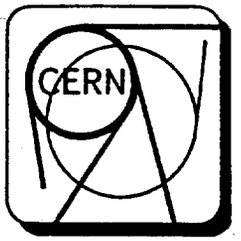
ATLAS Internal Note
TILECAL-NO-003
13 December 1993

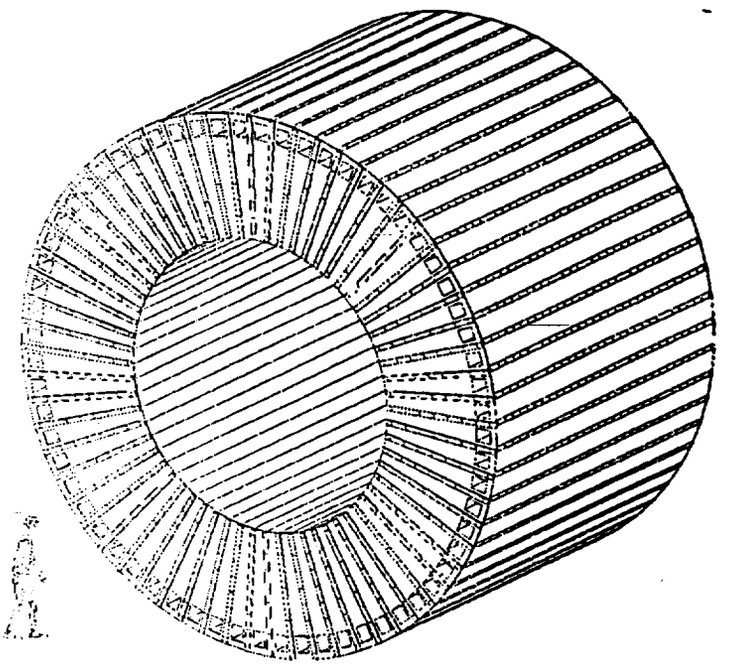


CERN/LHC/93
December, 1993
Hadron Calorimeter of ATLAS
IHEP, Protvino, Russia

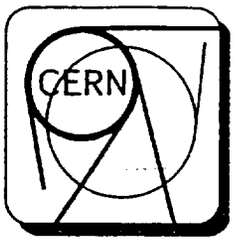
HADRON CALORIMETER OF ATLAS

CONCEPTUAL INTEGRATION PROJECT
(PRELIMINARY)

Presented by A.Surkov



INSTITUTE FOR HIGH ENERGY PHYSICS
Protvino, Russia



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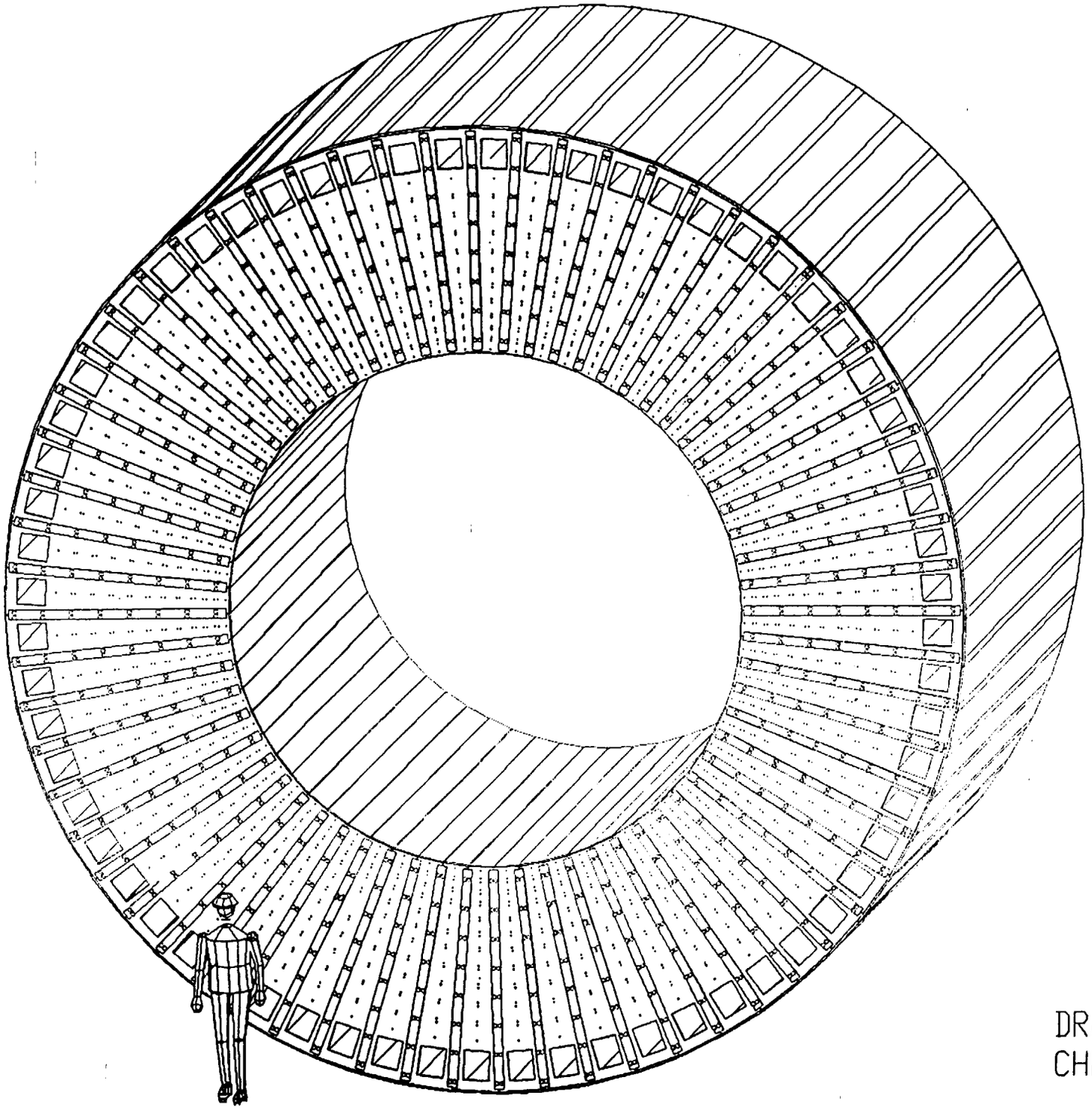


DRAWN SURKOV Y. N.
CHKR SURKOV A. N.

1. Hadron Calorimeter integration scheme. Design philosophy and assembly.

- The cylindrical structure of the Hadron calorimeter with the inner radius of 2250mm and the outer radius of 4200mm, with the barrel part of 5900mm long is formed by the assembly of the 64 sector supermodules.

- The angle regularity for the supermodule locations in barrel, the rigid agreement of the barrel inner and outer radiuses with the given values of the barrel length is provided by the using in the each single supermodule the end plates with the thickness of 20mm that are fastened to the girder.

- The mechanical rigidity and stiffness of the barrel outer cylindrical surface is provided with the tightening of the girder for the each supermodule with each other by the strength bolts.

- The mechanical rigidity and required flattening for the barrel end lids is provided with the tightening of the supermodule end plates with each other by the strength bolts.

- The proposed conception of the supermodule structure permits to provide the longitudinal dimension of barrel with the error not more than ± 0.8mm (technology and structure suggested by ALSTHOM provides the length scatter for the each supermodule $\Delta l = \pm 4.5$mm).

