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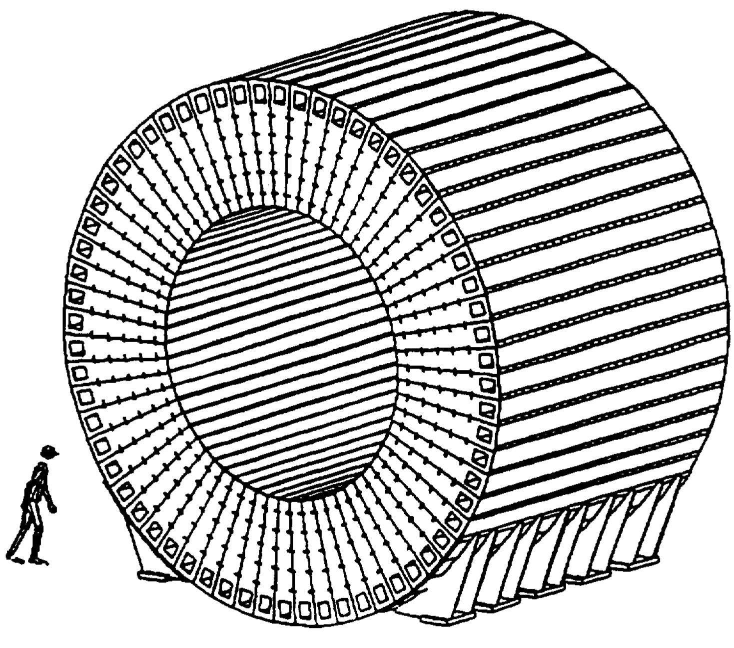
15 June 1994
Hadron Calorimeter of ATLAS
IHEP , Protvino , Russia

HADRON CALORIMETER OF ATLAS

CONCEPTUAL INTEGRATION PROJECT (PRELIMINARY)



INSTITUTE FOR HIGH ENERGY PHYSICS
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CONCEPTUAL INTEGRATION PROJECT (PRELIMINARY)

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Contents

1.0. Introduction

During a period after the April meeting on Hadron Calorimeter of ATLAS works on the following problems were carrying on at IHEP

- ♦ development for making of supermodules consisting from 6 individual modules;
- ♦ development for design of individual modules ;
- ♦ development for design of girder and carriage.

2.0. Mechanical Performance.

The design of the barrel for the Hadron Calorimeter with the cylindrical structure formed by 64 supermodules is shown in Fig.1.

2.1. Performance data.

Barrel.

Outer radius, mm	4230
Inner radius, mm	2250
Barrel length, mm	5900
Weight (total), t	1318
Number of supermodules in barrel	64
Length of the active section of barrel on Z-axis, mm	5860
Radial size of the active section of barrel,mm	1540
Distance between barrel supports on X-axis,mm	5500
Distance between support plane and barrel axis, mm	4000

Supermodule

Length of supermodule,mm	5900
Number of modules in supermodule	6
Azimuth size of supermodule,deg	5.625
Weight of supermodule,t	20
Number of half-periods in supermodule	651
Number of photomultipliers in supermodule	156

Module.

Length of the end modules,mm	965 (974)
Weight of the end modules,t	2.9 (2.87)
Number of half-period in the end modules	105 (106)
Number of the end modules in barrel	128
Length of the middle modules,mm	990
Weight of the middle modules,t	2.9
Number of half-periods in the middle modules	110
Number of the middle modules in barrel	256

Half-periods of modules.

Initial data for half-period geometry

Material for steel plates	steel 08 (identical to steel type E24)
Thickness of the long plates,mm	5
Thickness of the short plates,mm	4
Sizes for steel sheets under delivery,mm	
with thickness 5 mm	1200×1600
with thickness 4 mm	1000×2000
The required amount of steel under delivery,t	
with thickness 5 mm	1250
with thickness 4 mm	500

Girders of supermodules.

Total sizes LxBxH,mm	5860×410×380
Weight of girder,t	2.761
Number of girders of barrel	64

3.0. Supermodule. Design Philosophy.

The supermodule can be built by at least two ways.

The first way allows for the welding of the stacked half-periods to the girder. The given techniques is realized under the using of the expensive facility of the large sizes providing the all-round squeeze of the stacked plates and its precise positioning during the welding.

Following the second way the supermodule (see Fig. 16) can be assembled from the single short modules (see Fig.16,8-11) which then should be fastened on the girder.

The first way has the following disadvantages:

1. The assembly facility is too costly for the assembly operations.

2. The using of the expensive facility doesn't except the possibility of following deforming of supermodules from the residual stresses in the region of the welding joints.

3. The stacking of the half-periods formed from the steel sheets with the thickness tolerances inevitably leads to the summing up of tolerances

4. The tolerances on the plate thickness don't allow to provide the reproducibility of the length for each supermodule. In accordance with estimation given by the specialists of ALSTOM (see DBRE/NOTO 4) the tolerance on the length 5900 mm is equal to ±4.5mm.

5. To take into account the possible deformations the transportation of the supermodule of 5900 mm length and about 20 t weight is very problematic and unsafe.

From our point of view the second way of the supermodules assembly has the following advantages, namely:

1. It isn't required expensive facility of the large sizes for assembly operations.

2. The problems concerning the lifting and transport operations get essentially simplified.

3. In the short module the possible deformations provided by the welding joints are far less and can be easily compensated during the assembly of modules into supermodule.

4. The precise positioning of each half-period on Z-axis is provided in the limits of the supermodule and the whole barrel.

5. It's assured the reproducibility of the linear dimensions for each module and supermodule.

6. There is no problem of the joining and assembling for the end plates of barrel between each other (plates of 20 mm thickness), so one can organize the preliminary test assembly of the end "lids" of barrel.

In the proposed version of the supermodule there is the possibility of the insert the additional steel plate welded inside the slot organized on the inner radius (see Fig.3). The insertion of this plate allows to raise the linearity of supermodule and its stiffness.

Utilization possibility of thin steel strips welded by spot-weld was considered to improve mechanical protection of fibers and to ensure its firm fixation in tile recesses.

4.0. Module. Design philosophy.

Supermodule consists of 6 modules, each of them is formed from plates of half-periods welded to 20 mm thickness steel plate and fastened together with thread studs and strips Fig.

Assembly of 1m length individual module is carried out on jig. Assembled stuck of halfperiods is compressed with pressing device of the jig to stops which make the given dimension of a module in Z-direction. Outer plates of a module are pressed against movable and stationary plates of the jig for presence of elasticity forces in a module, i.e. geometry of a module in the jig conforms exactly to the given geometry. Studs are inserted into the holes in the compressed module and are drawn up with nuts (Fig.9-13).

Support plate of 20mm thickness is welded to the top part of the module. If assembly of module is completed at this stage and compressing forces are removed free edges of the plates which are clamped up on center with studs fold and module length changes by 2Δ (Fig. 12).

To exclude this effect and to reduce load to studs it is suggested to add strips into spacers overlap zones from two sides of the module.

During assembly when module is in compressed state strips are pressed into engagement with recesses, tightened and welded (Fig.9-11). Then ends are cut. Recesses are made in the parts (Fig.15-16).

Using the method of module forming we can produce necessary geometry of the module.

Proposed construction of modules allows to insure replication of linear dimensions from module to module, transportation problems become simpler.

Elements making base of modules construction are shown on Fig. 8-15

5.0. Girder and carriage.

It is suggested to examine new design of support girder and version of PMs placement on removable carriage.

Supermodule is assembled from individual modules which are fastened to two T-beams. In the zone of last spacers and tiles fibers are placed within girder, assembled as bunch and fastened to the plate (Fig. 19). Then ends are cut and polished.

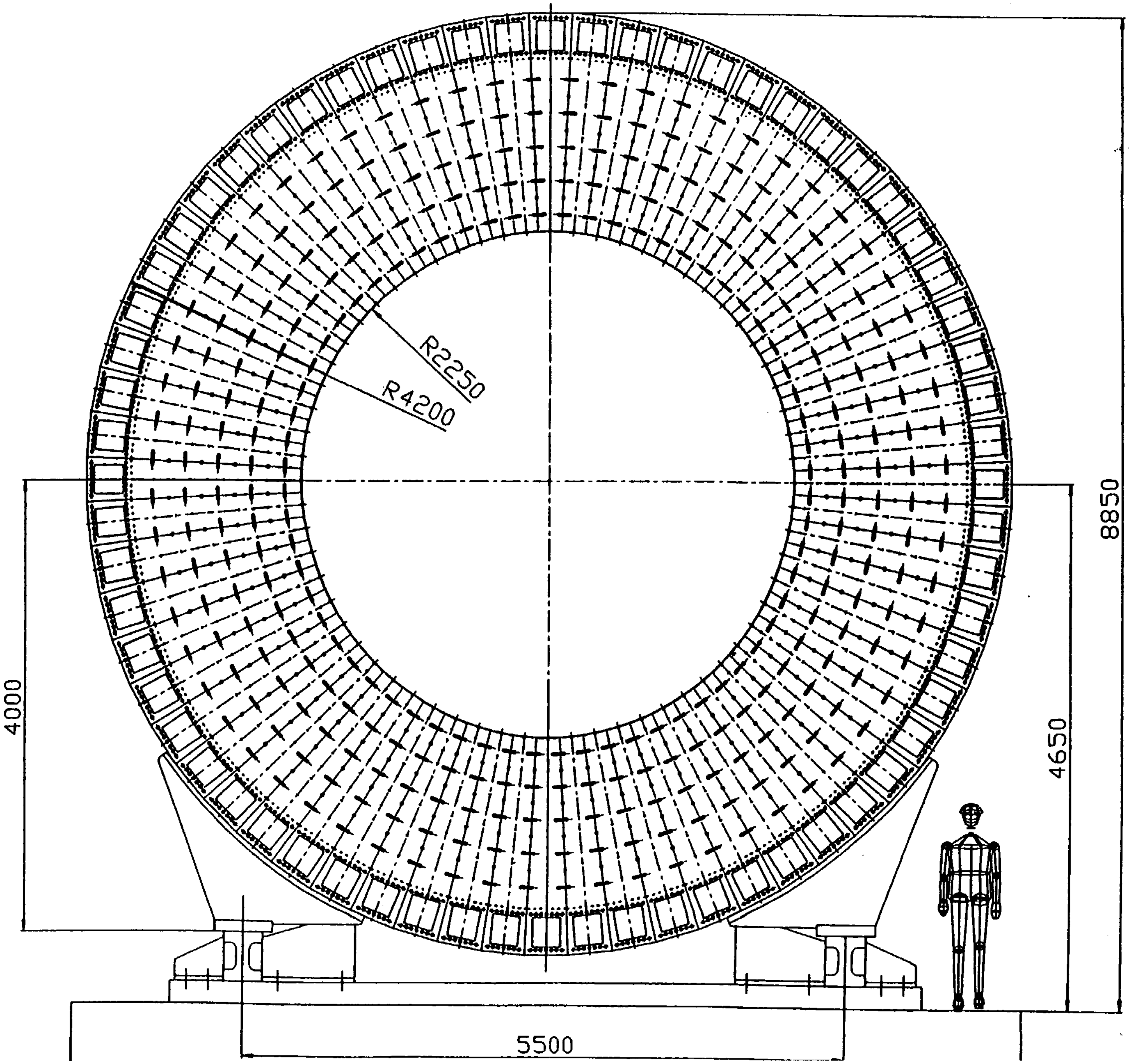
Guides are mounted on the plate on which carriage with PMs moves.

This design allows to produce contact of PM mixers with fibers accurate to ±0.05mm.

Suggested structure of the girder allows to make φ force closure between supermodules along lower and upper plates of girder (Fig.23-25).

Structure of the carriage with self-aligning PMs is shown in Fig. 26 .

During transportation PMs are pressed out with stop. After insertion of the carriage into the module the stop is removed and PMs are pressed to fiber bunches with spring. Gapless optical contact is produced.



