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Contents

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FRONT COVER: *Water tower at Orebro, Sweden (see page 28).*

FRONTISPIECE: *A new reinforced concrete footbridge fits admirably into its setting in private grounds. Bridge at Henbury, near Manchester, the property of Sir Vincent de Ferranti. Architect: Harry S. Fairhurst and Son. Designer-Contractor: Truscon Limited.*

ONCE AGAIN, we have had the exhilarating experience of a body of architects honouring a great engineer. After Professor Nervi's RIBA Gold Medal last May, we had, in November, the Architectural Association bringing Professor Torroja from Spain to lecture to a packed audience of young, and older, architects. His young audience was the more remarkable in that Torroja, pioneer of shell design thirty years ago, designer of the world-famous cantilevered hyperboloids of the Madrid racecourse, of the classic Fronton Recoletos, of the Algeciras dome, has had little of his more recent work published abroad. Indeed he has to some extent been cutting down its volume in favour of his other responsibilities—President of the International Association for Shell Structures, President of the International Federation of Prestressing, Head of the Central Laboratory for Testing Materials in Madrid, Director of Spain's Building Research Station (the Costillares laboratory designed by himself), as well as Professor of Civil Engineering at Madrid University. His most recent design work (it may surprise some who think of him mainly as a 'shell' man) has been dams, bridges, water towers.

All this gives some idea of the Professor's versatility—but none of his simplicity and self-effacing modesty. His talk at the AA was concerned with shells: there was something like reverence in his recurring references to Nervi's work, but he hardly mentioned his own.

He speaks fluent English, with a vocabulary remarkably sensitive to the subtleties of our language—though a discussion on the philosophy of aesthetics left him at last helplessly groping with expressive hands. The subject, though, shows something of the scope of the talk, which had ranged from the development of shells to the reasons for building them ("thin shells are very cheap") and the reactions of public opinion, which first clings to the familiar, then, needing change, seeks an artistic expression for the "something new" it wants, and finds Picasso; finds (he can even pun in English!) "*musique concrète*—and music in concrete".

Which came first, he was asked, the mathematics or the shape? "Hyperbolic paraboloids began because the calculation is very easy". On the other hand, many of his own shells started as ideas; "I try to make them nice-looking", and the mathematical expression of the surface came last. (The richly curving arches of the Costillares pergola may be "Bernoullian lemniscates with zero end curvature" but they are also lovely shapes!)

Other comments. Of folded plates, and curved forms generally: "Remember that these are all changed by angle and distance" and "each curve has its own personality". Then: "Art is a very difficult thing—more difficult than engineering!"

Throughout, the soft voice, the dry comment, the amused wry smile.

The architects are to be congratulated. Should not the engineers feel encouraged?—Encouraged, that is, to show a similar generous appreciation of their colleagues on the other side? Would it not be nice to see the Institutions of Civil and Structural Engineers doing honour to a great architect? It is not only the architects that have needed to broaden their vision; the undeniable *rapprochement* of today must be a two-way affair.

Form follows function in

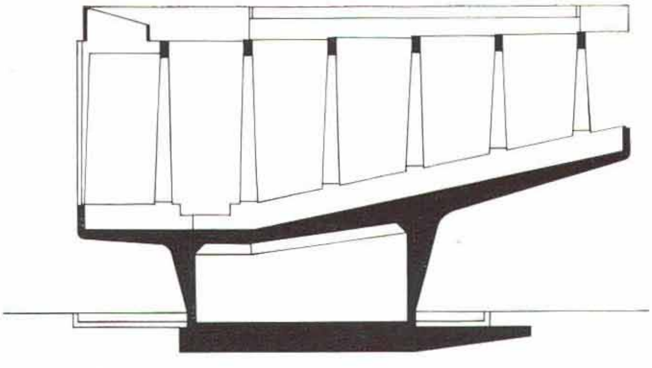
the new lecture theatre, Edinburgh University

PASSERS-BY IN MAYFIELD ROAD, EDINBURGH, may have been intrigued by the mystery box while it was under construction last year. The new lecture theatre for the engineering department of Edinburgh University is completely enclosed, a compact concrete box that cantilevers out its great, square chin; the neck is set back, the jaw projects defiantly. For the more discerning the mystery should by now be resolved, for the final shape of the box speaks plainly of its function. This lecture theatre, in fact, might almost owe something to contemporary trends in the design of good quality mass merchandise—it is exceedingly well packaged. Its outward form is a direct statement of the article enclosed.

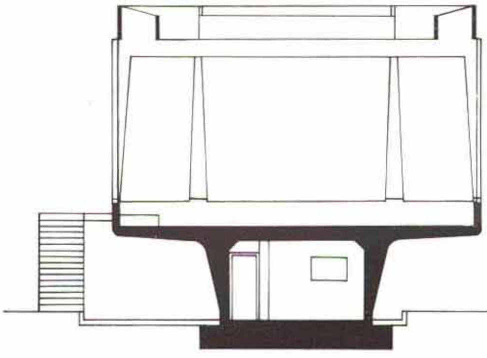
Recently completed extensions to the University's engineering department form a £250,000 scheme that approximately doubles the capacity of the Sanderson laboratories. Along with the lecture theatre, which will seat 200, a two-storey laboratory and drawing office unit, a five-storey reinforced concrete framed library and staff room block and a single-storey block of classrooms make up the scheme. From Mayfield Road the site rises to give fine views at the top to the Braid Hills and the Pentlands; its open character has been preserved by disposing the various buildings informally. The lecture theatre is at the lower end of the site and forms a focus for the whole development. It has been raised above ground so that its entrance level would correspond with the main floor level of the classrooms and laboratories and enable equipment for the demonstration purposes to be more easily transported. The concrete plinth upon which it is raised houses air-conditioning plant.

Main access to the theatre is on the north face, via a glass and steel-framed bridge that links it to the classroom block; secondary access is provided on the south face by an exterior in situ reinforced concrete stair that doubles as a fire escape and is in itself an attractive, strongly decorative feature.

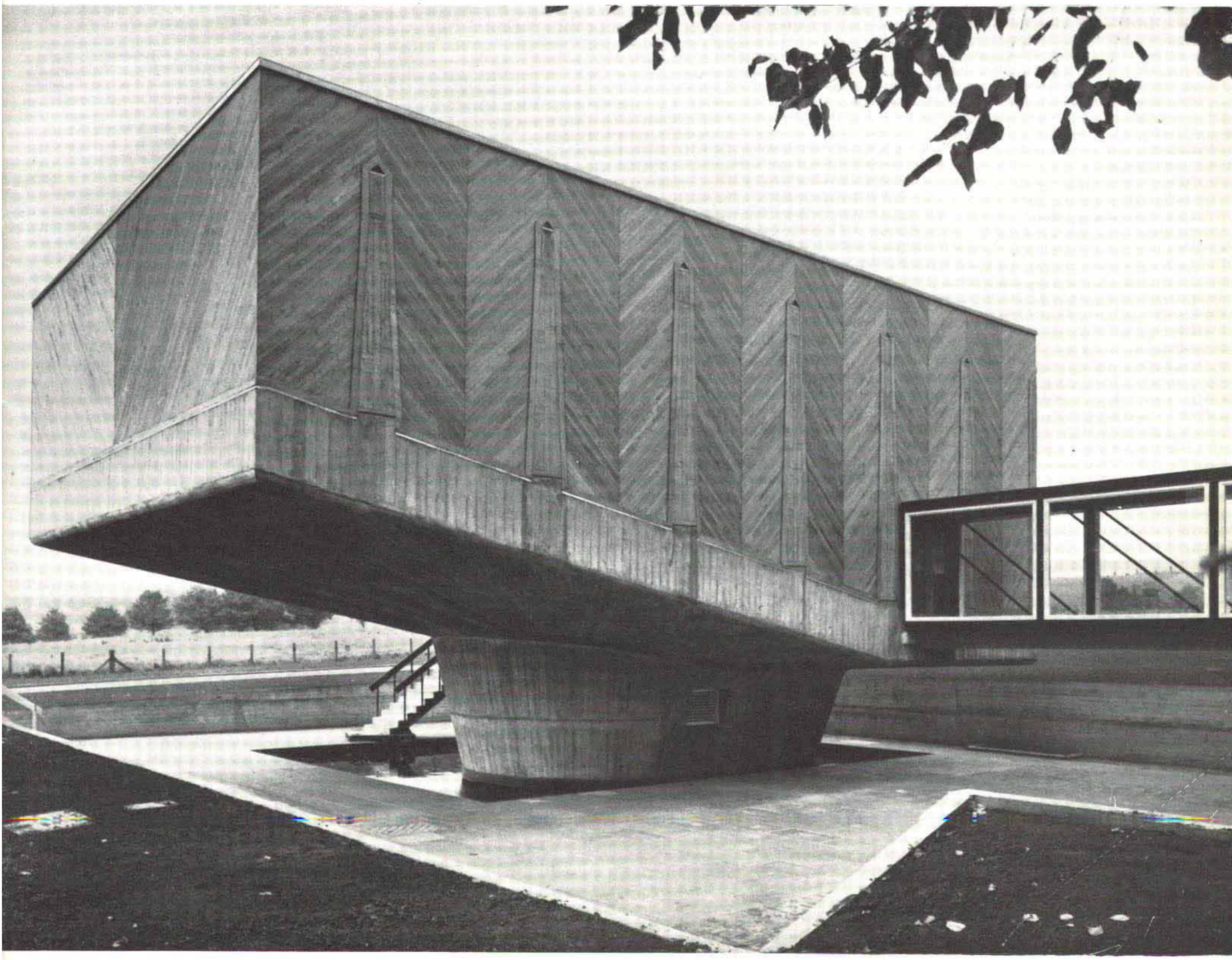
In designing the whole complex of buildings the architects decided that the basic structural system employed for each unit should be apparent to the engi-



Longitudinal section through the lecture theatre.

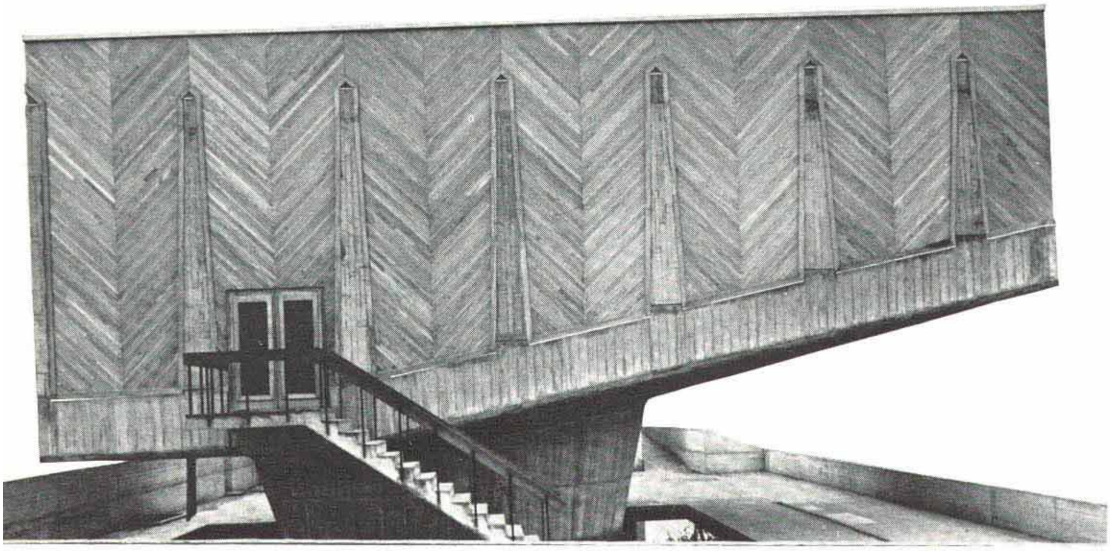


Transverse section.



The sunken court and the pool form a simple, effective setting for the new lecture theatre; the bridge at the right provides a link with the classroom block.

A lecturer's view of the interior. The projection box at the back has exploited its holes with an abstract relief treatment in plaster. The in situ concrete walls flanking the projection box, and the portal frame structure, are left untreated.



The south elevation, showing the strong, sculptured outline of the building.

neering students for whom they were built. Their architectural forms thus derive directly from their different structural systems. In the case of the lecture theatre all the structural members are of in situ reinforced concrete, the system consisting basically of a series of portal frames bearing on a floor slab cantilevered over the hollow, D-plan stem. There are six portal frames, of varying height, at 8 ft. 6 in. centres. Each spans 37 ft., with beams 11 in. wide and 21 in. deep carrying a timber roof structure. The legs of the portals have a two-way taper, varying from a section 9 in. wide by 21 in. thick at roof level to 21 in. wide by 9 in. thick, on the same axis, at pin level. Stiffening at the top of the frames is provided by a slender $4\frac{1}{2}$ in. wide beam on three sides. The beams are connected to rigid 9 in. by 9 in. posts at the corners of the western end of the building.

The 56 ft. $4\frac{1}{2}$ in. by 37 ft. 8 in. cantilevered floor slab tapers from a maximum root thickness of 30 in. to a constant thickness of 12 in. at the extreme edges, and slopes from a maximum height of 16 ft. above the level of the surrounding court to a minimum of approximately 8 ft. Round the slab perimeter a 9 in. wide by 30 in. high reinforced concrete upstand carries the reactions from the portal frames.

The plinth that carries this structure and houses the ventilation equipment has walls of 12 in. thickness at foundation level with a constant batter to the external face, giving a maximum thickness of 30 in. where they are joined by the cantilevered slab. The foundation itself is a 35 ft. by 19 ft. 6 in. concrete slab that was designed to restrict the maximum bearing pressure to $1\frac{1}{2}$ tons per square foot.

Externally and internally the structure speaks independently. Much of the concrete is left as it came from the forms, with the formwork carefully contrived to produce distinct patterns—vertical on the plinth and the 30 in. upstand around the floor slab and radial on the raking underside of the theatre. The end walls and infill panels between the frame members are sheathed in a light, red-brown Doussie boarding. Inside, acoustic considerations necessitated the introduction of side panels of wood between the portal legs, and wood panelling behind the platform. The side panels are penetrated with slits, a patterned effect resulting from direct acoustic calculations. A plaster ceiling reflector suspended above the platform helps to direct sound towards the back of the room. The demonstration bench is a raw concrete block that rises from structural concrete below the maplewood floor with both an apparent and an actual solidity.

In lighting the interior, reliance has been placed on artificial light rather than natural. Maximum enclosure ensures minimum heat loss, with good insulation from exterior traffic and considerable convenience in the showing of films and slides. Daylighting has therefore been limited to roof lights—over the platform and aisles—which can be blacked out easily by mechanical means.

The lecture theatre has been set in a sunken court, and a shallow pool round the plinth adds a play of light to the concrete surfaces when the weather is good. When it rains the rainwater from the roof discharges into the pool and adds, it is claimed, to the ripple reflections.

Taken either as a whole or as part of the scheme, this is a splendid, well-considered building. The detailing is good throughout, and the design is unified. It is difficult to imagine a material other than in situ concrete with which the architect could have achieved this particular and wholly commendable fluidity and integrity of form.

The architect was Professor R. Gardner-Medwin, F.R.I.B.A., M.T.P.I., in association with Stephenson, Young and Partners. The structural engineering consultants were Blyth and Blyth and the main contractors Cruden's Limited.

A new luxury hotel for London

is concrete-built throughout

THE TALL LUXURY HOTEL has made its first appearance on the London scene. Others will follow—in Park Lane and on the South Bank—but meanwhile we have a foretaste of this special kind of building in the Carlton Tower Hotel, which rises high over the plane trees of Cadogan Place.

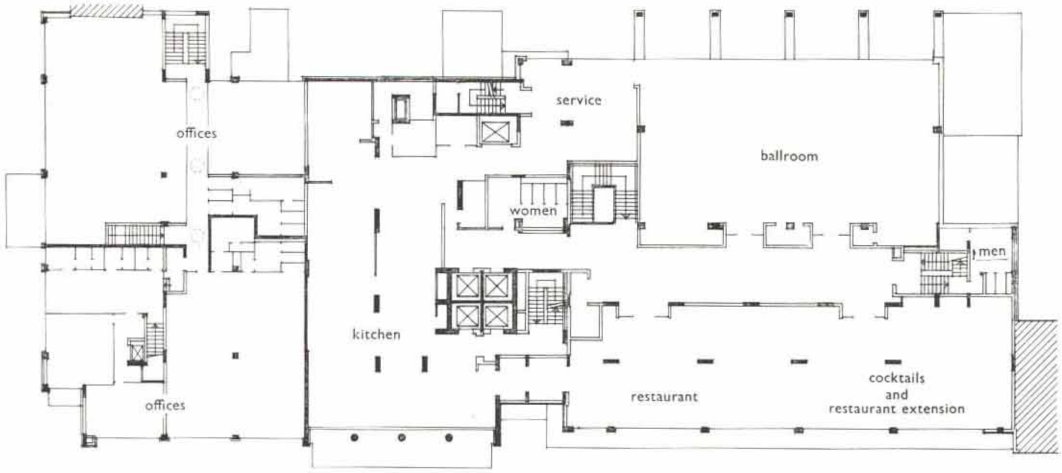
The area which it dominates is that well-known and discreetly expensive residential quarter between Belgrave Square and Knightsbridge: an area of miscellaneous Georgian and Victorian domestic architecture, some of it simple and restrained, and some of it heavily encrusted with late Victorian ornament. At all events, none of it is much higher than five or six storeys, which makes the sudden impact of the Carlton Tower Hotel, with its eighteen-storey tower, all the greater. The tower is 200 ft. high—about the same height as the Monument and also the new tower at Notting Hill Gate.

The hotel, which has just been opened, is operated by the Hotel Corporation of Great Britain Limited (a wholly owned subsidiary of the Hotel Corporation of America), and should do much to improve our stock with visitors from abroad. For big hotels have suddenly become big business in London, and the high standards set by modern hotels in other capital cities of the world must be maintained over here if our tourist trade is not to suffer.

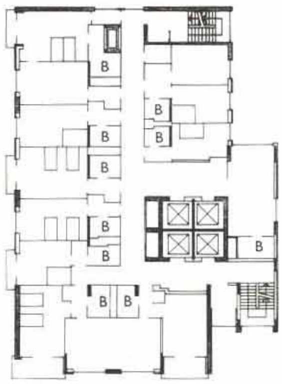
Accommodation offered amounts to 213 double bedrooms, 59 single bedrooms, and 37 sitting rooms which can be linked in various ways with the bedrooms to give 66 possible combinations of suites; all the rooms have private bathrooms, showers and television. In addition there are spacious air-conditioned public rooms in the lower two floors. At ground floor level the main entrance opens direct into a large reception lounge with a bar and restaurant to one side—the latter will be known as the 'Rib Room', specializing in "prime ribs of beef". At first floor level there is another large

The hotel viewed from the gardens of Cadogan Place.

A NEW LUXURY HOTEL FOR LONDON: *continued*



Above: 1st floor plan. Right: Plan of 14th and 16th floors.



restaurant and cocktail bar with windows overlooking the lawns of Cadogan Place. The restaurant is linked with extensive kitchens on one side, and at the rear with the ballroom where public functions and banquets will be held. Parking space is provided in the basement garage and at ground floor level, adjoining the mews at the back.