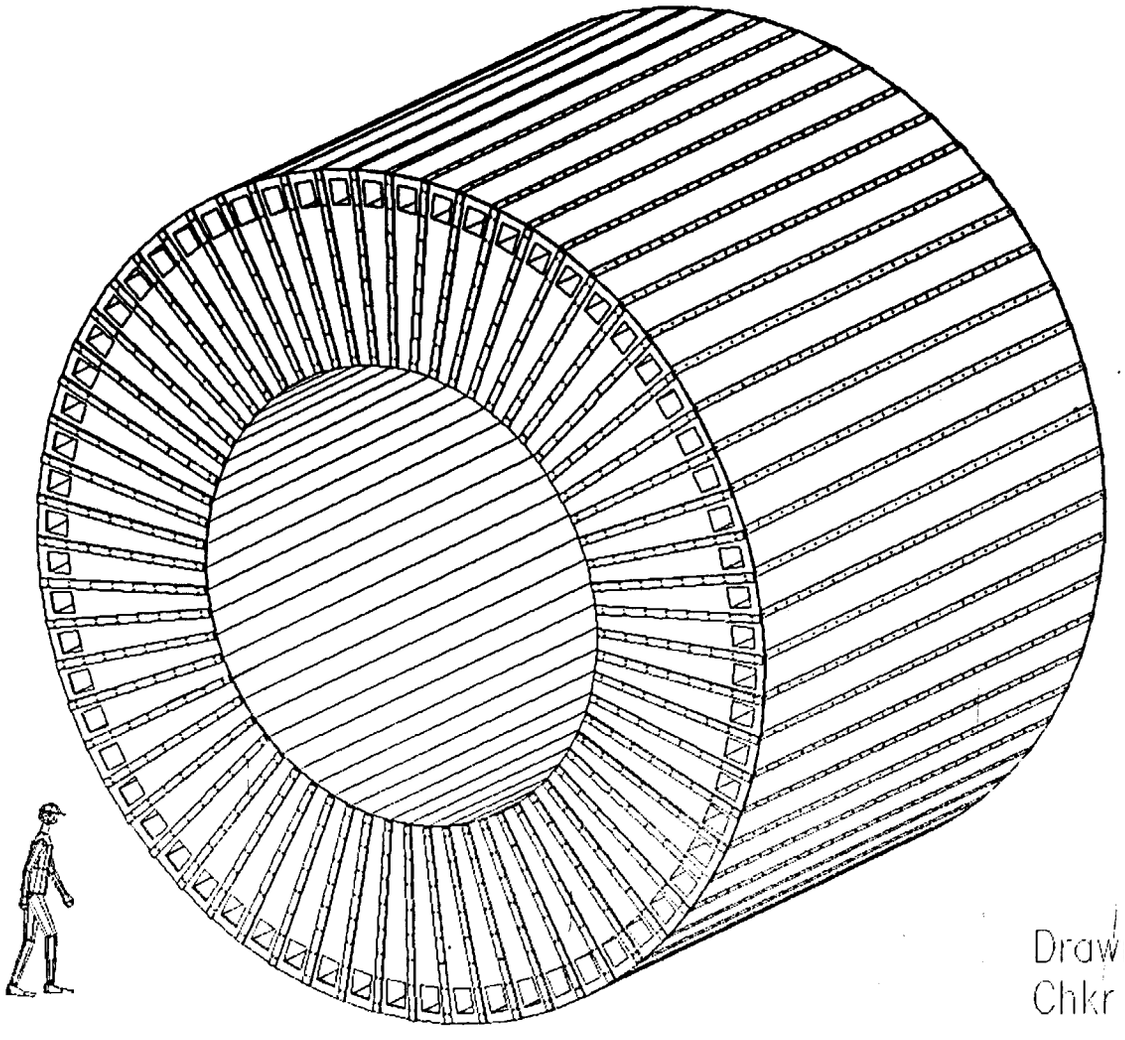
- The additional mechanical rigidity and geometrical stability of the barrel structure is provided by the using the microwelding joints on the inner surface of barrel. All adjacent supermodules along Z axis are connected with each other by the stainless steel rubber with the help of the point welding.

- For the purpose of the increasing the accuracy for the coordinate matching of the each period and half-period on Z axis, for simplicity of the assembly and transport problems and also for the reduction of financial expense on development and production of the high-size assembly press (its cost estimation is 1.633Ms Fr), we offer the conceptual decision for barrel sector (supermodule), that consists of a few single modules. (The number of the single modules in supermodule may be equal from 4 to 6).

- Before the final assembly of the supermodules and Hadron calorimeter the control assembly of the end lids, consisted of the supermodule side plates should be done.

- Assembly Hadron Calorimeter consists of the following stages:
  - the preliminary assembly of 8 supermodules (the total weight is 8x20=160T) is carried out on the assembly staple. The assembly is done on the earth the shaft;
  - the each supermodule is connected with the adjacent one in the interface regions of the end blocks and girders, the connection being done by the using the strength bolts and welding between plates;
  - all adjacent supermodules on the inner radius 2250mm are welded with each other by the stainless steel rubber with about 0.2mm thick and by the using the point welding;
  - the assembly blocks with trunnions are mounted on the ends of 8 supermodules connected with each other. The trunnions are fixed on the gravity centers of the eight supermodules;

- the lift of the preliminary assembly is done with the help of the crane and the traverse that has a special attachment for the rotating relatively the longitudinal axis;
- the final assembly of the Hadron calorimeter is provided in the experimental hall LHC-ATLAS;
- the Hadron calorimeter Support System is installed on the first preliminary assembly consisted of the eight supermodules;
- the preliminary assembly with the weight about 160T is put down into the experimental hall by using the crane with lift capability 360T;
- to avoid the high asymmetrical loads on the lower block consisted of the eight supermodules all next preliminary assemblies should include four supermodules.



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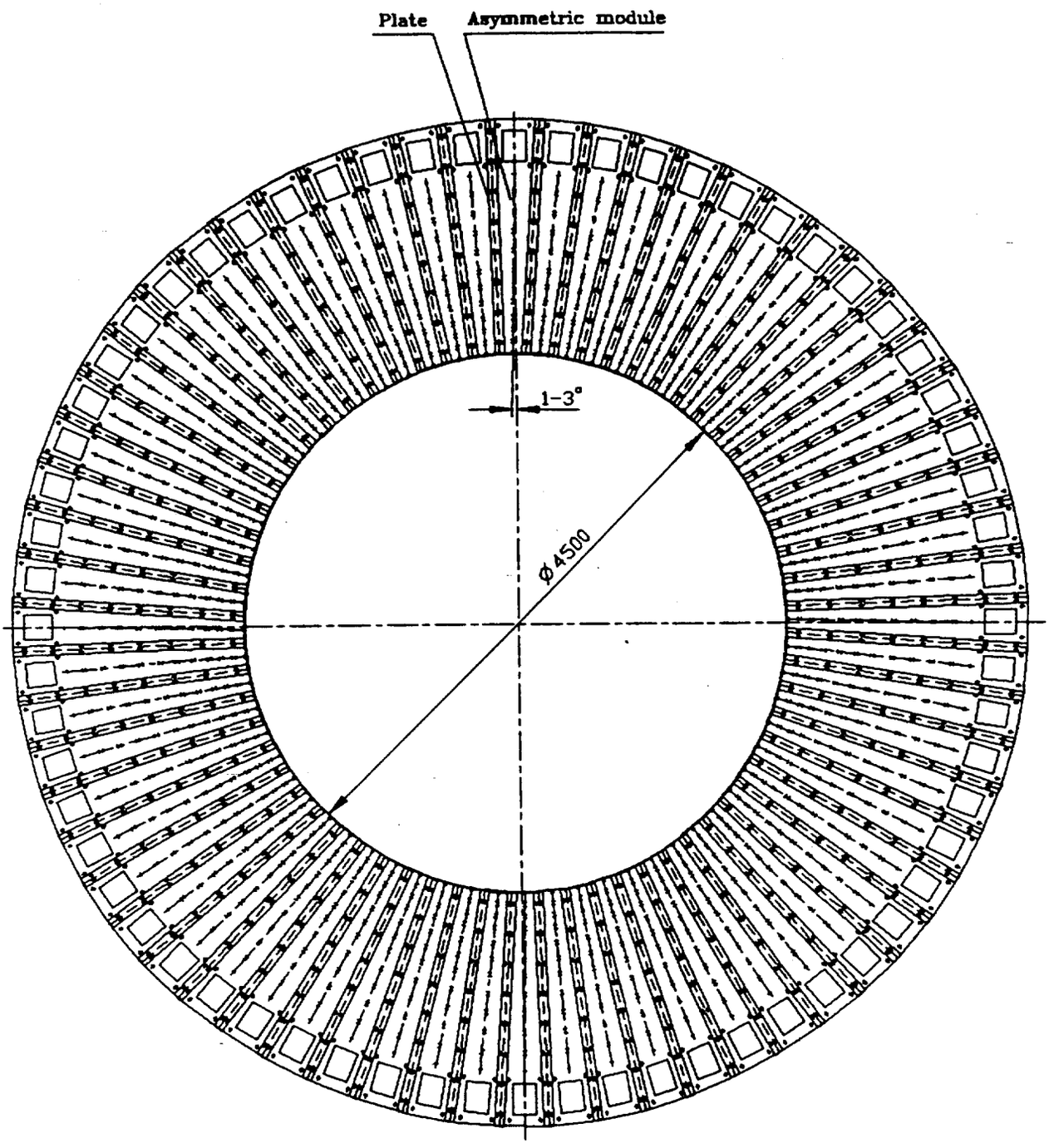
Chkr by A.Surkov