R2250
R4200
8850
4000
4650
5500

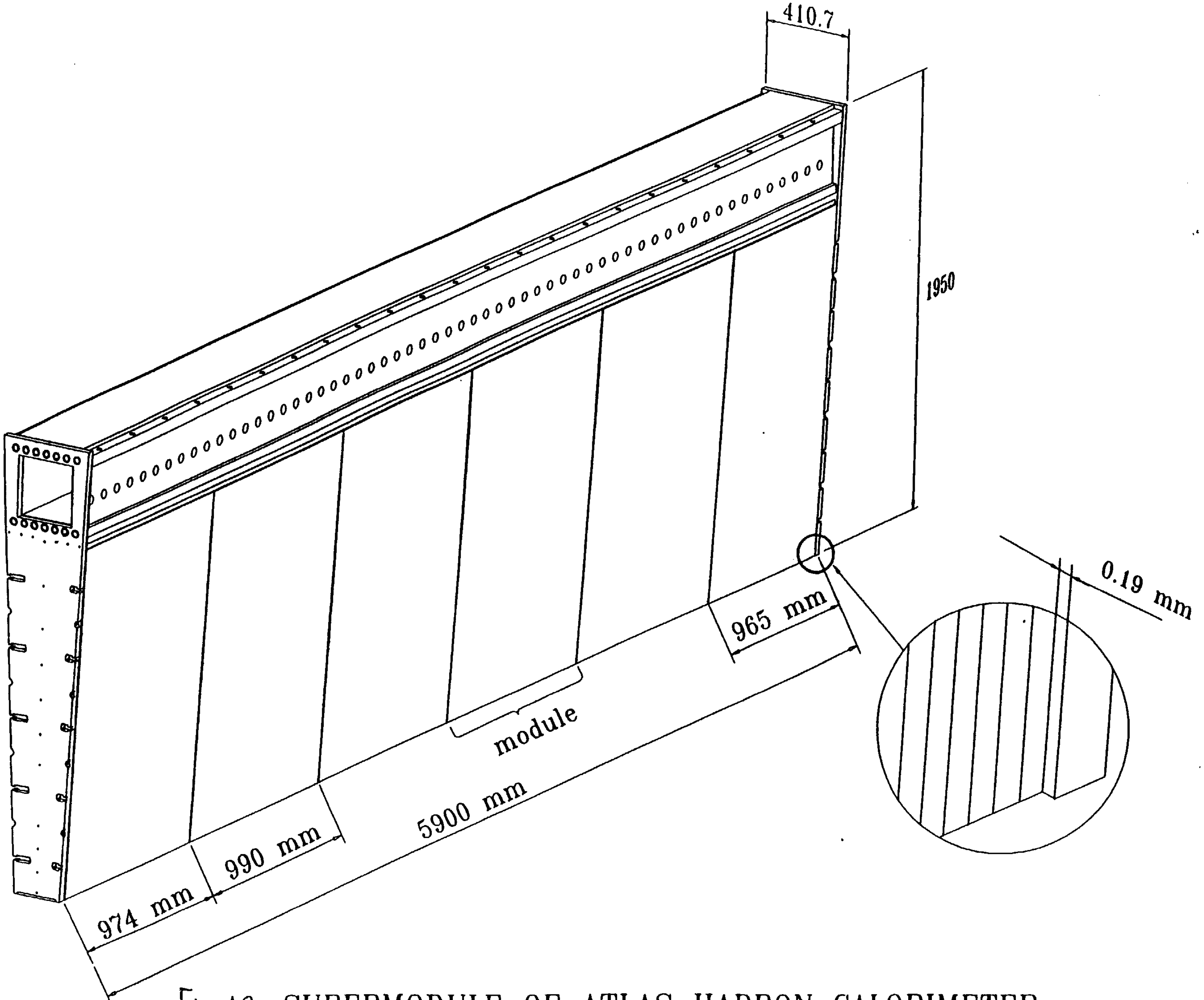


Fig.1B SUPERMODULE OF ATLAS HADRON CALORIMETER

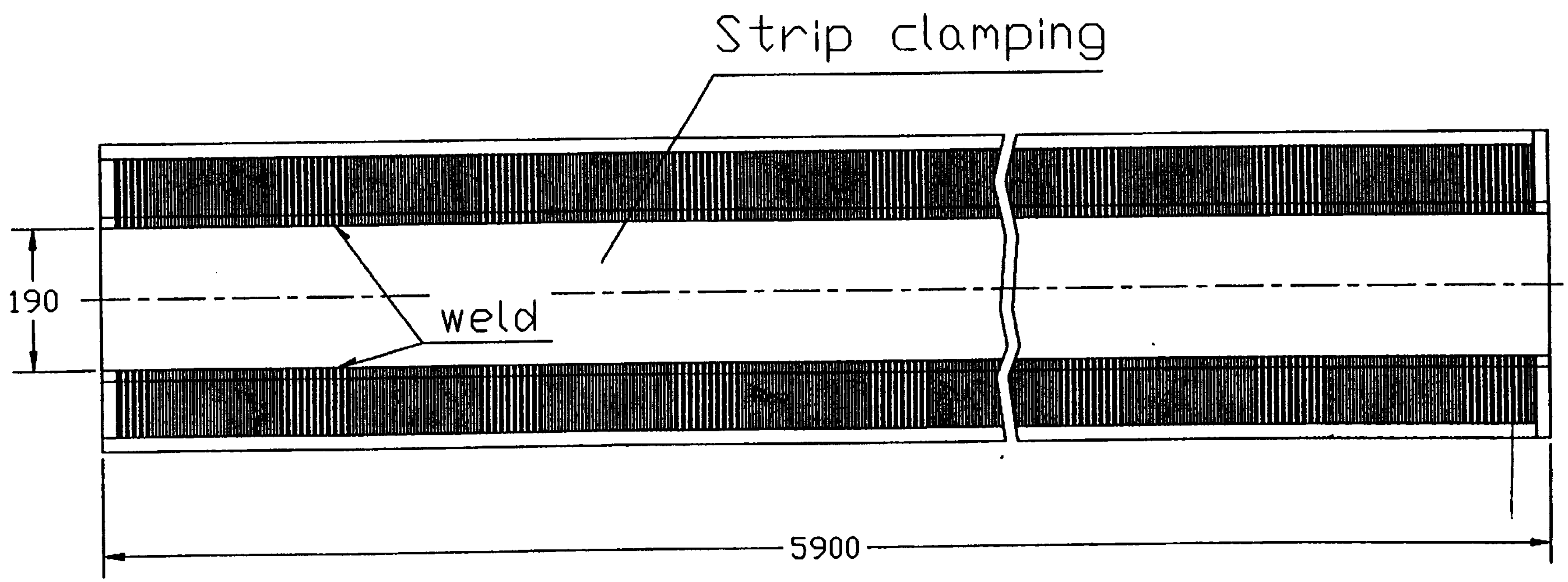


Fig.3 View from below of supermodule.

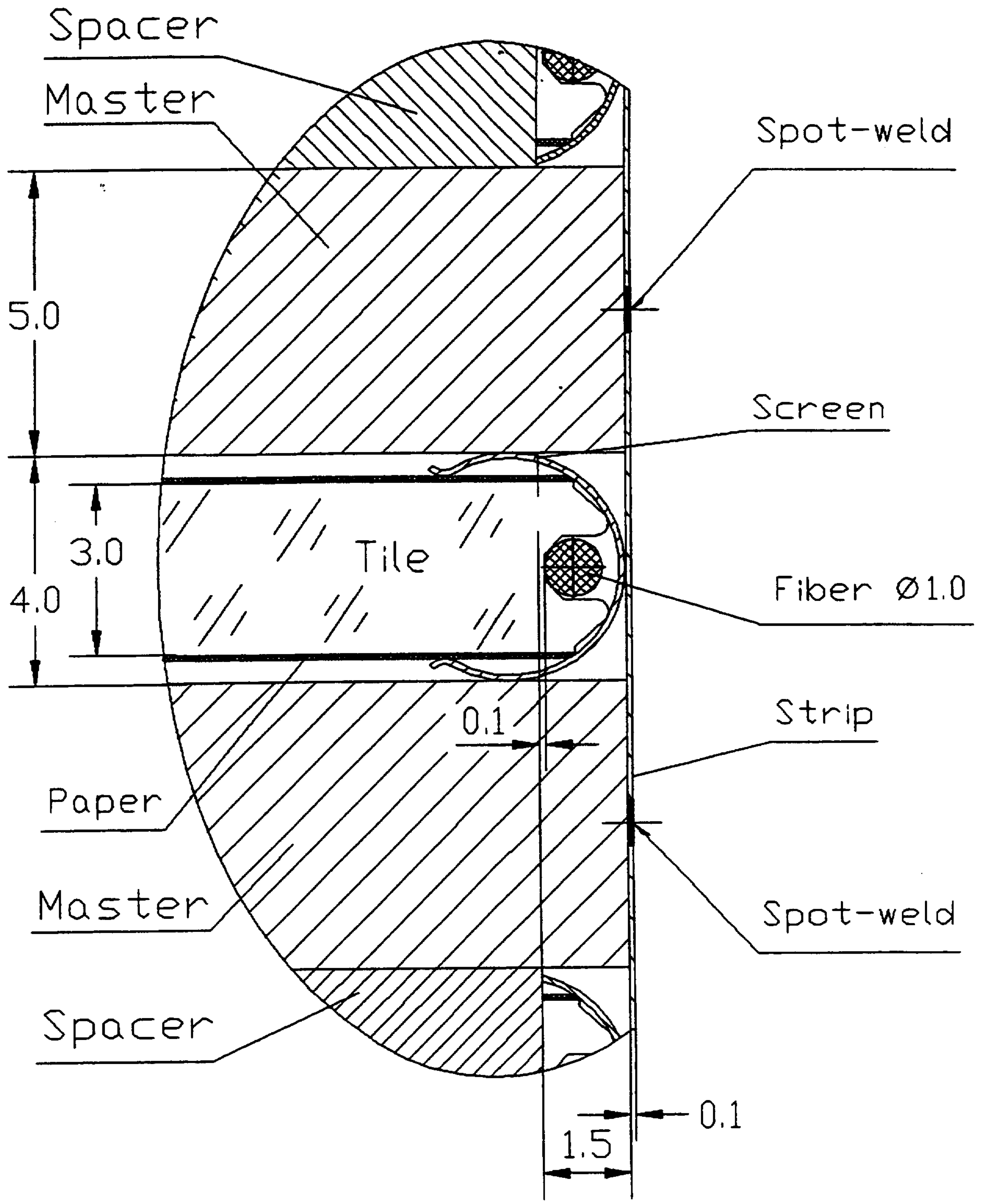


Fig. 4 Arragement of fibers in the first tiles row of supermodule.

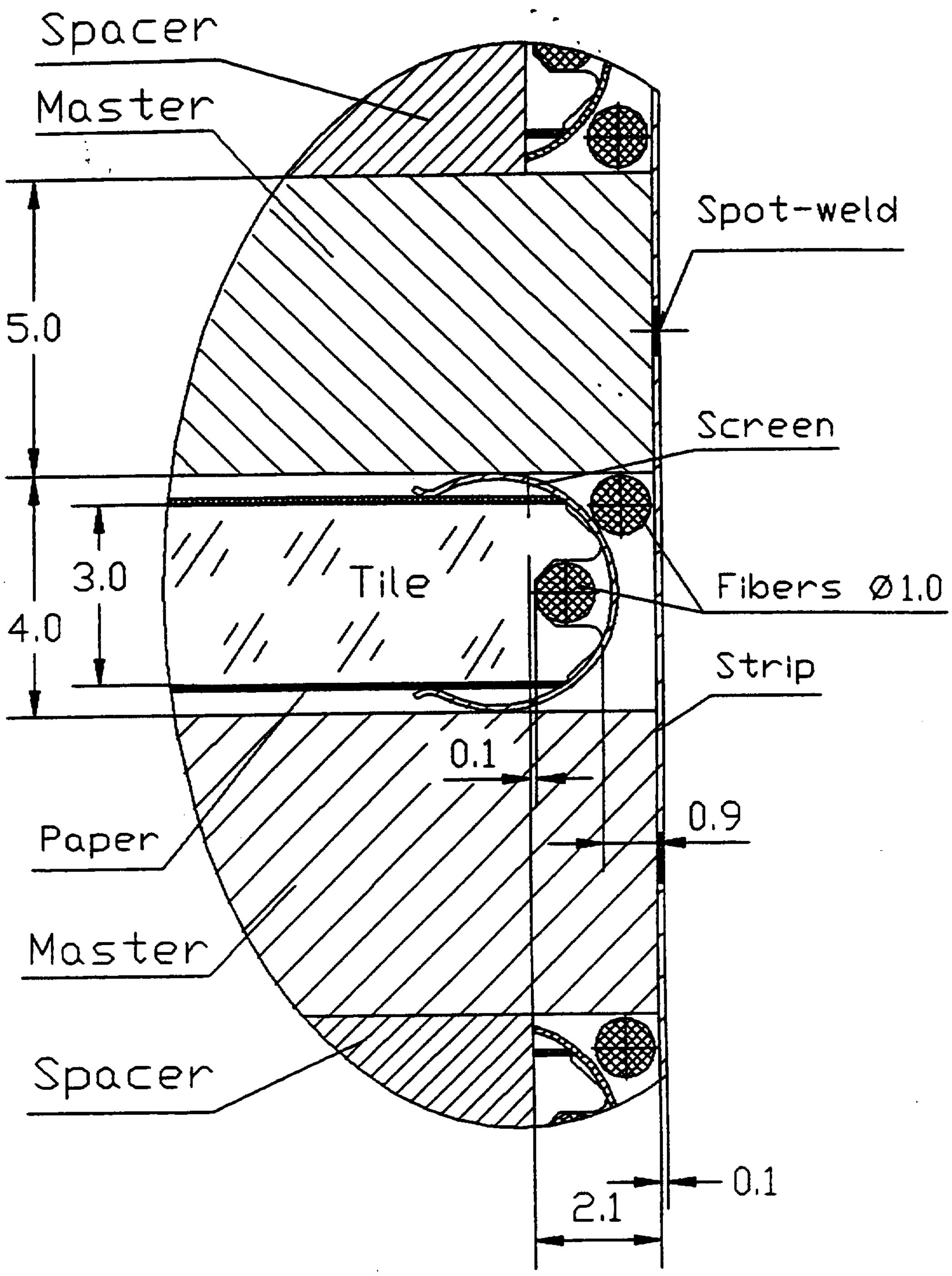


Fig. 5 Arramgement of fibers in the second tiles row of supermodule.