The building can be considered as three separate blocks with expansion joints between. The tower block, of course, dominates the other two and is rectangular on plan with its eighteen storeys set over basements on two levels; most of the suites and bedrooms are housed in this block. A ten-storey block over a basement extends on the east side of the tower and contains more bedrooms, the main reception lounge, and the first-floor restaurant and ballroom, whilst a small three-storey block on the west side, forming the corner between Cadogan Place and Sloane Street, contains Coutts Bank, which has been rehoused on its original site. The floors are linked by a range of four lifts rising through the centre of the tower.

The tower block rests on foundations taken down 70 ft. into London clay. Deep cylindrical shafts were bored, the bases enlarged to a bell shape and mass concrete placed to form a series of piers. These have shaft diameters of up to 7 ft., whilst the bases extend to as much as 15 ft. The heaviest load carried in this building on one pier is 1,050 tons.

The building has an in situ reinforced concrete frame which was specially designed to fit in with planning requirements as far as possible. Instead of the more usual rigid grid of columns, vertical support is provided internally by sections of walling usually 7 in. thick; externally, columns are placed within the thickness of the walls. In this way the structure has been designed to suit the planning, rather than the other way round. All the beams are contained within the 9 in. thickness of the reinforced concrete floor slabs; soffits throughout the building are therefore flush. The walls surrounding the central lift shaft are also of reinforced concrete and give stability to the tower block. Partitions are constructed of lightweight concrete blocks.

Prestressing has been used over the larger spans in the ballroom, where beams prestressed on the Freyssinet system span 53 ft. and support loads of 100 tons each.

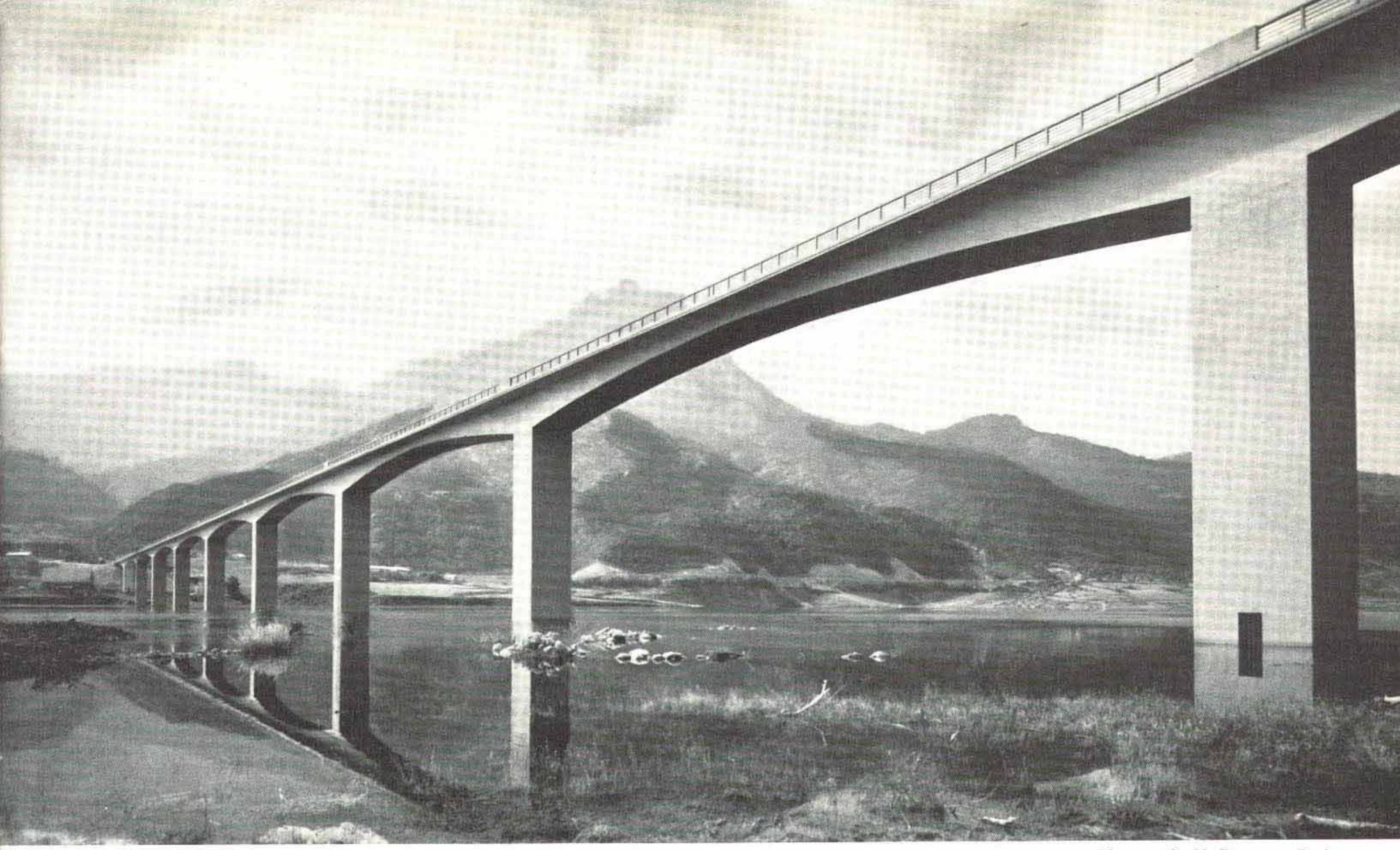
Provision has been made for extending the tower and east blocks at the rear of the building and for placing an extra floor on the small west block.

The main elevations have been treated in a fairly restrained manner, with the solids balancing the voids, much as they do in the surrounding buildings. External cladding is of Portland stone, except in the lower parts at the rear of the building where light buff brick has been used. The regularity of the window treatment is broken up with projecting balconies faced with opaque glass.

Internally, wood veneers and marble floors play an important part in the reception areas, whilst the bedrooms are simply treated, with plastered and papered walls in colour schemes of light grey and gold. Bathrooms have ceramic tiles of either grey or pale yellow.

The construction of the building, which is over 2,000,000 cu. ft. in content, was finished in eighteen months from the time when work actually started on the site—six months ahead of schedule.

The architect for the hotel was Michael Rosenauer, F.R.I.B.A., A.I.A. The structural design was carried out by Sir Robert McAlpine and Sons Limited, who were also the contractors.



Photograph: H. Baranger, Paris

Savines bridge, in the Provence Alps

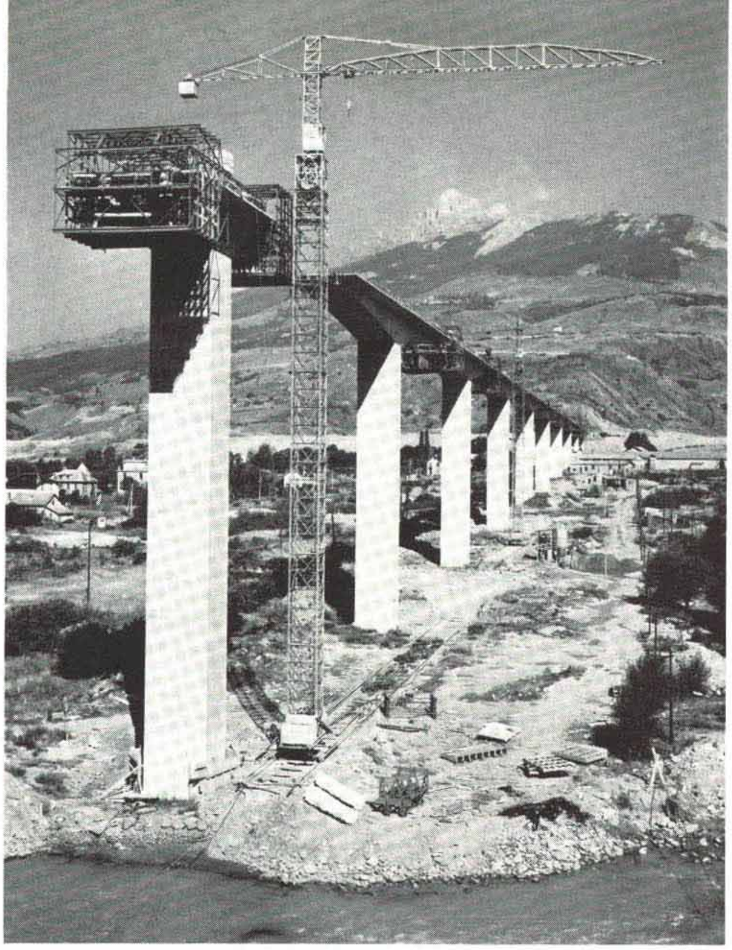
RISING IN THE SNOW-CLAD heights of the Alpes Maritimes, the river Durance flows down through the bare Provençal Alps, so beloved of Cezanne, to join the Rhône at Avignon—a glorious river course. One of the world's most notable prestressed concrete bridges has now been set against this magnificent background—the long, high Savines bridge which carries Route Nationale 94 across the Durance and its valley.

The dam at Serre-Ponçon in the Durance valley necessitated considerable alterations to the existing roads, and also the building of four structures, of which the Savines bridge is the most important. The great length of the bridge—over half a mile—was determined chiefly on economic grounds, as it proved cheaper to extend the bridge and reduce the amount of tortuous road-building on embankment which would otherwise have been necessary.

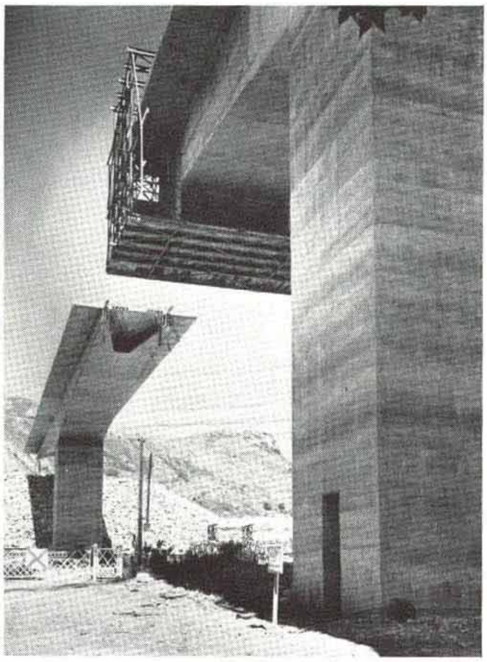
The bridge has eleven 253 ft. spans, with a half span at either side; the length of span was largely dictated by the fact that the river had to be crossed in one span. The 30 ft. wide roadway is carried 160 ft. above the valley floor on a hollow prestressed box beam, supported by thirteen hollow prestressed concrete piers.

The bridge was built by the balanced cantilever method, with mobile cantilever scaffolding used to carry the beam forms. It is believed to be the longest and highest bridge so far constructed in this way. The cantilevers are balanced on each column to form a T-shape, and each span consists of two cantilever arms jointed in the middle. The single cantilever end spans are each supported on a column. The load on the abutments is thus very light and massive abutments are not necessary.

Indeed, in spite of the size of this major bridge, its good proportions prevent it from appearing massive and the slender structural sections obtained through prestressing give a general appearance that is light and clear-cut. The tall hollow columns are 16 ft. 5 in. square, with walls 1 ft. 4 in. thick; the vertical cables used to prestress the columns are placed in these walls and anchored in anchorage blocks at the bases of the columns. The two tallest columns, 141 ft., on either side of the river, are founded on reinforced concrete caissons sunk to rock level. The caissons are filled with mass concrete, and have at the top a 10 ft. deep reinforced concrete slab which acts as the anchorage block for the



Left: the bridge under construction, showing the mobile scaffolding, and the tower cranes in operation. Below: a completed cantilever, with the mobile scaffolding in position on the other half of the span. Photographs: H. Baranger, Paris.



prestressing cables. The other columns, not subject to possible erosion from the river, rest on concrete footings set in the alluvial floor of the valley.

The beam and deck are remarkably slender for a bridge of this size. The top of the 16 ft. 6 in.-wide box beam is only 7 in. thick; it forms the deck slab, which also cantilevers 6 ft. 9 in. either side of the beam. The side walls of the beam have a uniform thickness of 1 ft. 4 in., while the bottom flange tapers in thickness from 1 ft. 6 in. at the column to 7 in. at the centre of each span. The beam's depth varies from 14 ft. at the columns to only 3 ft. 9 in. at the centre of the span, the two cantilever arms uniting to form a gracefully curved soffit arch with a radius of curvature of 313 yards. The bottom flange is cut out in trapezoidal form for a distance of 25 ft. from the end of the cantilever, in view of the very slight compression in the concrete in this area. The beam is filled with mass concrete for a length of 16 ft. 5 in. over the column head and a cross-wall of reinforced concrete 12 in. thick unites the two side walls 18 in. from the end of the cantilever. The two cantilevers are joined in the centre of the span by a steel ball-and-socket joint.

The construction of this bridge has taken just under a year—well under the scheduled time. This speed is largely attributable to the cantilever method of construction, in which the mobile scaffolding moves the formwork forward as fast as the concrete can be placed, cured, and prestressed.

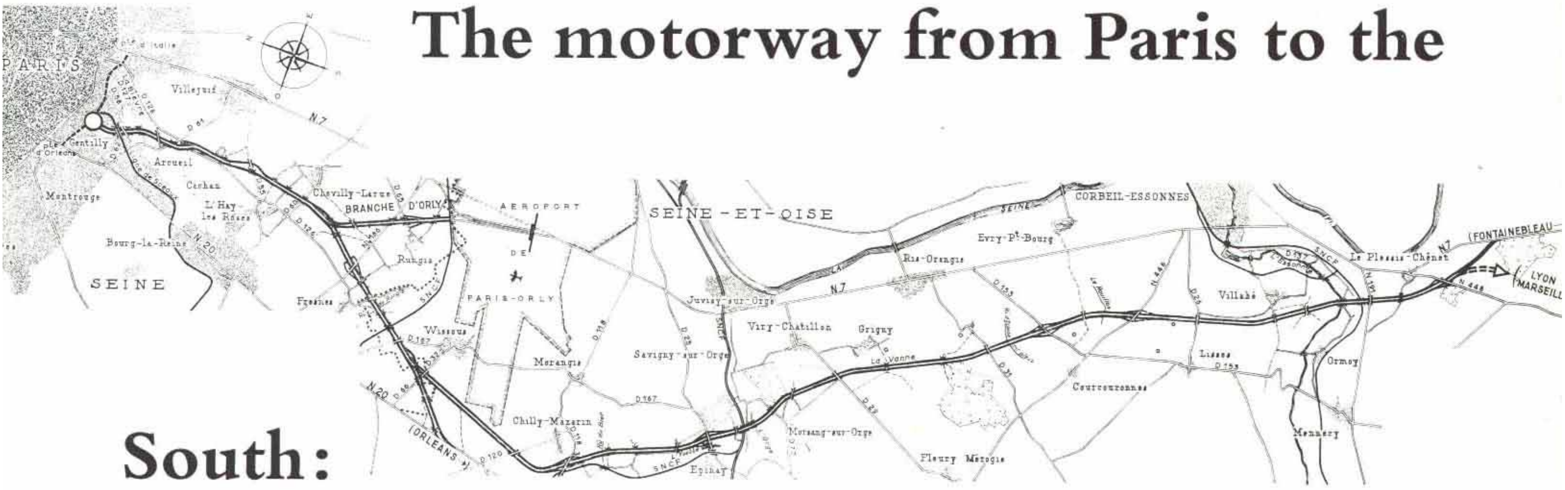
The steel scaffolding fits round the beam, and has a tail-piece that extends back about 25 ft. along it. This tail section runs on rails on top of the beam, and has a 35 ton counterweight at the rear end to balance the concrete in the forms.

The columns were constructed with sliding forms. After a column had been built the part of the beam directly over it and extending 8 ft. 5 in. either side was concreted and prestressed; formwork attached to the column was used. The mobile scaffolding was then attached to these embryo cantilevers, and the beams built out symmetrically in 11 ft. 7 in. sections. After each pair of balanced sections had been concreted, cured, and prestressed, the scaffolding was moved, and the operation repeated—nine times in all—until the cantilevers were within 4 ft. 9 in. of each other. This last section is in reinforced concrete. Concrete was mixed at several points along the line of the bridge, and raised to the forms by tower cranes.

In all, seventy-two cables of varying lengths, each made up of seven 7-wire strands, were used in the prestressing of the beams. As each 11 ft. 7 in. section was completed, eight of the cables were stopped off and anchored, and this continued progressively until prestressing was complete. Transverse reinforcement consisted of 'Tor' twisted steel bars.

The Savines bridge was designed by the Société d'Etudes et d'Equipements d'Entreprises, and built by the Société des Grands Travaux de Marseille.

The motorway from Paris to the South:



France's new concrete motorway

FRANCE'S WELL-KNOWN CONCRETE MOTORWAY from Paris to the west has been in use for a good twenty years. Now the city is served by another new concrete motorway, the first section of 'l'Autoroute du Sud' to Marseilles, which was opened on 12th April by the French Minister of Transport, Monsieur Buron. A detailed account of this new motorway was given to the Pavings Development Group (Concrete and Soil-cement) by Monsieur Gilbert Dreyfus, Ingénieur-en-chef des Ponts et Chaussées, at a meeting held at the Royal Commonwealth Society on 21st October.

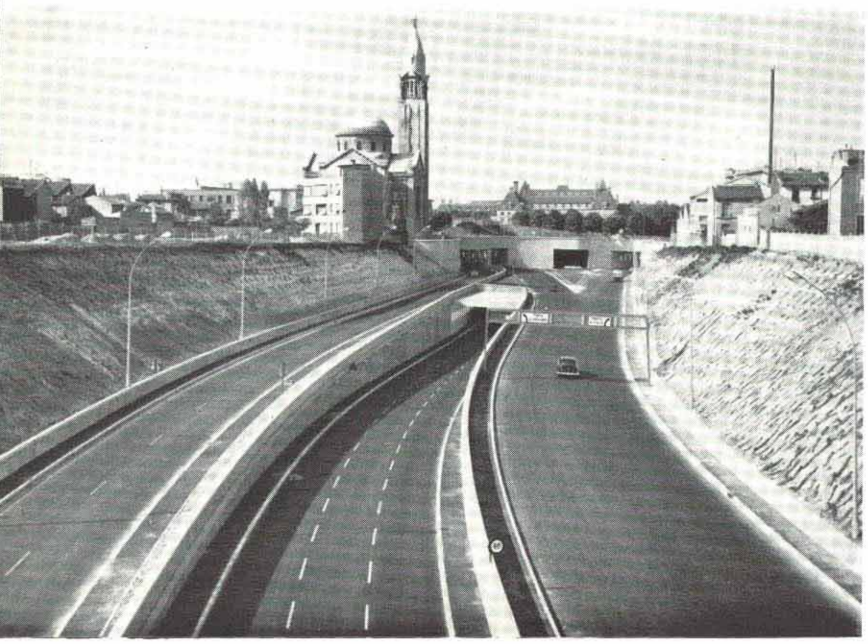
The motorway was included in the pre-war Regional Development plan for Paris, but its route was only definitely fixed in the modification of that plan which was approved by decree on 19th December, 1952. The two radial Routes Nationales leading to the south—R.N.7, the road to Fontainebleau and European artery E.1, and R.N.20, the road to Orleans—had become wholly inadequate to meet the increasing traffic, and it was therefore decided to take the long-distance traffic, and also that for the airport at Orly, along a motorway running between these two roads, keeping the R.N.7 and R.N.20 solely for local traffic. On this basis traffic on the motorway was expected to be about 40,000 vehicles per day, rising to 50,000 in the near future.

