AN ARCHITECTS VIEW OF THE DEVELOPMENT AND PERFORMANCE OF TWO FABRIC - STRUCTURE PROJECTS - PHILLIP ISLAND PENGUIN PARADE AND BOND UNIVERSITY

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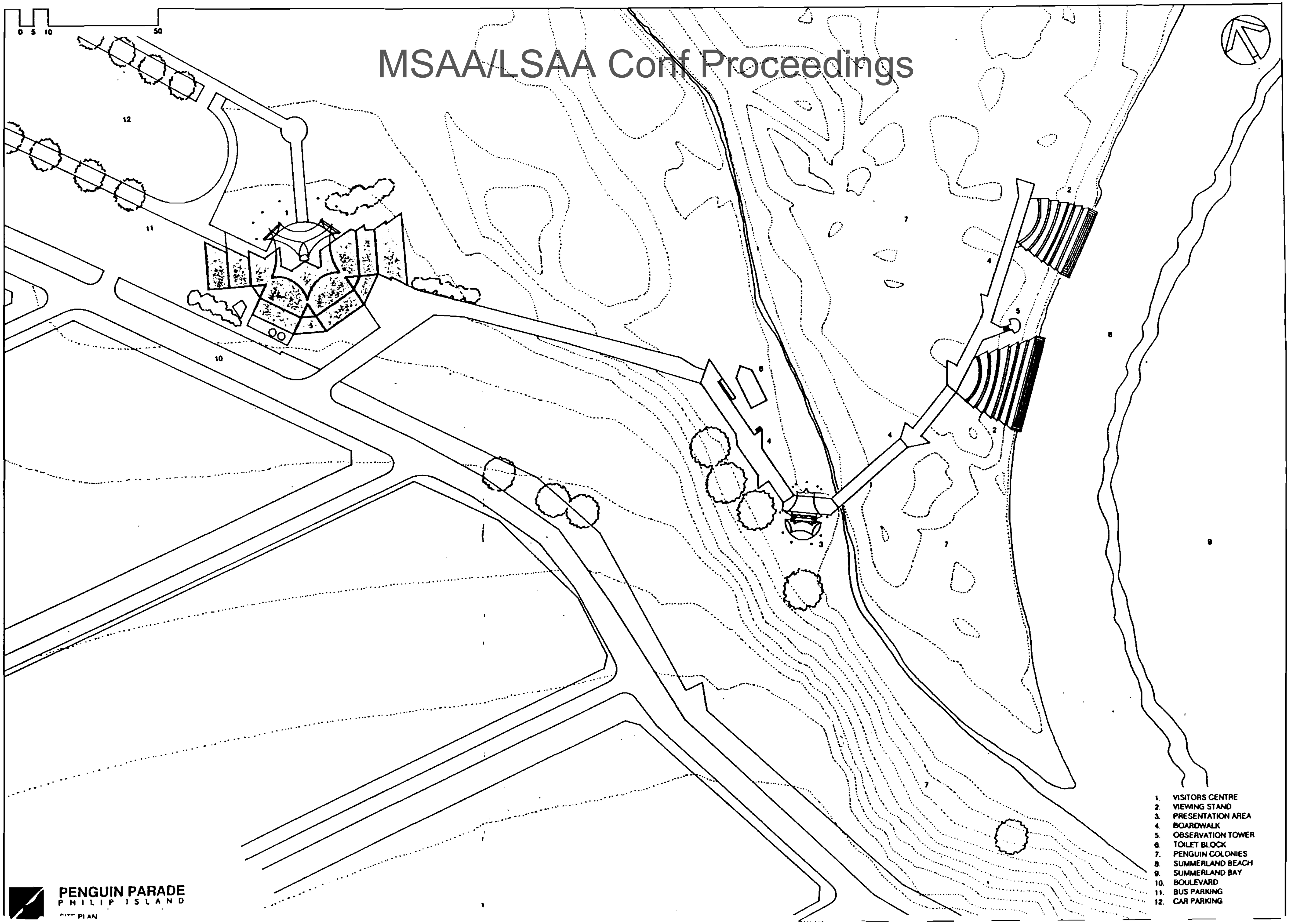
Synopsis

This paper traces the development of the Phillip Island Penguin Parade Fabric Structures from their original concept to their final realisation. In doing so, it attempts to give an insight into the way Architects respond to the challenge of designing Fabric Structures.

The second part of this paper deals with the Bond University Fabric Structures which, while similar to the Penguin Parade structures, experienced unique fabric attachment problems.

Finally the Design and Construct Tender employed for the Bond Fabric Structures identified problem areas with such tenders. These will be outlined to assist others contemplating a similar tender form.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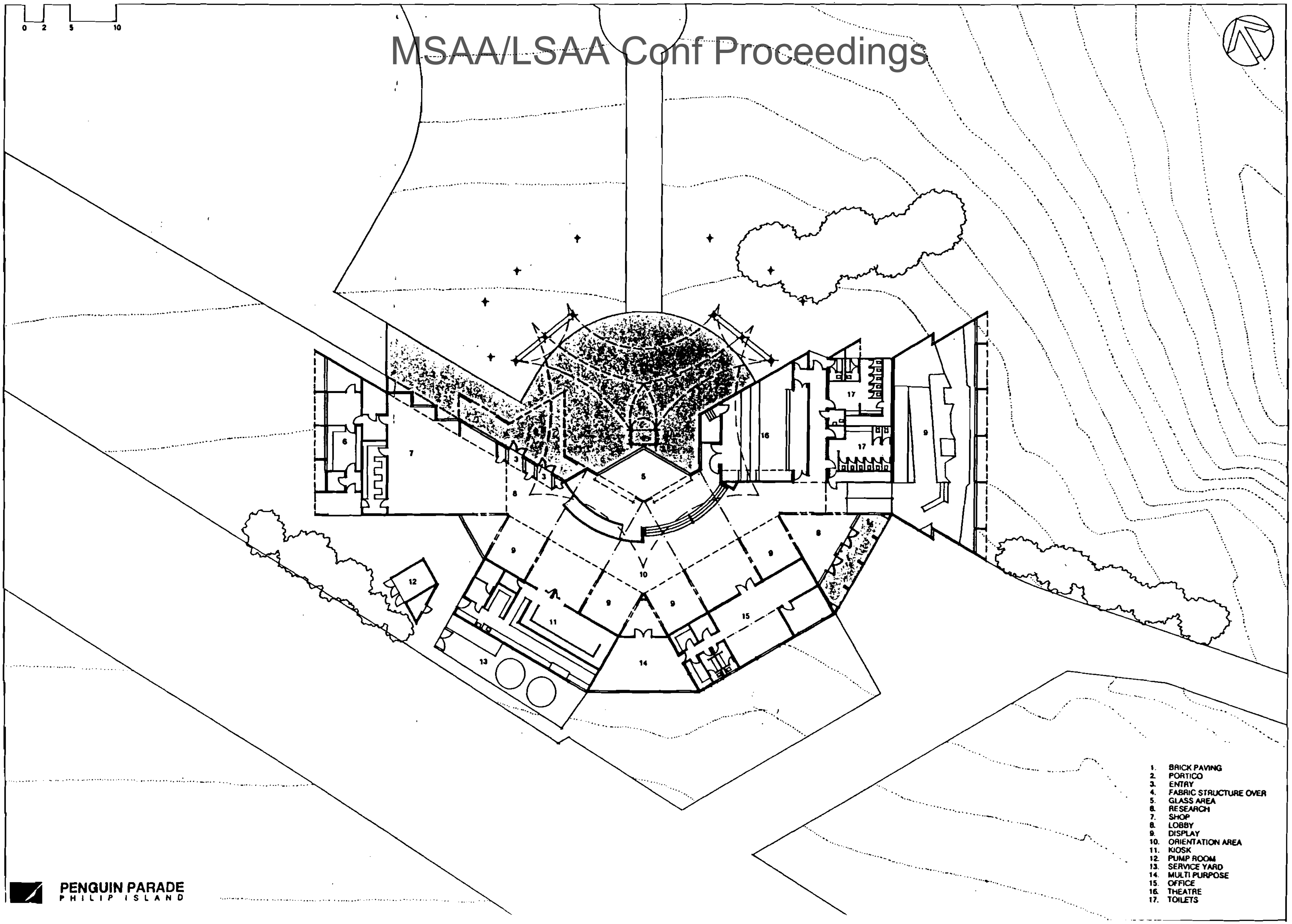
1. VISITORS CENTRE
2. VIEWING STAND
3. PRESENTATION AREA
4. BOARDWALK
5. OBSERVATION TOWER
6. TOILET BLOCK
7. PENGUIN COLONIES
8. SUMMERLAND BEACH
9. SUMMERLAND BAY
10. BOULEVARD
11. BUS PARKING
12. CAR PARKING
PENGUIN PARADE
PHILIP ISLAND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1. BRICK PAVING
2. PORTICO
3. ENTRY
4. FABRIC STRUCTURE OVER
5. GLASS AREA
6. RESEARCH
7. SHOP
8. LOBBY
9. DISPLAY
10. ORIENTATION AREA
11. KIOSK
12. PUMP ROOM
13. SERVICE YARD
14. MULTI PURPOSE
15. OFFICE
16. THEATRE
17. TOILETS
PENGUIN PARADE
PHILIP ISLAND

Phillip Island Penguin Parade

Victoria's Penguin Parade is arguably one of Australia's major Tourist attractions. Its half a million visitors are only exceeded in number by visitors to Ayers Rock and the Great Barrier Reef.

Recently it had reached the stage where predators such as Fox and feral cats and dogs were diminishing the penguins in alarming numbers. So 3 years ago the Victorian Government decided to acquire properties adjoining the penguin parade in an attempt to control this menace.

At the same time it decided to upgrade the dilapidiated existing visitors centre as well as replacing the concrete viewing stands that had been repeatedly added to in an ad hoc fashion.

Daryl Jackson Pty Ltd, were appointed as the architects for the redevelopment and our first task was to design new viewing stands and an elevated board-walk system in time to be completed before the penguin breeding season commenced.

The concrete viewing stands were located on either side of the well established path taken by penguins to reach their young in the burrows located in the sand dunes immediately behind the beach. The new tiered stands were designed to give all visitors better views and to illuminate the returning penguins with Area lighting that simulated the light of a full moon, doing away with the glare of the previously used spot lights that had blinded and disoriented the penguins on their journey up the beach.

Another improvement was the introduction of an elevated walkway which had the beneficial effect of allowing penguins free access to their burrows without having to cross a man-made hazard.
While still allowing the 3000 odd visitors to get very close to the returning food-laden penguins without distressing them through human contact as had been the case in the past with the level path, thus causing them to disgorge their hard won food supply before reaching their young.

As well as this, it prevented straying visitors from damaging the environmentally sensitive rookery habitat.

Finally the elevated walkway allowed services to be reticulated above ground, below the deck, thus giving easy access without the need for trenching the fragile sand dune.

The existing 10 year old visitors centre consisted of ramshackle toilets a Food Kiosk and an Information booth arranged in a boomerang shape. We wanted to demolish the lot and start from scratch but the Committee of Management was not prepared to support this recommendation on the grounds of excessive disruption and in order to maximise savings. As it subsequently turned out it would have been far less disruptive and cheaper to demolish the lot and it would have given us a far greater design latitude.

The clients brief for the new visitors centre required a large column-free central space as the arrival point for the nightly visitors. As well as this, a smaller covered assembly area was called for close to but separate from the viewing stands where smaller groups could be assembled by the Rangers and instructed on the penguins habitat as well as its breeding and social patterns. (See plans).

The decision was made early on to use a fabric structure to roof these 2 spaces because these would give this tourist facility an easily reecognised image as well as being functionally the correct choice.

For our first attempt at roofing the Visitors Centre, we used 2 central masts and the fabric attached to the buildings perimeter. This resulted in a flat connical shape that covered most of the conventionally clad roof and was an un-imaginative solution (see model photo.) This first shape model was built in ½ hour before rushing to an early meeting with the client to discuss the concept.

This model was followed by a second presentation model (see photo) which attempted to refine the entry and reduce the amount of fabric area. However fabric tie back points where set too far away from the structure and it still looked very bland. Apart from its visual failure, our design suffered because we were putting an expensive fabric roof over a large area of conventional roof that did not need it. As well as this the large foyer space could not be readily air conditioned because of the difficulty in sealing a necessarily moving fabric to a fixed, glazed clere storey wall.

The decision was thus made, to use a conventional roof for the air conditioned Foyer and to move the Fabric forward to provide a large external covered area to give a focus to the sprawling building and to receive the bus loads of arriving visitors. As well as shelter those departing.

In the meantime the smaller fabric structure had been advancing more satisfactorily with a good distribution of high and low points giving the fabric curvature and visual interest.

At this stage Daryl Jackson, who had just seen the prototype Bicentennial Exhibition Arcade Tent with its overlapping fabrics, came back from a weekends design re-assessment with the idea of having two overlapping fabrics: one receiving the other, to give what he called a "Zoomorphic" plan shape that is in the shape of an extended birds wing or a sting ray, somewhat complex in shape and edge overlap, to give a feel of mystery to avoid banality. The use of such a metalphor being entirely appropriate for this seaside location.

A very attractive conjunction of shapes resulted from the introduction of this metaphor. Similarly, in establishing the overall external colour scheme, Daryl selected the fabric colour to match the blue grey of the sea gulls that abound the site and gave the stick like mast and membrane plates the rich red of the seagulls legs. While the visitors centre was kept a neutral white with horizontal bands of grey green that picked up the colour of the coastal tea tree and echoed the strong horizontals of the coast line and its horizon beyond. Thus allowing the entry Fabric Structure to create an Architecture of Theatre and expectation entirely appropriate to its setting.

One of the unusual requirements of the structural design was that in designing the footings for the guy back masts to the smaller structure, Connells had to avoid the location of the existing penguin burrows that littered the area.

As it turned out when site works commenced a mast base had to be relocated to miss a burrow that had not shown up on the survey drawing.

With the layered and overlapping fabric achieving a satisfactory yet complex design solution for the smaller fabric structure it was decided to employ the same technique to the main Visitor Centre Fabric Structure with similar success.

This layering proved attractive as it brought the scale of the building down and it created superior natural lighting, sun penetration and sky views.

The photos of our next study model shows that the idea of the overlapping fabrics was explored with large apertures around the two central masts to bring light into the centre of the space and to emphasise the visual inter-cutting of the 2 layers.

The upper fabric was delicately brought together at a point in a crab like "pincer" fashion. The next study model (see photo) explored the idea of this junction occurring in the lower fabric for viewing from below. However this resulted in less protection for the visitors.

This model also introduced the idea of 4 masts which avoided the need to use catenaries that returned on themselves which, as I recall, were proving difficult for the Engineers to analyse at the time.

The Final model (see photo) returned the crab like coming together of fabric to the upper surface. It was also decided to introduce heavily reinforced Roof Monitors which allowed them to become tie back points for the upper fabric.

Note also the dowels cut back flush on the model photos at the front, showing intermediate position of fabric model tie back points.

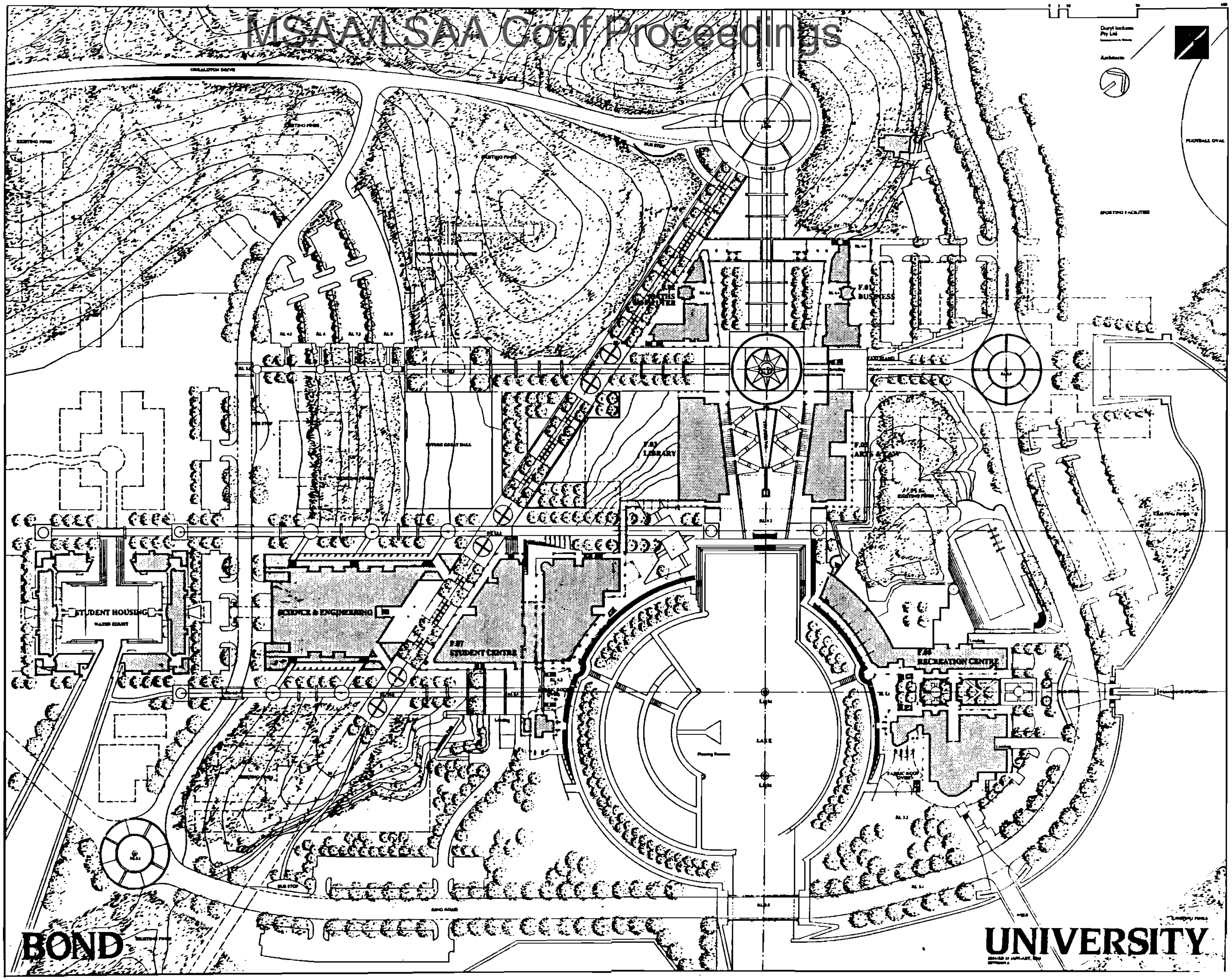
Finally to the central mast study.

