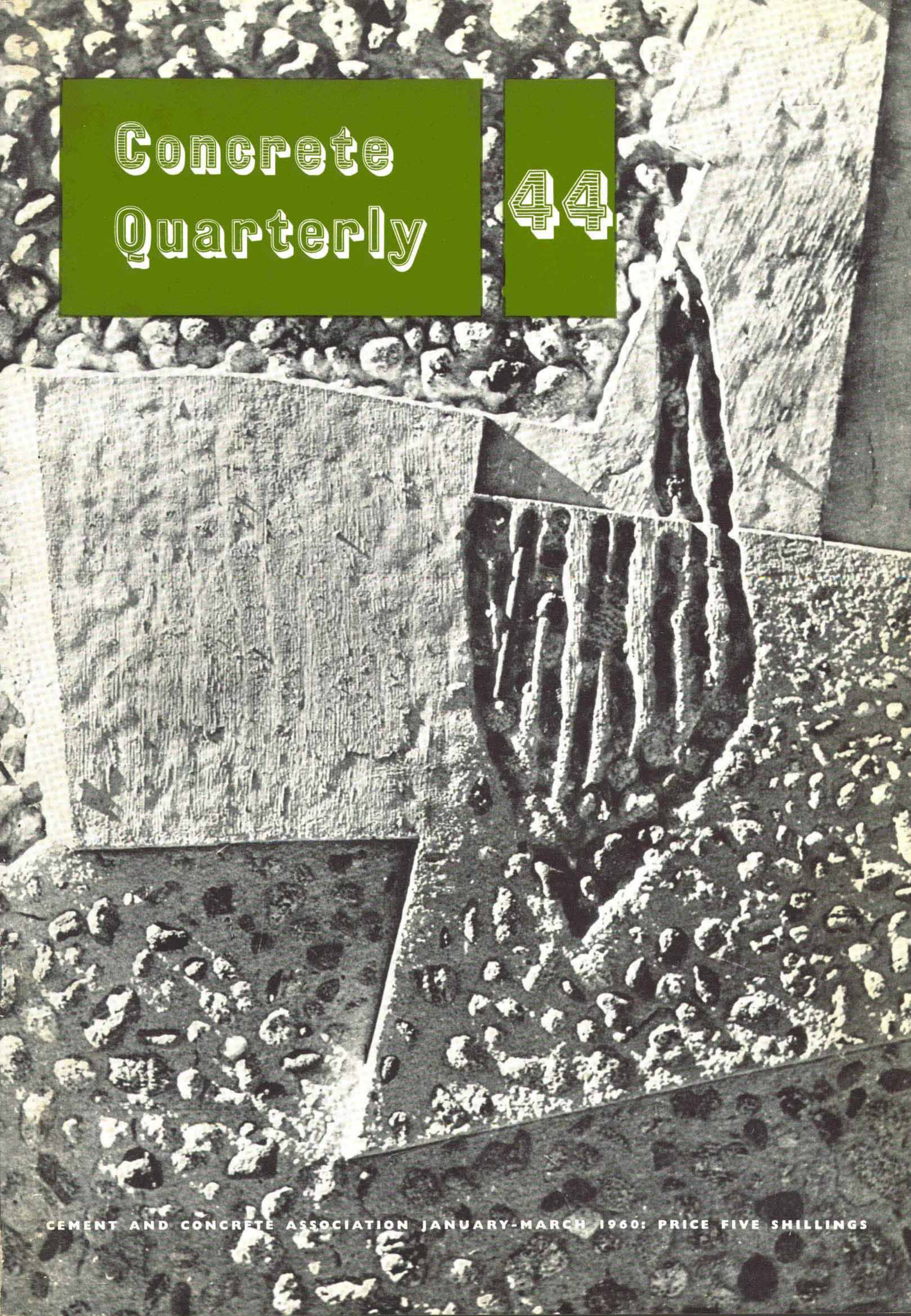
Concrete Quarterly

44



CEMENT AND CONCRETE ASSOCIATION JANUARY-MARCH 1960: PRICE FIVE SHILLINGS

Concrete Quarterly

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FRONT COVER: *Texture and decoration on the surface of a Naturbetong wall.*

FRONTISPIECE: *A fantasy by Picasso constructed of Naturbetong in the grounds of Erling Viskjö's home.*

IT IS NOT every day that the editor of *Concrete Quarterly* can claim to have just returned from a 10,000 mile architectural tour of Latin America; the occasion seems to merit some comment.

The visit was organized by the Cement and Concrete Association for a party mainly of architects; it lasted precisely a month, and took in Brazil, Venezuela, and Mexico; the flight home was from New York.

The days were packed, and impressions crowded in so violently and so continuously that it will probably be some time before they are properly sorted out (—to be described in our next issue). At the moment, what does one see? Sao Paulo, much more pleasant, and with much better buildings than one had been led to expect—busy, handsome, and hospitable. Belo Horizonte, just sixty years old, where outside its skyscraping centre (some nice buildings here too) a house, built in 1900, is preserved as a historic monument. Brasilia, of course—wide empty spaces with stupendous skies, but already taking a certain shape in the imagination—a big capital-city-to-be with, say, Buckingham Palace completed, the Houses of Parliament under construction, building around Victoria, building at Oxford Circus (about that scale!) and the bare red earth between. Impressions besides: the President's Palace, beautiful as a façade, lovely dark woods inside, mirrors, golden tiles; the Cabinet offices, still unfinished, with beautiful columns echoing the palace. Blocks of flats, finished, and very nice indeed; more under construction, grouped in 'supersquares' with gardens, main roads, shops, a school, a church, between each 'supersquare'. And the two- and three-level road system, still sketchy, but shaping into something that looks remarkable: of this more later. Next Rio, a sprawling, crowded, busy place, reminiscent of Genoa in its combination of town and port and beach, its mixture of old and new, its squares and avenues, with lush hills crowding behind and tunnels cutting through the headlands. Caracas, an odd place, in process of being torn down and built up, or torn down and just left; almost alone among Latin American cities it has none-the-less a very fine scheme of low-cost housing in hand, and a wonderful system of roads is under construction—motorways, rings, links, and multi-level intersections.

Mexico was almost all that Mexico should have been: the harshly dusty countryside with swirls of maguey cactus on the bare terraced hills and Popocatepetl snow-crowned, the impressive grandeur of the pyramids of Teotihuacan, the fantastic gold and silver convolutions of the Churrigueresque churches, and Candela's splendid shapes lovelier than the camera had disclosed.

Overall impressions: a standard of maintenance and finish generally far better than had been reported; originality in design, it seemed, slackening off from the grand flowering of a few years ago, and some lovely private houses forming perhaps the most characteristic local architecture, in Brazil as in Mexico.

Four recent office blocks

in London

THE COMING AND GOING of office blocks in London is a phenomenon of the present age. Cliffs of Victorian and Edwardian masonry crash to the ground; smoother and glossier cliffs rise in their place. Sometimes we stand and admire the results, but it must be admitted that occasionally we do not. What, then, can be the cause of our disappointment? It is not, unfortunately, always a matter of faulty design from the start; if it were as simple as this, the matter might more easily be remedied.

No, surely the trouble lies deeper. Often it springs from the fact that the architect can no longer be the sole master of his art which, intrinsically, is the most social of all the arts. Frequently he must make allowance for the wishes of others, particularly, perhaps, those with a finger in the financial pie. So we find that the requirements of town planning, rights of light, local authorities, fire regulations, the Royal Fine Arts Commission, property companies and syndicates—all tend to take control. The classic example of this is, of course, the recent Piccadilly Circus controversy, where it was practically impossible to discover just who was responsible for the design of the building which, it was said, had "designed itself".

At the final count, then, what we often see is not the architectural concept of a single mind or team, but a compromise designed to satisfy the various requirements, often conflicting, of half a dozen people. Sometimes the result of all this architectural wrangling is sadly evident; occasionally the storms are skilfully weathered and the essence of the original conception retained.

The four office blocks that we have chosen to describe seem to us to have successfully weathered these storms and to stand apart from the normal run. Two of them are tower blocks in the very heart of the metropolis which, apart from their size, stand out as works of exceptional architectural merit. The other two are smaller and of rather a different type: they are placed at key points in outer London and are significant in view of the Minister of Housing's recent drive to decentralize office acccommodation or, as he put it, "un-jam central London".

THORN HOUSE

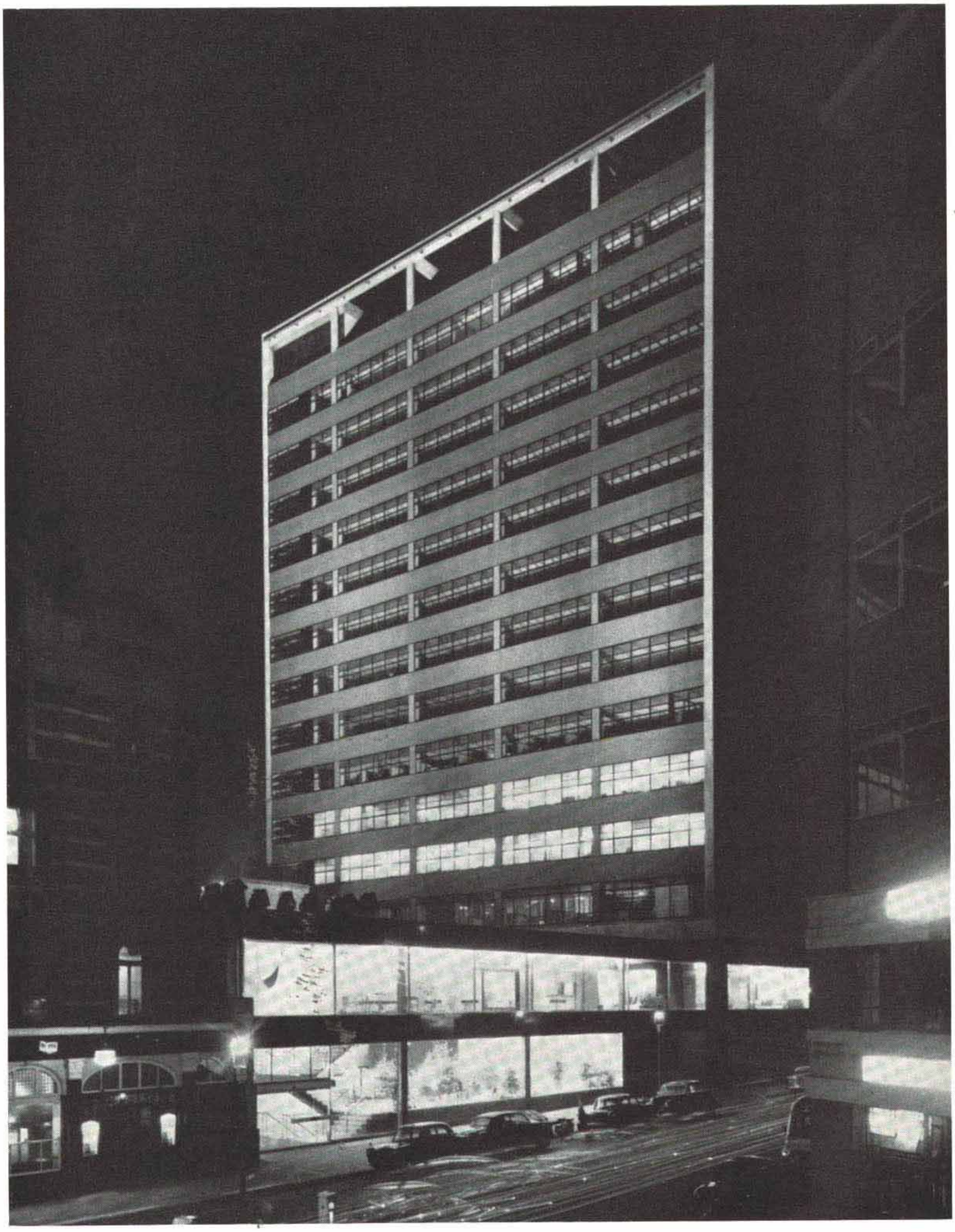
The new office building and showrooms for Thorn Electrical Industries Limited has a tower block rising 184 ft. above the pavement—about the same height as Nelson's column. It is a remarkable example of the way in which a site in a congested part of London can be imaginatively used.

The building is on the corner of West Street and Upper Saint Martin's Lane, in an area which, though a trifle down-at-heel, is none the less still in the centre of the theatre world, and therefore much in the public eye. Thorn House is expected to be the forerunner of other new development in the area.

Instead of building an eight-storey block covering the whole of the site, as they might have done, the architects have achieved the same floor area by building upwards on a small part of the site, leaving an attractive paved courtyard with plants and shrubs beneath the building at street level. This treatment creates a lively feature on what was once an uninteresting street corner—one would like to see more of this kind of thing in central London.

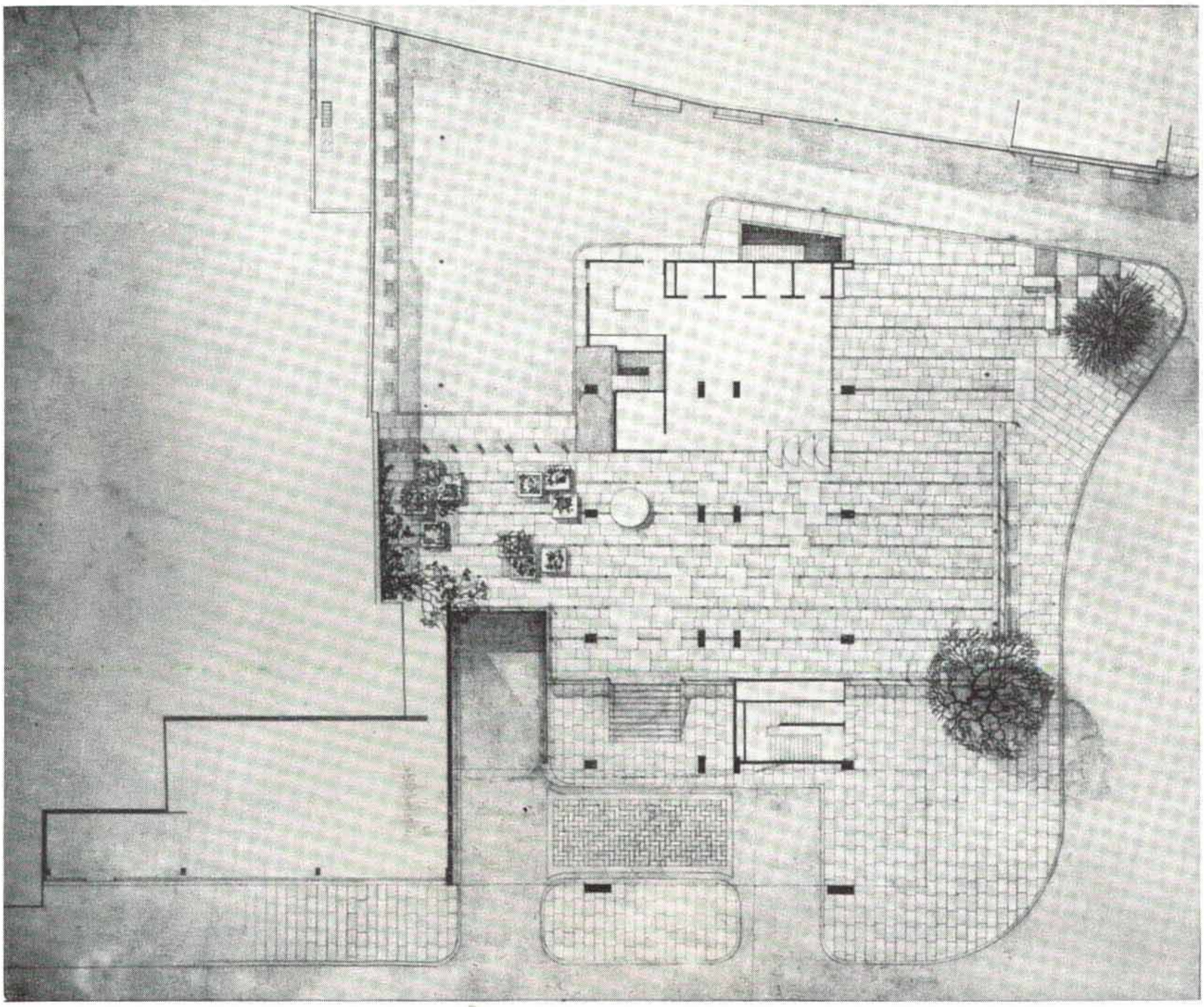
The building is clearly divided into two parts: the slim rectangular tower block containing offices on fourteen levels, and a long low showroom, two storeys high, which passes underneath at right angles. There is also a car park in the basement, and additional parking space on the ground floor, so that the building makes a positive contribution to the ever increasing problem of traffic congestion.

The tower block consists simply of a rectangle, approximately 125 ft. long by 53 ft. wide, containing an area of divisible office space on each floor, together with lavatories, two staircases, and a bank of four lifts at one end. This arrangement gives a net lettable floor area of 72 per cent on each floor. The first floor of the tower block is at present used for office and storage purposes, but it is hoped to provide space for confer-



Above: Floodlighting on the tower block of Thorn House. The brilliantly lit showroom can be seen in the foreground.

Left: Typical floor plan.



Plan of the entrance courtyard. A variety of patterned paving, varied levels and the arrangement of plants play an important part in the scheme.

FOUR RECENT OFFICE BLOCKS IN LONDON: *continued*

ences and lectures in a hall seating 200 people. There is a paved area on the roof, accessible to office workers, with fine views over London—to Hampstead and Highgate on the one hand, and over Westminster and the river to the North Downs on the other.

The showroom runs along Upper Saint Martin's Lane and is entered direct from the street. It gives about 7,000 sq. ft. of showroom space, and has large areas of glass, smooth polished surfaces and panels of strong eye-catching colour. It is designed to provide a shop window for the company's products, where clients can be conducted round the display and demonstration areas in air-conditioned and acoustically-controlled comfort.

The basement is entered by a two-way ramp under the showroom and has parking space for forty cars. All the main services are also housed here, including oil-fired boilers and pressurized cold water tanks; these are in the basement rather than on the roof, partly to save weight on the structure, and partly to leave as much space free as possible in the tower block for offices.

STRUCTURE The structural system used throughout the building is essentially simple: the tower block is carried on eighteen in situ reinforced concrete columns which are taken right down to block foundations resting on London clay. The column spacing is based on a 4 ft. 2 in. module, with five bays of columns at 25 ft. centres extending down the length of the block; a double row of spine columns is placed down the centre. This arrangement gives an office depth of 20 ft. 10 in. on either side of a central corridor.

The columns support in situ reinforced concrete edge beams externally and a series of spine beams, constructed with prestressed concrete planks, over the corridor. The beams are supported at either end of the building by reinforced concrete walls which also take the wind shear forces. There are no transverse beams over the office space: the flooring system used, which greatly speeded up construction time, was specially designed by the consulting engineers; it consists of prestressed concrete planks spanning between the edge and spine beams, hollow pot infilling, and a topping of in situ concrete. Suspended ceilings are used on all floors.

The structural system is clearly expressed over the entrance courtyard where the beams and prestressed planks are exposed in the soffit of the first floor slab. The space between the planks, in this instance, is filled in with precast concrete sections having an exposed aggregate finish and giving a flush soffit to the slab.

The edge beams are 9 in. thick and are placed in line with the external faces of the 1 ft. 8 in. square columns. This provides a recess behind the beams for convector heating. It also allows glazing to be placed near the external faces of the columns, giving an almost completely flush façade to the tower block.