The present section of the motorway is twenty-five miles long and has seventy major bridge structures on its route. A three-level intersection marks its start on the Ring Boulevard in Paris, near the Cité Universitaire church, and will ultimately connect it with the Place Denfert-Rochereau. After crossing the Bièvre valley at Arcueil the motorway sweeps west of Orly, with a three-mile spur leading to the airport. At Wissous, ten miles along the route, another short spur joins R.N.20, and the main route continues to join R.N.7 at Fontainebleau, whence the motorway will eventually be continued towards Lyons.

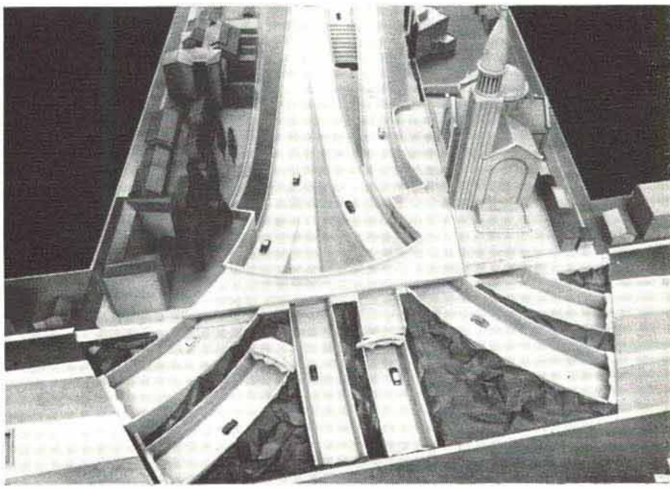
The six-mile section between Paris and Orly has dual carriageways 33 ft. 6 in. wide, a 15 ft.-wide central reservation, and 11 ft.-wide verges. South of Orly, and on the spur roads, the carriageway widths are reduced to 25 ft., with two instead of three lanes; the central reservation is 13 ft. wide and the verges 14 ft. wide. The design speed is sixty miles per hour, the minimum radius of curvature is generally 650 yd., except at forks and intersections, and the maximum gradient generally 4 per cent.

There are eight intersections, excluding the terminal intersections, connecting the motorway with other roads. On the three nearest to Paris no access or exit is permitted to the Paris traffic, as the purpose of these intersections is to act as a link for local traffic. On the two furthest from Paris, however, only Paris traffic is allowed on and off; the three middle intersections are open to all traffic. Of the terminal intersections, the Orly branch joins on to the airport approach: the junction with R.N.20 is a grade-separated fork junction—its construction graphically described by the French as a 'saut de mouton'—a sheep's leap! The junction with R.N.7 is on the level and the motorway will carry on through it when extended further.

Except for about a mile-and-a-half of bituminous surfacing, the whole motorway is constructed in concrete, with a concrete running surface. The design varies slightly according to the width of carriageway and to the nature of the foundation, which changes from sand to limestone and to clay. A 6 in. soil-cement



The motorway emerges from the three-level intersection on the Ring Boulevard in Paris. Below: the model shows the complex engineering design required to inter-relate the motorway, the Ring Boulevard and the roads of the area.



The three-mile spur from the motorway leading to the airport at Orly; here the carriageways are two-lane, as compared with the three-lane carriageways of the main motorway.

base is used for most of the route, consisting of fine sand stabilized with 5 per cent cement, mixed in place by two British Howard single-pass stabilizing trains, which together produced more than 2,000 sq. yd. of completed work per train in each nine-hour day. For the rest of the route the base consists of 6 in. to 8 in. of mechanically compacted gravel. Under the base there is a general drainage layer, 4 in. thick, which was laid on a sub-base of fine sand. This varied in thickness according to the terrain, increasing to 12 in. on bad ground.

The concrete slabs are 10 in. thick and are unreinforced, but are provided with tied contraction joints at 16 ft. intervals. At the start of the work dowelled expansion joints were also provided at 190 ft. intervals, but were soon discontinued without any disadvantageous results for the road. The longitudinal joints are tongued and grooved and are tied by tie-bars. The slabs are 11 ft. 6 in. wide in the three-lane carriageways and 12 ft. wide in the two-lane carriageways. Concreting was carried out with a S.G.M.E. train consisting of a spreader, a compactor-finisher and a vibrating joint cutter. The expansion joints are cut the full depth of the slab, with edges arrised by hand; the contraction joints, however, are formed by vibrating a strip of bituminized felt into the concrete by means of the vibrating joint cutter. A final finish is given to the concrete with a stiff brush before spraying with a membrane curing compound.

Of the seventy different bridge structures on the motorway, twenty-nine are overpasses and twenty-two are underpasses. The bridges carrying roads over the motorway are generally four-span reinforced concrete structures with the end spans carried right to the top of the cuttings and the supports concealed. Those carrying the motorway over existing roads are also in reinforced concrete. They are three-span and have two carriageways separated by a 5 ft.-wide grille which lights the road below.

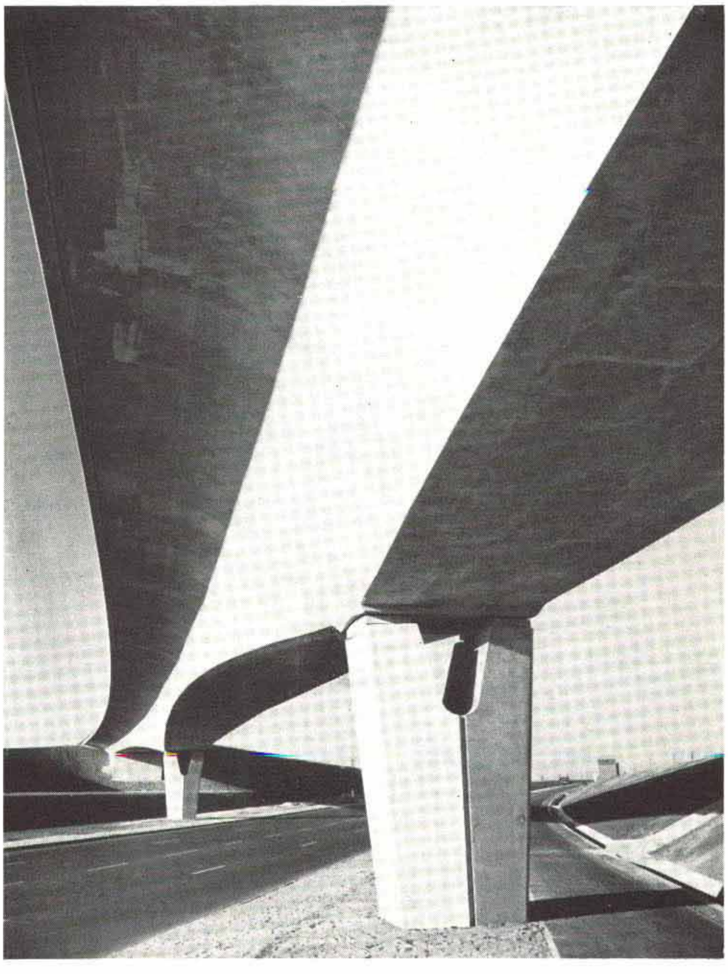
The three-level complex at the start of the motorway in Paris is only one of a number of concrete structures of particular interest. There is, for instance, another three-level intersection neatly engineered at Arcueil; here the railway crosses the motorway as it, in its turn, crosses Departmental road No. 62.

The prestressed concrete bridge at Orly shows a particularly distinguished treatment. This bridge, carrying the motorway spur over R.N.7 on a curve of 870 yd. radius, has remarkably good lines. It consists of a central span of 175 ft. and two side spans of 128 ft. each, all with gently curved soffits. The two supporting piers are an unusual V-shape with bases only 6 ft. 7 in. square; they are very compact in appearance and were so designed to obstruct visibility on R.N.7 as little as possible.

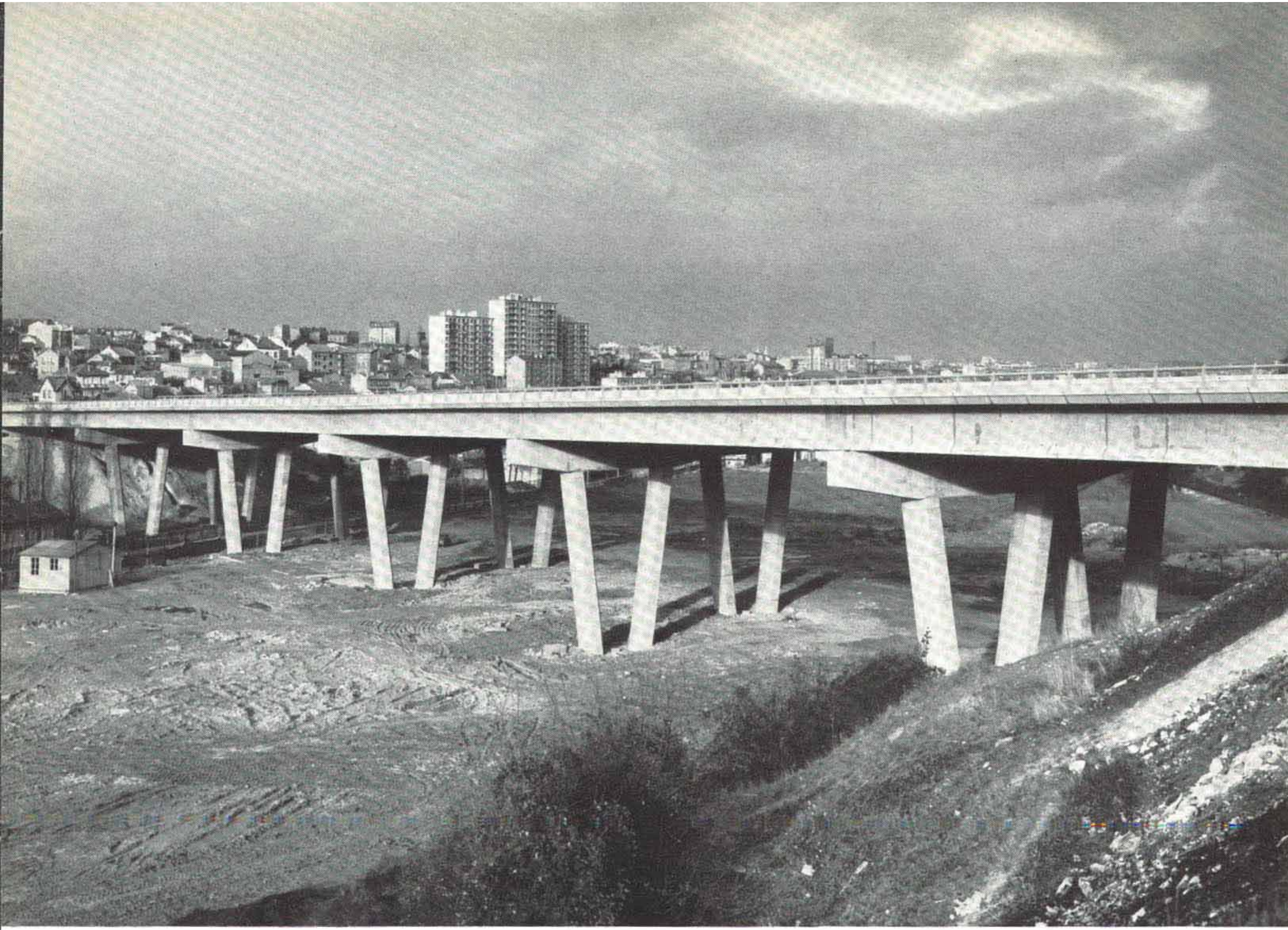
The most impressive of these structures is, however, the 730 ft.-long viaduct over the valley of the Bièvre; this also curves on a radius of 870 yd. Its six 122 ft.-long spans, made up of prestressed, precast concrete beams are carried, 45 ft. above the valley floor, on staggered supports, which consist of two slanted concrete columns surmounted by a cross-beam.

Great care has been taken with the appearance and the detailing of all the structures on the motorway. The Bièvre viaduct and all the bridges have exposed concrete surfaces, and the finish of this concrete straight from the formwork is particularly good. The lighting has also been most carefully treated throughout, and especially in the tunnels of the three-level structure on the Ring Boulevard. Here sodium vapour lamps and fluorescent tubes were used, also safety ground lighting to show up the curvature. The light-coloured walls also have good light-reflecting properties. They are faced with asbestos-cement panels which can be very easily unscrewed and replaced if damaged—and here again, under the panels, the finish of the concrete is excellent.

Fortunately the motorway has been carefully landscaped, since it has not generally the advantage of the naturally rich woodland landscape of the motorway to the west. For the southern motorway landscaping has a vital role—to prevent dazzle, stabilize embankments and offset erosion—as well as making the route attrac-



The motorway is carried in an arc-like sweep over R.N.7 at Orly on a prestressed concrete bridge, notable for its balanced curves and its unusual V-shaped supports.

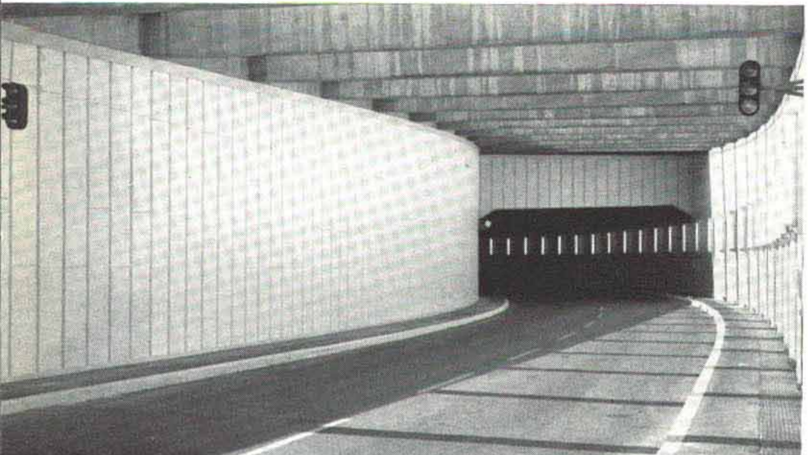


This precast prestressed viaduct carries the motorway for a distance of 730 ft. over the valley of the Bièvre at Arcueil.

THE MOTORWAY FROM PARIS TO THE SOUTH—FRANCE'S NEW CONCRETE MOTORWAY:

continued

A tunnel entry on the motorway, showing the light-coloured asbestos-cement lining panels, which can easily be removed if damaged. The overhead grille of concrete beams acts as a light break between daylight and artificial light.



tive to the eye. Embankments have therefore been covered in top-soil and planted with shrubs and forest trees. Screen planting has been introduced. Land has been purchased outside the strict line of the route and this has made it possible to protect an area such as the Bièvre. The first section now offers some fine views over the Bièvre, Yvette and Orge valleys, and over Paris from the redoubt at Hautes Bruyères. The latter part of the route has the advantage of running through the more open countryside of the Ile-de-France, in addition to careful landscaping.

The motorway was planned by the 'Service Special des Autoroutes' at the Ministry of Public Works; the work was actually carried out by the Roads and Bridges Department (Seine and Seine-et-Oise).

THREE NEW *exhibition halls* IN TURIN

IN 1961 ITALY celebrates the centenary of its unification and Turin which played such a leading part in the 'Risorgimento' has been chosen as the centre for six months of celebrations. These will include a number of special exhibitions which are being mounted on a gradiose scale: Turin, already endowed with two of the world's finest exhibition halls—the famous buildings designed by Pier Luigi Nervi in 1948-50—is building three new halls which will together add up to a total of approximately 1½ million square feet of exhibition space. Each one is intensely different from the others; each one is an outstanding structure, which any capital city would be proud to possess. And Turin can boast five halls of this scale and quality.

One—already completed and used for this year's Motor Show—was designed by Riccardo Morandi, the prestressing expert, world famous as a bridge designer; it is an underground structure linked with Nervi's original halls by a long underground passage and will house displays of large vehicles, machinery and other heavy exhibits. One is designed by Nervi, specifically to house the 1961 International Labour Exhibition, the theme of which is 'Man at Work'—man as producer and consumer against the background of his achievements in the technical and social field. One, finally, designed by Franco Levi in collaboration with Nicolas Esquillan, and very similar to the great CNIT hall which Esquillan recently designed in Paris,* will house a massive exhibition showing the work, problems and achievements of the Southern Italy Development Fund.

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* *Concrete Quarterly No. 40.*

Italia 61

An underground hall in prestressed concrete:

RICCARDO MORANDI

WHEN A NEW HALL was required as additional space for the annual motor show, and incidentally for the 1961 exhibitions, the only site available near to the original Nervi halls was in the well-loved Vatelino Park. But to the Torinese a large building breaking up this pleasant open space of grass and trees was as unthinkable as one in the middle of Hyde Park would be to Londoners. So the designer, Riccardo Morandi, was presented with the problem: a vast area of clear space to be set underground, and the park reinstated above it.

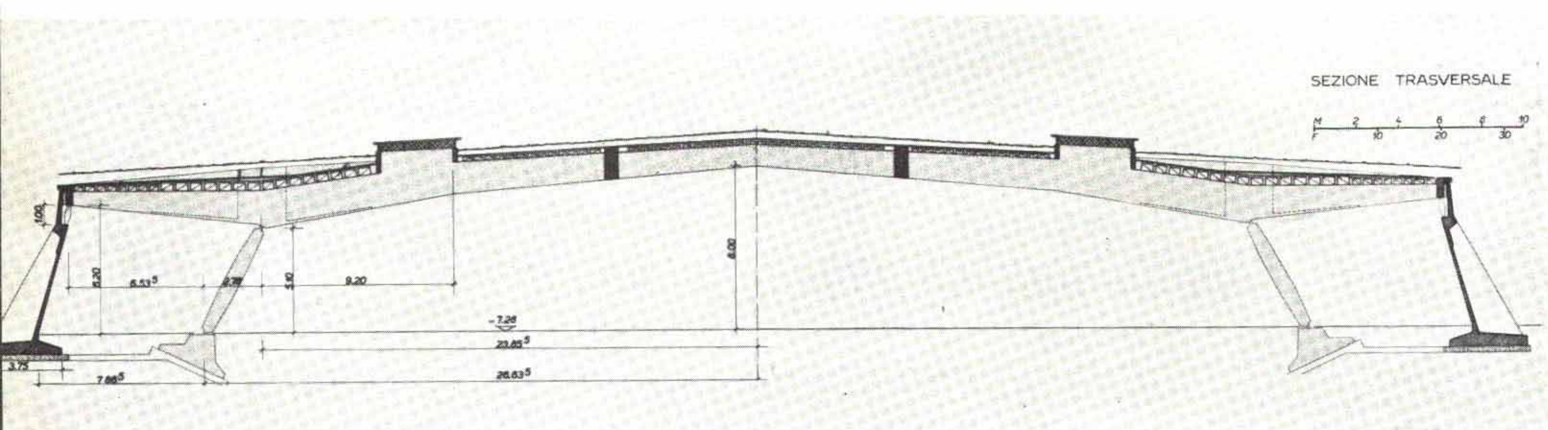
The hall he designed is 495 ft. long by 226 ft. wide; its floor is 26 ft. below ground level. The long sides are sunk in the earth, the reinforced concrete walls acting as retaining walls; the ends are glazed, and open on to an amphitheatre-like approach at each end, reached by a vehicle ramp and steps.

