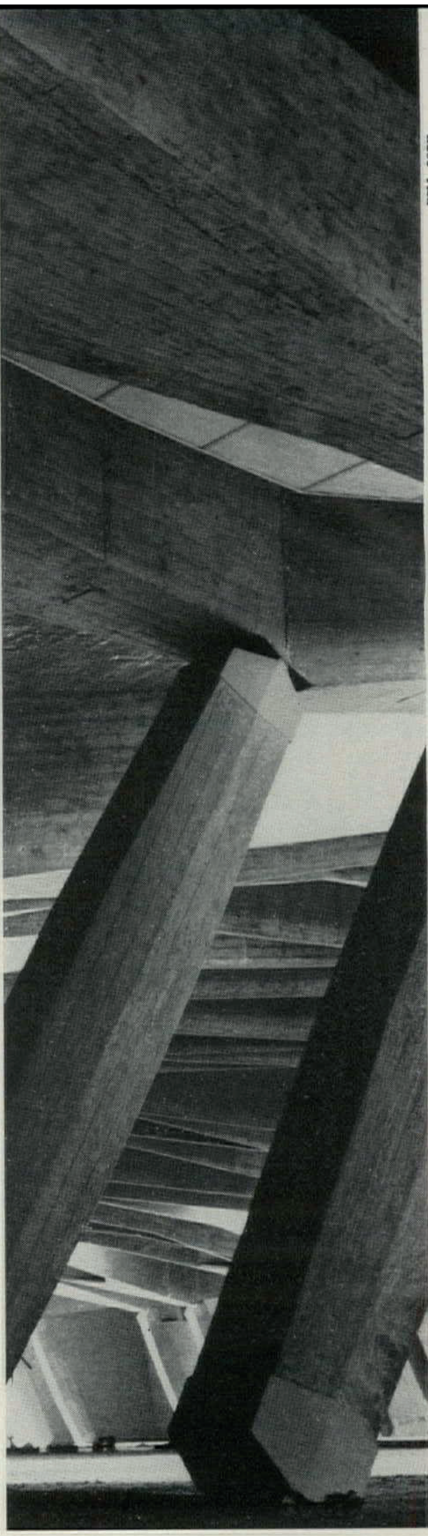
Four great pours

Here is one material—reinforced concrete—used to create four entirely different structural systems: a stand of gigantic columns, a huge, ribbed beam, a tension roof hung from pylons, and a matched set of vaults. The first two are enormous exhibition halls, the third is a great new airport terminal building, the last, a factory warehouse. The concrete may show its potential muscle or it may serve more to enclose the steel, but all have power, sweep, and scale enough to delight an imperial Roman.

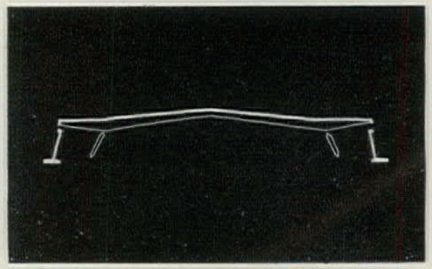
The exhibition halls are by modern Romans, Nervi and Morandi; the airport terminal is by the U.S.'s Eero Saarinen; the warehouse is by Mexico's Felix Candela. The technological significance is easy to see: the return of concrete as the confident spanner of great spaces.

In the U.S. the steel mills still dominate big building, in the current financial equation; but even here concrete has recently become a much hotter competitor. No longer is its surface left exposed with embarrassment. American architects, possibly influenced by what they have seen abroad, are beginning to convince clients of the possibilities of concrete. With theory advancing to help them, engineers are more willing to tackle unique problems; contractors are learning the tricks of formwork. Nevertheless, the steel men are not without consolation, for the resulting concrete buildings often have almost as much load-bearing steel inside the concrete as more admittedly steel buildings have.

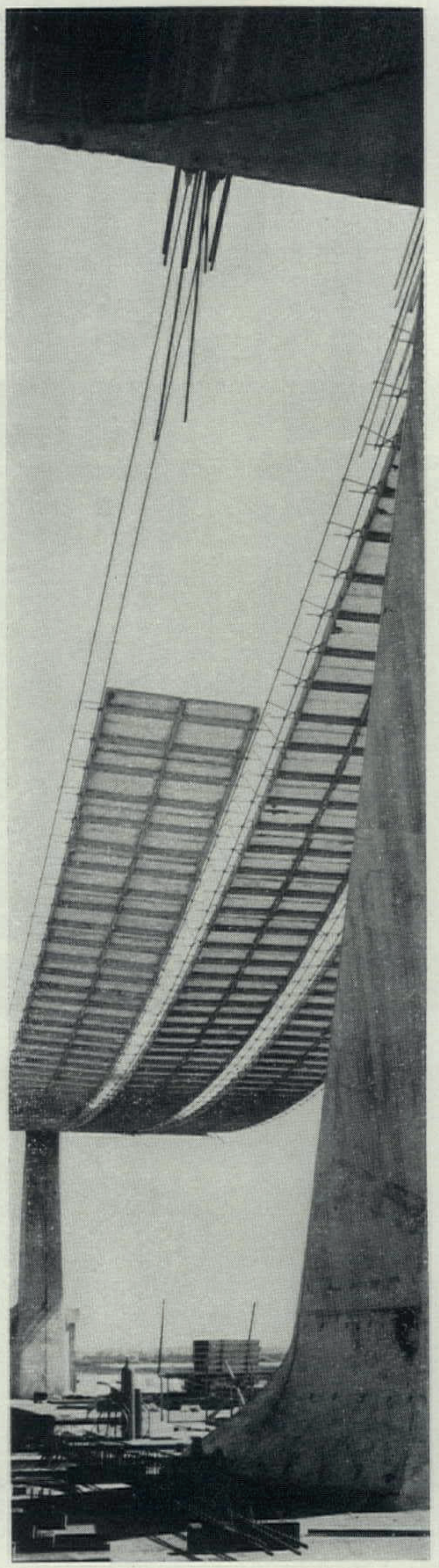
All four of these buildings exploit modern building technique and technology, although anything but modern production-line design. But there is an even sharper architectural significance. With concrete's rebirth, shape has returned to structure.