The smaller Fabric Structure had shown that the attachment of the lower fabric 3/4 way up the mast induced significant moments into the mast requiring large pipe sections to be used and that for the main building with its larger fabric, this problem would be accentuated.

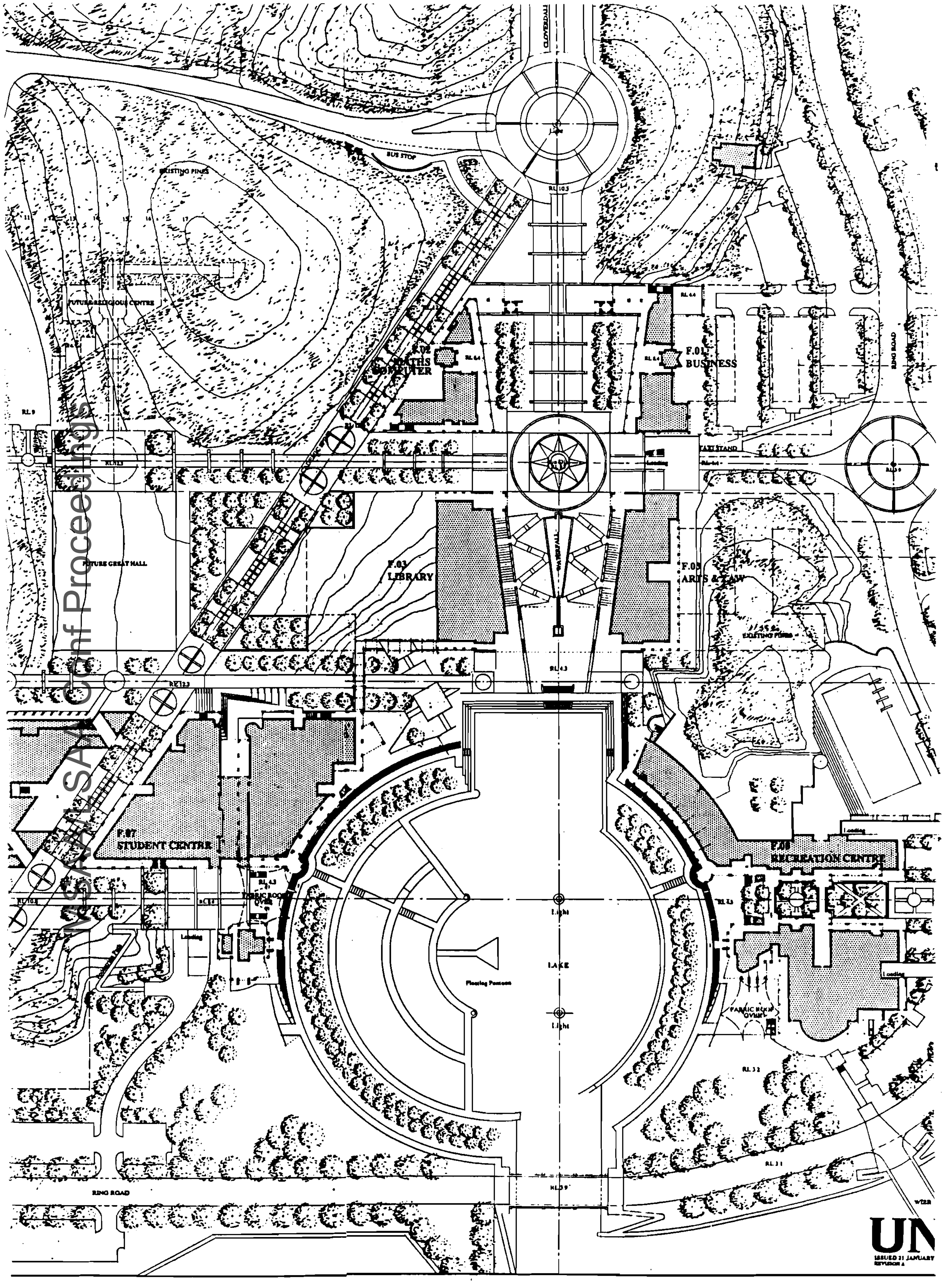
It was also recognised that the 4 masts would have to rotate together about a common point under wind action, so that a trussed mast solution was devised by Connells and then visually simplified by the Architects (see model photos.)

In fact the wire model of the truss was built to prove to ourselves how two intersecting trusses could form a mast. The same model was used to help visualisation during the shop drawing stage.

Having used ball and socket mast bases with success for the Australian Bicentennial Exhibition Structures, the decision was made to use the same detail again for all mast bases. This time Spacetech refined the detail by Teflon coating the ball, to allow long term movement and ease of adjustment.



BOND UNIVERSITY
STUDENT HOUSING
SCIENCE & ENGINEERING
STUDENT CENTRE
LIBRARY
BUSINESS
ARTS & LAW
RECREATION CENTRE
LAKE
SPORTING FACILITIES
FOOTBALL OVAL
BUS STOP
Architects


CLOVERDALE
BUS STOP
EXISTING PINES
FUTURE RELIGIOUS CENTRE
F.02 MATHS COMPUTER
F.01 BUSINESS
RING ROAD
TAXI STAND
FUTURE GREAT HALL
F.03 LIBRARY
F.05 ARTS & LAW
EXISTING PINES
F.07 STUDENT CENTRE
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Loading
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ISSUED 31 JANUARY

Bond University

The idea of an inter-meshing 2 layer Fabric Structure first developed for the Penguin Parade was used again by our office for the 2 major Fabric Structures on the Bond University Campus.

The University is surrounded by an extensive system of waterways including a 2.5 km long Olympic Class Rowing course and has as the focus of its ceremonial axis a large circular lake or water feature.

Symmetrically placed about this feature are the 2 major student facilities namely the Student Centre and the Recreation Centre each of which has an outdoor food court facing the lake and each has been given a highly visible Fabric Structure to provide shade and weather protection to the courts.

It was felt appropriate that in the context of such a nautical setting these Fabric Structures together with several other smaller ones around the campus should be used to evoke the idea of sails, masts, spars and rigging to reinforce the nautical nature of the campus and of its patron. We also felt that it was important that the Fabric Structures should be seen to have their own identity as well as to fit into the space created by the buildings as if they were designed for that space. These seemingly disparate requirements were met firstly by attaching the fabric not directly to the surrounding buildings but to steel frames which were in turn attached to the buildings. For the same reason attachment to the free standing concrete piers was via steel tie back frames mounted on top of these piers.

Secondly as the fabric model photos show the number of attachment points to the adjoining structure was increased so that the fabric was "teased out" and appeared to fill the space better, thereby making it appear to belong specifically to that space.

The fabric layering was arranged in such a way as to build up or rise when viewed from the lake. This reinforced the outward and upward rising steps and the landscape around the lake while at the same time allowing views of the lake from the buildings through the fabric layers.

The steel tie back frames were found to be useful in allowing the point loads coming off the fabric to be diffused into the slab edge of the adjoining structure without the need for additional reinforcement by having usually 4 fixings for each fabric tie back frame. They were also useful in allowing fabric attachments to be made where otherwise there may have been a downpipe or rain head in the way.

The major catenary of the Student Centre however could not be attached to such a steel frame and its 150 KN load required the Engineer to heavily reinforced the concrete stairwell and the floor slab to which it was attached.

Where the Fabric attached to wall mounted steel frames the connection was made using threaded U Bolts connected directly to the membrane plates to minimise the gap between fabric and building. This necessitated the use of SKF stainless steel spherical bearings to allow the membrane plate to be displaced. (See photo). Because of the limited rotation of these bearings ($\pm$ 10 deg.) about the horizontal axis, the support spigots had to be angled at right angles to the pre-stress-only resultant force.

As it turned out, the building contractor had great difficulty in accurately positioning the core holes in the concrete for the wall frame fixing bolts. Some being up to 50mm out and it was decided for the Recreation Centre built later to site drill these connections into the concrete. It became obvious that the normal building contractor is not capable of building to the fine positional tolerances required for fabric structures and Architects should require all fixings positions to be located by a qualified licensed surveyor not the builders foreman and to be securely fixed to the formwork.

The need to know early-on the forces coming off the fabric structures i.e. well before a design and construct contractor had been appointed - required Connells to do a preliminary analysis of the Fabric Structures in order to allow them to design the surrounding conventional structures.

Because an extensive amount of design work had already been done by the Connell Group we wanted them, together with Spacetech, to complete the design and carry out the construction. Having established a good working relationship with both during our earlier work on the Australian Bicentennial Exhibition and the Penguin Parade.

Unfortunately our client could not be persuaded to this course of action.

Frei Otto has been quoted as saying that when designing fabric structures it is of great importance to surround yourself with competent people who's views you absolutely respect and with whom you can work well together, and most importantly that once such a team has been welded together it remains together as far as possible.

As architects we have found that when dealing with a leading edge technology such as fabric structures, on which few text books have been written, the various proponents of the new technology can have very strong views about how things should or should not be done, or what is important or what is not important and as if life as an architect is not hard enough already, you may find having someone on your team who ends up rowing in the opposite direction to the rest.

Architects are concerned with the aesthetic expression of buildings as well as their functional performance.

They engage consultants including Structural Engineers, Mechanical Services Engineers, Hydraulic Consultants etc to assist them in optimizing the buildings functional performance.

In traditional construction the end product of the design of these consultants i.e. columns and beam connections, roof trusses, ducts, pipes etc., usually remain hidden from view by either concrete encasement, wall cladding, false ceilings, service ducts etc, and their impact on the aesthetic expression can to a large, extent be controlled by the Architect.

In contrast, Fabric Structures are minimal structures where nothing can be hidden from view. All is revealed. The Architect has to come to terms with this fact and the fact that his aesthetic agenda is set, to a large extent, by Engineering constraints which by their uncompromisingly demanding functionallity, leave very little room for the Architect to manipulate them.

His input would appear to be limited to establishing the principal shape of the structure by the use of "stocking" models while the final design including the all important connection details have to be left, by necessity, to the Engineer. However the shape of the membrane plates and other connections should be designed by the architect as part of the overall aesthetics and this may involve him in some prototyping work to ensure that the central features of his design are in fact practical. This was the case with the Australian Bicentennial Exhibition splice plate connections which borrowed the swaged stainless steel eyelet technology employed on a yacht sails head board.

Architects therefore look for Engineers with whom they can establish a design "rapport" someone who is generally sympathetic to the Architects design objectives and who will initiate ways of achieving these i.e., he may suggest varying the warp/weft stress ratios to bring the fabric shape closer to that of the Architects design model even when this results in say, non-symmetrically loaded membrane plates.

He may also vary the direction of cutting patterns pointing out the pros and cons of each. i.e. Architects look for Engineers who are prepared to enter into a dialogue who willingly become an "ideas - generating - member" of the design team. The interaction of a good Architect - Engineer design team is analogous to a good game of Tennis with ideas and challenges being hit backwards and forwards over the "net" culminating finally in a result that is satisfying to all involved.

As in a game of Tennis the degree of satisfaction achieved depends very much on the skills of the players and on their ability to allow overlap to occur between each others design skills. i.e. for the Engineer to play at Architecture and the Architect to play at Engineering.

Unlike a game of Tennis there are no losers only the design becomes the winner.

It has to be said that nothing turns an Architect off more effectively than a negative consultant who gives the impression that he is rowing in the opposite direction to the rest of the team.

This lesson has long been learnt by Engineers and Contractors that regularly work with demanding Architects.

However it is a lesson that has still to be learnt by some Design and Construct Contractors who have had little contact with Architects or only with Architects that have been happy to abrogate their design responsibility to the design and construct contractors. The entire design effort of such Architects appears to be limited to the issue of a general design statement in the form of a drawing and a specification followed by the appointment of the lowest priced Design & Construct tenderer who is then left to do as he pleases and who when later challenged by the concerned Architect on matters of detail, has as his stock response:- "This is what I had allowed for in my tender!"

Clearly this situation is unsatisfactory and in the interest of the industry has to be resolved. The present document issued by the MSAA "Guidelines for Design and Construct Tenderers for Tension Membrane Structures" is too general to be of use and needs to be overhauled.

The responsibilities of both Architect and design and construct contractor need to be clearly spelled out in such a document.

It goes without saying that such an update cannot be tackled in a conference forum such as this, but needs to be addressed in a dispassionate fashion in the calm, confines of a small committee room, where wise decisions can be reached after due discussion and consideration.

The attached Schedule of responsibilities and minimum documentation package is an attempt to highlight some of the areas which require further consideration.

TYPICAL FABRIC STRUCTURE

DOCUMENTATION PACKAGE

A) **Specification**

. Preliminaries and Technical

B) **Architectural Drawings**

1:100 Plans, sections, elevations of fabrics. Shown in context with rest of structures.

C) **Structural Drawings**

1.	**Typical Fabric Details:**	. Cable Sleeve Preparation, Fabrication, Dimensions, Details. . Cable convergent Geometries and Reinforcement Panels
2	**Layout and General Details**	. Plan and Elevation showing reference points and XYZ Co ordinates. . Mast and Membrane plate schedule. . Set out Tolerances . Cable length and size schedule including fittings . Webbing Schedule . Concrete footing schedule
3.	**Membrane Plate Details**	. Fully dimensioned and detailed for shop drawing purposes including webbing clamp plate and stud sleeve detail
4.	**Mast & Tie-Back Details**	. Mast Top and base . Tie-back cable anchorage
5.	**Footing Details**	

D) **Services Drawings** . Electrical etc.

BOND UNIVERSITY
FABRIC STRUCTURES

Preliminary Schedule of Responsibilities

	Contractor	**Architect**
Design	Computations proving design	None
	Shape finding Screen dumps	Shape making input
	Cutting patterns	Approval
	Proving Models	Approval
Fabrication	Fabric inspection off the roll for visual defects	None
	Quality control Production Weld Tests	Test weld approval and approval of welded fabric
	Shop Drawings for steelwork including membrane plates, cables and fittings	Approval
	Weld quality and general workmanship	Inspection of steelwork and paint finish
Erection	Procedure and liaising with Builder	None
	Stressing and tuning structure to eliminate wrinkles, etc.	Inspection and approval stressed structure

Comments on The Bond University Fabric Models
Recreation Centre

Option 1

The photos show our first in-house study model with the upper fabric facing the lake. Attachment to the buttress of the residential tower and to the free standing piers is asymmetric i.e. high fabric attaches high and next to it the low fabric attaches low.

Option 2

The upper fabric still faces the lake but instead of a single attachment to the tower buttress and the free standing piers as was the case with Option 1 this has now been replaced with two attachments. This has the effect of "teasing out" the fabric to give a better fit and to give a symmetrical disposition about the attachment piers.

Option 3

The upper fabric has now been swung against the high gymnasium wall reducing its scale when viewed from the lake and the lower fabric which faces the lake gives a more appropriate scale relationship to the terracing and the lake side landscaping.

Note: While the upper fabric remains unchanged from the final as built shape, the lower fabric went through a further transition stage. Contracting in size so that the lake side piers could be positioned at the top of the stair thus also reducing the tie back cable length for the upper fabric, and reducing the number of footing piles, as well as the number of free standing piers required.

STUDENT CENTRE

Option 1 & 2

The lower fabric faces lake with the upper fabric set back above an elevated walkway.

Note: The lower fabric attaches to the residential tower at a single point.

Free standing piers are set too far out, at the base of the stairs, resulting in large flat areas to the upper and lower fabrics near the catenary edge and also resulting in long tie back cable lengths to upper fabric.

Note: View of lake from bridge through overlapping fabric roofs.

Option 3

Both the upper and lower fabric have fabric area reduced in lake direction eliminating flat areas.

Free standing piers have been relocated at the head of the stairs giving shorter tie back cables for the upper fabric.

Lower fabric now attaches to both the adjoining buildings with twin attachment points.

Visually "stitching" or "tying" the fabric structure to the buildings and giving the fabric a better "fit".

Note: Lower fabric is still asymmetric. A further development had the free standing piers equi-distant from the masts and walkway.

PROBLEMS IDENTIFIED WITH

DESIGN & CONSTRUCT TENDERS

Architects considering calling for Design and Construct Tenders should issue a set of documents that are as comprehensive and as concise as possible. Any errors or inconsistencies must be avoided.

Make sure all documents are dimensioned correctly and identify if dimensions refer to Fabric Working Points or Steel Working points. The difference may be hardly visible on a 1:100 drawing but can have major repercussions on your support structure attachments. Any misunderstanding can be costly.