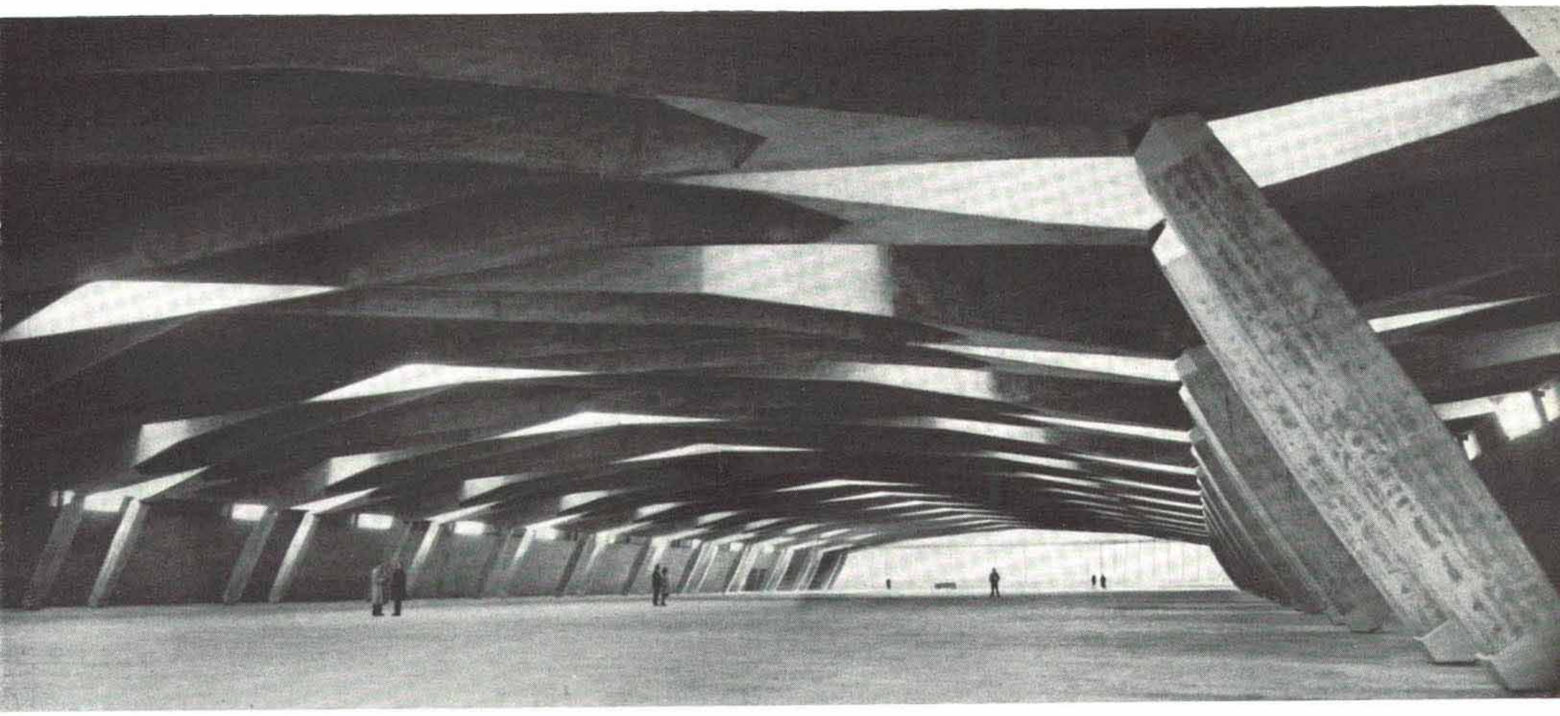
The building is reminiscent of the underground Basilica at Lourdes, with its roof spanned by shallow-curved prestressed concrete beams carried on raking supports along either side. The roof members are very thin membrane-like prestressed concrete ribs, 6 in. thick, 10 ft. 3 in. deep at the hinges and 4 ft. 3 in. at the crown, which are carried on free-standing raking supports hinged top and bottom. They span 156 ft. clear between hinges, and continue on to join the side walls which thus have a dual function, giving support to the roof while resisting the lateral pressure of earth. Small prestressed members tie the ribs to brackets at the head of the walls.

The supports are placed in pairs at 36 ft. centres along each side of the hall, the members of each pair being 10 ft. 3 in. apart. Each individual support carries two ribs, which span the hall diagonally to left and right, intersecting at the crown to form a grid which gives rigidity to the very thin members.

The side walls are of reinforced concrete, with wide footings and buttresses reaching back into the clay foundation. The prestressed concrete supports are similarly founded on reinforced concrete footings specially designed to transmit the oblique forces directly to the ground; they are linked to the wall footings by a concrete slab.

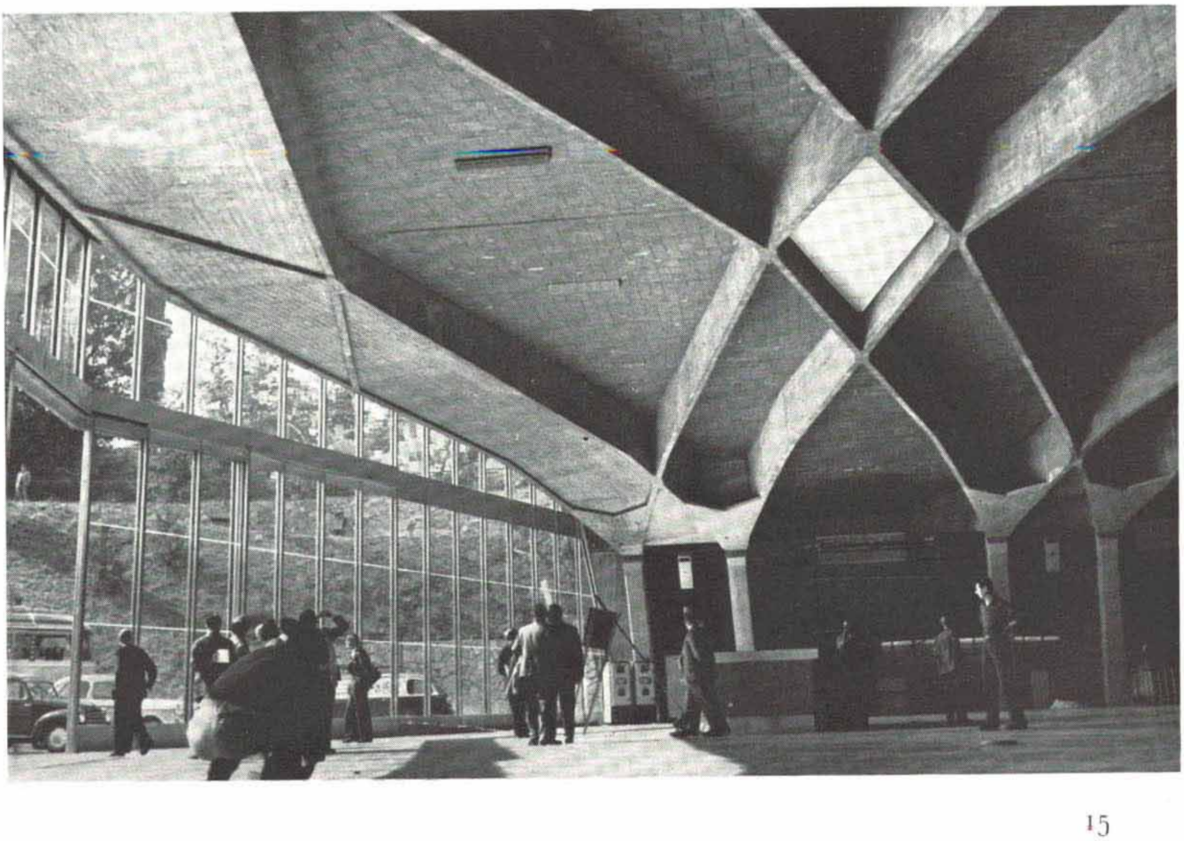
Cross-section through the hall.

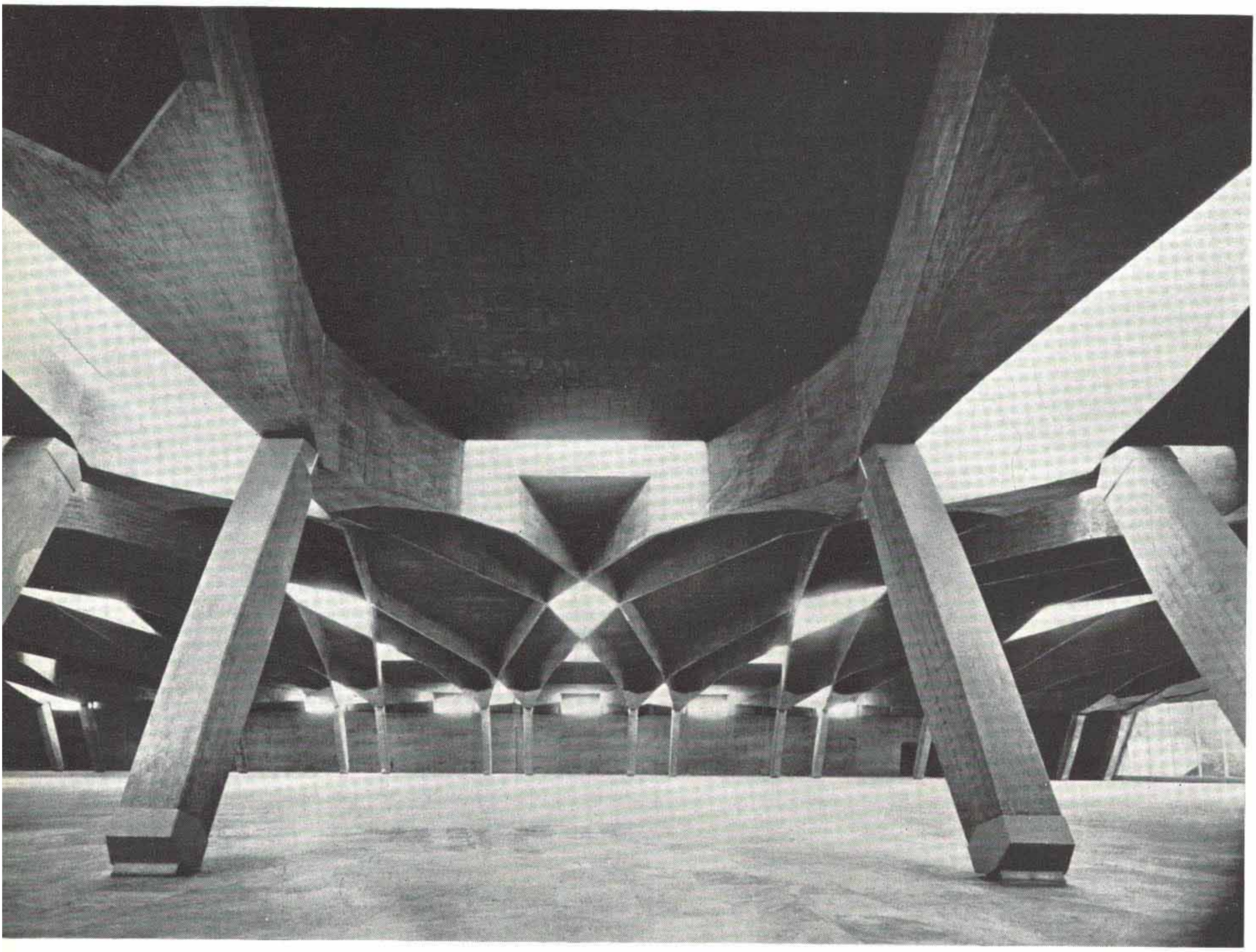




Looking down the length of the great hall, one is conscious of the vibrant quality conveyed by its interlacing beams and diffused light.

One end of the hall, showing the box beam which concludes the system of ribs, and the big glazed end openings.





Looking across the hall, the complex interlocking of the thin roof ribs becomes clear.

As a solution of a structural problem the treatment of the roof at the two ends and at the expansion joints is particularly interesting. At these points the continuity of the rib system in the longitudinal direction is abruptly broken, while the application of prestress gave rise to localized internal forces. The torsion in the supports which these factors tended to produce was dealt with by introducing reinforced concrete slabs between the top and bottom of the last two ribs, so as to form a box structure with adequate resistance to torsion.

The roof infilling consists of a slab of reinforced brick varying in thickness from $9\frac{1}{2}$ in. to $17\frac{1}{2}$ in. and curved to facilitate the shedding of rainwater. It is covered with three layers of bituminous felt finished with a layer of cold bitumen. Internally, all the concrete is left as it came from the formwork, which was made with special care. The floor is marble.

The method of construction was itself unusual. A peripheral trench was excavated, in which the supports were constructed, and the solid block of earth filling the body of the hall was left in place until the roof ribs were cast—thus obviating the need for special scaffolding. Only after the structure was finished was the final excavation carried out. After completion of the hall the surface soil was reinstated and planted with flowers and shrubs, and a children's playground installed.

A 200 ft. long underground passage links the hall with the original halls, with a 'travellator' installed along its centre.

The contractors for the building were the Società Fratelli Giovannetti, of Rome.

The Palazzo del Lavoro:

PIER LUIGI NERVI

"MAN'S WORK as the determining factor in the development and achievements of civilization in the last 100 years" is to be the theme of the International Labour Exhibition, to be presented in Nervi's new hall on the western outskirts of Turin. The hall, on the banks of the River Po,and with the foothills of the Alps as a backcloth, occupies an area 400 ft. square: St. Peter's, Rome, could easily be contained within it; the Colosseum would be a small oval in its centre. Its roof, 82 ft. above ground, is made up of sixteen separate sections, each carried on a central reinforced concrete column. A mezzanine gallery encircles its perimeter.

The beautiful tapering columns are cruciform in section at the base, smoothing to circular at the top, where they carry twenty slim steel spokes supporting the steel and vermiculite roof. Nervi had originally designed the entire structure in reinforced concrete (which would, in fact, have cost slightly less) but the extremely tight programme and rigid completion date (work was started in March 1960 and must be finished by January 1961) made it necessary to change his plans and use a mixed system which enabled the work to be divided between site and factory.

The hall is immense—160,000 sq. ft. really looks large—but the striking thing about it is less its size than the great beauty of the concrete columns, and the outstandingly fine narrowly board-marked concrete of which they are made. The hollow concrete shaft is 66 ft. high, with a base plan 16 ft. square at the tips of the cross, tapering to 8 ft. diameter at the top. The formwork in which they are being cast was given the most careful preparatory study and has been designed to give the maximum of beauty in the finished structure and of economy in construction. It consists of a steel framework lined with narrow timber boards, and is made up in three lifts. Only one set of formwork was used for all sixteen columns; one column was cast every ten days.

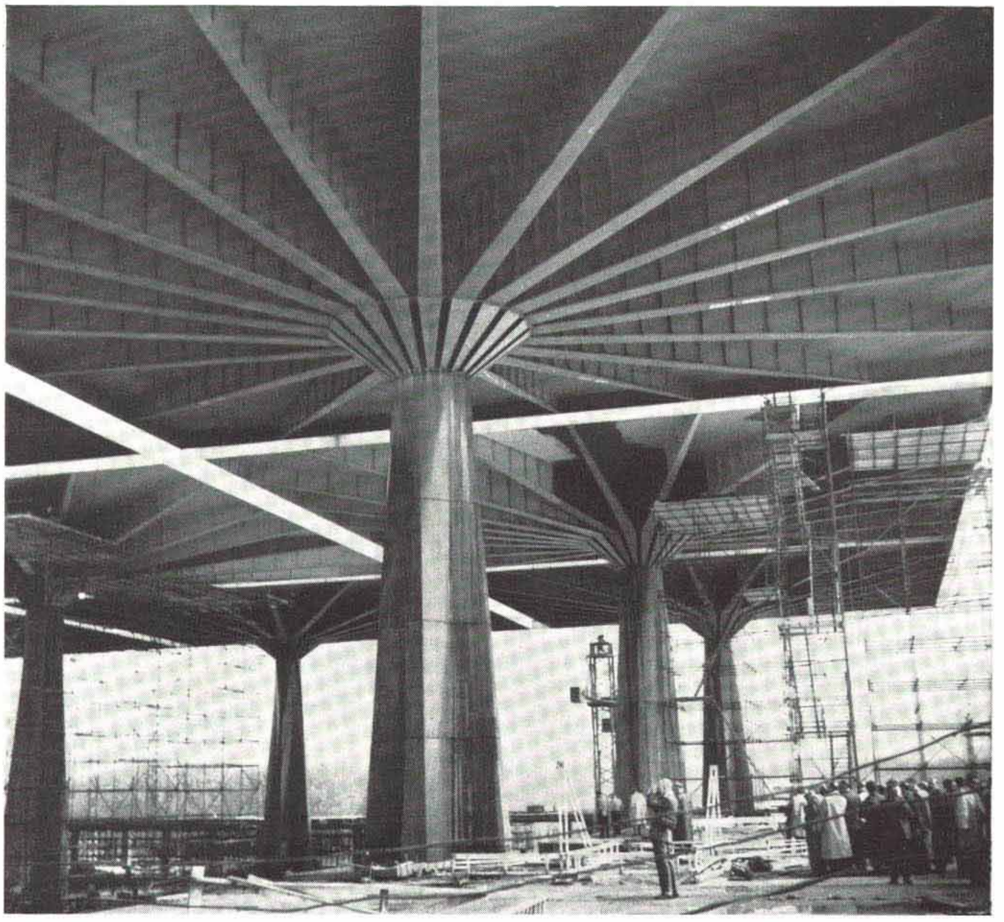
The columns stand free for their full height, openings in the gallery 44 ft. square surrounding each one. This gallery, carried on rectangular-section reinforced concrete columns, is a thin ribbed reinforced concrete slab cast against prefabricated ferro-cement forms made up in large sections and moved from section to section. The soffit ribs which, on Nervi's frequently used principle, follow the lines of the principal stresses, form at the same time a decorative ceiling pattern.

The finished hall will be wonderfully light and open in feeling. The whole perimeter will be glazed, giving views to the hills beyond, and the 6 ft. 6 in. glazed gaps between the sections of roof increase the natural lighting over the whole interior. Artificial lighting follows the lines of natural light.

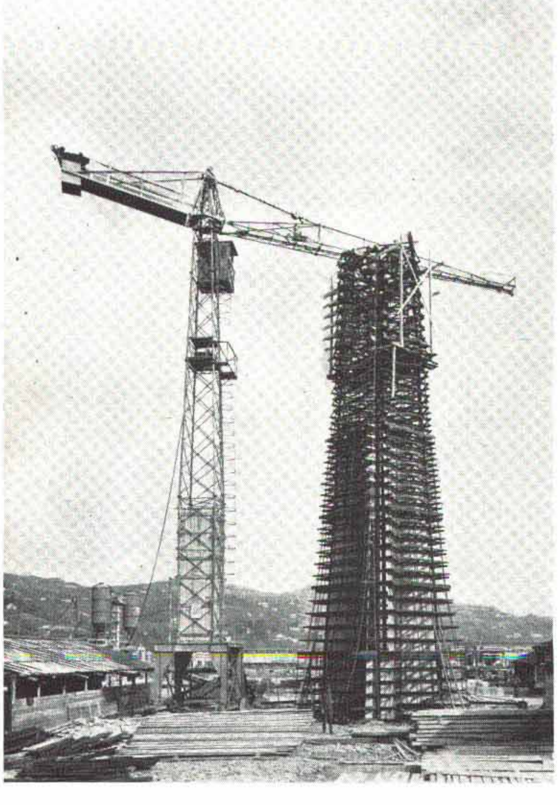
The glazing is carried by great steel mullions, tapering and hinged top and bottom, which reach from the intermediate floor to the roof and also carry the movable louvres which on the south and west faces protect the hall against the heat of the sun.

