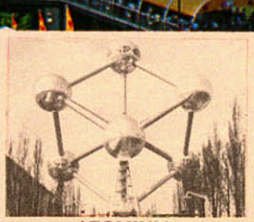
The Sunsphere...

and other famous structures of past world's fairs

CRYSTAL PALACE

EIFFEL TOWER

FERRIS WHEEL



ATOMIUM

SPACE NEEDLE

The Sunsphere...

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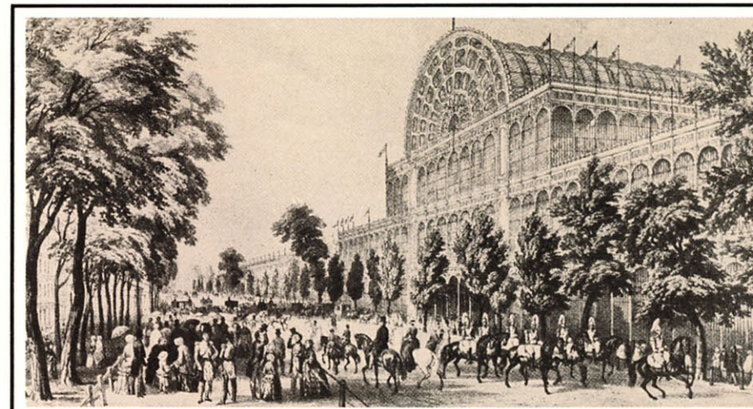
First printing, May 1, 1982

Famous Exhibition Structures

The Crystal Palace was the first one, the first of a handful of exhibition structures that were so amazingly beautiful or innovative that they lived in the imaginations of all who saw them long after the memories of exhibits and entertainments and experiences had faded into a blurred impression of the marvel that was the Fair that year.

The Crystal Palace was a dazzling glory of glass built to house the first world's fair, The Great Exhibition of the Works of Industry of All Nations, held in London in 1851. It was an architectural triumph. Its clean lines and gorgeous utilitarianism captured the imagination of the fussy Victorians as did no other element of The Great Exhibition. In an age when sofas and cook-stoves and clothing alike were as elaborately embellished as possible, the Crystal Palace was a revelation. It derived its functional, symmetrical simplicity from nature. It owed its existence to one extra-ordinary man, Joseph Paxton.



South transept of the Crystal Palace, from Kensington Drive
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1851

The Crystal Palace, built for the 1851 Great Exhibition in London

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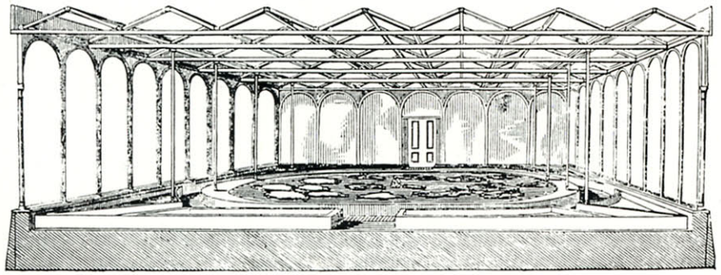
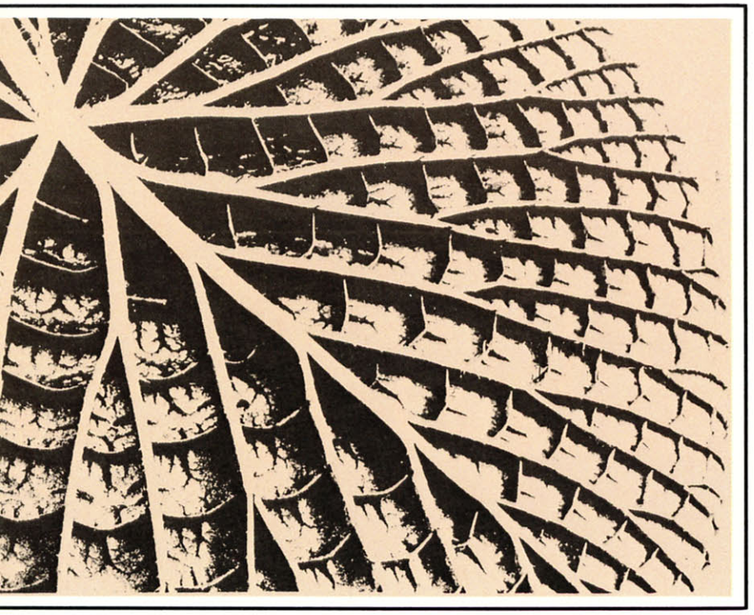


Cross-section of Paxton's lily house at Chatsworth

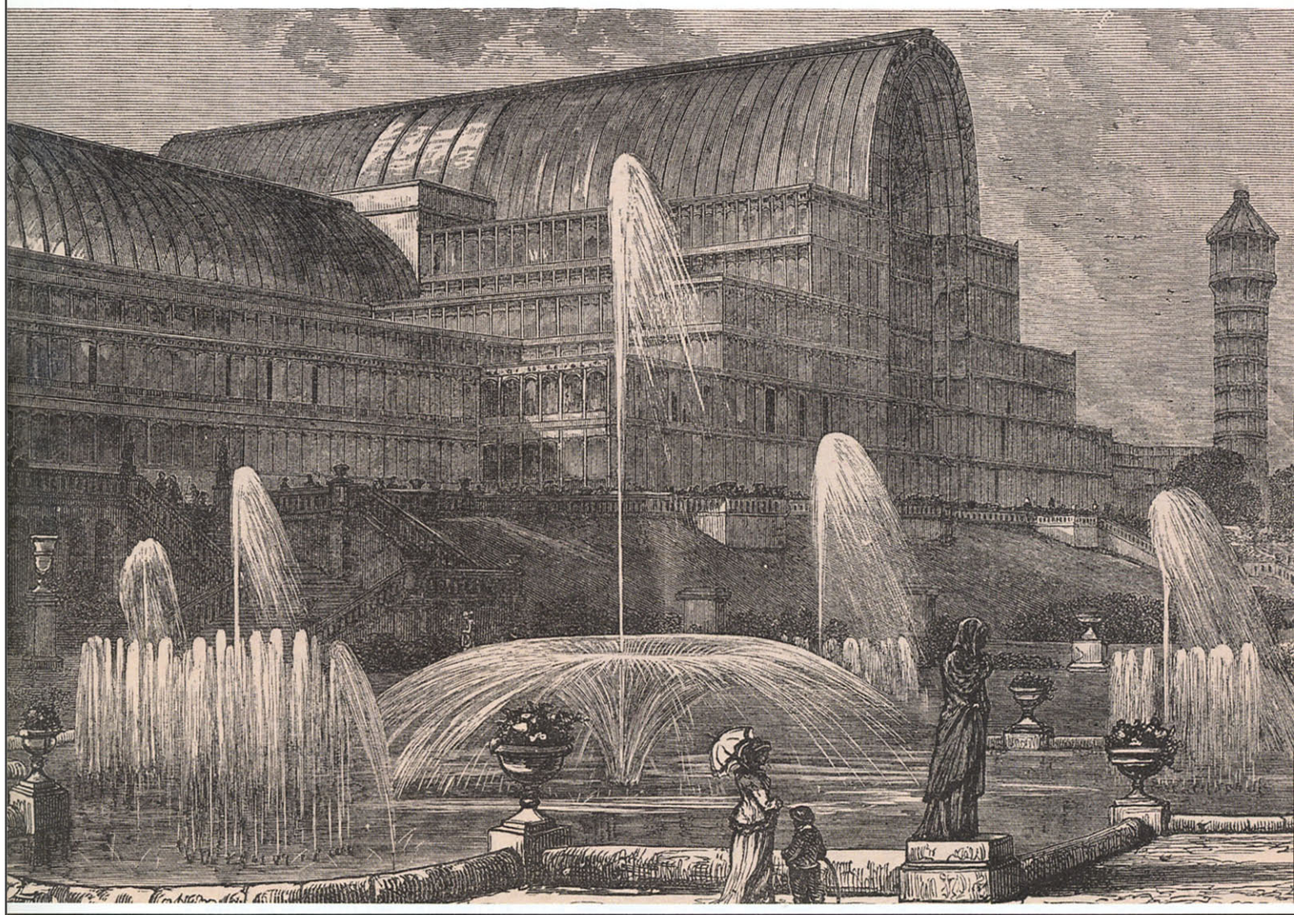


Underside of the Victoria regia water lily, showing rib system

Paxton, the seventh son of a poor schoolmaster, had risen to become a sort of combined executive gardener and close friend to the Duke of Devonshire. Shortly before the conception of The Great Exhibition, he had designed and constructed for the Duke's estate a 300-foot glass conservatory to house an unusual water lily, the *Victoria regia,* a cultivated variety of a giant Amazonian water lily first brought to England in the mid-1800's. The huge round leaves of the lily reach widths of up to six feet and, though thin themselves, are capable of supporting many times their own weight because of a radiating trusswork on their undersides of strong ribs held taut by light crossribs. The ribs and their arrangement gave Paxton the idea for the supporting structure of the glass lily house he erected at Chatsworth and, later, for the graceful network of trussed girders and arches supporting the glass roof of the Crystal Palace.

In 1850 the sponsoring organization for the Exhibition, the London Society of Arts, formed a building committee to select plans for a structure to house the Exhibition. Two hundred and thirty-three plans were submitted, but none were accepted. The committee members instead came up with their own design, a sprawling brick edifice topped by a vast,

The Crystal Palace from the south



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bulbous dome sheathed in sheet metal. When the plans were published in the Illustrated London News, they caused an outcry. Londoners objected angrily to the erection of what was certain to become, given the materials to be used, a permanent blot on the lovely landscape of Hyde Park, the site for the Exhibition. There was doubt as to whether the enormous solid structure could even be completed in time for the opening, less than a year away. The Society's commissioners were in a predicament.

Paxton decided to submit his own plans for the exhibition hall. During a couple of busy weeks Paxton expanded his idea from a sketch he had scribbled on a scrap of blotting paper into a full set of drawings incorporating structural ideas he had tested in smaller buildings at Chatsworth. In late

June, he presented to the Society his plans for a long, airy, clean-lined hall with a triple-tiered flat roof, the whole to be constructed of clear glass supported by an intricate network of light iron trusses.

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Interior of the Crystal Palace, looking north under the central transept

The harassed commissioners were indecisive. Paxton, characteristically impatient, took matters into his own hands and published his plans in the same London newspaper which had just published the unpopular official plans.

Public reaction was immediate and overwhelmingly favorable to Paxton's plans. Londoners felt Paxton's building would be more beautiful than the committee's brick 'monstrosity' and were gratified that it would be temporary. The commissioners bowed to public demand and adopted Paxton's plans, after asking him to modify his design to accomodate the Hyde Park elm trees, much beloved by Londoners. A central barrel transept was added to the plans to roof the trees, financing was arranged, contractors were contacted and construction began.

In late September, 1850 the first column was erected for the great glass building, christened by then the 'Crystal Palace' by Punch magazine. Many followed the construction with misgivings. Some prophesied that such a huge building of glass and iron could never be made stable, that the whole structure would collapse in the first gale. Others said the heat of the sun on the glass would be so great that humans inside would be roasted to death. Nevertheless, the construction continued apace and the delicate structure rose with an almost miraculous speed. It was 1851 feet long (to commemorate the year), 456 feet wide, 66 feet high and it covered an amazing 18 acres. It employed 3,300 prefabricated tubular iron columns and iron girders, 300,000 panes of glass (the largest glass panes yet manufactured), 200 miles of sash bars and 34 miles of special Paxton guttering, designed to solve the potentially major problem of condensation under the expansive glass roof. Most of the iron and glass and wood components of the structure were manufactured to dimensions standard throughout the structure by specially constructed machines. The construction itself was carried out using mass production techniques unusual for the era. The Palace went together like a well-designed puzzle. Within a short 17 weeks after construction began, the Crystal Palace was completed and turned over to the Exhibition commissioners.

It was soon filled with more than 13,000 exhibits, exotic as well as domestic, since The Great Exhibition was the first *international* exhibition. Queen Victoria and Prince Albert, who had supported the Exhibition from the beginning, opened it on May 1, 1851. At the last moment the doomsayers prevailed, at least in a small way. The guns announcing Victoria's arrival in the park were not fired for fear the concussion would shiver the Palace's glass roof and cut to bits the assembly of aristocrats as they sat in their box seats. The guns were silent, but the Exhibition began with a bang. During the next six months, more than six million people trooped through the Crystal Palace to wonder at the products of art and science and whimsy displayed there.