There is a need for the industry to establish a standardised system of scheduling Fabric Working Point co-ordinate information and to define such terms as what is meant by Fabric Working Point. Steel Working Point, Cable intersection Point etc to make absolutely sure that such information is presented concisely and accurately and that architects understand what is meant by such terminology.

Remember unlike conventional structures, Fabric Structures do not allow you to change one dimension without involving you in a major and costly redesign.

With conventional buildings you can change several beams and the Engineer will show no great concern, with Fabric Structure's you change the location of any part of it in either the X, Y or the Z direction by even 10mm and you are in for a complete re design.

A further difficulty that must be recognised is that the Architects Design and Construct Tender drawings must by their very nature be unresolved, since they lack any engineering design input contrary to what would normally be the case in a conventional tender. Items such as fabric offsets from the supporting structures, tie back frame geometries and sizes, cleat sizes, etc. can only be shown indicatively for tendering purposes and as a consequence fabric dimensions have to be indicative too.

Where Fabric Structures are required to fit an existing space such as was the case at Bond University, architects must allow for a tolerance zone between the Fabric working point and the fixing point on the adjacent structure to allow for the following:-

1. Tolerance in positioning these fixing points on the adjacent structures.
2. Accumulated errors in manufacture of the fabric including in cutting and in welding.
3. Rigging Hardware size.
4. Outward displacement of the membrane plates due to need to prestress the fabric.
5. Additional outward displacement of the membrane plates to compensate for the long term creep.

Architects Tender Drawings inveriably require further resolution, even the fabric geometry which has after all only been stablished from stocking models needs to be confirmed with respect to minimum slopes, membrane plate positions in space, cable angles, mast guy cable attachments, etc. All this can only be finally resolved together with the input from the membrane structures contractor and his engineer.

Part of the responsibility of the successful design and construct contractor is to fully acquaint himself with the architect's documents and to draw the architect's attention to any inconsistencies or omissions, and to seek proper instructions where the intent of the documents is unclear to him or needs further resolution before proceeding with his design. The Design and Construct Contractor has to remember he is dealing with a relative novice on the subject.

Such a reviewing exercise should properly culminate in the issue by the design and construct contractor of his confirming documents for approval by both the architect and client and which then forms the basis for the contractor completing the design.

This activity must be completed before any design work is commenced. It is not good enough to proceed on an assumption as to what the architects intentions were without giving him the opportunity to confirm these.

It is also an important function of the confirming documents to inform the architect and client of any parts of the architect's design that cannot, for various reasons, be achieved by the contractor.

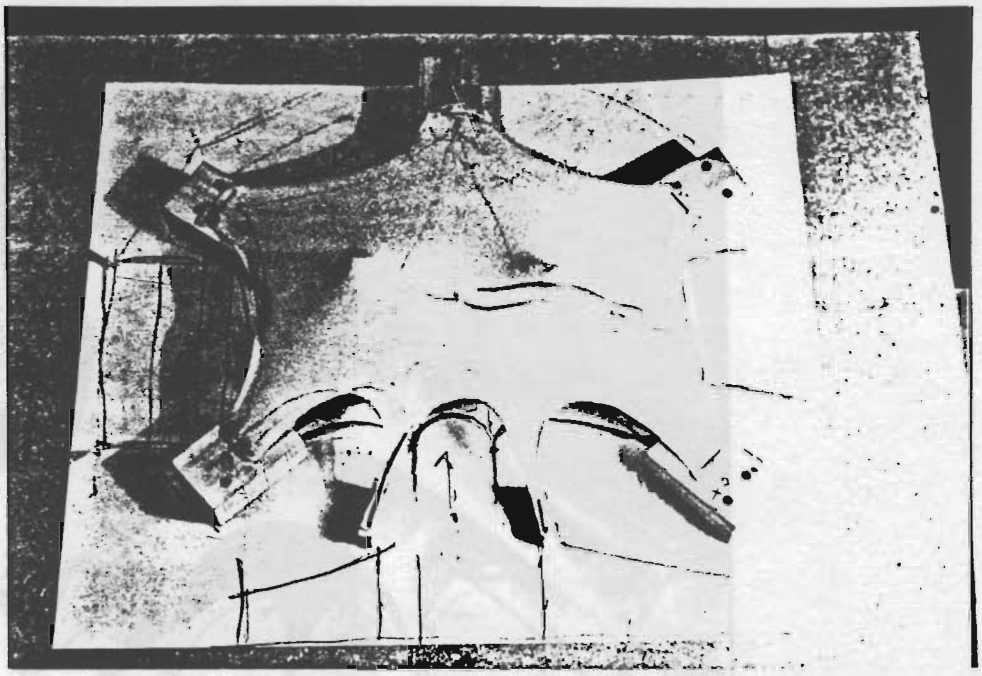
For example the fabric offered by a contractor may not allow him to achieve the deeply cut catenary shapes shown on the architects drawings which has a major impact on the appearance of the structure.

Every Design and Construct Contractor has his own way of detailing things which may or may not be visually acceptable to the architect.
Thus it becomes important that the architect define exactly what he requires in terms of connection details, rigging hardware, finishes etc. He should visit work done by the lowest tenderer and note any details etc. which he objects to and have the tenderer agree to the proposed changes before appointing him.

Tenderers may state in their tender submission that they "have conformed with the intent of the tender documents, should however some of the details shown require to be varied then these changes will be of a standard equal or superior to that shown."
It is important for the architect to realise that what is meant here by the contractor is the engineering standard not the aesthetic standard. The architect must insist on being the final arbiter in matters of aesthetic design judgement.

The architect should state in the tender documents that he wishes to be involved in the design development phase to allow a continued aesthetic input into working up the final design and a monetary allowance should be included in the tender sum for architects fees for such work.

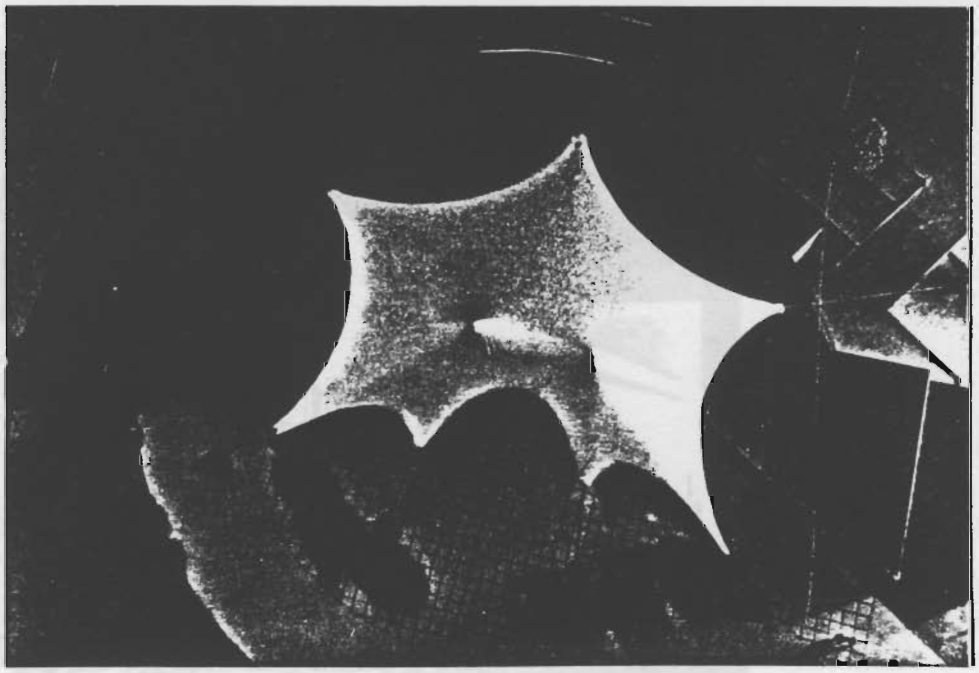
I hope these comments will be of some assistance to all those architects contemplating letting a design and construct tender for a Fabric Structure.



PENGUIN PARADE

VISITOR CENTRE

FIRST SHAPE



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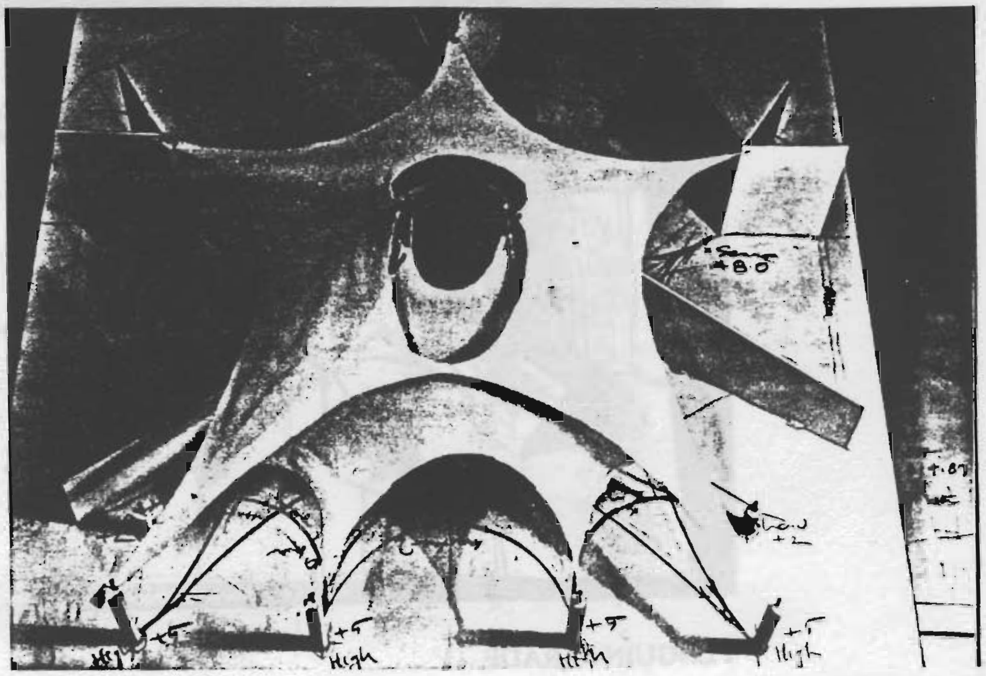
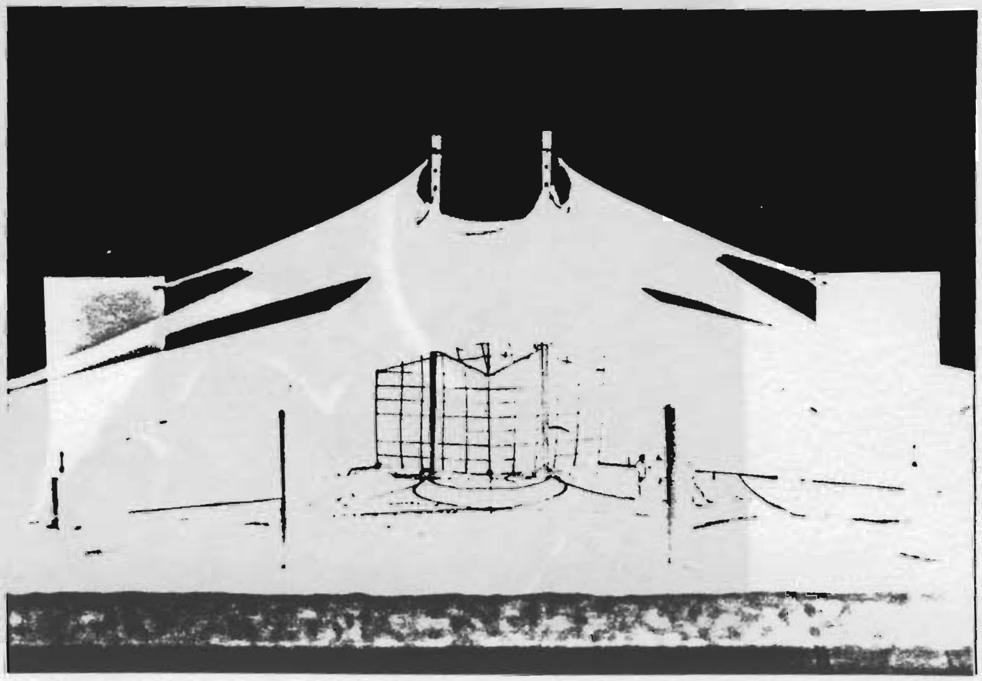
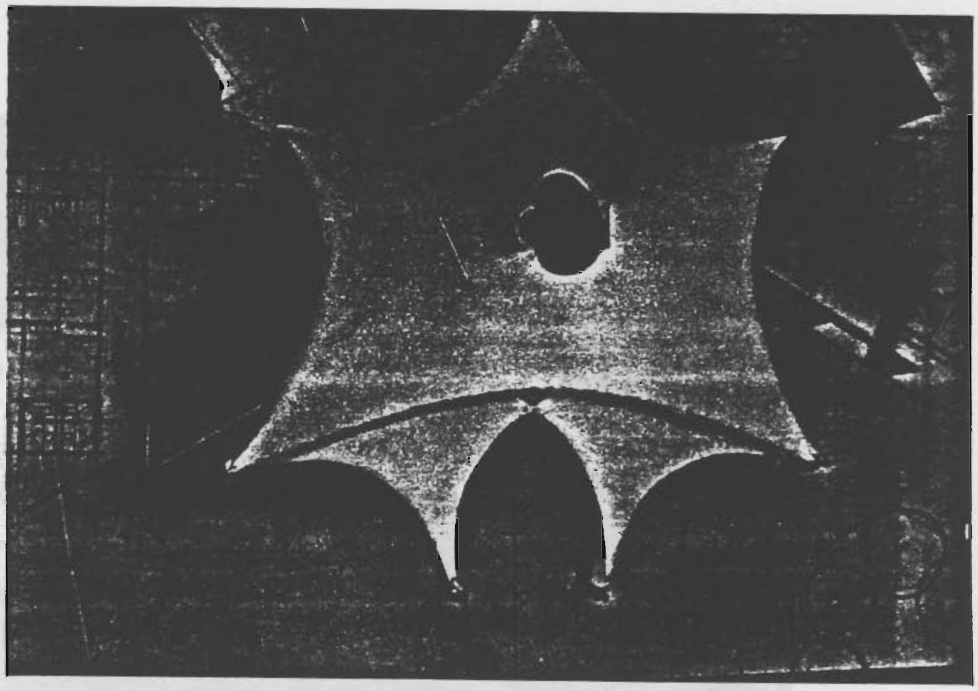
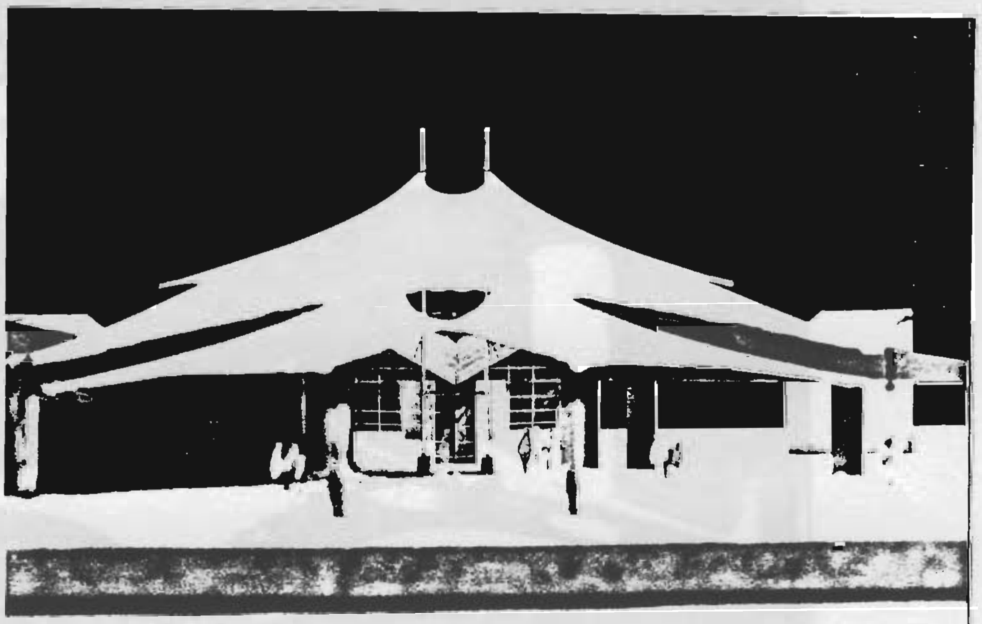