With the help of careful planning, close consultation and two tower cranes, construction on this restricted site proceeded quickly: the majority of the tower block floors were completed at the rate of a floor a week.

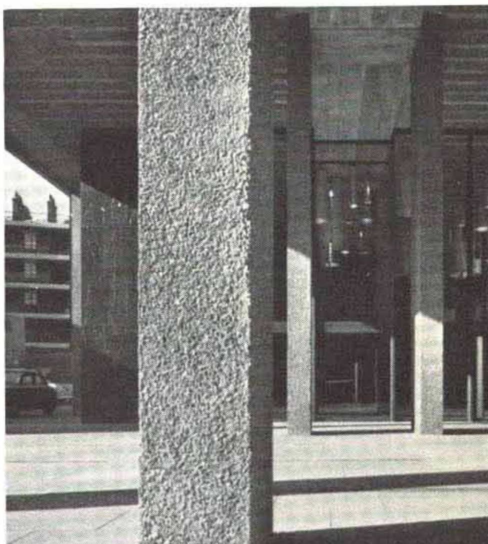
FINISHES The exterior of the building is clad with materials calculated to weather well in the murky atmosphere of London. Bands of greyish-blue glass mosaic provide a smooth surface between glazing, which is divided up into small ventilating panes, and large contrasting areas of glass. The divisions of the glazing are very important in keeping the scale of the building down to human proportions. The upper part of the windows, above transom level, are glazed with special tinted non-actinic glass to reduce excessive direct heat from the sun.

At roof level, where the frame is taken up to the top of the lift motor room to form a pergola, all the concrete has been left exposed; a board-marked finish with $2\frac{1}{2}$ in. rough-sawn boards has been used.

The east wall of the block is faced with Derbydene stone, whilst the west wall is clad with a particularly fine series of precast exposed aggregate slabs. The slabs were used as permanent formwork to the end wall; they are of a greyish-buff colour, uniformly textured and applied as storey-high panels.

An exposed aggregate finish has also been used on the outer faces of the columns in the tower block, and for most of the exposed concrete around the entrance courtyard; this includes all the columns between ground and first floor level. The aggregate was carefully selected for its sharpness and was exposed by using a retarder on the rough side of hardboard liners to the formwork, and brushing down the concrete immediately after the removal of the forms. The result is a pleasant fairly coarse-textured surface which lends considerable character to the columns. The concrete flower boxes in the courtyard are made with black and calcined flint aggregates which were exposed by bush-hammering; the result is silver-grey in colour and matches the granite kerbs and steps.

Paving in and around the courtyard has also received special attention. Round the perimeter of the site, where the pavement merges with the courtyard, precast concrete paving slabs have been used as well as precast concrete pavement lights. In the courtyard itself, a carefully worked out pattern of Portland and York stone slabs has been used, with strips of brick paving;



Left: View of the entrance courtyard, looking through to West Street.

Above: The exposed aggregate finish on one of the columns in the courtyard.

granite setts are placed around the flower boxes. A stepping-stone pattern of slabs is designed to lead the eye from the steps to the entrance doors; the main divisions of the paving scheme are carried through into the white mosaic floor of the entrance hall, so that continuity is preserved between the outside and inside. Finishes in the glazed entrance hall include black marble on the reception desk, and a pinkish-buff marble on the lift wall. Lighting is provided by a series of copper and aluminium tubes of varying size, which at night lend a touch of mystery to the courtyard.

The showroom, the interior of which was designed by John and Sylvia Reid, is faced with polished black granite which contrasts well with the stainless steel window frames.

The east wall of the tower will receive an abstract piece of sculpture, by Geoffrey Clarke, in bronze.

The architects for Thorn House were Basil Spence and Partners. Ove Arup and Partners were the structural engineers; the general contractors were Bovis Limited. Cawood Wharton Limited made the prestressed concrete floor planks; Precon Limited of Rye made the precast exposed aggregate slabs.

CASTROL HOUSE

Castrol House in Marylebone Road, headquarters of the Wakefield Castrol Group, is surely one of the most spectacular office blocks to be built in London since the war. The high standard of finishes and detailing would in any case be enough to command attention: with its clear colour, clean lines and shining surfaces it is as welcome, amidst the gloomy architecture of the street, as a bright shop window on a dark Sunday.

The massing of the building as a whole follows the pattern set by Lever House in New York, and since followed with success in other parts of the world—that of a slim tower block set on a two-storey podium covering the entire site. This is normally a logical solution to a schedule of accommodation which includes large public rooms in the lowest floors, with repetitive office accommodation rising above.

In this instance, however, the massing represents a compromise between the original conception and the wishes of the Royal Fine Arts Commission: the architects had designed a high tower over a patio at ground level; the Fine Arts Commission wanted a rectangular building parallel with Marylebone Road. A further complication arose over the close proximity of the Marylebone Town Hall tower. Because of this, the height of the building had to be reduced, and the lost accommodation placed over part of the two-storey podium to make a third floor. In this way, the impact of the building has to some extent been lessened.

The twelve-storey tower block rises 168 ft. above the pavement and is rectangular on plan, measuring approximately 52 ft. by 110 ft. overall. It contains divisible office space, with the main lifts, staircase and lavatories placed in one corner, and a secondary staircase and lift at the opposite end. The main entrance hall, at the front of the podium block, extends through two floors and is made a special feature of the building. A ramp at the rear of the block leads down from the street to a car parking area in the basement which, together with stores and workshops, covers the whole of the one-acre site.

STRUCTURE The building has a frame of reinforced concrete placed in situ, with columns kept to three basic sizes to save construction time; column caps and staircases were precast. The columns are arranged in 23 ft. 4½ in. bays down the length of the tower block. To allow for flexibility of planning, and the easy running of services, a flat slab system of flooring was used. Consequently it has not anywhere been necessary to drill holes for services through downstand beams. A series of beam strips about 6 ft. wide, designed within the thickness of the 8½ in. floor slab, extend between columns. This type of reinforced concrete construction has been found to be very rapid, as it cuts down on formwork by approximately 30 per cent.

The structural design of the tower block presented a certain number of problems as regards rigidity, and it was found necessary to provide continuous reinforced concrete diaphragm walls. One of these runs along the north side of the main service core; the other is L-shaped and extends round the secondary staircase. The walls are on the average 12 in. thick and are taken right down to the main raft foundation.

The tower block foundations consist of two independent reinforced concrete rafts some 6 ft. lower than the foundations for the rest of the building. Settlement joints extending from the basement to the roof level separate the tower structure from the lower parts of the building, and so allow for unequal settlement. Independent mass concrete column bases are used for the remainder of the building.

FINISHES The dominating factor in the surface finishes is necessarily the glass and aluminium curtain walling which entirely encloses the building. This is particularly well designed and detailed, and is the result of very close co-operation between the architects and the curtain wall manufacturers, who had their own designers working actually in the architects' offices for two months.

The curtain walling for the tower block has an aluminium grid with glass spandrel panels of a clear viridian. A system of cold cathode floodlighting behind the spandrels dramatically lights the building at night to give an effect of a series of green glowing 'trays' suspended one over the other.

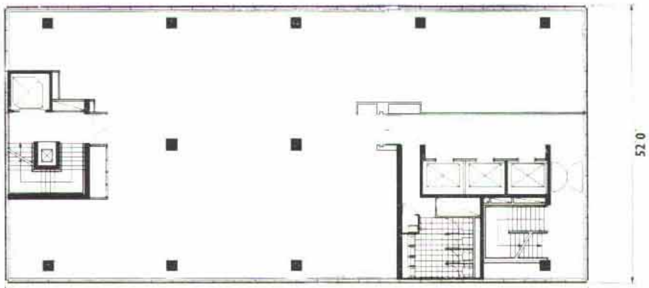
The curtain walling in the podium block has black anodized aluminium mullions, connected by naturally coloured aluminium sills and transoms. Spandrel panels on the main elevations are of strongly contrasting white Sicilian marble.

The finishes of the main entrance hall can only be described as magnificent. The entrance screen, below a 60 ft. long canopy, consists of large areas of plate glass framed in stainless steel and aluminium. Inside, a wall

Above: Castrol House seen from the Marylebone Road.

Right: The entrance hall with part of the sculptured wall panel depicting the processing of oil.

Below: Typical floor plan.



of orange mosaic contrasts with a range of subtle grey finishes, slightly varying in tone, produced by a floor of Belgian fossil marble, wall and column facings of white Sicilian marble, and a neatly detailed stair of granite, glass and stainless steel. In addition, there is a fascinating piece of wall sculpture extending over the full height and width of the entrance hall in a panel 50 ft. long by 24 ft. high. The panel was designed in aluminium by Geoffrey Clarke and is in bold relief; it depicts the processing of oil, in all its various stages, from the first experiments to the final end-product—speed.

The architects for this extremely satisfying building were Gollins, Melvin, Ward and Partners in association with Sir Hugh Casson, Neville Condor and Associates. The structural engineer was W. V. Zinn. Sir Robert McAlpine and Sons Limited were the contractors.

PUTNEY BRIDGE HOUSE

Further afield, on the fringe of the congested areas, Putney Bridge House is strategically placed. Standing, as it does, at the northern approach to Putney Bridge it is particularly conspicuous—with traffic streaming past in and out of London. The bold treatment of its tower block catches the eye in passing, and leaves an impression of crisp design and smart finishes.

The building was designed for Church Gate Investments Company Limited. It is T-shaped on plan with a low two-storey block, slightly curved to the line of the road, forming the head of the T along Putney Bridge. Seven floors of offices are placed in a rectangular block, 83 ft. by 44 ft., at right angles; from the upper floors, workers will get fine views over the Thames and surrounding parkland to Fulham Palace.

An open car park is neatly contrived in a semi-basement approached by a curving ramp at the rear. The boiler house and storage rooms are also placed at this level. Tank and lift motor rooms on the roof are concealed by the frame of the tower which projects upwards one storey.

STRUCTURE The building has an in situ reinforced concrete frame, with load-bearing mullions at 4 ft. 4½ in. centres extending the length of the tower block; the mullions are linked by precast concrete sill units. A single row of spine columns is placed down the centre of the block at twice the spacing of the mullions.

Prestressed precast "Pierhead" floor units were used from the first floor upwards; these were combined with in situ concrete beams cast within the thickness of the slab. The infilling tiles, normally placed between the units, were in this case omitted to reduce the dead weight; instead, a 2½ in. in situ topping to the slab was placed on permanent expanded metal formwork. Apart from the saving in weight, this method of construction, combined with false ceilings, proved to be more economical than the usual method. The 'beamless' slab would seem to have much to recommend it for office purposes and appears to be increasing in popularity.

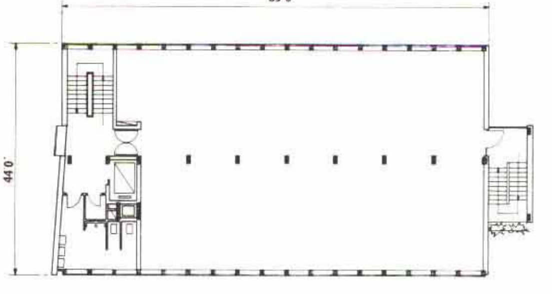
Columns in the low block are more widely spaced, at 14 ft. 6 in. centres, with spans of 29 ft. between. The columns along the front of the building are set back to allow curtain walling in the main façade.

Because the building is sited close to the river, it is carried on 114 reinforced concrete Franki piles. Reinforced concrete retaining walls are used below ground level.

FINISHES White "Mineralite" has been freely used in the external finishes to exposed concrete. It has been used on the whole of the frame of the tower block, and contrasts with spandrel panels of black vitrolite.

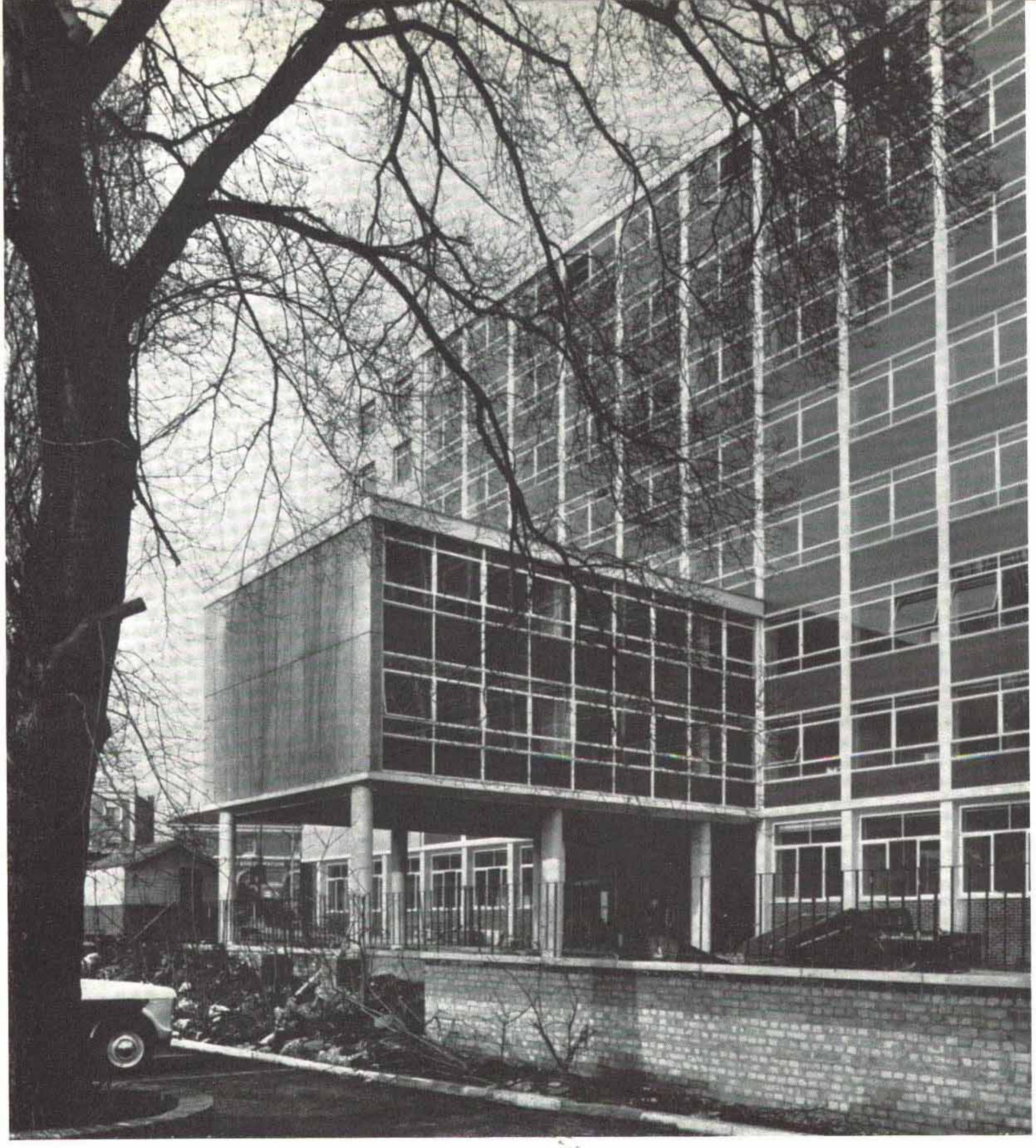
The gable end wall at the rear of the building is also partly finished with white "Mineralite", but has, in addition, light silver grey facing bricks. The front gable wall is faced with light grey mosaic, providing a textured background for some free-standing sculpture at the base of the wall; this is known as "Swan Man", and was designed in fibreglass by Bainbridge Copnall who has done, amongst other things, sculpture for the R.I.B.A. building.

The blank end walls of the low block are lavishly faced with Piastraccia marble, which is white with a heavy grey graining. Full height plate glass windows in finely wrought bronze frames extend along the front of the block, the whole enclosed by a simple rectangular



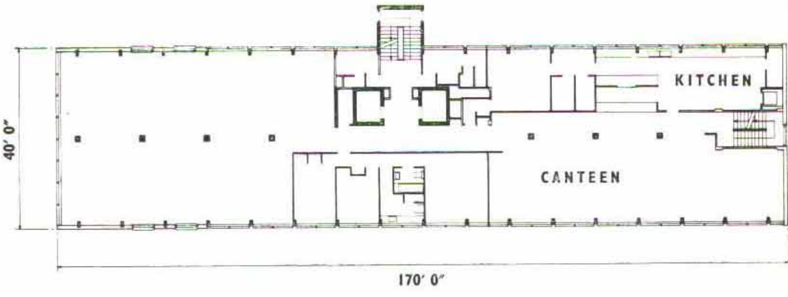
Above: Typical floor plan of Putney Bridge House.

Left: The tower block has a bold external treatment.



Left: The projecting wing over the entrance to Yeoman House: exposed aggregate slabs on the end wall contrast with the light blue glass spandrel panels which cover much of the building.

Below: The seventh floor plan, showing the provision of canteen, kitchen, executives' dining-room and caretaker's flat.



frame of white marble. Exposed concrete columns in the basement garage have a regular board-marked finish.

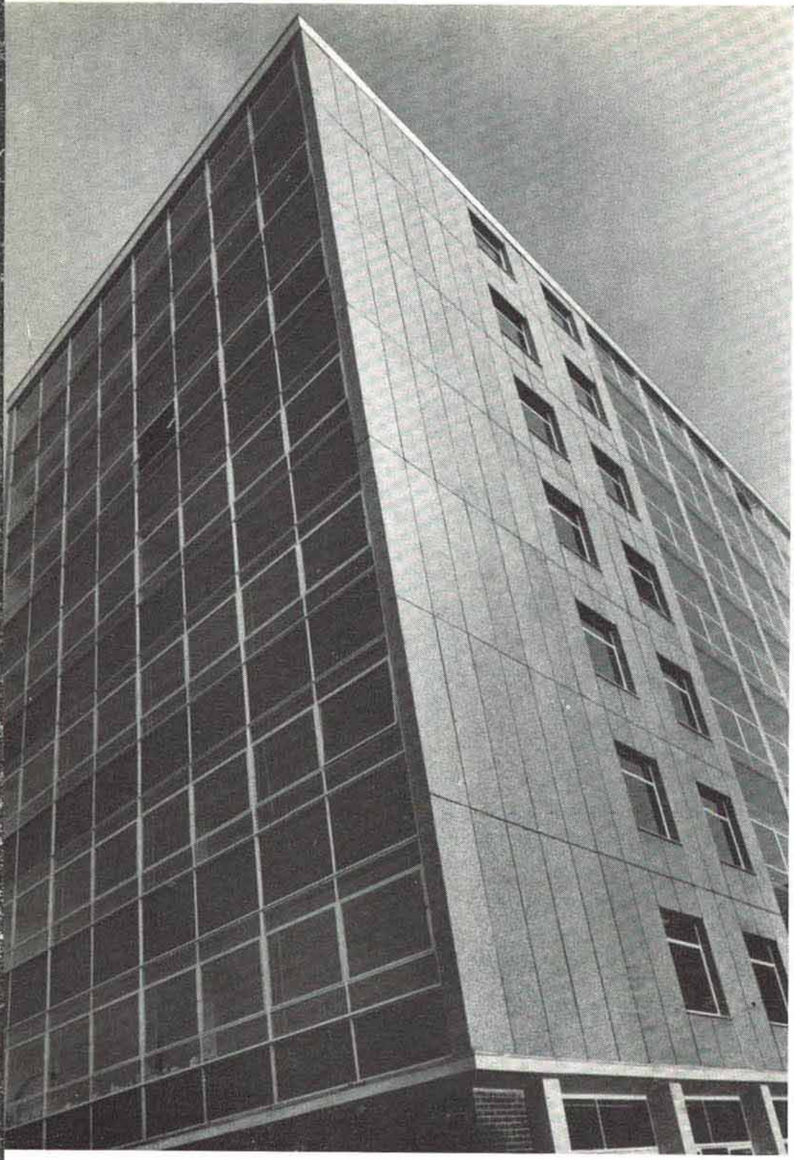
Internally, the entrance hall is faced with greenish-grey Cippolino marble and a floor of rubber mosaic. The ceiling is strongly contrasting and painted almost black. Staircases are free-standing and finished with light grey rubber, and specially profiled aluminium nosings.