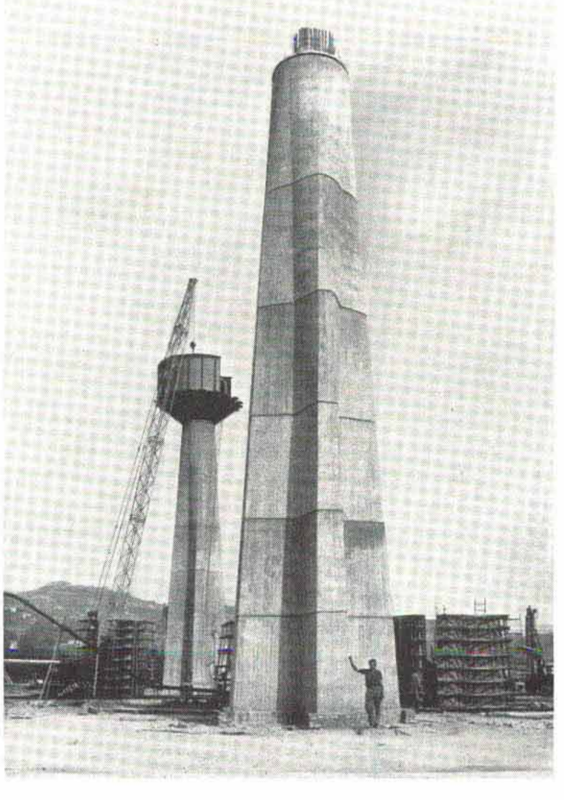
The interior of the hall has been arranged to provide the maximum of free exhibition space, by grouping such services as restaurant, bars, cloakrooms, lavatories, rest rooms and also the offices, on an intermediate floor placed between the ground floor and gallery in the vicinity of the main entrance. It is reached by three great staircases and a passage; communication between all three floors is provided by sixteen escalators and eight fixed stairs.

The structure of the hall was designed by Pier Luigi Nervi in association with Architects Antonio and Vittorio Nervi; Gio Ponti is architect in charge of the interior design, and construction is being carried out by the firm of Nervi and Bartoli.

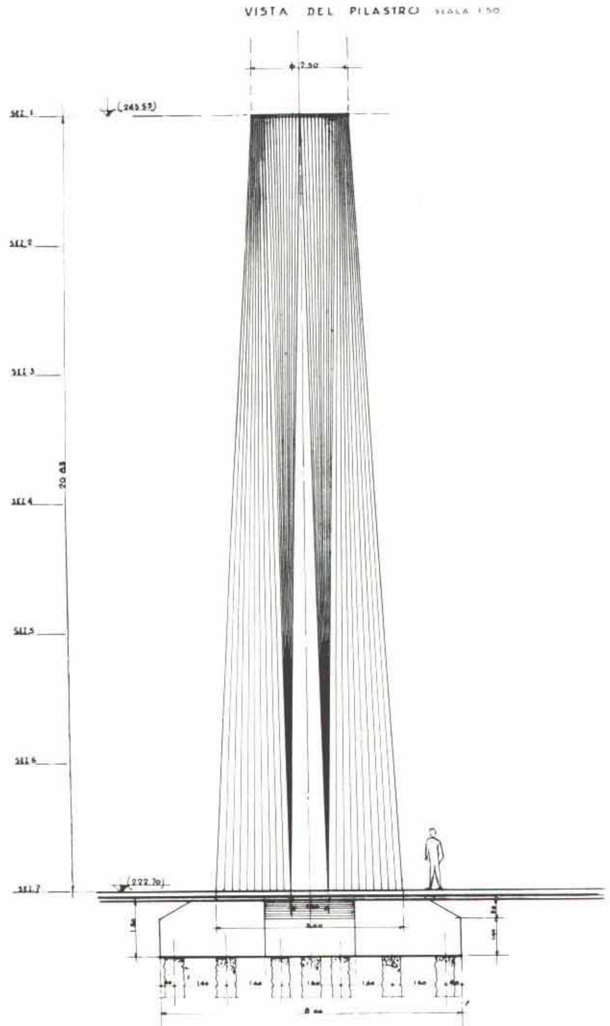


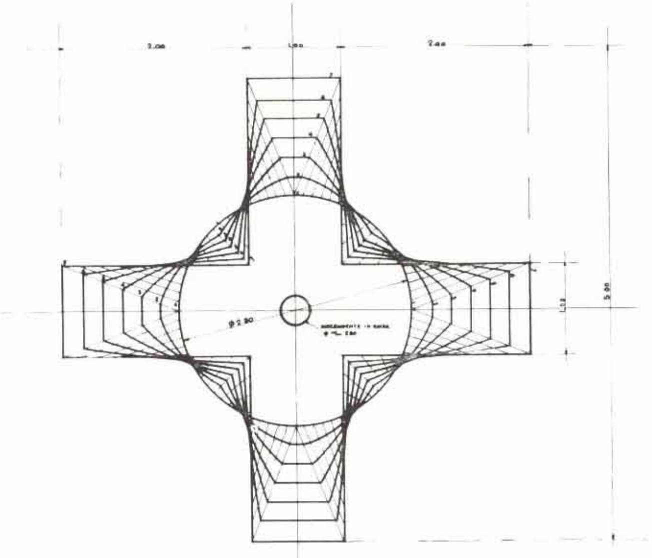
A corner of Palazzo del Lavoro, showing the unusual profile of the columns, each carrying an independent section of roof; the spaces between the sections will be glazed.





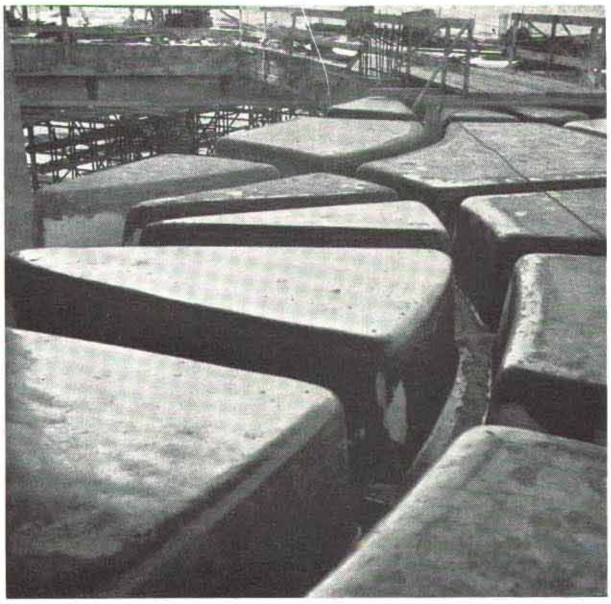
Left: the formwork in which the columns were cast, one set being used for all sixteen columns. Right: newly completed columns, with the dismantled formwork in the background.

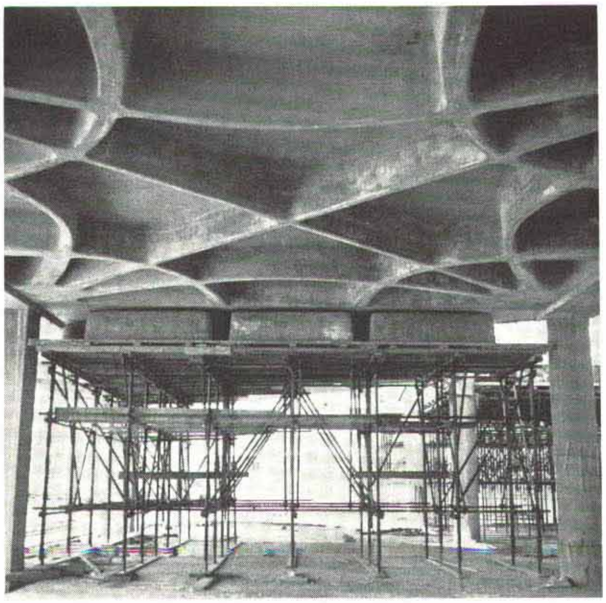


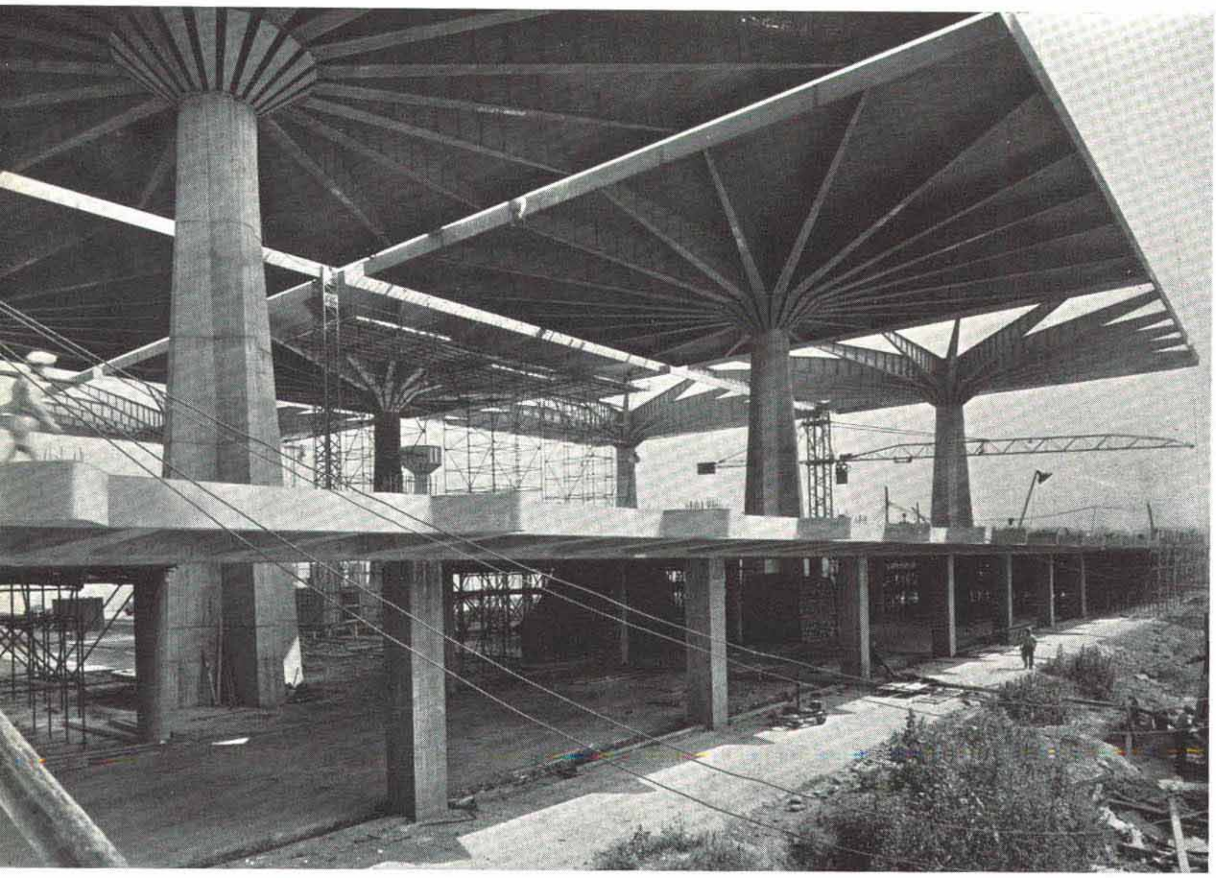


Plan and elevation of a column, showing the gradual changes in section.

Construction of the gallery. Left: the ferro-cement forms in position, prior to casting. Right: the underside, showing the completed ribbed floor, and, in the background, a set of forms being removed.

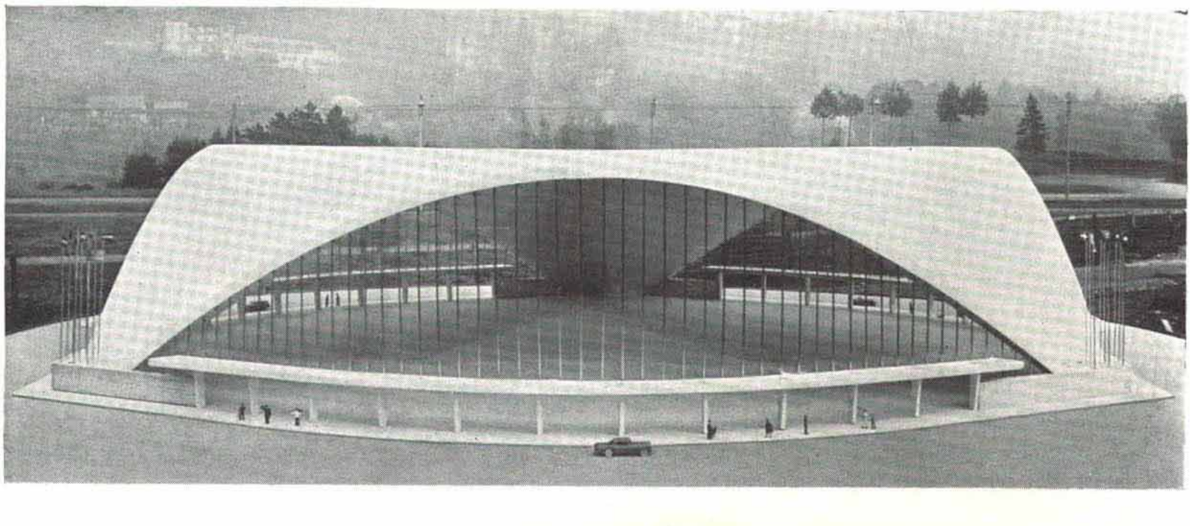






The Palazzo under construction—a photograph which shows the peripheral gallery; glazing will run from its edge to the roof.

The 'Cassa del Mezzogiorno' hall. A preliminary model of the hall seen against its natural background.



A three-groined vault

for the Cassa del Mezzogiorno exhibition:

FRANCO LEVI : NICOLAS ESQUILLAN

TURIN'S THIRD NEW HALL is a near neighbour to the Palazzo del Lavoro; to one side of it is the cluster of pavilions which will house the Italian Regional Exhibitions and beyond is the Luna-Park fun fair. A monorail will run from end to end of this exhibition sector.

The hall is a single vast three-winged shell roof resting on the ground at three points only and covering a clear area of 161,500 sq. ft. The plan of the hall is hexagonal, the two planes in each long façade from abutment to abutment giving the building a much richer modelling than its prototype in Paris. The roof further differs from that of the CNIT building in being smooth surfaced inside and out, without the secondary undulations of the earlier shell.

The structure, however, is similar: the roof is a three-groined vault, its three great wings springing from abutments 426 ft. apart and rising to a height of 98 ft. at the crown. It consists of two $2\frac{1}{2}$ in. thick shells 4 ft. apart, joined by vertical and transverse diaphragms—a form which combines great lightness with resistance to buckling, provides good thermal insulation, and facilitates the installation of services. Where the three wings meet at the crown, the diaphragms are replaced by a prestressed concrete I-beam which takes the transverse thrust. Apertures in the diaphragms make it possible to pass within the thickness of the roof for inspection purposes and installation of ventilation, lights and other services, or the attachment of exhibition material, for which provision is made.

The abutments which sustain this huge vault take up a surprisingly small area—only 377 sq. ft. together. They rest on reinforced concrete box foundations that go down 40 ft. into the ground and are linked together at ground level by prestressed steel ties.

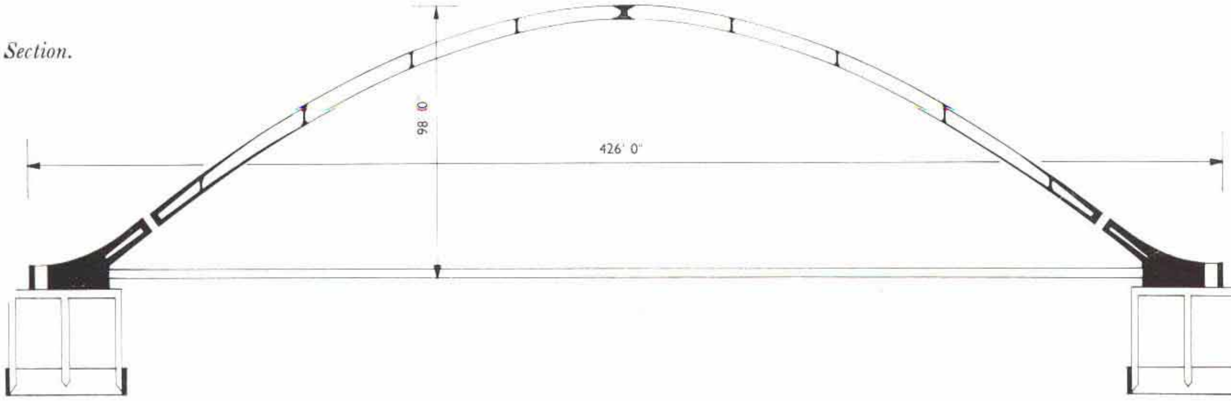
The sequence of concreting differs from that used in Paris. For construction purposes the roof here was divided into three sections: first, a central three-pointed star rising from the abutments to the crown; second, the three adjoining symmetrical lozenge-shaped sections, and lastly, the three outermost points which project over the intermediate angles of the hexagon. These sections are all separated by expansion joints.

De-centering was a major undertaking, carried out with perfect success; it consisted in bodily lifting the huge 15,000 ton vault. This was done in two simultaneous operations: tensioning the ties between the abutments, and at the same time opening up the joint between the abutments and the vault by means of a series of hydraulic jacks. Eight 200-ton jacks were used at each abutment. Lifting was carried out in three stages, at two-month intervals, and the whole process controlled by a great battery of gauges of all kinds. At each stage the space between the jacks, and ultimately the space occupied by the jacks, was filled in with concrete.

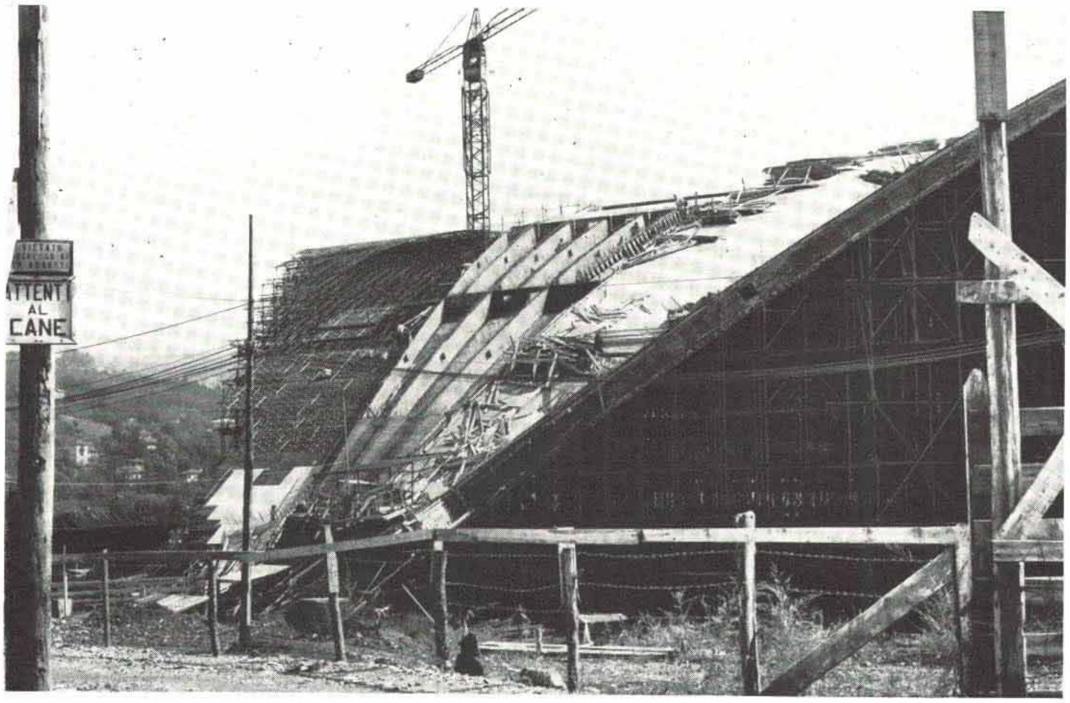
Internally and externally the concrete is being left as it came from the forms: it is of very fine quality. The great side openings will be entirely glazed.