PENGUIN PARADE SECOND SHAPE

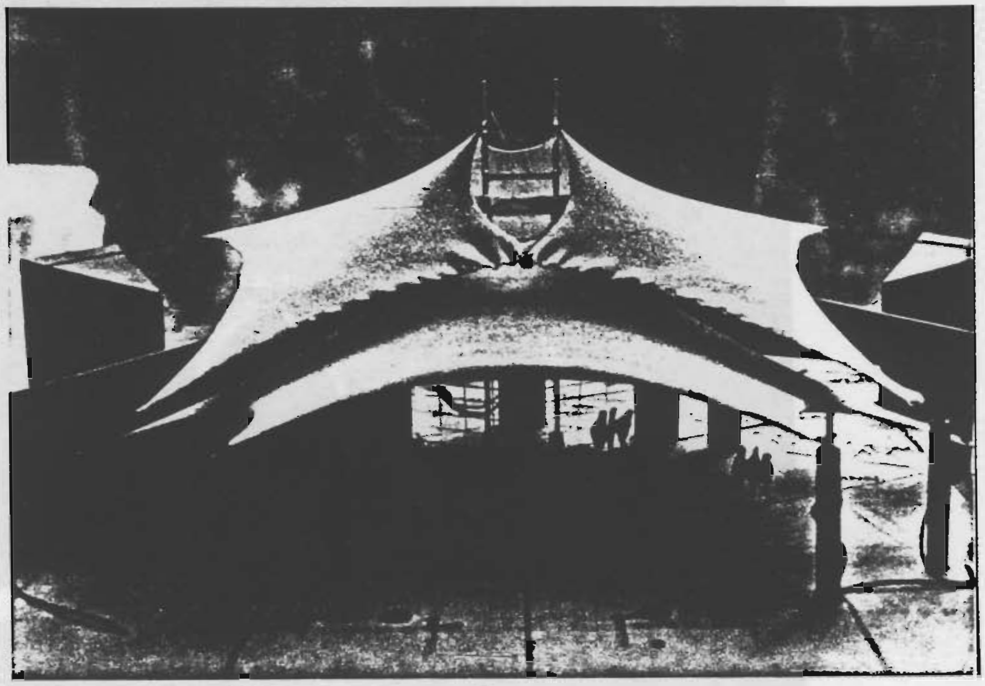






PENGUIN PARADE

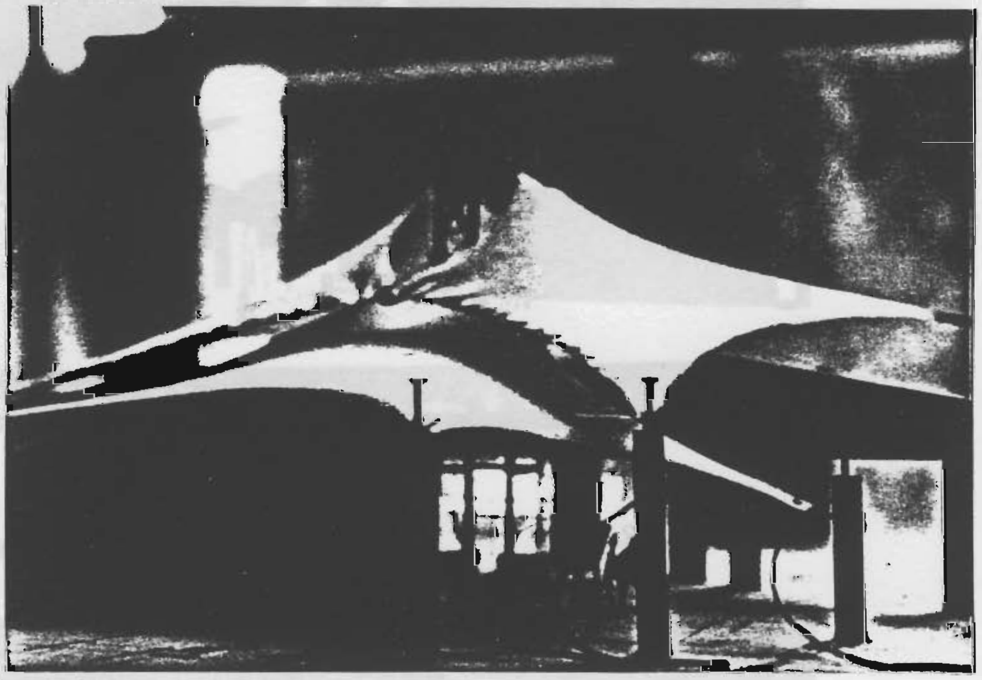
THIRD SHAPE



PENGUIN PARADE

FOURTH SHAPE

VISITOR CENTRE



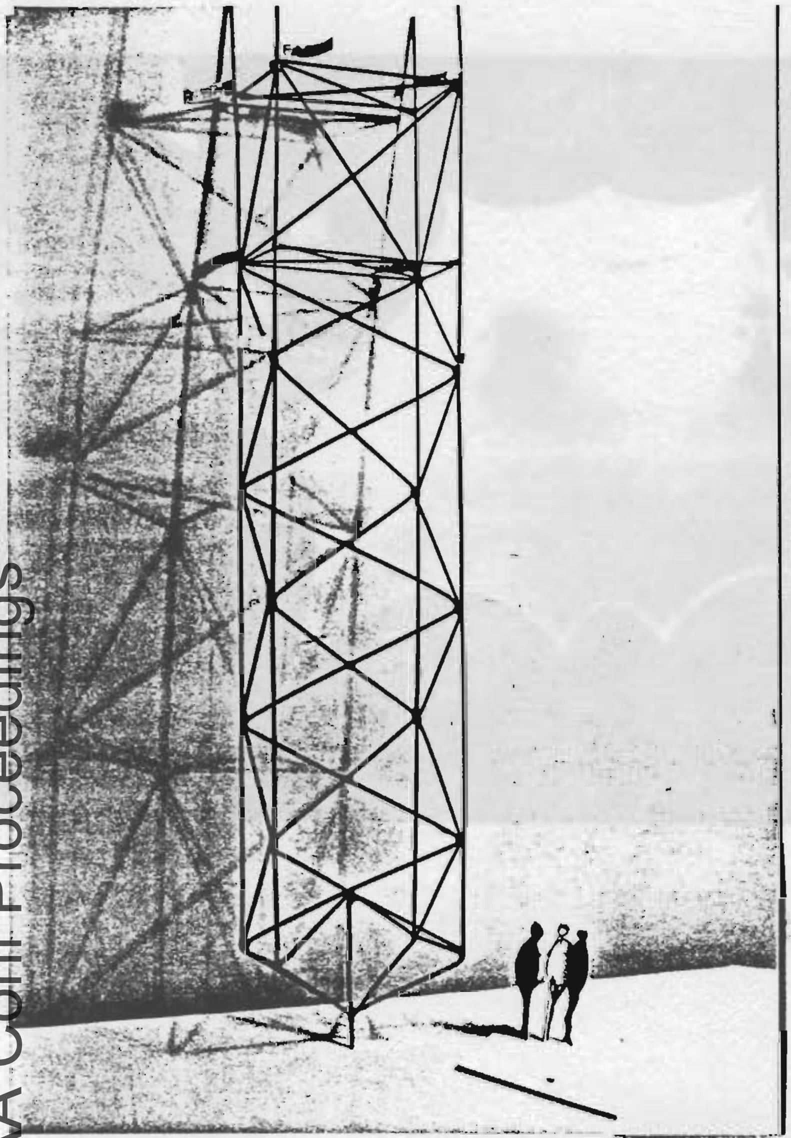
1:50 SCALE

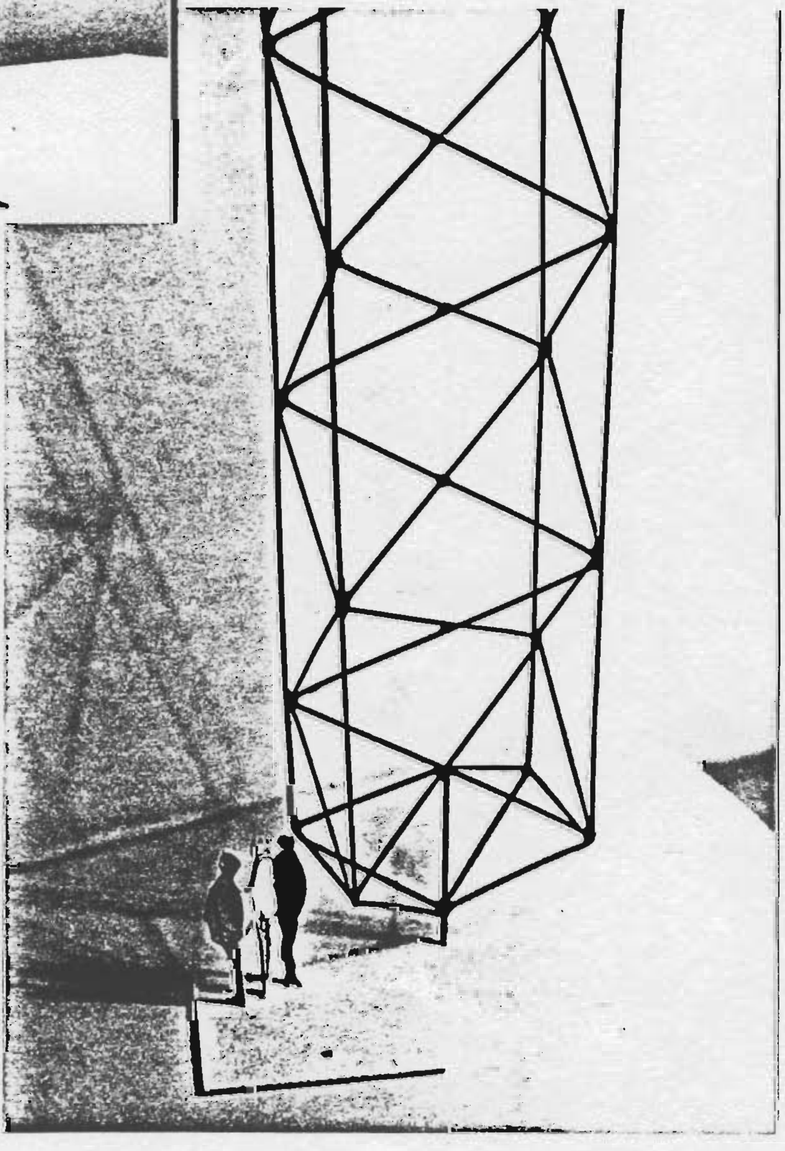
PENGUIN PARADE

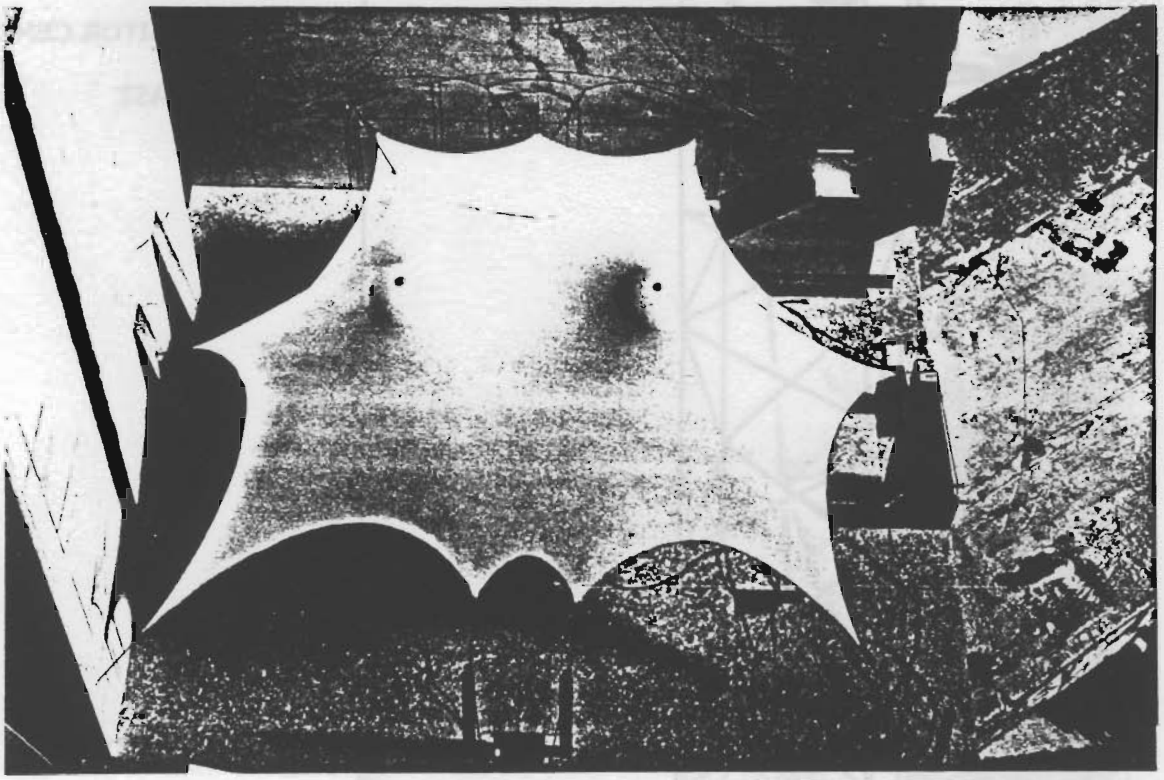
VISITOR CENTRE

MAST

1:50 SCALE







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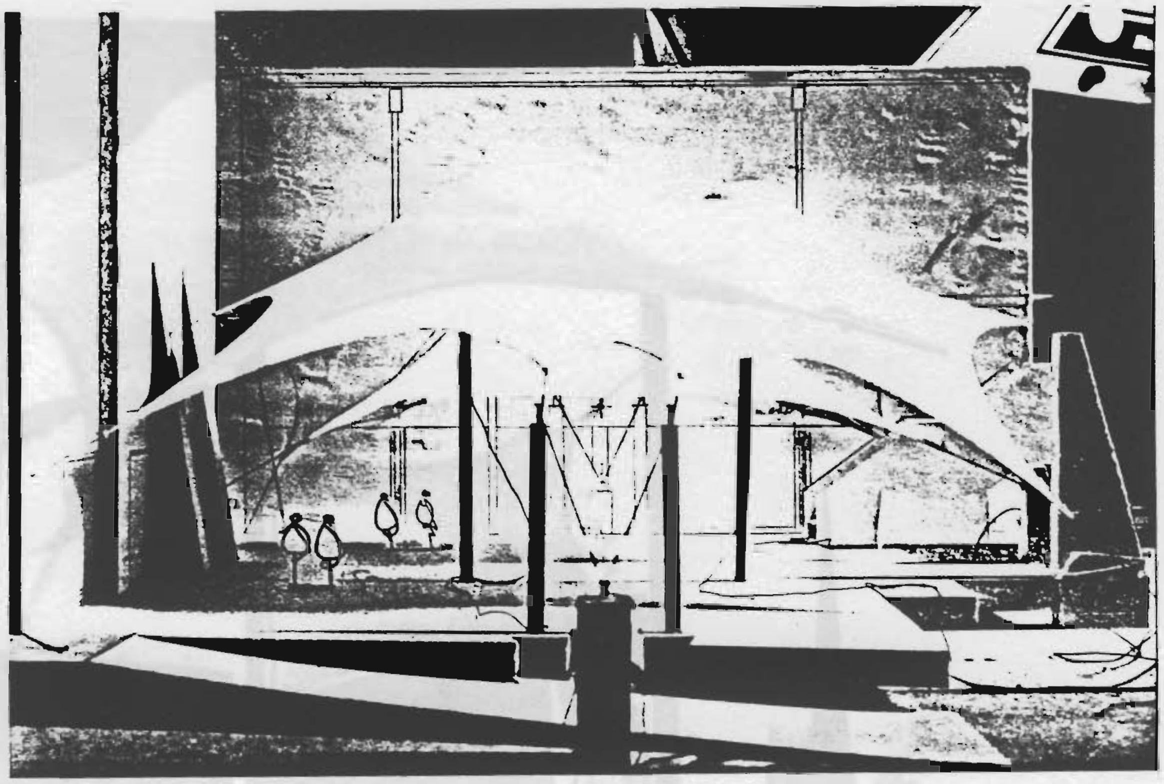

RECREATION CENTRE

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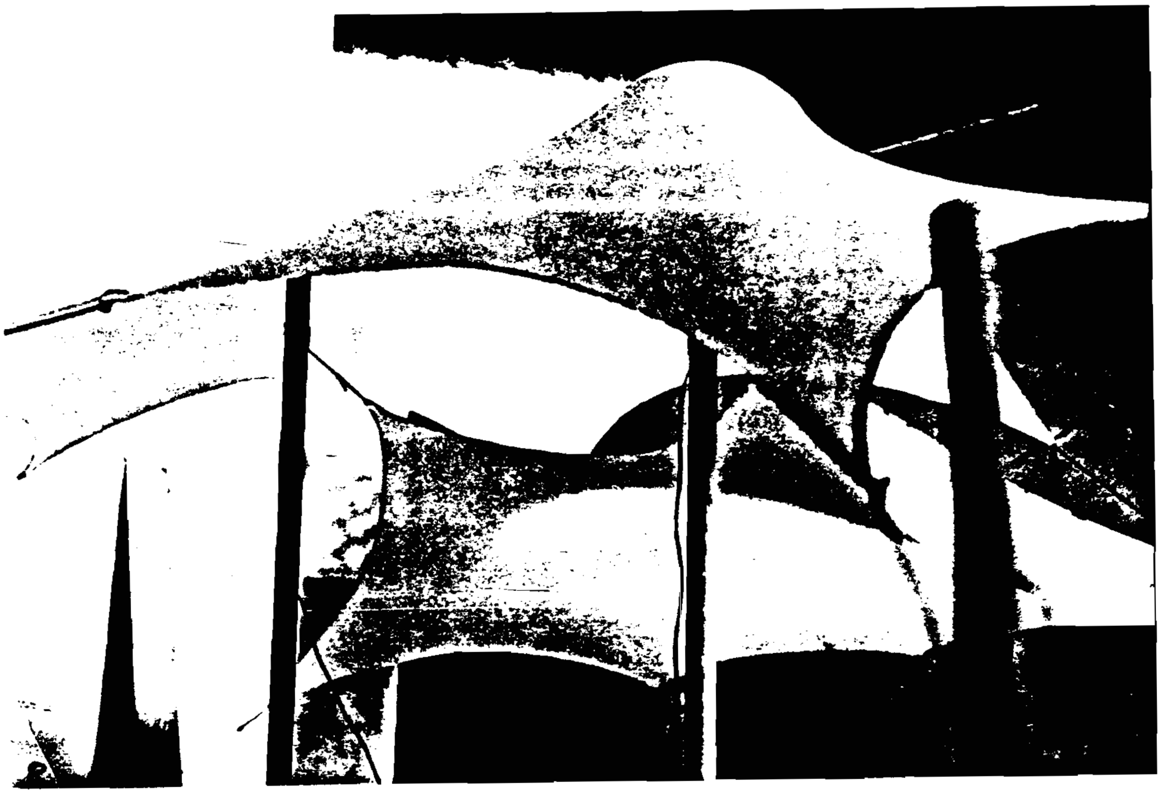