Putney Bridge House was constructed in a little over twelve months. The architects were R. Seifert and Partners; H. G. Marsh and R. F. Morris, A./A.R.I.B.A., were the architects in charge. The Reinforced Concrete Steel Company were the structural engineers; the general contractors were George Wimpey and Company Limited.

YEOMAN HOUSE

On the site of the old "Q" theatre and overlooking Kew Bridge, Yeoman House (formerly known as Kew Bridge House) has recently been built for Rodwell Properties Limited. The building has figured prominently in the drive for decentralization of London offices, and was officially opened by the Minister of Housing and Local Government at the end of last year.

The site is near the end of the new Cromwell Road extension, and is adequately linked by public transport with central London. The economic advantages in building offices in such areas are quite considerable: for example, office rents in Kew and similar districts



Storey-height exposed aggregate slabs provide a pleasant contrast with the curtain wall treatment on the end of the tower block.

FOUR RECENT OFFICE BLOCKS IN LONDON: *continued*

average 12s. 6d. a sq. ft., whereas in Holborn, for instance, rents are more than 30s. a sq. ft. This means that for the same cost a higher standard of amenities can be offered to employees by building outside central London. At Yeoman House these include a large canteen, and generous parking space around the building.

The offices are housed in a long eight-storey rectangular block, with a short two-storey block projecting as a canopy over the entrance on the south side. The main longitudinal axis of the building runs east and west, with the southern elevation parallel to and overlooking Kew Bridge and the River Thames. Whichever way one approaches, the building is a conspicuous landmark—glimpsed between the small brick buildings of Kew or from the sprawling vegetable markets and gasworks of Brentford.

The main eight-storey block, containing divisible office space, measures 170 ft. by 40 ft., while the small projecting block measures 30 ft. by 40 ft. The main stairs, lifts and lavatories are placed in the centre of the north side; a secondary staircase is placed at the east end. On the seventh floor there is a large canteen, an executives' dining-room and a kitchen, together with a caretaker's flat.

STRUCTURE The building is carried on 170 reinforced concrete piles driven to a depth of about 30 ft. Retaining walls to the basement are constructed of dense concrete with a waterproof additive: no tanking was therefore used. The superstructure consists of an in situ reinforced concrete frame, with three rows of columns extending the length of the main block; these are spaced at 10 ft. centres externally, with the central spine columns at 15 ft. centres. The columns support edge and spine beams within the thickness of the floor slab. A transverse reinforced concrete wall in the service core area, connected by a beam to a column on the southern elevation, provides resistance against wind forces.

There are in situ reinforced concrete floor slabs 5 in. thick in the service core area; throughout the remainder of the building composite floors 10 in. thick have been used. These have precast prestressed concrete joists 7 in. deep at 2 ft. 6 in. centres spanning approximately 18 ft. between the main beams. A 2 in. structural screed was laid on top of these joists, and a 4 in. space left for services between the floor soffits and suspended ceilings.

FINISHES Spandrel panels on the two main elevations are faced with light blue glass, this being a dominating feature of the building. The bays at the west end of these elevations are faced with precast concrete slabs which have a pleasant silver-grey exposed aggregate finish, and lend solidity to the elevations; they also tone well with the blue spandrels and white paintwork on windows. The slabs are storey-high and measure 2 ft. 6 in. by 10 ft.; projecting nibs cast in with them rest on the floor slabs, to which they are secured by dowels. The wide recessed joints were finally pointed in black cement mortar.

The entire end wall at the rear of the building, and the end wall of the small projecting block are also faced with these exposed aggregate slabs; the end wall facing on to Kew Bridge Road has curtain walling of blue panels to match the main elevations.

The elliptical columns supporting the small block over the entrance are faced with white rendering; exposed concrete surfaces elsewhere are painted white, or faced with artificial stone.

Finishes in the entrance hall include walls of white Calacata marble, floors and stairs covered with terrazzo, and glazed screens in aluminium frames.

The architects for Yeoman House were Duncan and Partners. C. J. Pell and Partners were the consulting engineers. Tersons Limited were the contractors. Fram Reinforced Concrete Limited were sub-contractors for the reinforced concrete work; the exposed aggregate facing slabs were made by Stent Precast Concrete Limited.

A concrete hyperbolic paraboloid roof over a Lincoln garage

THE CONCRETE hyperbolic paraboloid has at last made its debut in this country. The event is welcome, not because we necessarily want a spate of hyperbolic paraboloids throughout the land, but because it strengthens the growing trend over here towards experiment and the more imaginative use of structural concrete. We have watched with enthusiasm what Candela has done with this form of structure in Mexico; it is encouraging to discover that architects and engineers in Britain are gradually dispelling the fogs of our own innate conservatism towards design, which still linger in patches here and there.

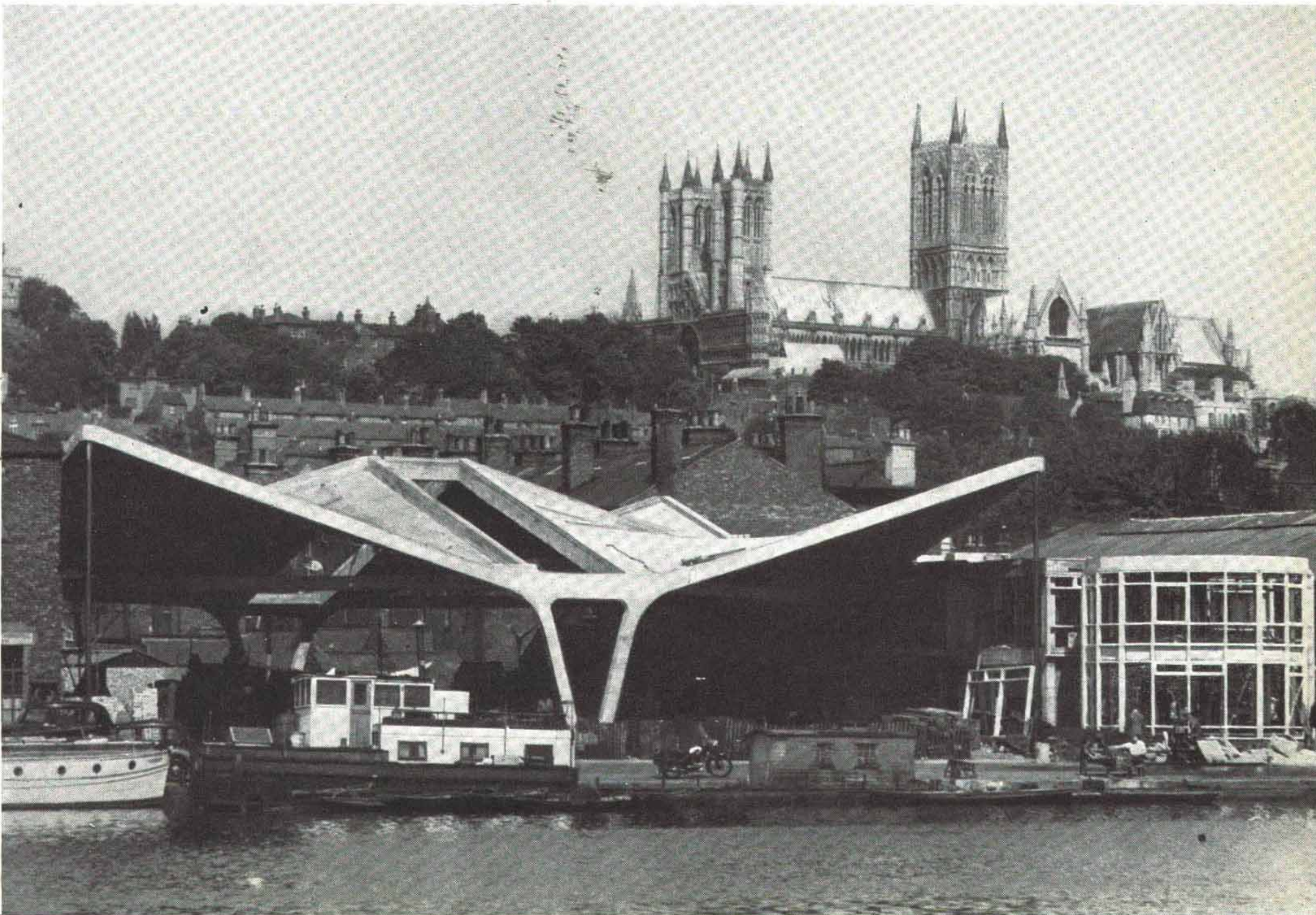
At Lincoln, a new garage has been built with a hyperbolic paraboloid roof of concrete. As a measure of the stir it has caused, it is worth recording that whilst it was under construction, the *Lincolnshire Echo* received a number of telephone calls from passers-by informing them that the roof had subsided in the middle and was about to collapse!

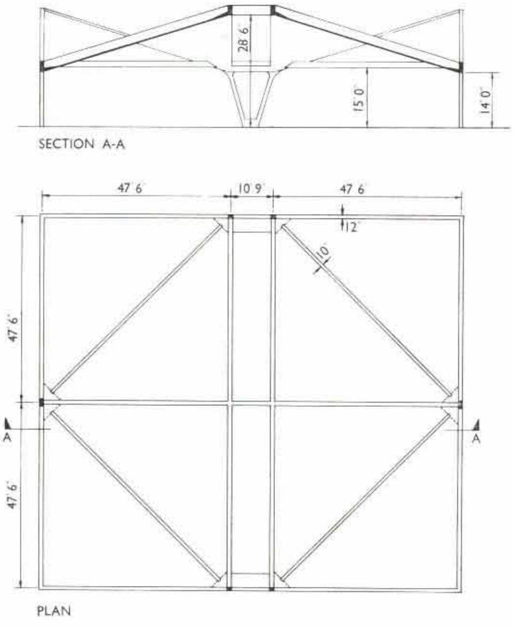
Although not the first hyperbolic paraboloid roof to be constructed of concrete in Britain (there were two earlier ones, at Bristol and Bedford, and a small experimental one at Ilkeston), it is the largest to be completed at the time of writing. The garage which it roofs has been built, together with offices and a showroom, for the Lincolnshire Motor Company Limited. The building is pleasantly sited on the edge of a waterway dotted about with small craft, known as Brayford.

The different elements of the building form three independent structures separated by expansion joints. The circular showroom and manager's office form a two-storey cylindrical building placed at one corner of the site; the main showroom and first floor offices are contained in a two-storey rectangular block extending down one side. The remainder, and greater part, of the site is taken up by the garage.

The garage roof is composed of two pairs of identical hyperbolic paraboloid concrete shells which, for the most part, are no more than $2\frac{1}{2}$ in. thick. The shells are arranged so that their highest points are at the centre and the four corners of the garage. Each shell is

The garage roof under construction, with Lincoln cathedral rising above in the background.





Above: Section and plan of the garage.
Below: Uncluttered space is a feature of the garage interior.
Bottom: The finished garage viewed from the front.

A CONCRETE HYPERBOLIC PARABOLOID ROOF: *continued*

47 ft. 6 in. square on plan, the two pairs being separated by an intermediate strip, 9 ft. 9 in. wide, containing roof lights and ventilators.

The roof covers a completely uninterrupted floor space, 96 ft. by 106 ft. 9 in., and is supported by four reinforced concrete columns—one in the centre of each side. Two of these columns are V-shaped; the remaining two are rectangular and measure 1 ft. by 2 ft.

From a point 5 ft. away from the edges, the thickness of each shell is gradually increased to 9 in. to meet upstand edge beams; these are 12 in. wide by 18 in. deep round the perimeter of the garage, and 12 in. wide by 30 in. deep elsewhere.

The horizontal thrust exerted by the shells acts diagonally. For various reasons it was not possible to provide external buttresses to take up these thrusts, so that it was necessary to arrange four diagonal tie beams connecting the lowest points of the shells. These are of precast prestressed concrete and are placed 15 ft. clear of ground level, spanning 67 ft. Vertical movement in the shells is prevented by $6\frac{1}{2}$ in. diameter steel tubes placed at the four corners.

Tubular scaffolding and timber formwork were used for each pair of shells, one shell being cast at a time. On completion of the first pair, the same formwork was re-erected for the second pair. The two highest points of the roof—at the intersection of the central beams—were supported by a specially designed steel tower until the whole reinforced concrete structure was complete.

The shells were cast on V-jointed timber formwork made up of wrought timbers from 4 in. boards. The board-marking is left exposed on the underside of the roof, as it was felt that this treatment helps to express the geometry of the shells. As the underside of the roof is required to act as a light reflector, two coats of very light grey distemper were sprayed on the concrete. The top surface of the concrete was finished with a steel trowel to receive waterproofing treatment.

Plywood formwork was used for the remainder of the in situ concrete, the surface being left with a fair-faced finish and painted on the main elevations only. The precast tie beams were delivered with a fair-faced finish and painted dark grey.

The ground floor slab was cast after the roof was completed; it consists of an 8 in. concrete slab incorporating a 1 in. granolithic topping.

The front of the garage, facing on to the water, has a recessed lay-by for petrol pumps, backed by a glass partition. The rest of the garage is enclosed with brick walling; there is glazing in timber frames above a height of 12 ft.

The architects were Denis Clarke Hall, Sam Scorer and Roy Bright, F./A./A.R.I.B.A. Dr. K. Hajnal-Kónyi, M.I.C.E., M.I.Struct.E., was the consulting engineer. The contractors were Gee, Walker and Slater Limited; Cawood Wharton Limited manufactured the prestressed concrete tie beams.

NATURBETONG—

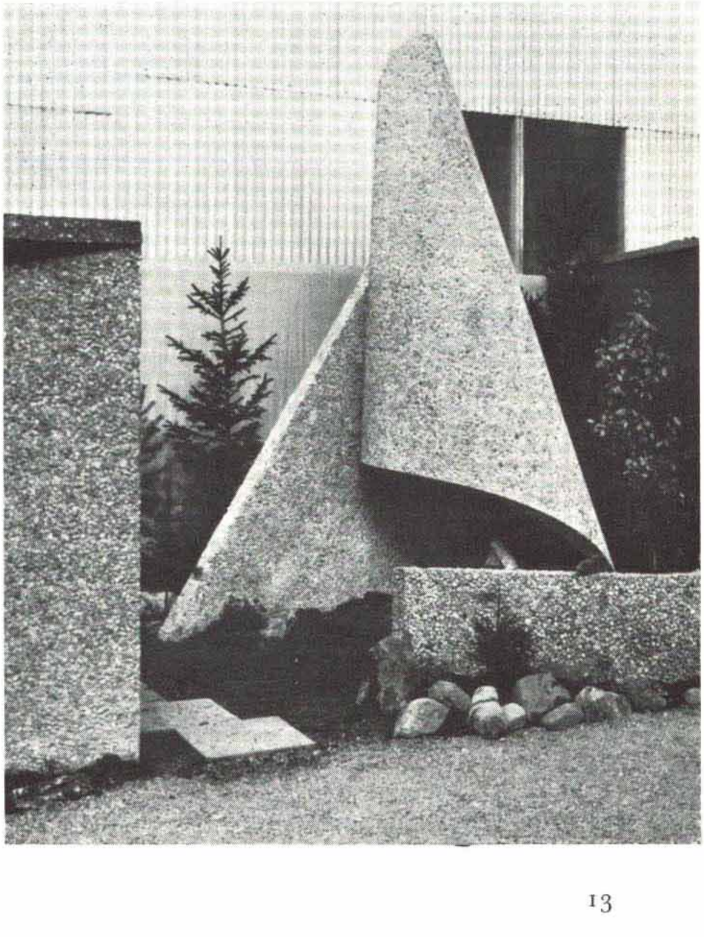
a common ground for the architect and artist

THE PROBLEM of how best to finish concrete has long been a tricky one. The Romans first dealt with it by covering up their concrete vaults with marble, stone, brick or mosaic. Until comparatively recently there was a similar tendency in this country: concrete was thought of merely as an engineering material to be faced with something else more decorative. With Corbusier came the idea of concrete as an architectonic material, expressed in his beloved chunky shapes of concrete straight from the forms.

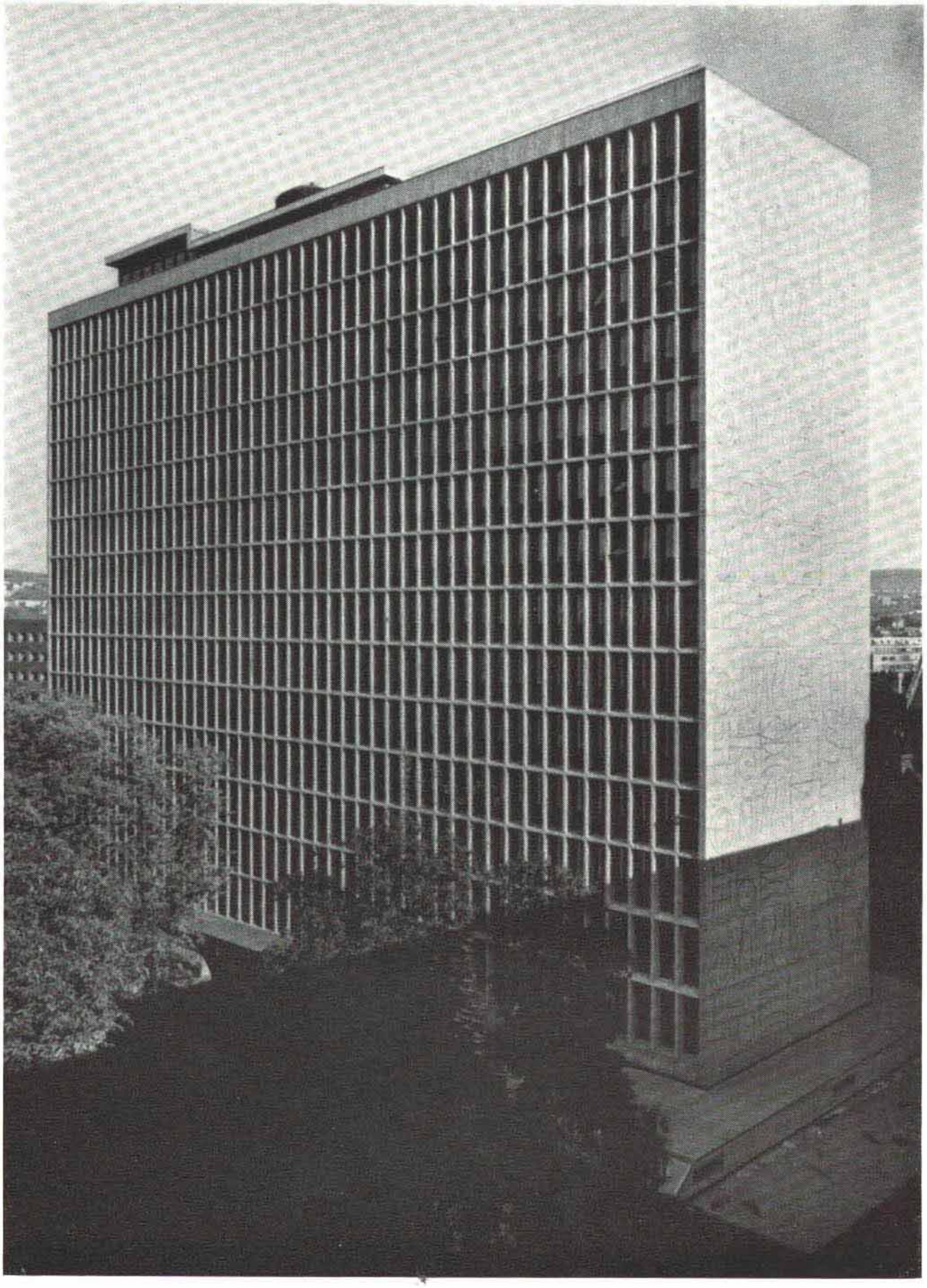
However, there are some who find this sort of treatment a trifle too *brut* for their liking, and who, whilst not wishing to disguise the material, cannot accept that formwork should be expressed as an integral part of concrete construction. For them, the alternative is to bring out the true nature of the concrete, and to obliterate all traces of the forms.