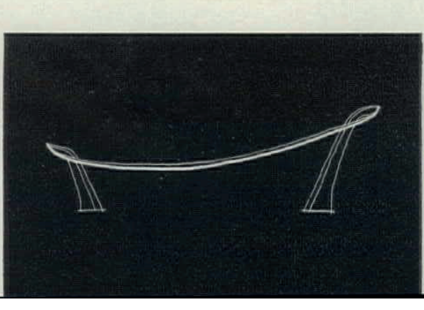
Morandi. *An Italian engineer, whose international reputation is just beginning to soar, builds an immense automobile exhibition hall in Turin (page 106).*

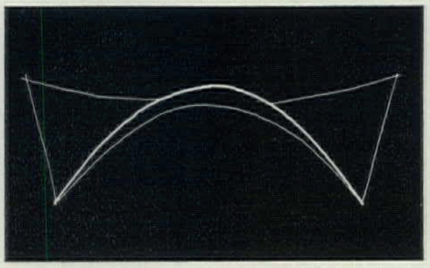


DAN PAGE



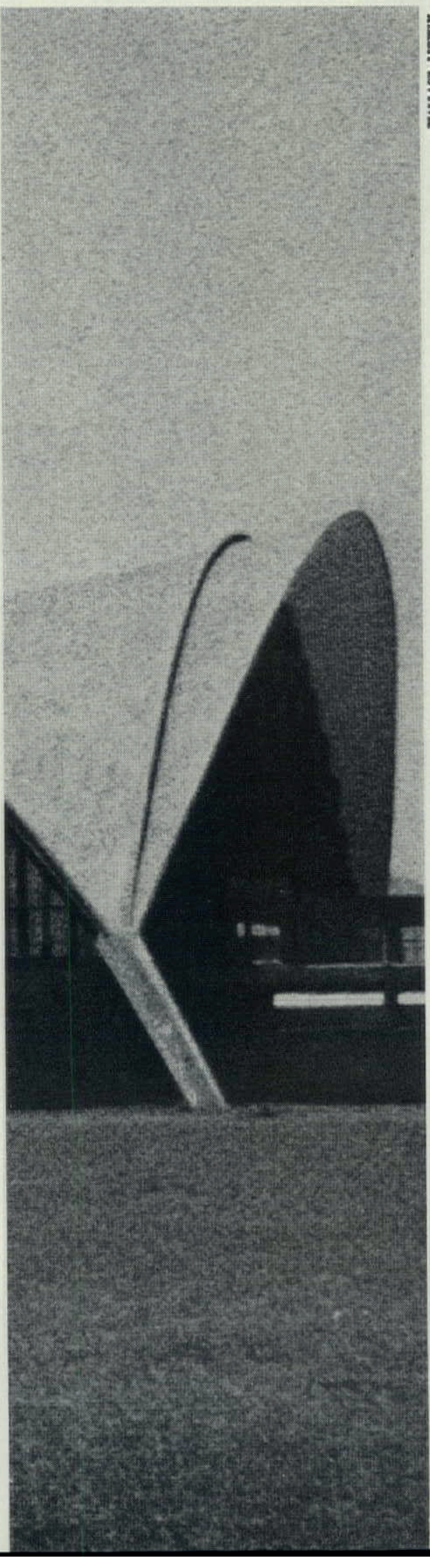
Saarinen. *With Engineers Ammann & Whitney, this U.S. architect slings a suspension roof over the terminal for a jet airport near Washington, D.C. (page 111).*

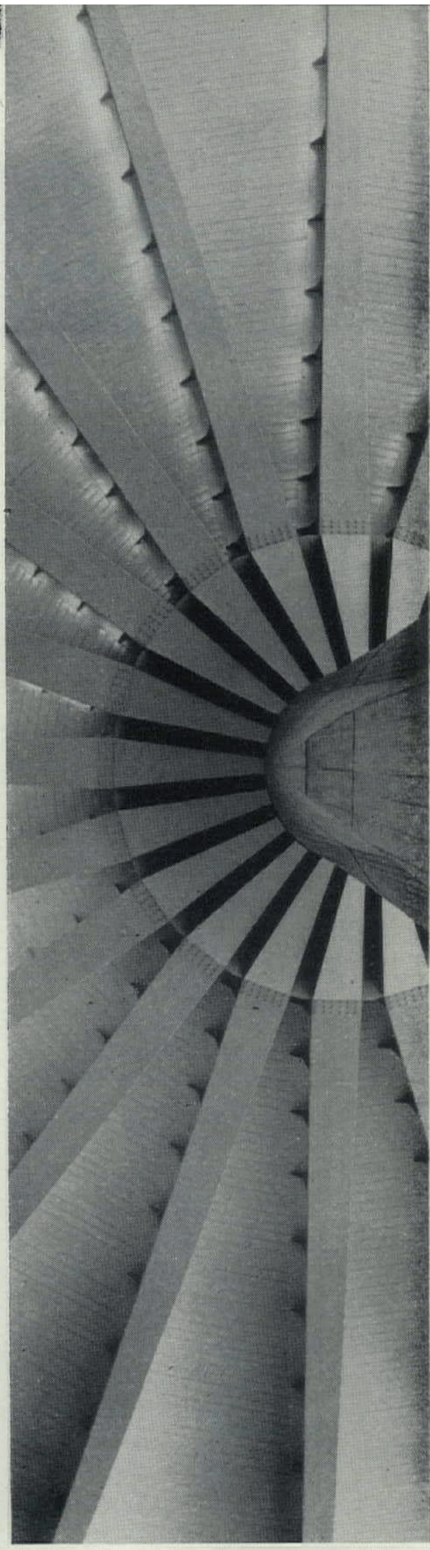




Candela. *In Mexico City the shrewd artist of thin-shell engineering designs and builds a rum warehouse for Bacardí de México, S.A. (page 108).*

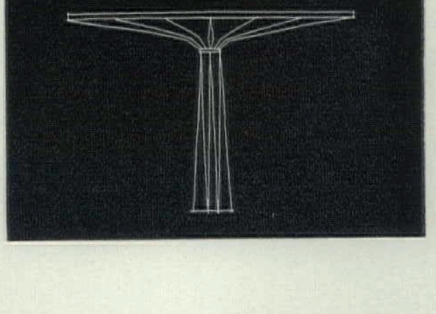
WALLACE LITWIN





ALEX LANGLEY—TIME

Nervi. *This prize-winning exhibition basilica in Turin is now complete, built immaculately as always by Nervi's own construction company (page 114).*