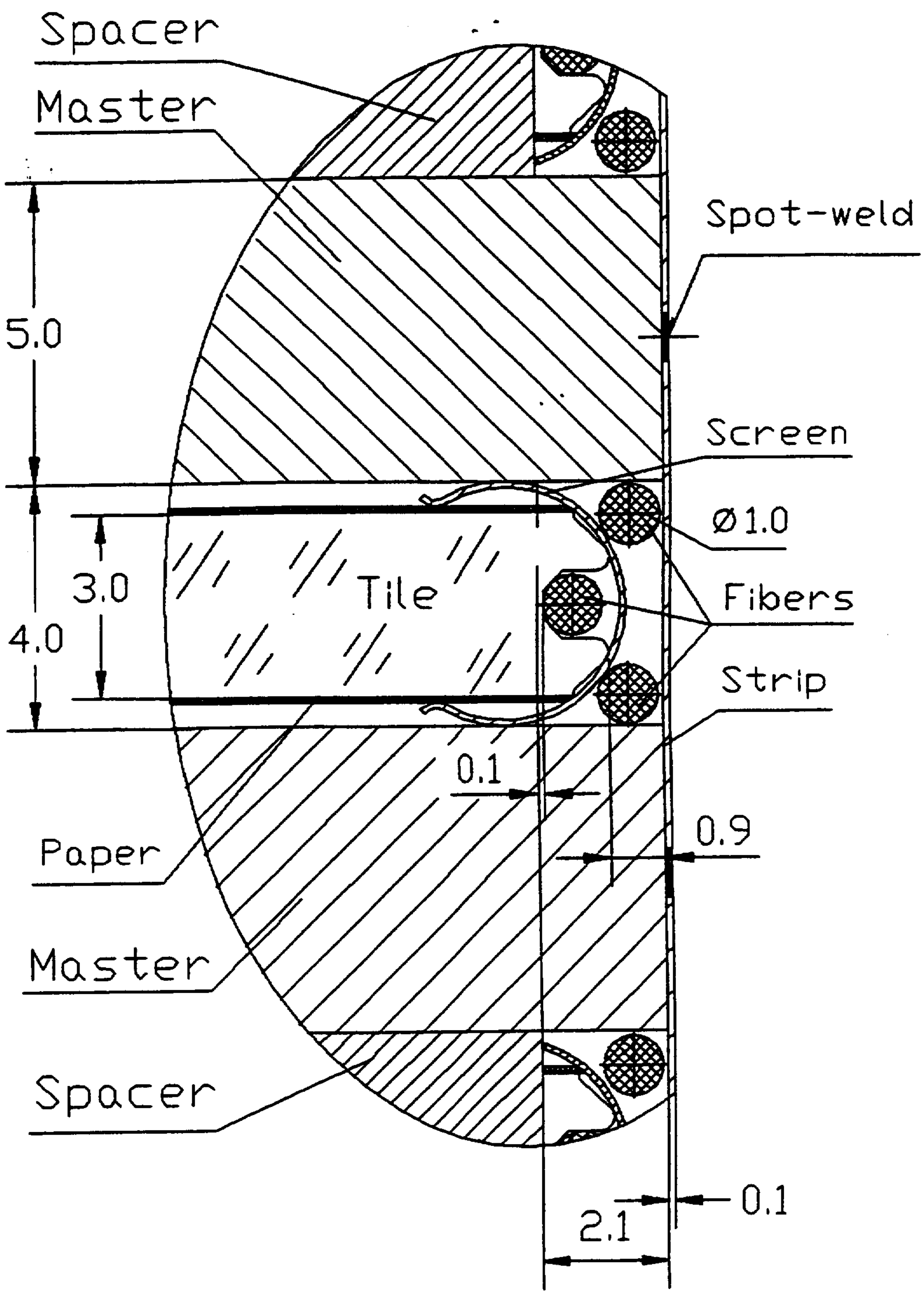


Fig. 6 Arramgement of fibers in the third tiles row of supermodule.

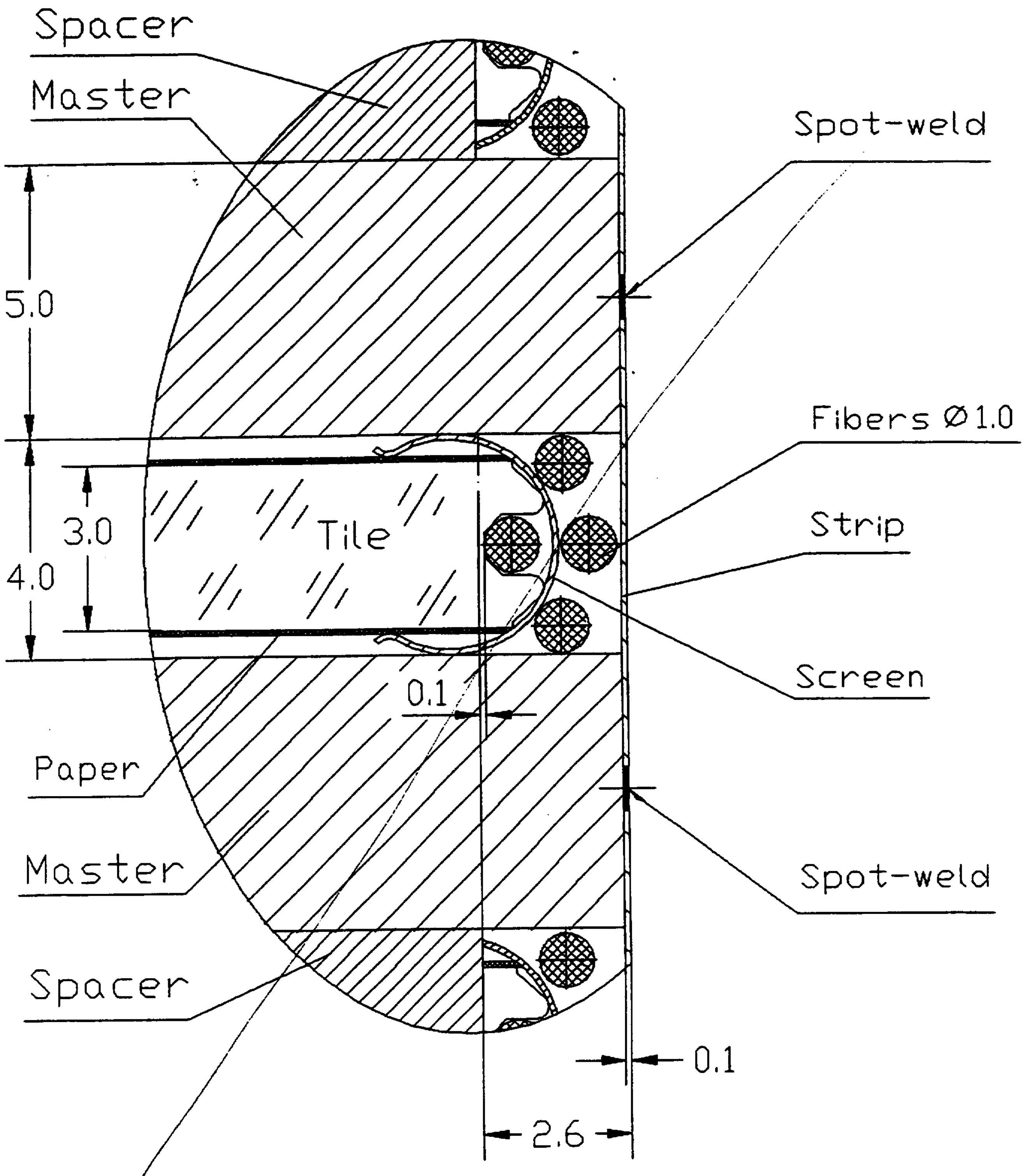
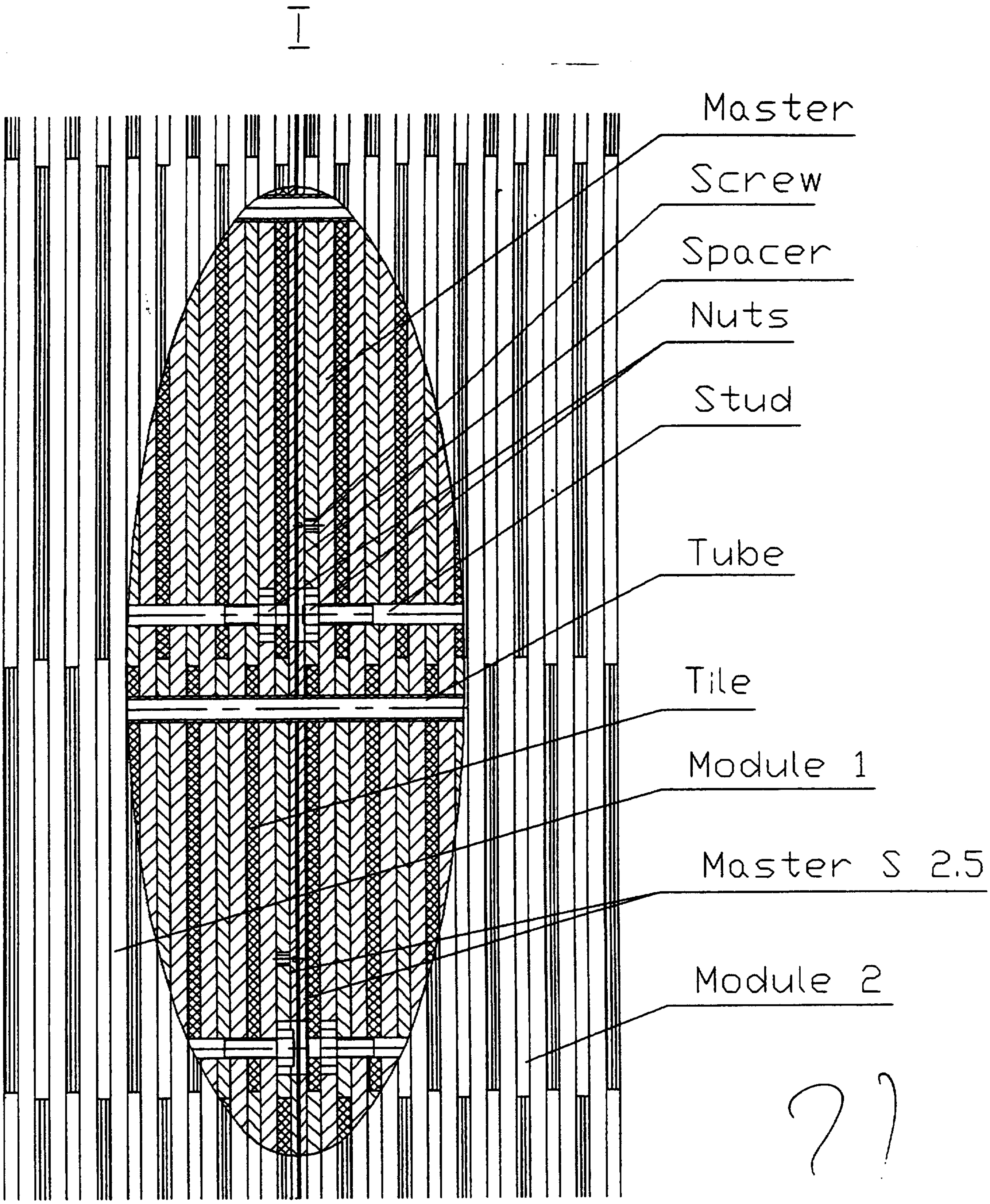


Fig. 7 Arramgement of fibers in the fourth tiles row of supermodule.



77

Fig. 8 Fastenning two modules.