This approach would seem to have much to recommend it, the only snag being—what is the true nature of concrete and, having discovered it, is it acceptable as a finish on its own? Natural materials, such as wood and stone, present few difficulties when it comes to finish: the structure is already arranged to produce surface patterns, textures and colours which are sufficiently uniform to be acceptable on their own. But with an artificial material, such as concrete, this is not necessarily so. This is because ordinary concrete is not a homogeneous and uniform mass, and there is always a chance that any inconsistencies in the material may be reflected on the surface—particularly if workmanship is not perfect or insufficient care is taken in placing. It would seem, therefore, that the less that can be left to chance the better, if a satisfactory surface finish is to result. In other words, the structural composition of concrete must be specially arranged, as far as possible, to give a uniform mass and consequently a uniform surface pattern. Gap-graded concrete, by eliminating the smaller aggregate, does this to a certain extent. The Norwegian architect, Erling Viksjö, who has been working on the problem for some years together with Sverre Jystad, a civil engineer, has gone a stage further. The result he calls Naturbetong—or natural concrete—which, by exposing the maximum amount of aggregate, opens up a whole range of possibilities for rich and decorative surface treatments.

The method might be described as a refinement of



A curling structure of Naturbetong, with an evenly sandblasted surface texture, houses a fireplace for a barbecue.



The new Government building, Oslo.

the intrusion method of placing concrete, coupled with sandblasting. The first stage is to fill the formwork with thoroughly washed and graded aggregate of over $\frac{5}{8}$ in. (In all Viksjö's recent work, rounded granite aggregate of $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. has been used.) This coarse aggregate is then thoroughly consolidated by tamping or vibrating.

The next stage is to inject the mortar, consisting of cement, water, fine-grained sand and various chemical admixtures. The mortar will fill all the voids amongst the coarse aggregate until the form is filled. There are several methods of injecting the mortar, one of which is through pipes previously placed in the forms. The pipes are then gradually pulled up as the mortar rises.

After a suitable period of time, when the mortar has reached sufficient strength, the forms are removed. The timing is a very important factor and, for the best results, should be between eight and thirty hours after injecting the mortar, depending on the temperature and humidity.

The surface of the concrete will, at this stage, be completely smooth, with a good deal of mortar (which, of course, may be white, grey or coloured) showing. The mortar will be still fairly soft, and is next removed

—to a lesser or greater extent—by sandblasting.

The surface which now appears is considerably more uniform and true than the sandblasted surface of ordinary concrete. One of the most important differences is that all the outer surfaces of the coarse aggregate remain in one vertical plane, no matter how much mortar is blasted off. Also the maximum amount of aggregate is exposed.

The compressive strength of Naturbetong has been found to be particularly satisfactory, and is at least equal to that of a good quality normal concrete. In one instance, cubes sent to the testing laboratory in Oslo could not be crushed with the equipment available, and were returned!

A further advantage is that all lift marks and construction joints can be made invisible—frequently a stumbling block with other techniques. In addition, the possibility of voids and other irregularities forming is reduced to a minimum; any that do occur can easily be repaired without leaving any visible trace.

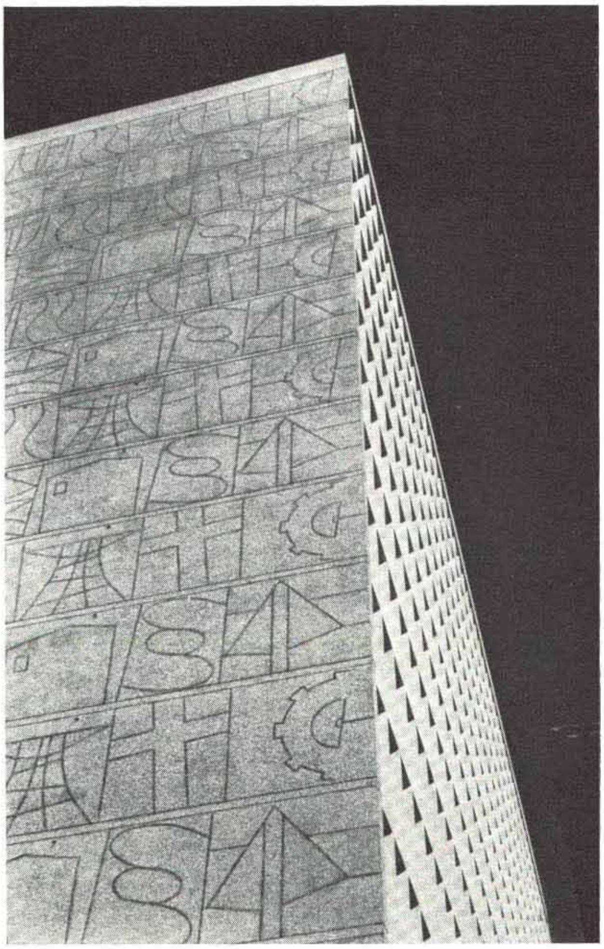
In spite of its relatively coarse texture, the material can be used for quite slender elements. Also, the possibilities for a varied and individual treatment of concrete surfaces are unlimited: by varying the depth of sandblasting, or by leaving some parts unblasted in regular or irregular patterns, a whole range of treatments becomes possible.

From this, it will be appreciated that the sandblasting instrument, in the hands of the right person, has as many possibilities as the pencil or graver in the hands of the artist, and is a great deal more than a mere builder's tool. In fact, this method should at last provide a common ground on which artist and architect can meet—a matter, until recently taken up by the London County Council, far too long neglected. In the past, the artist has occasionally been called in to art up a completed building with a few murals, or a piece of extraneous sculpture. This has too often been quite ineffectual: one might as well hang a daisy chain round a tiger's neck. . . . In the end, it seems that architect and artist must surely work together if surface texture and decoration are to become properly integrated with architectural design, as indeed they always were during the Greek and Gothic periods of architecture.

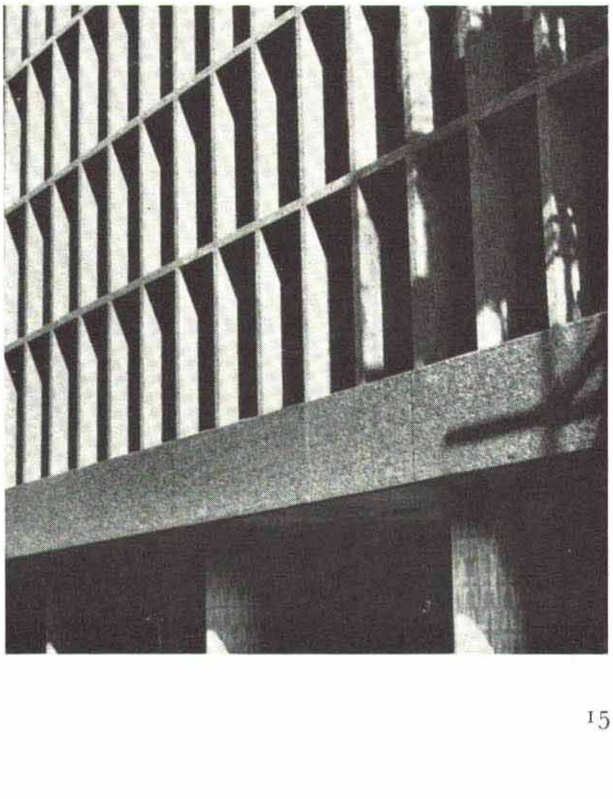
THE NEW GOVERNMENT BUILDING, OSLO

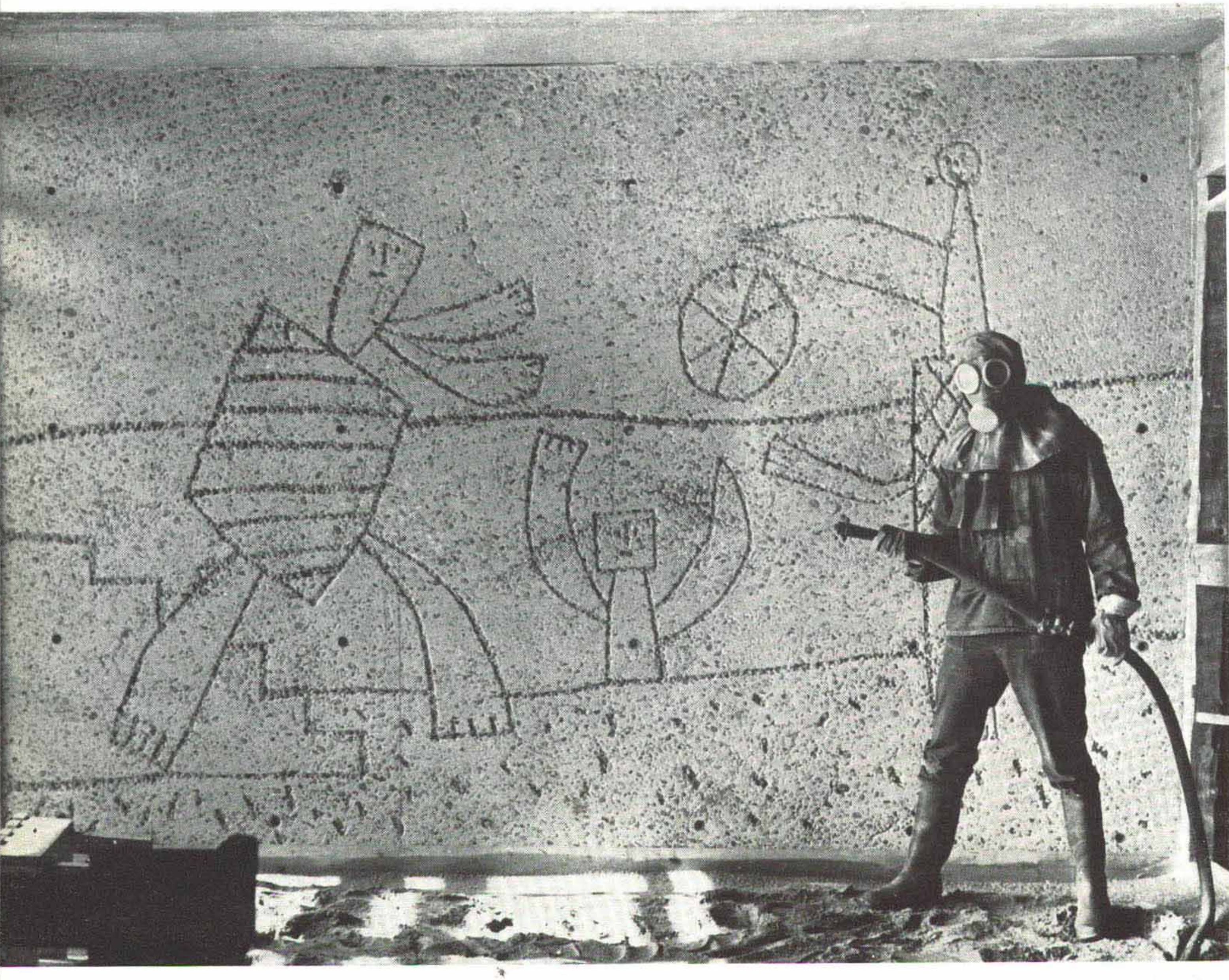
In Oslo, efforts at combining art and architecture have not, in the past, been very successful. The grandiose Town Hall, for instance, brought forth a shower of criticism—its art and architecture were kept strictly apart. Although separated from the Town Hall by only a few years, the new Government building from this point of view represents a work of the greatest significance.

Designed by Erling Viksjö, as the result of a competition held in 1939, the drawings were shelved during the war and later brought up to date, although the essence of the design remains the same. The build-



Above: Detail of a gable end wall in the new Government building. The repeating pattern is sandblasted through rubber stencils.
Below: The exposed concrete elements on the window walls have an evenly sandblasted texture.

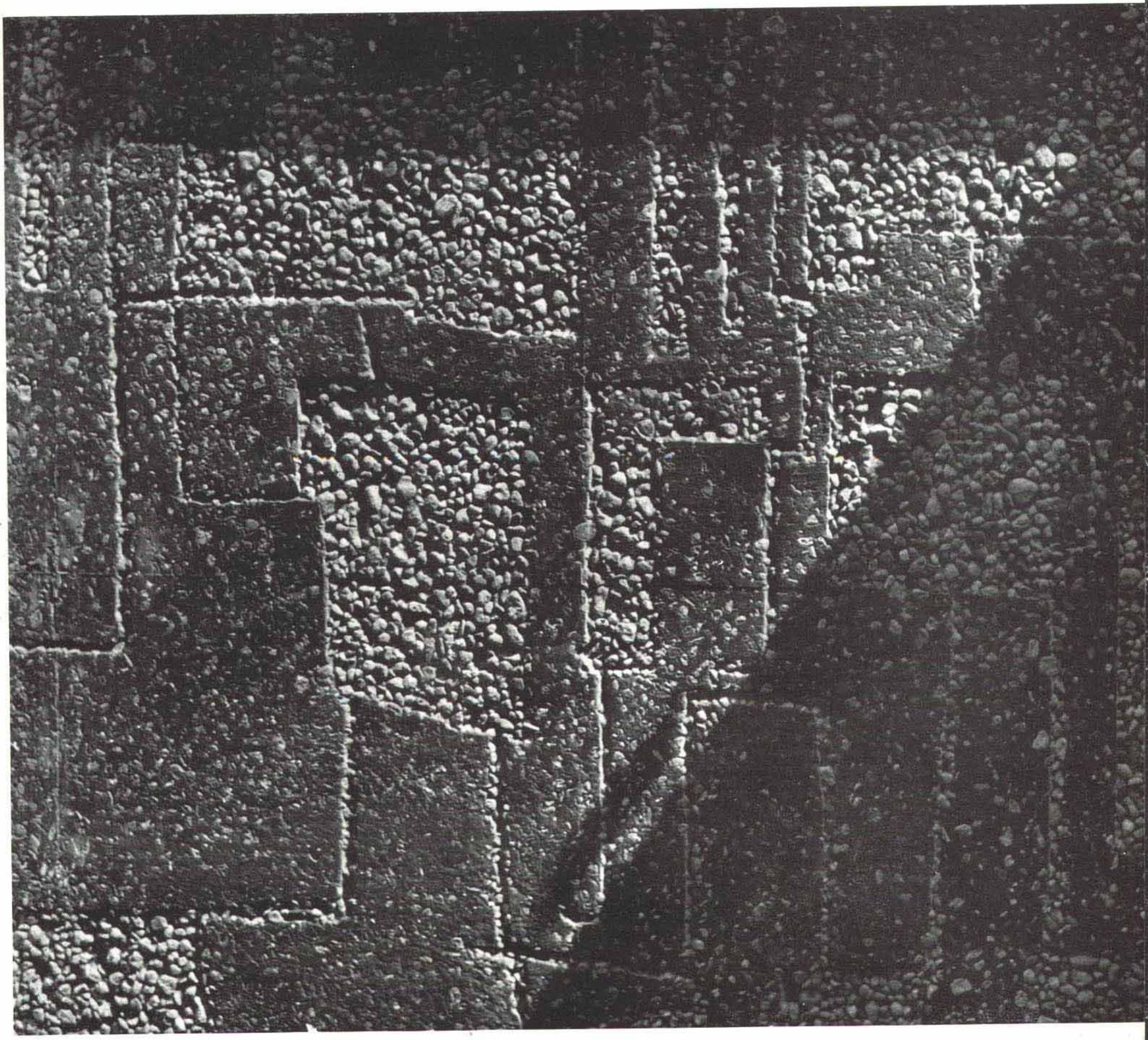




One of the staircase walls in the new Government building in the process of being sandblasted by Carl Nesjar; the design is a beach scene by Picasso, initially projected on to the wall through a lantern.

ing contains fifteen storeys of government offices in a neat slab, 49 ft. by 196 ft. on plan and 159 ft. high. It has a reinforced concrete frame, and a boldly expressed pattern of fenestration on the long elevations, formed by an overall concrete grid. The total cost for the building was about £800,000.

The building is constructed of Naturbetong with decorative surfaces used extensively both inside and out; a rounded granite aggregate has been used throughout. For the decorative scheme, Viksjö has sought the collaboration of some of the best young Norwegian painters, including Carl Nesjar, Inger Sitter, Tore Haaland, Odd Tandberg, and Kai Fjell. It happened by chance that Picasso also came to collaborate in the mural designs: shown some photographs of experiments in the technique, he became so interested that he presented Nesjar with some drawings designed for experimental use in concrete. These were simple line drawings and were projected, by means of a lantern, on to the walls. The sandblasting was then



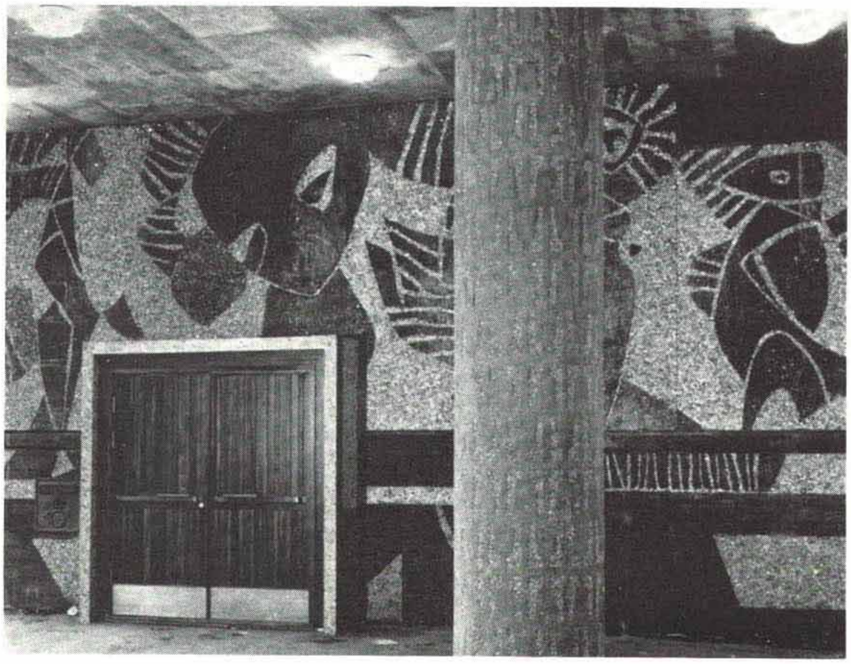
Another staircase wall in the new Government building, treated with an abstract design and cast with black cement.

carried out by Nesjar himself. Experiments were also made with figures from Picasso's "Tripticon" in the museum at Antibes; this design, which has for its central figure a dancing calf, was used for one of the staircase walls. Two other such walls have designs specially worked out by Picasso for the purpose.