Hadron Calorimeter of ATLAS



DRAWN V.SIDOROV

CHKR A.SURKOV

Hadron Calorimeter of ATLAS
with asymmetric modules.

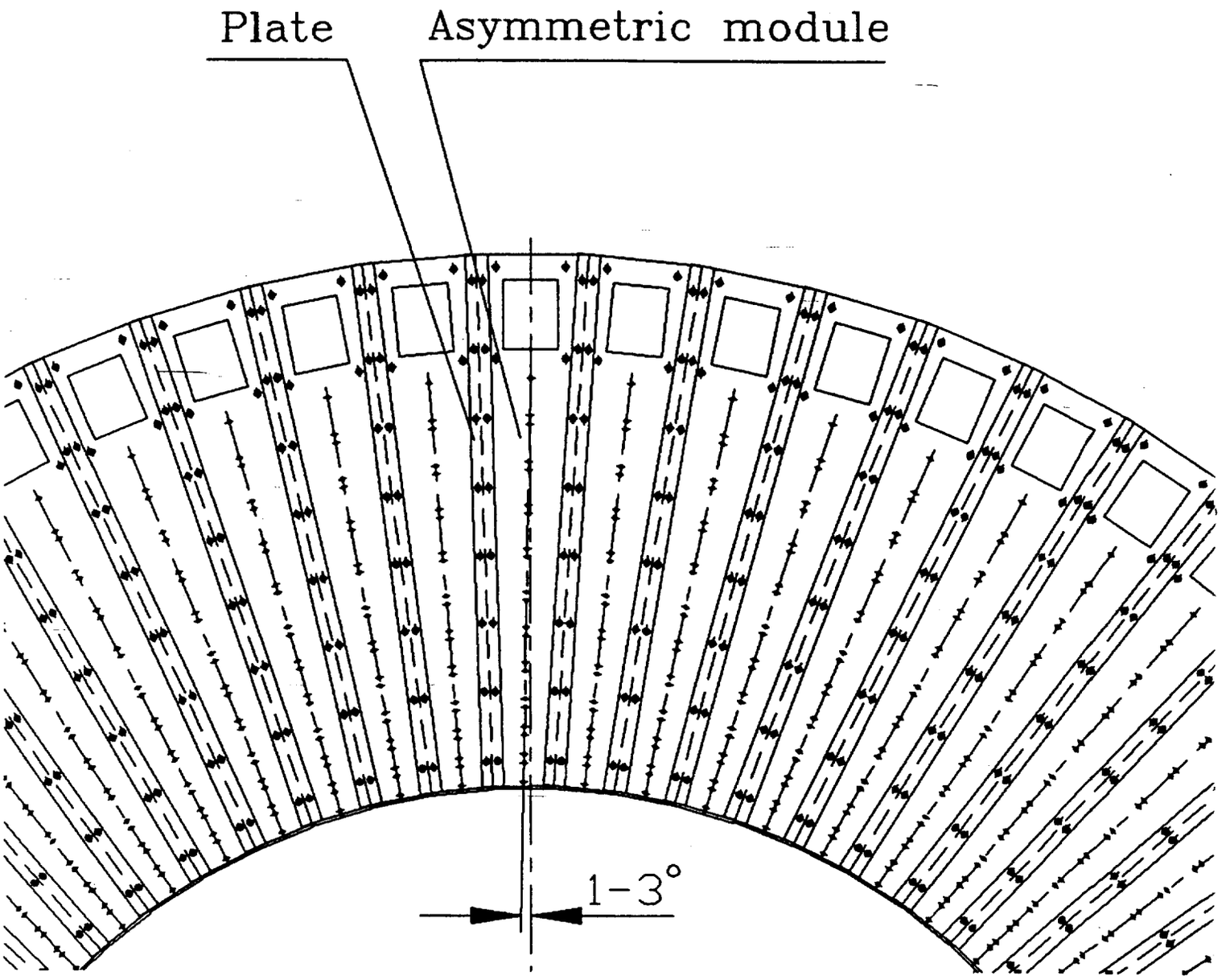
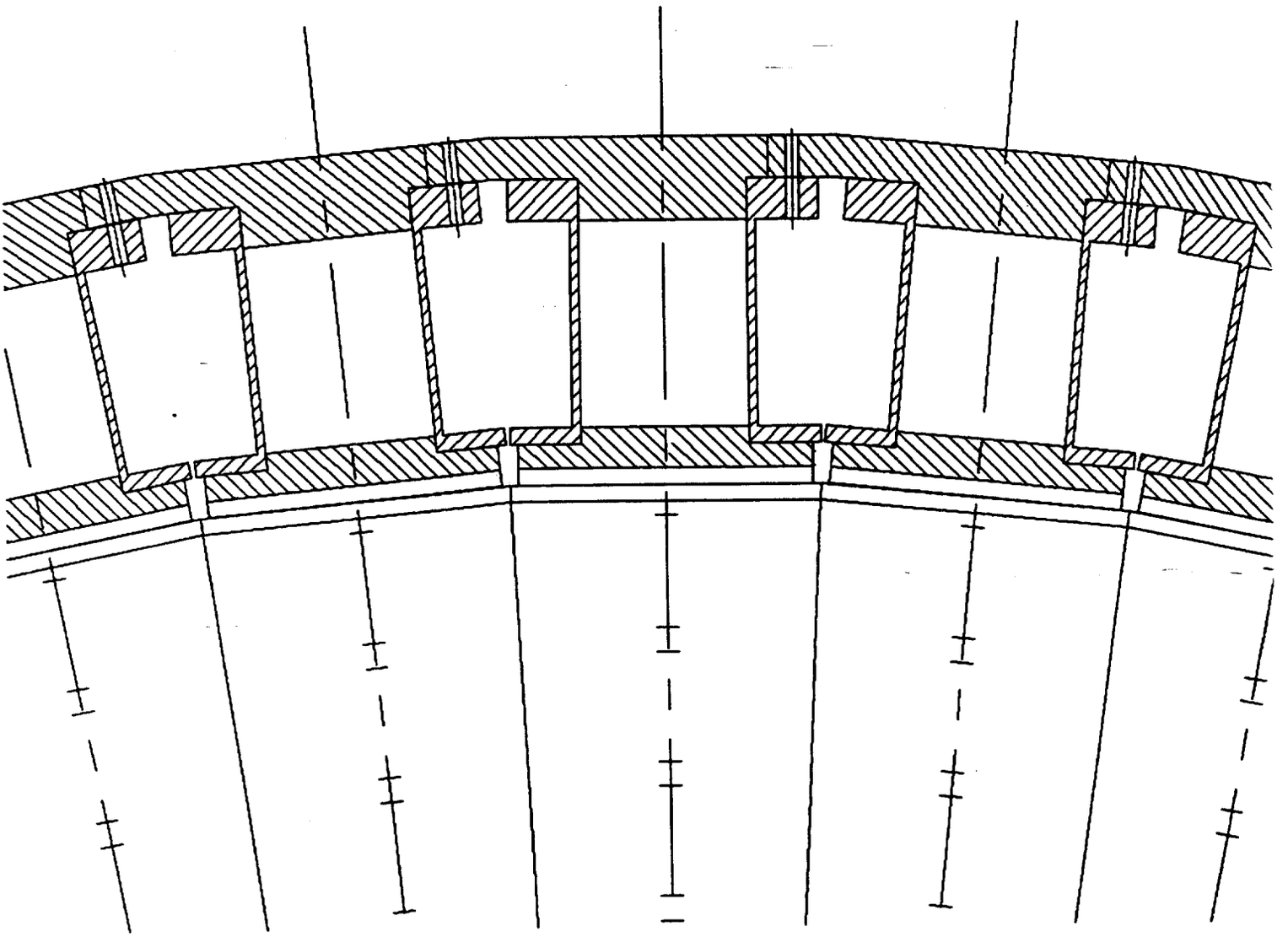
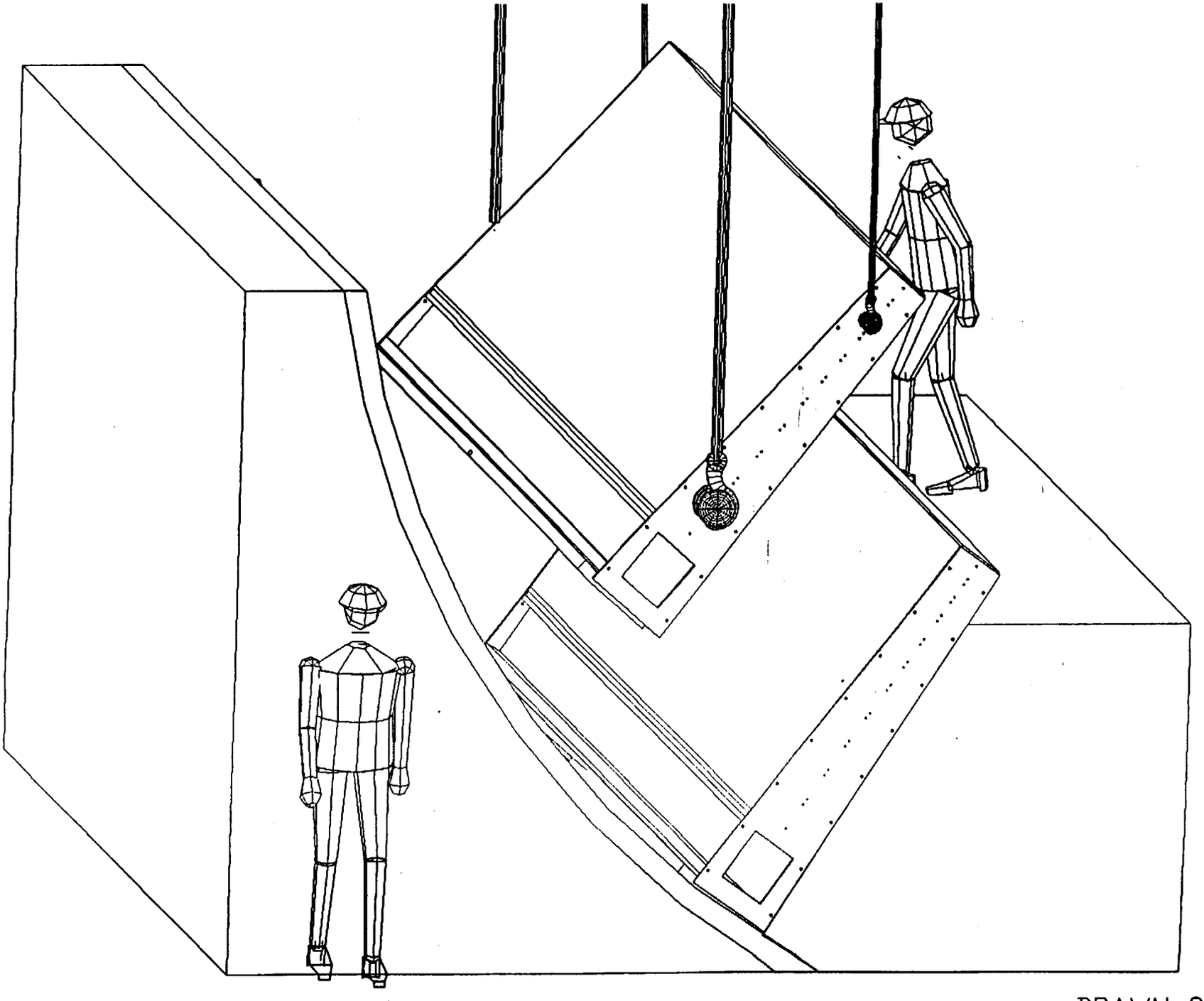