The success and popularity of The Great Exhibition are legendary, and the chief feature of the legend is the Crystal Palace itself. As an exhibition hall, it was admirably suited for display of the innumerable items exhibited. It was itself beautiful to see and pleasant to stroll through. William Makepeace Thackeray called it 'a blazing arch of lucid glass' and other writers celebrated it in prose and poetry.

When The Great Exhibition closed in the autumn of 1851, Paxton's creation in glass and iron was dismantled and re-erected, with some modifications, on a new site in the English countryside near Sydenham, where it served as a cultural center until it was destroyed by fire in 1936.

The Crystal Palace is no more, but its legacy has never died. In the years following The Great Exhibition, ambitious international expositions became almost yearly events. There were world's fairs in Ireland, the United States, Germany, Peru, England, Australia, Belgium, Scotland and France. The French exhibitions were especially well done. There had been several Parisian expositions following the first Exposition Universalle in 1855, but the 1889 Exposition Universalle Internationale is the one the world remembers. That was the

1889

The Bettmann Archive

The Eiffel Tower, on the Parisian exposition grounds where it was built in 1889

exposition that gave Alexandre Gustave Eiffel the opportunity to build his famous Tower.

The official reason for holding the 1889 French Exposition was the centenary of the French Revolution, but, as with other expositions, the theme was lost in the hubbub of staging the grand event and the excitement of experiencing it. The exposition was held on the by then traditional Champs de Mars site in central Paris, first used for the first French national exhibition nearly a century beforehand and the site of all Parisian exhibitions since. Two specially commissioned structures were to dominate the site, the Palais des Machines and the Eiffel Tower. The Palais des Machines served as the exhibition hall. It was nearly as beautiful and, with its springing arches spanning a vault of 375 feet with no intermediary support, as architecturally innovative as the Crystal Palace. Unfortunately, it was torn down in 1910.

The Eiffel Tower has fared better. Over the years it has become the international symbol of the City of Paris and the world's most familiar exhibition structure. When Eiffel proposed it in 1885 as a suitable symbol for the exposition, however, Parisians hated it with a passion that was truly French. It immediately became the center of an incredible controversy which lasted until several years after it was completed. The most powerful and angry of the tower opponents were the writers and artists of Paris, who submitted to the director general of the Exhibition a petition to 'express our deep indignation that there should stand in the heart of our Capital this unnecessary and monstrous Tour Eiffel.' The proposed tower was viewed as an ugly metal horror which would ruin the staid beauty of central Paris. Others called it 'impossible' to build. No structure approaching the height of the Eiffel Tower had ever been attempted in iron and structural steel was not yet available. Eiffel, an energetic

The Eiffel Tower and the 1889 exposition under construction in 1888

The base of the Eiffel Tower during the 1889 Exposition Universalle Internationale

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engineer who, with a staff of 40 assistants, had spent two years designing the tower and had mortgaged his company to raise four-fifths of the estimated $1,000,000 cost of building it, was unperturbed. 'When it's finished they will love it,' he said.

Eiffel drew on his bridge-building experience to build his gravity-defying iron tower, which was begun in January of 1887. In its building, Eiffel used 15,000 wrought iron sections precisely constructed to his specifications and fastened them into a metal latticework with more than 2,500,000 rivets. The four uprights swoop to a height of 984 feet from the corners of the tower's square base (which covers an area of two and a half acres). Eiffel anchored the uprights firmly in stone masonry foundations which anticipated the modern use of reinforced concrete foundations. Eiffel showed surprising insight in solving his construction problems. By prefabricating the tower parts, he could use a relatively small crew of 250 unskilled men at the site. He also designed his own winches and rigging to haul the prefabricated iron parts up the rising tower and devised a scaffolding system to overcome the problem of vertigo among workmen unused to working at such heights.

When the tower was completed early in 1889 reaction to this new addition to the Paris skyline was varied. Some said it was beautiful, some thought it 'ridiculous.' Eiffel himself said, 'Now the French flag is the only one to have a 984-foot pole.'

The tower turned out to be a gold mine for Eiffel. The exuberant engineer had contracted with the City of Paris for all revenues from admissions to the tower for the next 20 years in order to liquidate his investment. Enough of the Exposition's more than 32 million visitors paid to ride American-made Otis elevators to view the entire spectacle of the Exposition from several levels of the tower to make Eiffel a wealthy man even before the Exposition ended.

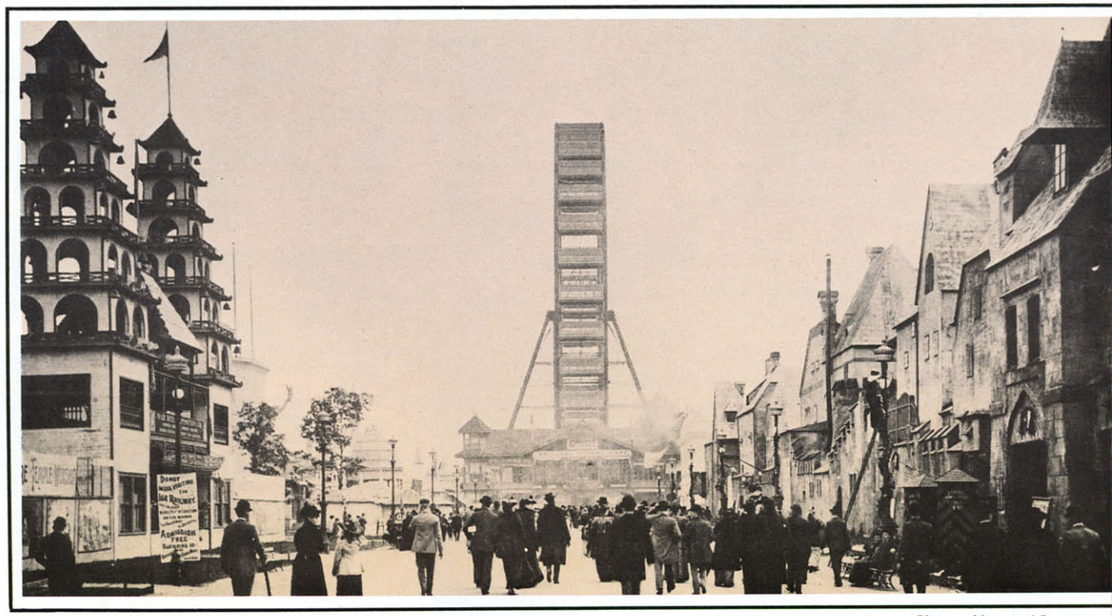
The Eiffel Tower was to remain the world's highest man-made structure for 40 years. It was eventually dwarfed by the skyscrapers that Eiffel had helped to make possible by his pioneering work.

Unlike the Crystal Palace, the Eiffel Tower still stands where it was constructed during the waning years of the last century. Since then it has been a focal point for other Parisian expositions as well as the emblem of the city. And the 'impossible tower' has changed with the times. It now contains restaurants and a weather station and is topped by a television mast.

1893

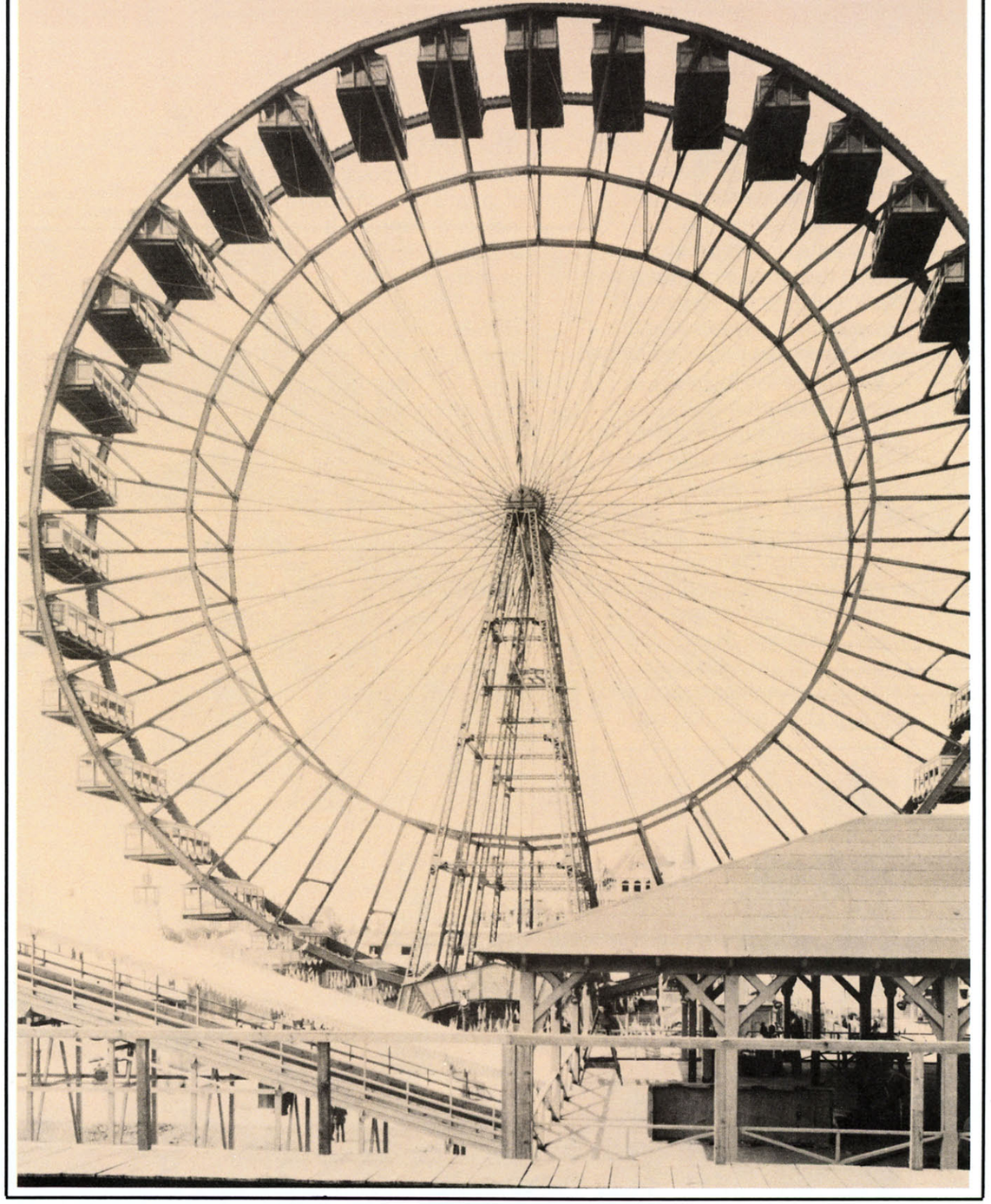
The 1893 Chicago World's Columbian Exposition was the last great extravaganza of the nineteenth century. It was named the Columbian Exposition to commemorate the four-hundredth anniversary of Columbus's discovery of America, but it was called 'The White City' after the city of temporary white plaster buildings constructed around the seven miles of lakeside, lagoons and canals of the Exposition site in Jackson Park.

The Columbian Exposition was one of the most successful expositions ever. More than 21 million people came to Chicago in 1893 looking for a rousing good time. They found it. They were mostly innocents from the farms and villages of the



View of the midway of the 1893 Chicago World's Columbian Exposition, with the Ferris Wheel in the background

Chicago Historical Society



Chicago Historical Society

The Ferris Wheel, showing the size of the roomlike cars

surrounding prairies who were easy to dazzle. They rolled along in wheeled chairs when their feet gave out, gaped at reconstructed villages from China, Alaska, Germany, Turkey, Persia and more than a dozen other countries, were shocked by the 'authentic' Egyptian *danse du ventre* (belly dance, as it was translated) of the infamous Little Egypt and fearlessly queued up to ride George Ferris' Great Wheel, the star of the Columbian Exposition's 'Midway Plaisance.'

Before the fair opened, the organizers had tried to come up with an idea for an attraction that would do for the Chicago exposition what the Eiffel Tower had done for the Paris exposition a few years earlier. A tower was rejected as having already been done. At one of their meetings a young Pittsburgh engineer, George Washington Gale Ferris, sketched a huge wheel on a piece of paper and presented his idea to the committee. At first they objected to Ferris' wheel as 'undignified.' Then they voted to try it. It was a decision they did not regret.