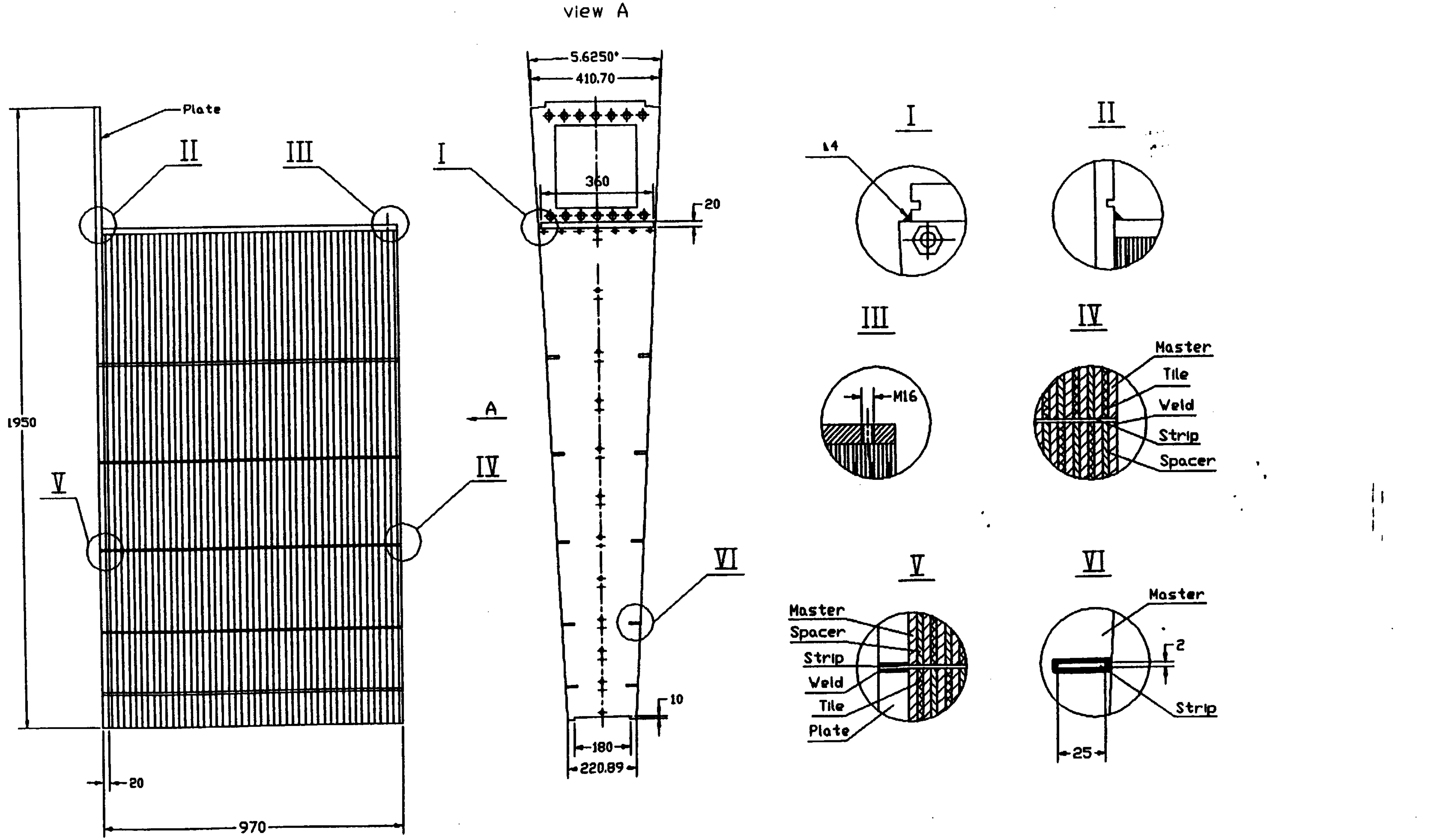


Fig. 9 Left module

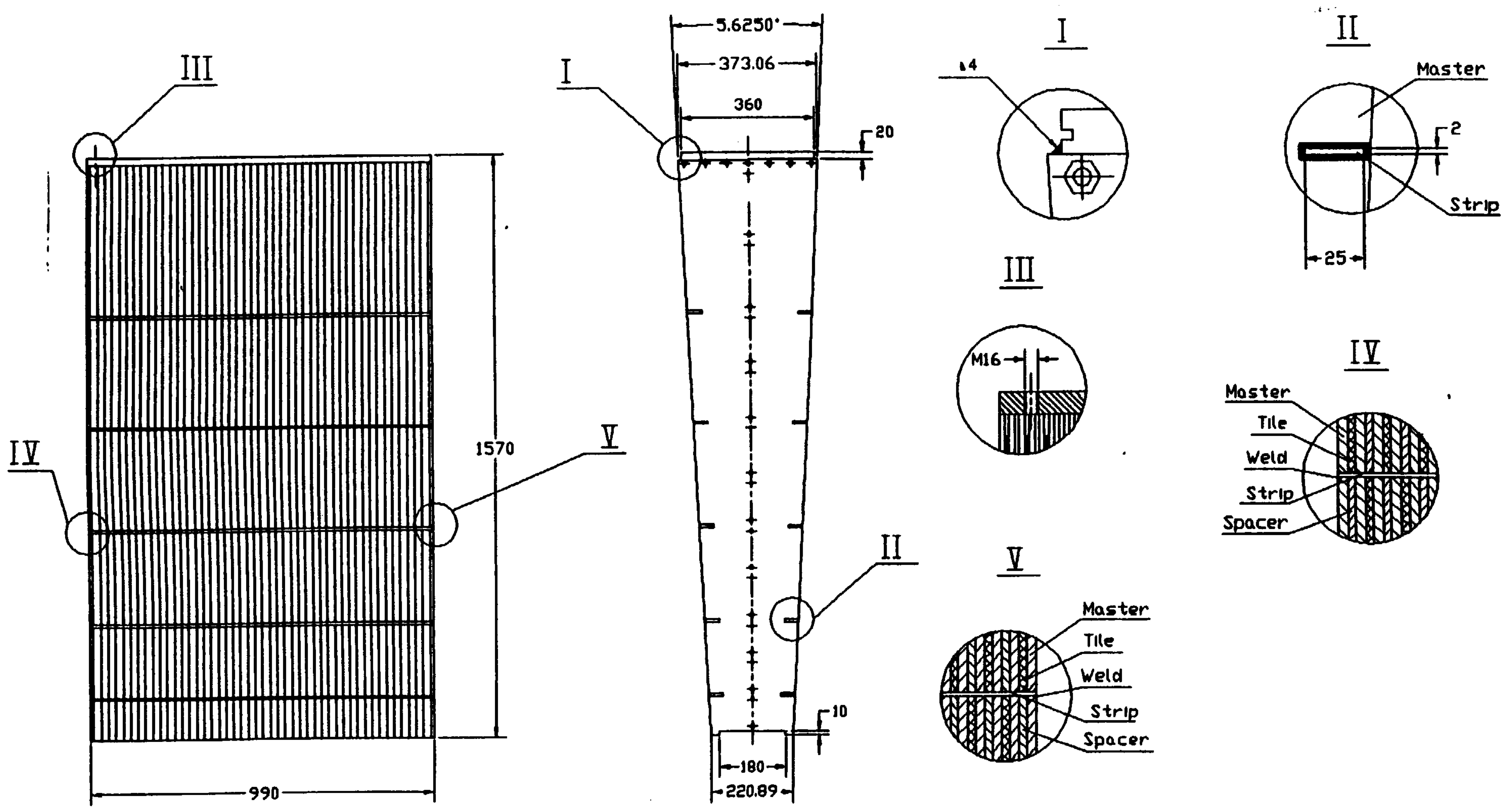


Fig. 10 Midle module

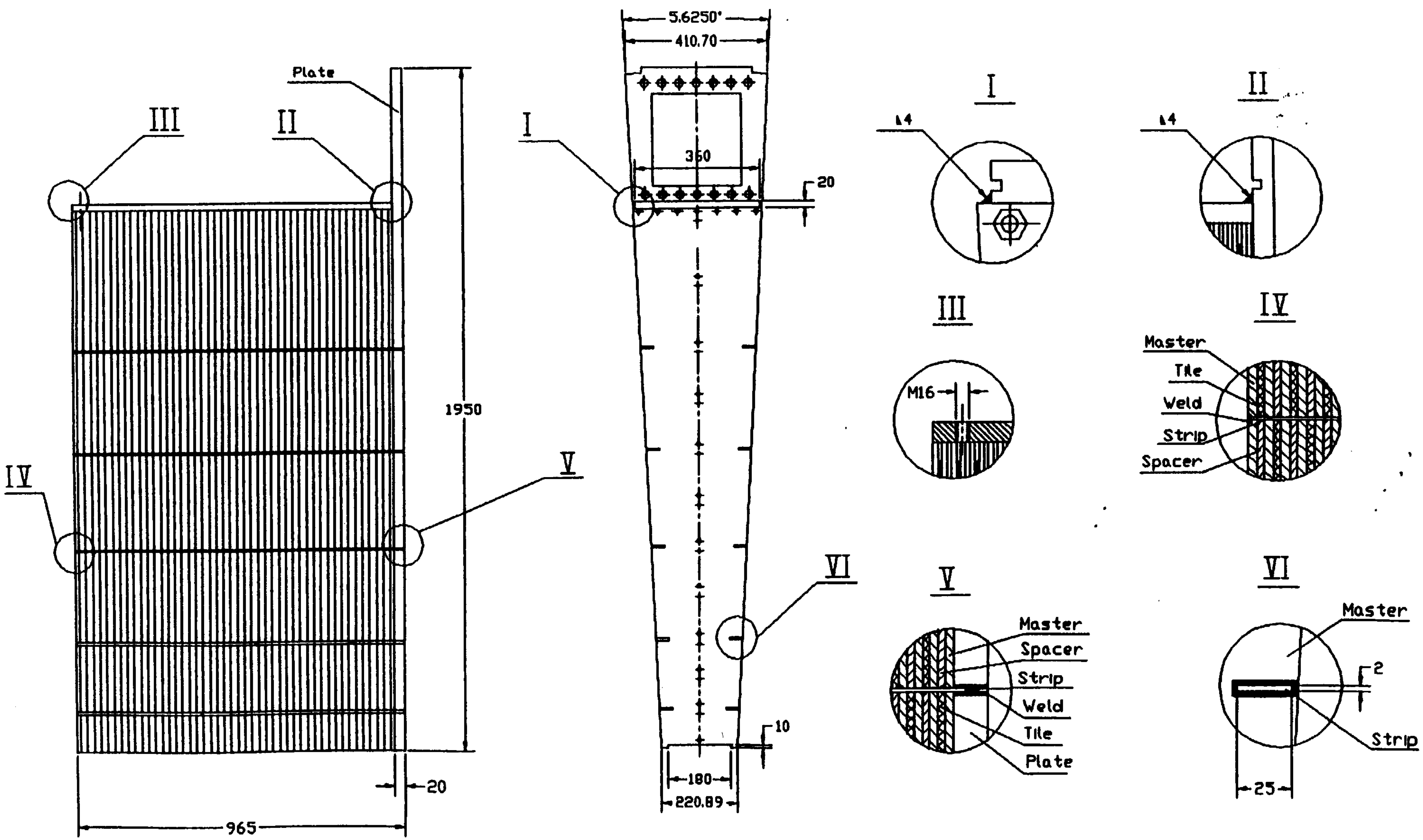


Fig. 11 Right module

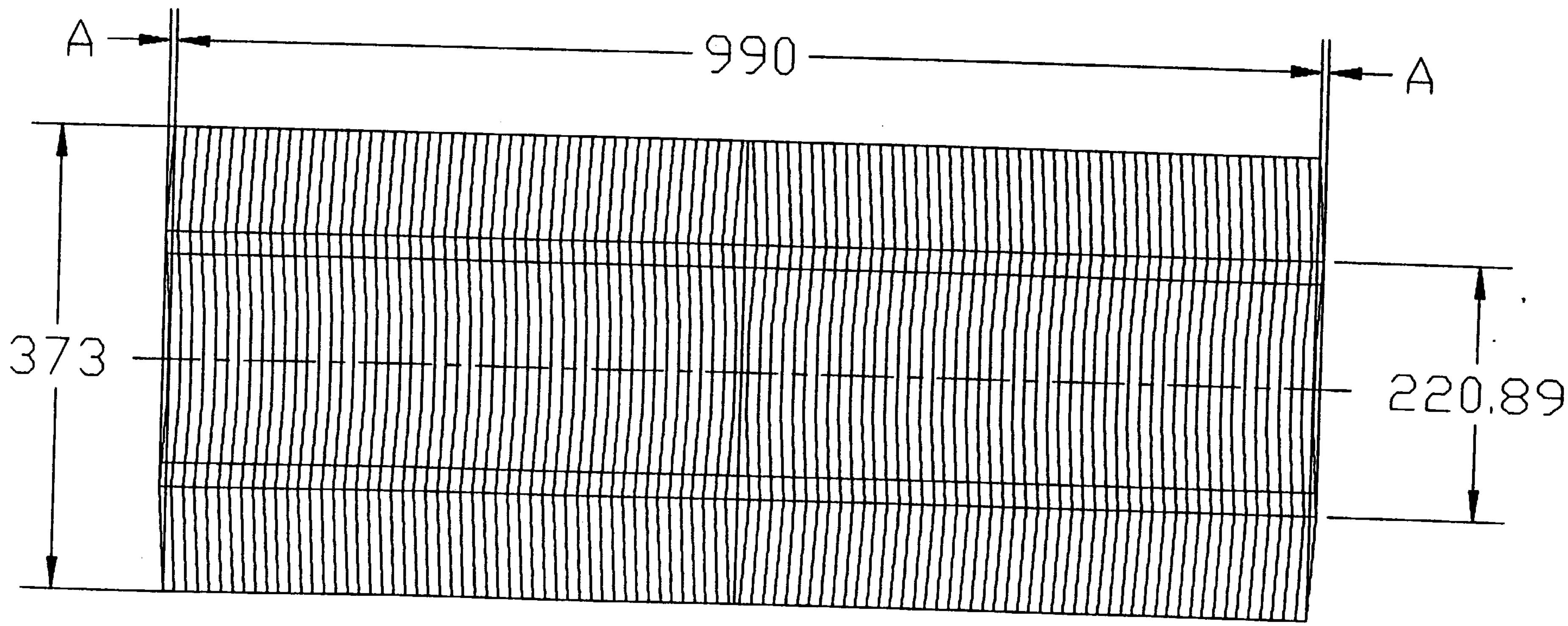


Fig. Assembly of module without strips.

