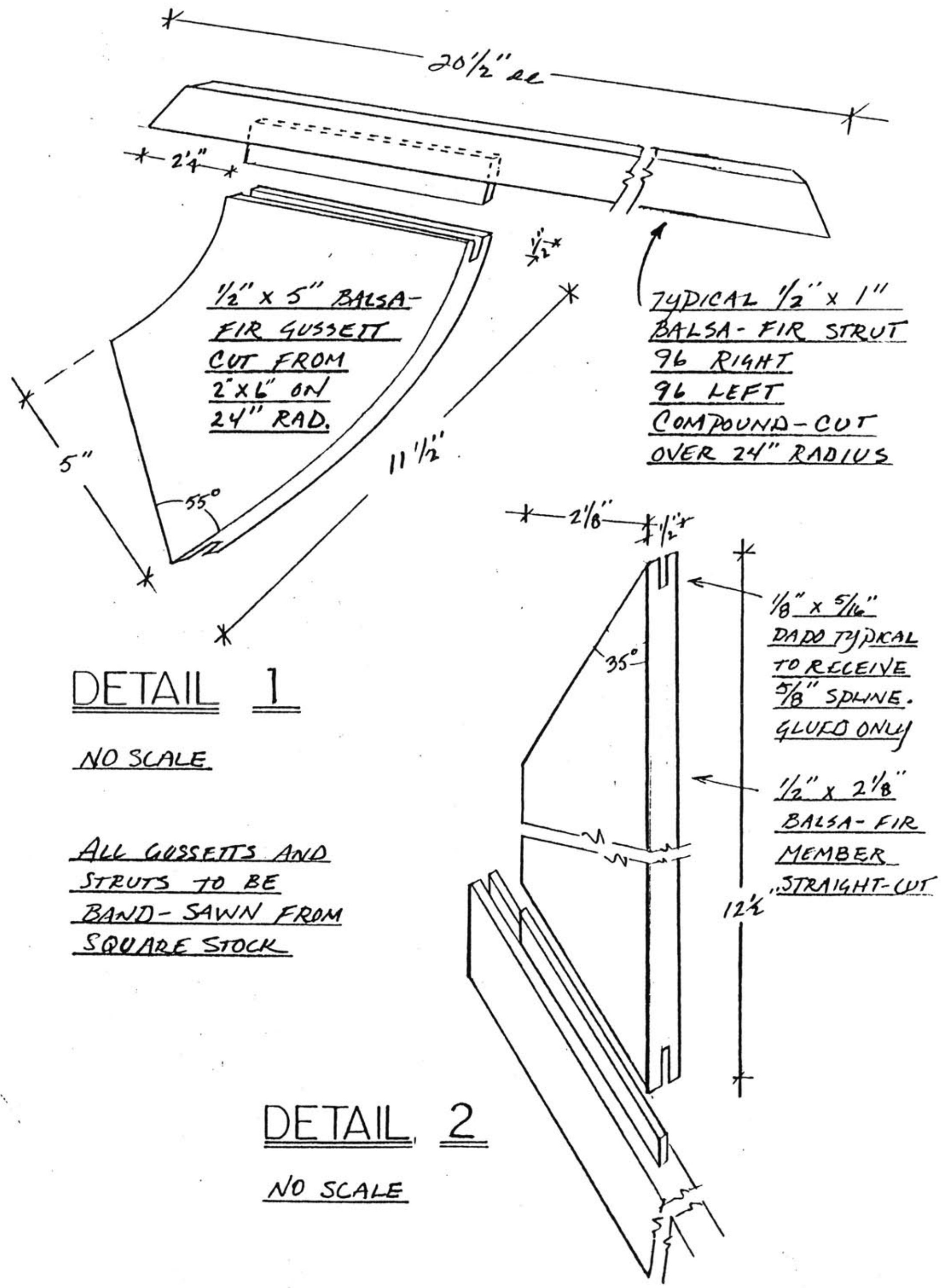
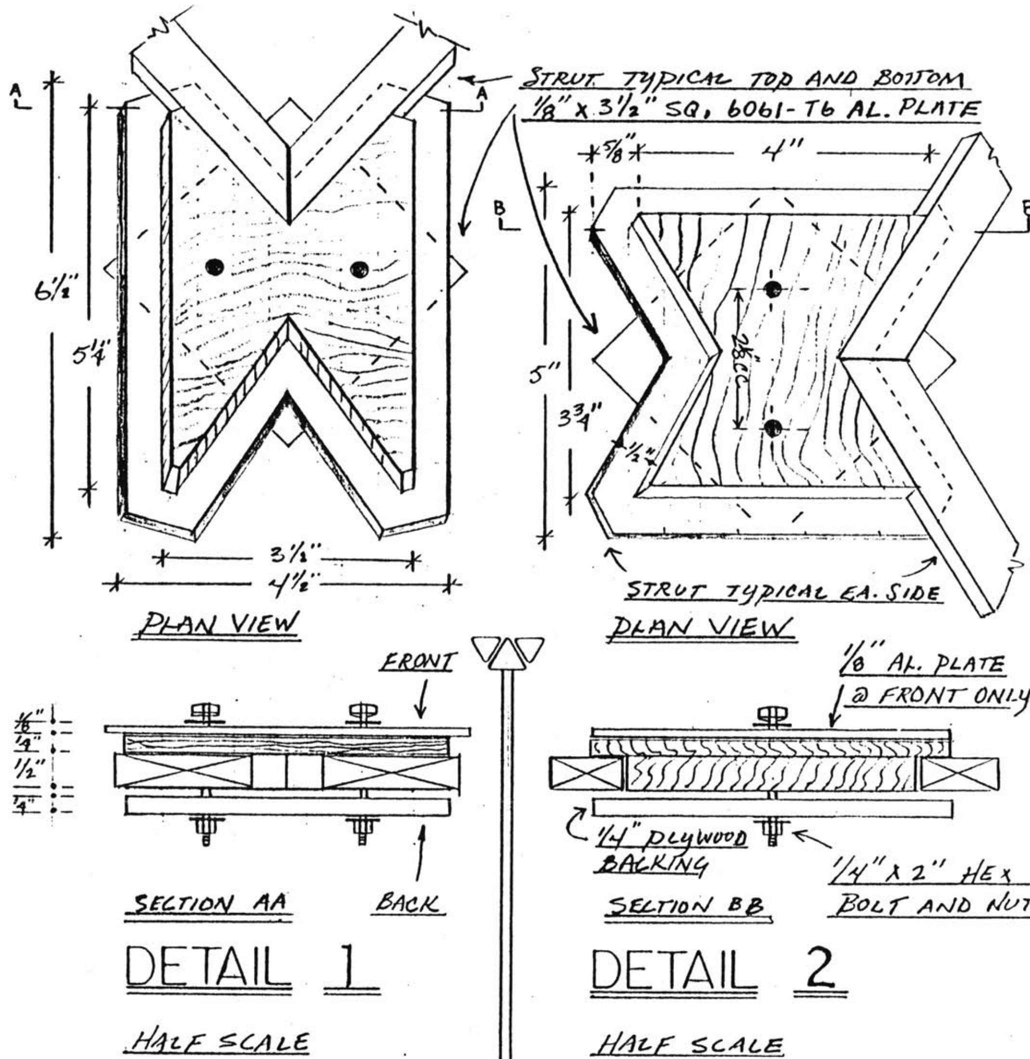