The Bettmann Archive

Visitors on the 'Midway Plaisance" of the exposition, with the Ferris Wheel in the background

Chicago Historical Society

Close-up view of the Ferris Wheel

Ferris, like Eiffel, was a bridge-builder. He had envisioned his wheel years beforehand, but it was not until the Exposition organizers granted him a concession that he had the chance to build it. The giant wheel was never to be equalled in size. It was 250 feet in diameter, 825 feet in circumference and 30 feet wide. Around the parallel rims of the giant wheel were suspended 36 cars, each larger than a Pullman coach and capable of holding 60 people. At capacity the Great Wheel carried 2,160 people. It rotated on an axle 45 feet long and nearly a yard in diameter. The axle, made by the German Krupp steelworks, was, at that time, the largest single piece of steel ever forged. Two skeletal steel towers supported the Wheel. Engineers claimed the towers were so strong that the Wheel could easily withstand 100 mile per hour winds. A 2,000 horse-power engine rotated the Wheel at a speed of one revolution every ten minutes.

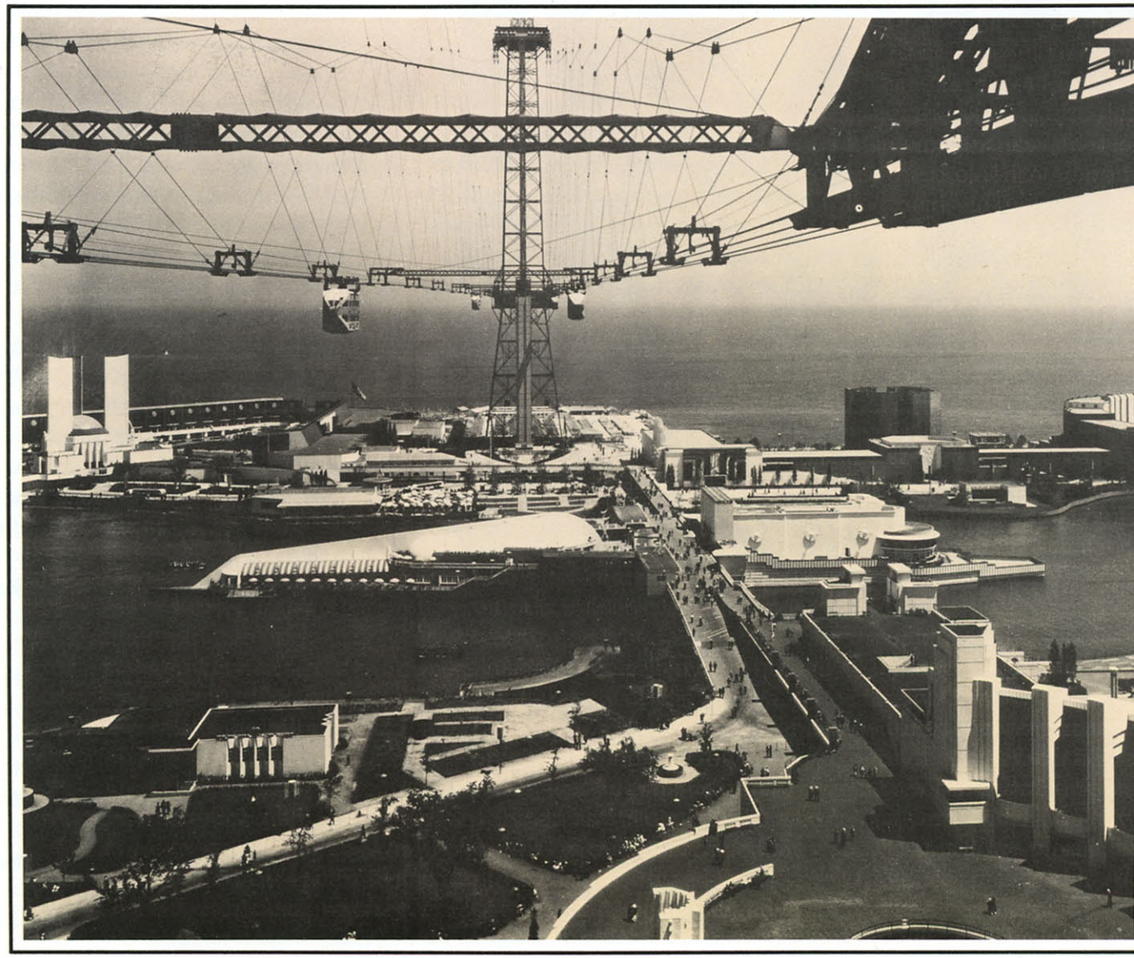
On the day the gigantic toy was put in operation, crowds gathered to watch it turn but were too afraid to ride it until Ferris' wife volunteered to board the monster. A newspaper account reported, 'She showed no fear!' The crowds soon followed her brave example, paying 50 cents a head for a ride of two revolutions. Ferris, a canny merchandiser, published a pamphlet with photos of the spectacular views seen by riders on the Wheel. Like Eiffel, he had used his own money to construct his masterpiece and the revenues from admissions were his. He became a rich man from the success of his Great Wheel and his name lives on in that of the one ride found at every American carnival to this day– the ferris wheel.

1933

Others followed these three. Other beautiful, fantastically-shaped buildings, other towers and one other imaginative ride.

The ride was the Sky Ride of the Chicago Century of Progress exposition in 1933-34. Like the 1893 Chicago fair, this one had a nickname, the 'Rainbow City,' so called because of the brilliant colors of the neon, helium and krypton gas tube

Chicago Historical Society



View east from the west tower of the Sky Ride of the 1933 Chicago Century of Progress exposition

lighting that transformed the fairgrounds into a fairytale city every day at dusk. The fair site stretched for three miles along the shoreline of Lake Michigan and covered an island in the lake which had been built especially for the fair. The theme of the fair was 'Science' and, though neither they nor anyone else knew much about rockets in the early 30's, the fair architects felt a rocket ride would be an appropriate way to both express the fair's theme and attract visitors. They called it the 'Sky Ride.'

The Sky Ride consisted of a pair of 600-foot towers, one on the shore of the lake, one on the island, connected by a tramway. Fairgoers could ride to the observation platforms at the top of each tower on a conventional elevator and board a 'rocket' for a ride over the water to the other tower. The towers were beautiful at night when, amid that dazzle of colored lights below them, bright white shafts of light were shone on them from the ground. They were higher than any of Chicago's buildings and fairgoers could see four states from their observation areas, as well as the colorful midway, but their basic function was supporting the cables for the rocket cars. The cars themselves were rather disappointing. For a 50-cent fee each, 36 people could board each car to ride towards the opposite tower at an elevation of 200 feet–and at the un-rocketlike speed of five miles an hour.

At the end of the fair, the builders of the Sky Ride built thermite fires at the base of two legs of each of its towers. The 64-story towers quickly buckled and collapsed. And so ended the slowpoke rocket ride of the 1933-34 Chicago fair.

The 1939 New York World's Fair was the first fair ever to focus entirely on the future. Many innovations which were later to become accepted parts of everyday life, such as television, were introduced to the public for the first time at this fair. Its theme, 'The World of Tomorrow,' was symbolized by two adjacent futuristic structures, the Trylon and the Perisphere. The Trylon was a 728-foot triangular obelisk that served as the entrance to a large circular ramp leading into the Perisphere, a hollow globe 180 feet in diameter. Both the Trylon and the Perisphere were a stark white. They were set in the center of the exhibition, with tree-lined avenues stretching away from them like the spokes of a wheel. The buildings along the avenues progressed from pale shades near the white Trylon and Perisphere to vivid primary colors. Each street was of a different hue. The Trylon and Perisphere were intended to express 'the shape of things to come.'

Visitors entered the Perisphere on two of the longest moving stairways ever built. Inside one gazed upon a model of the perfectly planned city of the future, 'Democracity,' featuring wide highways, garden apartments for children on the city outskirts and factories banished to satellite towns. The exhibit was highlighted by movies projected on the dome above the viewers' heads, showing, among other visions of the future, happy, singing workers marching through the clouds of the 'sky' over Democracity.

By 1958, the year of the Brussels World Exhibition, the world had a better view of both science and the future. Indeed, by the late 50's, the two had begun to appear synonymous. The Exhibition provided the stage for Russia's revelation of its successful Sputnik and for the first public demonstration of nuclear fission. The 500-acre fair in tiny Belgium was attended by more than 41 million people, a record for European fairs.

The symbol for the Exhibition was the Atomium, a 360-foot tower modelled after the structure of a molecule of iron. Symbolizing the peaceful uses of the atom, the Atomium consisted of nine 60-foot spheres, representing the atoms of the iron molecule. There was one at the base, which supported the structure, one at the center, one at the top and six in two circles of three spheres each, connected by large steel tubes. The

1939

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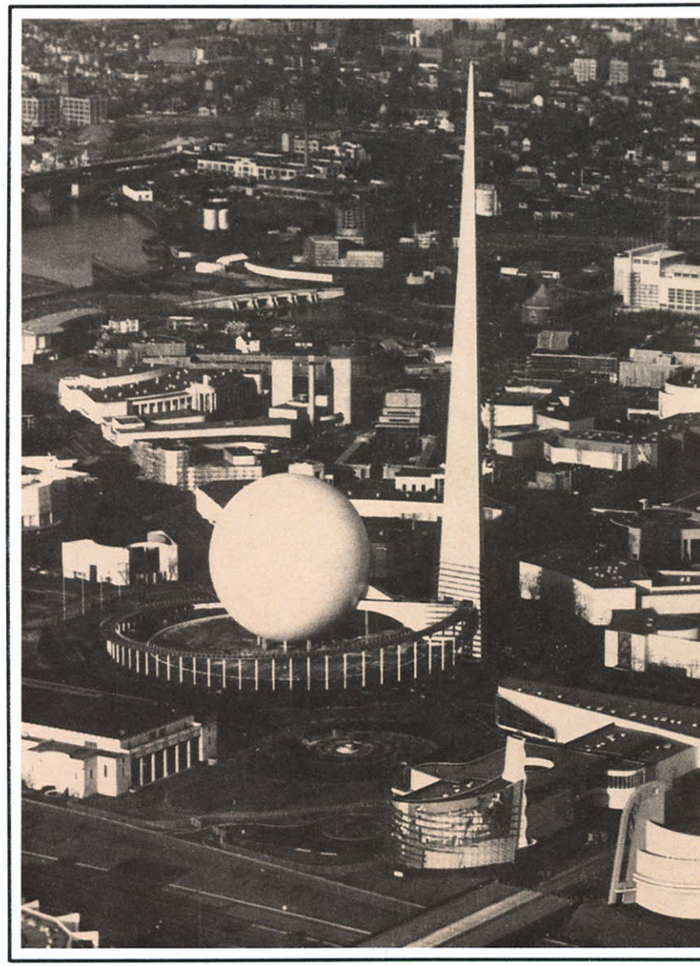


The Trylon and Perisphere, centerpieces of the 1939 New York World's Fair

1958

United Press International

The Atomium, built for the 1958 Brussels World Exhibition

aluminum cladding for each sphere consisted of narrow bands forming nine great circles, which divided the surface of the sphere into 48 curved triangles. Fairgoers ascended into the Atomium by a central elevator and escalators. The top and center spheres were divided into two floors, each circled by windows. The lower floors were viewing platforms; one upper

floor contained a restaurant, the other a bar.

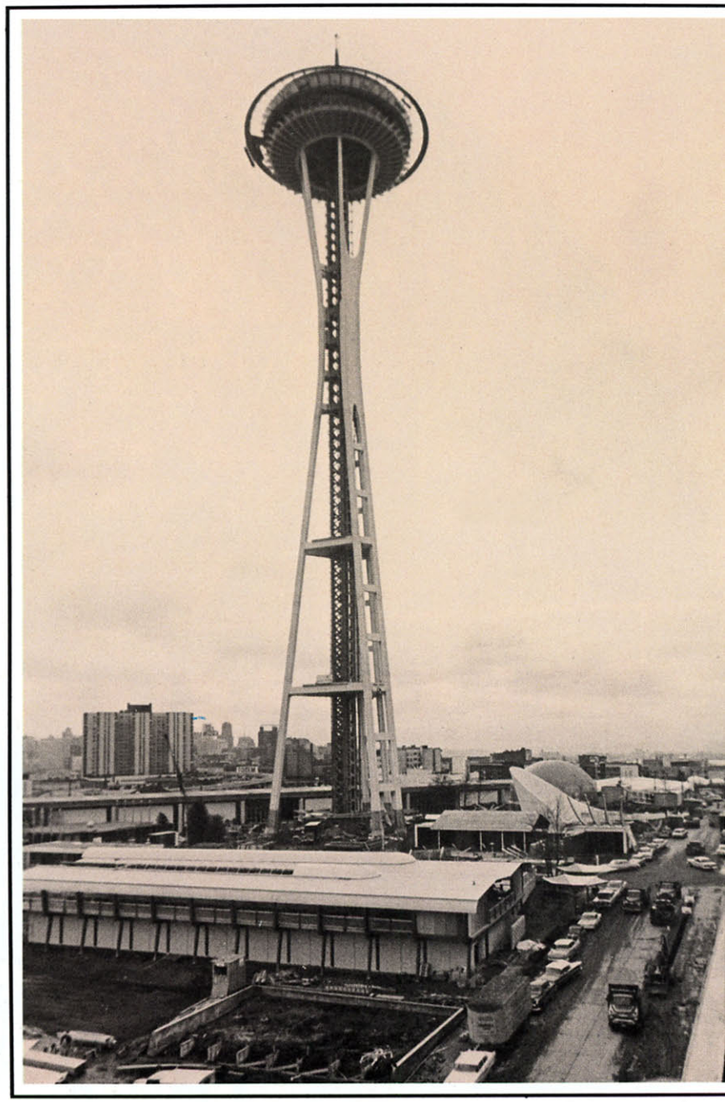
The Space Needle, the theme structure of the 1962 Seattle world's fair, officially named the Century 21 Exposition, was more graceful than the Atomium. Century 21, like its recent predecessors, emphasized science and technology.