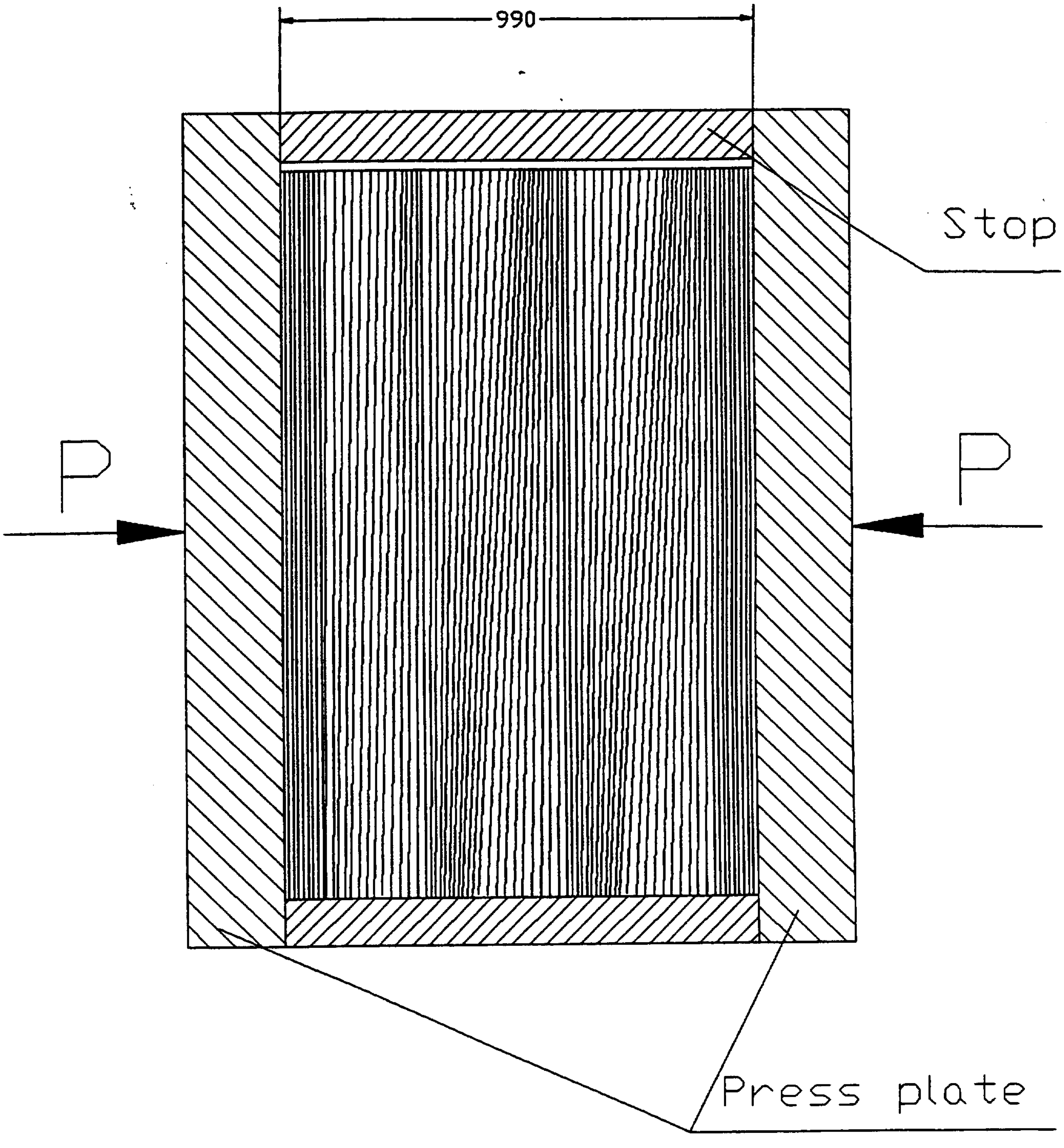


Fig. 13 Packing of module.

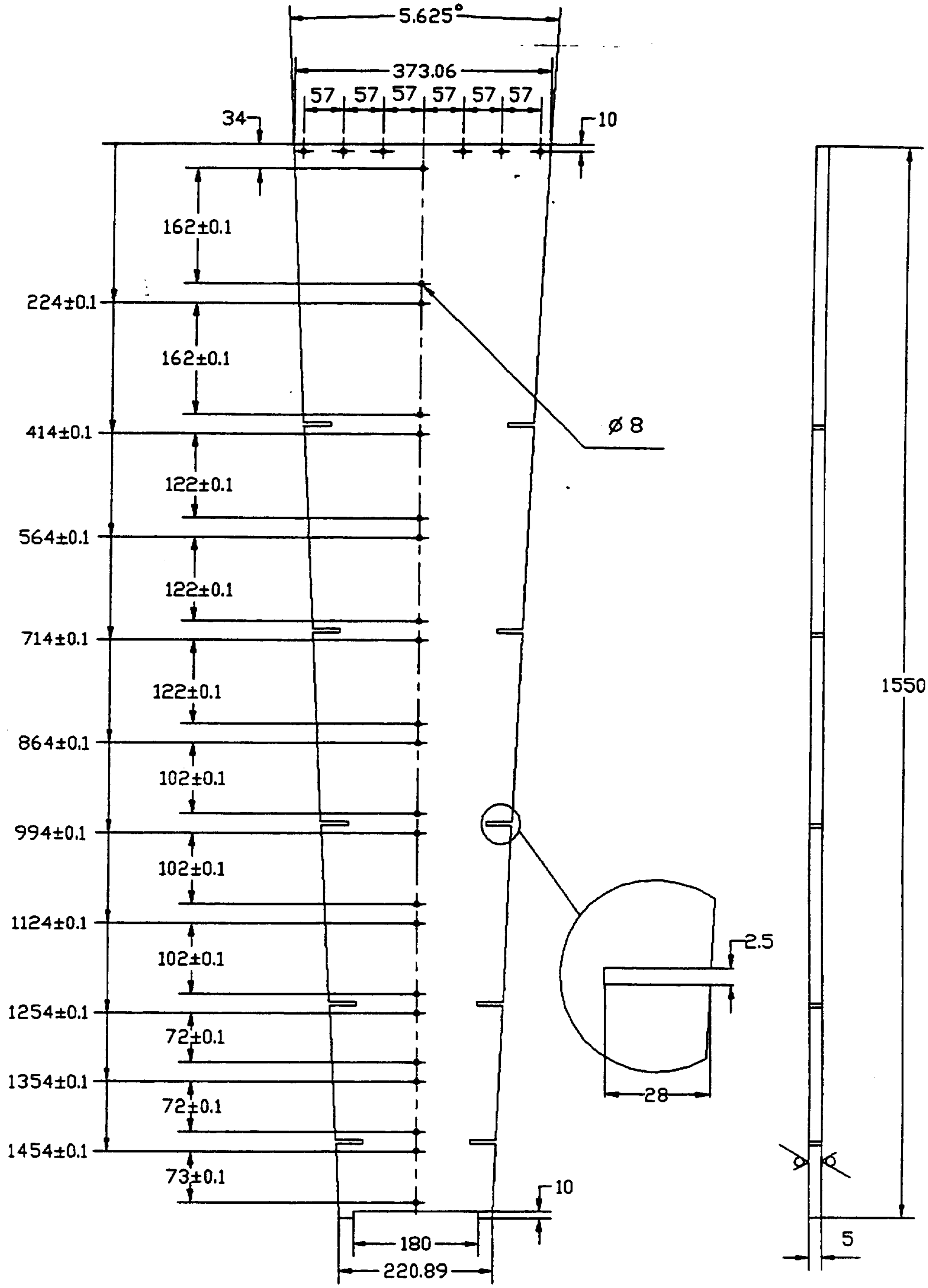
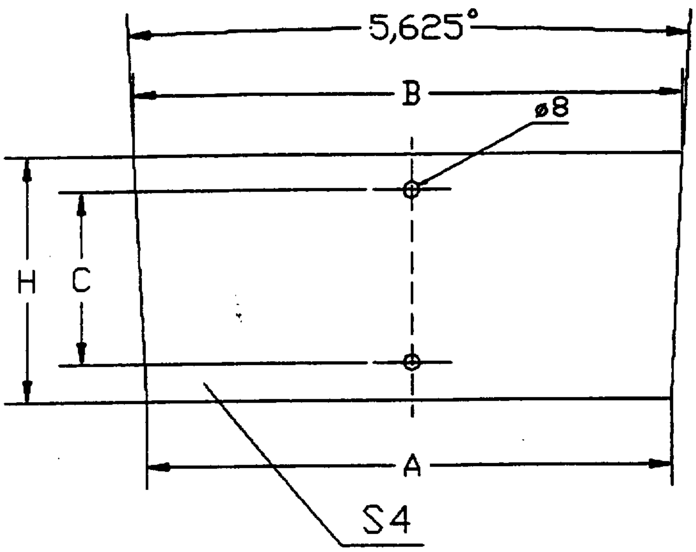


Fig. 14 Master



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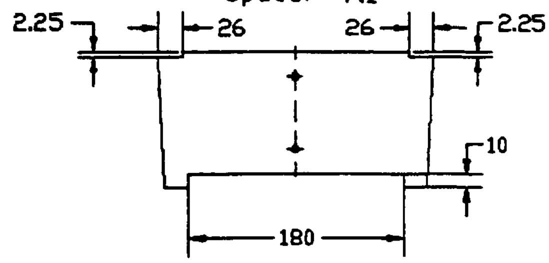
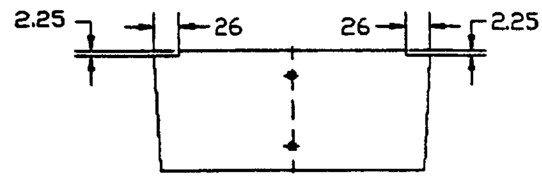
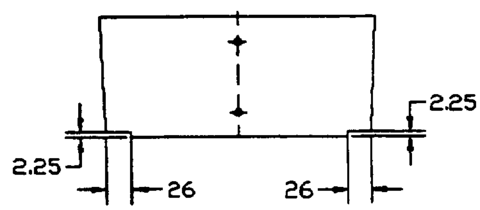


Spacers N3,5,7,9



Spasers N2,4,6,8,10



N	A	B	C	H
1	220.89	231.78	73±0.1	111
2	227.58	237.59	72±0.1	102
3	237.40	247.41		
4	247.21	260.17	102±0.1	132
5	259.98	272.94		
6	272.74	285.70		
7	285.5	300.43	122±0.1	152
8	300.23	315.15		
9	314.96	329.88		
10	329.69	348.54	162±0.1	192
11	348.34	369.06	162±0.1	211

Spacer N11

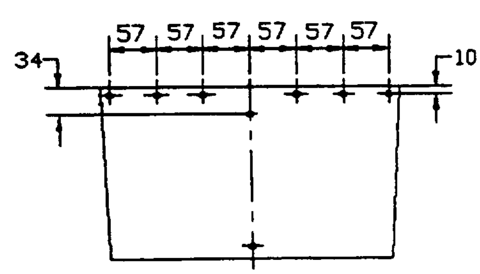


Fig. 15 Spacer

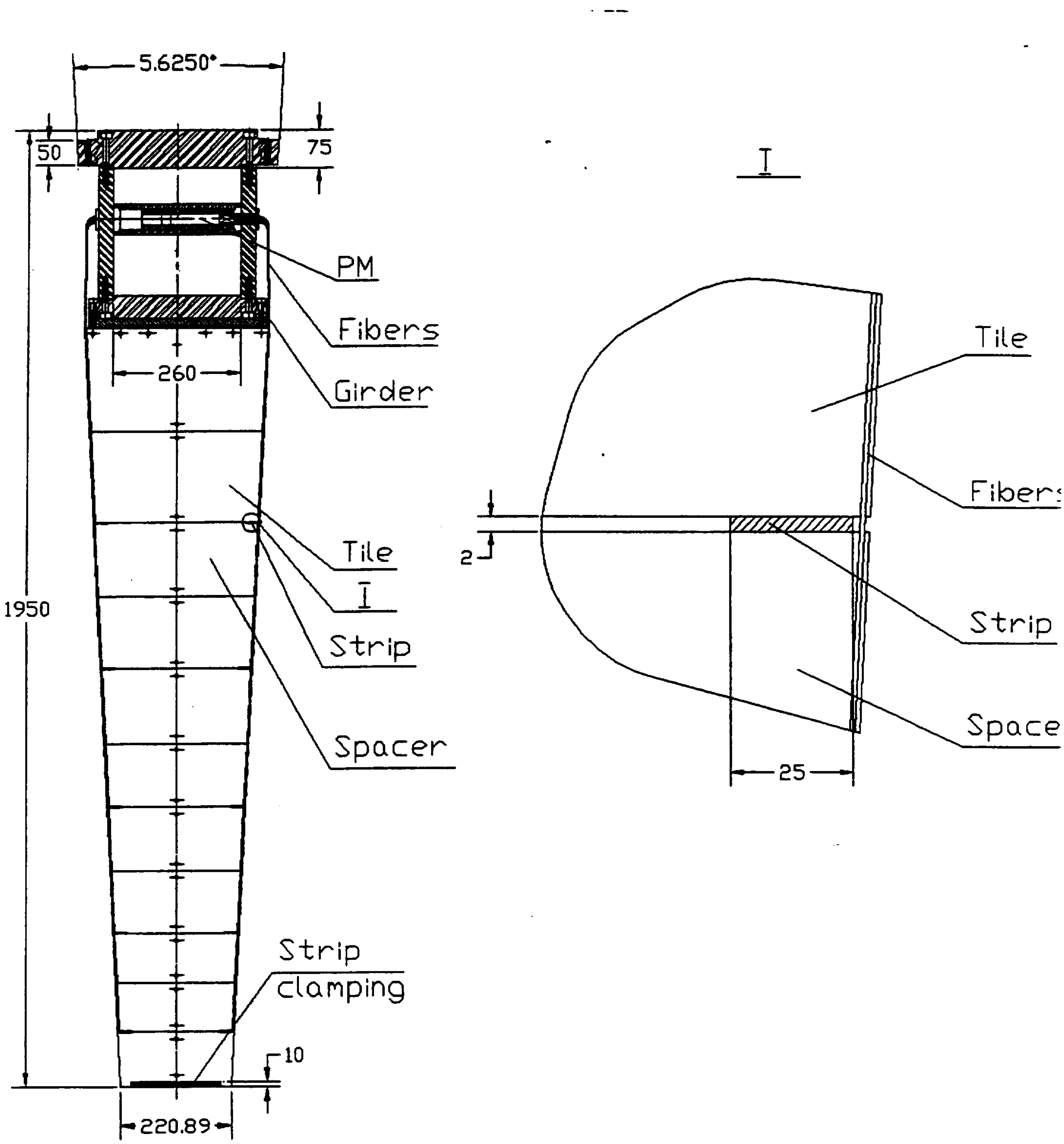


Fig. 16 Cross section of supermodule.