Figure 8-32: Details



NOTE: THIS JOINT PROVED TO BE THE WEAKEST, THE MOST DIS-JOINTING AND SPLINTERING OCCURED FROM OR AROUND THIS JOINT: SPIRE COLLAPSE 8:15 AM MAY 6, 1989

NOTE: THESE TWO JOINTS HAVE NOT BEEN DEVELOPED TO CHARACTERIZE AN IDEAL CONNECTION FOR A DIAGONAL FLOW OF FORCE AROUND THE CYLINDER. WITH THE SAME STRUCTURAL SCHEME IN CON-CRETE I HAVE COME TO A BETTER RESOLVE: SPRING 1988

Figure 8-33: Transition Piece Section

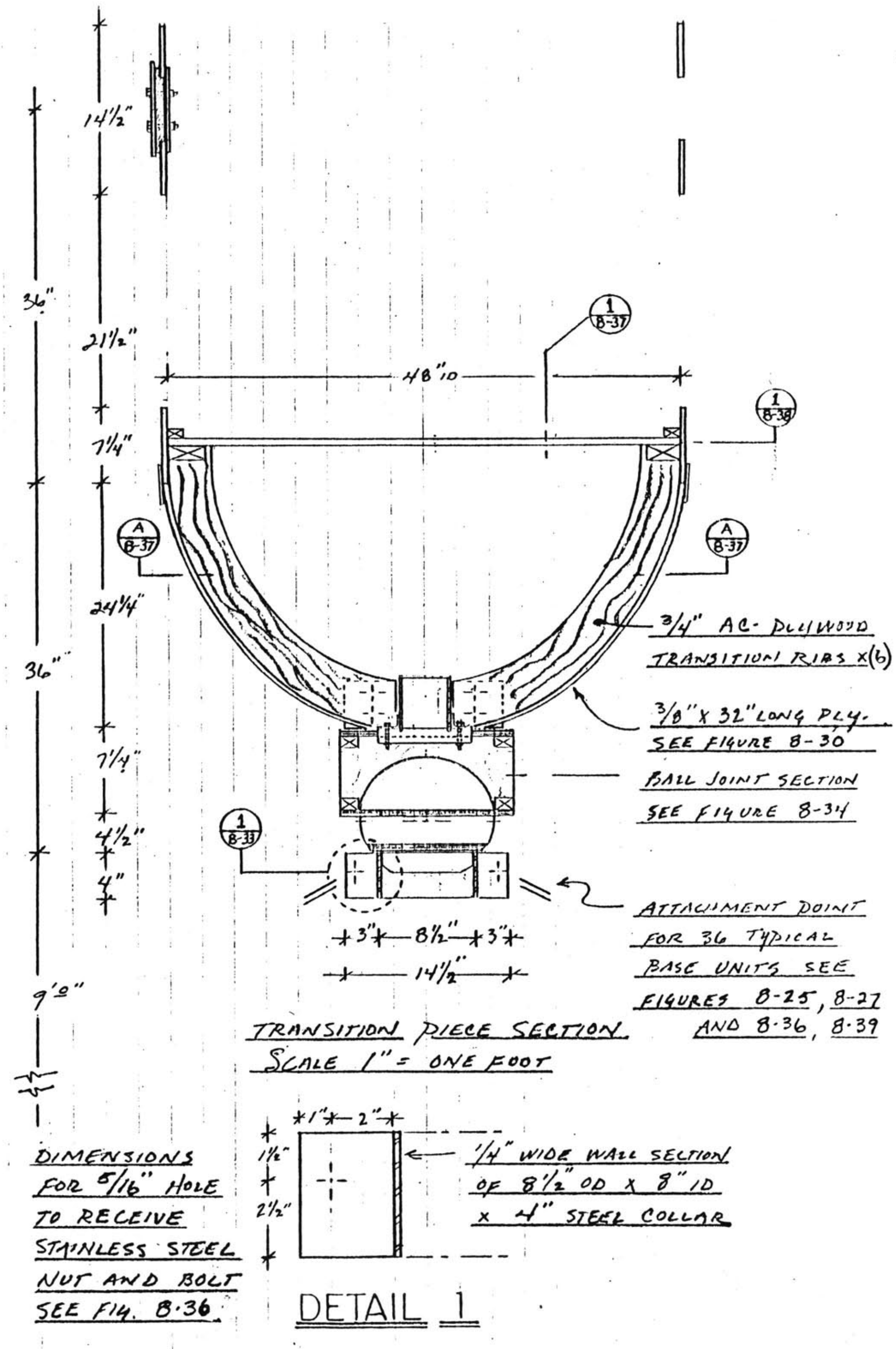


Figure 8-34: Ball Joint