Decoration internally is largely concentrated on the twenty-eight walls of the main staircase, resulting in a fascinating survey, as one climbs, of the possibilities of the technique (the artists insist that their work is experimental).

The eldest of the artists, Kai Fjell, is the only one, apart from Picasso, to favour 'naturalistic' shapes; the others have all used abstract or geometric patterns, some of them quietly harmonious, others more restless and even aggressive in effect. Most of the designs have been carried out with black or white cement, although other colours, such as terracotta, have been used.

Occasionally heavy rubber stencils, or templates, have been used for the more intricate designs—as on

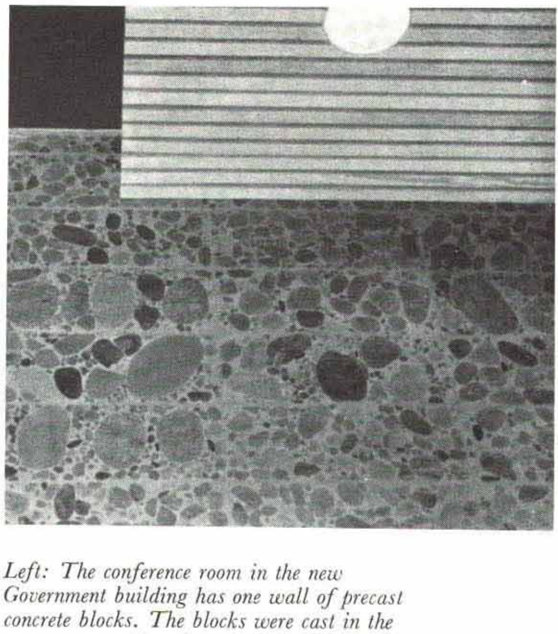


Bold figures, designed by Kai Fjell, are sandblasted on to a wall in the entrance of the new Government building; columns are treated with a delicate lace-like pattern.

the circular columns in the entrance hall which are decorated with delicate lace-like patterns; this sort of motif seems to have something traditionally Norwegian about it, like the designs on those thick woollen sweaters which are so commonly worn in Norway!

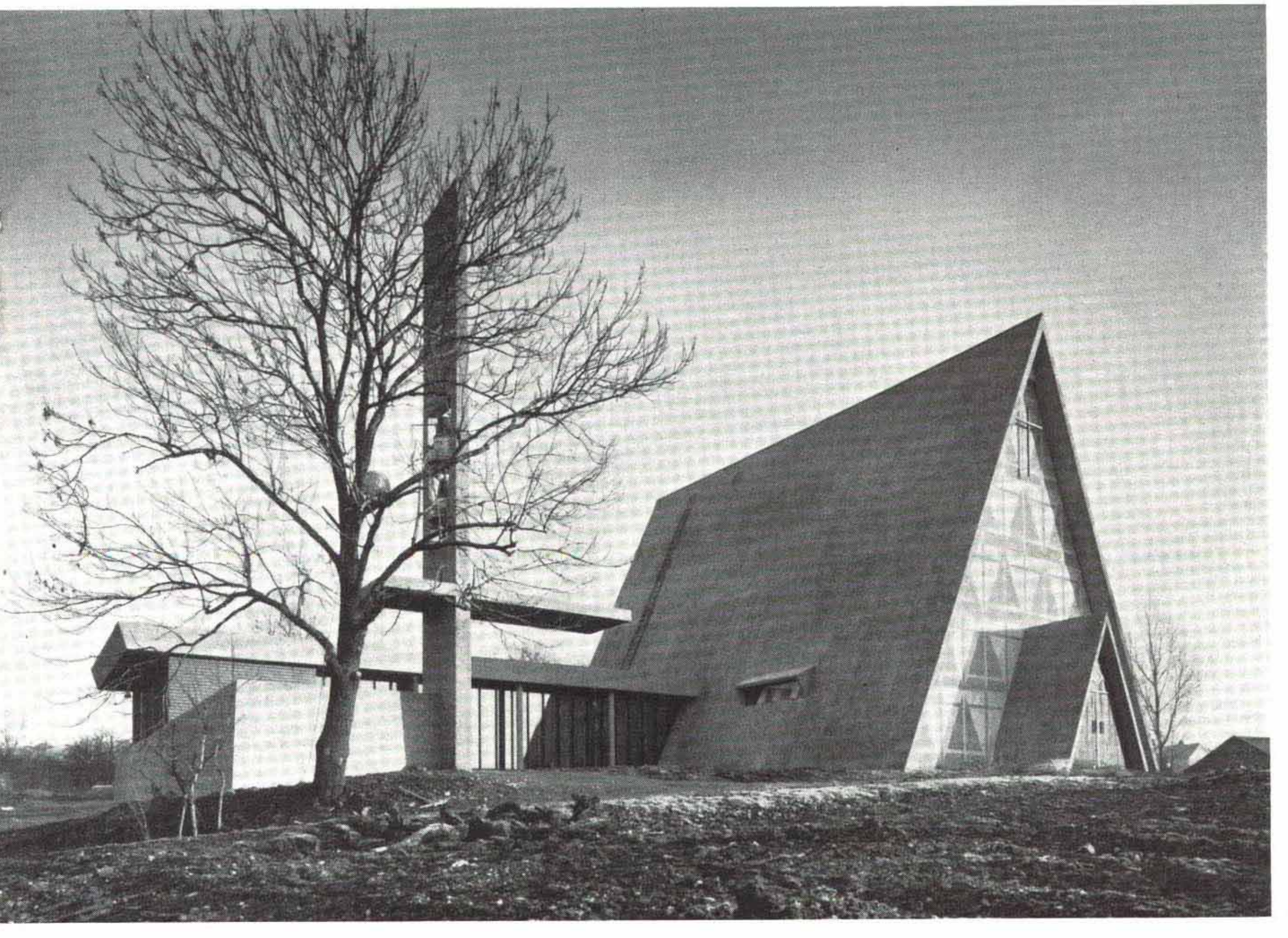
In the conference room precast concrete blocks, containing large multi-coloured aggregate and placed in the same way as Naturbetong, have been used; the blocks were sawn in half and cover the whole of one wall, providing a rich decorative background for the simple lines of the furniture.

Externally, surfaces have been evenly sandblasted



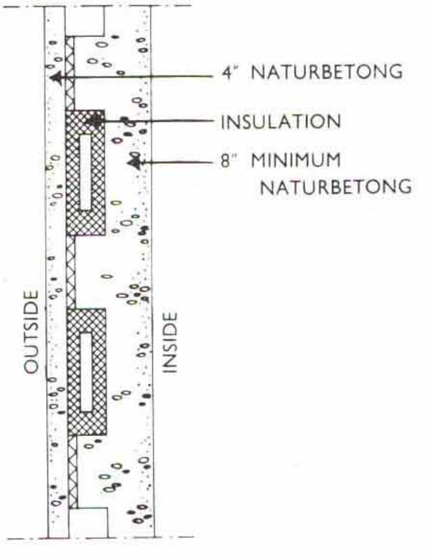
Left: The conference room in the new Government building has one wall of precast concrete blocks. The blocks were cast in the same way as Naturbetong and sawn in half.

Above: A close-up of the wall showing the rich surface pattern formed by the various sized aggregates.



Bakkehaugen church, Oslo. A triangular motif representing the Trinity and echoing the shape of the church is sandblasted on to the front wall.

Section through the church roof.



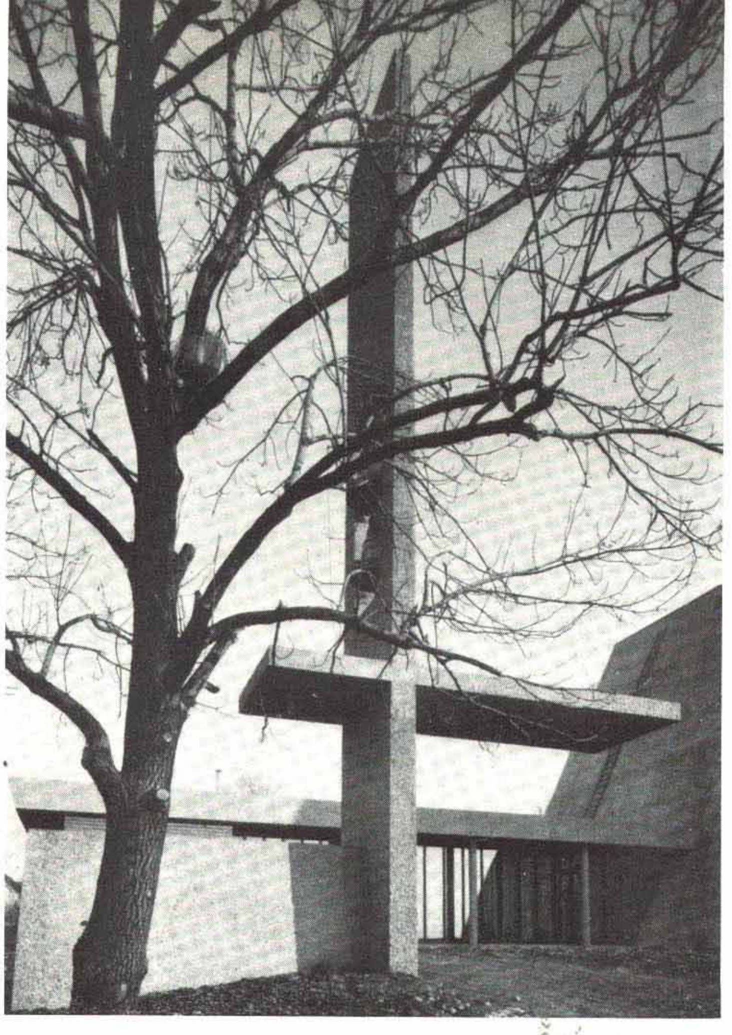
on structural members, some of which have been cast with black cement. The whole of the solid gable end walls have also been decoratively treated with linear designs sandblasted through rubber stencils, and used in an overall repeating pattern from the roof line to the ground.

BAKKEHAUGEN CHURCH, OSLO

The most recent, and perhaps the most striking, example of Naturbetong technique is shown in the new Bakkehaugen church, in a suburb of Oslo. This small but charming building is again the work of Erling Viksjö, Sverre Jystad and Norwegian artists.

It is quite simple—rectangular on plan with seating for 300 people; a glazed corridor leads off to a vestry on one side. In section the church is triangular, a shape chosen to represent the Trinity and echoed in the decorative scheme. At the same time, this particular shape gives the building a strongly traditional flavour, with its steeply pitched roof (or walls—there is no difference) and boldly projecting eaves. A simple free-standing concrete belfry, near the vestry, in the shape of a cross gives vertical emphasis to the composition as a whole.

A folded slab of Naturbetong forms the roof of the church, cast in a sandwich construction with a central



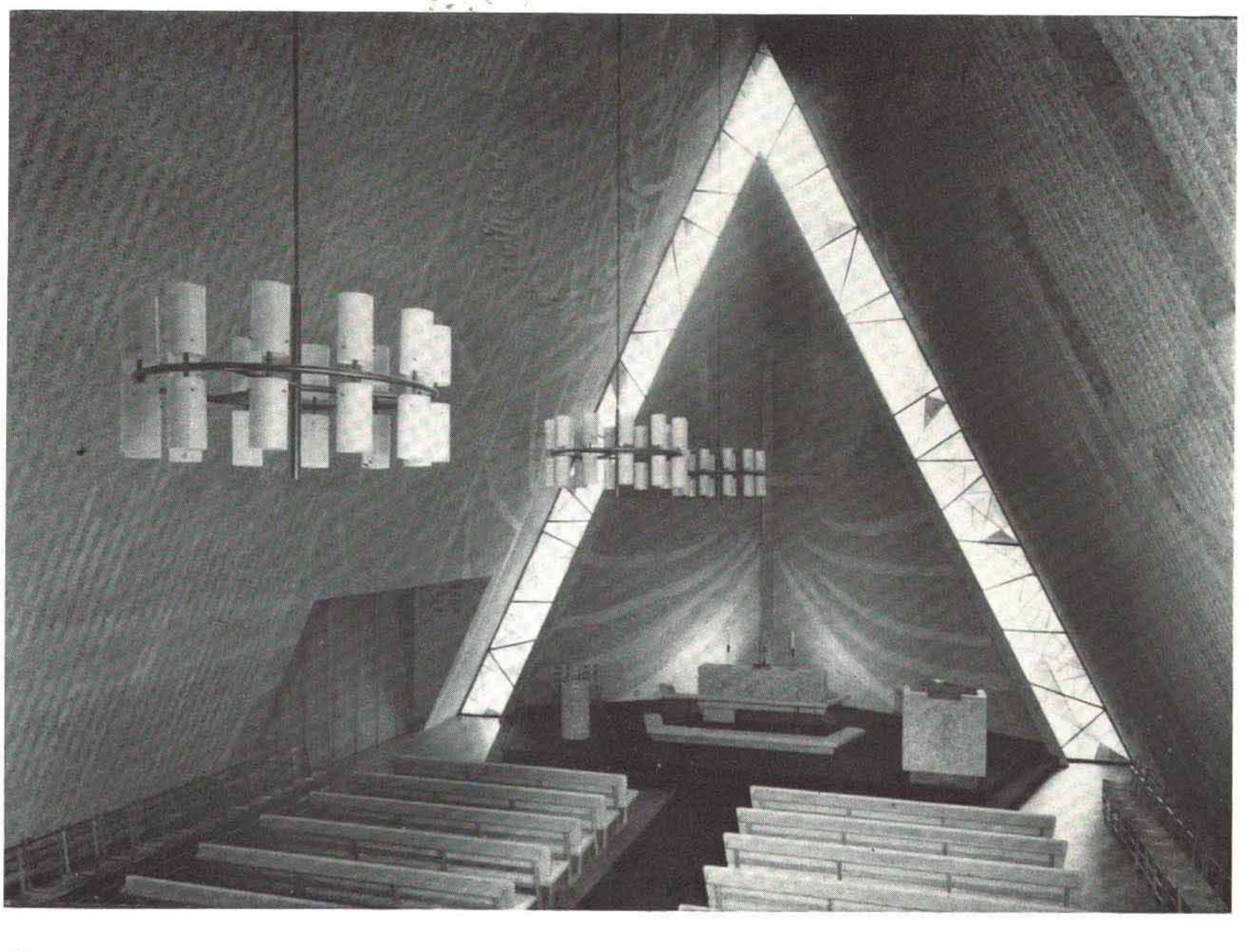
NATURBETONG: *continued*

insulating layer of foamed plastic. The internal and external surfaces are then decorated by sandblasting.

Inside, the effect is one of primitive simplicity although considerable richness has been worked into the concrete surfaces; the decorative scheme of the whole church relies on these alone for its effect. A narrow ribbed pattern covers much of the soffit, emphasizing the triangular shape of the building. The four apostles appear on the surfaces flanking the altar —two on each side—and are represented as striking simplified figures extending from the floor to the apex of the triangle, where they are crowned by halos and two points of natural light. A madonna is portrayed at the back of the church, tending a manger which is represented as a rectangle made up of large coloured aggregate, polished to the richness of precious stones.

Left: The belfry of the church.

Below: Interior view of the church, showing the variety of pattern sandblasted on to the surfaces. The figures of the four apostles can just be seen on either side of the altar.



The altar, font and lectern are all of Naturbetong in simple shapes, with all the interest centred on the surfaces which are strongly textured. A cross, similarly treated, projects from the wall behind the altar; attention is focused on to it by sweeping draped curves etched into the wall.

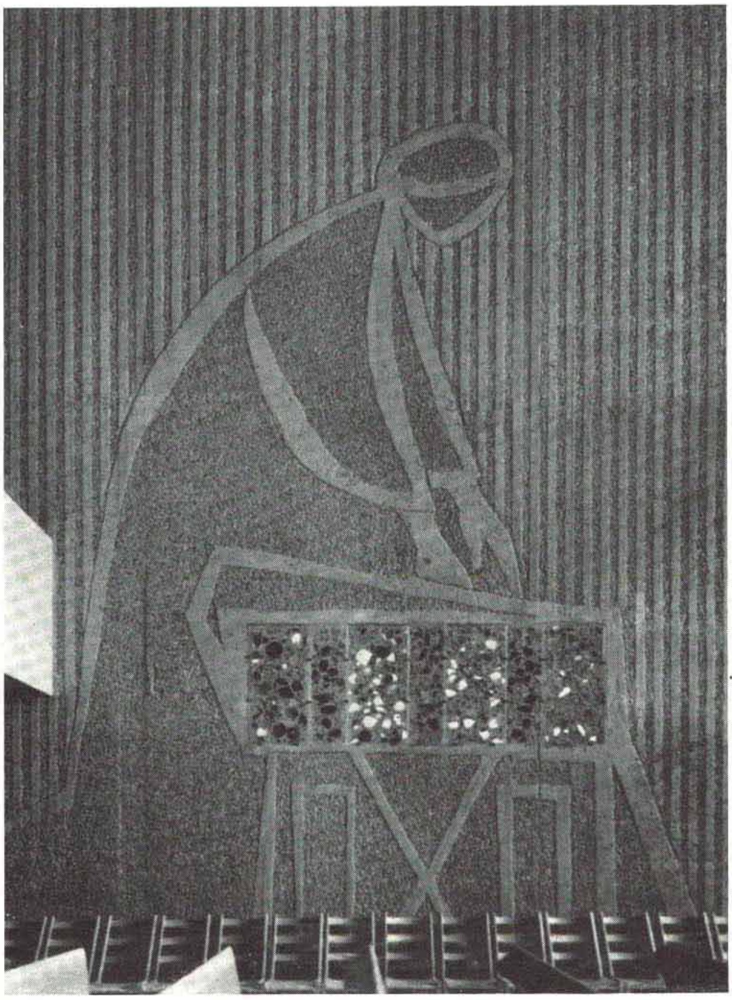
Natural lighting is kept to a minimum, which provides a feeling of mystery and a sense of enclosure and privacy. A glazed strip round the altar emphasizes the triangular shape of the roof; this is the only natural lighting, apart from the small amount over the figures of the apostles, and a narrow window in one side containing chunks of rough glass of glowing colours placed in concrete.

Colour elsewhere, set against the grey backcloth of the concrete, occurs in carpets and leather furnishings —these are of the three primary colours, again used as a symbol of the Trinity.

Externally, the wall over the entrance is treated with a subtle triangular pattern echoing the shape of the church, and combining a cruciform motif. The external surface of the folded slab is sandblasted evenly all over. The belfry is similarly treated, and contains two bells, placed one over the other, in a space in the vertical member of the cross.