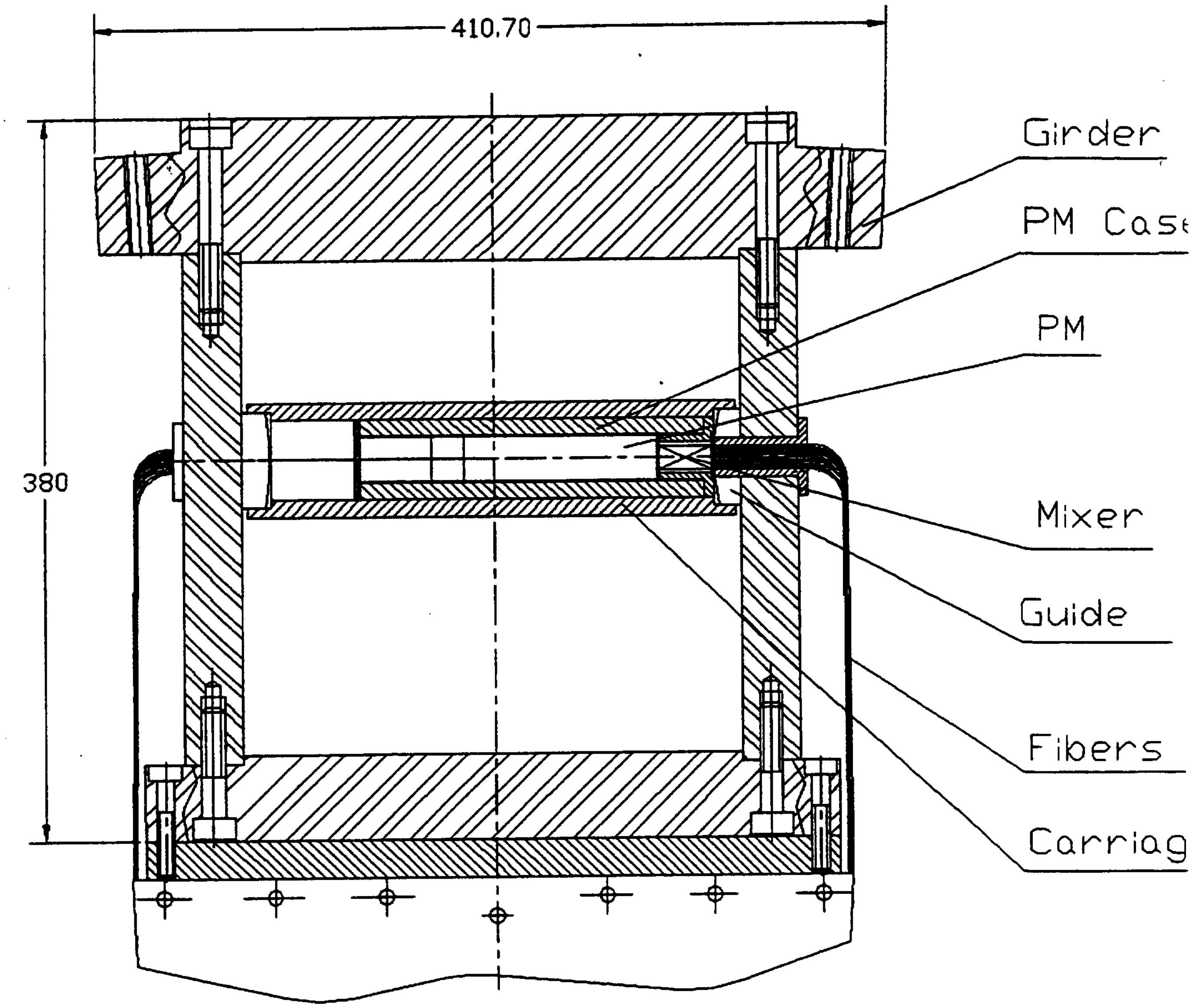


Fig. 17 Cross section of girder.

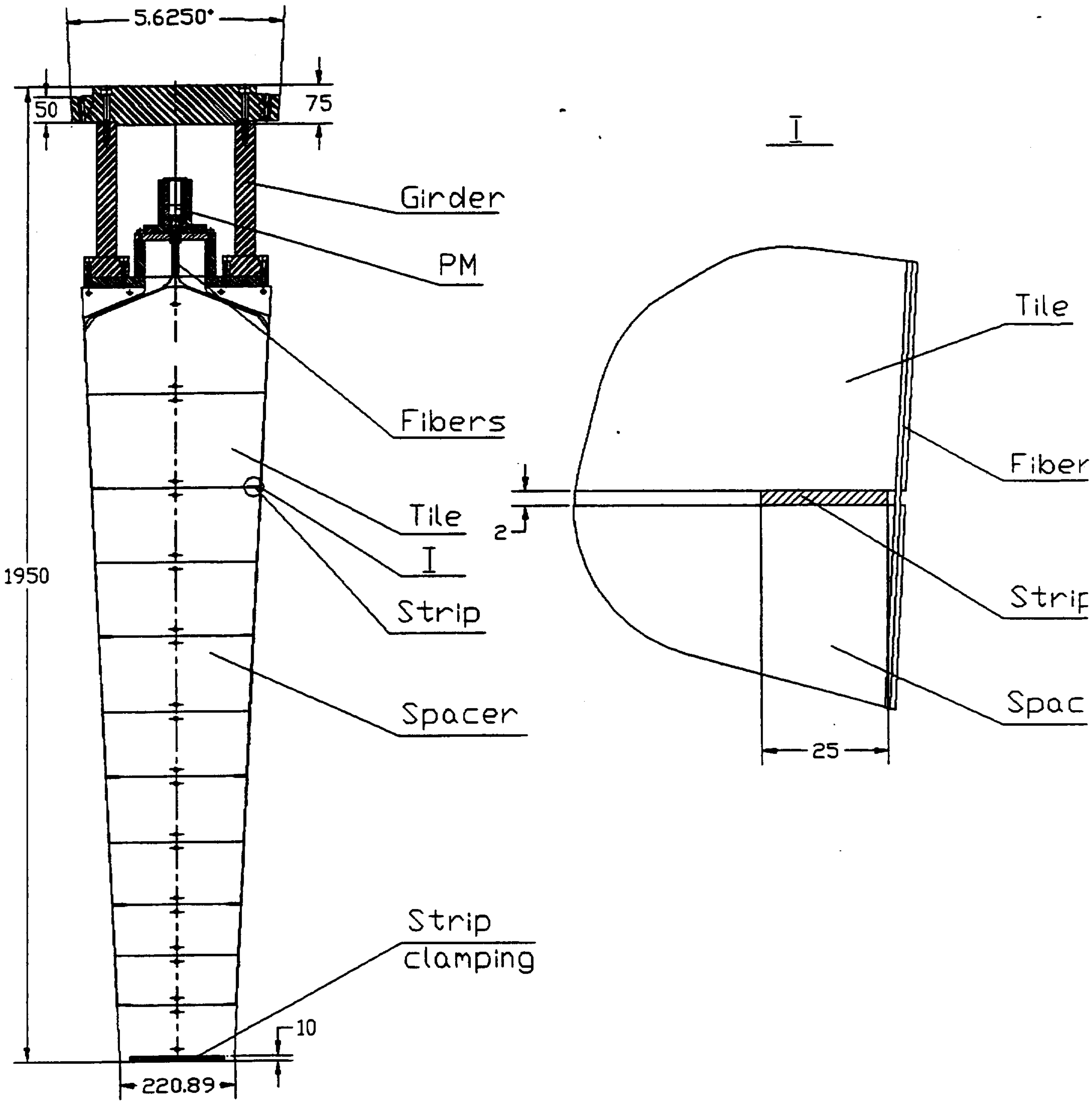


Fig. 12 Cross section of supermodule.

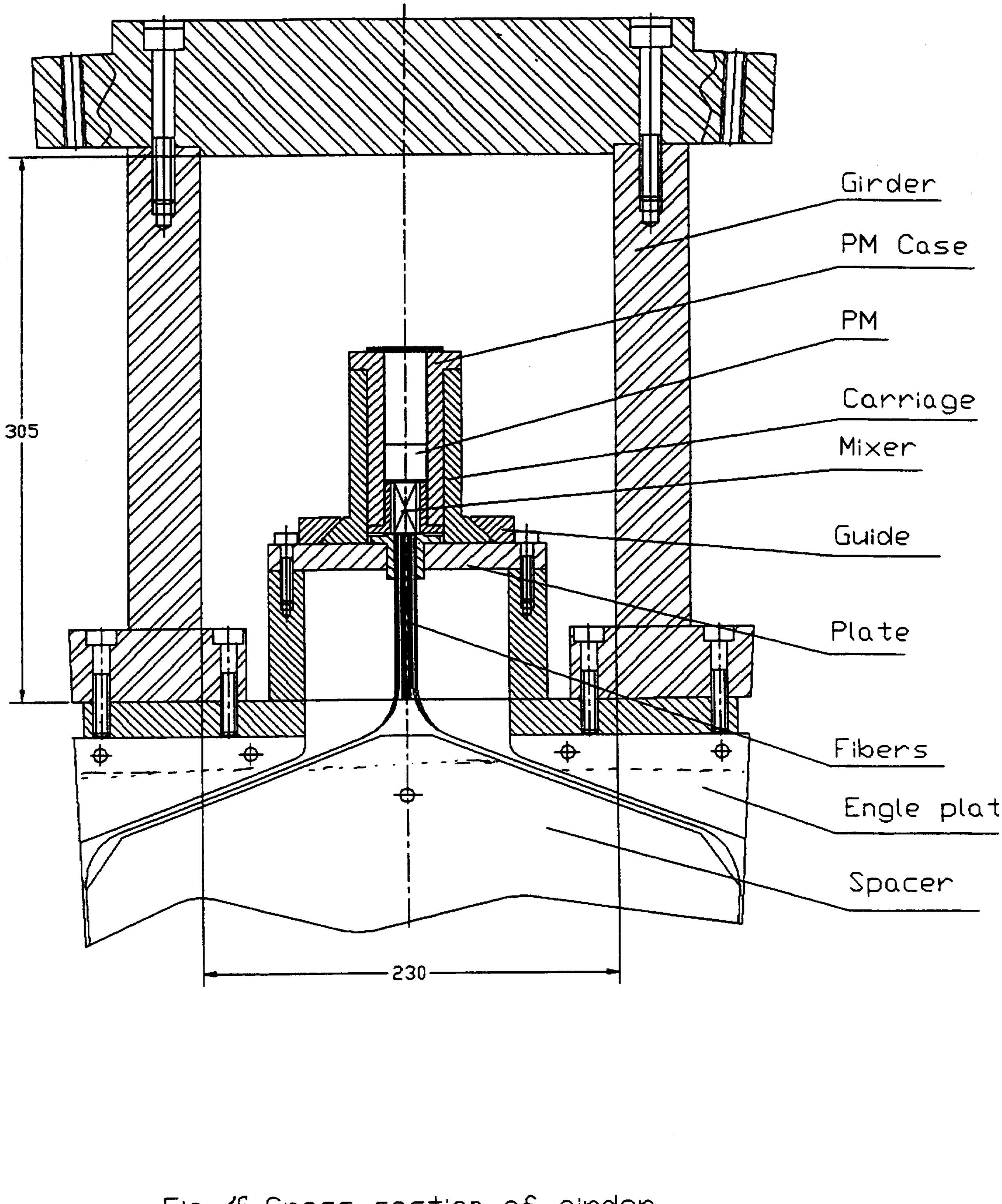


Fig. 19 Cross section of girder.