The Space Needle is a 600-foot steel tripod, 384 feet shorter than the Eiffel Tower, its closest ancestor among fair theme structures. It is topped by a revolving restaurant that affords diners a spectacular view over Puget Sound and the mountains beyond. During the run of the Exposition, an elevated monorail train moved passengers from downtown Seattle to the fair-grounds in an almost instantaneous 94 seconds. The Space Needle and the Monorail were so popular as symbols of the Seattle Exposition that they replaced the fair's original official symbol and were the subjects of a U.S. postal stamp, which cost, in 1964, only four cents.

The Space Needle was not dismantled after the fair. It, and other of the fair buildings, remain as part of the Seattle civic center.

A major architectural and technological development was displayed in Montreal at Expo '67, which commemorated the 100th anniversary of the confederation of Canada. The U.S. pavilion was a $9,300,000 250-foot transparent geodesic

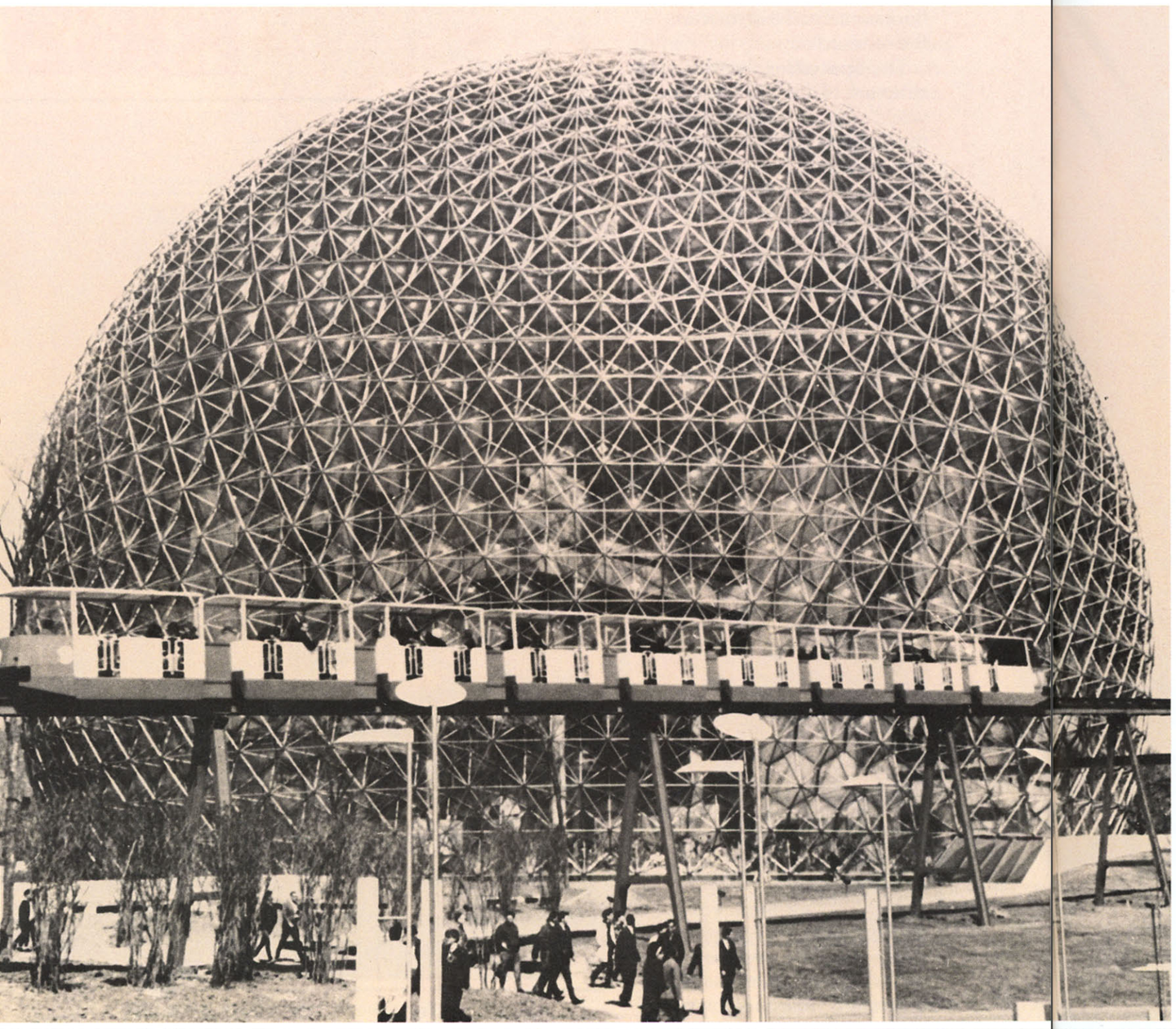
1962



The Space Needle, theme structure for the 1962 Seattle world's fair

United Press International

Buckminster Fuller's geodesic dome U.S. pavilion at Expo '67 in Montreal



United Press International

1967

dome designed by the originator of the geodesic dome concept, R. Buckminster Fuller, a free-wheeling American thinker and inventor.

Fuller's domes combine features of the sphere and the tetrahedron (a four-sided pyramidal solid) and are nearly spherical. Their framework follows a geodesic pattern– that is, the structural elements follow the shortest paths between points on the dome. This produces a gridwork of triangles which support a lightweight 'skin,' usually, as in Montreal, of lightweight plastic. The dome's self-supporting framework allows all the space it encloses to be utilized with no interference from ordinary interior supports such as pillars or beams and is very strong, so that the dome can withstand high stresses.

Nine million people witnessed the revolutionary geodesic dome design in Montreal in 1967. The dome itself had its problems, such as leaks and malfunctioning solar-activated sun blinds over its 600 window sections, but its design was recognized as an architectural breakthrough. Thousands of geodesic domes have now been erected over the world, some even larger than Fuller's 1967 Montreal pavilion.

1851
1889
1893
1933
1939
1958
1962
1967
1982

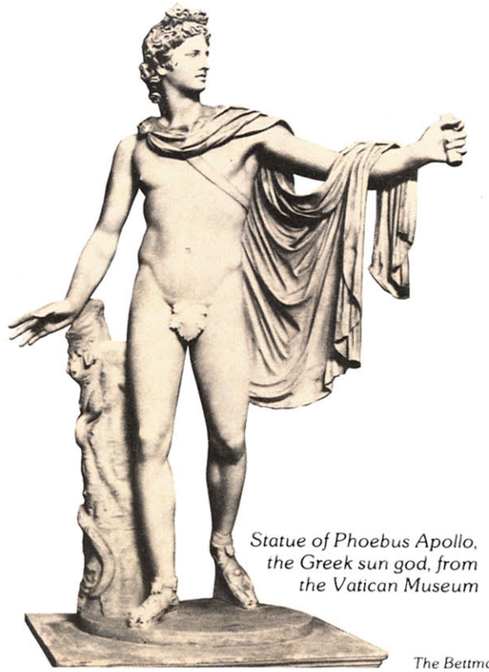
The Sunsphere is the newest in this wonderful series of unusual buildings constructed to highlight world's fairs. To fully appreciate the Sunsphere as a modern expression of an old tradition, one has to consider the power and mystery of the star that inspired it–the sun.

The Sun In Our Lives

The sun is a glowing, gaseous ball hanging in the center of our solar system 93 million miles from the little planet we live on. It and its satellite planets were formed several billion years ago from a cloud of the ashes of unimaginably ancient burned-out stars. Our sun is itself a star, but only an average one. At 865,000 miles in diameter, it is about midway between the largest and the smallest stars in size and, in brightness, midway between the brightest and the faintest stars known. It consists of roughly two-thirds hydrogen and one-third helium and very small percentages of carbon, nitrogen, oxygen, magnesium, sulfur, silicon and iron.

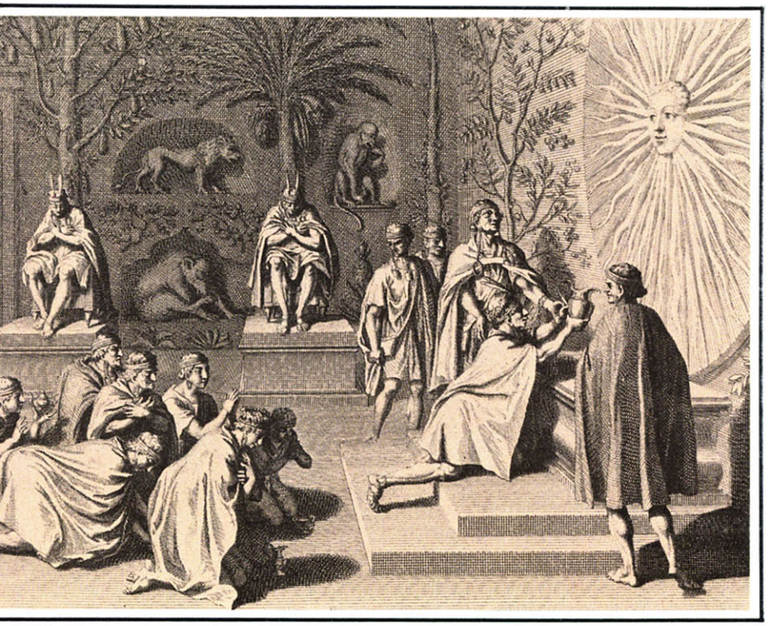
The sun is essentially a very, very large hydrogen nuclear reactor. The enormous energy produced by the sun comes from the conversion of hydrogen to helium at tremendously high temperatures and under great pressure deep in the center of the sun. The phenomenal energy produced by this transformation at the sun's core is radiated towards the sun's surface and out into space. The earth, so dependent on the sun's radiated heat and light, intercepts less than one part in two billion of the sun's output of energy. That energy production has remained constant enough over hundreds of millions of years to allow for the development on earth of complex life forms. All the earth's energy, all the power represented in the winds and dams and flowing rivers and all the power contained in natural fuels such as wood and coal and oil, is simply stored sunlight. Without the sun there would be no life on earth in any form we know. Our planet would be nothing more than a cold, barren, insignificant cinder hurtling through the universe.

Scientists know that eventually the sun will consume itself, glowing brighter, expanding, dimming and finally collapsing as it goes through the spectacular phases of star death. Since the sun has enough fuel to sustain its present rate of energy production for 10 billion years into the future, give or take a million years or so, the earth may be long gone before the fiery sun burns out.



Statue of Phoebus Apollo, the Greek sun god, from the Vatican Museum

The Bettmann Archive



An 18th Century engraving of Incas consecrating a vessel to the sun in their temple at Cuzco

For as long as there has been human life on earth, men have been awed by the sun. Even prehistoric peoples recognized the sun as necessary to their survival. Over the centuries man has pondered the sun's daily journey from horizon to horizon, spun tales about it, worshipped it, built monuments to it, basked in its warmth.

One of the first mysteries that primitive man sought to explain was the sun's origin. Most solar creation myths regard the sun as having been made and set in the sky after the creation of the earth. An Australian aboriginal legend attributes the creation of the sun to a star-dwelling ancestor who took pity on man living in darkness and tossed an emu egg into the sky, where it became the sun. Navajo Indians believed that their wise old men made the sun to light the daytime sky but left the creation of the moon and the stars to other tribes. The Bushmen of South Africa believed the sun was originally a luminous man who was seized while sleeping by a group of Bushman children and hurled into the sky, where he assumed a round form and made the earth bright with his light.