Plate
Asymmetric module
1-3°





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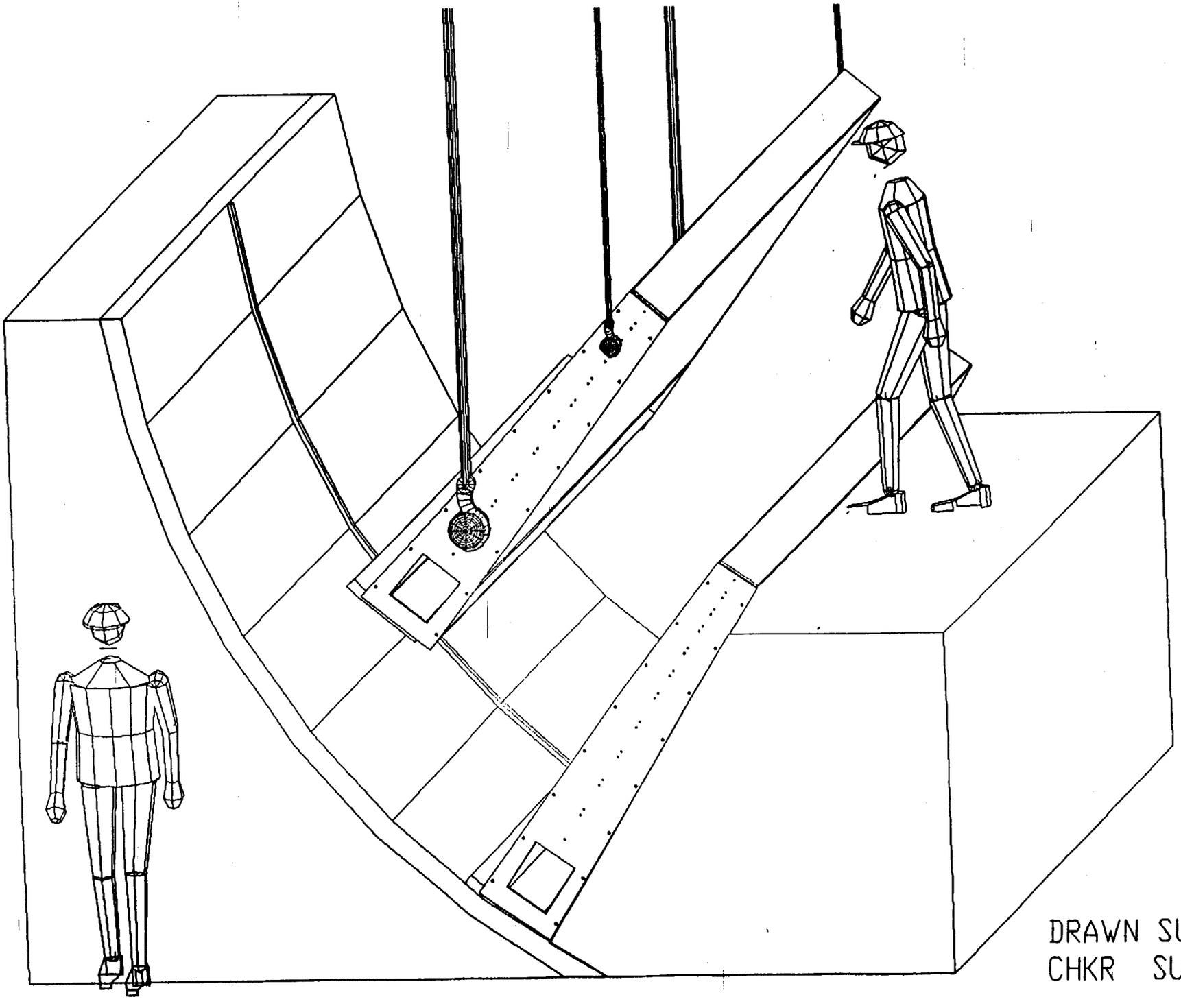