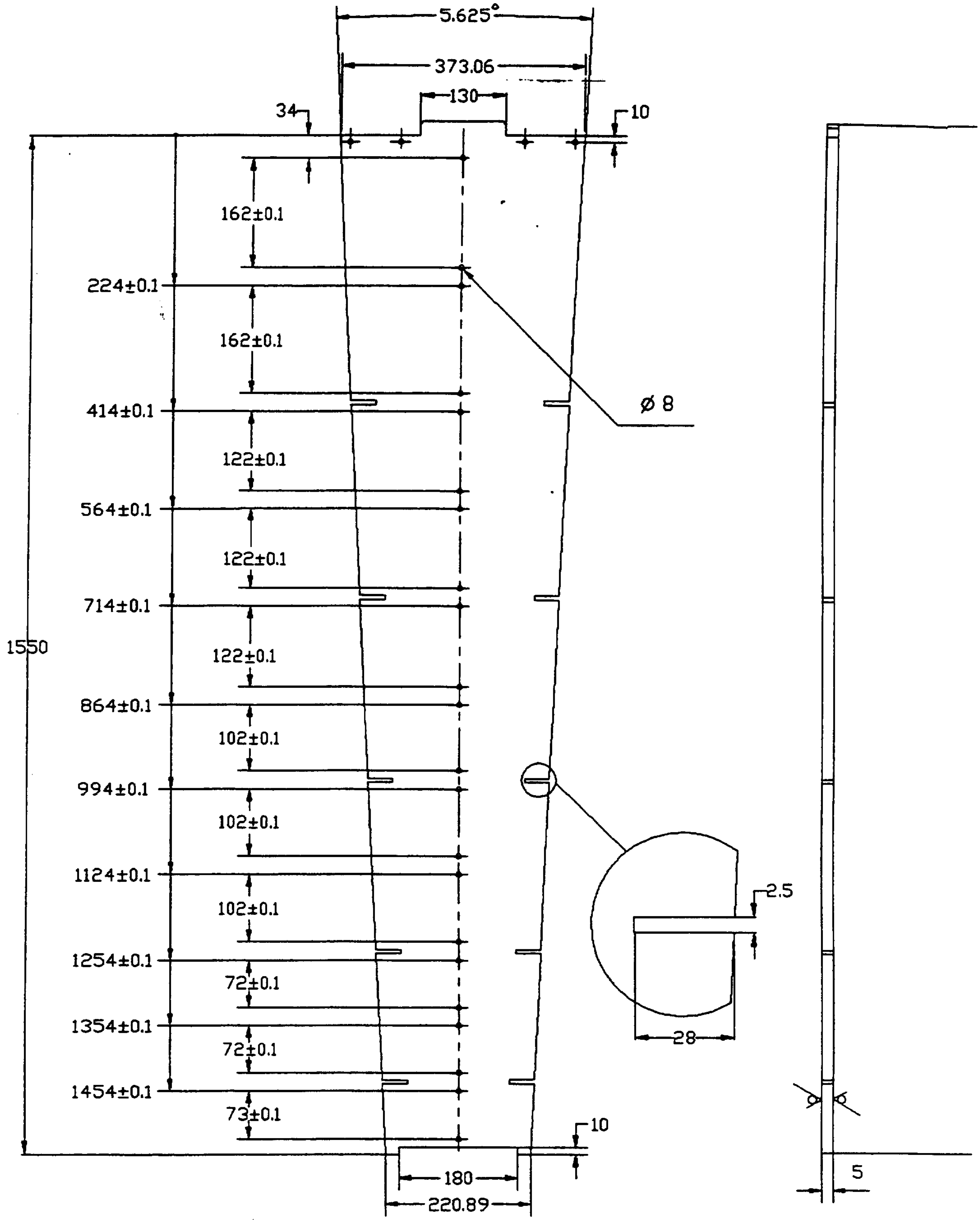
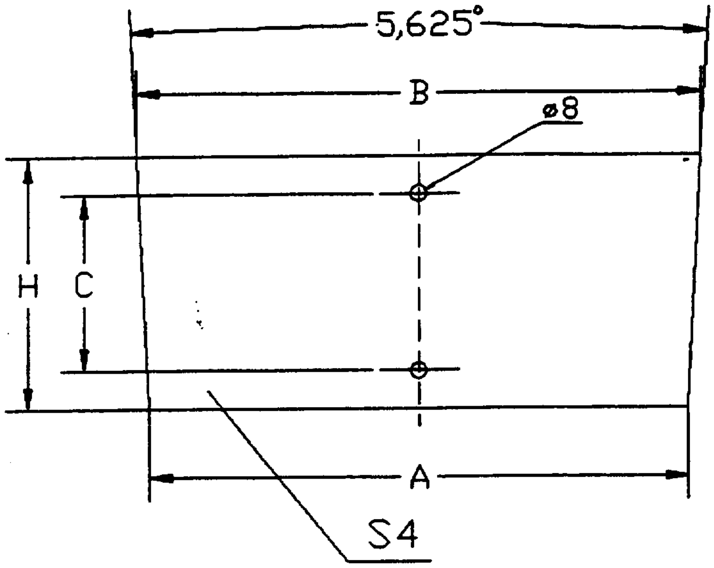
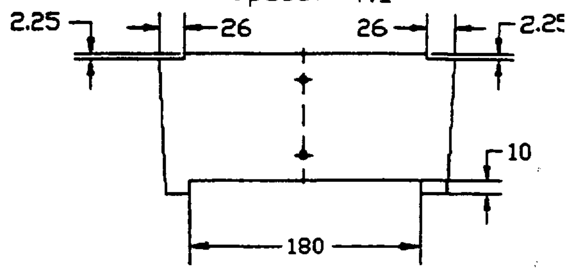


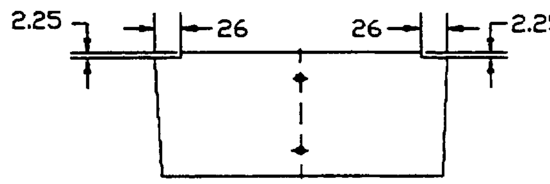
Fig. 20 Master



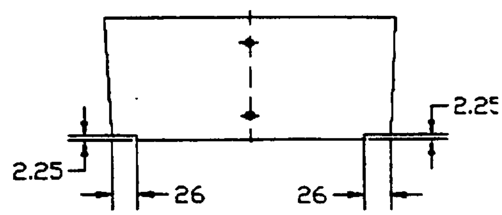
Spacer N1



Spacers N3,5,7,9



Spasers N2,4,6,8,10



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Spacer N11

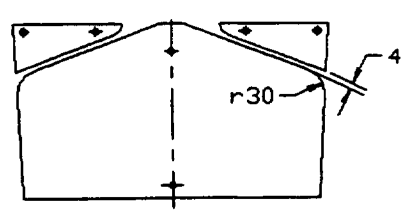


Fig. 21 Spacer

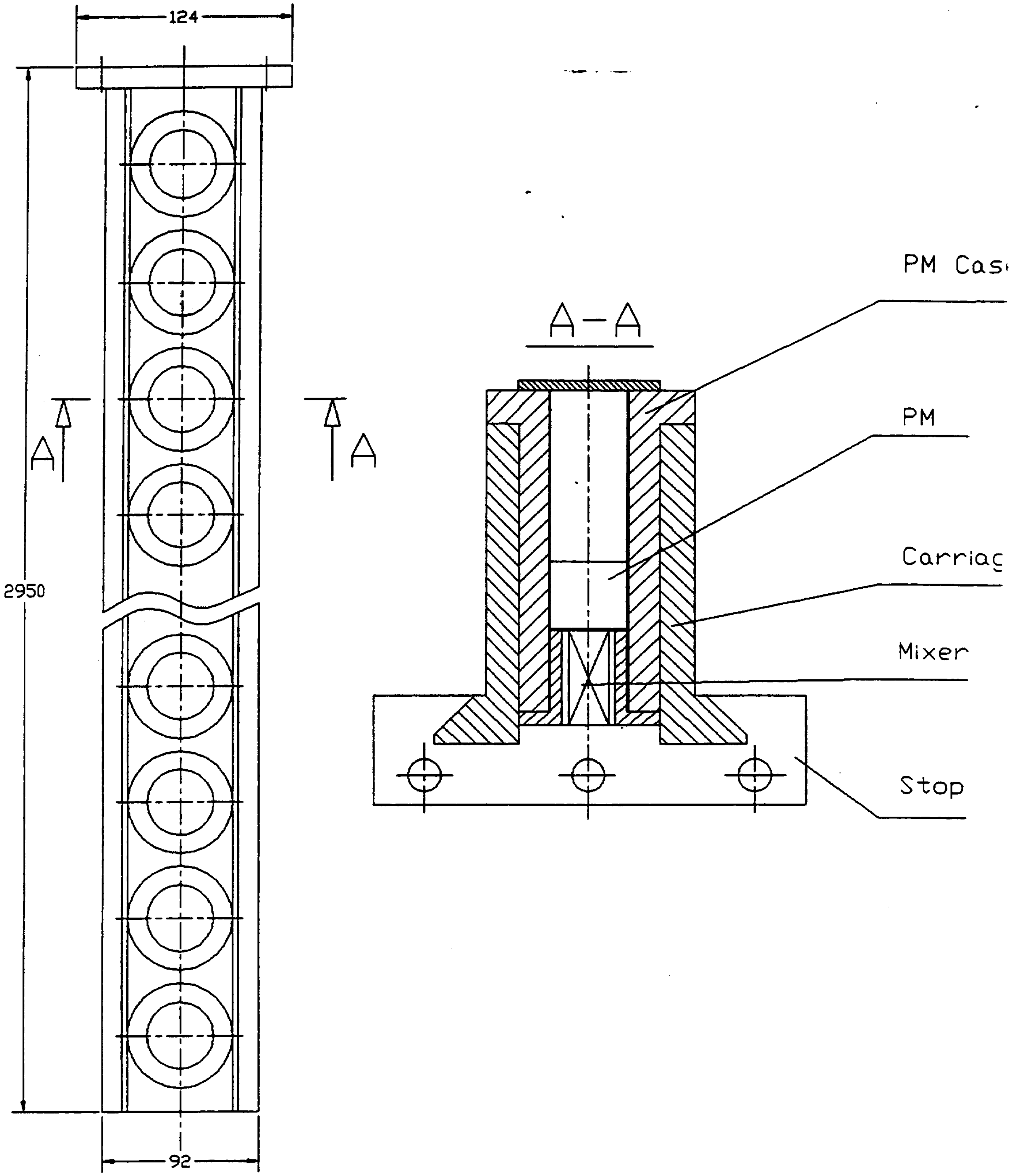


Fig. 22 Carriage.

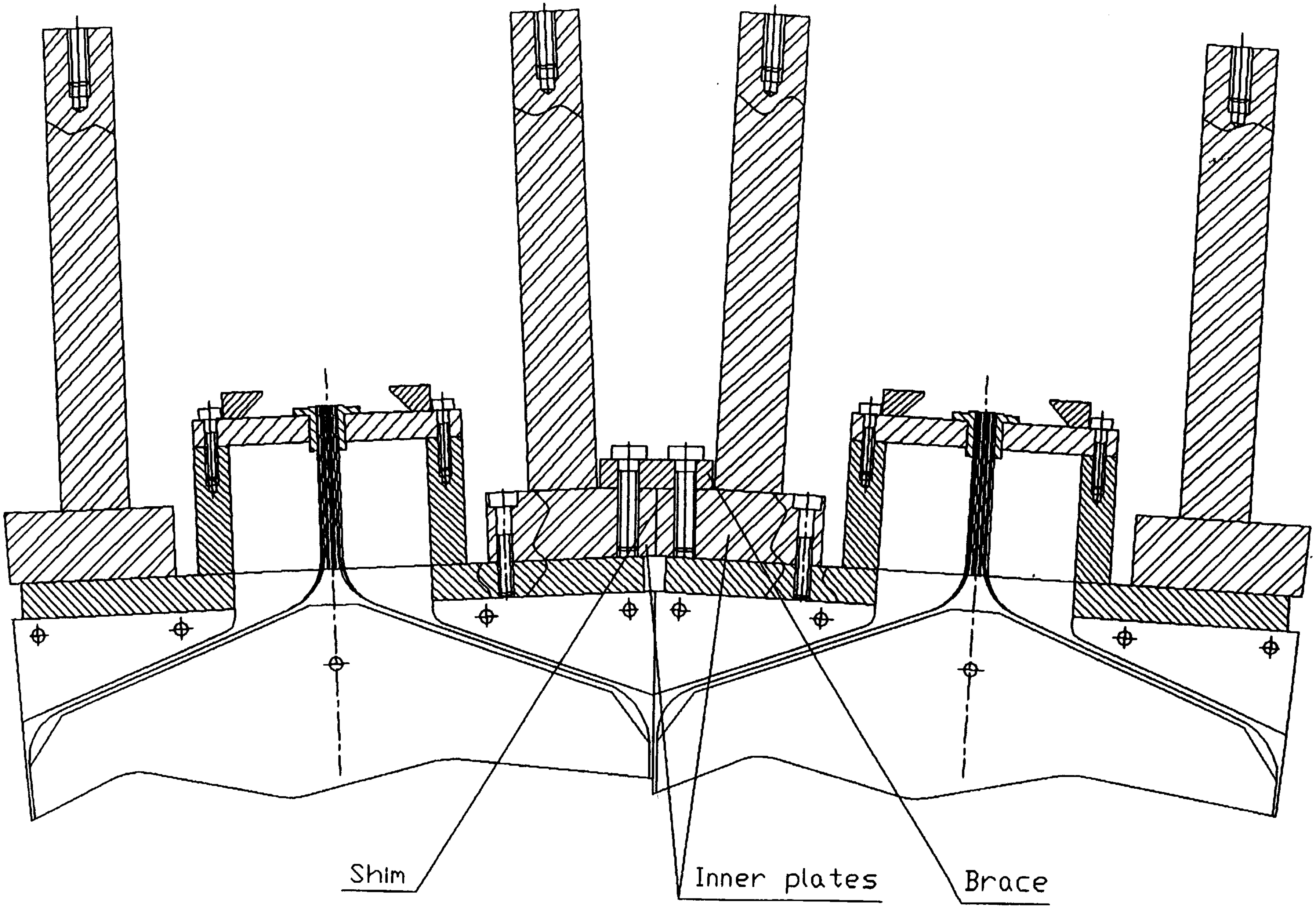


Fig. Fastenning modules together.