Most solar myths assign human qualities to the sun. Often the sun and moon were paired as mates. A tradition of the Masai of East Africa tells that the sun and moon were mates but quarreled; in shame the sun became bright so that men could not look at him. The charming idea that the sun and moon are the father and mother of the stars occurs in the mythology of many cultures. The Wyandot Indians believed the Turtle created the sun and moon, as well as the fixed stars, but that the stars which 'run about the sky' were offspring of the sun and moon. The Paiute Indians of California also believed the stars were the children of the sun and moon but thought the stars fled before the rising sun and hid until he slept again because he ate any star he could catch.

In other myths, the sun and moon were viewed as brother and sister. In both ancient Peru and Egypt the moon was viewed as both the sister and the wife of the sun, a belief reflected in the custom of sister marriages among royalty in both countries. But the sun was not always portrayed as male. The Iroquois and the Cherokees believed the sun was female, as did the early Germans, the Hittites of biblical times, some Arab tribes, several Siberian peoples and the ancient Japanese. An old Norse legend tells of Sol (Sun) and her brother Maane (Moon) and the Eskimos believed the moon was the younger brother of the female sun.

Man has been worshipping the sun since he first recognized its immense power and its importance to his life. There have been many sun gods. The Greeks called their sun god Phoebus Apollo and believed he drove a golden chariot across the heavens each day. Returning Roman legions brought the Persian sun cult of Mithra to Western Europe. There Mithra became Sol Invictus, the 'Unconquerable Sun' of the Roman military emperors. The Chaldeans, Assyrians, Moabites, Canaanites and Phoenicians worshipped the sun as Baal. High places and groves were sacred to Baal and the Israelites found his priesthood widespread when they came out of Egypt. The Hindus worshipped the sun in its various aspects. The rising sun was called 'Brahma,' on the meridian it was known as 'Siva,' and in the west at sunset, 'Vishnu.' Among the Japanese Shinto deities, the sun goddess Amaterasu was supreme. Her shrine stood in the residence of the Mikado, and Japanese emperors were considered her descendents until Emperor Hirohito disavowed his divinity in 1946. The sun remains even now the emblem of Japan.

Three important ancient civilizations were built by peoples who worshipped the sun; the Egyptians, the Incas and the Aztecs.

The Sun

The Egyptians worshipped many sun deities, the greatest of which was Ra, creator of the universe and original king of Egypt. The Egyptians believed Ra travelled the heavens in a boat accompanied by the divine falcon Horus and conquered the dragon of darkness every morning, creating and regulating the balance between dark and light by his regular rising and setting. Egyptian pharoahs after the fifth dynasty were regarded as the earthly embodiments of Ra. An Egyptian pharoah or queen ruled with the absolute conviction that he or she was the child of the sun, which accounts at least in part for the devotion of their subjects, who believed that service to a pharoah was service to the great god Ra.

Scholars have speculated that in the remote past Egypt's ideas about the sun as god may have been carried from that rich gold and green country by adventurers or merchants to Europe and the Americas. The most striking similarities to the Egyptians can be seen in Inca practices. The Peruvian royal family, like the Egyptian pharoahs, mummified their dead, practiced marriage of near relatives, built pyramids and called themselves 'children of the sun.' The Incas' extraordinary kingdom among the peaks of the Peruvian Andes ended abruptly with the arrival in 1527 of the Spaniards, who brought Christianity to the sun worshippers and destroyed the orderly Inca society within a few years of their coming. The story is told of how, during the last days of the Incas, a Spanish officer, awarded as booty the great gold sun disk which had lit the Sun Temple at Cuzco with reflected sunlight one day a year, gambled away his priceless prize before morning.

The religion of the Aztecs, who dominated central Mexico at the time of the Spanish Conquest, centered on Huitzilopochtli, a warrior sun god who died every evening and was born again each dawn. The Aztecs believed that if their sun warrior was to triumph in his daily struggle to subdue the stars and moon and darkness, thereby guaranteeing human existence, they had to nourish him with human blood. Because they needed prisoners to sacrifice to the sun god, war became both their favorite occupation and religious obligation. Human sacrifice was a daily occurrence for the Aztecs. In war they opened the chests of their enemies, tore out their hearts and raised them to the sun in offering. Aztec priests used ritual knives to sacrifice victims, who were sometimes prisoners of war and sometimes Aztecs who died voluntarily, atop the great Sun Pyramid.

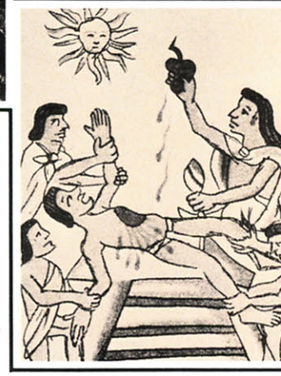
There have been many sun monuments. The largest and most spectacular were the sun temples.

The magnificent solar temple at Karnak in Egypt was dedicated to the worship of Amen-Ra and covered about twice the area of St. Peter's in Rome. It was ingeniously planned and constructed so that once a year when the sun set during the winter solstice, the light could pass unobstructed through the whole length of the temple to illuminate the temple sanctuary. This magnificent burst of light into the sanctuary at sunset revealed to the Egyptian priests that a new solar year was beginning.

The sun temple at Cuzco in Peru was built so that each day's first sunlight would strike the temple's great golden sun disk and reflect the sunlight throughout the temple.

A sacrifice to the Egyptian sun god Ra

The Bettmann Archive



An Aztec sacrifice to the sun, from a 16th Century manuscript illustration

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England's famous Stonehenge

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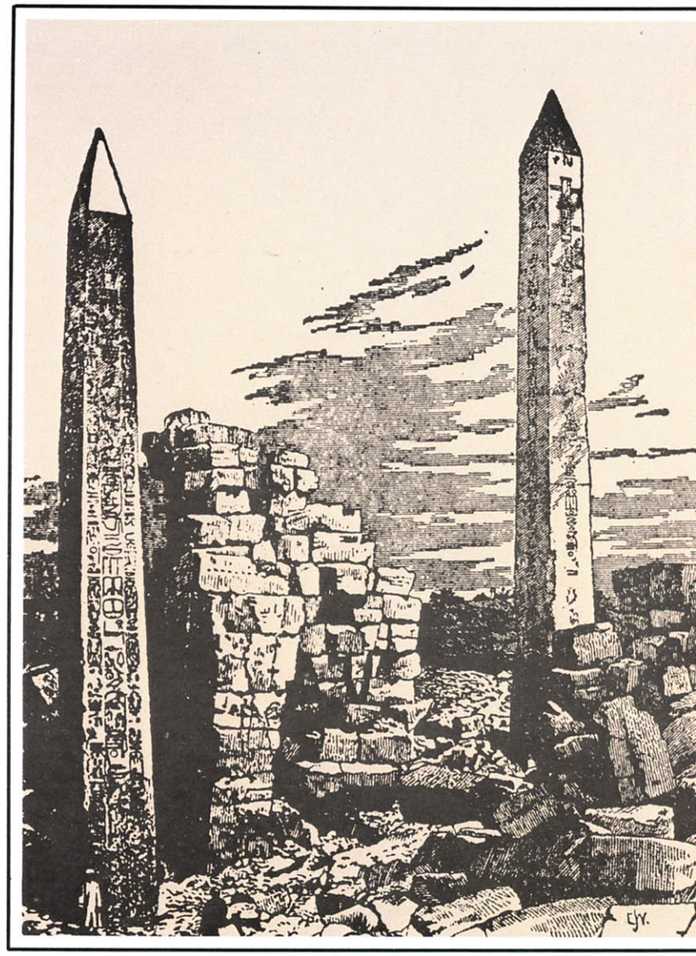
The great Aztec calendar stone

The monolithic grey stones of the famous Stonehenge in England were so arranged that the rising sun at the summer solstice cast the shadow of one of the monoliths in the circle exactly onto the great stone in the center of the circle, thereby indicating to priests that a new year had begun. It is thought that fires were then lighted to signal the news throughout the countryside. Modern students of Stonehenge have determined that it also is an amazingly accurate solar eclipse predictor. While the people who worshipped at Stonehenge may not have been Druids, as is commonly believed, they were almost certainly sun worshippers.

The Aztecs' most remarkable tribute to the sun was their great circular Calendar Stone, the 'Stone of the Sun.' This immense stone is 22 feet in diameter, three feet thick and weighs 24 tons. Its face is carved in low relief with many chronological and astronomical signs in geometrical order, as well as sun emblems and ornaments. The stone evidently served the Aztecs both as a calendar and a sundial. Its symbols show that their priests knew how to determine the hours of the day with precision, as well as the periods of solstices and equinoxes and the transit of the sun across the Mexican sky. The Calendar Stone is now on exhibit at the National Museum in Mexico City.

Egyptian obelisks are among the most beautiful of sun monuments. These pillars of stone were squared and tapered to a pyramidal top. Their summits were covered with a sun-reflecting alloy of silver and gold and they may have been topped by golden balls. Smaller obelisks were quartzite or basalt and large ones were granite from Aswan, where the quarries still contain a large obelisk only half-carved out of the solid rock. Special boats transported the completed obelisks from the quarries in upper Egypt down the Nile. The best surviving examples of Egyptian obelisks are at the Temple of Karnak. The largest one there is 96 feet high, five feet four inches square at its base and weighs 325 tons.

It has been a very long time since the last sun monument was raised, Now, after centuries, a new one has been erected in a small city in the eastern end of a green state in North America. Knoxville, Tennessee may seem an unlikely place for a new sun monument, but the Sunsphere is one of the most beautiful ever.

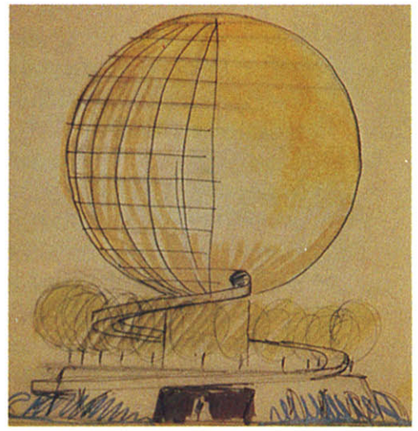


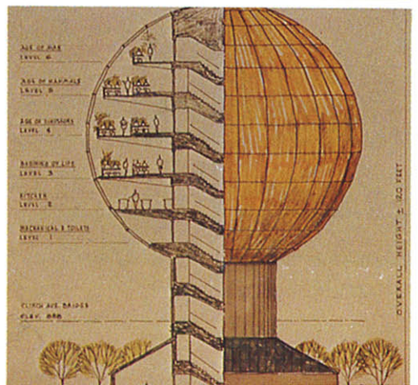
Obelisks at Karnak in Egypt

The Sunsphere Story

Man's newest monument to the sun is an exhibition structure –the Sunsphere, the theme structure for the 1982 World's Fair. It is a beautiful mirrored golden glass globe held aloft over the Fair site by a graceful tower of blue steel and is the first permanent spherical building of any consequence on earth. The Sunsphere represents the sun, the source of all the earth's energy, and reflects the energy theme of the Fair. The Sunsphere is symbolic of the Fair's purpose, the gathering together of the best energy ideas and innovations from 22 countries and many corporations to enlighten and excite and inspire those who came to the Fair to see them. Without the Sunsphere the Fair would have been like a symphony without a title, but the logistical and technical problems facing the developers of the Sunsphere very nearly decreed that it would remain forever only a set of sketches in an architect's file cabinet.