Construction of this hall was carried out by the Turin contractors Gastone Guerrini S.A.S. Technical assistance was given by the Guerrini design office, with the Sté Boussiron, of Paris, as consultants.

Section.

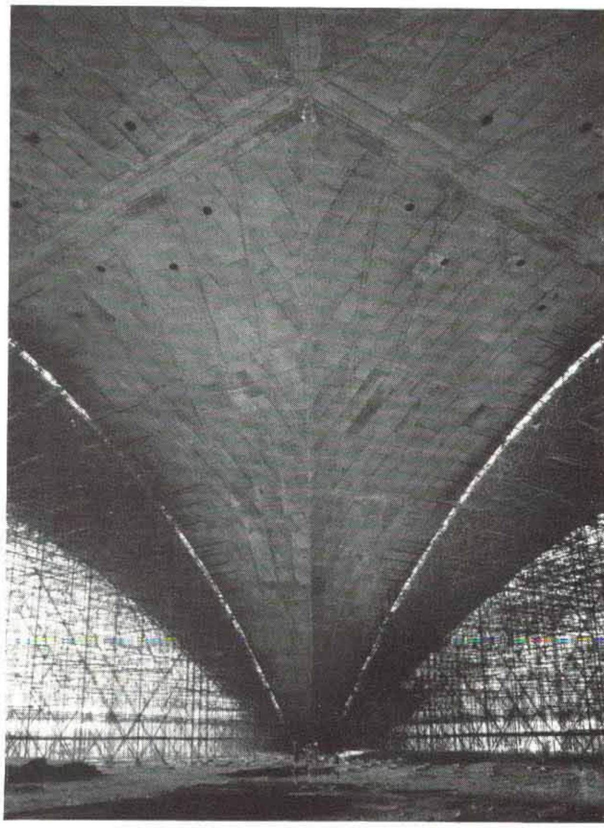


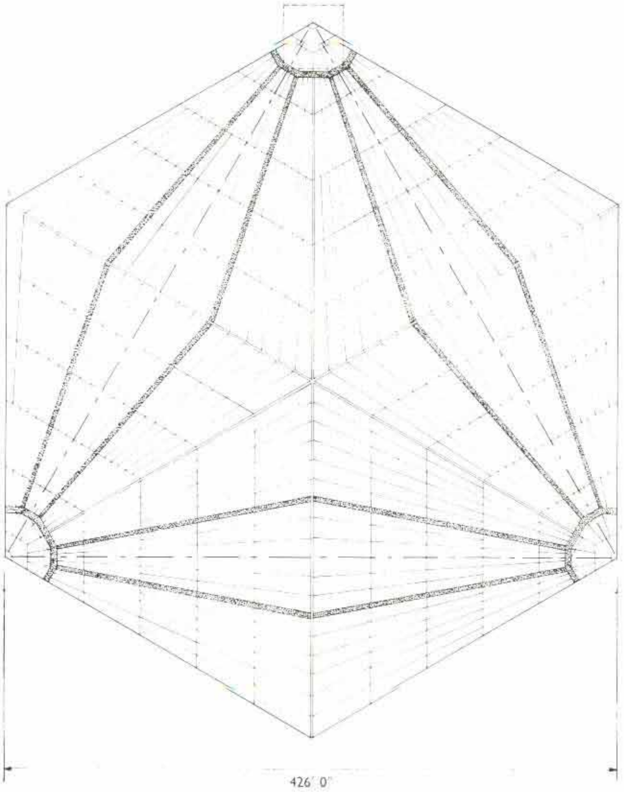
A THREE-GROINED VAULT: *continued*



A corner of the roof under construction, showing the structure of two skins with intermediate diaphragms.

The interior of the hall; the joints between the first section to be cast (the central 'three-pointed star') and the next will later be filled in with concrete.





Plan of the roof, showing arrangement of diaphragms, and construction stages.

Off-street space as an answer to the parking problem—

the multi-storey parking garage at Bristol

ON OCTOBER 6TH this year at the Central Hall, Westminster, over 900 delegates attended a convention arranged by the Institution of Municipal Engineers on 'The problem of car parking' and had the opportunity of seeing the exhibition of multi-storey parking garages shown originally at the Institution of Civil Engineers last January.

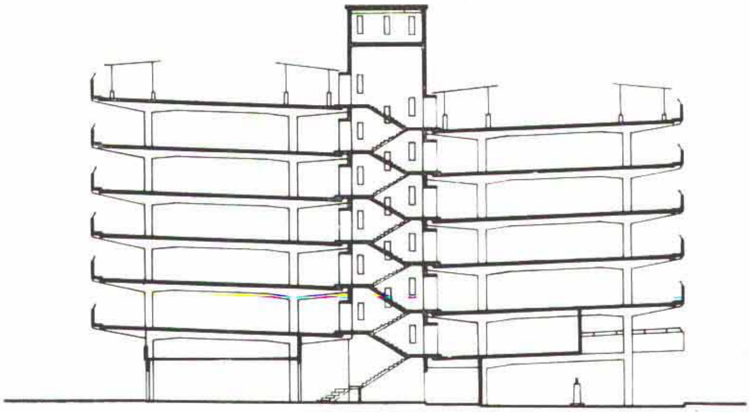
Most of the speakers stressed the importance of the multi-storey car park in any integrated scheme designed to tackle the parking problem. Mr. Meffin, one of Coventry's city councillors, pointed out that "off-street parking facilities are as integral a part of the road system as railway sidings to the railway". Coventry has already pioneered a scheme of roof-top parking allied to parking garages (this was described by Mr. Granville Berry, the City Engineer and Surveyor); Mr. John Beckett, City Surveyor and Planning Officer for Leicester, described a scheme for nine multi-storey parks on the inner line of the ring road in Leicester—a scheme on which a report has been prepared. A number of other cities have also prepared reports and formulated their ideas on multi-storey car parks—among them Bristol. Bristol's first 'Multidek' car park was, in fact, opened there last month through private enterprise.

The Minister of Transport recently commented that "the motor car is here to stay". He might, of course, have been sitting in a traffic jam at the time, but what he undoubtedly intended was a comparison with the television set and washing machine—the car is no longer a luxury for the few but a necessity for the majority. The post-war years have seen the number of vehicles registered in Great Britain rise from just over 3,000,000 to nearly 9,000,000. At the current rate of increase of 700,000 vehicles a year the post-war vehicle population will have trebled by 1961, and it is highly possible that in another ten years traffic will have increased by 100 per cent. There seems to be a nightmare inevitability about the situation: cars must have room in which to move (ideally) and room in which to rest (obviously); the main stream of traffic is into the city centre, where car owners go to shop or work; while they are working or shopping their cars must rest; if they park them at the sides of streets the flow of traffic through these streets is restricted; meanwhile the standard of living is rising and the population grows—more people buy cars; more cars—more street parking and more congestion; eventual saturation and complete blockage.

But this is more than an abstract problem. It is to be hoped that off-street parking will prove the ultimate solution, and the best way of achieving off-street parking at present is the multi-storey car park. As permanent off-street space becomes available, however, it seems likely that the squeeze will have to be applied hard to street parkers so that their habit becomes progressively more expensive, or even illegal. Undoubtedly the demand for off-street parking exists among motorists, but to clear roads enough to maintain an even flow of traffic it will probably be necessary to increase this demand artificially.

The multi-storey car park in Rupert Street, Bristol,

Rupert Street garage: cross section.



The garage from Rupert Street: the parapets are exposed-aggregate panels.

THE MULTI-STOREY PARKING GARAGE AT BRISTOL:
continued

can accommodate between 500 and 540 cars at a time. The site covers approximately 35,000 sq. ft. close to the proposed inner ring road at Lewins Mead and in the heart of the city's rebuilt shopping and commercial centre.

The building is elliptical on plan, based on axes of 209 ft. and 129 ft., and consists of a continuous ramp ascending gradually for a total of six circuits round an open area with a central lift and staircase block. A parapet runs around the perimeter of each circuit; apart from this the sides of the building above ground level remain open. The ground floor is occupied by motor showrooms, fuel pumps and workshops.

As the ramp spirals it rises at the relatively slight gradient of 1 in 32 and in the entire length of one floor the total rise from one end of the building to the other (one half-circuit) is 5 ft. The elongated spiral effect in the street elevation, therefore, is not obvious. In addition, the main axis of the park does not run parallel to the road off which it is built but at an angle, and this also tends to reduce any impression of non-horizontality.

The overall width of the ramp is 56 ft., providing a centre carriageway 24 ft. wide, which is sufficient for two-way traffic, and allowing 16 ft. by 8 ft. parking spaces at each side. Vehicles are parked at right angles to the line of the carriageway.

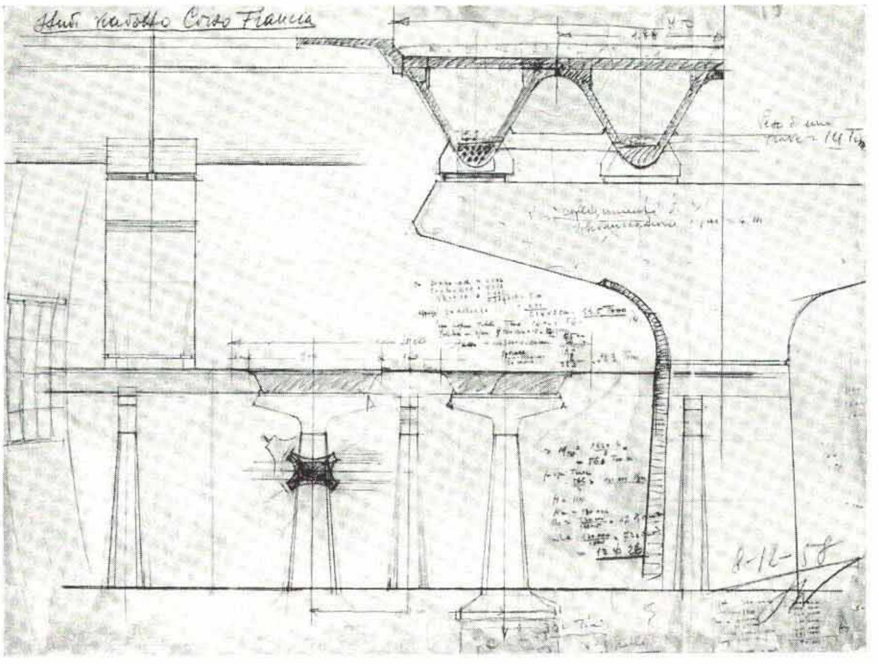
Foundations are precast reinforced concrete piles, 40 ft. to 52 ft. long, that take a working load of 65 tons each, and were driven to resist 130 tons. Above ground all the structural members are of reinforced concrete. The spiralling reinforced concrete slab is carried on a series of in situ reinforced concrete portal frames at 16 ft. centres, with beam members cantilevered beyond the two lines of columns. The columns have a 12 in. by 24 in. section; the beams average a depth of 2 ft. The 8 in. thick ramp slab is of composite construction, with precast reinforced concrete ribs at 2 ft. centres spanning between the beams, and an in situ concrete topping. Asbestos-cement sheets over the precast ribs were used as permanent formwork to the in situ concrete, which in places is 3 in. thick and in others 4 in., depending on the required length of the 'fire period'. The parapet is made up of long, 4 in. thick precast panels, 16 ft. by 3 ft., that are jointed with a straightforward tongue-and-groove abutment to run continuously round the whole six circuits. Reinforcement that was left protruding at the bottom of the panels is tied in with the reinforcement of a 4 in. high 2 ft. concrete kerb that also runs the length of the perimeter. Holes in the top of the panels form the anchorage for a 12 in. railing.

The structural concrete has largely been left as it came from the formwork. The precast panels have an exposed aggregate finish using a local quartzite from the Gloucestershire area that has an attractive pinkish colour.

The garage will be operated by Lex Garages Limited, for Brockenhurst Investments Limited, who have leased the building from Multidek Car Park Developments.

The consultant architect was R. Jelinek-Karl, F.R.I.B.A., and the engineers G. C. Mander, and Partners and E. N. Underwood, B.SC., M.I.C.E., M.I.STRUCT.E. The contractor was William Cowlin and Son Limited.

THE CORSO FRANCIA, ROME



One of Nervi's early sketches for the viaduct.

FOR THE 1960 OLYMPIC GAMES the Italian Olympic Committee put in hand a magnificent series of structures which will stand, one imagines, as the circuses of ancient Rome have stood, a monument for centuries. Three of the buildings, designed by Pier Luigi Nervi —the Palazzo and Palazzetto dello Sport and the Flaminio Stadium—have already been described in *Concrete Quarterly.** Besides these are the new swimming stadium—a beautiful scheme for which the architect was Vitelozzi (who was architect to Nervi's engineer for the Palazzetto), the elegant and unusual Velodrome at the EUR—another concrete structure—by Ligini, Ortensi and Ricci, and the Olympic Village itself, which will later provide flats for government employees. Simultaneously, the Ministry of Public Works undertook a series of major works—a network of outer roads linking Rome with the Castelli Romani and Lake Albano where the canoeing tests were held, the Via Olimpica on the western outskirts of Rome, which links the Flaminio sports area with the EUR without entering the city, and the Corso Francia viaduct which facilitates access to the city from the north, leading, by the Viale Pilsudski, to the Via Flaminia and the city centre on the one hand, and to the fashionable district of Parioli on the other.

The Corso Francia is carried on columns for its whole length; 3,000 ft. long, it was built in thirteen months at a total cost of £690,000. It consists of two separate carriageways with a 16 ft. space between; each carriageway provides a three-lane road 34 ft. 6 in. wide and two 3 ft. 3 in. footpaths. Footbridges every 157 ft. link the two carriageways, and carry lighting fixtures. At the junction with the Viale Pilsudski each carriageway divides again, intersecting on two elevated levels to provide the four-directional links. These branches are 24 ft. 6 in., or two lanes, wide.

The layout of the road was designed by five architects—Cafiero, Libera, Luccichenti, Monaco and Moretti—in association with Professor Nervi, who thus, at sixty-eight, enters road design for the first time; its outline has a flow that—inevitably—combines elegance with safety: curves are joined to straight sections by carefully calculated arcs and no curve has a radius of less than 260 ft.

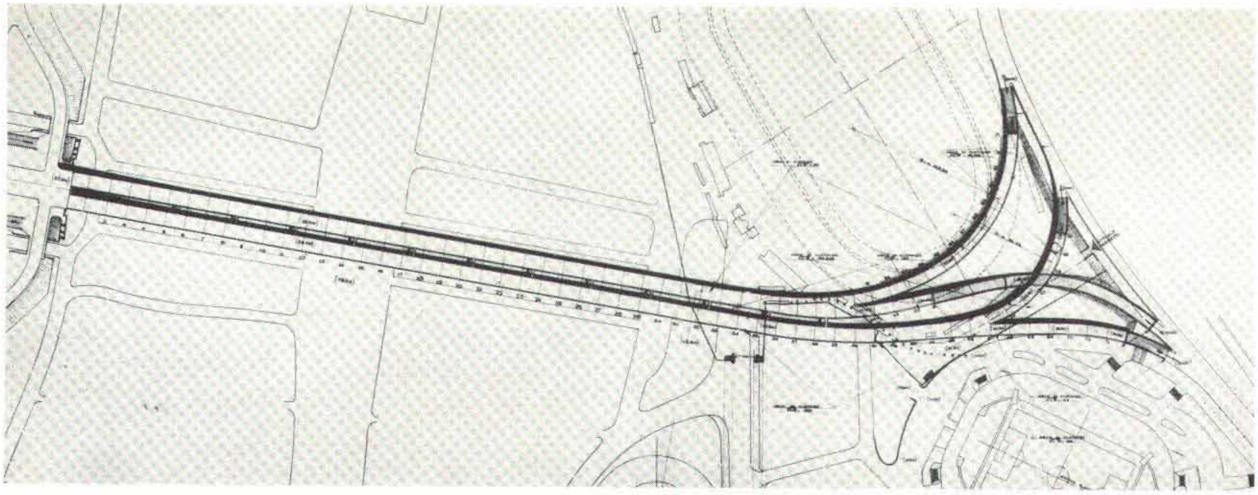
The structure of each carriageway consists of a central row of reinforced concrete columns carrying a cantilevered deck. Each column carries a cantilevered transverse beam member and between these span a series of V-section beams which carry the concrete deck slab.

The column foundations consist of Franki piles approximately 46 ft. long and varying from 16 in. to 20 in. in diameter; in all 960 piles were driven between July 1959 and March 1960.