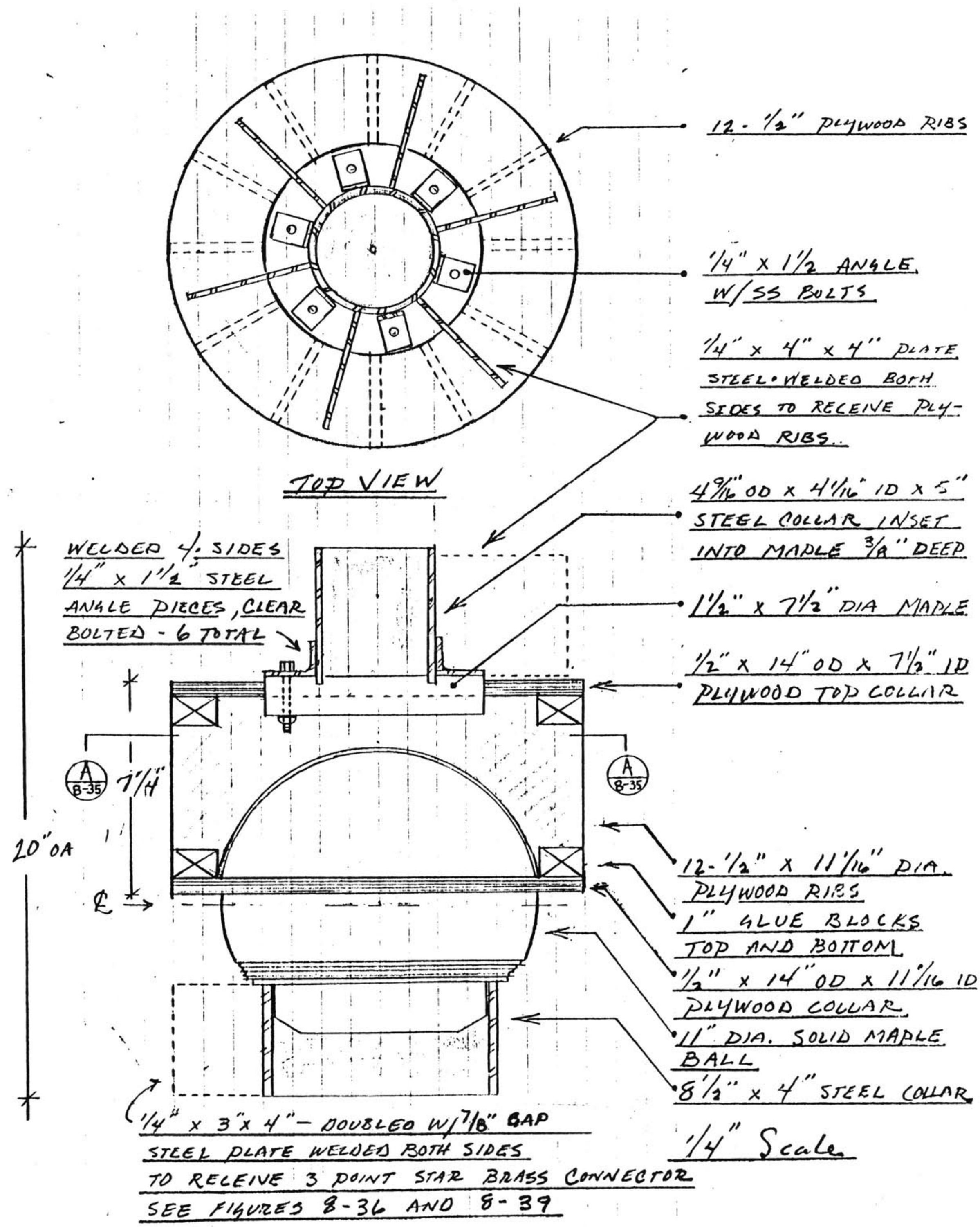


Figure 8-35: Ball Joint Section

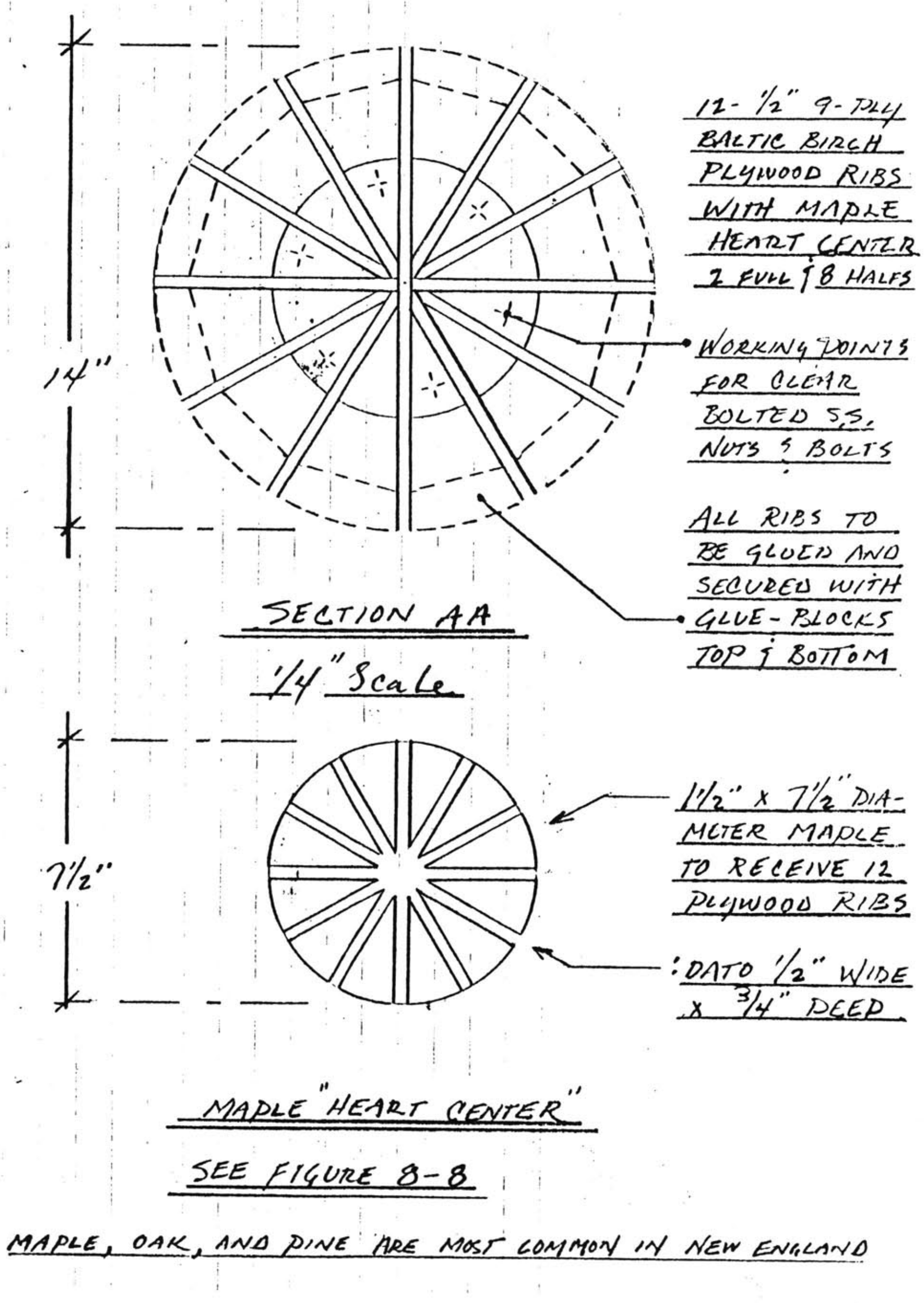


Figure 8-36: Ball Joint Collars

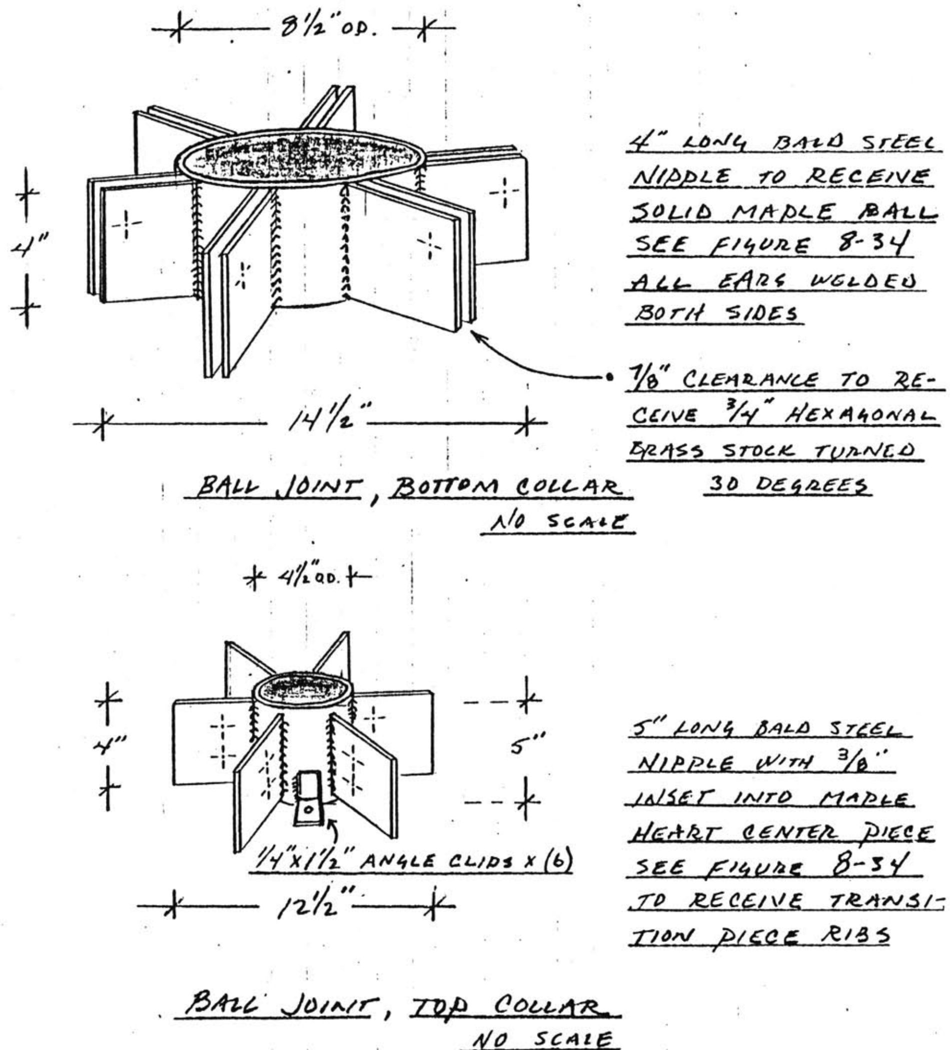
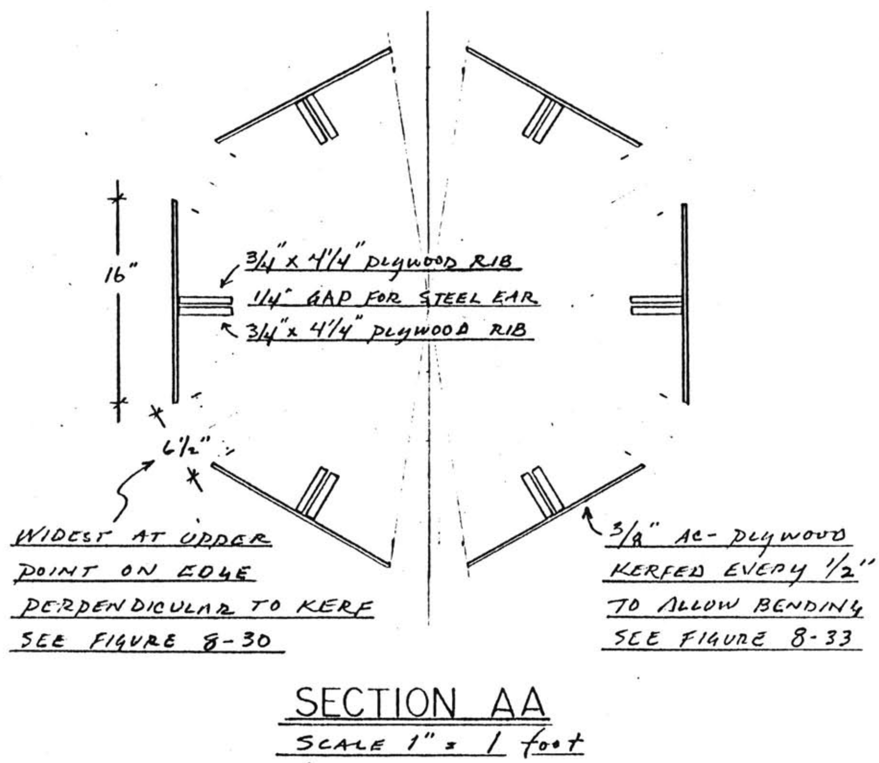