The Sunsphere had its genesis at a meeting one November



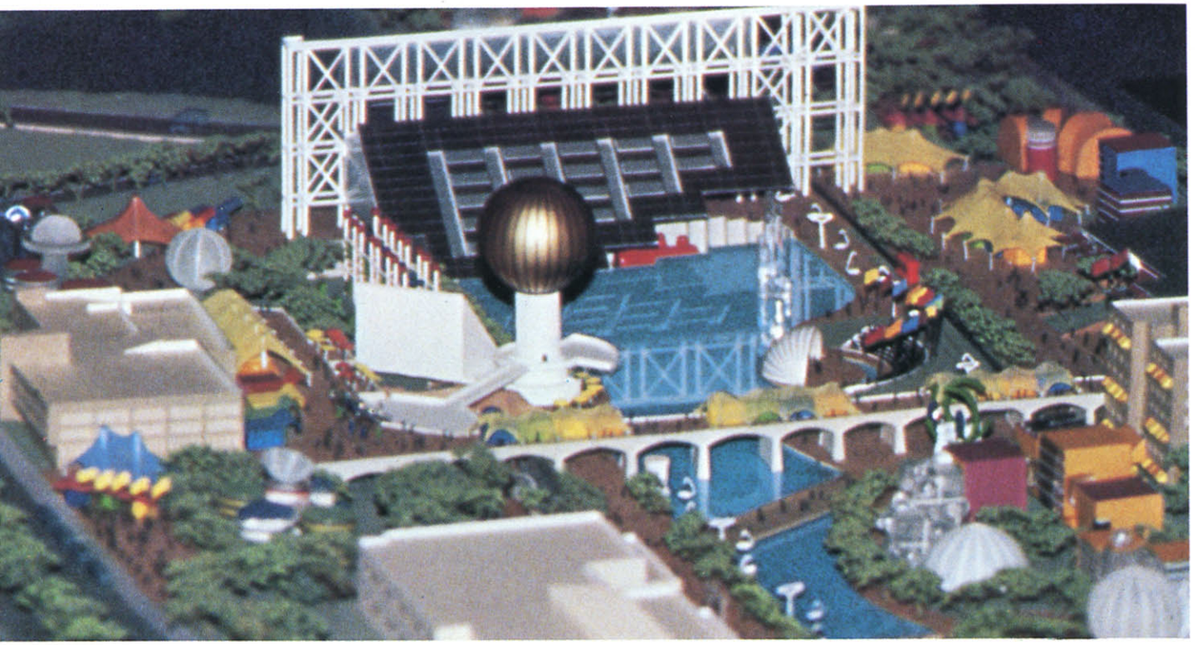


afternoon in 1979 at the Knoxville office of Community Tectonics, Inc., an East Tennessee architectural firm. The main order of business, plans for a fast food restaurant, had been disposed of when Litton Cochran, owner of the restaurant and a member of the 1982 World's Fair management committee, mentioned that the Fair as yet had no theme structure or focal point, though planning for the event was well under way. Cochran, as he had several times before, asked the Community Tectonics architects, among whom were Hubert Bebb, a founder of the firm, and Bill Denton, its president, if they would submit to the committee a proposal for a theme structure.

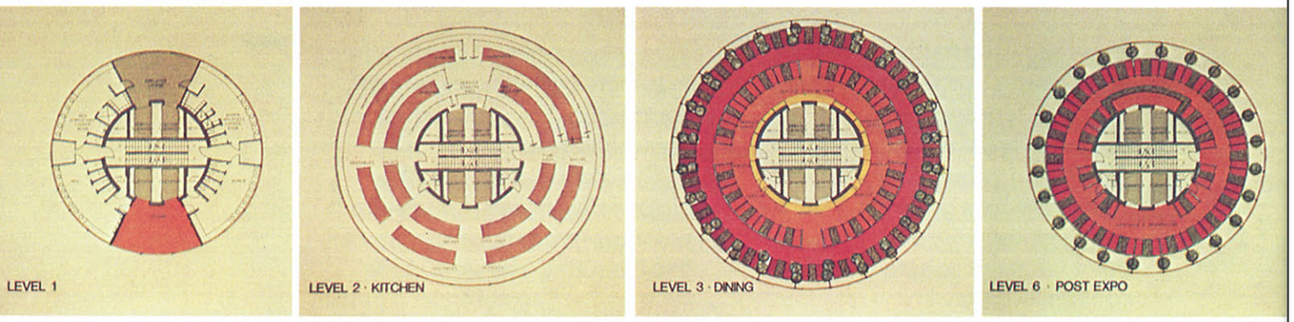
There was little time. Cochran needed a proposal to present the next morning at a meeting of the management committee. Bebb and Denton set to work immediately after the meeting, one at either end of a conference table. Bebb, senior architect at Community Tectonics who counts among his credits exhibit design work for the 1933-34 Chicago Century of Progress exposition, drew rough sketches while Denton drafted a proposal describing what this signature structure could be. From the first glimmer of a concept, their ideas involved the sun. Since the Fair was to have an energy theme and the sun is the source of all energy, it seemed only natural to Bebb and Denton that the proposed structure represent and commemorate the sun. Bebb sketched a great golden sphere supported by a pedestal. Neither architect knew for sure at that point what the sphere would contain, but they knew already that they would call it the 'Sunsphere.' It was a good name, short and easy to say and remember. They wrote the name into the proposal, attached the sketch and dispatched a courier to slip them into the mailbox at Cochran's suburban Knoxville home within only hours of his request for ideas.

The next morning Cochran presented the Community Tectonics proposal to the other members of the management committee. They liked the idea immediately.

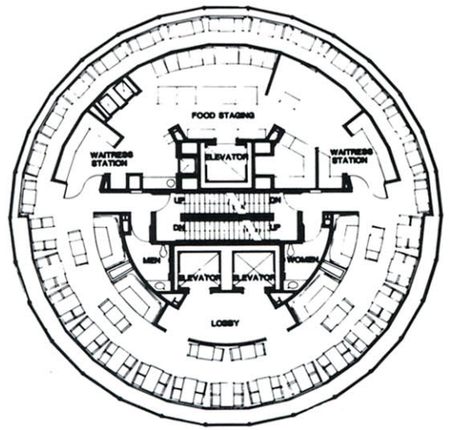
The committee knew that, historically, successful fairs had been centered around imaginative, beautiful 'drawing cards' such as the Crystal Palace or the Eiffel Tower or, most recently, the Space Needle. They recognized in the Community Tectonics proposal the beginnings of just such a central Fair attraction. The day after its inception, the Sunsphere project had a green light from the Fair's management committee, but the long, difficult task of turning the initial concept into reality had just begun.



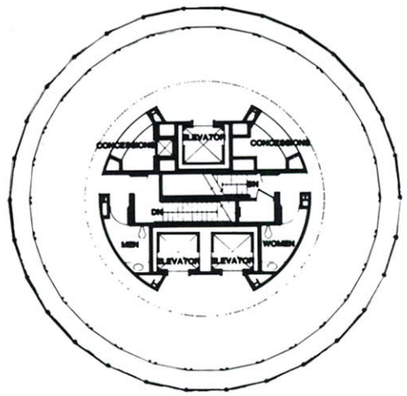
OLD PLANS



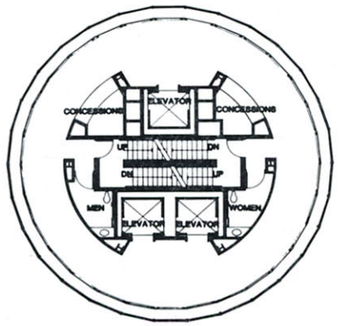
SCHEMATIC PLANS



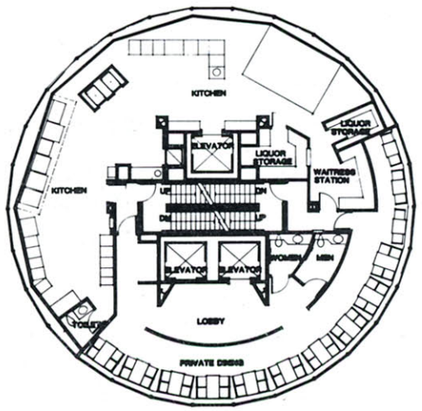
LEVEL FOUR: UPPER LEVEL DINING PLAN
LEVEL THREE SIMILAR



LEVEL FIVE: BAR OBSERVATION LEVEL PLAN

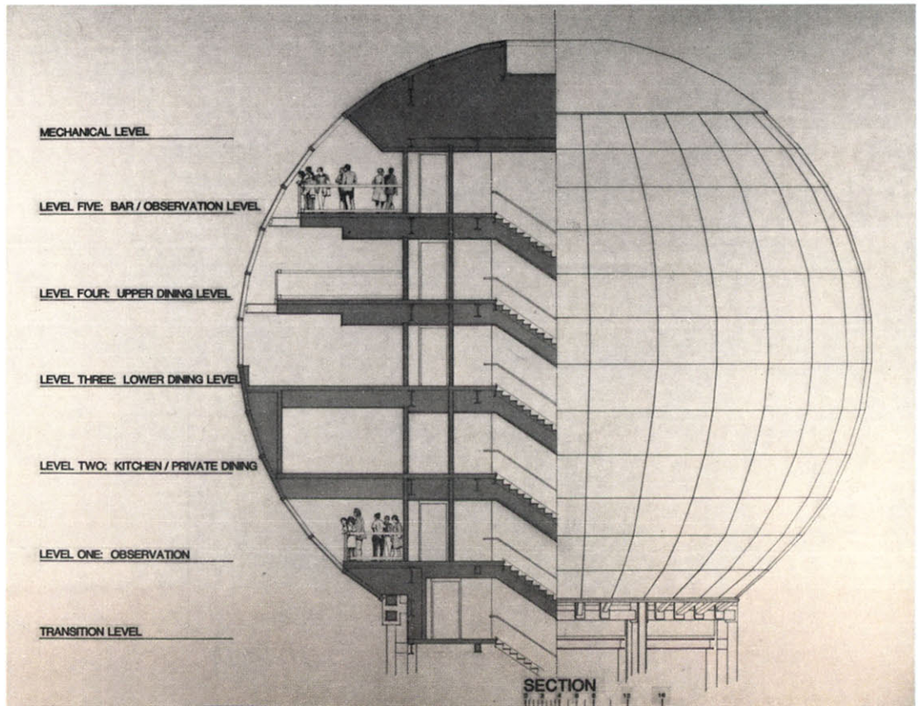


LEVEL ONE: OBSERVATION LEVEL



LEVEL TWO: KITCHEN PLAN

FINAL DESIGN PLANS



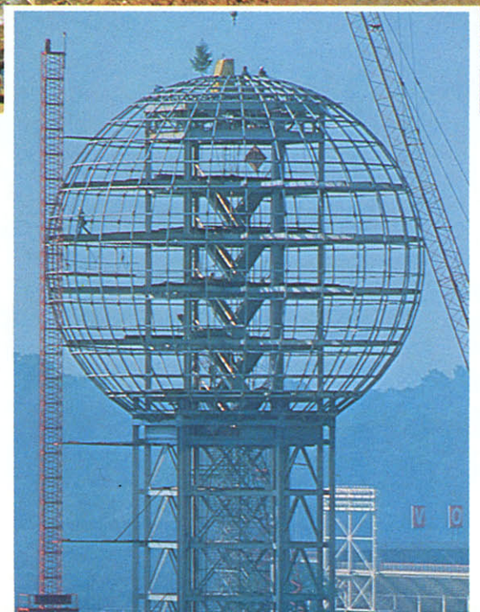
Site selection was first on the agenda. High traffic flow was a major objective in placement of the Sunsphere on the 72-acre Fair grounds, which were at that point little more than a scraped-out, meandering, mile-long valley separating downtown Knoxville from the nearby main campus of the University of Tennessee. Since the Sunsphere was to remain after the six-month run of the fair as a centerpiece to the city park which was to be created from a central chunk of the Fair grounds, consideration had to be given to easy accessibility for both visitors during the Fair and university students and Knoxvillians afterwards. The site chosen is in the middle of the Fair grounds, near other permanent Fair structures, new hotels, a convention center and parking garages, and is on a line between the campus and the busiest section of downtown Knoxville. The land chosen as the Sunsphere site was owned by several different owners. Untangling the legalities involved in buying the small but highly desirable parcel of land on which the Sunsphere is built was but the first of many complex problems the Sunsphere developers had to solve before construction could begin.

One such puzzle was financing. The Fair itself had set aside no money to build a theme structure like the Sunsphere. Community Tectonics was a healthy firm, but too small to bankroll such a big undertaking. Area banks had lent their limit to Fair-affiliated

projects and, in any event, the entire project was as yet too speculative to inspire the confidence of investors. The best thing going for the Sunsphere in the spring of 1980 was a favorable feasibility study by a Washington consulting firm which said a well-planned tourist attraction such as the proposed Sunsphere could pay for itself if it included restaurants, observation decks and gift shops.