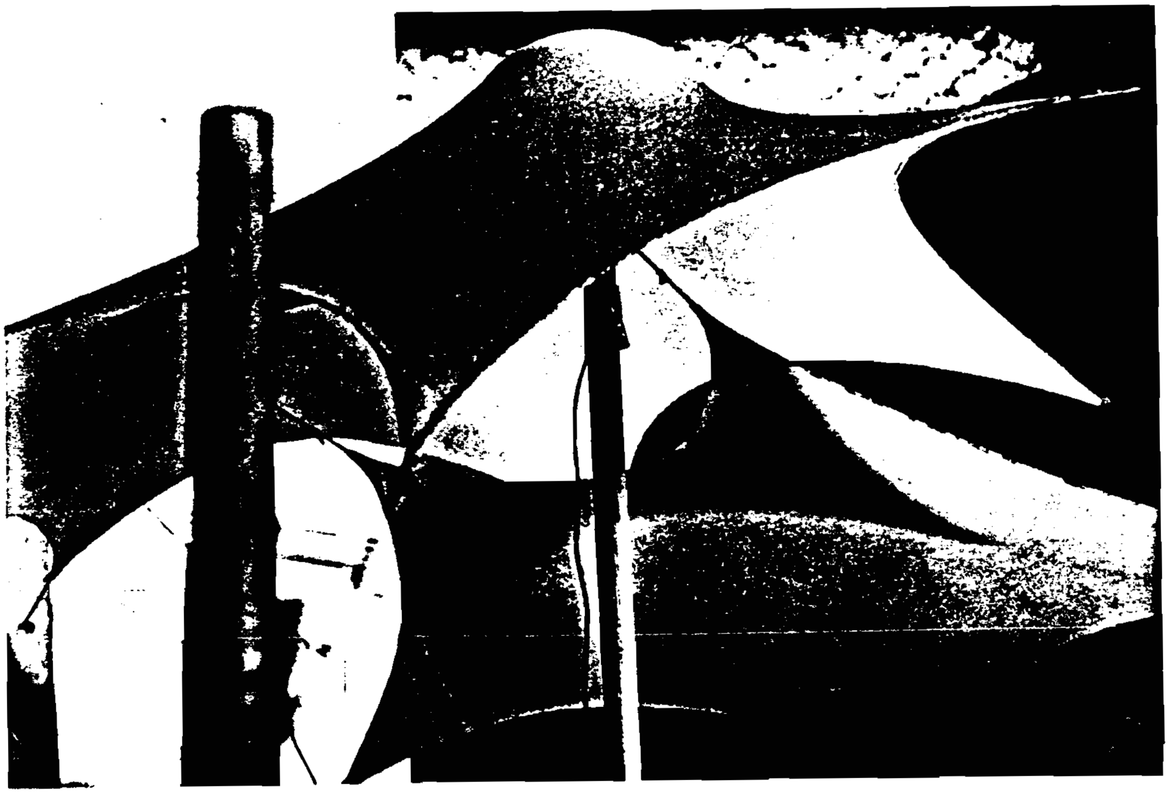

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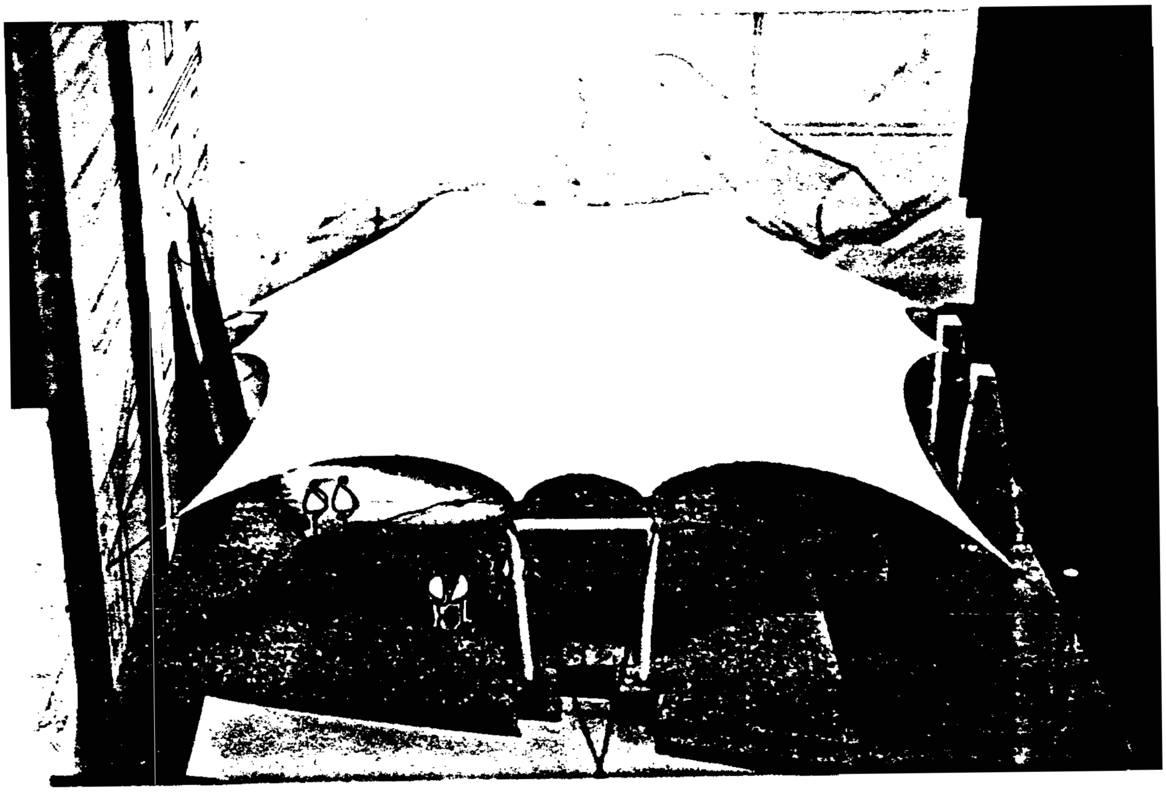

RECREATION CENTRE

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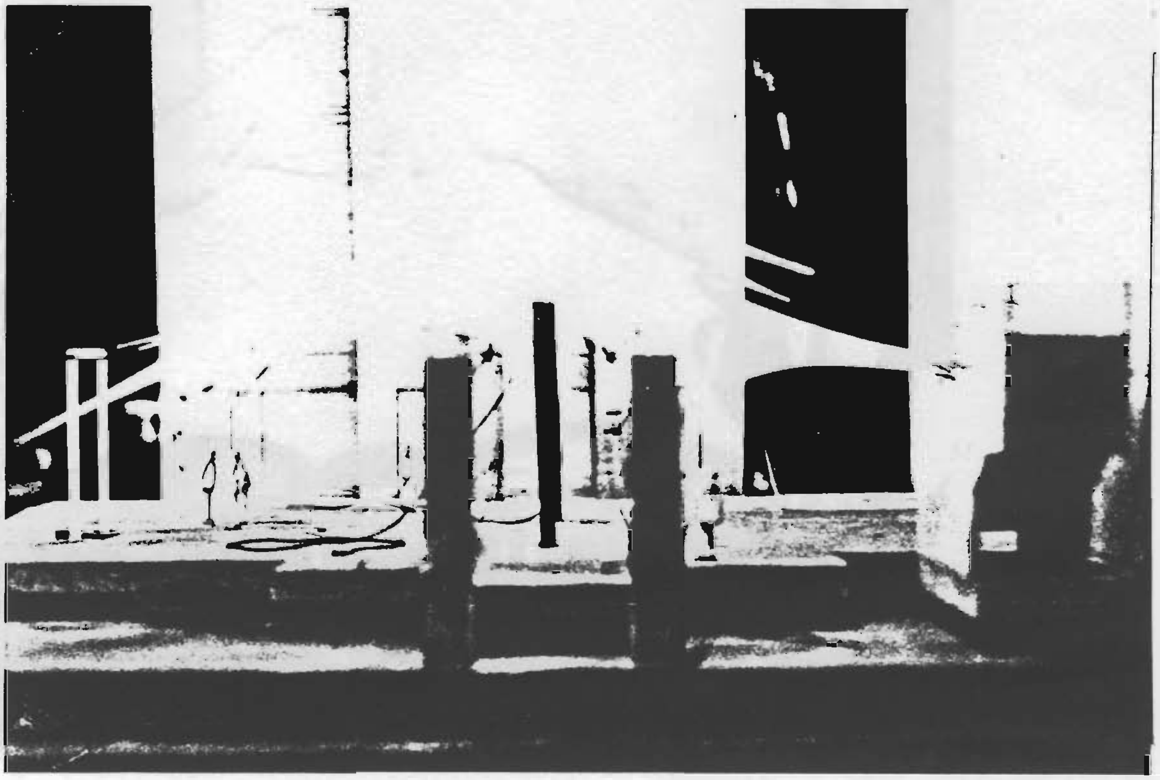

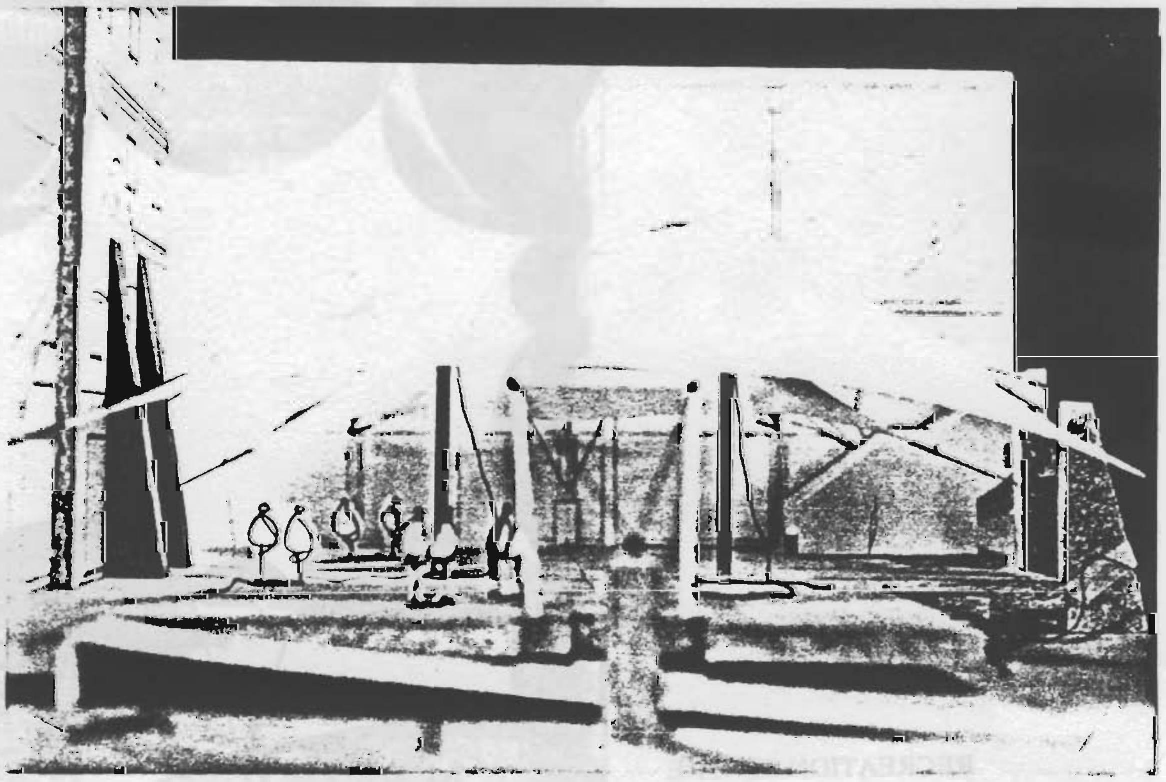

RECREATION CENTRE

OPTION 2

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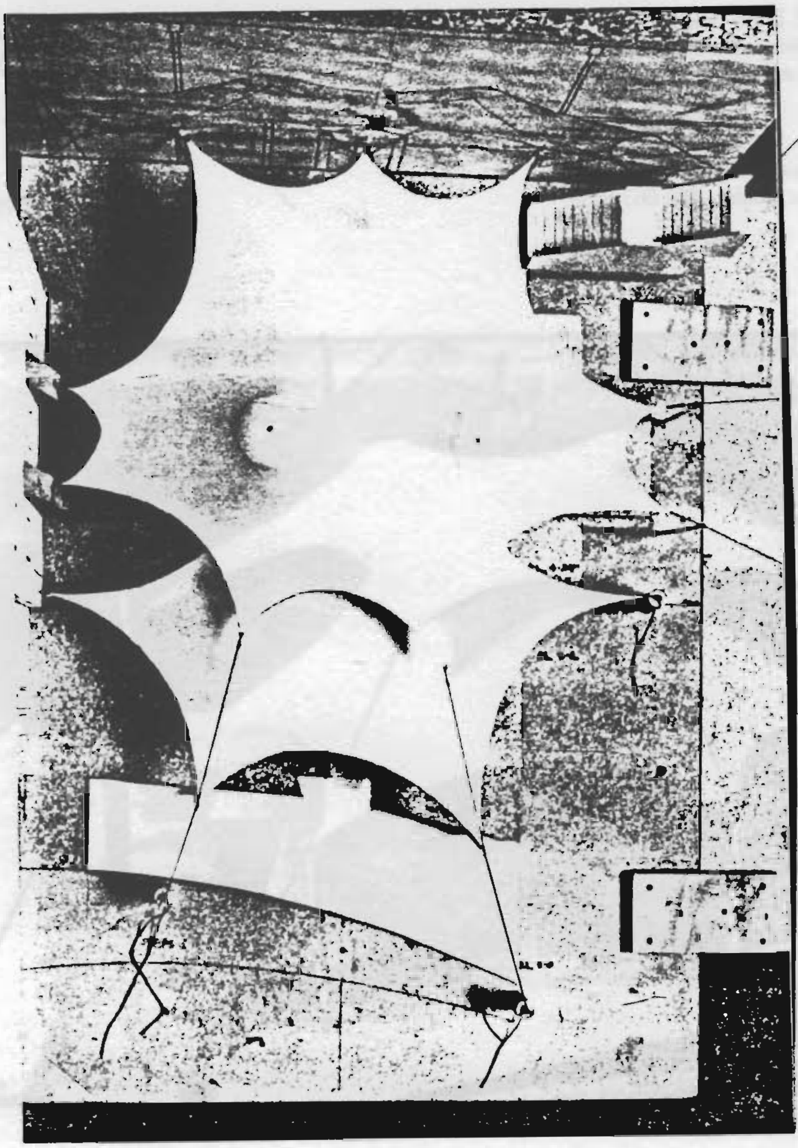
Pty Ltd

Architects



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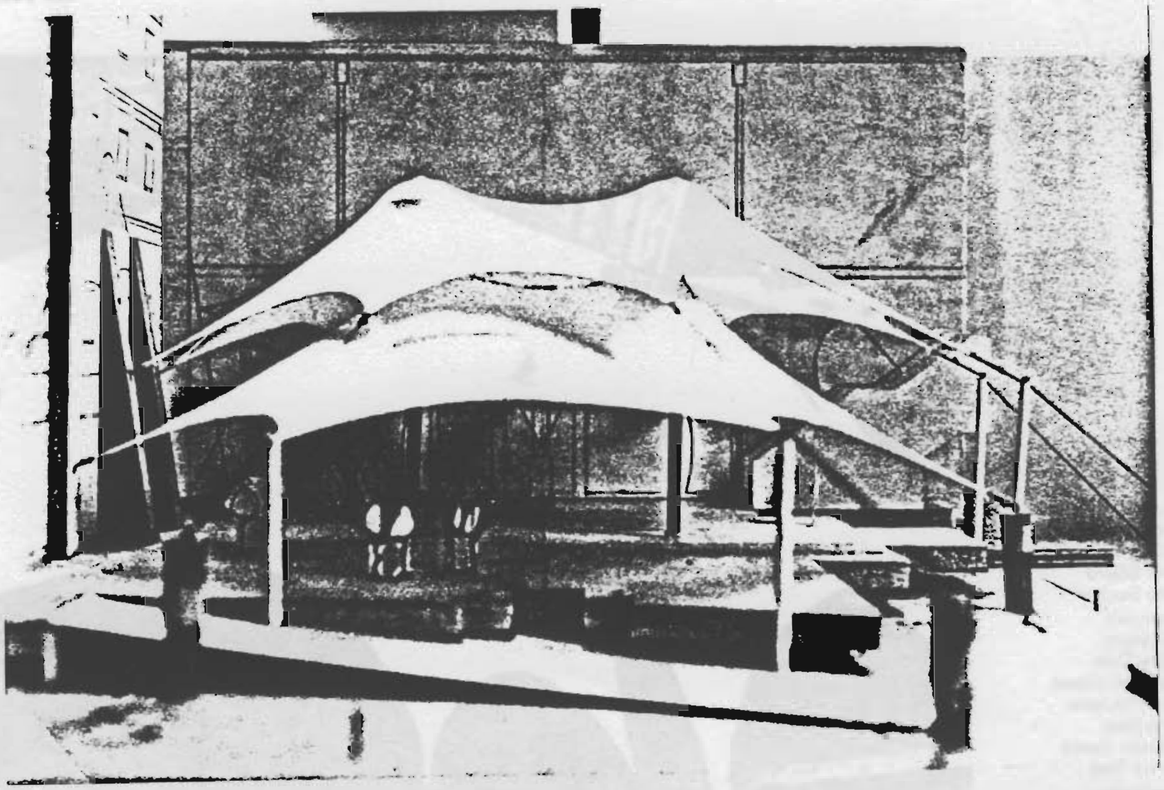