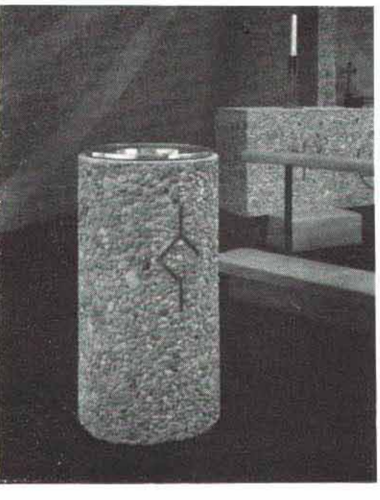
Besides the new Government building and church in Oslo, several buildings have recently been constructed of Naturbetong. These include office buildings in Oslo and other Norwegian towns, as well as one in Sweden, and another in Finland. In addition, there is a library for Bergen University, a students' hostel in Oslo, a villa and a country house. Many more buildings of Naturbetong are planned for the future.

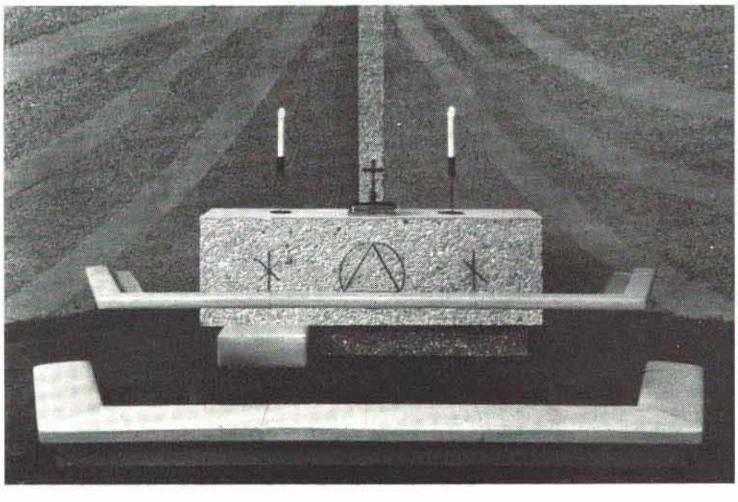
It is hoped that the technique will arouse a certain amount of interest in this country. Erling Viksjö is coming over to lecture in the autumn. And at Wexham Springs, the research station of the Cement and Concrete Association, a sample wall of Naturbetong is being built with carefully selected aggregate to demonstrate the technique.



The simplified figure of the Madonna with a manger represented by a rectangle of polished coloured aggregate.

Below: The font, altar and lectern—all of Naturbetong—rely on rich surface texture for their interest.





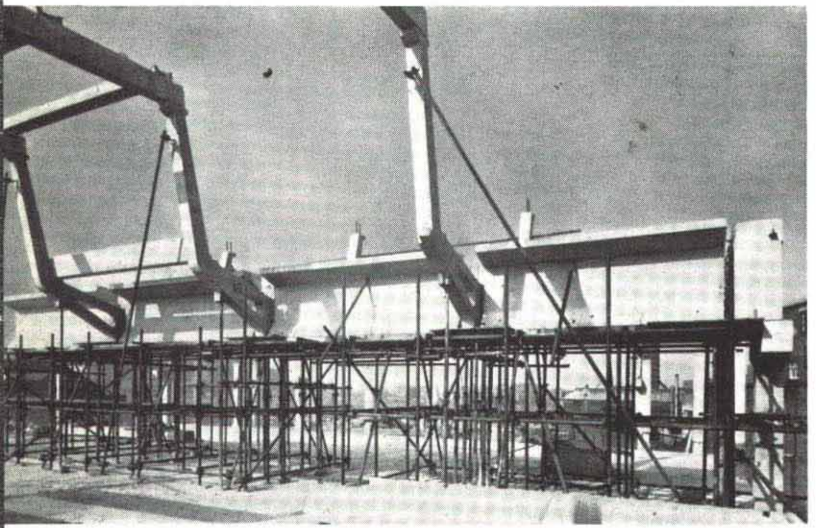
Precast units form

AN UNUSUAL ROOF STRUCTURE

on a Battersea factory

A LARGE new power tool factory in a crowded London district is a conspicuously good example of the economy, convenience and speed of construction offered by precast concrete framing. The building, which faces York Road, Battersea—a cramped and busy thoroughfare—will eventually cover 2¼ acres. At present a quarter of the factory has been completed, at a cost of £187,000.

The choice of concrete framing in order to save on construction time and cost is by now commonplace; in this case, there was an additional reason for using concrete; the London County Council required that the building be designed to a high degree of fire resistance (four hours), and the client—S. N. Bridges Limited—needed long spans of uninterrupted floor space. Concrete was the only material which could satisfy both of these requirements. Precasting was used to the maximum possible degree in the building, not only for reasons of speed and economy, but because it simplified the inevitable problems of an urban site with cramped and difficult approaches.



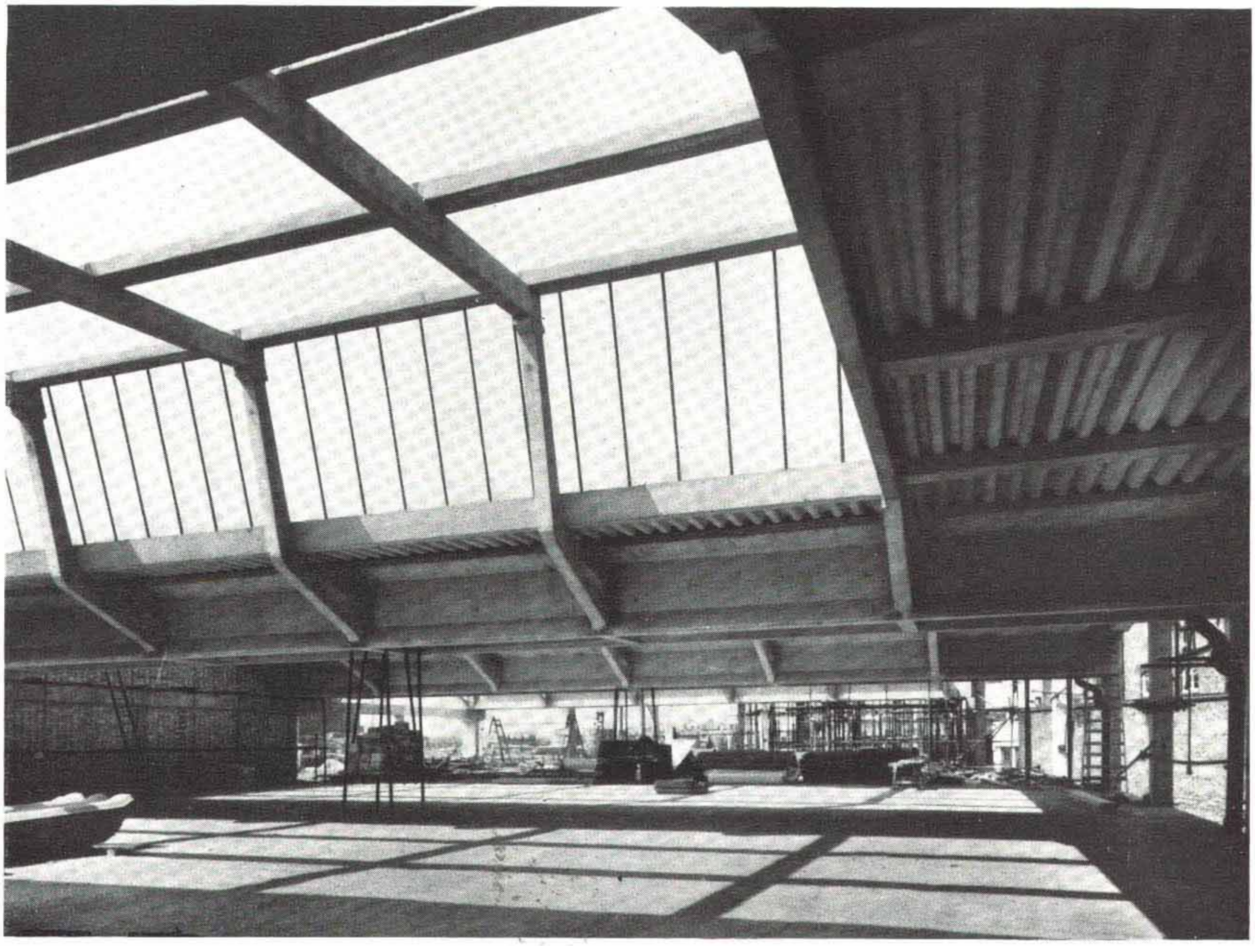
The precast monitor roof under construction, showing main beam sections in position on scaffolding, with precast U-units supporting secondary beams and purlins.

The first stage of the building, now completed, comprises a factory block with a particularly interesting roof structure, a canteen block, and a lavatory block. These blocks, all of which are two storeys high, are arranged along two sides of the roughly triangular site—the canteen block at the apex of the triangle, with the factory block, a 78 ft. wide strip, along the opposite side. These two blocks are joined by a long, narrow, two-storey existing office block, which was the only section of the building previously occupying the site which could be incorporated into the new factory. The lavatory block, with its first aid room, adjoins the factory block.

A useful design was evolved for the factory block; it is made up of a series of 76 ft. by 78 ft. structural units, each standing completely independent of its neighbours, with expansion joints between; this unit will be repeated over the whole of the remaining factory area when it is built.

The factory foundations extend 12 ft. below ground level to a firm gravel bed. Rectangular ground beams of precast pre-tensioned concrete span between the foundations and support the brick wall infilling.

The factory and canteen blocks are of similar construction, with precast concrete columns and beams carrying precast concrete floor slabs. In the factory there are three rows of columns, on a 38 ft. by 39 ft. grid, on the ground floor, and, on the first floor, two rows of columns, on a 38 ft. by 78 ft. grid, placed along the outside edge of the building and leaving the floor entirely clear of obstruction. The main first floor beams rest on the columns at 39 ft. centres; their shape—an inverted T—provides support for the 12 in. by 27 in. precast pre-tensioned secondary beams which occur at 13 ft. centres and span the 38 ft. between the main beams.



Roof structure almost completed; the main beam sections and the U-units have been stressed together, the joints between them filled with in situ concrete, and the scaffolding removed.

Precast 'Bison' slabs, 7 ft. 2 in. wide, span the 13 ft. between secondary beams. Where main beams occur, the slabs are replaced by 6 ft. 8 in. wide in situ concrete strips which form the top flanges of the main beams.

The monitor roof—the most interesting structural feature of the building—is carried on the first floor columns.

The main roof beams occur at 38 ft. centres and span 78 ft. They are made up of a series of 11 ft. 10 in. sections, and intermediate U-shaped units, prestressed together. Each straight section consists of two precast channel units placed back to back and 3 ft. 7 in. apart (the gap forms a gutter and accommodates heating ducts) and the precast U-shaped units are placed between these sections, their arms projecting upwards to form part of the framework for the monitor roof. The channel units and the U-units were jointed with high quality concrete, and then prestressed together to form the main beams. They were post-tensioned externally by a hundred 0.276 in. diameter wires, using 4-wire P.S.C. anchorages, and the wires were then covered with protective concrete.

The projecting arms of the U-units support pre-tensioned secondary beams, which in turn support 14 in. by 6 in. hollow pre-tensioned purlins.

A variation in the shape of the U-units at each end of the building forms a flat roofed section.

In the canteen block the precast columns are on a 19 ft. by 38 ft. grid, and main beams occur at 19 ft. centres. Secondary beams at 13 ft. centres span the 19 ft. between the main beams and precast 'Bison' floor slabs span 13 ft. on to the secondary beams. The canteen roof is flat; it consists of asbestos cement decking supported by 14 in. by 10½ in. hollow prestressed concrete purlins.

The lavatory block is separated from the factory block by an expansion joint, and its framework is again entirely precast. The columns are on a 20 ft. by 19 ft. grid; they rise through the full two storeys, a height of 41 ft., and were precast in one length. Beams are attached to them either by means of projecting concrete brackets, or by steel plates projecting from the beams being welded on to T sections projecting from the columns. The 7¾ in. thick floors are made up of 14 in. wide 'Bison' precast slabs spanning 19 ft. on to the beams.

The architects for the new factory were L. W. Tomlinson and Partners. The general contractors were W. H. Gaze and Sons, and the framework was designed, cast, tensioned and erected by Concrete Limited.

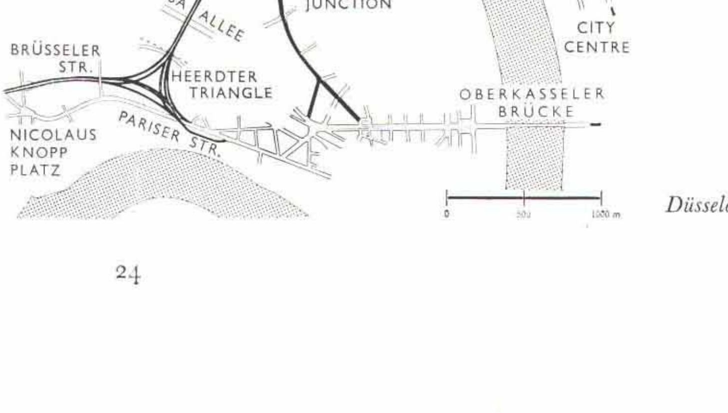
DÜSSELDORF'S URBAN MOTORWAYS

DUSSELDORF, the capital of the 'Land', or county, of North Rhine-Westphalia, is an agreeable West German city straddling the Rhine, with a population of 685,000. Much of the new building being carried out in the city is lively and forward-looking—most of all, perhaps, the first part of the system of urban motorways which is now nearing completion. A party of over a hundred engineers and members of city councils who visited German urban road schemes in October 1959 under the auspices of the British Road Federation, found the Düsseldorf schemes particularly well integrated into the city as a whole, and *The Architects' Journal* (26th November 1959) commended the completed parts of the new motorway as "examples of the highest standard in design". Particular attention is being paid to the roadside planting, to make the motorway harmonize with its surroundings.

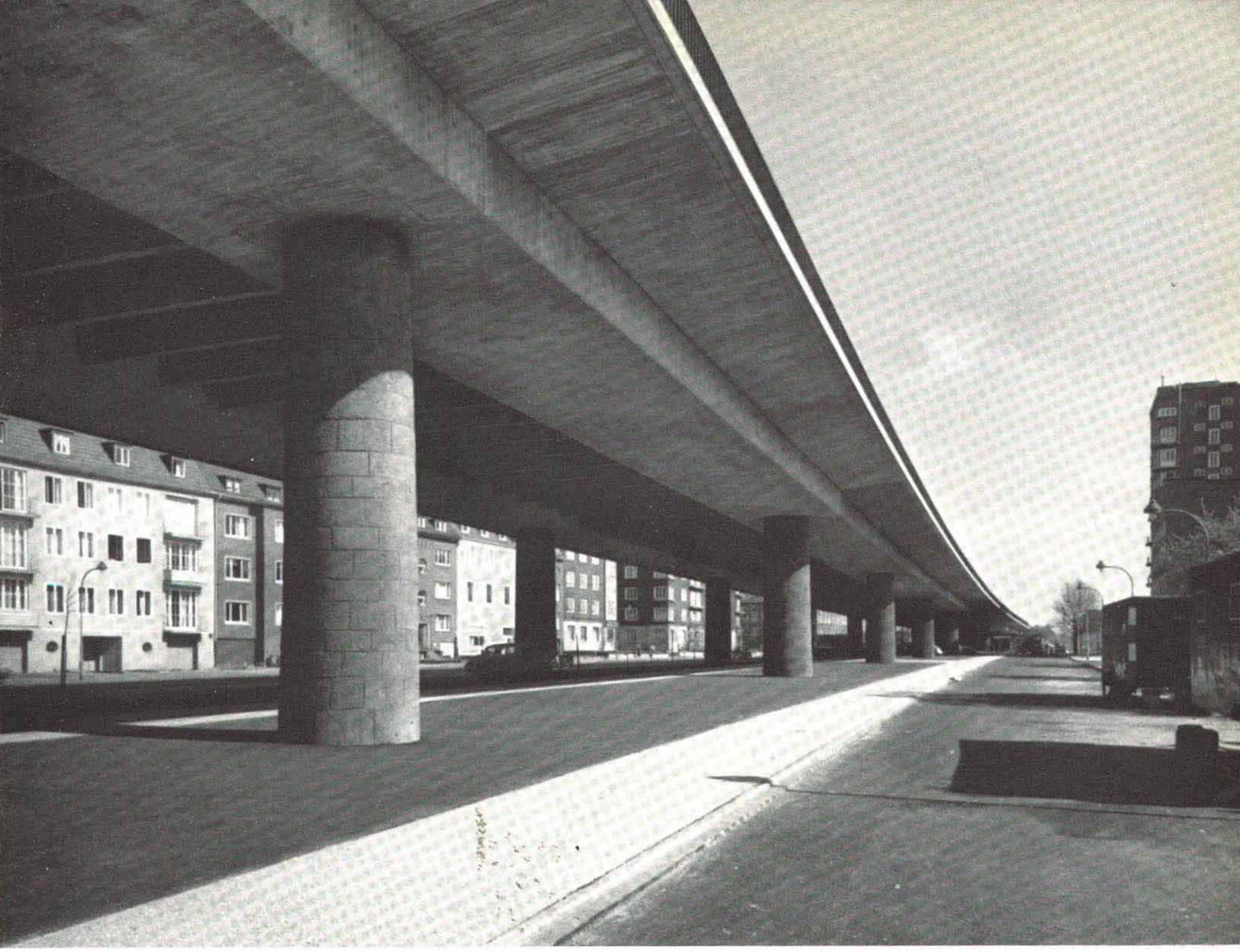
The main object of Düsseldorf's first urban motorway is to enable the traffic from the Ruhr to cross the Rhine by the new Nordbrücke and continue to the west without going through the city centre. The motorway will be sixteen miles long in all, four miles of it on elevated roads and bridges.

This motorway is, however, only part of the Düsseldorf scheme, in which city and regional needs have been combined under a 'Guiding Plan'. This was based on a traffic survey carried out in 1954, and on which further work is still continuing; as a result of the survey it was decided that a system of radial and tangential roads was right for Düsseldorf. The German authorities have now realized that the pre-war deliberate avoidance of the towns by the autobahnen was a mistake, and that it is the thoroughfares leading from the town centre to the highway network which handle most of the traffic. To quote the Mayor of Düsseldorf, "It has become apparent that efficient traffic facilities *inside* the town and modern highways must be built at the same time, and with a better integration". Accordingly the city centre of Düsseldorf has already been tackled, with new road-building and improvements and as the pre-war autobahn is nine miles from the city, a new motorway is to be built on the eastern side, only two miles from the centre, as a tangent in the north-south direction. The new urban motorway which forms the east-west tangent on the northern perimeter of the city is reached by a radial road from the centre which will be continued further to the north in due course.

The motorway begins at the Nordfriedhof roundabout on the east-west Federal Highway No. 7 (where it will eventually intersect Federal Highway No. 8 at right angles), and runs westward on an elevated viaduct to the new Nordbrücke, the focal point of the new road. This bridge is a very elegant suspension structure, described by the engineers responsible as "a girder bridge suspended on ties in the shape of a harp". Federal Highway No. 7 will subsequently be re-



Düsseldorf's new urban motorways are shown in black.



The prestressed concrete approach viaduct to the Nordbrücke on the right bank of the Rhine, the first stretch of the motorway.

designed as an urban motorway as far as the north feeder road to the new autobahn, by carrying the Nordbrücke approach ramp below the Nordfriedhof roundabout as an underpass.

