Building a Unisphere

How U.S.Steel innovated the largest earth model in history

When the final section of Unisphere was hoisted into place, a "shelf man" shouted good news from his perch on the equator: the giant pieces of this twelve-story stainless steel "world" fit precisely as planned.

The pieces *had* to fit: there wasn't a replacement part on earth, because this was the first time in history that anything like Unisphere had been attempted.

Unisphere, which towers 140 feet over a circular reflecting pool, is being presented by U.S. Steel to the 1964-1965 New York World's Fair as the symbol of the Fair and as a permanent monument for Flushing Meadows Park. The largest replica of the earth ever constructed, Unisphere involved unprecedented design, engineering, and construction problems; yet it was completed by U.S.Steel five months ahead of schedule.

A mile and a half of meridians, parallels, and orbit rings frame this stainless steel planet and support its continents. All told, more than 500 major structural pieces were assembled to mount a 120-foot diameter armillary sphere on a 20-foot base, at a total weight of 900,000 pounds.

All this stands as an open sculpture with virtually every part exposed: exposed to view, and exposed to rain, ice, salt-laden dampness, and the stiff gales that sweep across Long Island.

For permanent, weatherproof beauty, the designers chose USS 18-8S stainless steel (AISI 304). The three-point base that supports the sphere is USS COR-TEN Steel, a low-alloy high-strength steel that has unusual corrosion resistance. Each corner of the base is anchored to the foundation with ten 2¾-inch diameter bolts of USS "T-1" Steel, the remarkable constructional alloy steel with a minimum yield strength of 100,000 pounds per square inch that can create up to 50 per cent savings in weight.

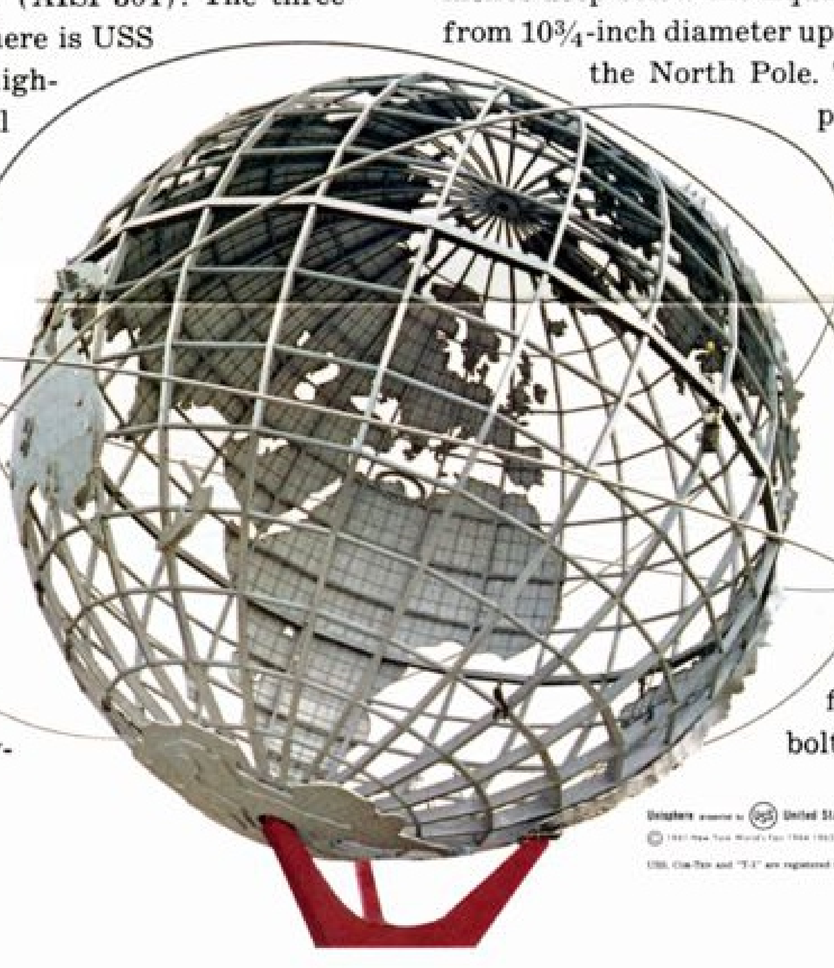
Structural support presented unusual problems. The spherical shape would impose enormous loads on curving structural members. Yet these members could not be thick and could not be cross-braced without detracting from Unisphere's beauty. To fulfill the design concept, slim meridians and parallels had to be spaced according to map-making custom rather than engineering expediency and had to carry irregularly shaped, irregularly spaced land masses. Even the pedestal that would support the entire sphere had to be gracefully slender.