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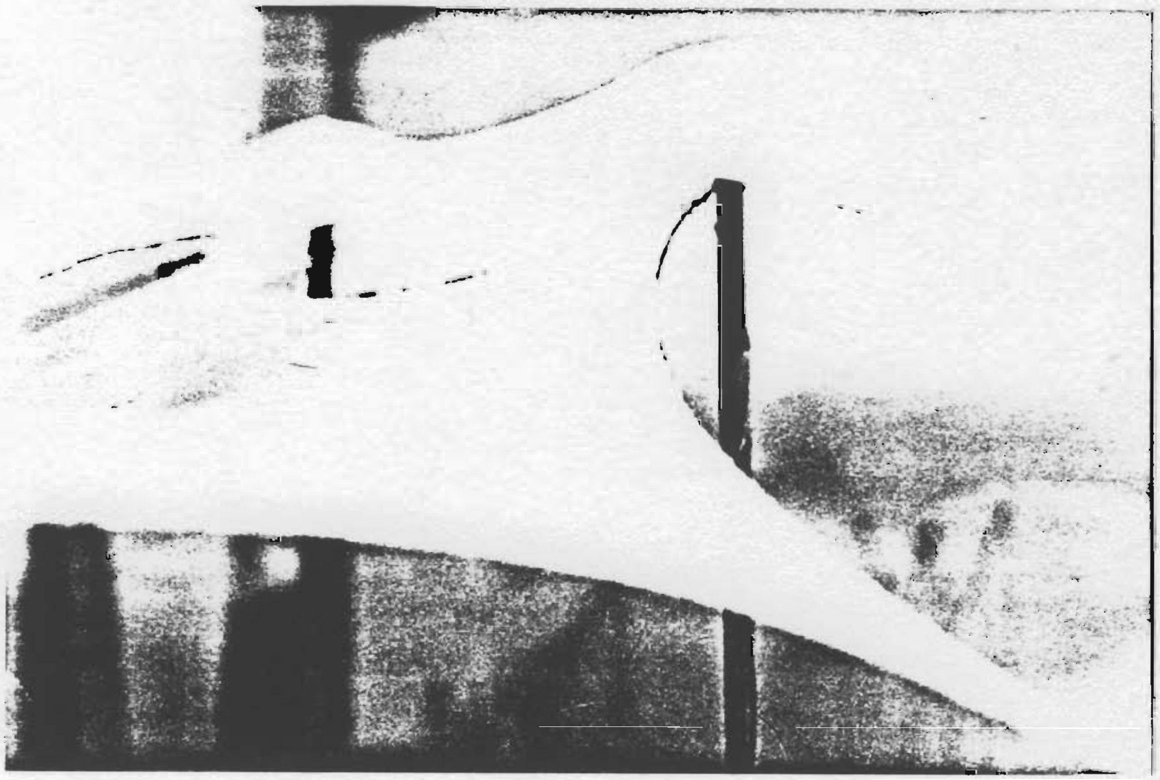

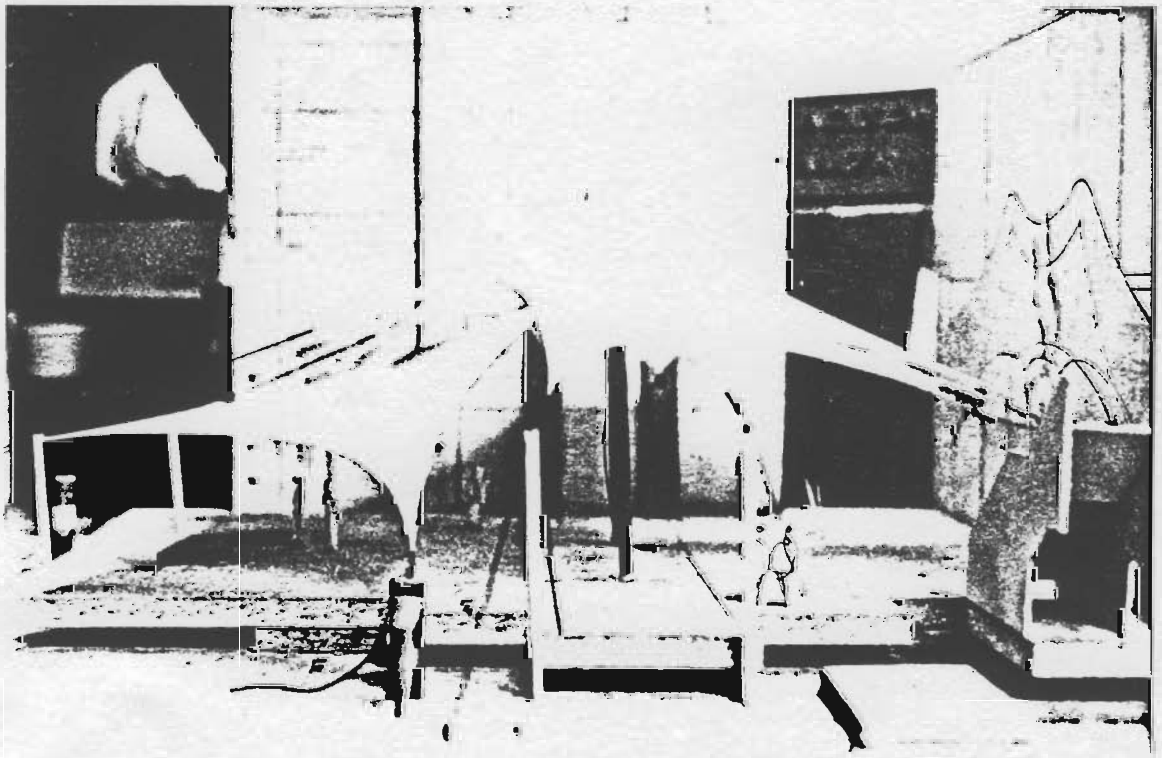

Directors:
Daryl Jackson
Bill Ryan
Ron Billard
Bob Sinclair
Associate
Directors:
Peter Cole
Manfred Libbert
Peter Quigley
Jaro Safer
Alastair Swayn
David Trott
Associates:
Ivars Dalins
Lyndon Haywood
Chris Johnston
Richard Marendaz
Barry Merritt
Helen Rice

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Robin Dyke
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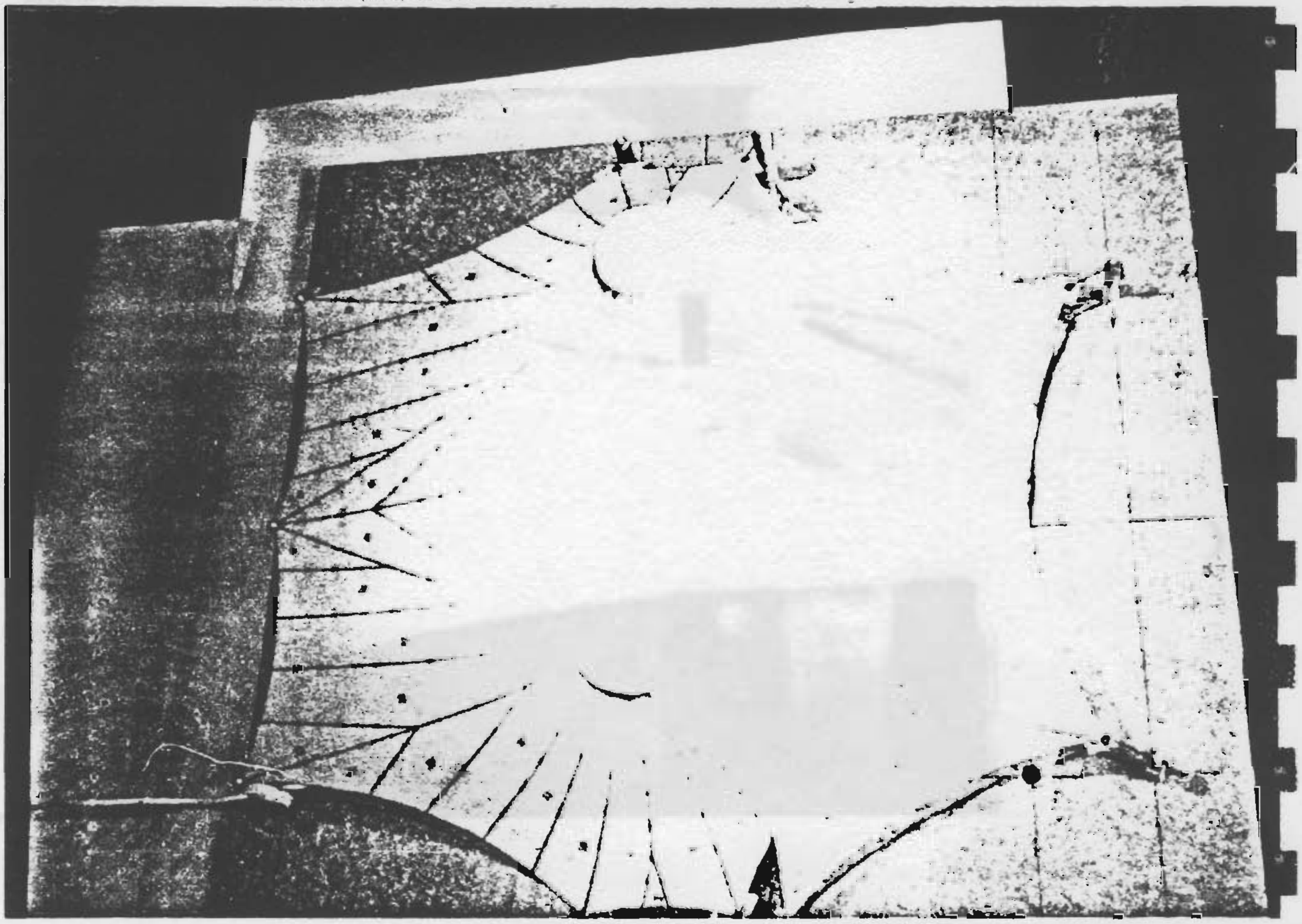

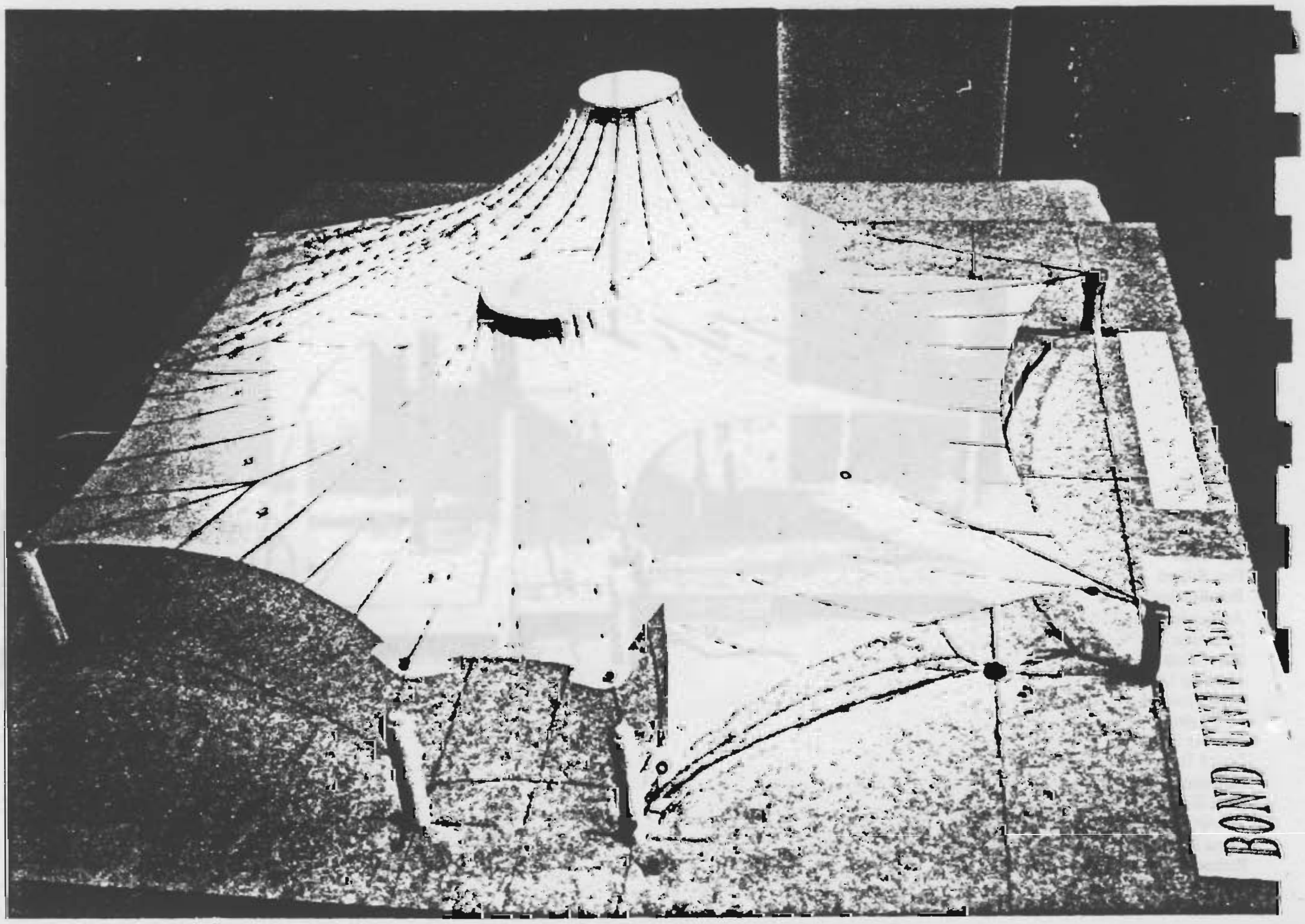

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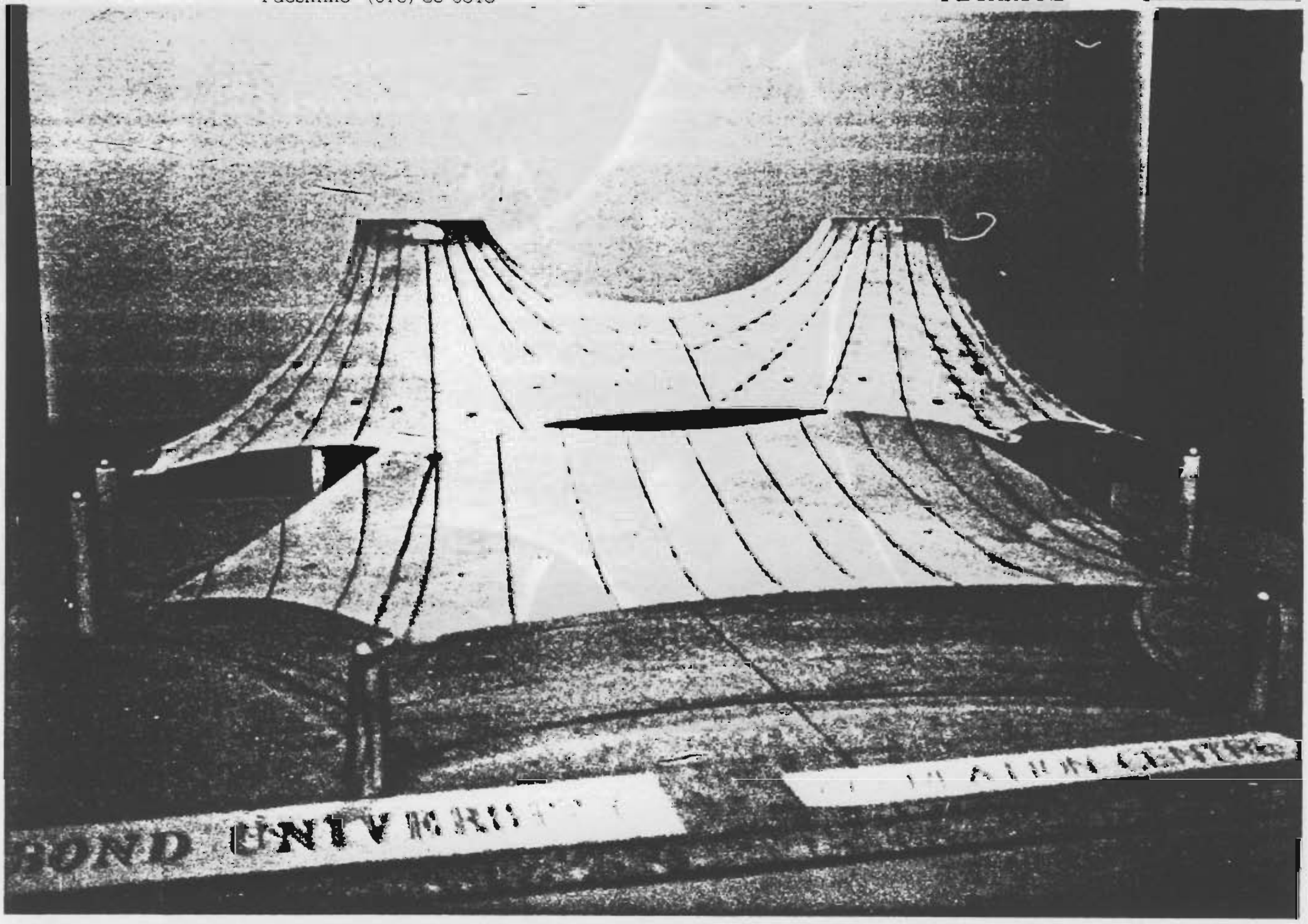