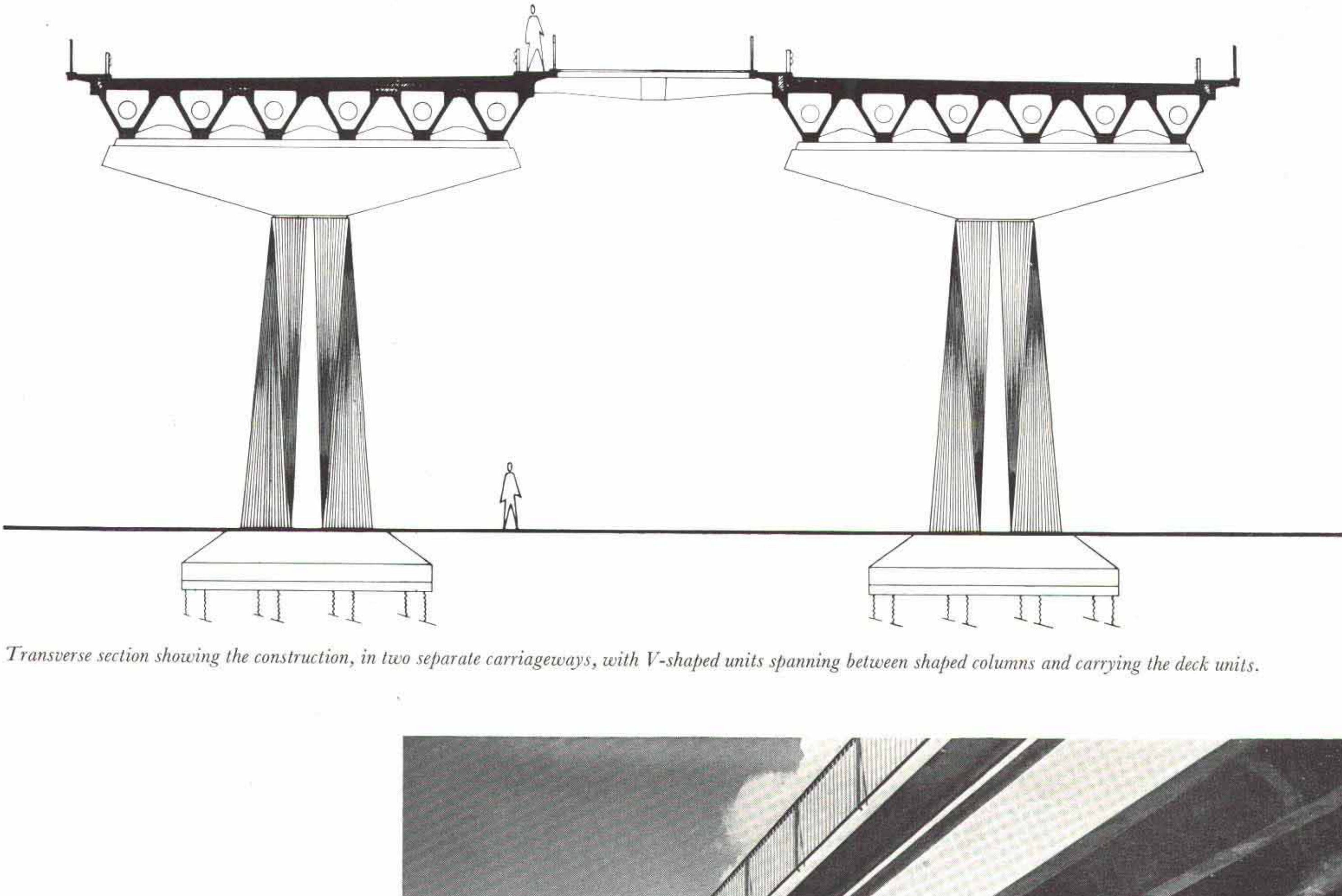
The columns are of the beautiful twisted shape which Nervi has adopted recently: cruciform at the base, on a rectangular plan that gives a long axis of 11 ft. and a short one of 7 ft., and, at the top, a 6 ft. 6 in. by 4 ft. rectangle. Their height varies according to the terrain from about 11 ft. 4 in. to about 26 ft. They were cast in situ in forms made up of a steel armature lined with two layers of fir boards; the inner lining, of $2\frac{1}{4}$ in. boards, was designed and made with meticulous care. Three sets of forms, each re-used on average forty times, made the 120 columns. The different heights were cast from the same forms by progressively shortening them from the bottom; thus only the taller columns have the strict cruciform base—in the shorter ones the arms of the cross take on a trapezoidal shape.

The transverse beam members were cast in situ on top of the columns and carry similar narrow but clearly defined board marks. All these natural concrete surfaces were finished with a light sand-blasting, sufficient to remove small irregularities or traces of mould oil while in no way obliterating the board marks and texture of the material.

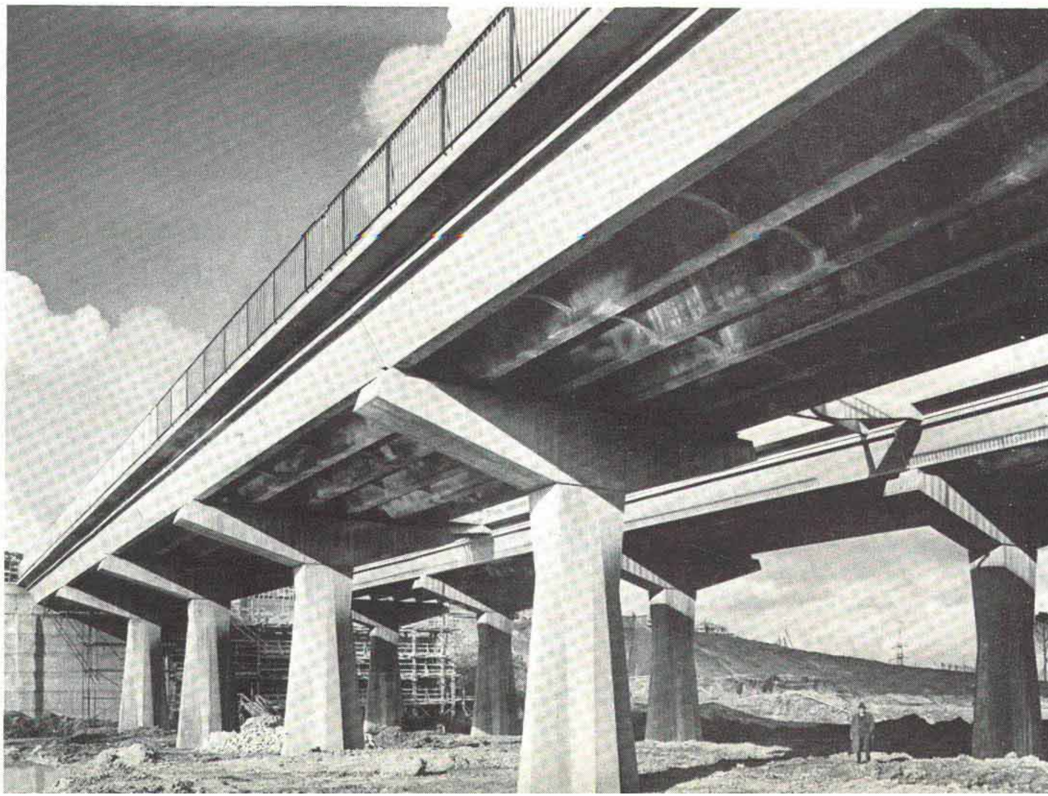
*Nos. 37 and 42.



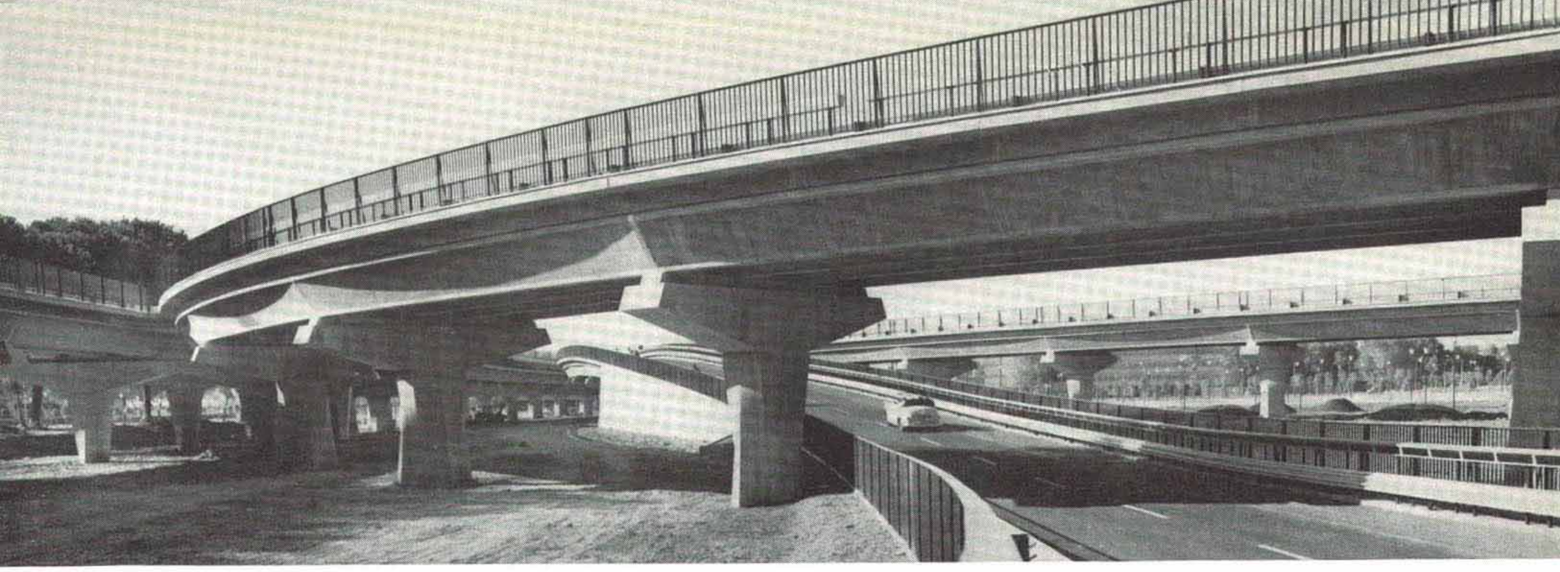
Outline of the viaduct, showing its overpass junction with the Viale Pilsudski.



Transverse section showing the construction, in two separate carriageways, with V-shaped units spanning between shaped columns and carrying the deck units.



A view of one end of the viaduct, where it joins the reinforced concrete retaining wall.



The system of overpasses at the junction with the Viale Pilsudski.

THE CORSO FRANCIA: *continued*

The V-section beams which span between the columns have a depth of about 3 ft. 8 in.; their width across the top is 6 ft. 2 in. and at the bottom of the V 1 ft. 3 in.; their wall thickness is $2\frac{3}{4}$ in., increasing to $6\frac{1}{2}$ in. at the ends. Each beam is stiffened by three diaphragms, from 4 to 8 in. thick. In addition to mild steel reinforcement, the beams have prestressing cables along the bottom, designed to counteract compression in the top flanges, particularly on placing, and after placing of the deck slabs. The cables are anchored on the Freyssinet system, within the beam and about 9 ft. from the ends.

The beams were precast, in a casting yard set up close to the site, in fixed moulds made up of brickwork lined with cement mortar, which gave an outer surface of perfect smoothness. Four beams per day were produced.

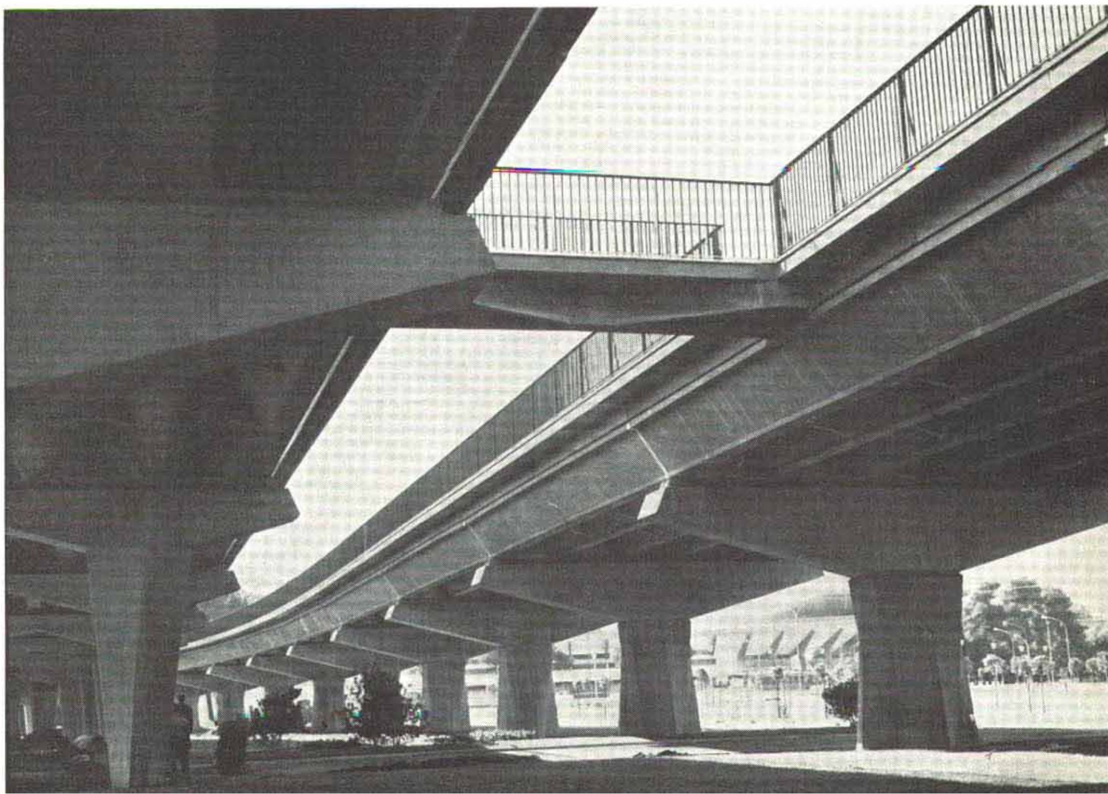
The 6 in. thick concrete slabs which close the tops of the beams were also precast in the adjoining yard; they are connected by sections of in situ concrete cast on the beam flanges between them. This composite concrete slab carries a layer of lean concrete laid to a camber, and the surface layers follow this line, draining surface water to the sides. The water passes into the outermost V-beam on either side, which acts as a channel; from it down pipes lead into the transverse members and through them down inside the columns.

The structure is completed with precast inverted-L shaped footpath units which cantilever beyond the beam line, separated from the carriageway by a guard rail. External parapets are slim metal handrails.

Here is a viaduct which is really a beautiful object—easily flowing in its lines, elegant in its elevation, splendid in the quality of its material. Not to be overlooked, either, is the car park laid out below the 'delta' sector where it joins the Viale Pilsudski. This area is arranged for saw-tooth parking, with red-coloured paving denoting the parking position and natural buff the intermediate paths. And in rows between are planted young trees, already sufficient to give shade to parked cars from the blazing Italian sun, and adding immeasurably with their pleasant green to the appearance, and indeed, to the whole feeling, of the scheme.

The Corso Francia was constructed by Ingg. Nervi and Bartoli s.p.A.

A view of the viaduct, with the Flaminio Stadium in the background.



WATER TOWERS

can enhance a landscape

THE APPEARANCE of a water tower on the horizon has often caused shudders of distaste among those who regret the proliferation of ugly objects on the British countryside. An ungainly tank perched on a thick post has been the most common formula; the occasional attempts at camouflage—resulting in structures resembling Norman keeps or Greenwich Observatory gone wrong—have in no way improved the situation.

In the past decade or so, however, things have been looking up; the imaginative thinking which has been producing such gratifying results in other fields of structural design has, fortunately, extended to water towers. Fortunately—because water towers are invariably conspicuous, and are also increasing in number.

Growing suburbs mean a growing demand for new and improved water supplies, and elevated reservoirs have several distinct advantages over hydrophore and direct pumping systems—little variation in head, and a reserve for emergencies, for instance.

Developments in Sweden are a good example of this; almost all large and medium sized towns have constructed new water towers within the past fifteen years, and Stockholm is planning to replace direct pumping systems with water towers in several large areas.

And Sweden, of course, has been in the vanguard of improved water tower design, making full use of the possibilities offered by developments in concrete construction—improved sliding formwork, for example, and prestressing. Prestressing has, in fact, proved to be the greatest single boon to water tower designers: it has made possible much greater freedom in the choice of shape, permitted thinner walls and supports, and simplified the watertightness problem.

SWEDEN

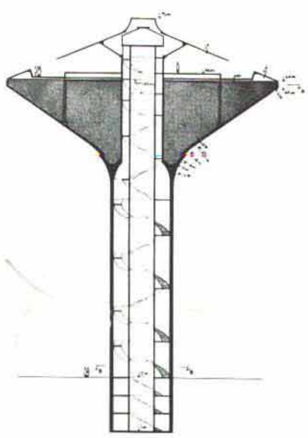
The 'star' of the recent Swedish water towers is certainly the one at Örebro. It is a model of elegant simplicity—an inverted cone flaring out from a supporting stem. Architectural merit was, in fact, the main consideration in the design: the tower is located in a residential district, and the local authorities decided that it must not only look well, but be designed to cast as little shadow as possible on the nearby houses and flats. A slim funnel shape, with its bulk reduced to a minimum by the skilful use of prestressing, proved to be the best solution: it was not only visually satisfying, but very economical of material. The tower cost approximately £165,000; it is estimated that a conventionally designed tower of equal capacity would have cost between £15,000 and £20,000 more. When it is considered that the structure, besides improving the water supply, offers such fringe benefits as an up-in-the-clouds restaurant and an observation platform, it seems an even more worth-while investment in community amenity.

The 100 ft. high reinforced concrete supporting stem, which houses the stairs and lifts, is polygonal in shape, with thirty-two faces; it has an external diameter of 35 ft. The stem extends 30 ft. below ground level to the bedrock on which it is based, forming three basement storeys which house storage rooms and a boiler room for the restaurant.

The conical tank is 145 ft. in diameter at the top, and has a capacity of 2,000,000 gallons. The polygonal faces of the stem extend up into the walls of the tank; every other face projects 8 in. from the wall surface. These projections provide end anchorages for the prestressing cables.

The roof of the reservoir (which serves as the floor for the restaurant and observation platform) is a flat concrete slab resting on thirty-two precast, pretensioned radial beams, which are supported by the central stem wall and by a ring of columns resting on the tank wall. The roof of the restaurant is a 5 in. thick conical shell of reinforced concrete.

One of the most interesting aspects of the tower was the novel construction method used. If it had been built on scaffolding in the usual way, formwork supports 132 ft. high would have been necessary and, because of the conical shape of the tank, even a slight deformation of these complicated supports would have created stresses in the concrete which might have led to cracking. The contractors therefore decided to con-



Prestressed concrete water tower in a Swedish residential area. A restaurant is incorporated at the top.

struct the tank on the ground and lift it up during the construction of the supporting stem.

The first stage of construction was the casting of the underground portion of the stem. Then the tank was cast, and prestressed circumferentially with Freyssinet cables. Before lifting began, the tank was carefully inspected for watertightness and freedom from cracks, and given two coats of cement paint (in alternate stripes of white and grey).

The tank was lifted by thirty-two specially made hydraulic jacks, while the supporting stem was cast by means of sliding formwork. After each lift of 4 in. by the jacks, a light metal disc was inserted below each jack. When three such discs had been placed, they were replaced by a precast reinforced concrete cylinder which was then built into the wall of the stem. Construction proceeded at the rate of about two such cylinders (2 ft.) per day, so that the whole process took about two and a half months.

One of the main problems encountered was ensuring that the lifting of the tank was absolutely perpendicular. To achieve this, the lifting was controlled by hand. First, twenty-nine machine-operated jacks would take the major part of the load off the supports; then three men, operating the three remaining jacks, would ease the tank upwards slowly. Special instruments were used to check that the ascent was vertical.

The Örebro tower was designed by AB Vattenbyggnadsbyran, consulting engineers, of Stockholm. General contractor was AB Svenska Stenbelaggningar of Uppsala.

Conical tanks like that at Örebro have certain practical advantages—for instance, during normal use, the variation in head is small. However, when a conical shape is chosen, it is usually for architectural reasons—the structure can be much more slender and graceful.

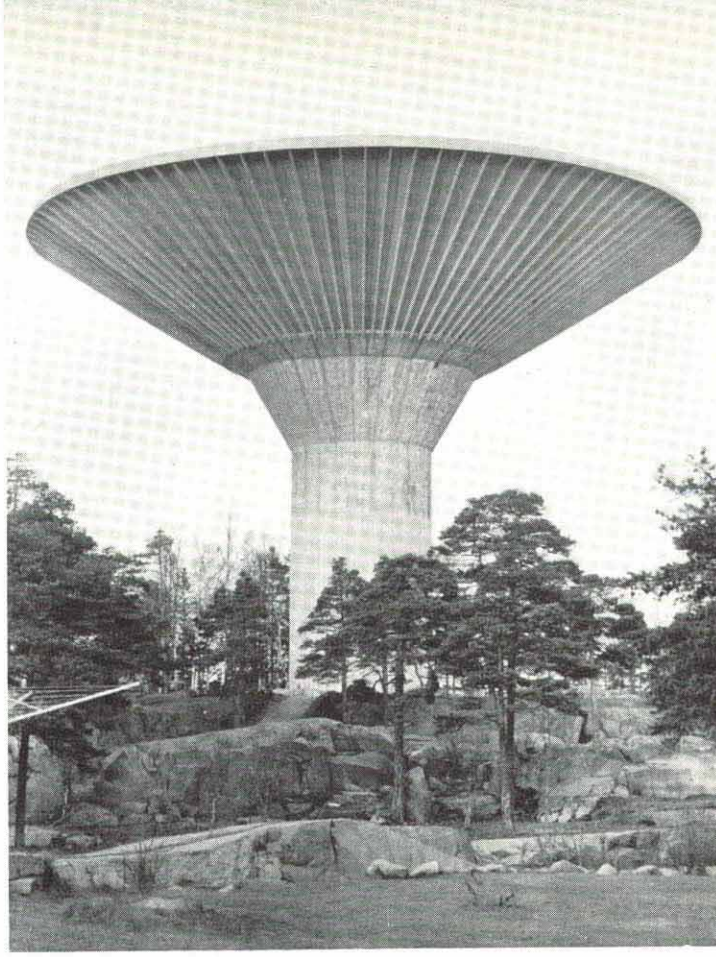
Further examples of this form of tank are to be found as far apart as Finland, Hungary and Morocco.