But the most formidable problem was wind load. In shaping convex land masses to fit the curvature of the earth, U.S.Steel knew that concave inner surfaces would trap wind like the spinnaker of a sailboat. Wind tunnel tests of a scale model confirmed the enormity of this problem: at wind velocity of 110 miles per hour, there would be a total drag of 396,000 pounds.

All of these wind and weight factors had to be translated into a stress distribution pattern that would indicate what structural strength each section would require: a computation so complex that 670 simultaneous equations had to be solved for just one of three sets of calculations. U.S.Steel called on advanced computing equipment to supply the answers in a matter of weeks; without high-speed computers, it would have taken years.

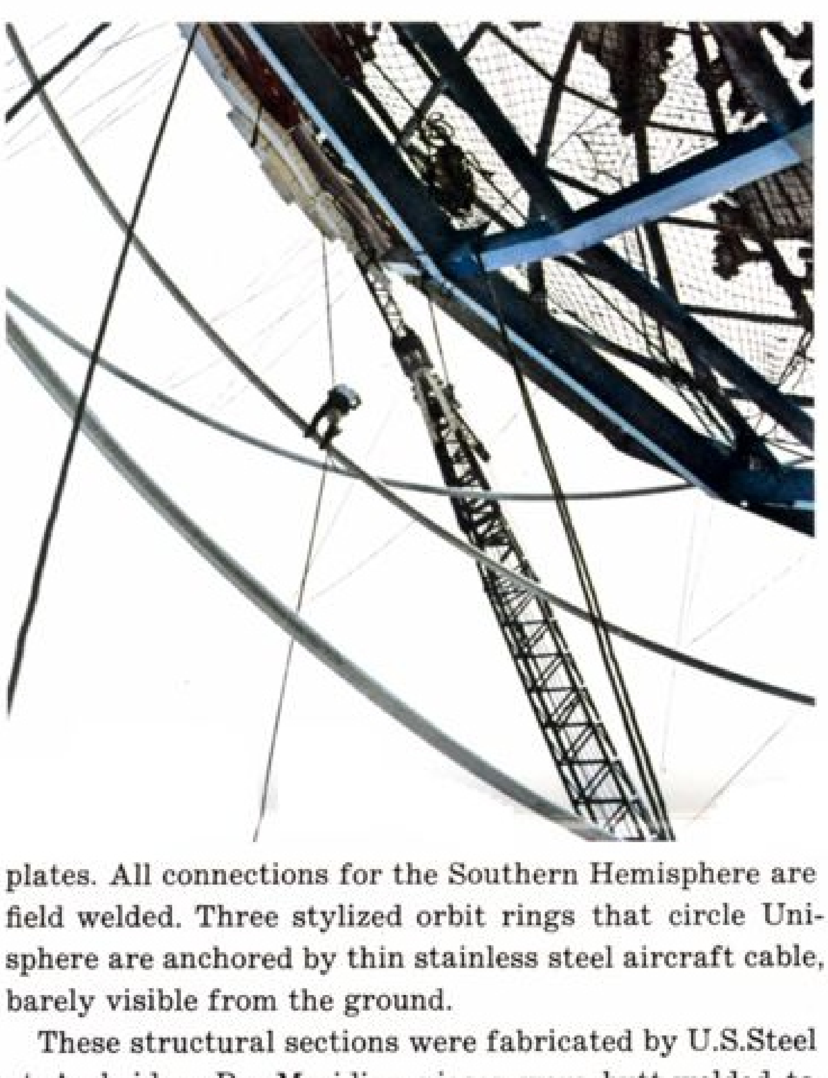
In its final design, Unisphere has ample strength and stability to stand up in a hurricane.

North-South meridians are hollow rectangular sections, 6 inches wide and 12 inches deep above the Equator, and 10 inches wide by 14 inches deep below the Equator. Parallels are round tubes from 10¾-inch diameter up to the Equator, to 6-inch near the North Pole. The Equator is an H-section prestressed by 15/16-inch stainless steel guys connected to a floating tension ring at the center of the Unisphere.



In the area surrounding the main supports, both meridians and parallels are heavy box sections which taper to meet the normal size members.

In the Northern Hemisphere, connections of parallels to meridians are field bolted with stainless steel bolts through shop-welded cap



plates. All connections for the Southern Hemisphere are field welded. Three stylized orbit rings that circle Unisphere are anchored by thin stainless steel aircraft cable, barely visible from the ground.