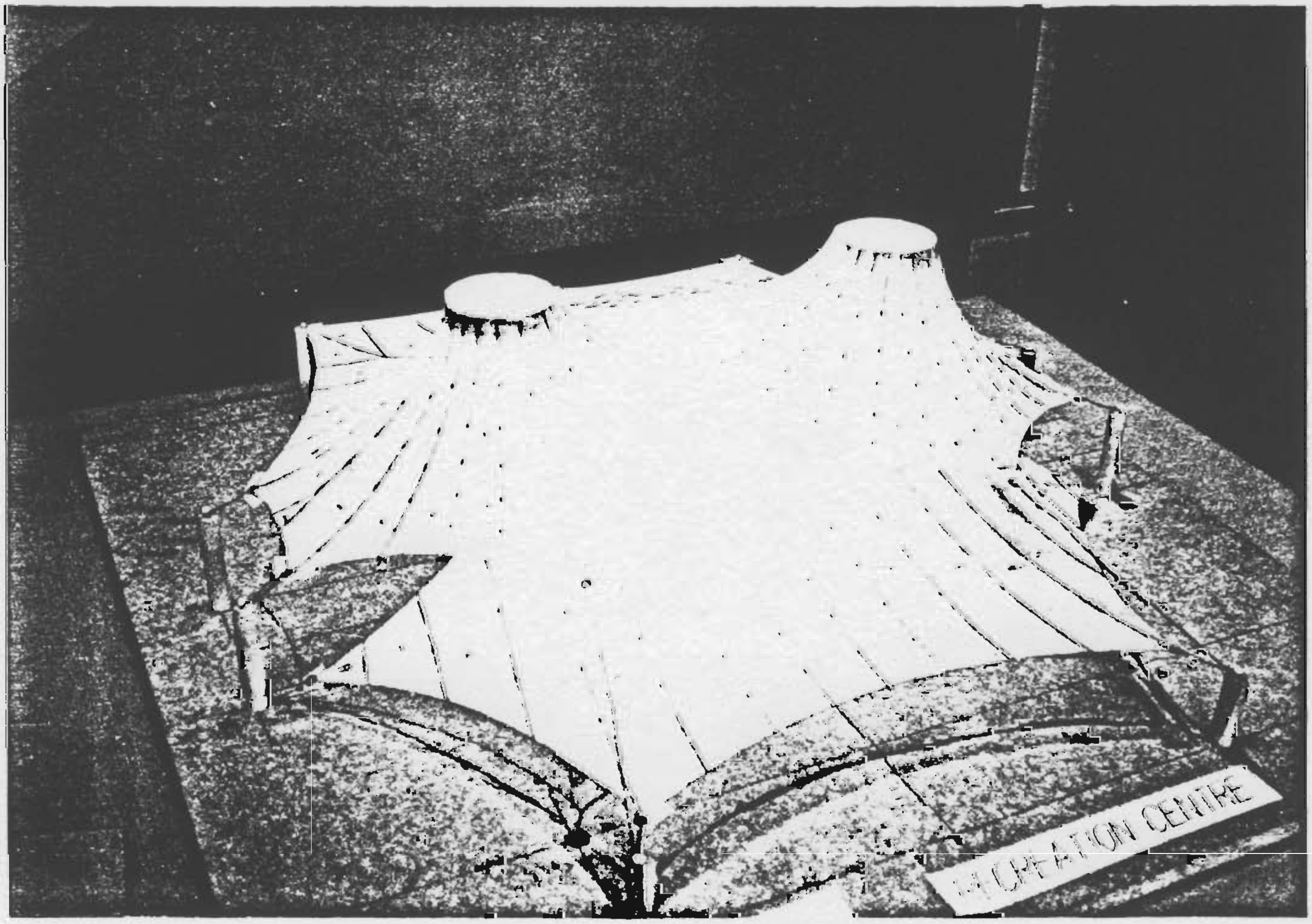

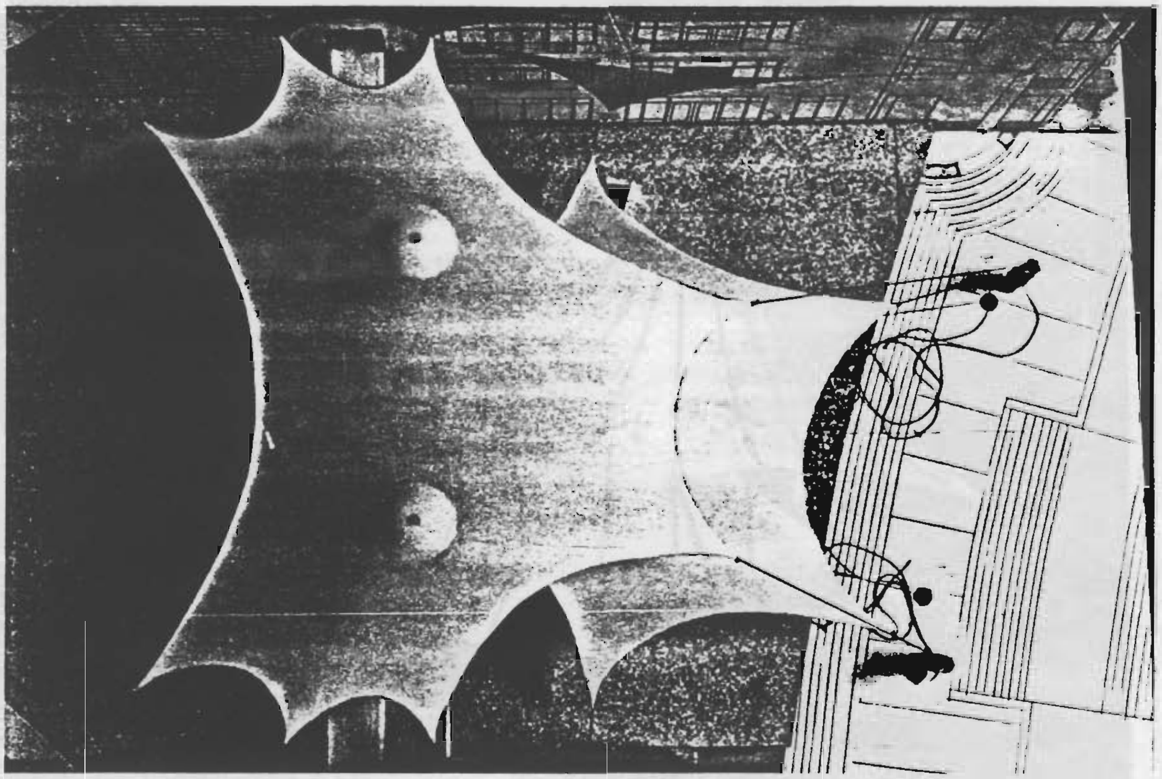

STUDENT CENTRE

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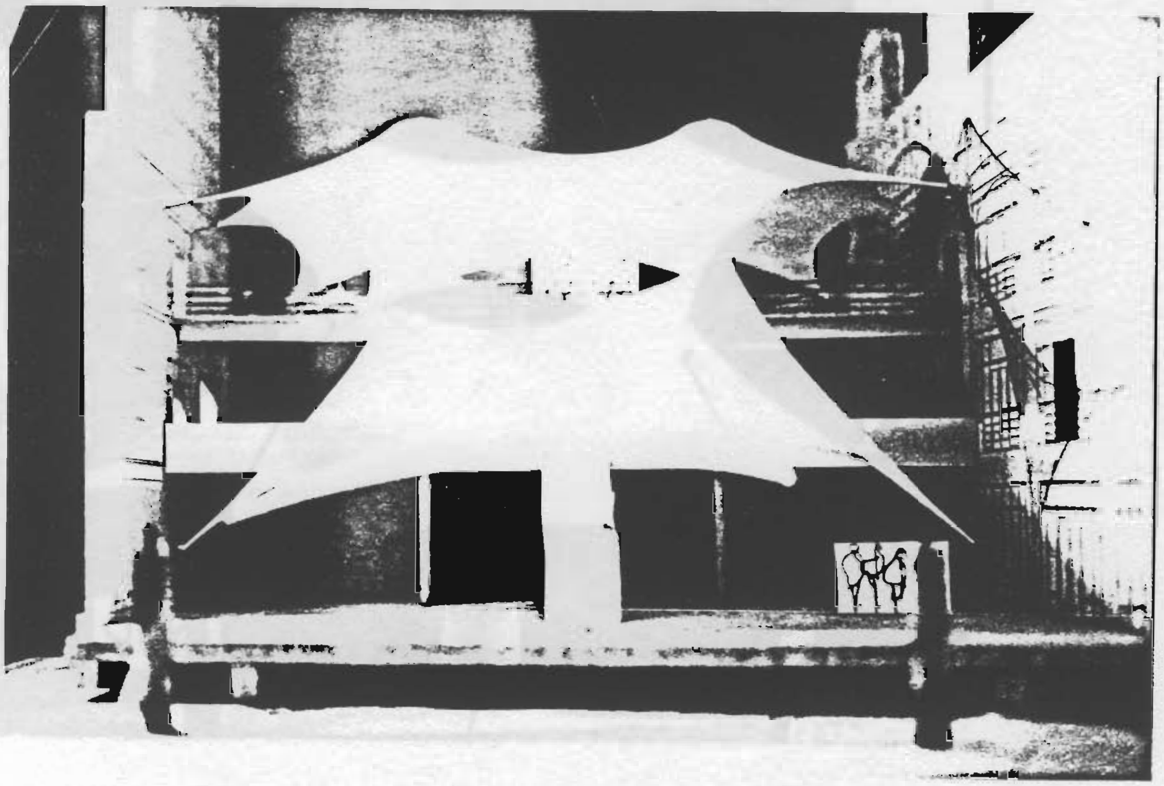

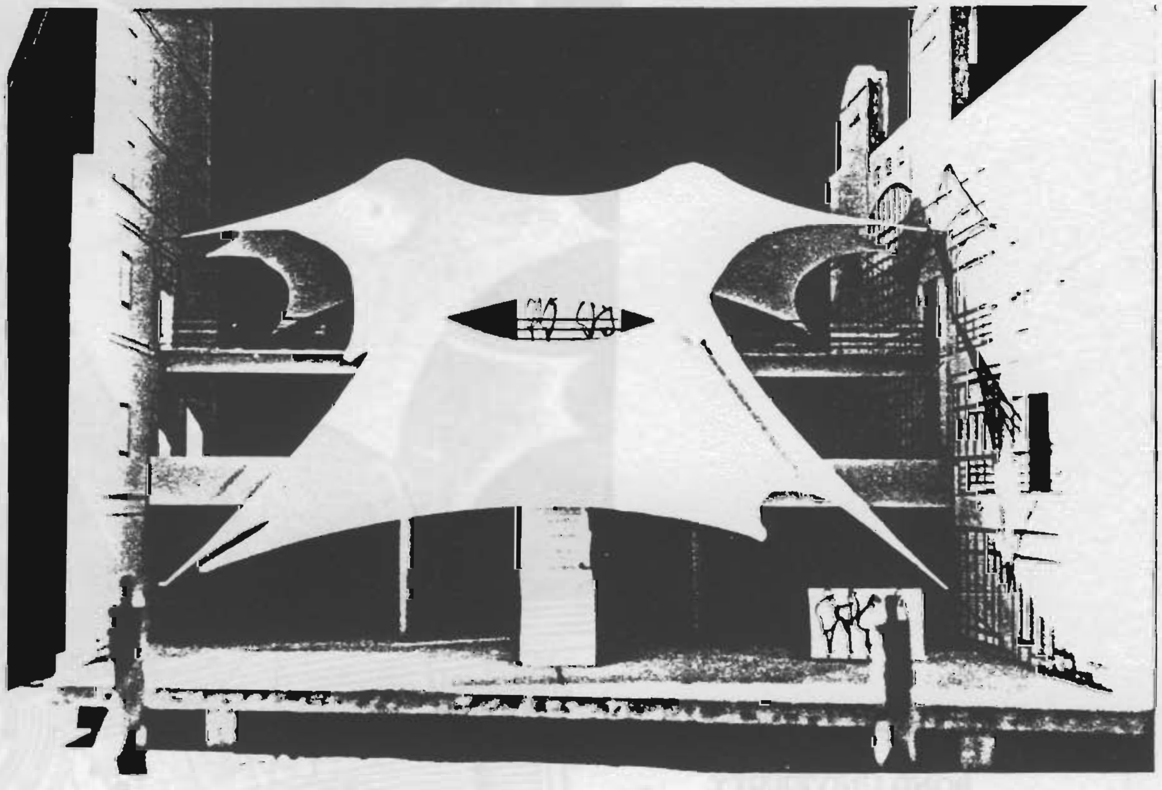

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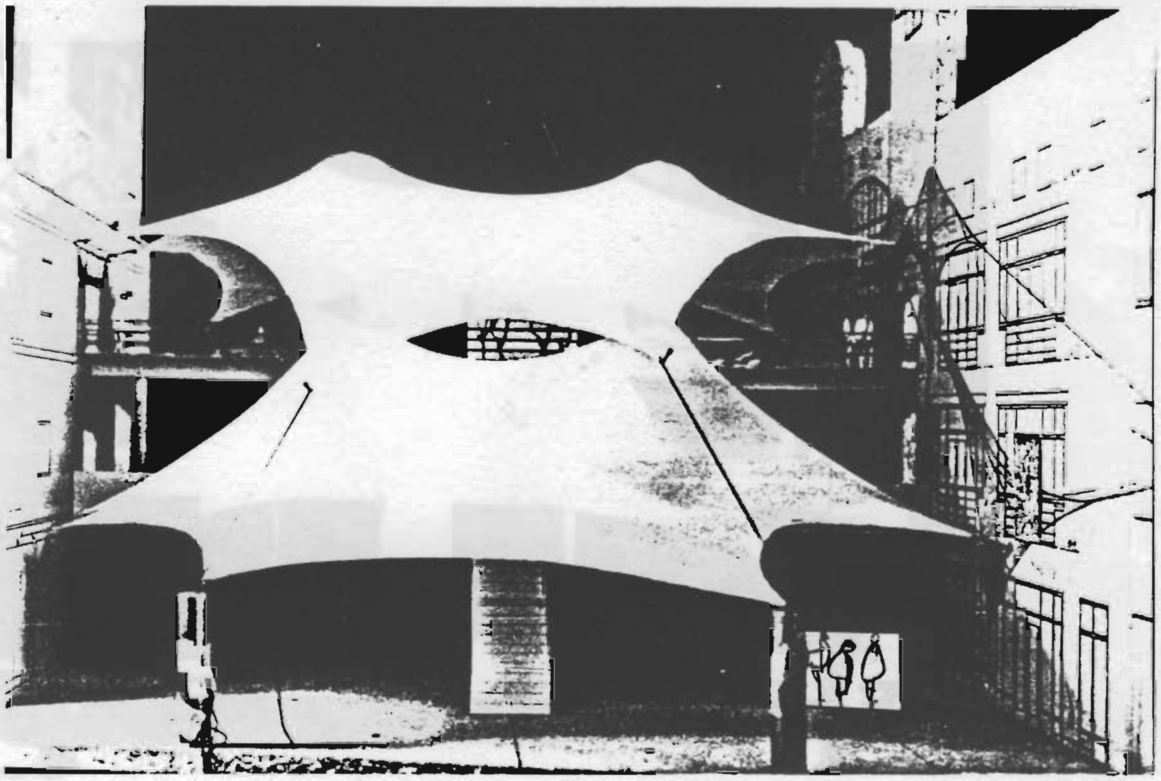