Figure 8-37: Transition Piece Details



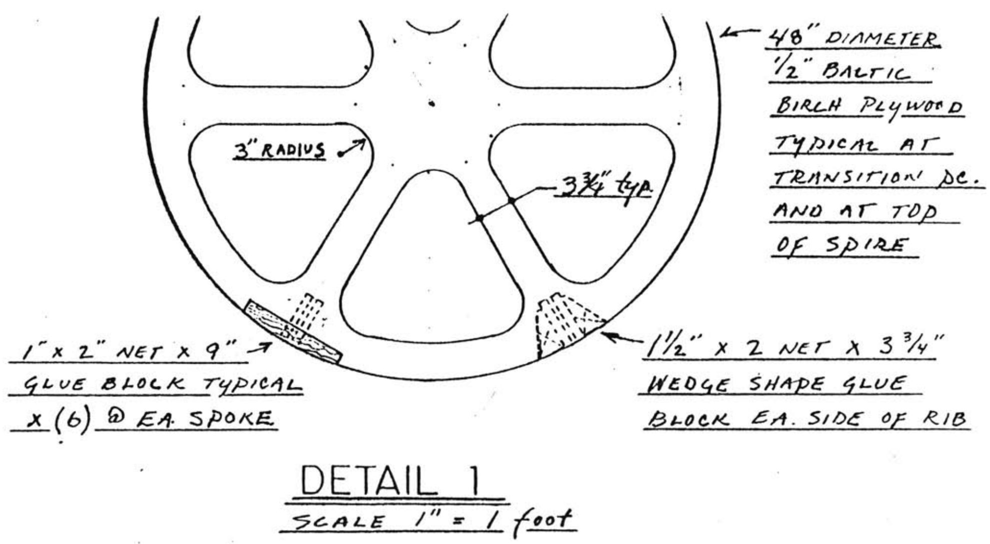
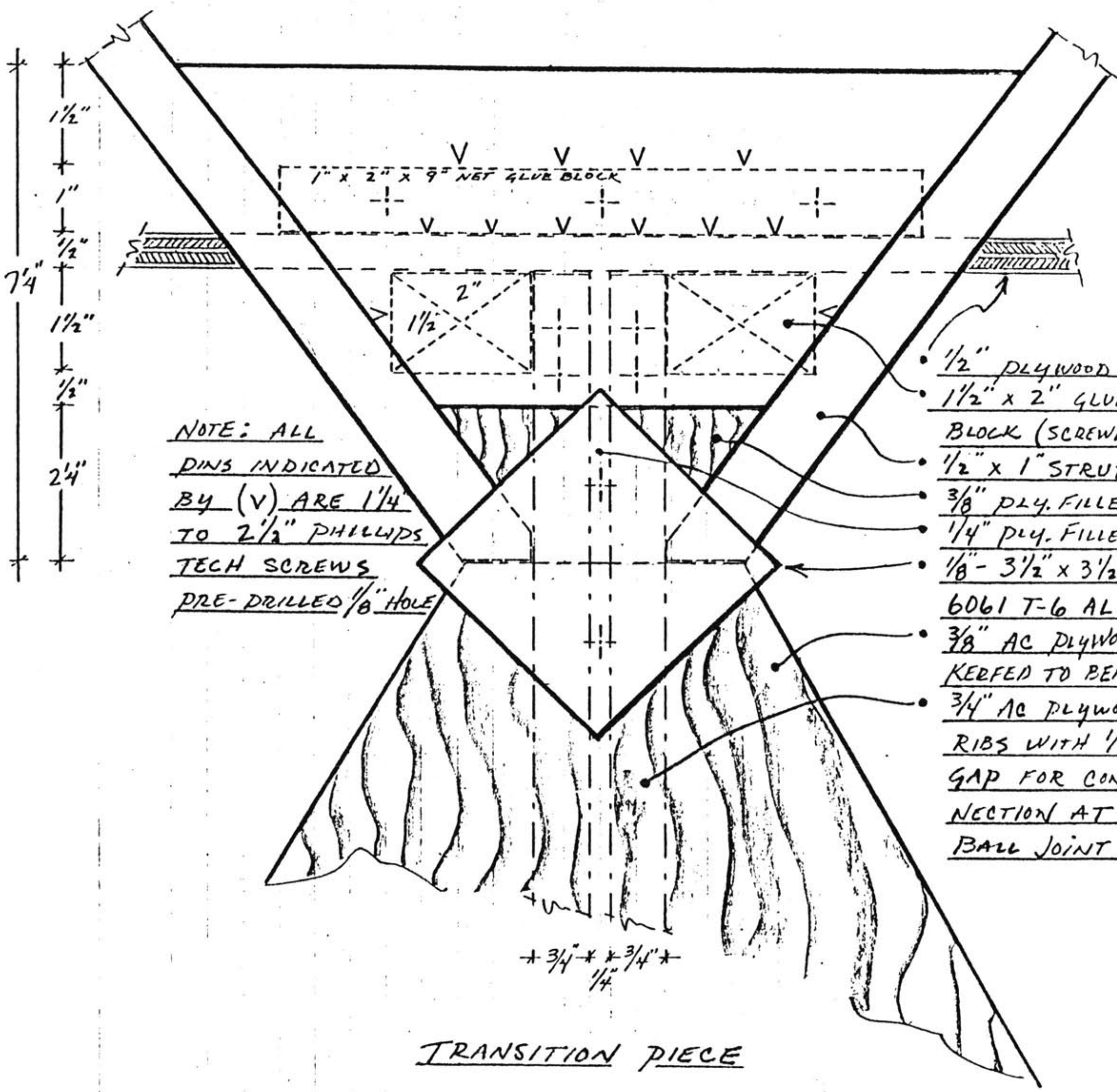


Figure 8-38: Transition Piece Details



TRANSITION PIECE

DETAIL 1

SCALE - HALF.

Figure 8-39: Brass Connectors

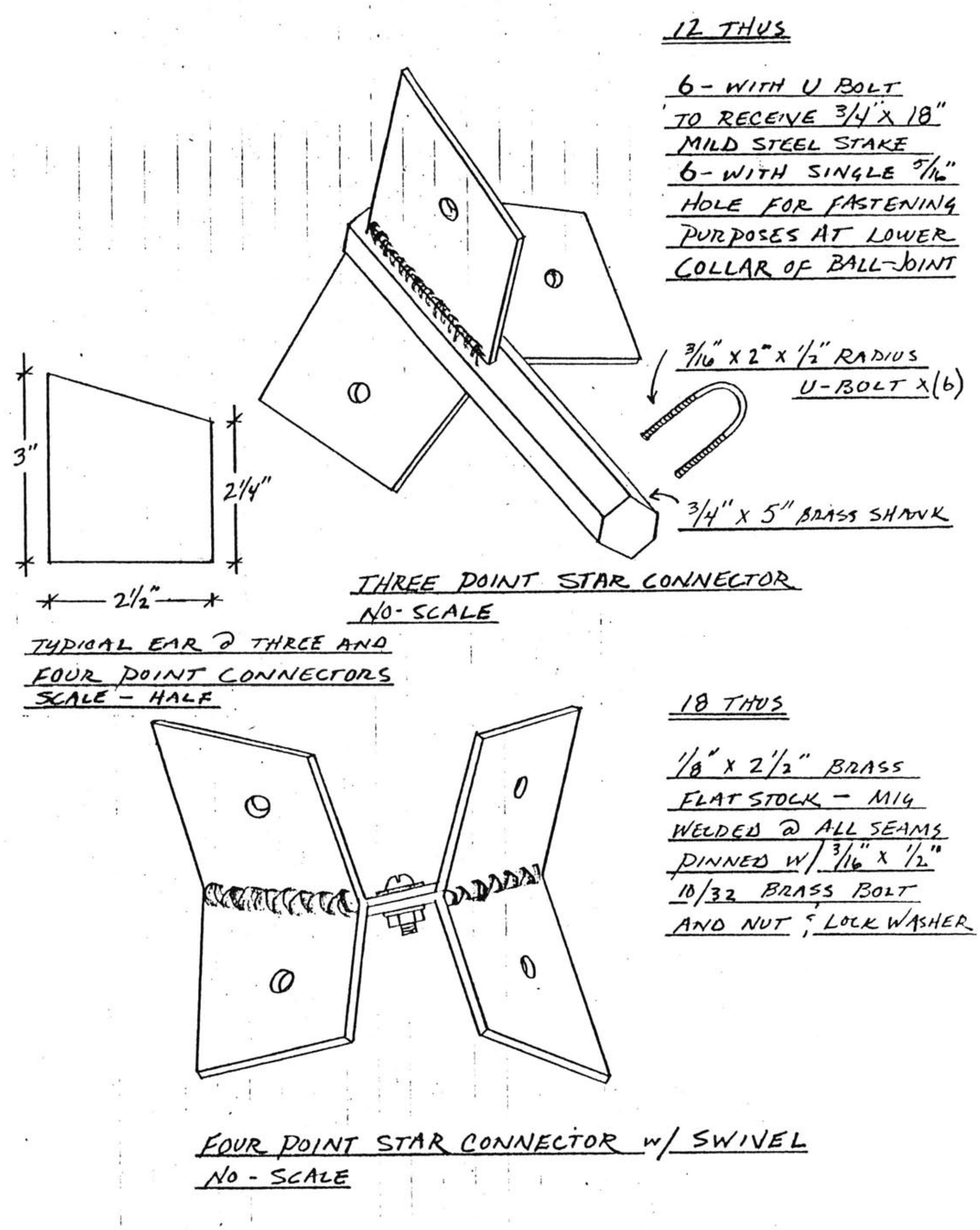


Figure 8-40: "Light Tower" Foundation Plans

Chapter 9

Technical Problems

9.1 General Concerns when building large-scale work within a community

The concept of any work I do imparts immediate notions about the site of the work and the materials to be used. I have tried to overcome any hesitation in the selection of topics or material by learning as much as I can about the basic nature of most standard building materials and the process of working them.