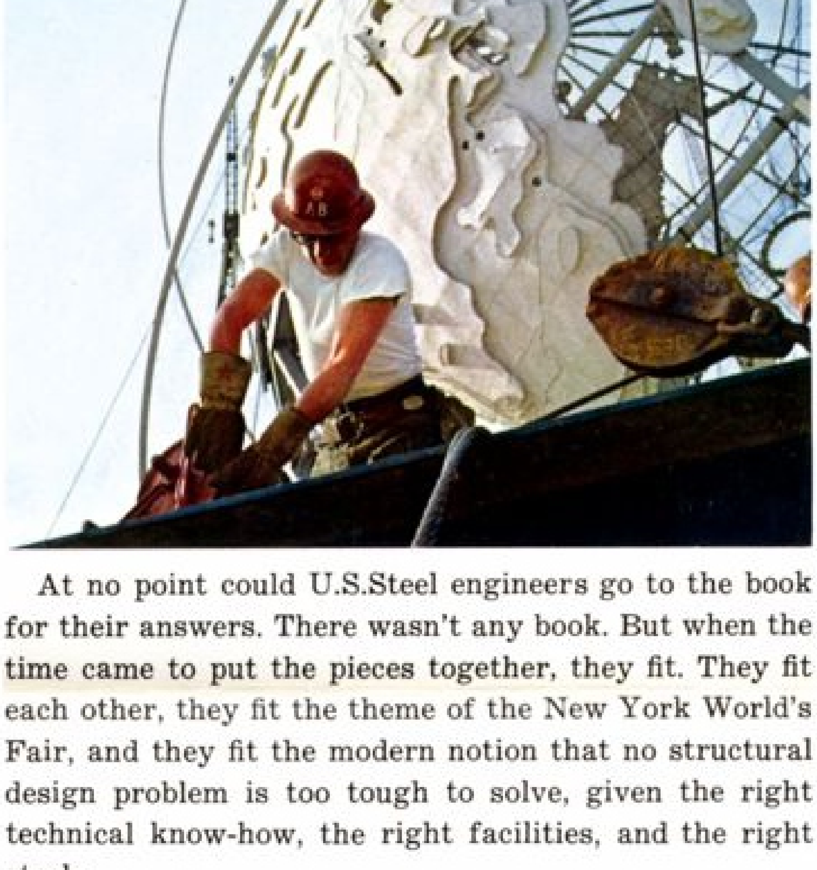
These structural sections were fabricated by U.S.Steel at Ambridge, Pa. Meridian pieces were butt-welded together in the shop, and each meridian quadrant—the quarter circle from equator to pole—was shipped in two sections. Already installed inside these members were tubular and plate diaphragms positioned for the 360 intersections of meridian and parallel.

Land masses were fabricated by U.S.Steel at Harrisburg, Pa., after careful studies to find what surface texture would look best at viewing distances of 90 feet and more. Continents and major islands are made of textured stainless steel sheets, mounted on a framework of channels and angles. Land elevations are built up in layer cake fashion, like a huge contour map. Since every coastline and contour line is irregular and every land mass must fit the earth's curvature, fabrication became a highly complex task in which no section was square in any plane.

From beginning to end, Unisphere demanded entirely new techniques to solve entirely new problems, even after the unprecedented design and engineering questions had been settled. A few examples:

Standard bending equipment wouldn't curve the orbital rings without crimping or defacing them, so U.S.Steel engineers designed a die that would do the job. Meridian sections had to be welded together *after* they were polished, so the engineers worked out a method to remove discoloration caused by welding. Working with polished sections during fabrication also required a whole new system of materials handling, using vacuum lifting equipment, protective tapes, and nylon slings.

After tests of various surface materials including stainless steel mesh, land masses were made of a new non-directional patterned stainless steel sheet designed especially for Unisphere. In construction, meridians and parallels were connected by what is probably the first application of inert gas shielded short-circuited arc welding to heavy stainless steel structural members in the field. And U.S.Steel construction engineers had to invent some new hoisting techniques: to raise large curved sections of the continents into place, they made a lift from a thirty-foot piling section, angles, clamps, and a rolling hitch; to position the huge orbital rings aloft, they welded each ring completely together, surrounding the sphere on the ground, then used four cranes to lift it in one piece and hold it until anchor cables were placed.



At no point could U.S.Steel engineers go to the book for their answers. There wasn't any book. But when the time came to put the pieces together, they fit. They fit each other, they fit the theme of the New York World's Fair, and they fit the modern notion that no structural design problem is too tough to solve, given the right technical know-how, the right facilities, and the right steels.

"To quote Mr. Robert Moses, president, 1964-1965 New York World's Fair: What stronger, more durable, and more appropriate metal could be thought of than stainless steel? And what builder more imaginative and competent than United States Steel?"

United States Steel