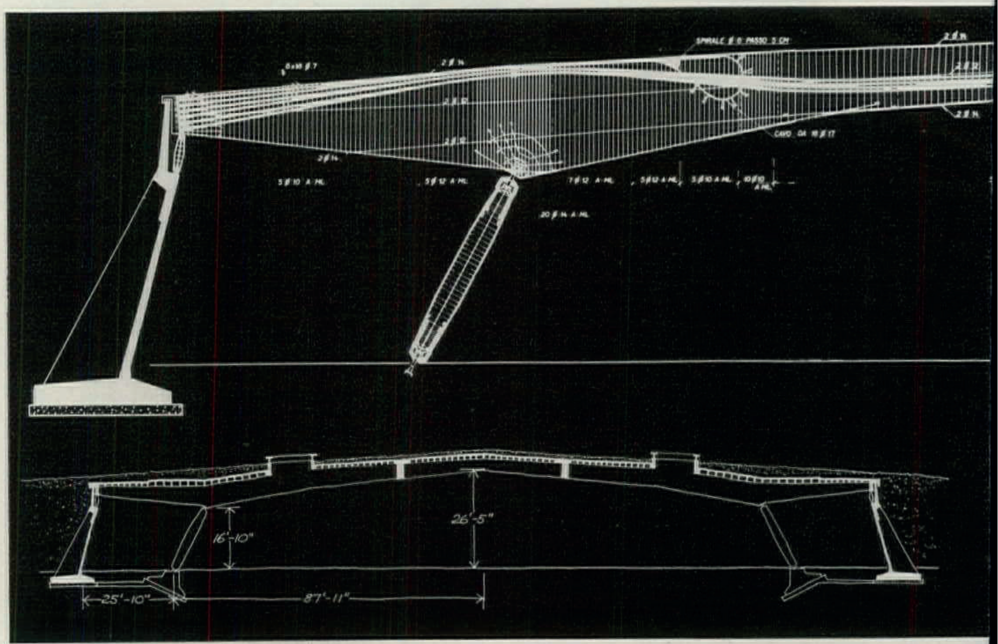
Morandi

Engineer Riccardo Morandi's pavilion for Turin's Annual Automobile Exhibition is directly across the street from Nervi's early postwar halls for the same purpose. But where the world-celebrated Nervi insists that form must develop inevitably from the material and methods chosen, the lesser-known Morandi states flatly he is a designer in structure—and proves it here in a way that is anything but flat.

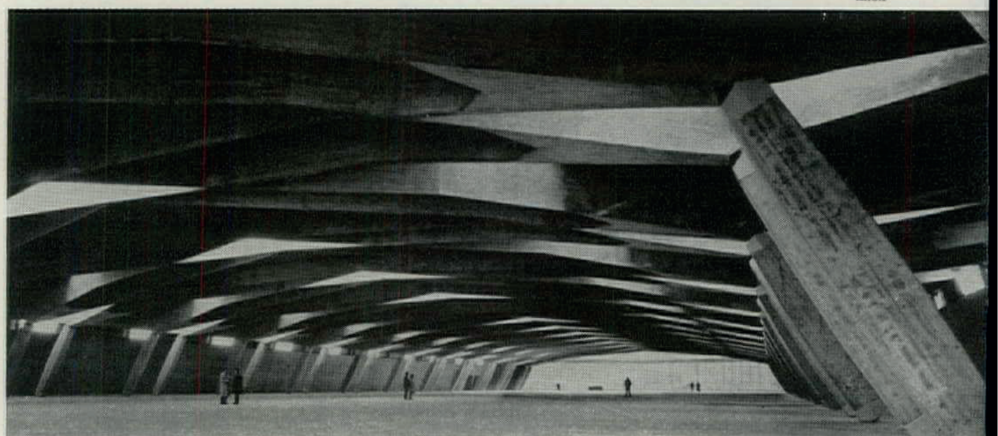
Morandi's career of calculating loads and expressing stresses dates back to 1927, when he graduated from engineering school in Rome. His outstanding works before completion of this immense exhibition hall have been bridges—concrete spans conceived with the same spareness as Maillart's. The exhibition hall shown here is also in essence a bridge.

Sunk into the earth of Turin's *Parco del Valentino,* with only its ends exposed, the hall has a clear span of 176 feet and is almost 500 feet long. In engineering terminology, it is an eight-hinged structure. This is, in reality, much simpler than it sounds. What Morandi has done is place a cast-in-place and post-tensioned roof on top of four parallel rows of supports; a small pair sits atop the retaining walls while a much larger, inner pair does almost all the supporting. As the supports are hinged at both ends to cope with the expansion and contraction due to temperature change, there are then eight rows of hinges (see sectional drawings). To prevent the structure from toppling over, Morandi has notched the ends of the roof over the top of the retaining wall at each side, thus allowing the weight of the earth against the retaining walls to provide the required lateral stability.

On a true bridge, Morandi might have run his beams straight across, but here he has laced them diagonally to gain lateral stability. As a result they are proportioned as leanly as knife blades with their bottom edges only about 5 inches wide. Large skylights divide the ceiling into bright and dim bays and shadow the elegant beams effectively at the same time. The building has been likened to the Gothic in effect; it has also been traced back to the famous Palace of Machines by Dutert and Contamin at the 1889 Paris Exhibition.



ARCA



Morandi's hall *is used as a skating rink, when not filled with gleaming Ferraris, Fiats, and Alfas. Right: view out from under the inner columns and across. Above: looking down the long way.*