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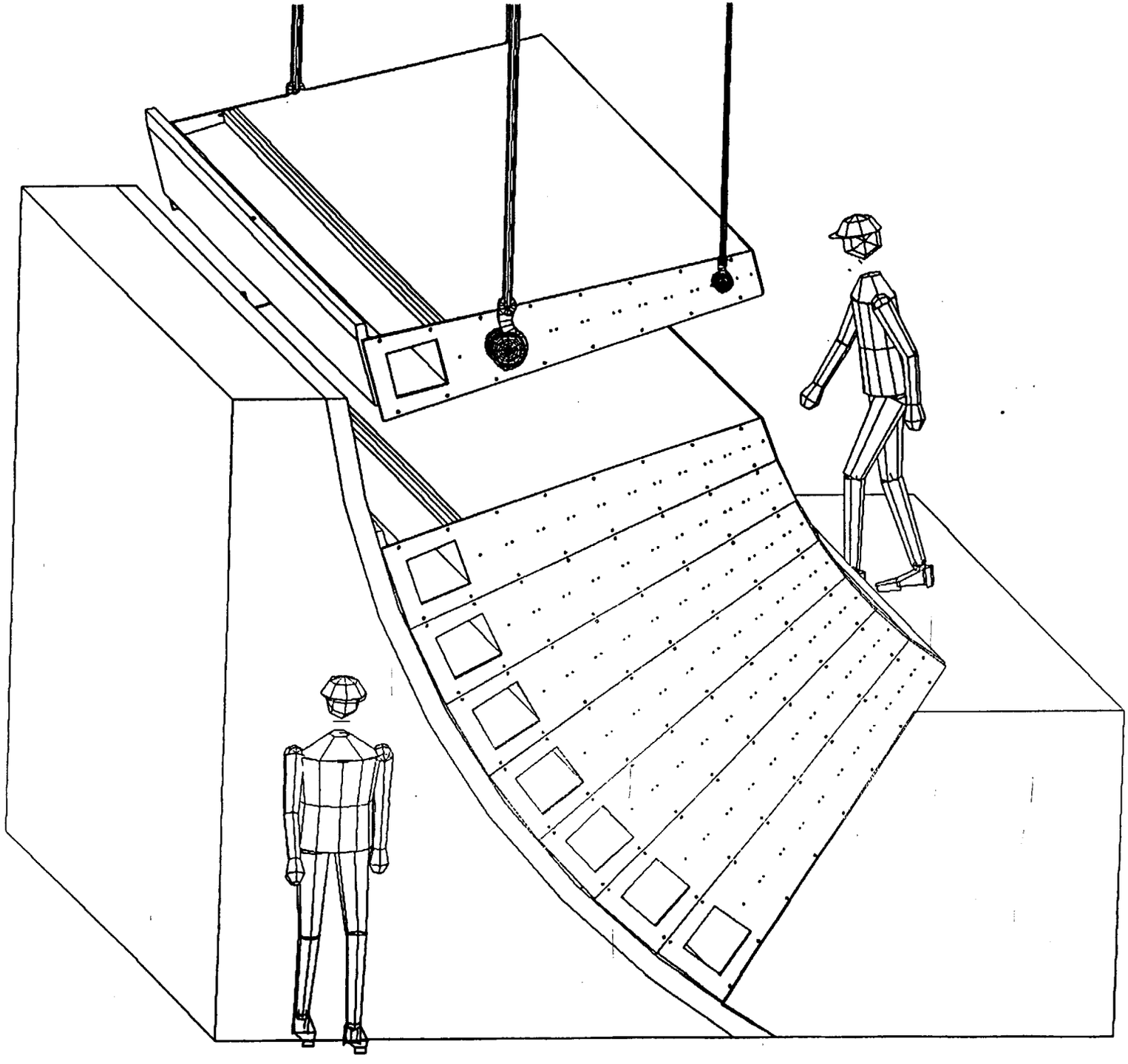

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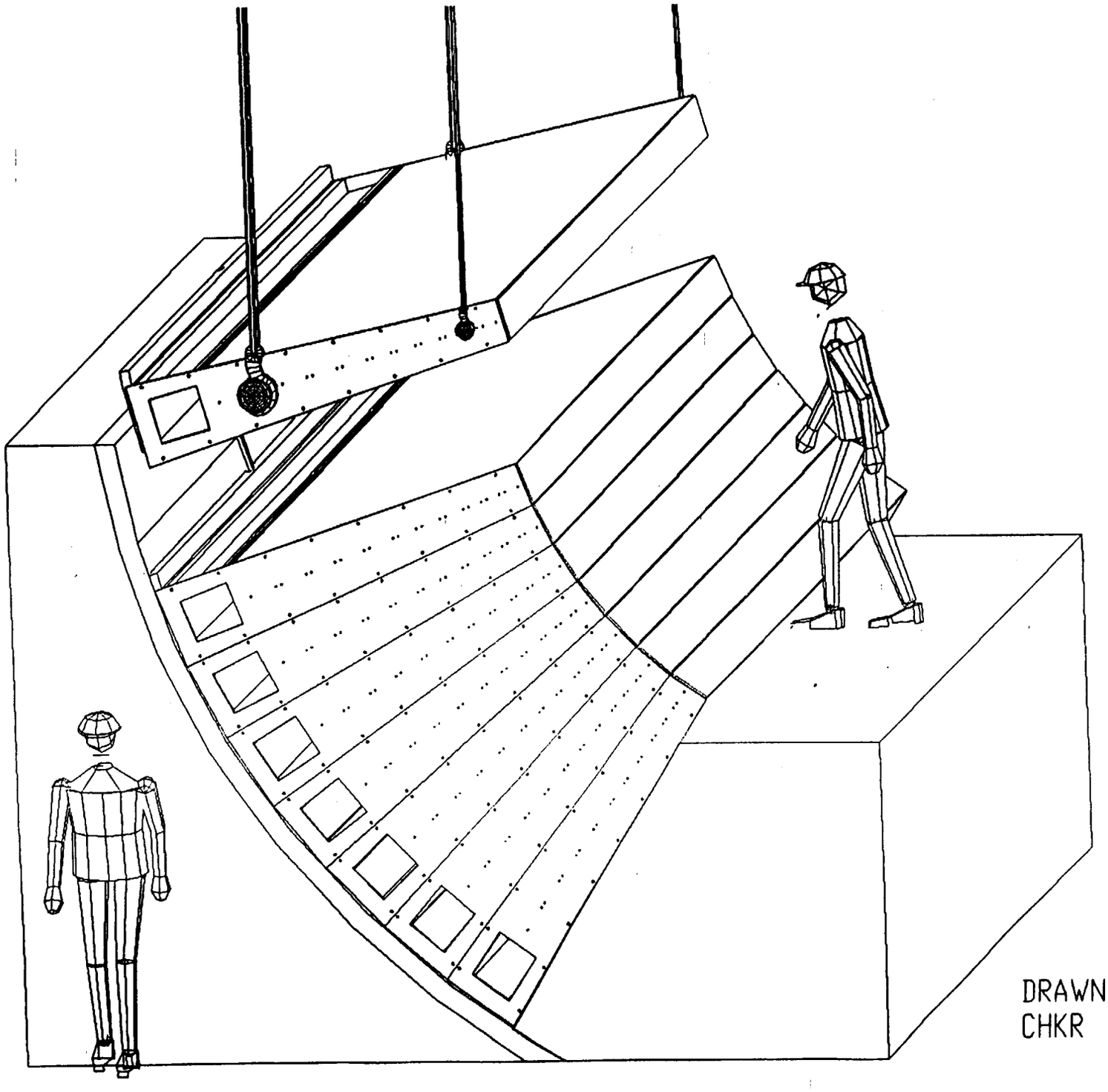