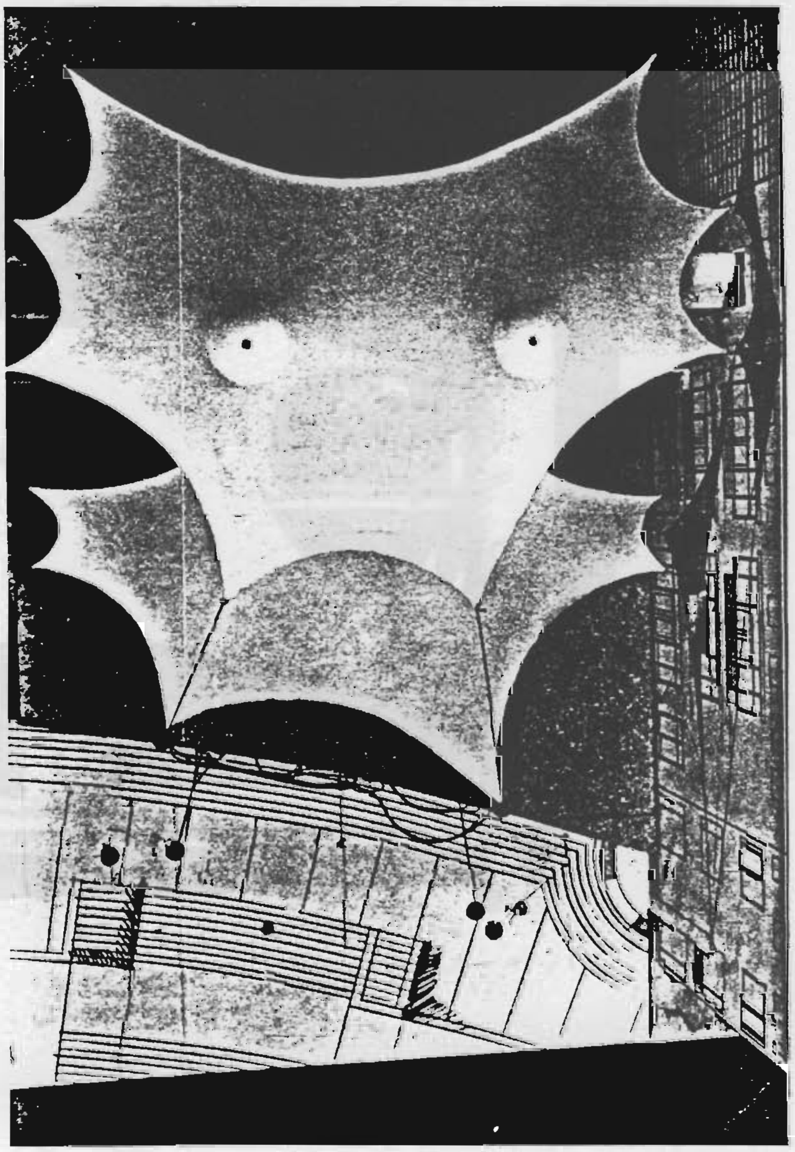

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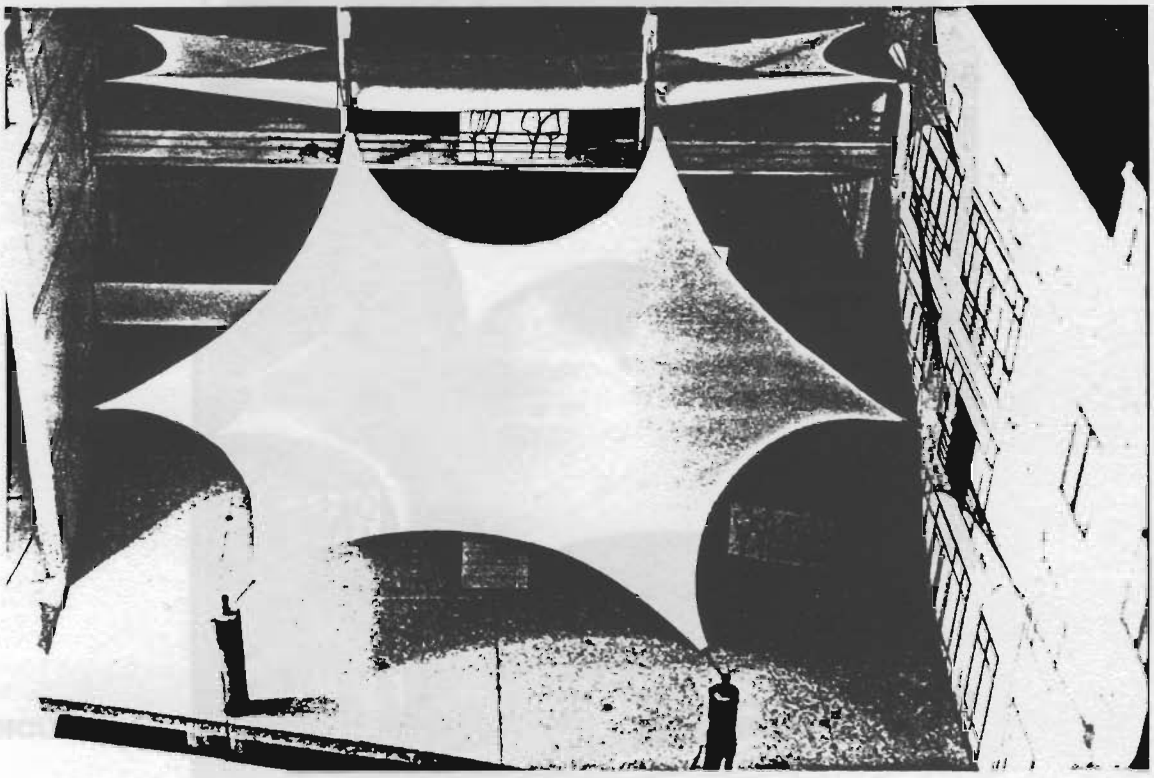

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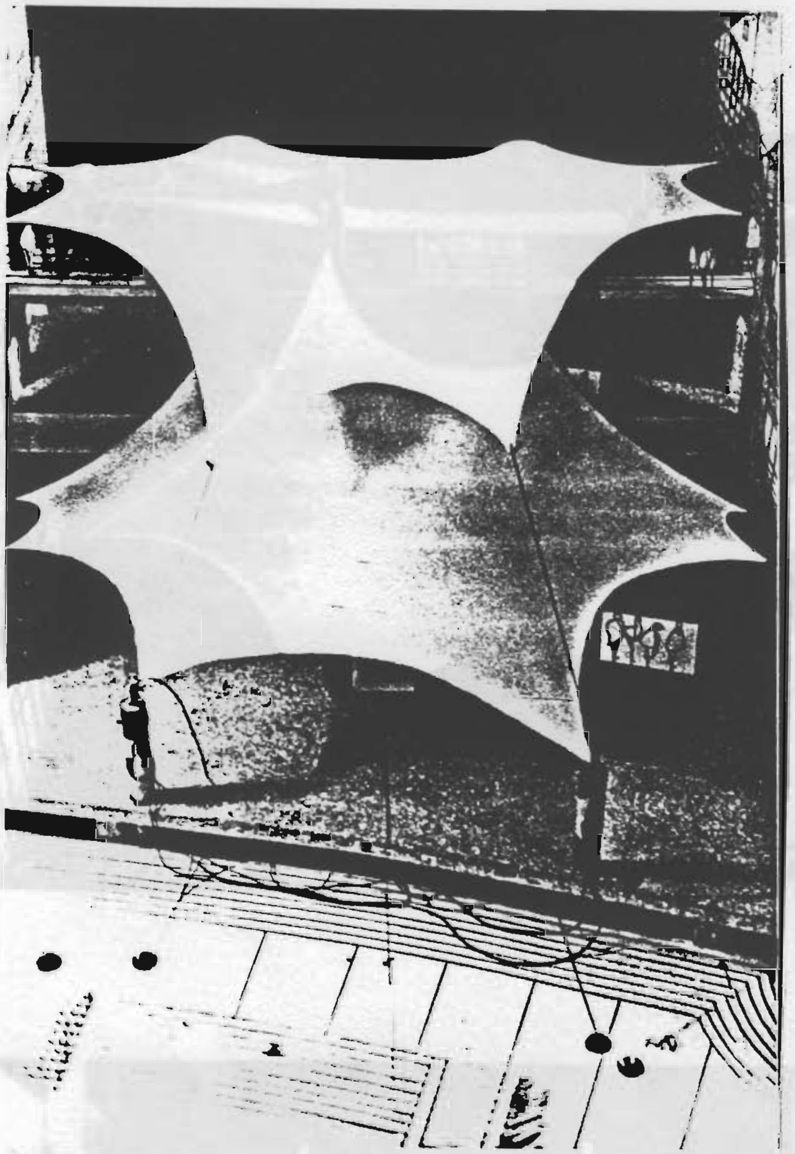

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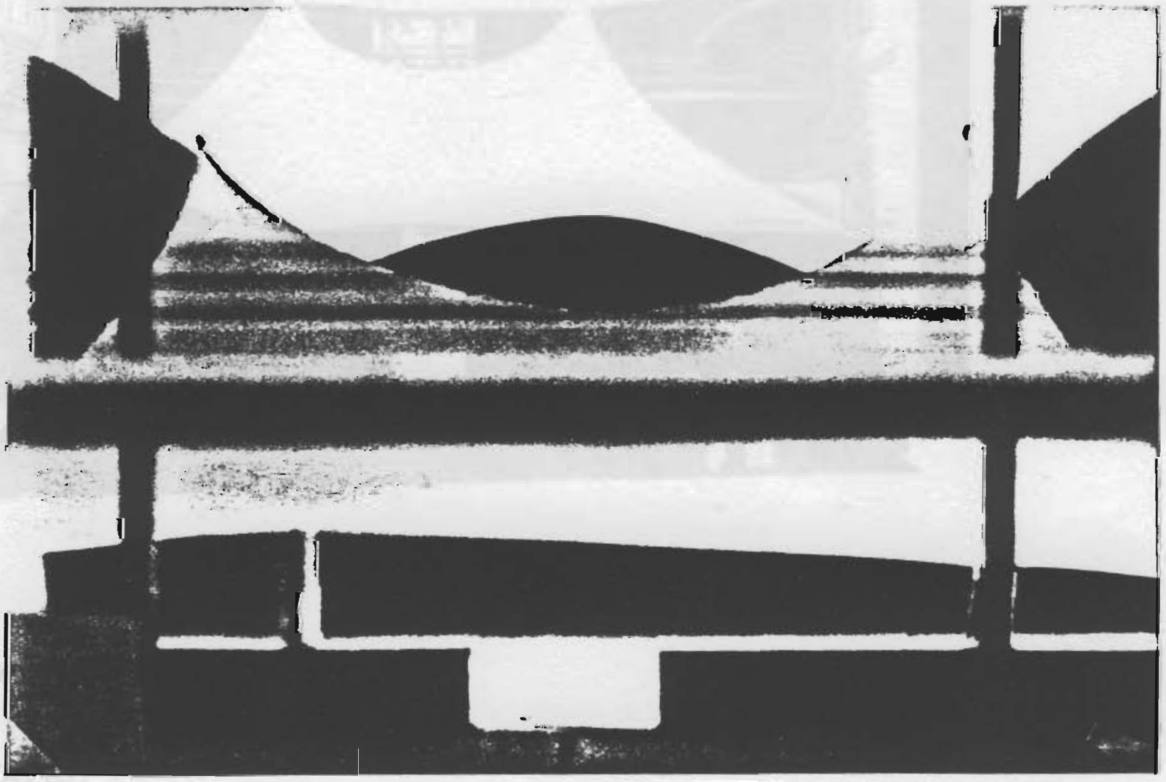

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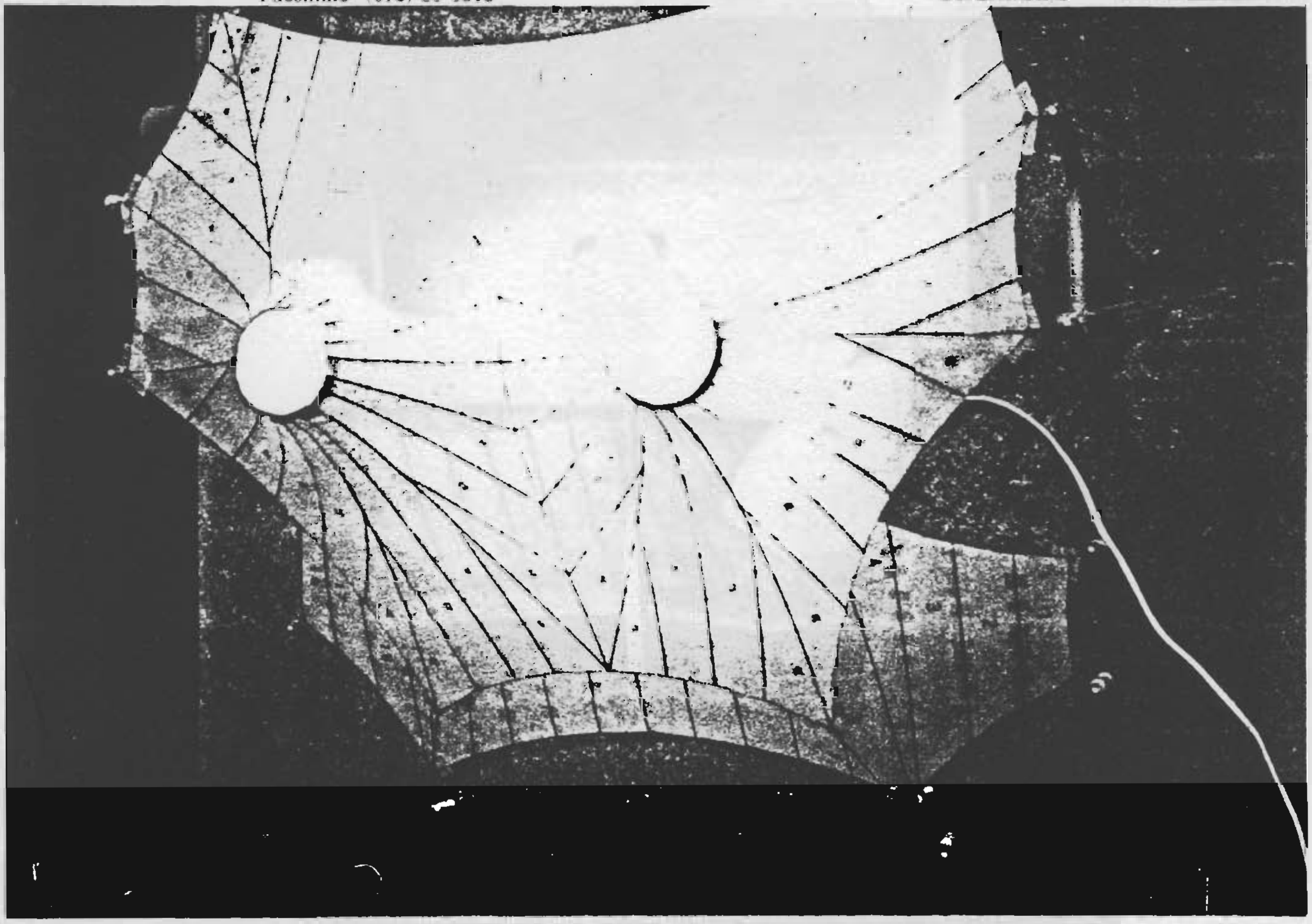

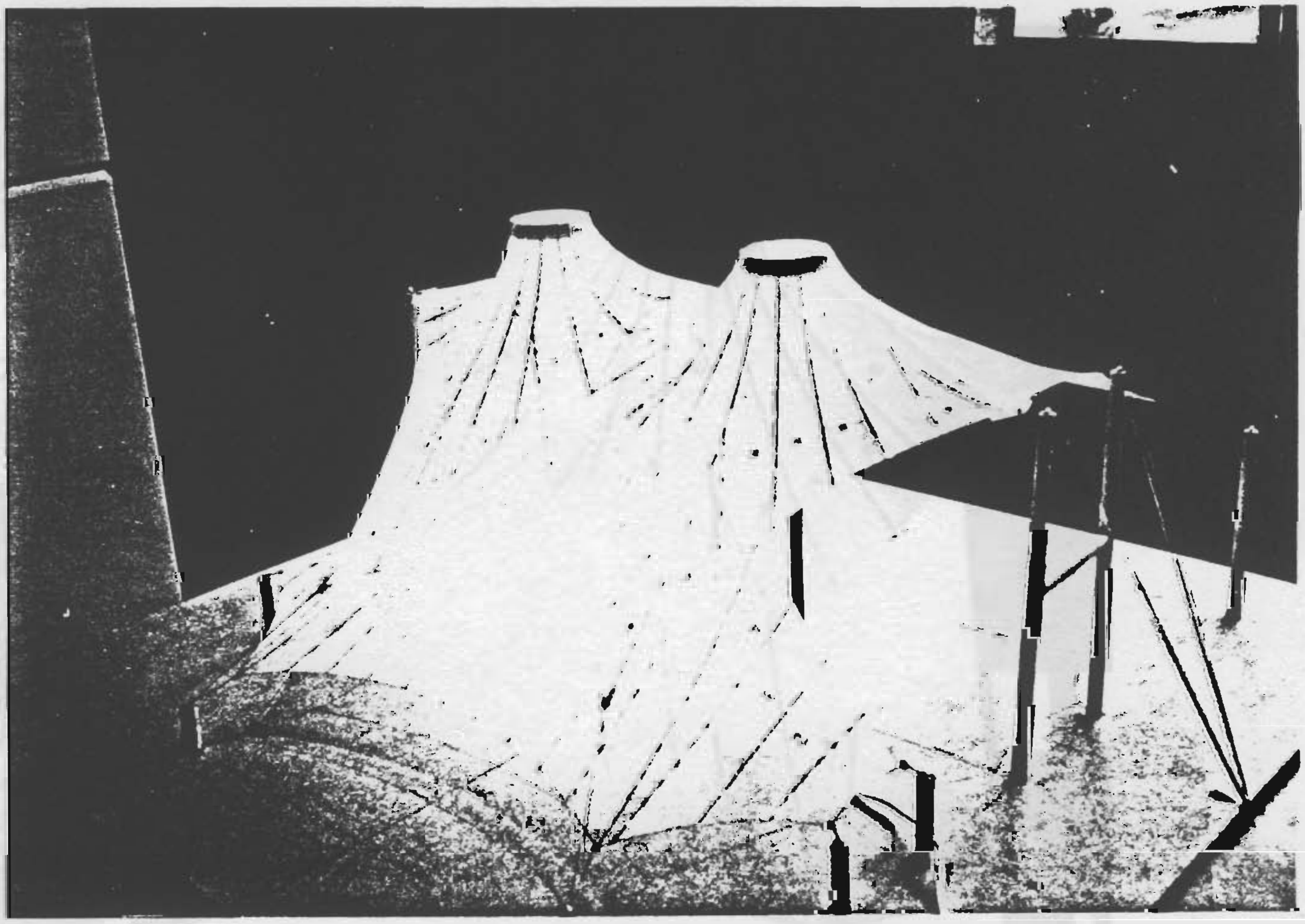

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