Wood, as a plant, can be treated softly and more meticulously than steel. Clay and wax suggest sweeping motions of the hand, while bronze is permanent before the hand cleans, plugs, and patinas the surface. Like nature and its patterns, all materials can each be worked in some fashions better than they can be in others. In, for example, the process of stone working, technical problems arise on several levels. The choice of a marble with suitable grain is not much different than the choice of a suitably grained wood. Fine detail that demands attention can rarely be achieved without the correct density and grain. Concrete is a liquid searching for a form, and steel demands deliberation in plan, but not while working with it. Moreover, the longevity of the work when exposed to man and natural weather can be ensured by using practices that preclude damage and decay. The casting of the image demands a high level of craft from the artist.

At a scale that is larger-than-life, the construction of a work will require a basic understanding of engineering principles. Knowledge of the mechanics of materials is essential to anyone wanting to gauge the effects of filling a space with larger-than-human scale solid objects. At this scale, the mechanical requirements of the objects become important, because the increase in mass causes a corresponding increase in static forces, as well as altering the effects of any dynamic forces acting on the structure from the outside.

Thus, even a simple building needs a foundation, to overcome the force of wind acting on its structure.

Tension and compression in structural members of an art work are not necessarily recognized by a passive user of the space concerned, yet the work is made secure through various processes that ensure the safety of the general public.

The attention to details when compressive and tensile members come together, are nonetheless an engineering problem. The artist often generates form and scale from his knowledge of what is practical, and from viewing historical examples can arrive at a logical boundary in which to work. I have asked myself an important question: "To what extent is the scale important, and do I have the capacity to arrive at that scale ?" . When working with raw materials, such as wood, stone, and metal, the safety factor applies again on a more personal level; that of the hands and psyche of the artist. The recognition of limitations speaks of economy, and by virtue of this recognition the artist can better focus on the work's statement.

The conceptual process always needs to be clearly identified as a building block upon which the materialization of the idea will rest. "Sculptors" working within the context of "conceptual art" equate the conceptual process with the ultimate work, disregarding the very real issue of manipulation of physical form. The codes and regulations on use of public spaces, i.e. galleries, museums, parks, etc., govern the basic engineering principles by which a work must be constructed and displayed.

Technical problems multiply, as do costs, each time there is an additional mind or set of hands creating the work. The logistics of large-scale environmental work therefore, depends on a mature and well thought out process that ultimately will conclude with a finished product on a specific date. In many cases, an artist will have someone else prefabricate parts of the work. There is nothing wrong with this, in fact most large scale projects could simply not be accomplished without such outside aid. The character of the final work can be specified to the fabricator to an extent that the fabricator can achieve the same likeness that the artist would have himself. When technical problems are shared, the artist gains more time to spend on details and the generation of new work. One of the best experiences an artist can have in learning the technical problems associated with making art, is to work with other artists who are engaged in the same process. Beyond the intellectual provocation and sharing of ideas gained, the art of doing is best learned through the act of doing itself.

The artist must learn his role as liason between the client, the fabricator, the insurance company, the engineer, and ultimately, his students. My experience at M.I.T. while preparing to build my thesis project, *36 Diatom Tower* involved planning and consulting with many groups. My peers at the Center for Advanced Visual Studies, M.I.T., as well as a number of architecture and engineering students, acted as a professional team, observing and criticizing the development of the project from its inception. They offered advice on the content and context of the work, as well as advising on the building process. Other M.I.T. groups involved were as follows.

- Campus Activities Office
- Grounds Office
- Structural Engineering Office
- Safety Office
- Campus Police Department
- Attorneys Office
- Architectural Woodshop
- Mechanical Engineering Laboratory
- Nuclear Science Laboratory
- Nuclear Reactor Laboratory

The combination of wood and metal in my project necessitated a variety of laboratories to work in. The architectural woodshop served as a fully equipped laboratory in which to execute the larger pieces of the base. The logistics of coordinating my work with other students' projects were worked out with the supervisor, Chris Dewart. I had to coordinate my steel welding with a very busy mechanical engineering lab (2.70, a mechanical engineering robotic design class, had final projects due in 1 week). The nuclear reactor laboratory allowed me to use their MIG welder to fabricate my brass connectors.

The thesis project was a tower installation consisting of a 36 foot high tower (with base) on the grass in front of Kresge Auditorium, M.I.T.'s central auditorium and concert hall. The tower was hexagonal in plan, with a two part assembly made up of a base and a spire. Made primarily of wood pieces, it also had brass steel wood and aluminum joinery. The logistics of building and installation are discussed in the following text, Section 9.2.

9.2 Technical Problems and Considerations

Many technical problems can be predicted if a list of concerns about material, material process, and desired effects is made. Such a list might include the following items.

- **Physical and Visual Lightness of Material:** Handling during fabrication and assembly to save labor; Ability to withstand loading; General aesthetic character and joining capabilities. Ineed the spire to be light enough to be handled by 16 people and erected as such, by hand.
- **Physical and Visual Heaviness of Material:** The overall weight of the project; its shipping and handling capability; strength; ability to visually adapt to lighter materials; maximum lengths maneuverable in the woodshop space.
- **The Opening of a Solid:** To sculpt a material or to open its form does not necessarily mean to make it weaker. An all encompassing, cylindrical form can be thought of as a solid, yet in nature the stems of plants are hollow tubes [1] With a modified cylindrical form, research in diagonal loading forces is necessary to determine the forces at various points. An example of such a form is the cylinder with multiple penetrations at its skin, a form used as a spire in my thesis project. Spiralling diagonal ribs make visual these forces in the spire.
- **Quality of the Material's Grain:** Strength of wood under tension for a particular application, depends on the selection of soft or hard wood. A straight grain is generally better than a swirly pattern. The pattern of the grain depends on the part of the log the wood is cut from. For my thesis tower, ash was used at the base, and balsa-fir at the spire. Both the woods used were

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[1]Like, totally tubular, man, y'know?

straight-grained. Grain quality effects the materials properties of many other materials besides wood. Marble and metals both have grains, metal having discrete crystallites, as opposed to marble's continuous grains. The quality of graining will affect the performance of these materials as well.

- **Color of Material:** All material has an intrinsic color that is transformed during the manufacturing process. Industrial colors can be used and protected with the great variety of synthetic sealers available today. Material can be colored by staining or painting. I installed my thesis project without adequate time to seal the wood. I reasoned that the wood and joints would not be critically damaged over a period of one week, even if as many as two rainfalls were expected during that period.

- **Reflectancy Quality:** Materials absorb and reflect light. Any treatment of a material's surface, i.e. stain, paint, sealer, etc., will inccrease or decrease the reflective quality of that material. In the case of *36 Diatom Tower*, the natural wood color worked best for the image intended.