UELI ROTH

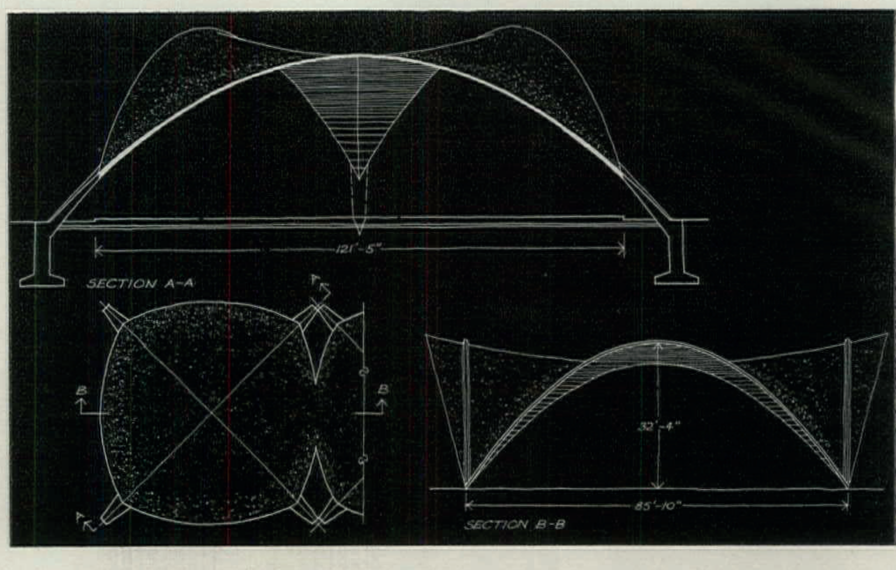
Candela

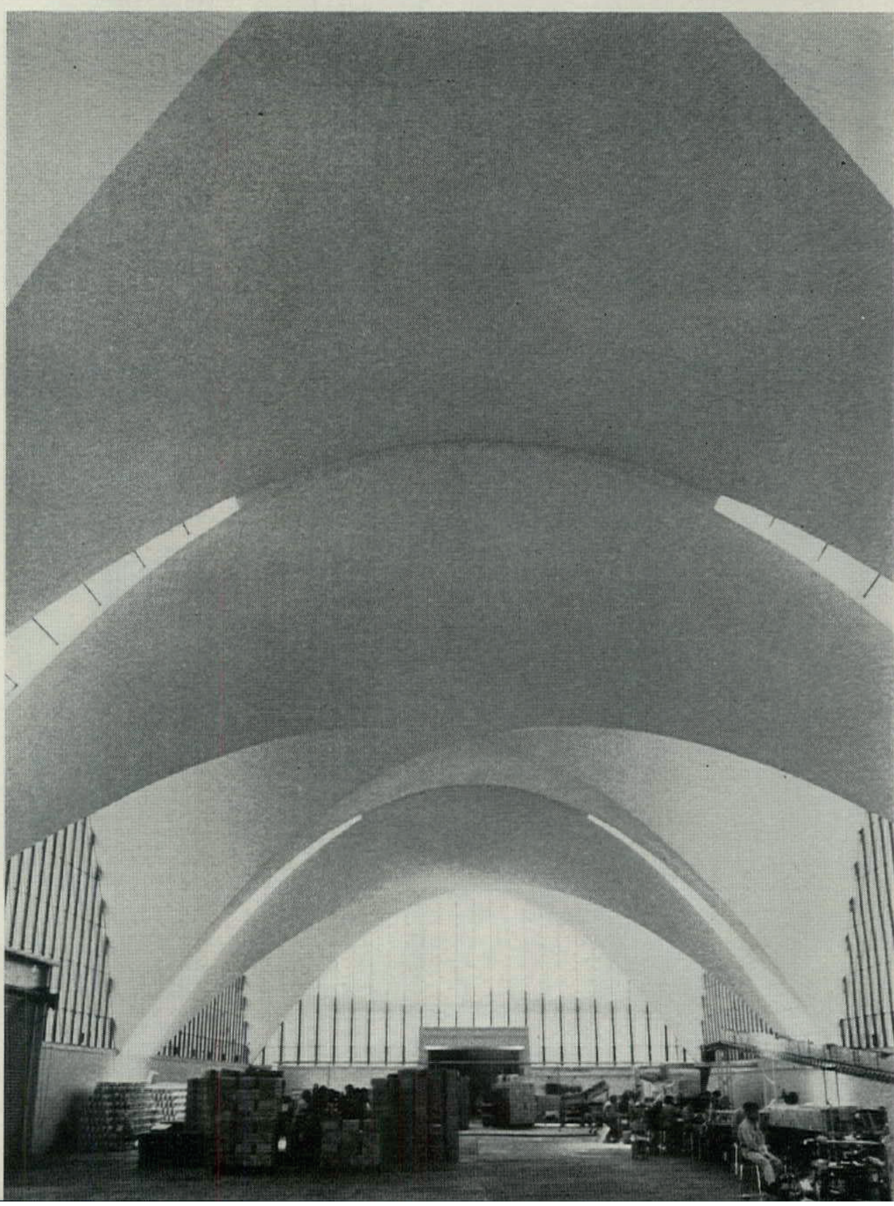
With Felix Candela *as medium, an ancient system is interpreted by modern mathematics. Drawings and photographs show hyperbolic paraboloids and parabolic curves, viewed from the inside and outside.*

Architect - Engineer - Contractor Felix Candela has recently completed the first third of a new warehouse in Mexico City for the Bacardi Rum people. (A less Latin and better known neighbor is Mies van der Rohe's adjacent administration building for the same client.) The warehouse is currently in use as a bottling plant, but it is easily capable of containing the massive distillation equipment itself. Two identical rows of three vaults each are to stand beside those seen here. When they are completed, one side wall of the present row will be removed and a great hall nearly 300 feet square will result.

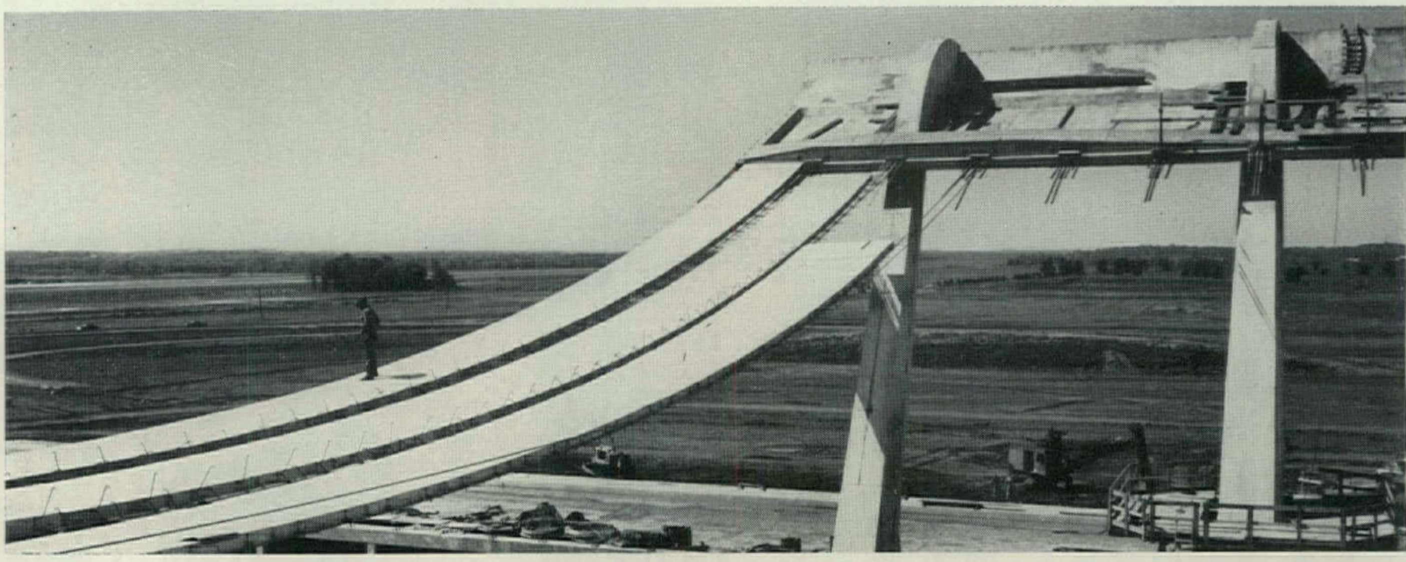
As Candela is the first to point out, the structure is in reality a contemporary version of one of the oldest known spanning systems: the groin vault. The Romans formed theirs by intersecting a pair of barrel vaults; Candela substitutes instead two hyperbolic paraboloids per unit. The result is, of course, double-curved surfaces in place of single-curved ones, but double-curved surfaces whose formwork can be constructed entirely of straight pieces of wood. The vaults frame over a square surface about 86 feet to a side. Loads are transmitted through the parabolic-sectioned groins and into the four buttressed legs upon which each unit rests. Diagonal underground ties between legs absorb outward thrusts leaving the foundation piers only vertical loads to carry. Since each unit is an independent structure, the resulting voids between units can become nonbearing walls of glass or skylights as the case may be.