In the process of design research, the Sunsphere architects realized that the Sunsphere, when completed, would be the only multi-story, fully occupied spherical structure in the world. There have been many spherical and near spherical predecessors to the Sunsphere, some connected with past world's fairs. The vast but nearly empty Perisphere of the 1939 New York World's Fair was temporary; the Atomium of the 1958 Brussels World's Fair was a series of spheres; Buckminster Fuller's geodesic dome pavilion at Expo '67 in Montreal, as innovative as it was, was only a partial sphere, or dome. And there have been spherical monuments, the last famous one a stainless steel openwork globe of the world, called the Unisphere, which was the symbol of the 1964-65 New York World's Fair. But never a permanent, single, multi-storied, habitable sphere. The revelation


ASHEVILLE STEEL



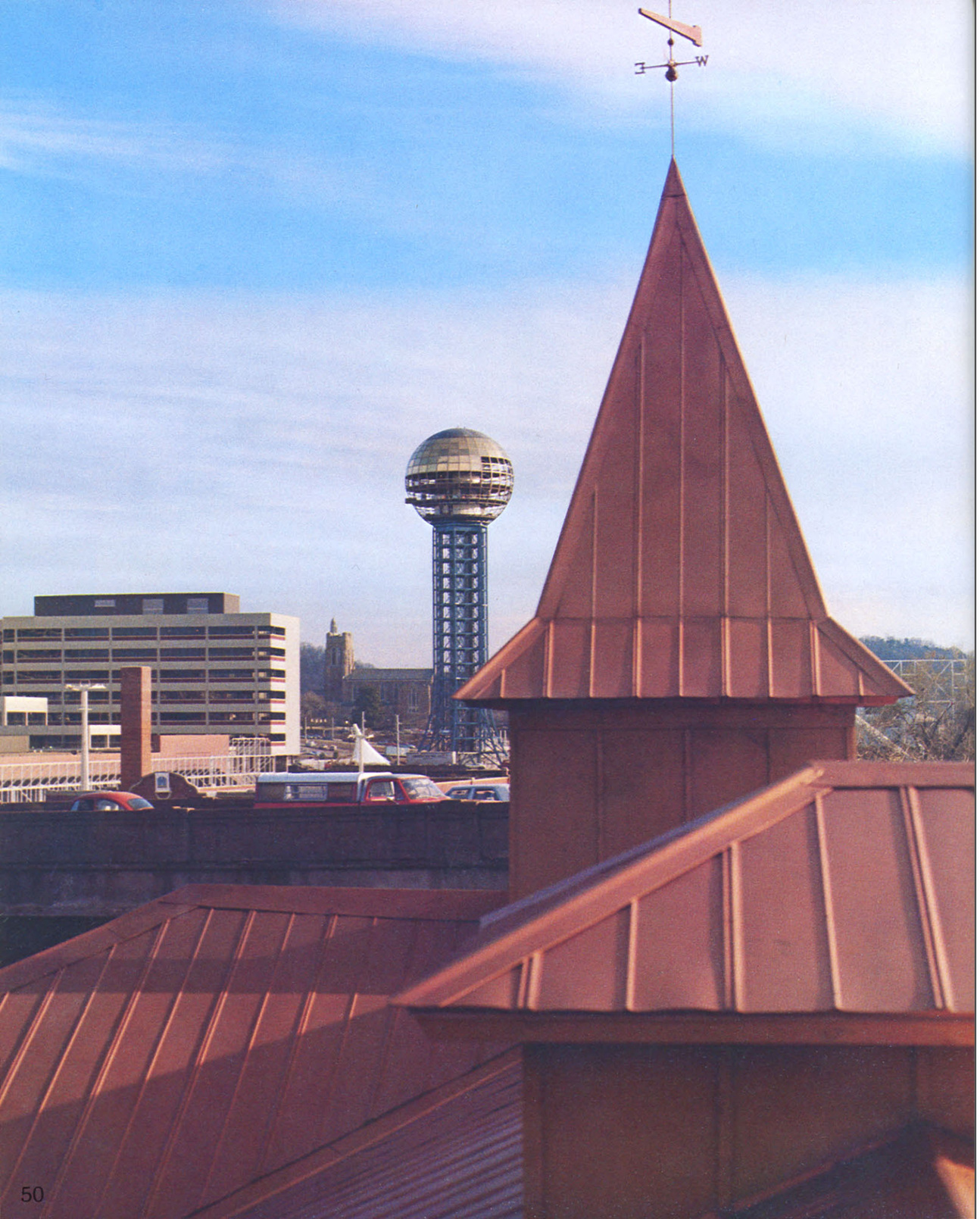
that the Sunsphere would be the first and only structure of its kind anywhere made the people at Community Tectonics determined to find a way to build it.

The problems of investors, financing, contractors and design were wrestled with simultaneously. No investor could sign on the dotted line without knowing that the project was workable and promising; no bank could lend money for construction without knowing exactly what that construction would cost and who would perform it; no construction company could commit to a construction cost figure without a detailed study of very precise blueprints and specifications; and those precise plans had to call for a design and building materials and construction techniques that added up to no more than what the budget allowed.

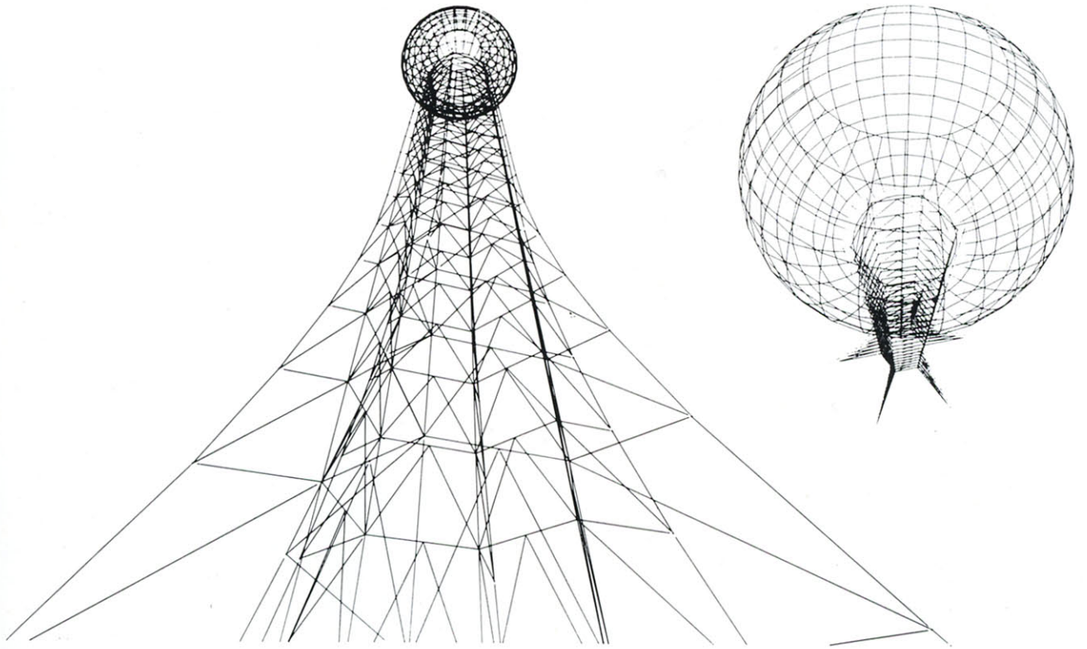
All of these problems hinged on the biggest dilemma the Sunsphere architects faced– building codes. No one at any time entertained any thought of building a structure that was any less than absolutely safe, but from the beginning the Sunsphere designers knew that they would have a difficult time meeting building code regulations. The reason was simple; the Southern Building Code was written to regulate conventional houses and office buildings and factories, not unusual structures like golden glass spheres supported by towers. It was as if the Sunsphere architects were trying to bake a wedding cake according to a recipe for blueberry muffins; it couldn't be done. Or, at least, it seemed that the building codes were an insurmountable problem. The Community Tectonics architects met many times with city codes officials and committees. Outside consultants, such as a Nashville engineer who helped write both the National Fire Protection Association Code and the Southern Building Code, were hired to help. At every step the codes variance committees had to be convinced that the unique structure the developers proposed to build would meet the objectives, if not the letter, of the codes.

After many months of hard work and setbacks, things began to look hopeful for the project. A final design was developed that satisfied the codes officials, met budget restrictions and fulfilled the aspirations of the architects.

The architects had originally envisioned the Sunsphere as a golden glass sphere 86.5 feet in diameter, containing six interior levels and supported by a relatively low pedestal. This concept was modified several times during the process of design refinement. The most important change was the height of the Sunsphere. Building code regulations



required that any building more than seven stories high had to be built of concrete, since concrete is fire-resistant. Unfortunately, the cost of a concrete pedestal for the Sunsphere was more than the construction budget allowed. The codes committee granted a variance to the Sunsphere architects only after they were able to convince the committee that they should consider only the number of stories in the sphere itself in their count. This permitted the architects to plan an open steel tower. It had also become apparent that if the Sunsphere was to achieve the landmark status its developers desired for it, it would have to be tall enough to rise above the other Fair buildings, many of which were to be remarkable structures themselves, and the planned high-rise convention center and hotel complex adjoining the Fair site. So the sphere rose to a height of 266 feet, almost 100 feet higher than originally planned. Elevating the globe of the Sunsphere made a smaller sphere more feasible; the planned diameter was reduced to 74 feet. The designers decided to abandon their plan to construct two of the levels of the sphere to revolve when they realized that the reduced diameter of the sphere alone, without revolving floors, would afford diners in any location on any level a



spectacular 270-degree view of the Fair site, Knoxville and its suburbs and the hazy Smoky mountains. Plans for a fast food restaurant at the base of the tower to serve Fair lunchers and park users were also added.

A group of local business people were approached as investors; they formed a partnership, called Sunsphere, Incorporated, to back the project. First National Bank of Louisville, Kentucky agreed to lend the $5.2 million needed for development, construction and financing after the City of Knoxville agreed to lend the partnership $1 million of a federal grant, on a second mortgage, to help repay the Louisville loan. Stan Lindsey and Associates of Nashville were chosen as consulting structural engineers; West, Norris, Welch

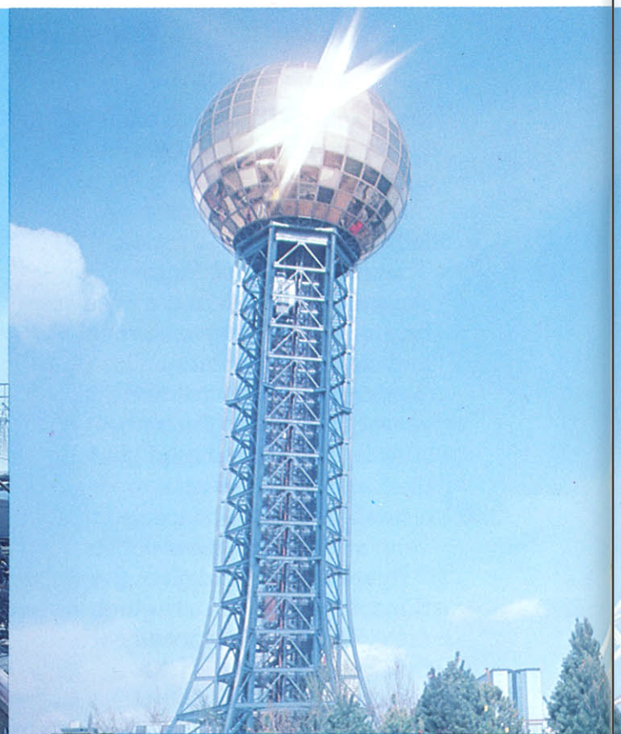
and Miller of Knoxville were commissioned to serve as consulting electrical and mechanical engineers. Rentenbach Engineering Company of Knoxville, the company responsible for managing construction for the entire Fair site, was contracted to construct the Sunsphere. In January of 1981, ground was broken on the site selected so many months earlier, and the Sunsphere began to rise out of the winter mud.

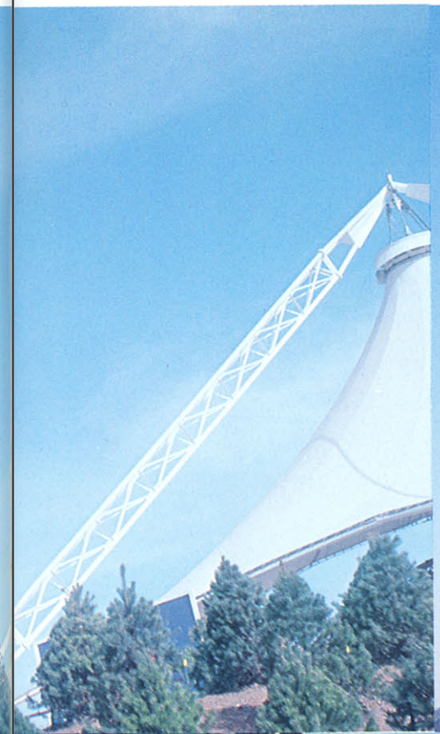
The 198-foot tower of the Sunsphere is hexagonal. From each point of the hexagon a steel column rises vertically to the base of the sphere. For the sake of speed and efficiency, the structural steel components of the tower were ordered in American Institute of Steel standard sizes. When the 600 tons of tower sections arrived in Knoxville, they were set in place and bolted together like a giant erector set. Two 418-step fire stairs and three glass-enclosed high-speed elevators are contained in the tower, which was painted blue in an effort to make it 'disappear' against the sky, giving a floating effect to the sphere.