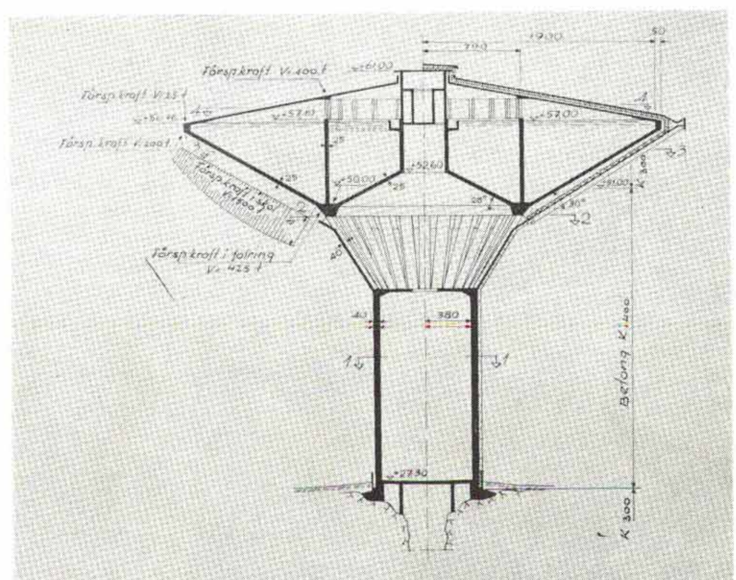
FINLAND

The Helsinki tower, which has a capacity of about 950,000 gallons, was designed by Ossi Leppamaki, of the Helsinki City Architect's Department.

The tower consists of a cylindrical stem supporting twenty-four columns which slant outwards towards the top. These columns touch each other, forming, in effect, a solid wall. A concrete ring beam rests on the top of the columns, forming a base for the 10 in. thick prestressed concrete wall, and also for a cylindrical internal wall which divides the tank into two sections.

Because of the extreme cold of the Finnish winter, the whole structure has been insulated. The stem and columns are insulated with a 6 in. thick layer of cork, the tank with a 1 in. thick layer of cork strips, and the roof with a 4 in. thick layer of mineral wool. The cork insulation for the tank is fastened to T-shaped precast concrete facing units; the stems of the T's project from the outside faces of the units, giving the tank a distinctive fluted appearance like the underside of the mushroom.





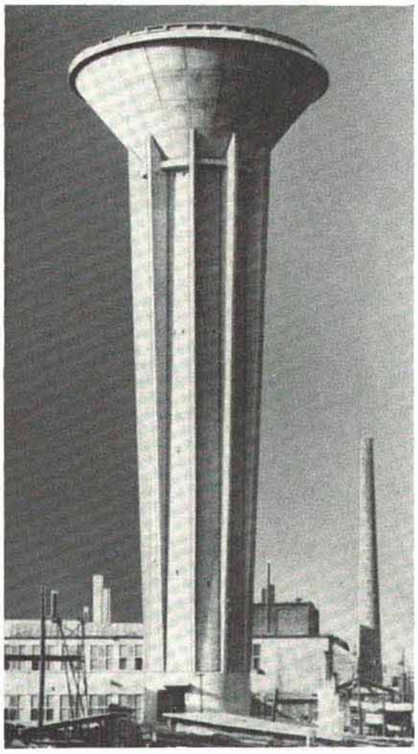
Precast facing units give a distinctive appearance to a water tower in Helsinki; the units support a layer of cork insulation.

Construction of the tower was begun in April 1958 and completed in February 1959. The consulting engineer was Paavo Simula, and the general contractors were Oy Yleinen Insinooritoimisto of Helsinki.

HUNGARY

The Hungarian tower is an industrial structure 154 ft. high; although its tank is conical, it differs considerably in appearance from those just described.

The central stem, which was constructed with



An industrial water tower in Hungary, in which precasting was used extensively.

sliding formwork, is supported on a circular foundation of reinforced concrete. The stem, which accommodates a precast concrete staircase and a subsidiary water tank holding 68,500 gallons, is strengthened by reinforced concrete fins. These fins taper to a few inches deep at the base of the tower, and are tied at the top by a reinforced concrete ring beam which provides a base for the main tank.

The principal structural interest of the main tank, which has a capacity of 124,000 gallons, is the precast concrete facing units which act as permanent formwork for the tank walls. These units, each weighing about 12 cwt. and incorporating insulating material, were placed in position by a rotating crane, and temporarily connected to a central newel post; the reinforced concrete tank was then cast.

The use of precasting both for the staircases and the tank facing units made possible considerable economies in labour and construction time, as the precasting could proceed while the in situ stem was being constructed.

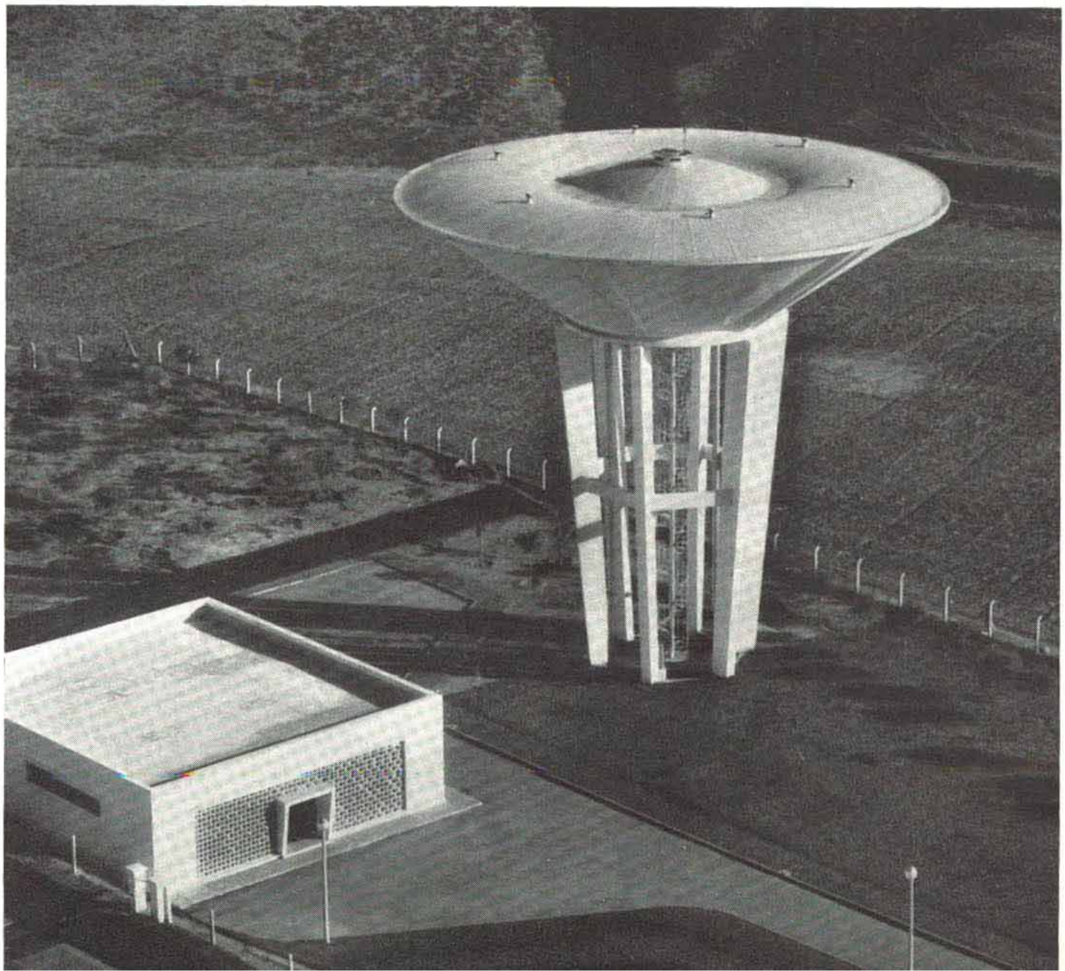
The tower was designed by engineer Jozef Thoma.

MOROCCO

The tower built in 1954 at the Moroccan seaport of Rabat has a capacity of 220,000 gallons.

The tank is supported by six slim rectangular concrete columns arranged in a hexagonal pattern, sloping outwards slightly from bottom to top (thus accentuating the inverted cone shape of the tank). The columns are braced by two rings of concrete tie beams, one at ground level, and the other half-way up. An open spiral staircase rises to the tank in the middle of the circle of columns.

The tank itself is 78 ft. 9 in. in diameter at the top,



Conical, circumferentially-prestressed water tower in Rabat, Morocco.

tapering to 31 ft. at the bottom. It is 18 ft. 9 in. deep (making the total height of the structure 73 ft. 3 in.). The bottom of the tank curves upwards, a shape which increases its resistance to the weight of the water.

The inclined wall of the tank, which ranges in thickness from $4\frac{3}{4}$ in. to $7\frac{3}{4}$ in., is strengthened by six concrete ribs, arranged as a continuation of the supporting columns.

An interesting feature of the tank is the circumferential prestressing of the wall, on the BBR-Boussiron system. The cables, each made up of six strands of 8 mm. wire, encircle the tank and overlap at the ribs, where they are anchored.

The tower was designed by Entreprises Boussiron of Paris, and constructed by their North African subsidiaries.

FRANCE

Another product of French engineering skill is the prestressed tower at Corgenon, which is completely different in appearance from those just described. It might be called a wheat-sheaf form—narrow waisted and flaring more widely towards the top than towards the base. (Actually, it is a conical tank supported by walls instead of a central stem or columns.) The windows are placed in vertical rows up each face, an arrangement which adds an incidental decorative touch to the structure.

The total height of the structure is 126 ft., and the maximum external diameter is 86 ft. 6 in.

The tank, which has a capacity of 396,000 gallons, has walls 6 in. thick. The supporting walls are 10 in. thick.

The walls are prestressed horizontally on the Fresyssinet system. The space between the cables decreases from $31\frac{1}{2}$ in. at the bottom to $15\frac{3}{4}$ in. at the top. Each circle of cable is made up of two half circles; two jacks were used to prestress each half circle, then turned around to prestress the opposite half.

The whole structure was cast in situ. The consulting engineers were Charles Brand and S.T.U.P. The contractors were Entreprises Maillard et Duclos.

ITALY

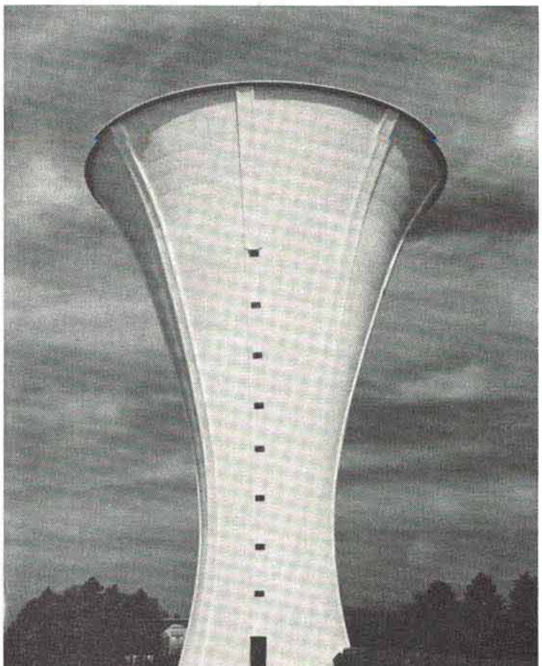
An important Italian contribution to the new trend in water tower design is the 164 ft. high tower, with glass enclosed observation platform, built for the E.U.R. site outside Rome.

The supporting structure for the tank is particularly worthy of note. It consists of slim reinforced concrete columns arranged in a pattern of continuous V's. This arrangement, which creates a strong and rigid supporting structure, enabled the designer to dispense with the tie beams which would have been necessary if the columns had been arranged in a conventional manner.

The V-shaped patterning of the columns, and the absence of tie beams, combined with the unusual mushroom shape of the tank, make the tower most interesting both visually and structurally.

The tank, which has a capacity of 550,000 gallons, has a diameter of 98 ft. at the base, its widest point. The tank, and the observation platform around its perimeter, are supported by a ring beam and eight radial beams cast integrally with the tank floor. Access to the tank is by means of a staircase and lifts located in a central column.

The tower was designed by architect Sergio Varisco and engineer Aldo Capozza. Consulting engineer was Prof. Ing. Roberto Colosimo.



Prestressed tower at Corgenon, with a capacity of 396,000 gallons.

Water tower with glass enclosed observation platform built for the E.U.R. area, Rome.

An exciting–

and quickly built–

new shop in Ilford

ON 17TH MARCH 1959, black headlines and front-page pictures in London newspapers told of a disastrous fire that had raged most of the previous night in the business district of Ilford, one of the dozens of small communities encompassed by Greater London. Damage ran to nearly £2,000,000; Harrison Gibsons, an old established and flourishing furniture shop, was totally destroyed.

Little more than a year later, the effects of the fire were far more gratifying than depressing: it had provided the opportunity for a piece of business property development such as few suburban High Streets can boast of—as well as a demonstration of the speed with which a precast concrete frame can go up—the new shop was opened to the public on 16th June 1960.

Speed was the central consideration in Harrison Gibsons' rebuilding programme. Within a fortnight of the fire, the architect, engineers and contractor for the new, ten-storey building had been nominated, planning permission obtained from the local authorities, and site clearance begun.

One of the factors in the choice of Gilbert-Ash Limited as contractors was their ownership of the 'Intergrid' system of precast concrete construction, with its huge beams which look like an oversize child's Meccano set and can be erected almost as easily and quickly. There was only one problem: Harrison Gibsons wanted building operations to start immediately, but there would be an inevitable time lag while the first instalments of precast units were being manufactured. This was solved by using in situ concrete construction up to first floor level. By the time this section was completed, the precast units for the rest of the building were ready. From then on, the frame was erected at an average rate of one storey per week. The first, and largest, stage of the new store was completed only a little more than a year after its predecessor's destruction. The second stage, which includes additional shop space to the rear of the new building, and two restaurants on the roof, is almost completed; parts of the 'Intergrid' framing will be left exposed in this area to provide a setting for the roof gardens outside the restaurants.

There is a great deal more to a good building than speedy construction, however, and the Harrison Gibson store has had the benefit of some sensible thinking about shop design. The ground floor, for instance, is made up entirely of display windows: a network of glass-walled corridors surrounds the main lifts and staircases in the centre of the building and the customer is thus led into the store past attractive exhibits of goods.

Inside the store, the same display principle has been adopted and has led to an original design. In the normal multi-storey shop, the customer who comes to make a specific purchase is encased in a lift and deposited in the appropriate department without seeing the goods on other floors. According to modern merchandizing ideas, this is all wrong: several different departments should be visible at one time, so that the customer will be tempted to look at—and perhaps buy—something he (or more likely she) had not previously intended buying. The ideal of every department being visible as soon as the customer enters the door is, of course, economically and structurally impossible, but in this case the architect has managed to ensure that at least two other departments can be seen from any part of the store. This has been accomplished by a system of staggered and interleaved floors, which produce a series of low ceilinged areas alternating with high ceilinged areas and two-storey voids. The customer can thus look up, down or across at other areas; bridges at strategic points provide easy access. This floor arrangement has other advantages as well; the alternation of high and low ceilings breaks the monotony inherent in conventional store design, and the low ceilinged areas enable furniture to be displayed in conditions more nearly comparable to those found in a small home.

Another interesting point in the design is the almost complete absence of windows; since they tend to be a nuisance from the point of view of display arrangements, they have been omitted except in such departments as carpets and soft furnishings, where customers may wish to compare colours by natural light. The building has electric under-floor heating throughout and is fully protected by a sprinkler system. A basement car park, which will accommodate seventy-eight cars, has been incorporated in the building; it is entered by ramps at the rear.

The store has a frontage of 150 ft. on the Ilford High Road, and a depth of 180 ft. It is 110 ft. high and provides a total of 200,000 sq. ft. of floor space.

The subsoil on the site was found to be varied, and therefore a raft system of foundations has been used, to ensure uniform settlement. The rafts, in places 6 ft. 6 in. thick, are of reinforced concrete.

In the early stages of construction there was uncertainty as to the final extent of the frontage; the structure thus consisted of the main store area, which has a column grid of 40 ft. by 21 ft. 8 in., and make-up areas at each side with external columns at 10 ft. centres. At front and back, the floors cantilever out beyond the main column grid.

The street elevation of Harrison Gibsons: precast facing slabs and free fenestration make an unusual façade.

Above first floor level the columns used in the main store area are of in situ concrete in association with 'Intergrid' beams. Precast post-tensioned 'boundary' beams rest on the columns and precast post-tensioned 'primary' beams span between the 'boundary' beams, and support the precast reinforced concrete floor slabs. In some parts of the building, small precast secondary beams span between the 'primary' beams to give added support to the floor slabs.

In the make-up areas along either side (which accommodate stairs and ancillary rooms), precast external columns support the 'boundary' beams, which in turn support precast reinforced concrete floor slabs which span the full width of the make-up areas.

The building's main stability against wind loading is provided by the in situ reinforced concrete bracing walls of the main staircase in the centre of the building and the subsidiary staircases at three corners. Staircase landings and flights are of precast reinforced concrete. The whole structure is finally made monolithic by the placing of a structural screed on the floor.

Small precast 'Intergrid' columns are fixed between the floor slabs around the perimeter of the building to support the precast concrete walling panels which are a standard feature of the 'Intergrid' system. These panels have an exposed aggregate surface of greyish-white Norwegian quartz. Interest is added to the cladding by forming U-shaped recessions in the sides of some units. An overall pattern of projecting and recessed areas of cladding has also been employed. The few windows—long, narrow, horizontal slits—are grouped according to internal requirements. The main entrance, on the Ilford High Road, is emphasized by a curved cantilevered polished concrete canopy.

The internal finishes are simple: the walls are plastered and painted white to provide a neutral display background. The floors are finished with linoleum or wood blocks, with the exception of the ground floor display-window area which is paved with 15 in. square precast slabs designed by Fulget of Italy: rounded marble pebbles set in fine textured concrete, and ground and polished smooth.

The building was designed by Donald Forrest, A.R.I.B.A. Structural engineers were the Prestressed Concrete Associates, and general contractors were Gilbert-Ash Limited. The precast concrete cladding was manufactured by Girlings Ferro-Concrete Company Limited. The ground floor tiles were supplied by Zach Cartwright Limited.

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