The vaults are subjected only to membrane stresses, in which there is no bending, only pure, uniformly distributed tension or compression. Although Candela maintains the stresses are so low that, in theory, it is possible to eliminate the reinforcing steel altogether, he placed a ⅜-inch steel mesh to aid construction and to prevent cracking from temperature change. As a result, the thickness of the shells can be the bare workable minimum—in this case, an astonishing 1½ inches. Since there are no forces to resist at the free edges, these are without reinforcing ribs. Waterproofing is accomplished by means of a gold polyester paint. The interior is a warm off-white color.

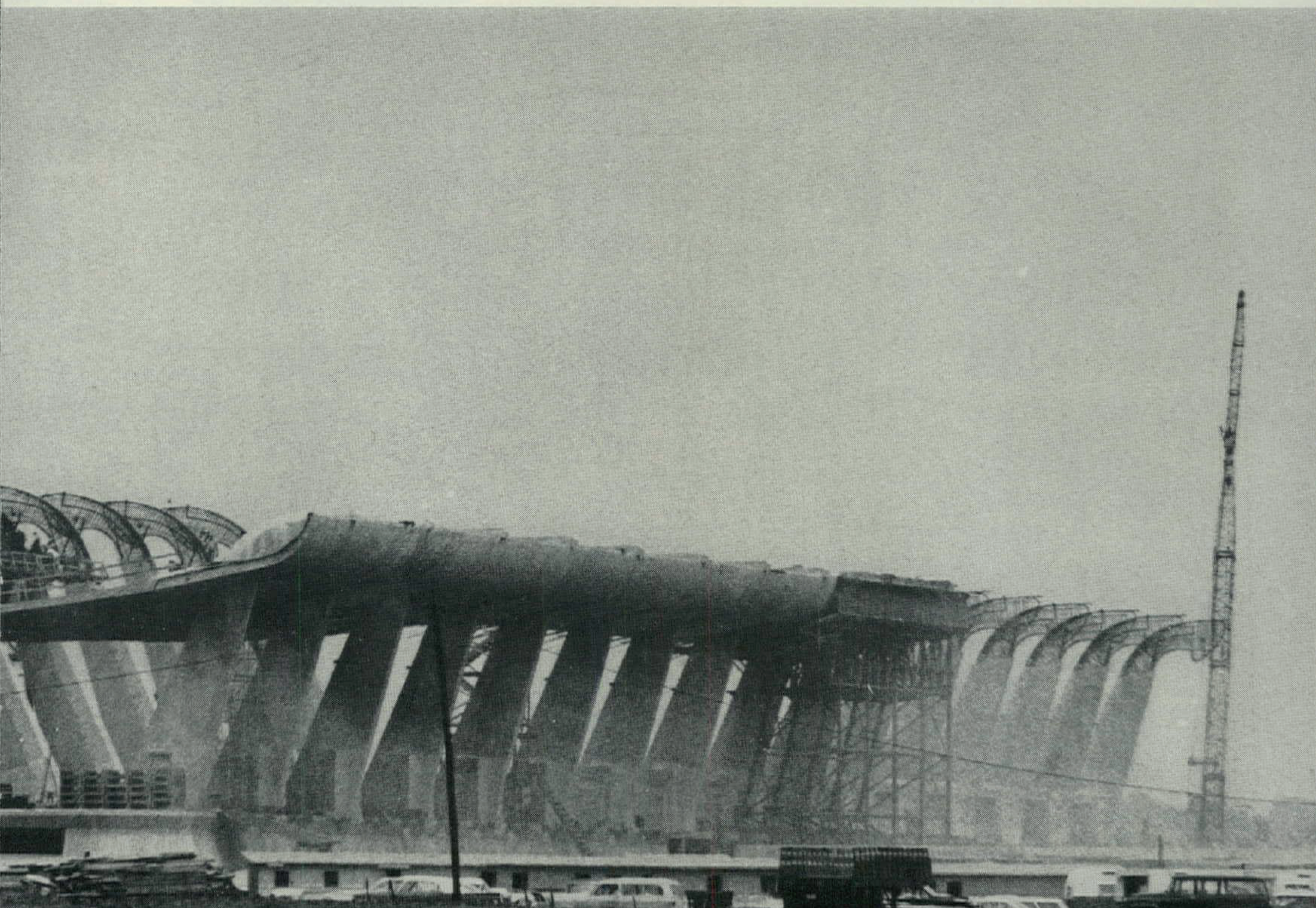


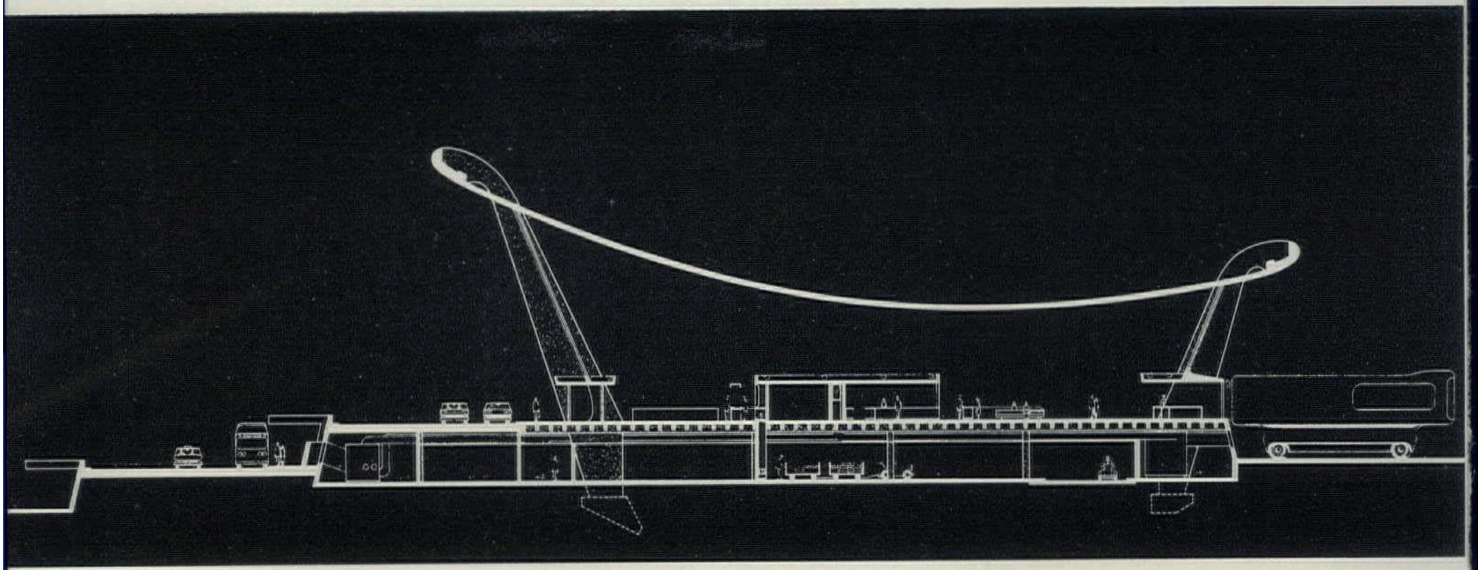


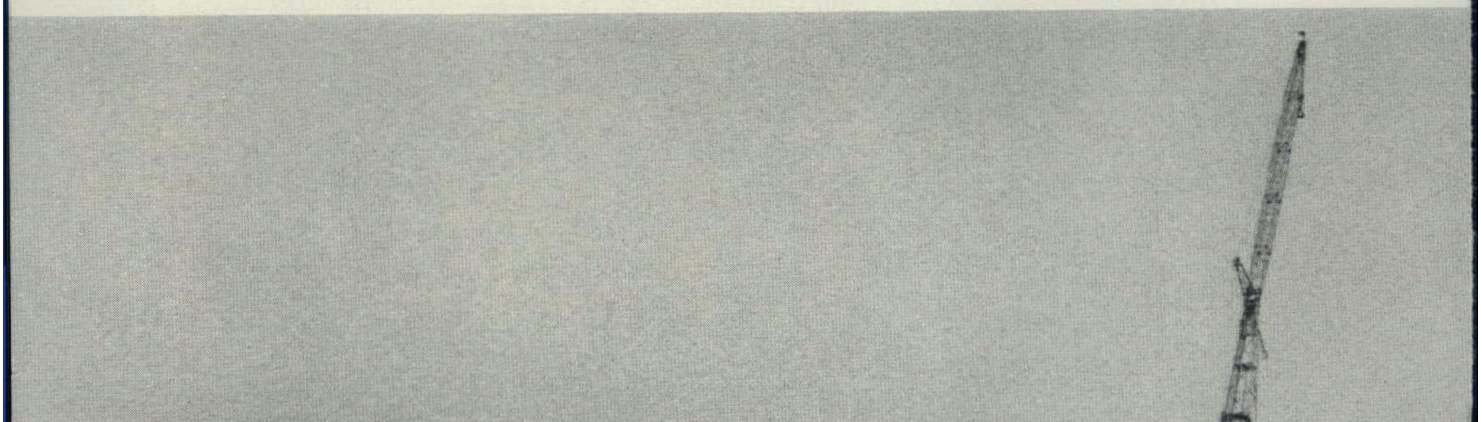