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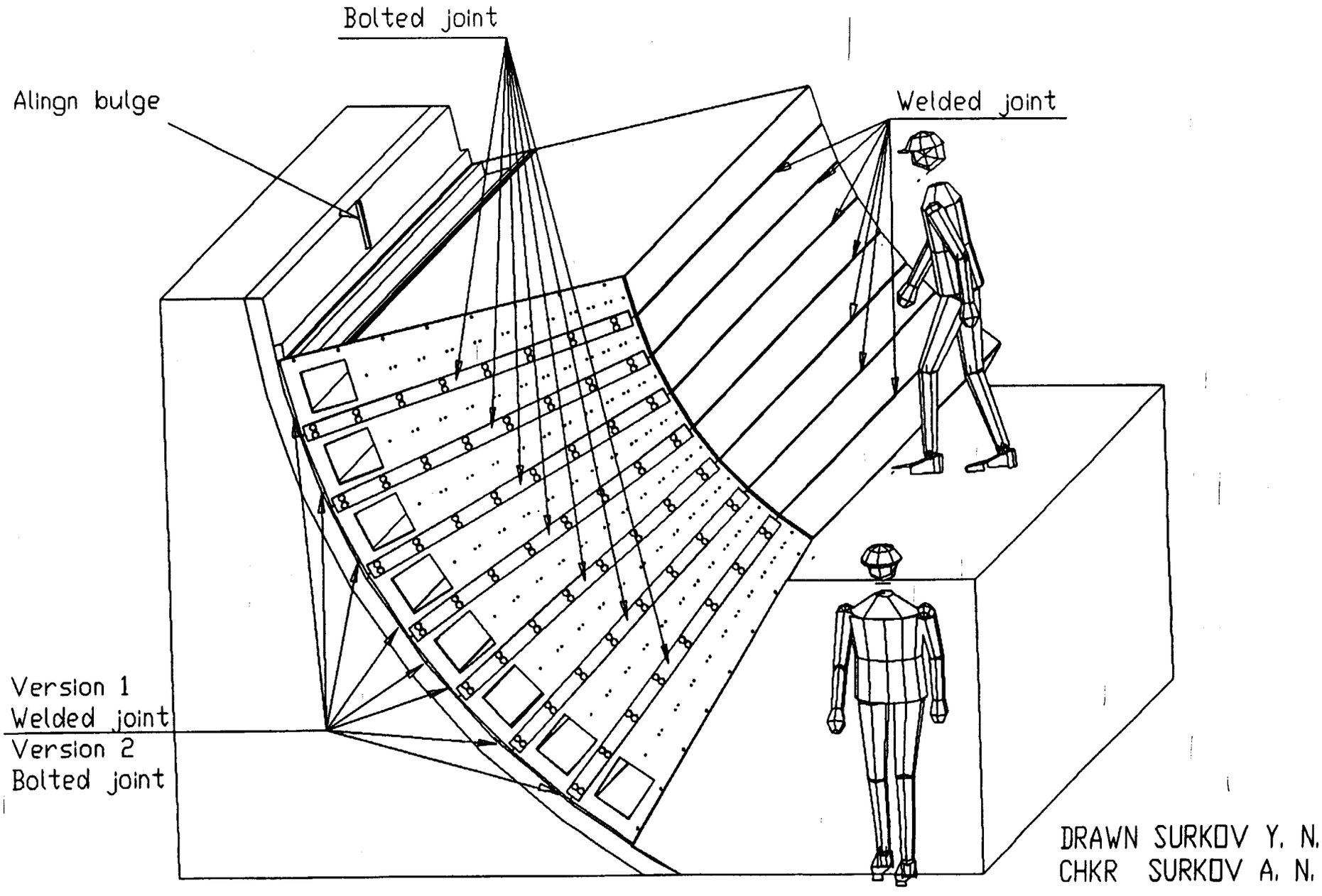
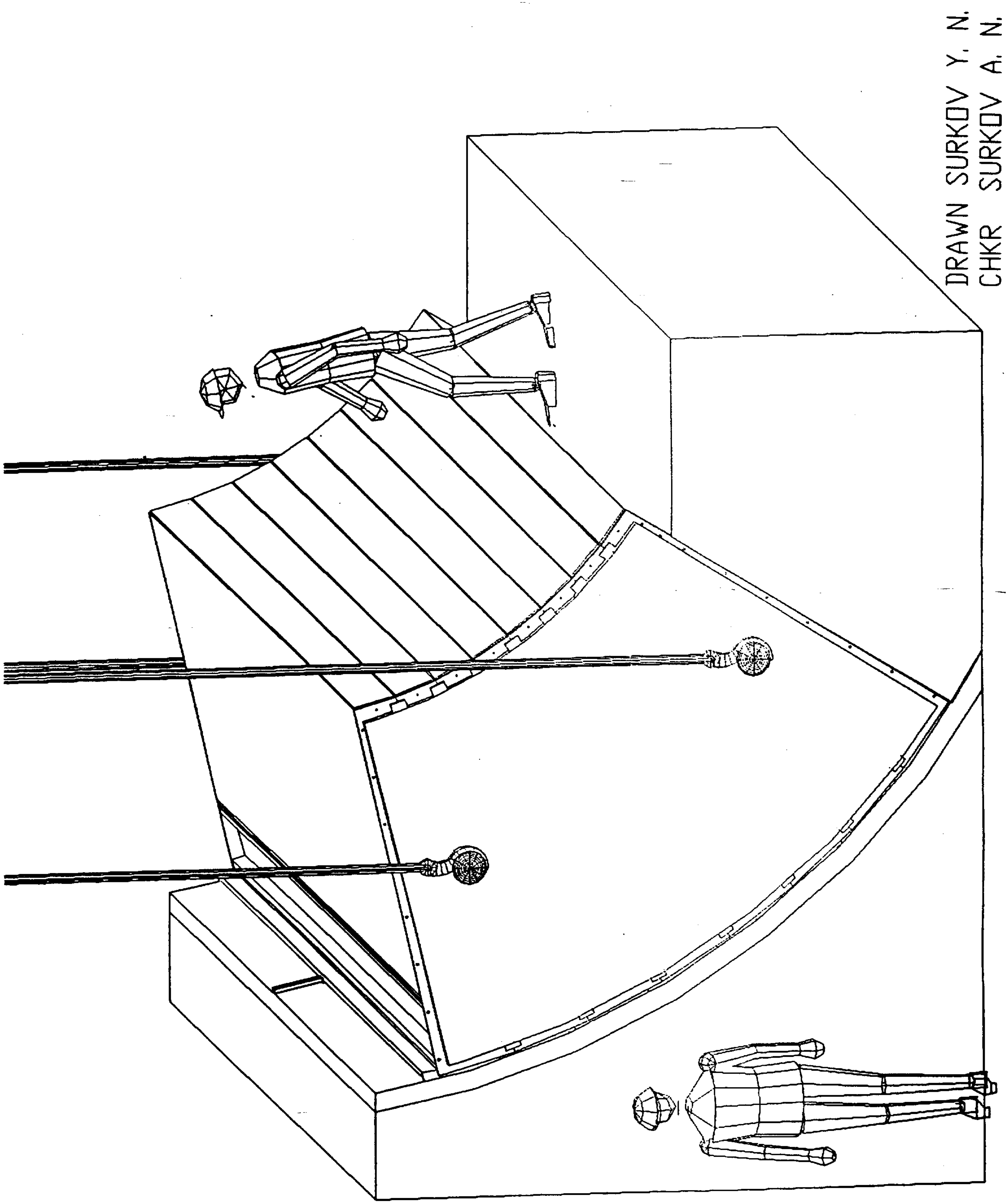