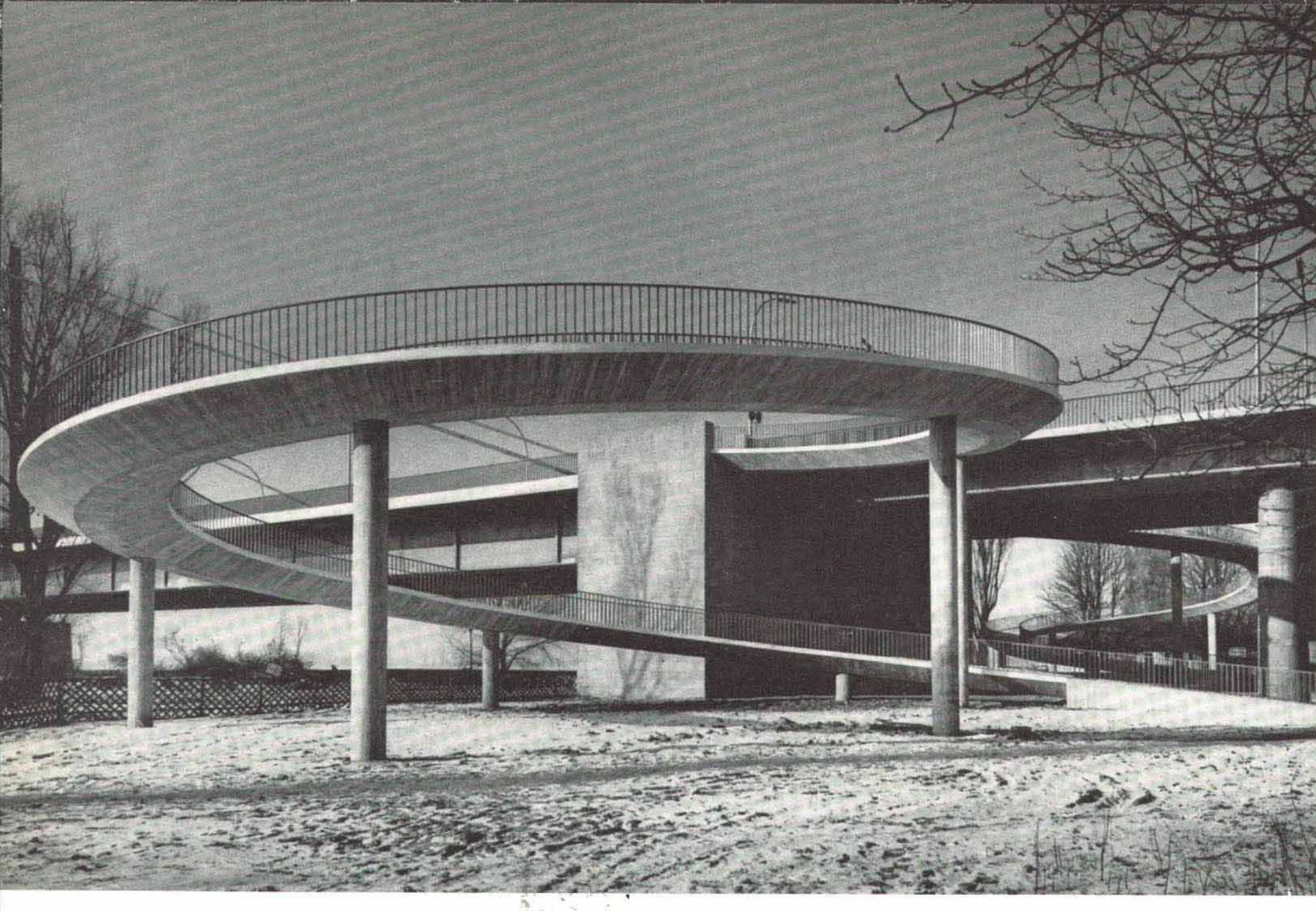
The first stretch of the motorway—the elevated approach road to the Nordbrücke—is a prestressed concrete viaduct 360 yd. long, reached by a solid ramp with concrete walls, about 300 yd. long. There is car parking space beneath the viaduct and at the junction with the bridge there are elegant curved reinforced concrete footways which lead up on to the bridge. The Nordbrücke proper, 520 yd. long, continues on the left bank as a flood bridge 500 yd. long and with a prestressed concrete deck; below this the roadway again comes down to the level on a solid, concrete-walled ramp. The present volume of traffic using the bridge is 13,400 vehicles per day, and this volume is expected to increase considerably in the near future.

In situ concrete construction has been used for the completed elevated approach viaduct to the bridge on the right bank. It is a continuous multi-span prestressed concrete structure, curved on plan, with a radius of curvature of 3,280 yd., and a longitudinal gradient of 0.6 per cent. The superstructure has a construction depth of 4½ ft. and an overall width of 75 ft.

The four-lane carriageway is 50 ft. wide, with 1 yd. safety margins on each side; it has a central reservation of an unusual type, consisting of concrete slabs in which there are built-in holes letting light through to the ground-level roads underneath. There are in addition footpaths and cycle tracks, 1 yd. and 2 yd. wide respectively, cantilevered out from the main beams. These main beams are placed at 40 ft. centres and are box section in type, with diaphragms at 2 yd. centres. They are supported on ten pairs of reinforced concrete columns elliptical in section, and faced with natural stone. These columns are spaced at 100 ft. intervals.

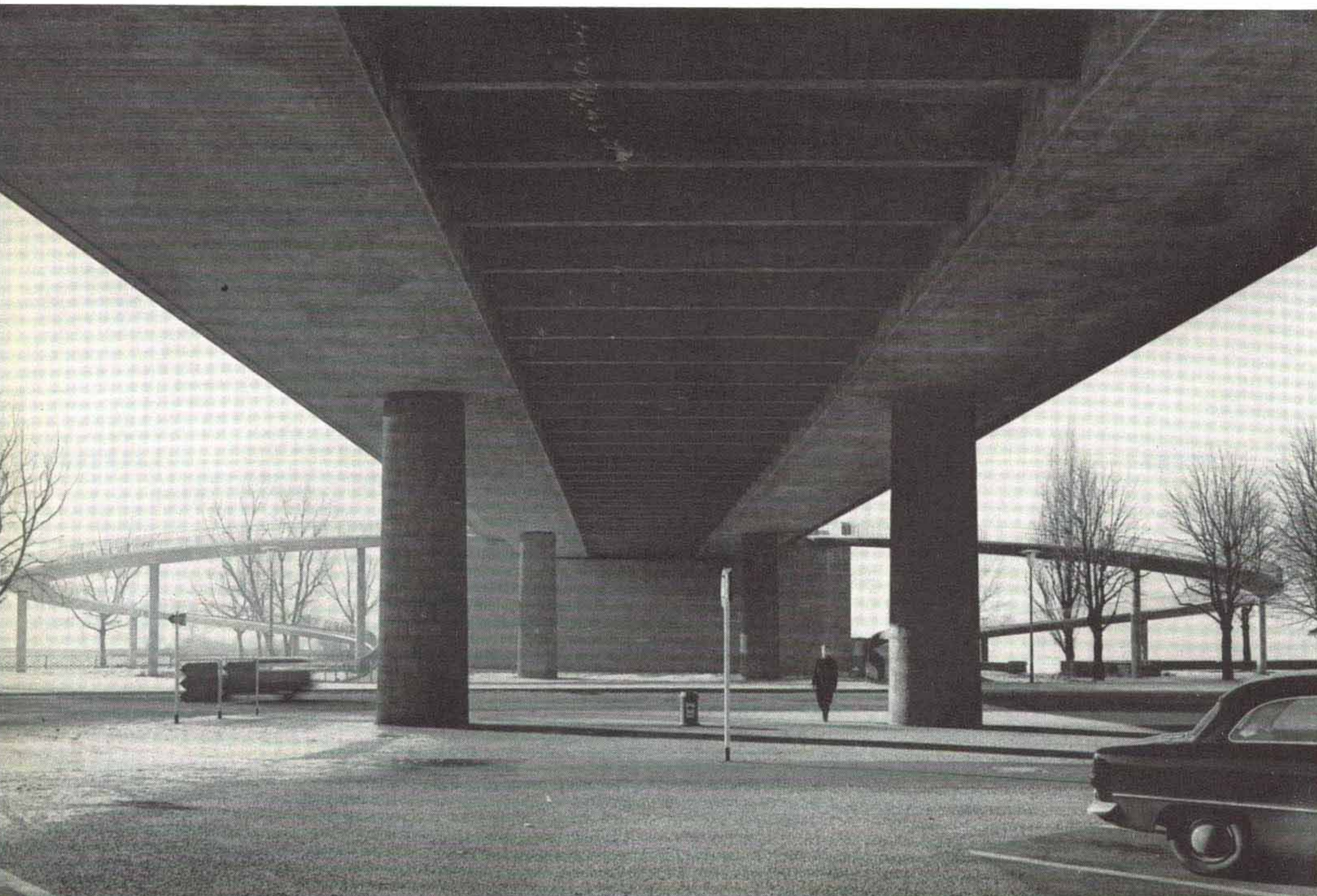
A number of the columns of the viaduct are founded on caisson type cylinders, 3¾ yd. in diameter and 9-13 yd. in length, each of which virtually forms an extension of the column into the ground. The rest of the columns have stepped block type footings 3½ yd. by 5½ yd. on plan. The working load per column is 700-850 tons.

The viaduct beams were prestressed longitudinally and transversely on the Dywidag system, the prestress-



Reinforced concrete footways lead up to the Nordbrücke at its junction with the approach viaduct.

The footways curve gracefully on either side of the viaduct.



ing being applied in two stages. The beams and the deck slabs were concreted in a continuous operation, working span by span.

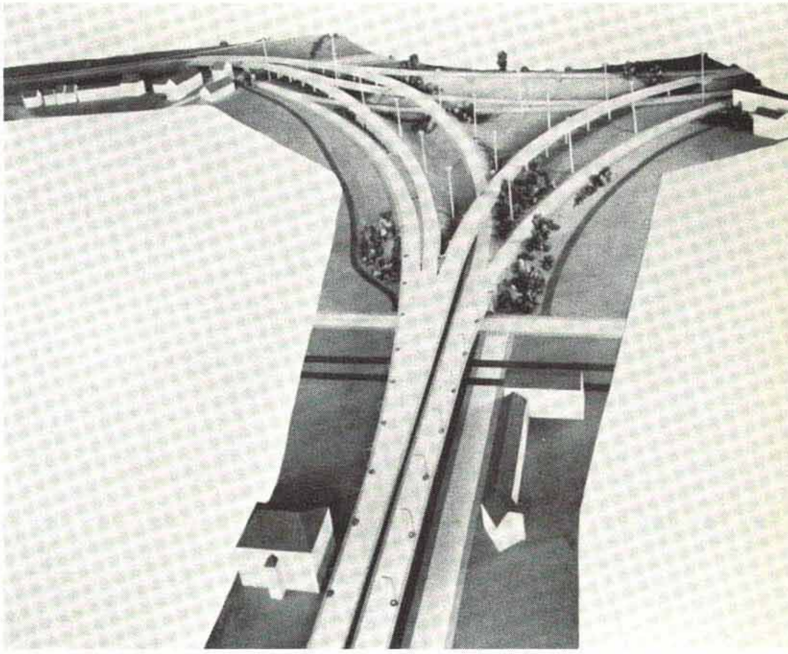
The concrete was mixed in a central batching plant equipped with two mixers with an hourly output of 16-20 cu. yd. About 400 cu. yd. of concrete were required for each span, so that it was generally possible to complete a span in the course of two extended working shifts. The concrete had a specified minimum 28-day strength of 4,250 lb. per sq.in.; the actual average 28-day strength obtained was 6,700 lb. per sq. in. The water/cement ratio of the mix was 0.50.

The ramp structure leading up on to the viaduct has an earth fill between its reinforced concrete walls, and cantilevered concrete slabs carry the cycle tracks and footpaths. Expansion joints are provided at 60 ft. intervals and each of these sections is stiffened by two diaphragm walls.

After crossing the Nordbrücke the motorway becomes the Brüsseler Strasse. There are a number of grade-separated intersections on this side, the first being the 'Seestern', or 'starfish' elevated roundabout, so called because of its shape on plan. This flyover carries the express road from Oberkassel to Krefeld over the motorway, which continues on the level.

The motorway next crosses the Hansa Allee by means of an overpass, and continues to the Heerdter Triangle Junction. This multi-level interchange, now under construction, serves several traffic routes. It takes the traffic from the motorway itself—the Brüsseler Strasse, from the suburb of Kassel, and also that from the Heerdt district and the Oberkasseler bridge, which comes via the Pariser Strasse. This last road, which lies between the Triangle and the Rhine, underwent considerable improvement in 1955 and will have a grade-separated connection with the Triangle. The volume of traffic using the Triangle is expected to be at least 40,000 vehicles per day, increasing to some 50,000 vehicles per day when the Knie bridge over the Rhine is built. The skew angles of the intersections at the corners of the Triangle necessitated long elevated structures and at the northern tip there are additional flyovers for the crossing of the railway tracks. As far as possible all these structures will be carried on viaducts supported on concrete columns, rather than on solid embankments. In some instances, owing to the multiplicity of intersections, the dual carriageways of a particular route have had to be separated, each 27 ft. wide carriageway being carried on a single row of columns. The use of viaducts rather than solid embankments barely increased the cost of the structures and permitted the design of much smoother gradients, by obviating the need of keeping the structures as low as possible. The elevated structures of the Triangle will have a total length of 1,444 yards when completed.

Still as the Brüsseler Strasse, the motorway continues west, but it now has also the function of the Heerdt



The model of the Heerdter Triangle, showing the different levels of the carriageways.

district bypass. It has to cross the three roads bringing the traffic from the Nikolaus Knopp Platz to the bypass, and this will be done by means of a 330 yd. long elevated roadway. Beyond this Heerdter junction the final form of the junction of the motorway with Federal road B9 has not yet been decided; it awaits the design of the Federal road by the State Highway authority, and the present arrangement is only temporary.

On the right bank also further plans are in hand. Federal Highway No. 8, which runs northward to the Nordfriedhof roundabout from the Homberger Platz near the city centre, is already a road free from intersections and frontage access, and it can be carried over the roundabout on a flyover for its further northward extension without extensive structural alterations. At its southern end, the Homberger Platz, space has been reserved for carrying the two streams of traffic which combine and diverge there over and under the Platz by flyover and underpass. So it will be possible, when the scheme as a whole is completed, for traffic coming from Cologne, Aachen and Krefeld in the west to come right through Düsseldorf by urban motorway to the Nordfriedhof roundabout and beyond to the autobahn, or, alternatively, to proceed to the city centre. The traffic from Duisberg will also be brought right into the city centre by urban motorway.

The cost of the Nordbrücke and its approaches will be about £7½ million. And last year—to the envy of a number of the local authority engineers on the British Road Federation party—the Düsseldorf authorities had more money available to spend on roads than they could actually use. The planning and execution of the scheme has all been carried out under the lively and enterprising direction of the City Engineer of Düsseldorf, Herr R. Auberlen.

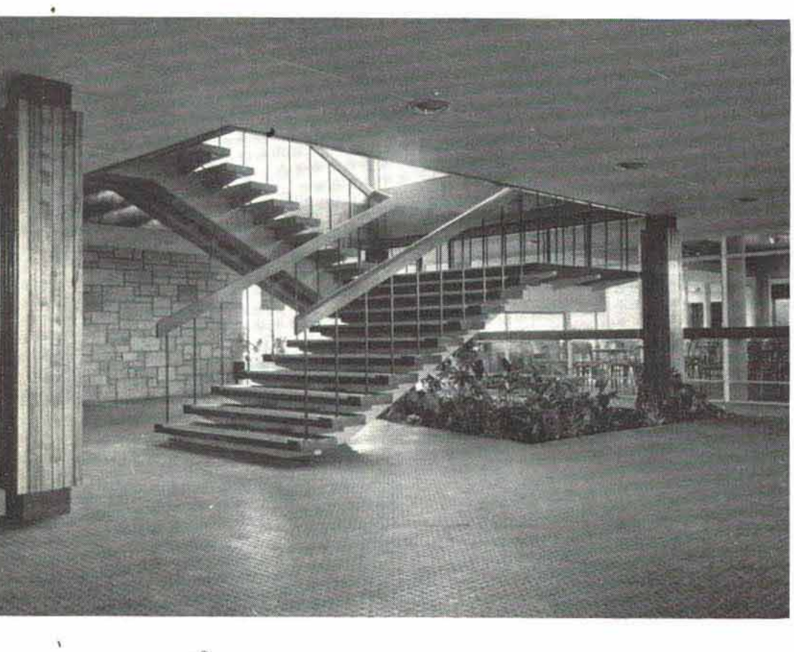
Denny High School, Stirling

a compact layout, using precast concrete construction

A SCHOOL WITH CLEAN LINES and an open air atmosphere is Denny High School, recently built for Stirlingshire Education Committee and opened by the Secretary of State for Scotland. This makes yet another contribution to the fine record of schools built in Britain since the war—a record which still seems to be unsurpassed elsewhere.

The school is set down in wooded countryside on what was once a 22-acre golf course at the southern boundary of Denny borough; it occupies a commanding position over the Stirling-Glasgow main road and surrounding country. The site slopes downwards from south to north, and the school is placed on the highest part.

The various blocks are well articulated and arranged in a plan which is approximately cruciform. A six-storey classroom block is placed at the eastern end of the cross, linked by a two-storey glazed bridge with the entrance hall—the centre of the scheme. On one side of this, a two-storey block projects containing classrooms and library over administrative offices and shelter space. On the other side is a single-storey block containing the assembly hall, a gymnasium, swimming-pool and changing-rooms. A fourth block to the west, forming the base of the cross, consists of a single-storey wing containing laboratories, workshops and housecraft rooms.