PHOTOS: WALLACE LITWIN

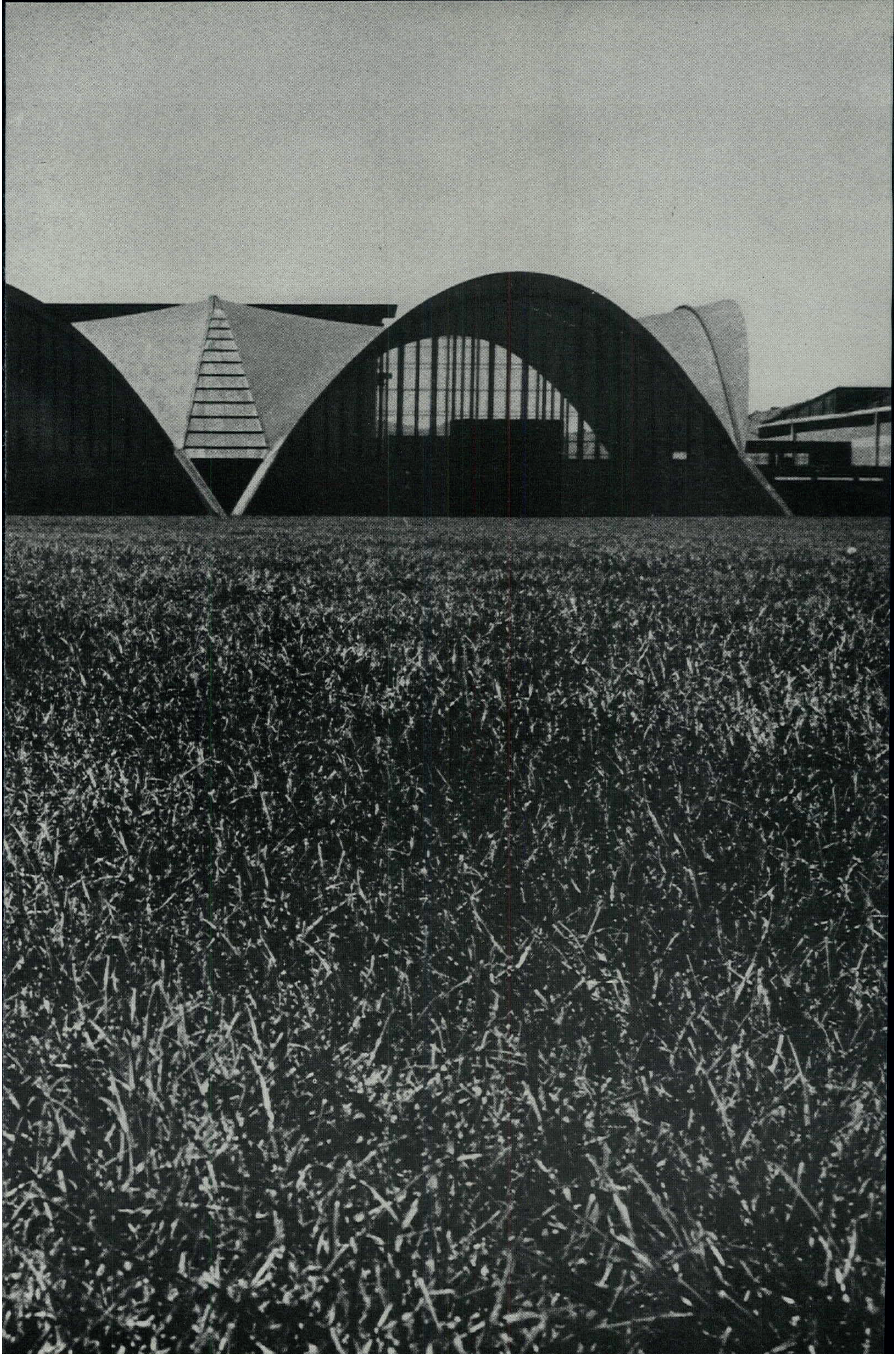


PHOTOS: DAN PAGE



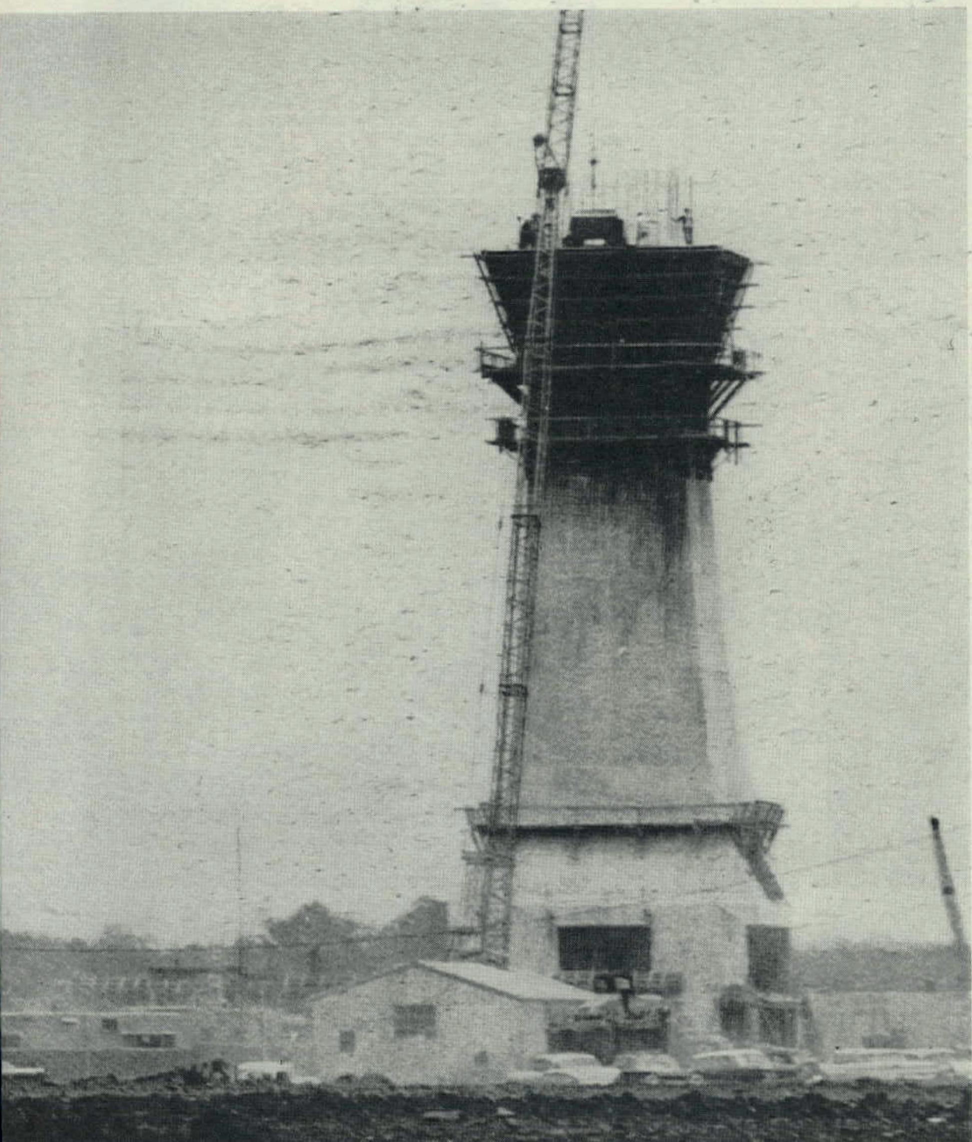






Saarinen

The suspension roof *(left) helps provide the "monumental but nonstatic design" Saarinen envisioned. Emplaning passengers enter mobile lounges on the lower side of the terminal. Below, the control tower under construction.*



For the terminal building at the Dulles International Airport, 23 miles west of Washington D.C. at Chantilly, Virginia, Architect Eero Saarinen and Engineers Ammann & Whitney devised one of the biggest hammocks of concrete ever suspended in the sun. Now it is almost constructed. The roof deck is in place, riding steel cables slung between two rows of immense leaning pylons which will define the terminal's long sides. When these photographs were taken recently, stiffening ribs were being poured with sandbags stacked to stress the cables to the proper curve. (In his earlier tension-roofed building, the Yale Hockey Rink, Saarinen used a different system. There, a flexible roof was stretched between a central arch and the walls on either side. See FORUM, Dec. '58.)

A roof slung like a suspension bridge is not a new idea; the Bedouins were doing it in the desert centuries ago with canvas. But today's buildings and building codes demand starch in the canvas, and this is the reason for the stiffening ribs. For if the wind sweeping over the curved plane at Dulles developed sufficient lift to flap the roof, the motion could destroy the structure, to say nothing of its designers.