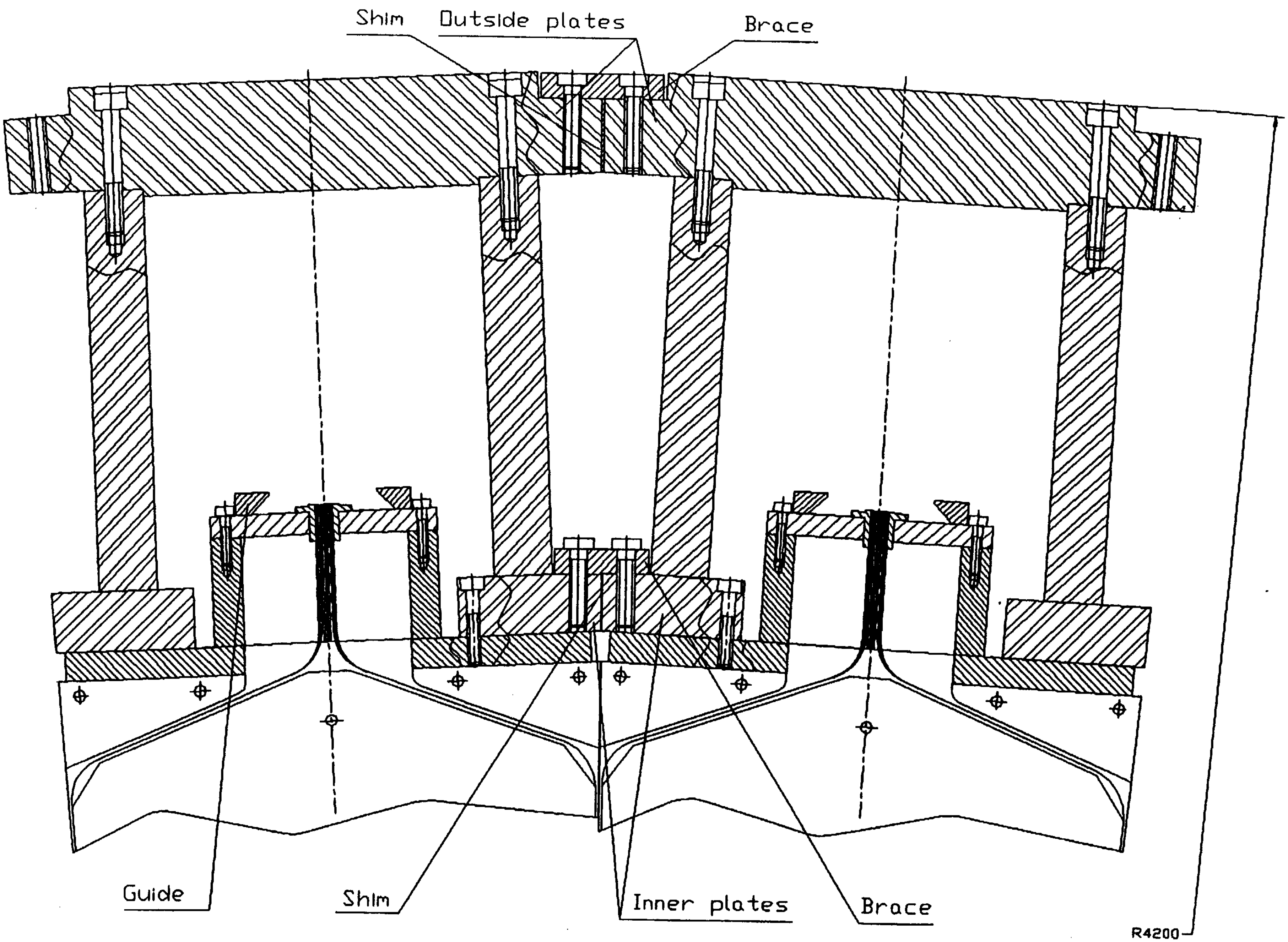
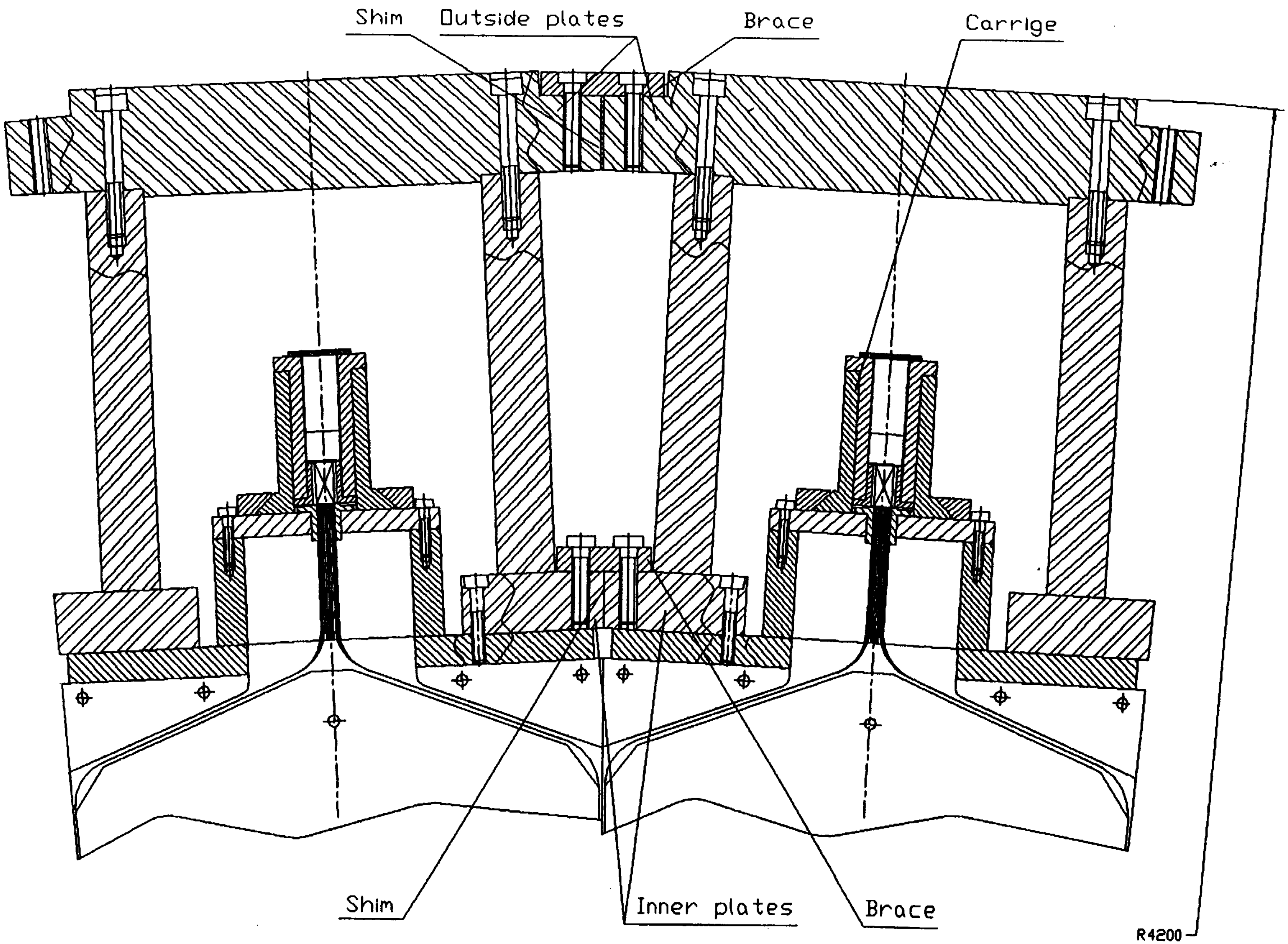


Fig.24 Fastenning modules together.


Shim
Outside plates
Brace
Carrige
Shim
Inner plates
Brace
R4200

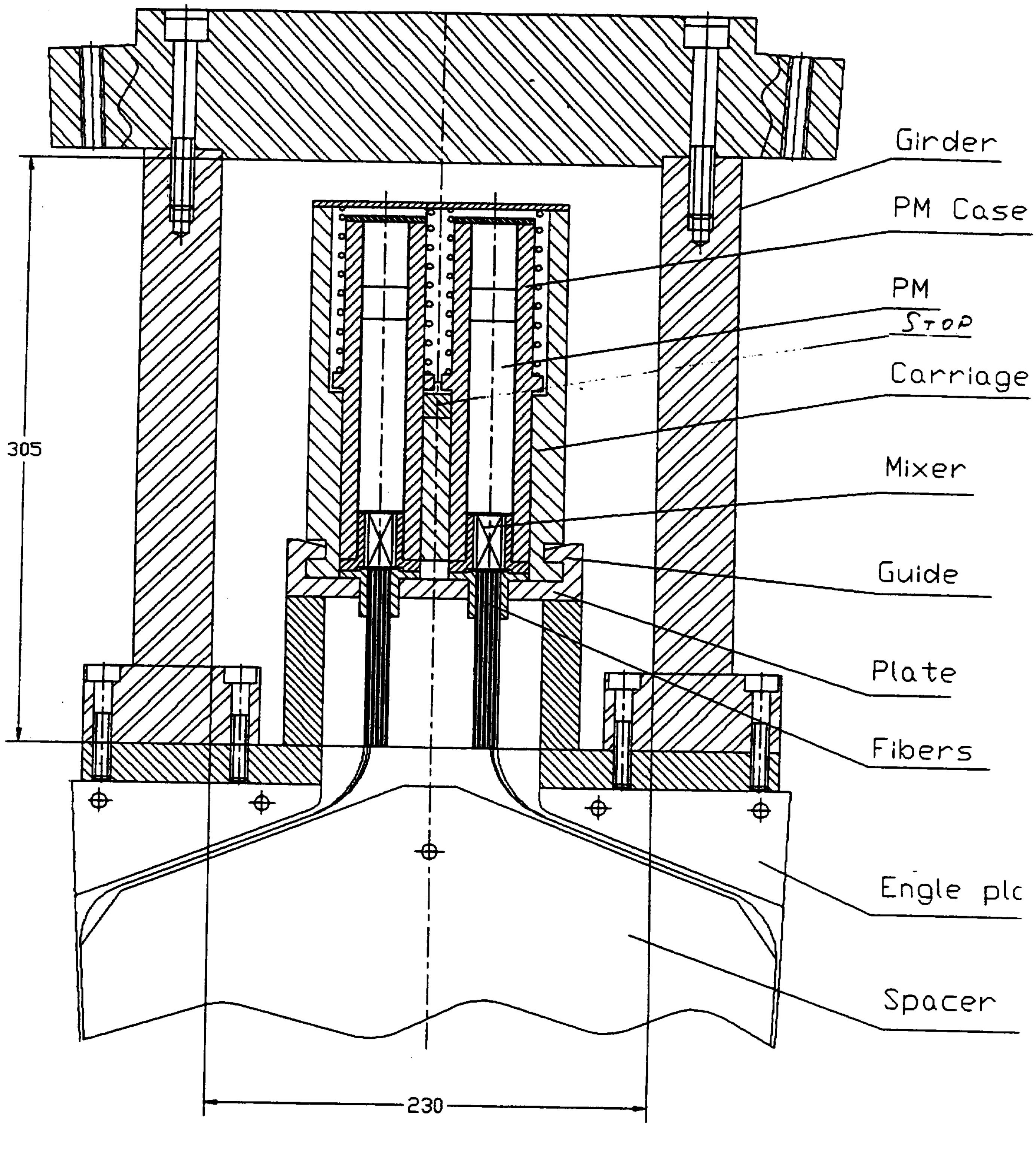


Fig. 26 Cross section of girder.