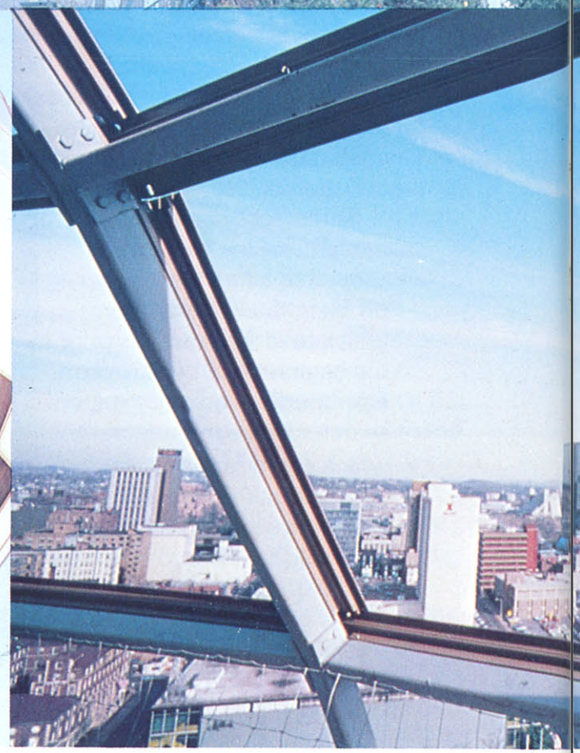
The patented framework system for the Sunsphere globe is based upon the most ancient post-and-beam construction techniques. Each floor within the sphere is supported by radiating beams cantilevered from the core of the sphere. The ends of these beams meet a series of evenly-spaced, curved tubular 'columns' that stretch from the sphere's 'north pole' to its 'south pole.' The sphere is topped by a skullcap-like roof which covers heating and cooling equipment and elevator machinery. This 'skullcap' section is painted the same gold color as the frames surrounding the panes of golden glass and is pierced at its top by a small well which conceals ventilation and exhaust outlets.

Real 24-karat gold gives the Sunsphere glass its rich, gorgeous color. The inner surface of each outer pane of glass on the sphere is lined with a vinyl film impregnated with gold dust. Because the glass is reflective, the apparent color of the Sunsphere varies from a brilliant metallic gold to a duller, paler gold, depending on the weather and time of day.

Finding gold-colored glass for the 'skin' of the Sunsphere proved to be a much bigger problem than its designers anticipated. For months prior to the beginning of construction, Community Tectonics staffers searched for a manufacturer which could furnish golden glass to meet their specifications. They were told again and again that glass that would meet the highly specialized design requirements of the Sunsphere simply was not available. For one sad short period it seemed that the







The Sunsphere

Sunsphere would have to be glazed with *silver* glass. Finally a New Jersey company was located to manufacture the nearly 14,000 square feet of reflective glass needed to enclose the sphere. Each pane of the beautiful glass cost, on the average, $1,000.

The Sunsphere glass system was developed especially for the project and is unique. Each unit of glass on the sphere consists of two quarter-inch panes of glass, one interior, one exterior, held in place by an aluminum frame, or mullion. On the top half of the sphere the outer-most pane of glass is tempered and the inside pane of glass is laminated. Between the two panes is an insulating airspace. Besides conserving energy, the design of the glass system also promotes safety. If, for example, a passing airplane lost a rivet which fell and hit the Sunsphere, diners inside would be safe. The exterior tempered glass on the upper half of the sphere would break into harmless small rounded pieces which would collect in the airspace and be prevented from falling into the restaurant itself by the laminated interior pane, which might crack after a blow but would remain intact. Since objects dropped from the interior of the sphere are the biggest threat to glass in the lower half of the sphere, from the equator of the sphere down the interior pane of glass is tempered and the outer pane is laminated.

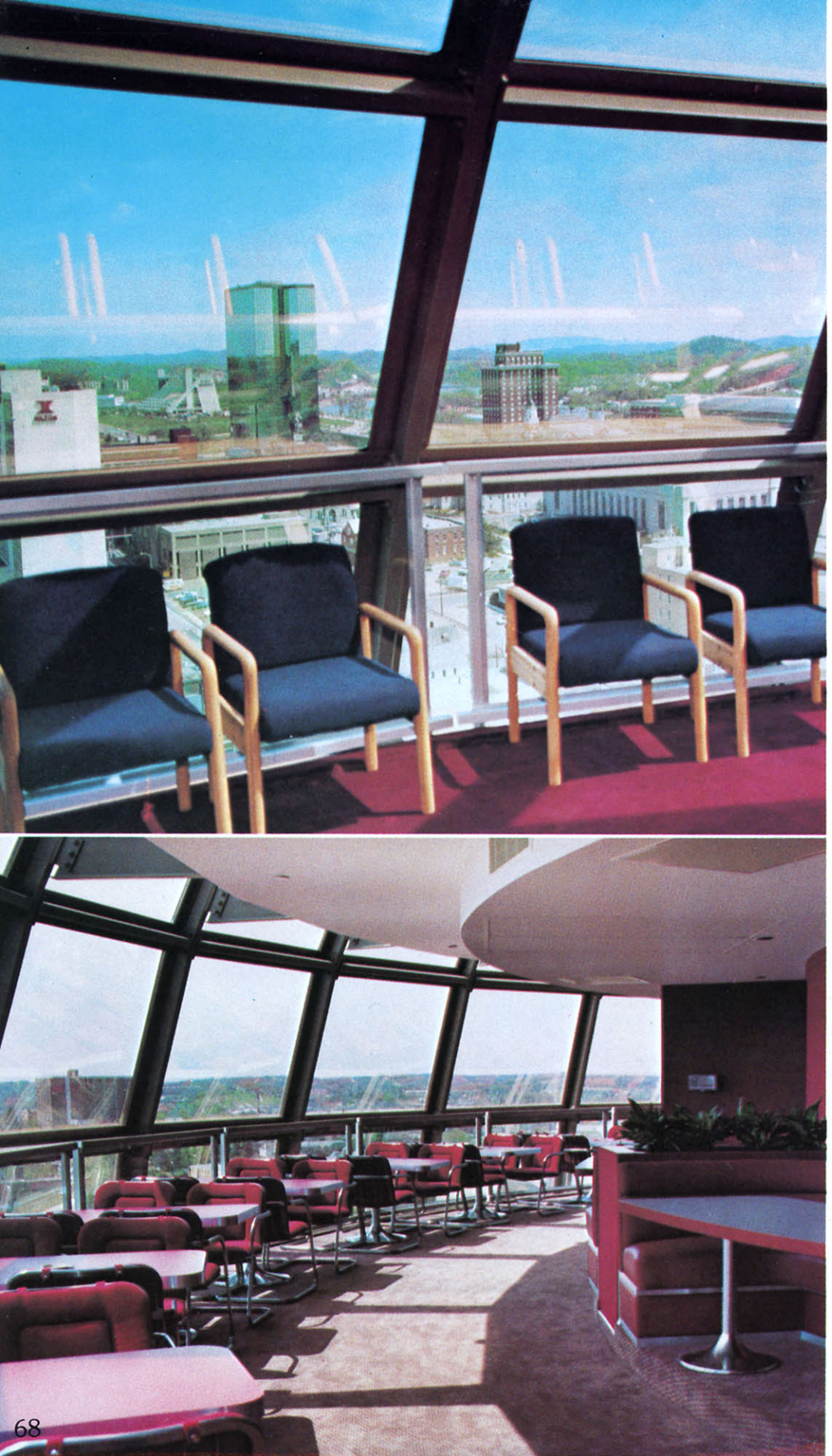
Like the tower girders, both the glass panes and mullion sections were prefabricated by their manufacturers. The mullions have a baked-on finish in a shade of gold chosen to match the gold of the glass under as many different weather conditions as possible. The panes had to be cut to size before being either tempered or laminated. The 360 panes which enclose the Sunsphere were manufactured in seven shapes. One shape is a square–those panes run around the equator of the sphere. The other

six shapes are trapezoids. To allow construction workers to install these various panes in their proper places, the glass manufacturer carefully numbered each pane according to its shape and what row above or below the equator it belonged. The last pane of golden glass was installed in the sphere on February 19, 1982. All three local television stations sent news crews to cover the event. Knoxvillians had been watching the progress of the Sunsphere as carefully as Londoners watched the building of the Crystal Palace.

Considerable attention was given to making the Sunsphere energy efficient. Solar collectors were part of the original plans for the Sunsphere, but the cost of enough collectors to do the job in cloudy East Tennessee was prohibitive. The designers decided instead to concentrate on energy conservation. They were aided by natural attributes of the sphere. A sphere is the most heat-conserving building shape because it presents the smallest possible surface area for the volume it encloses. Because it radiates much less heat from its surface, the Sunsphere retains more of the heat generated by its kitchens, occupants and lighting than would a rectangular structure of the same interior volume. The designers boosted the natural energy conservation capabilities of the sphere with their double-layer insulated glass system. The airspace between the panes retains interior heat, thus reducing the need for heat production during the winter. The gold outer pane reflects the heat-producing rays of the sun during the hottest parts of the year, reducing the need for air conditioning. Water source heat pumps furnish extra heat when it is needed. Water heated by the Sunsphere's air conditioning and kitchen equipment is circulated to heat the side of the sphere which is shaded. When the sun shades the other side, the process is reversed.

The Sunsphere was built to be extremely fire-safe. A sprinkler system would extinguish most fires likely to occur, but several backup safety systems were included in the Sunsphere design. There is a smoke evacuation system to protect occupants from smoke inhalation. An interfloor speaker phone system allows for communication between firemen and occupants on other floors. Special drains were installed to catch water from the sprinkler system in order to prevent its freezing on the steel fire stairs in the event of a fire during cold weather. And every piece of elevator equipment is designed to function for a minimum of four hours during a fire–more than ample time to evacuate sphere occupants safely.

What you see in the Sunsphere depends on which of its elevators you board for a 43-second ride to the sphere interior. One of the elevators goes to the bottom observation level, which is the first floor within the



sphere and like a circular hallway. Visitors on this level are presented with a spectacular view of the Fair site and can even see the support tower beneath them through the sloping glass wall. During the run of the Fair, the Pennsylvania-based Sun Company, a broad-based multi-source energy company, sponsored energy education displays on this bottom observation level, as well as on the top observation deck on the fifth level and at the tower base near the elevators.

Levels two, three and four of the sphere are reached by the dining room elevator. The elegant Sunsphere Restaurant, which seats a total of 300 people, occupies the third and fourth levels. No one at any table on either level has a bad view. The panes of glass are so expansive at this point on the sphere that diners can see the beautiful view–on a good day, all the way to the Smoky Mountains, nearly 40 miles away–almost unimpeded by structural elements. Tables surrounding the sphere's core have been raised slightly to ensure that diners there have as good a view as those along the glass perimeter of each level. Since light passing through the gold glass seems to change many colors, the restaurant designers scrutinized every part of the restaurant decor, including carpeting and china and

uniforms of restaurant personnel, under a sample of the gold glass before making decorating decisions.

The kitchen for the restaurant is located on the second level. Hardee's, the company which

operates the Sunsphere restaurants under a 20-year lease, was forced to have some standard restaurant appliances modified or even specially constructed in order to fit the equipment they needed for a quality restaurant into the limited circular space. The V.I.P. Lounge, an exclusive wedge-shaped, reservations-only dining room which seats only 40 people and has its own kitchen and serving personnel, is also on the second level.

The top level of the sphere, level five, is an observation level. It can be reached by the third of the Sunsphere elevators, which departs from the Clinch Avenue level entrance to the tower. All the elevators return to the arcade level where passengers walk across the pedestrian bridge. They can choose to go up one flight of stairs to Clinch Avenue or down one flight to the Hardee's fast food restaurant nestled in the base of the tower. This picturesque restaurant is like a sidewalk cafe beside the Fair's seven-acre Waters of the World lake.

The Sunsphere is already a landmark. The curve of its golden sphere can be seen rising over the buildings surrounding it from almost any approach to the city. On sunny days it shimmers; at night it glows. And, until someone builds another, it remains unique in the world, a modern spherical monument to the sun.

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