- **Moisture Absorption:** Some projects must meet certain standards of longevity, especially in cases of permanent display. Protection from damage and decay are prescribed in most specifications to or from the artist. The array of wood pieces used in *36 Diatom Tower* will be sealed from moisture at a future time.

- **Acoustical Character:** Any surface will reflect and absorb sound to varying degrees. Industrial charts can supply precise sound absorption data on any standard industrial materials.

- **Choice of Material for Joints:** Different joints within a structure will experience different stresses. These stresses depend on the location of each joint as well as the specific function of the joint within the whole. Materials must be chosen to withstand these directional stresses. The joints in my thesis project did not all work uniformly well. Maple blocks (See figure) were a poor choice in assisting the plywood heart in restraining the ash members. Even though the pieces were pre-drilled, the maple was too brittle. Aluminum at the spire joints (see figure) compressed a wood-joint, 2 part assembly. It proved adequate. Yet another joint , reflecting the character of the space and transfer of forces diagonally, should be developed. The steel collars, one and two (figures) were, without question, the strongest joints in the work. Each part was welded continuously, top, bottom, and sides. Shearing action was prevented by clear bolting with stainless steel bolts and nuts.

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9.3 Formulation of Aesthetic

It helps to have worked with different materials in a variety of projects in the past. Beyond the technical properties of the materials, there are the tactile and kinisthetic values of association, where the human body responds on two levels: metabolically and perceptually. The heading "metabolic" covers the chemistry of thermal, atmospheric, aqueous and nutritive processes; whereas the perceptual takes in vision, hearing, smelling, taste and touch. These are not systematically employed as a science in making choices as to my likes and dislikes, but they are a part of the natural order by which my body responds to matter. I enjoy feeling the material I use, as I enjoy technically manipulating it. Through experience, I can register many impressions of material quality and predict a final image somewhat through projection. Beyond engineering necessities, my personal sensibilities are an intricate part of the aesthetic selection process.

* * * * *

9.4 Site Considerations

The use of equilateral, hexagonal, and tetrahedral units in the making of form (i.e. my thesis project) required a site that reflected an anthropological generation of the same. I was opposed to developing a project that exhibited differences in scale and texture between it and the chosen site. The challenge was to have the piece blend, yet still remain autonomous. It was also important to remain near the Center for Advanced Visual Studies, to maintain optimum control over liability and dialogue about the process. I chose the Kresge Oval, with Eero Saarinan's chapel and auditorium, because of the similarity in expression, which I desired. Saarinen had used the equilateral triangle in plans for the auditorium, as he did for an elaborate landscape design , to connect the auditorium with the chapel. Granite chips, bituminous paving, blue stone, and Belgian block were to be used in an equilateral triangulated pattern with 5 foot wide concrete and brick borders. (See figure 8-6)

I developed a new axis, 12.5^{o} off the line of the infinite corridor, beginning with the entrance to Lobby Seven, and extending on to the center of Kresge Auditorium. By triangulating the plan of Kresge, both parallel to and perpendicular to Amherst Street, I intersected the new axis with the Kresge plan once removed from its present location (See Figure 8-8). I field measured all dimensions to accurately place *36 Diatom Tower* at that precise intersection.

The chapel, measuring 48' in height, and Kresge, measuring 30' in height at the crown of its face, and 50' high at the top of its dome, presented a scale that is not necessarily obtrusive to the human scale. The glass curtain wall of Kresge is transparent and reflective at the same time. The glass wall offers a lightness to the form, which sillhouettes the feeling the arches give at the base of the chapel. The chapel is pure in form and ascends upward into a 30 year old growth of trees. The east side of the chapel is flanked with a brick wall that defines the east side of the Kresge oval court. The elements of structural lightness, natural reflection and light interplay, pure form, and references to base line perception along a developed axis all played important roles in the placement of *36 Diatom Tower*.

* * * * *

9.5 Structural Considerations

The tower would be placed upon the grassy lawn. With no foundation work permitted, I had to resort to pinning each of the six double tetrahedra to the earth (See figure). The 3/4" x 18" mild steel stakes, shown in the figure, were driven through a 1/8" x

2" x 1/2" radius U-Bolt, which was fastened to the three point brass star joint at the perimeter. In order to accomodate wind loading a six point wire rope system was designed for the six interior ground points (See figure).

An upper collar, placed at 34.5 foot elevation and within the eighth and uppermost tier of the spire, performed as a compression ring. It was essential to have a ridged point to attach the six wire ropes. The lower ends of the wire ropes were fastened to the upper knuckle of the base perimeter (elev. 7'4")[See figure].

A ball joint at the spire's base made my objective, to record visual phenomena due to the wind acting on the spire, possible. I observed these wind phenomena only at the final stages of securing the guy wires, at a time when the scaffolding was still in place. Rotation of the spire was limited to 15^{o} by use of a ball joint together with 30" of 5/8" diameter rubber inserted at the end of the 27.5' length of guy line. The spire returned immediately to its former position after rotation, with a time lapse of no more than a second. This phenomenon was observed exactly at the upside down cup resting on the ball. I also observed rotation about the center of the spire. Again, the time was a second at most. there was a full oscillation (360^{o}) about the spire's center. The camber appeared to be approximately 2-3 inches over the developed length of 24.5 feet. At this time winds had been gusting to approximately 20 m.p.h.. I decided to remove the 30" rubber sections and replace them with solid wire rope links with two turn buckles each. I had envisioned placing 6 scales to record foot-pounds at that same connection. Each scale would act similarly to the rubber used previously, and record a precise loading due to wind. I was expecting to observe motion at the base joint and not the rotation about the center of the spire. I should have planned, as suggested by Otto Piene, to insert an additional collar and set of guy wires before dismantelling the scaffold. I had thought about it, but did not do it. Had I been less fatigued and less emotionally drained, I probably would have taken the extra step to prevent what was the demise of this spire; buckling about the middle from winds in excess of 50 m.p.h.. The Logan Airport Weather Service confirmed 52 m.p.h. gusts between the hours of 8 A.M. and 8:30 A.M. on May 6, 1989, only 18 hours after the scaffold was removed.

I find it fascinating that the spire design with its wooden modular components actually moved gracefully and securely in the 20 m.p.h. gusts. Even in the 20-40 m.p.h. range it must have been secure. I will rebuild that spire to the same dimensions with better joints. The ribs were fine. The greatest breakage occured at the glue and spline joint (See figure). I have made provisions to use an aluminum insert to replace the need for gluing. Later designs will include lightweight metal and rubber throughout.

Chapter 10

Conclusion

Artists working with Art and technology fuse the imagery of nature and man from a compelling point lodged deep within the inner and outer environmental dilemma of today. The betterment of life's quality depends upon the mechanization of systems employed with the ultimate concern for our environmental future. Art and technology need each other on the common threshold of discovery, insight, and image making, allowing a delicate balance to exist between the practical and the aesthetic.