Bolted joint
Alingn bulge
Welded joint
Version 1
Welded joint
Version 2
Bolted joint
DRAWN SURKOV Y. N.
CHKR SURKOV A. N.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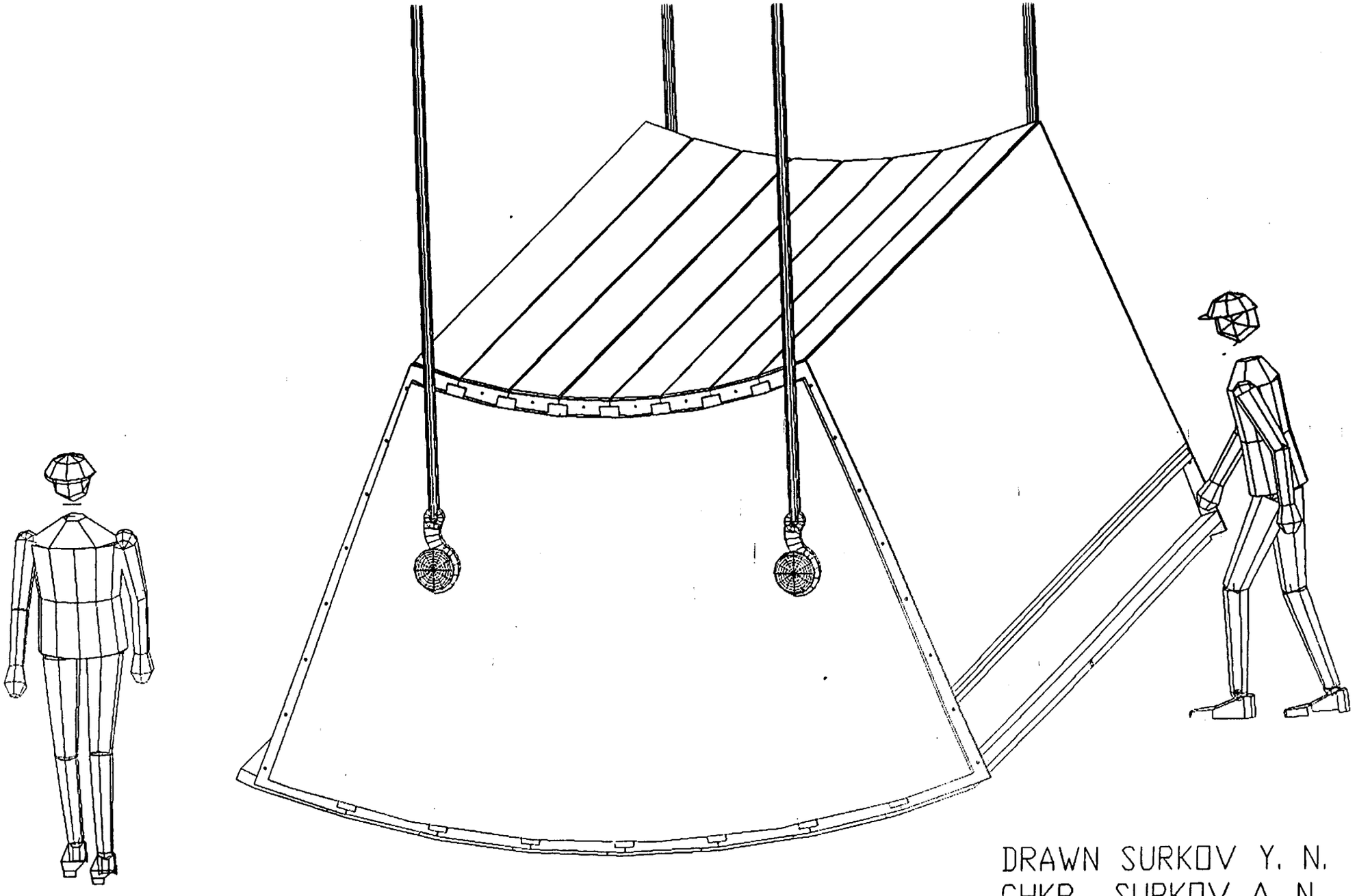

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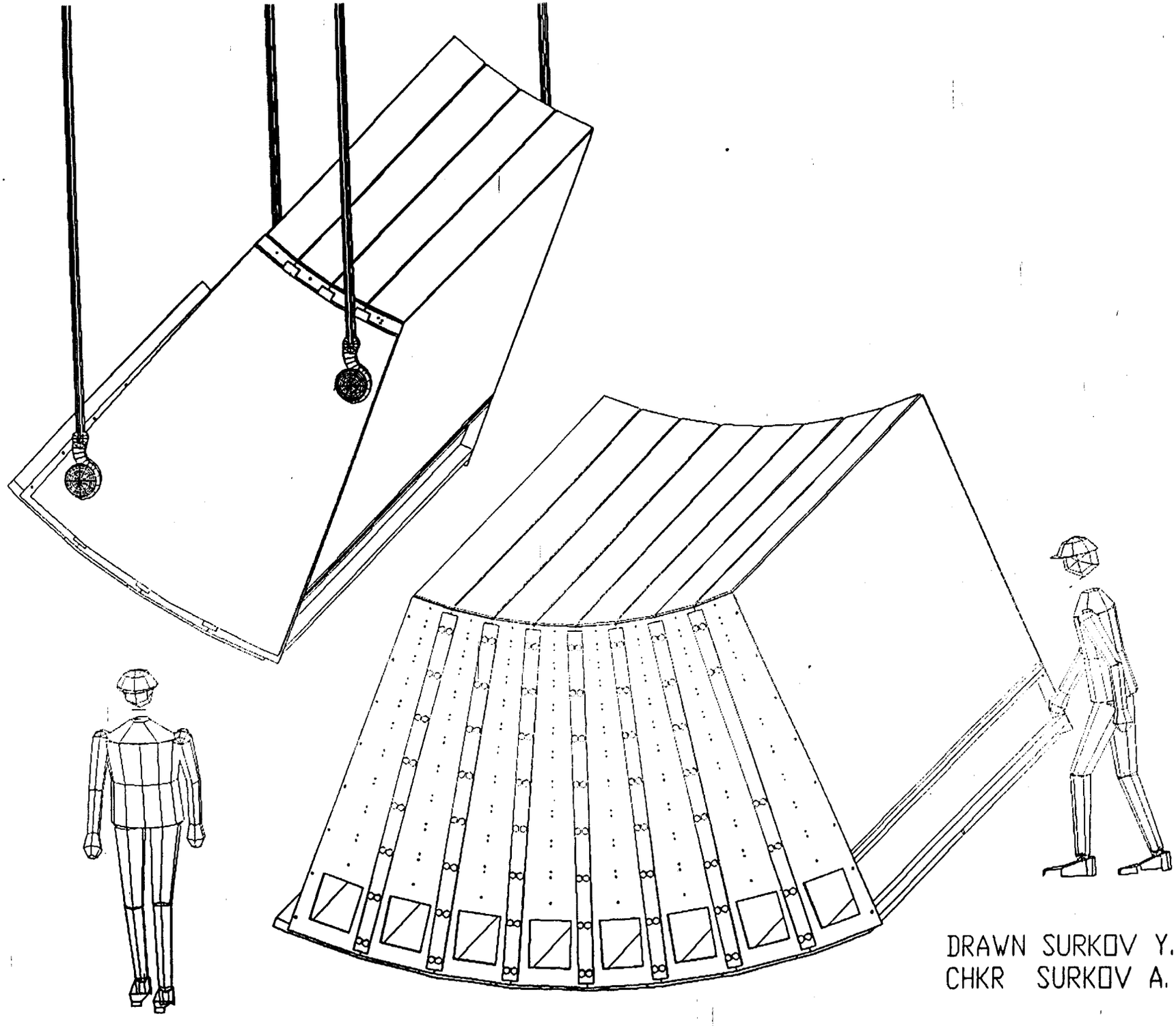