The pouring of the stiffeners is a combination of complex computations and sweat. When one rib is completed, the crews heft the heavy sandbags over two stations being formed for pouring, and put them into place at the third. Before the concrete work is called complete the immense edge beam will be test-loaded—and that will mean a lot more sandbagging.

Everything at Dulles is conceived on a massive scale. The plot is 9,800 acres; total cost will be $175 million, without hangars. The terminal's pylons are 65 feet tall on the higher side of the terminal, 40 feet on the lower. Each of the 16 larger pylons has 20 tons of steel reinforcing rods in it. (A workman with a vibrator had to be put *inside* the metal cage of reinforcing when the pour of each commenced.) The terminal site is surrounded by completed runways and acres of neatly trimmed grass. Work is progressing fast, and the Federal Aviation Agency believes the first plane and passenger will meet here about May 1962. When opened, it will be—in terms of acreage—the country's largest airport. Temporarily.

Nervi

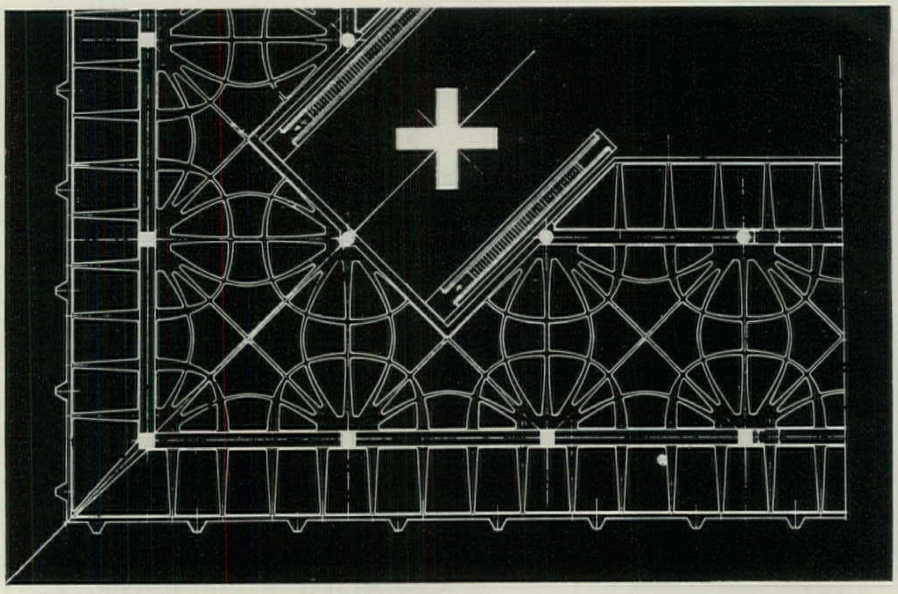
Of all the sights at this summer's celebration of Italy's century of unification in Turin, none is more imposing than the gigantic basilica produced by Pier Luigi Nervi to house the International Labor Exposition. It could hardly be otherwise, for this mute box some 525 feet square and 90 feet high covers an area greater than Saint Peter's and contains a space to inspire a Piranesi.

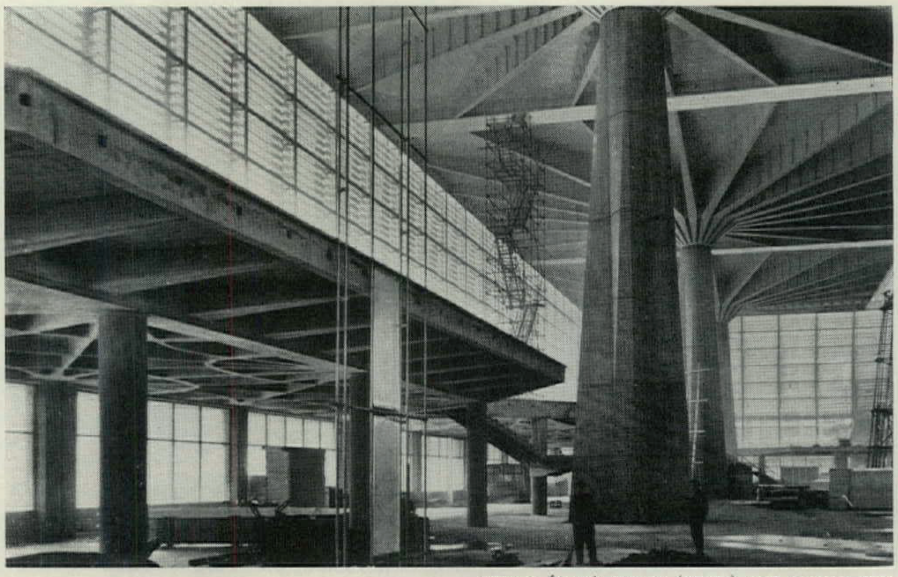
As winner of the competition held for this building (FORUM, May '60), Nervi here faced the largest enclosed structure in his career of large structures: a building to be erected in 17 months—including two winters—and one to be capable of conversion into an industrial school after its days of glory. He, therefore, rejected his usual soaring spans and precast units and chose instead a structural concept of monumental simplicity and great ease of erection. It consists of 16 entirely independent cruciform concrete columns, each tapering from 18 to 9 feet in an 82-foot run, and capped with prefabricated steel umbrellas. (Steel was chosen for speed of fabrication. Nervi maintains that, time aside, concrete would have been just as suitable.) A separate post and ribbed-slab balcony skirts the periphery. With actual erection times running eight days for each column and another 12 days to add the umbrella, the construction process was almost architectural sleight of hand. Son Antonio and Gino Covre (for the steelwork) were associated.

At least until October of this year, the interior is cut into 39-foot-high chunks of exhibition space by Pirelli Building Architect Gio Ponti. It can be argued that this arrangement adds scale to the proceedings by allowing only a few columns to be glimpsed at a time, but it does, in the process, obscure any over-all view of Mr. Nervi's magnificent conception.

Since Nervi's new palazzo contains a large part of the Centennial's modern exhibit, it is fitting that Guarino Guarini's Palazzo Carignano—where the unification was proclaimed—is the scene of the Historical Exhibit, for Guarini is Nervi's closest Renaissance counterpart. But Guarini's palazzo is also a nontypical work of its designer, so Turin has at least two reminders that the truly creative are beyond classification.

Louvers on three sides *make Nervi's building something of a surprise package. The building concept may be departure, but the balcony structure is standard Nervi. Note size of human figures.*





PHOTOS: (ABOVE) MOISIO; (OTHERS) ALEX LANGLEY—TIME