Present day technology allows us to further define our notions about the natural world, and thereby ourselves. From the sub-strata upwards to the atmosphere and into the cosmos beyond, we have gained an infinitesimal perspective of our universe. With no beginning and no end, the venture upon which visual nuances are contrived through the development of opposites seems logical. To create new boundaries to work within, one must understand the limitless limitations brought forth through the magnification of optical data and the visibility of the micro world. Shapes, forms, colors, and behavior patterns of natural and man-made phenomena, never seen before, now have a place in the storehouse of knowledge. Most important are the measures of real and projected time that catalogue placement of these elements within the whole.

Through my thesis work I have brought forth images of past and present work by artists, artisans, and scientists. I have given special attention to the tower and its metamorphic communication in the anchoring of human rites and rituals as well as the direct ascendancy of the tower form, in establishing the physical and temporal measure of man.

Gyorgy Kepes brings to mind the new world of vastly expanded dimensions in his writing.

> To make this unfamiliar world ours, to comprehend this enormously elongated scale and to orient ourselves in accord with it, we will need to revaluate many traditional conceptions. As old relationships lose their validity a new configuration will be felt: large and small, opaque, transparent, fixed, changing, surface, shape, form, time, space--all will receive new meanings. By grasping the continuity of the scale and the correspondence of forms and patterns of greatly different sizes, we become aware that certain underlying laws operate at different levels--and so be able to bring the hitherto isolated experiences of the world into a common focus. [Kepes 56]

In gauging the success of *36 Diatom Tower* with respect to the written thesis "Tower as Communication" I find myself indebted to those people who assisted in making the work, and also those people who took time to ask about the work during its assembly and display. I give special thanks to John Bristo.

Dialogue with interested people helped me to formulate the concept of the tower better, as part of the process. I cannot personally prove the work useful or not, but must depend on the group's interaction and their ultimate response. In general, the interest level was high among the M.I.T. offices contacted for permission and the Kresge Oval users. People from the Biology, Mechanical and Structural Engineering, Architecture, Nuclear Physics, and Aero/Astro Departments were there observing, helping, and appreciative. One Chinese man said, in the aftermath of the spire being destroyed by the wind, "I think of the rose, it grows, it opens, it is a rose, and then it goes away."

The work that I and others have invested in this thesis is intended to be a building block for my future work in the context of "Art and the Environment". I will continue to develop tower images along with their neccessary components. I intend to eventually display and finally implement these tower forms in the forseeable context of a "greater human use". The two notions that have been most important to me in the creation and documentation of these towers have been "structural expressionism" and "light".

Photo Credits

Michael Bauer: Figures 8-15, 8-17, 8-18, 8-19, 8-20, 8-21, 8-22, 8-23

Anastasias Petropolis: Figures 8-14, 8-16

Al Sanders: Figures 8-3, 8-4, 8-13

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- Fall 1987 - Design of the International Space University Facilities and the Lunar Base on the South Pole of the moon.
- Fall 1988 - Design of a Mars Colony

References

[Alexenberg 88] Alexenberg, Mel and Piene, Otto.
Lights Orot.
CAVS-MIT, Cambridge, 1988.

[Arnheim 67] Arnheim, Rudolf.
Toward a Psychology of Art.
University of California Press, Berkely, 1967.

[Atil 75] Atil, Esin.
Art of the Arab World.
Smithsonian Insititution, Washington D.C., 1975.

[Blaine 86] Blaine, John.
Sky Art Alaska.
Visual Arts Center of Alaska, Anchorage, Alaska, 1986.

[Bronowski 72] Bronowski, Hienz and Meissner, Gunter.
Towers and Turrets of Europe.
Edition Leipzig, East Germany, 1972.

[Fletcher 75] Fletcher, Sir Banister.
A History of Architecture.
Charles Scribner's Sons, New York, 1975.

[Fuller,Crit 81] Fuller, R. Buckminster.
Critical Path.
St. Martins Press, New York, 1981.

[Fuller,Syn. 75] Fuller, R. Buckminster.
Synergetics.
Macmillan Publishing Co., New York, 1975.

[Gardner 75] Gardner, Louise.
Art Through the Ages.
Harcourt Brace Jovanovich, Inc., 1975.

[Giedion 65] Giedion, Sigfried.
Space, Time, Architecture.
Harvard University Press, Cambridge, 1965.

[Goldring 87] Goldring, Elizabeth.
Desert Sun/ Desert Moon.
Leonardo 20(4), 1987.

[Gombrich 69] Gombrich, E.H.
Art and Illusion.
Princeton University Press, Princeton, 1969.

[Gropius 65] Gropius, Walter.
The New Architecture and the Bauhaus.
M.I.T. Press, Cambridge, Massachusetts, 1965.

[Hayden 77] Hayden, Dolores.
Skyscraper Seduction, Skyscraper Rape.
Heresies , May, 1977.

[Hayes 78] Hayes, John R.
The Genius of Arab Civilization.
M.I.T. Press, Cambridge, 1978.

[Heidegger 77] Heidegger, Martin.
The Question Concerning Technology.
Harper & Row, New York, 1977.

[Hirshorn 79] Hirshorn, Paul and Izenour, Steven.
White Towers.
M.I.T. Press, Cambridge, 1979.

[Jung 58] Jung, C.G.
Psyche and Symbol.
Doubleday and Co., Inc., Garden City, New York, 1958.

[Kepes 56] Kepes, Gyorgy.
The New Landscape.
Paul Theobald & Co., Chicago, 1956.

[Levi-Strauss 62] Levi-Strauss, Claude.
The Savage Mind.
University of Chicago Press, Chicago, 1962.

[Milner 53] Milner, John.
Tatlin and the Russian Avant-Garde.
Yale University Press, New Haven, Connecticut, 1953.

[Moholy 67] Moholy, Nagy .
Paintings, Photographs, and Film.
M.I.T. Press, Cambridge, 1967.

[Moon 36] Moon, Parry.
Scientific Basis of Illuminating Engineering.
McGraw-Hill, 1936.

[Otto 69] Otto, Frei.
Tensile Structures.
M.I.T. Press, Cambridge, 1969.

[Piene,CAVS 88] Piene.
Otto Piene Und Das CAVS.
CAVS-MIT, Cambridge, Massachusetts, 1988.

[Piene,Sky 73] Piene, Otto.
More Sky.
M.I.T. Press, Cambridge, 1973.

[Porter 38] Porter, C.W.
The Carbon Compounds.
Ginn & Co., 1938.

[Stein 71] Stein, Donna M.
Thomas Wilfred : Lumia.
Corcoran Gallery of Art, Washington D.C., 1971.

[Steiner 75] Steiner, George.
After Babel.
Oxford University Press, London, 1975.

[Taillanier 78] Taillanier, Y.
Rodin.
Crown Publishers, Inc., New York, 1978.

[Tompkins 81] Tompkins, Peter.
The Magic of Obelisks.
Harper & Row, 1981.

[Van Leeuwen 86] Van Leeuwen, Thomas A.P.
The Skyward Trend of Thought.
M.I.T. Press, Cambridge, Massachusetts, 1986.