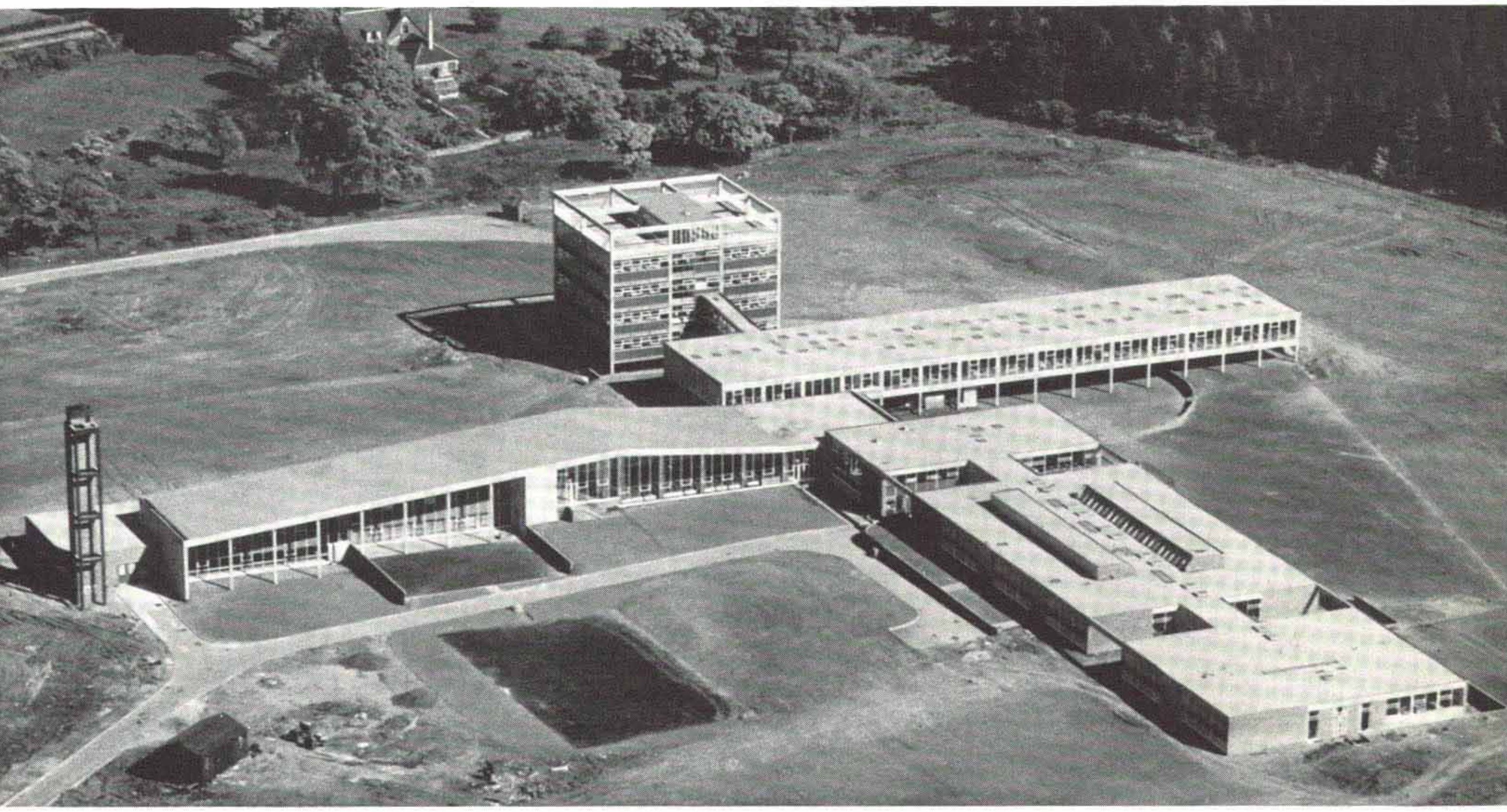


Because the school is compactly planned, it was economically possible to make the classrooms larger than was basically required, and at least 100 sq. ft. have been added to the basic size in each case. Classrooms are placed on either side of corridors, which has led to the introduction of slatted ceilings and roof monitor lights to deal with daylighting problems. Classrooms in the six-storey block are designed on the principle of having two adjacent walls of glass, and controlling the daylight by venetian blinds.

The blocks are constructed, for the most part, with precast concrete frames. The six-storey classroom block is 60 ft. high and has precast columns 20 in. by 12 in. cast in two-storey and four-storey lengths. These support precast concrete beams which carry prestressed concrete flooring; the latter has spans of up to 28 ft. with a thickness of $9\frac{1}{4}$ in. The columns are exposed externally for the full height of the block; all the exposed concrete surfaces are painted with a specially developed stone paint technique.

The lift shaft in this block was precast in storey-height sections, the heaviest of which weighed a little over seven tons. The stairs are of central spine beam

The open staircase in the entrance hall.



Aerial view of the school, showing the neat cruciform arrangement of blocks. The six-storey teaching block can be seen in the background, the library and classroom block on the right, the gymnasium block on the left, and the laboratory block in the foreground.

construction with cantilevered treads.

The two-storey classroom block has three rows of precast concrete columns, each 10 in. by 10 in., at 16 ft. centres. The columns support precast beams which carry two spans of hollow prestressed concrete flooring, one span being 30 ft. long with floors 10 in. thick, and the other 24 ft. long with floors $8\frac{1}{4}$ in. thick. Roof construction is of hollow precast concrete purlins at 4 ft. centres carrying "Stramit" and felt roof covering. The complete absence of cross beams allows for simplified services and economical ceiling construction. One expansion joint is included in the 190 ft. long block.

The assembly hall has a clear span of 46 ft. with roof construction similar to the two-storey block; the roof is carried on 12 in. diameter circular columns. A similar construction is used in the remainder of this wing for the gymnasium and swimming-bath. The roof over the whole of this wing has a shallow pitch in two directions which helps to break up the strong horizontality of the roof lines in the other blocks.

One elevation of the assembly hall is clad with precast concrete panels finished with off-cuts of green Westmorland slate; the largest of the panels is 4 ft. wide by 16 ft. high. Elsewhere, curtain walling is of steel and aluminium, with panels of coloured glass and vitreous enamel. Internal finishes are of hardwoods, wood veneers, and wallpapers. The entrance hall is specially treated with a wall of natural stone, textured rubber flooring and an area for plants below the open staircase.

Another feature of the school is the 66 ft. high brick boiler chimney, at the northern end of the swimming-pool block, which is supported by a rectangular precast concrete frame with four columns extending the full height of the chimney.

A prestressed concrete bridge, with two spans of 26 ft. each, carries the main entrance road for vehicles over an artificial pool; there is also a paved area of cobbles set in concrete for pedestrians.

Construction of the framed parts of the school was completed in seven months, the entire building being completed in twenty-one months. The total cost was approximately £350,000, the low cost of 62s. 2d. per sq. ft. resulting from economical design and construction, and close consultation between architect and contractor.

The school was designed by Alison and Hutchison and Partners, F.R.I.B.A., F.R.I.A.S. of Edinburgh. John Wight and Company (Edinburgh) Limited were the general contractors. The sub-contractors for the structural frame were Concrete (Scotland) Limited.

The architectural treatment of

SCOTTISH UNDERGROUND POWER STATIONS

By ROBERT HURD, A.R.I.B.A.

IN DESIGNING the setting for generating plant in an underground station, careful thought has to be given to the effect on skilled staff who have to work wholly underground. Experience in other countries has shown that daily occupation in such surroundings can prove depressing. A close study of the varying treatments adopted in underground installations in North Sweden (including Lapland), Germany, and Switzerland, has accordingly been made by Robert Hurd and Ian Begg, partners in the firm of Robert Hurd, architect, Edinburgh, during the past few years. They concluded that above all, an effect of spaciousness, serenity, and brightness must be created, no matter how great the original physical limitations might be.

Apart from the obvious matter of the size of the cave initially excavated, a governing factor is the quality of the rock forming the sides and roof of the station—that is, its structural soundness and its ability to resist the penetration of water. Given reasonably sound rock, at least the sides can be left bare, having been trimmed roughly to a fair surface, even if the roof has to be infilled and supported by a concrete vault. In North Sweden this basic treatment tends to be frowned upon as having proved depressing, but in view of the fact that the personnel employed underground in Scotland is numerically very small, the North of Scotland Hydro-Electric Board decided to adopt it in principle where possible, and indeed to turn it to good account. Paradoxically, acceptance of bare rock as the walls of a station makes it desirable to create an illusion that the rock face is at a comfortable distance from the main floor. The reinforced concrete crane beam structure with its rails and columns does, of course, provide a framework through which the rock is seen; but this alone is not enough—the aid of lighting and colour is also necessary.

Lighting has to be considered from several standpoints. First, sufficient light must be provided for dials on the control panels to be read easily and without distracting reflections, and adequate provision must be made for occasional dismantling and repair of machines. Secondly, if the rock face is left exposed, its oblique illumination from a concealed source can provide a lively and attractive texture visible between the columns of the crane beam framework. Thirdly, for eye comfort, it is desirable that the source of light should be invisible wherever possible, for lines of naked or insufficiently masked fluorescent tubes can prove exceedingly trying over long periods. The use of the vault as a primary reflective surface (with floor tiles as a secondary reflective surface) for fluorescent tubes directed upwards from a concealed source behind the crane beam is ideal for general lighting. Fourthly, the risk of over-lighting has to be avoided; in an entirely artificially lit station a shadow (where technically harmless) provides a welcome oasis of relaxation for the eye. In other words, a comfortable balance has to be achieved between a uniformly lit and shadowless interior, and one that is under lit. In this connection the actual shade of 'white' of the fluorescent tubes has to be selected very carefully; the wrong 'white' can prove very distorting to the colour of objects that are illuminated.

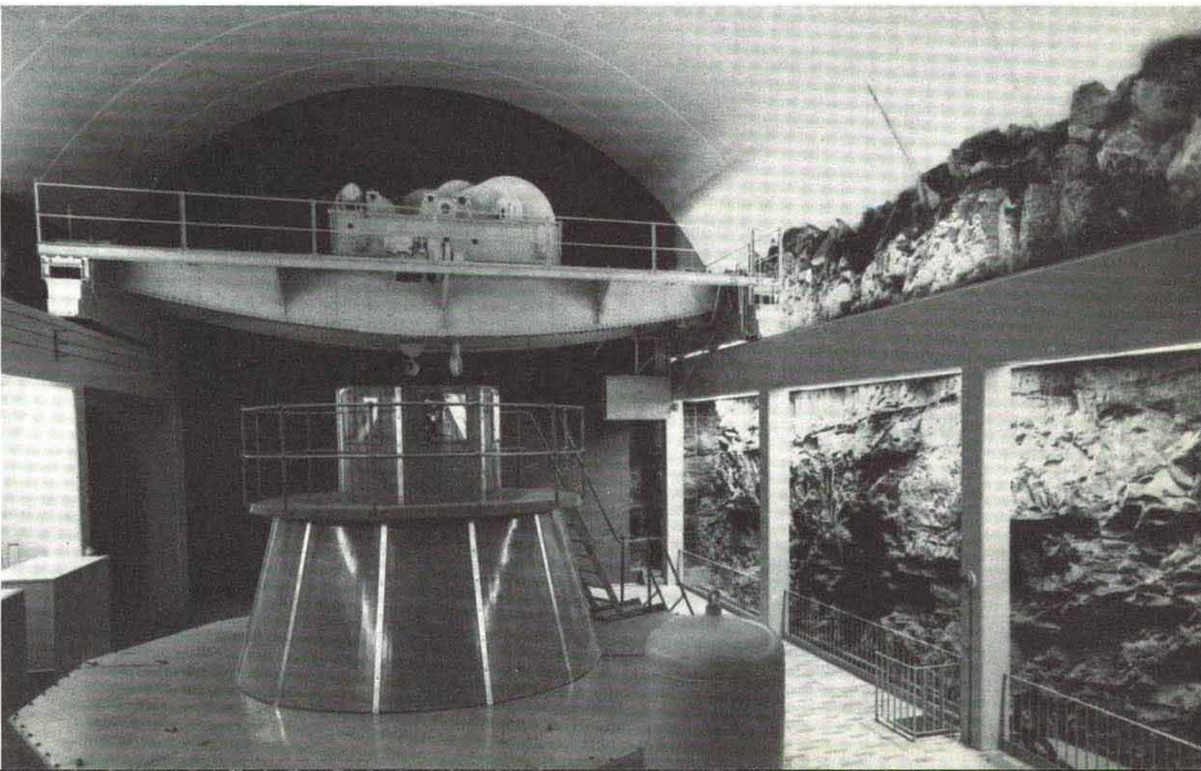
Colour variously used in an underground station can enhance light, create an illusion of serenity and space, and stimulate. To these ends, our tendency has been to paint all concrete white, both crane structure and vault, and to install white tiles (with or without pattern) on the main floor; to employ deep rich colour where a sense of distance is required or to give a feeling of warmth, and to stimulate by using crisp colouring on the turbine panels grouped along the sides of the station.

Apart from Clachan, which scarcely qualifies since the site in the hillside was excavated from outside and subsequently covered in, there have so far been three major underground power stations in Scotland: Ceannacroc and Glenmoriston, in the Moriston Scheme, and St. Fillans in the Breadalbane Scheme.

Ceannacroc At Ceannocroc (1957) the station is, equipped with two vertical 16 and 4 m.w. sets, the switch gear being housed in a small stone building erected at the tunnel entrance. The rock conditions in the turbine hall were fairly good, so that although it proved necessary to stabilize the roof with a concrete vault, to line one gable with concrete, and to apply "Gunite" over part of the other gable, it was feasible to leave the rock exposed over practically the whole length of both upstream and downstream walls. Fortunately, it proved possible almost entirely to eliminate water seepage through the concrete lining of vault and gable, so that surface staining was not a serious factor. Accordingly it was decided to paint the vault white, so that it functions as a reflector for the main fluorescent lighting which is concealed behind the crane beams. Reflected initially from the ceiling, the light is also diffused by means of secondary reflection off the white tiled floor. A lesser source of light comes from other fluorescent tubes, also concealed behind the crane beam, which are directed obliquely downwards over the rock face, thus heightening the rugged texture of the rock seen beyond the white painted concrete crane beam frame.

In order to counteract the sense of proximity of the rock face as seen from the main floor area, a simple wrought iron balustrade, set on a raised kerb forming the edge of the tiled floor, was placed between the columns. The delicate upright balusters were painted white and the handrail a pure yellow. In principle this is an age-old device, used in pictures and stage design to create a sense of distance; it has not hitherto been used for a purpose of this kind. However, having been

The concrete structure, lighting and colour create interest and an illusion of space at Ceannacroc. The concrete vault, beams and columns are painted white, the gable end wall terracotta, the turbine casings oriental blue, and the balustrade white and yellow.



successfully used at Ceannacroc, this feature was subsequently incorporated elsewhere.

Apart from the liberal use of white paint already described, the architects felt that the concrete-lined gable should be painted a warm colour in the terracotta range, in order to counteract a sense of chilliness induced by the fluorescent lighting. Remembering the stimulating effect of limited areas of strong colour in the Maggia Valley underground stations in Italian Switzerland, as opposed to the somewhat cold and sanitary effect of grey-green in underground stations elsewhere on the continent, the architects selected a rich terracotta colour for the gable wall, and a brilliant 'oriental' blue for the two turbine casings set in the middle of the white and grey-green patterned tiled floor.

St. Fillans At St. Fillans (1958) the underground station is much smaller than Ceannacroc, and although it contains only one vertical generating set together with control panels and other technical equipment, it could have looked rather overcrowded. Another factor was that the plan incorporated two arched recesses in the gable wall at both ends, to contain equipment.

In view of these circumstances, the Ceannacroc approach to internal treatment had to be varied. As a light-reflection factor the concrete vault had to be discounted completely, since the concrete had to be coated with a dark bituminous paint in order to conceal staining caused by moisture penetration. Further, since there were safety limits to which the rock face could be cut back on the side walls, it was found impracticable to house the fluorescent lighting out of sight behind the crane beams. Instead it was installed with "Perspex" masks and metal louvres over the complete soffit of the beam, and directed obliquely on to the rock face, while at the same time shedding direct light into the area of the turbine hall. The floor of the hall was covered with white and grey tiles, to make the most of the available luminosity.

The challenge of the twin-arched recesses in the gable end was met by painting their back walls (seen over the top of the control panels) a deep rich blue lit by fluorescent tubes concealed behind the control panels, so that the recesses, instead of confusing the design of the station now contrive to give it an appearance of greater length. Since both the crane structure along the sides and the concrete lining flanking the twin-arched recesses at both ends are painted white, the effect of the areas of blue is quite striking. The generator casing has been painted a warm terracotta with thin white margins to emphasize its form.

Once more, as at Ceannacroc, where there was space the device of the light iron balustrade between columns was employed to enhance the apparent distance between the rock face and the floor area.

The floor tiling has been mentioned as a reflection factor, but it has a further function. In order to enhance the apparent floor area by the illusion of perspective, a chequered pattern has been introduced of alternating white and mottled grey-white tiles in 12 in. squares. This treatment was a development of that adopted at Ceannacroc, but in view of the more crowded conditions at St. Fillans, its importance in creating a sense of space is relatively greater.

Glenmoriston Glenmoriston (1958) is the largest of these three underground stations, equipped with two 16 m.w. vertical turbines, and has in several respects proved the most difficult to handle. The dominant factor here has been the doubtful nature of the rock, so much so that the interior has had to be lined with concrete throughout, and concrete walls provided on three sides with an inner lining of aluminium sheeting. Seepage of water with accompanying staining has been persistent and although a suspended ceiling has been avoided, the condition of the concrete vault was such that there was no question of painting it white as at Ceannacroc for use as a reflector, and as at St. Fillans, it was painted with black bituminous paint.

In the circumstances, the simplest approach to the

At St. Fillans, the white concrete frame contrasts with a gable end wall painted a deep rich blue.

The concrete vault at Glenmoriston is treated with black bituminous paint to avoid staining; the end wall is painted midnight blue to create the maximum illusion of space.

provision of general lighting would have been to install visible fluorescent tubes directed downwards and outwards from the soffit of the crane beam over the whole length of the station as at St. Fillans, but the architects felt that in a station of this size a less obvious and possibly more imaginative solution was required. Furthermore, there was insufficient depth between the crane beam structure and the upstream wall to accommodate properly shielded lighting, in addition to a lining of aluminium sheeting. Nevertheless owing to seepage and consequent staining of the concrete, the whole surface had to be masked; accordingly the lighting installation had to be designed both to mask the wall and to provide general lighting in an acceptable manner, all within the shallow depth available between the concrete lining of the rock face and the face of the crane beam structure. Another problem was to light the control panels lining the downstream wall, without distracting reflections on the dials, and without the irritation of having the light source directly visible from the floor of the station.

The architects therefore decided to treat the interior asymmetrically. On the upstream wall, a series of timber frames was fitted into the 16 ft. spaces between crane beam columns, each frame being subdivided into 4 ft. squares into which panels of translucent opal "Perspex" and cross-reeded glass, arranged alternately, were fitted. Fluorescent tubes are installed behind the "Perspex" panels, and only indirect light filters obliquely through the cross-reeded panels, which have a natural sparkle contrasting with the flat even light of the "Perspex". As an additional baffle to hide the stained concrete lining completely, sheets of white-painted plywood have been installed behind the cross-reeded glass. The squared pattern of the lit screens seen in perspective along the length of the station lends scale to the whole interior, and a pleasant tranquil light is shed across the station. The concrete crane beam structure and the wooden screens themselves are painted white and very pale grey respectively, in order to obviate undue contrast between the lit panels and the framing.

For the downstream wall, an entirely different approach was adopted. Lighting here has two distinct functions: first to light the dials on the control panels between the columns, and second, to shed general illumination on to the painted aluminium lining, set well back behind the crane beam structure. Accordingly a continuous masked strip light has been fitted on brackets along the top of the control panels, shielded from the eye. The wall in the background has been painted a deep midnight blue so that the maximum sense of space is induced beyond the white painted crane beam structure.

The aluminium-lined gables at either end have been painted a brighter blue, along with the control panels.

As at St. Fillans, the floor has been tiled white, with a chequered pattern in speckled green-white tiles, but here emphasized by a red spot set at intervals in order to stress the sense of diminishing perspective along the length of the station.

The casings of the two generating sets have been painted pale grey with thin white margins to clarify their form; while for sharp contrast, the tall compressor units stand out in a deep red.

Here, quite distinct from the visibly rock-lined stations at Ceannacroc and St. Fillans, is an interior which, owing to different physical conditions, had to be lined completely, almost to the point of becoming a building within a cave, since one is totally unaware of the existence of rock. Had cost been no object, it might have been possible to carry the notion of a building within a cave to its logical conclusion by forming real windows looking out on to a brightly lit mountain landscape painted on to the concrete lining beyond, as has been done in certain underground stations in northern Italy. But such fantasies were completely alien to the more functional approach implicit in the Board's policy; and instead, the engineers—Sir William Halcrow and Partners, and Kennedy and Donkin—working in close co-operation with the architects, have sought an imaginative solution arising more directly out of the physical and economic conditions.

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