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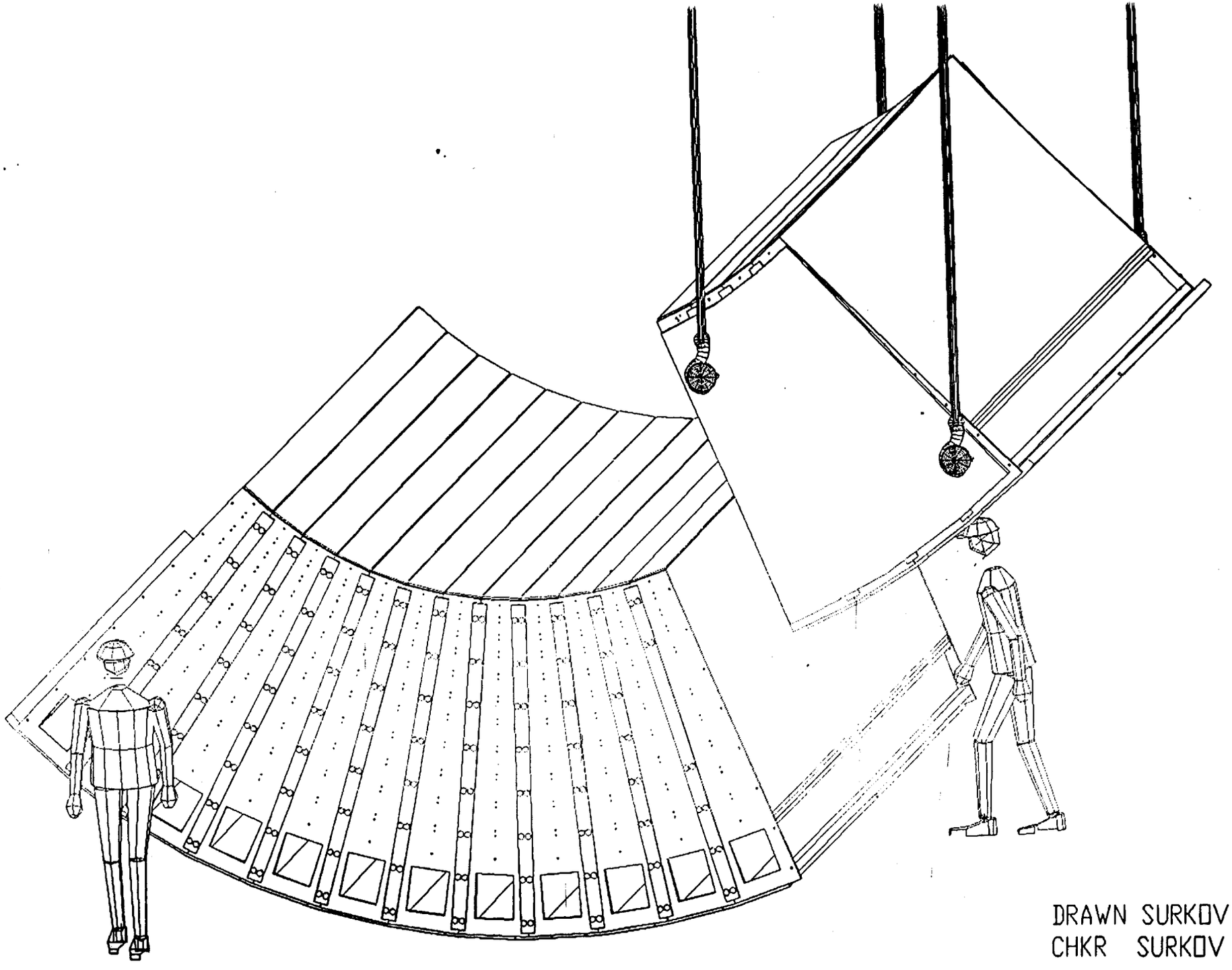


DRAWN SURKOV Y. N.
CHKR SURKOV A. N.

2. Supermodule. Design Philosophy and supermodule assembly.

- Supermodule the trapezium shape with the weight about 20T and sizes 5900x1950x(221÷412)mm is formed by the four supermodules fixed on the girder.

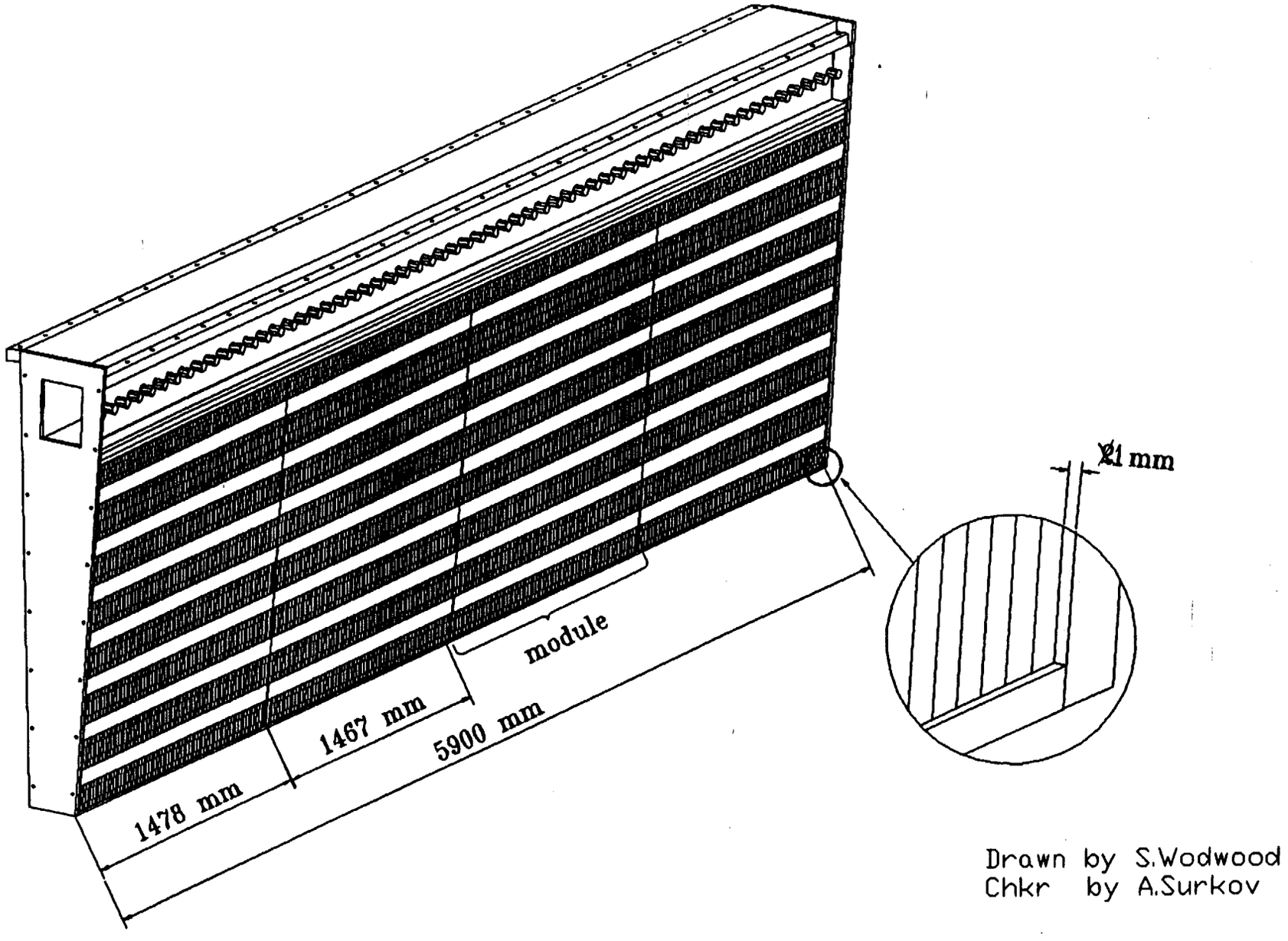
- The each edge module has the single end block with the thickness 20mm.

- The each module is connected with the adjacent one by the stainless steel rubber approximately 0.2mm thick with the help of the point welding.

- The calculation value of the gaps between each module is $\Delta = 0.3$mm.

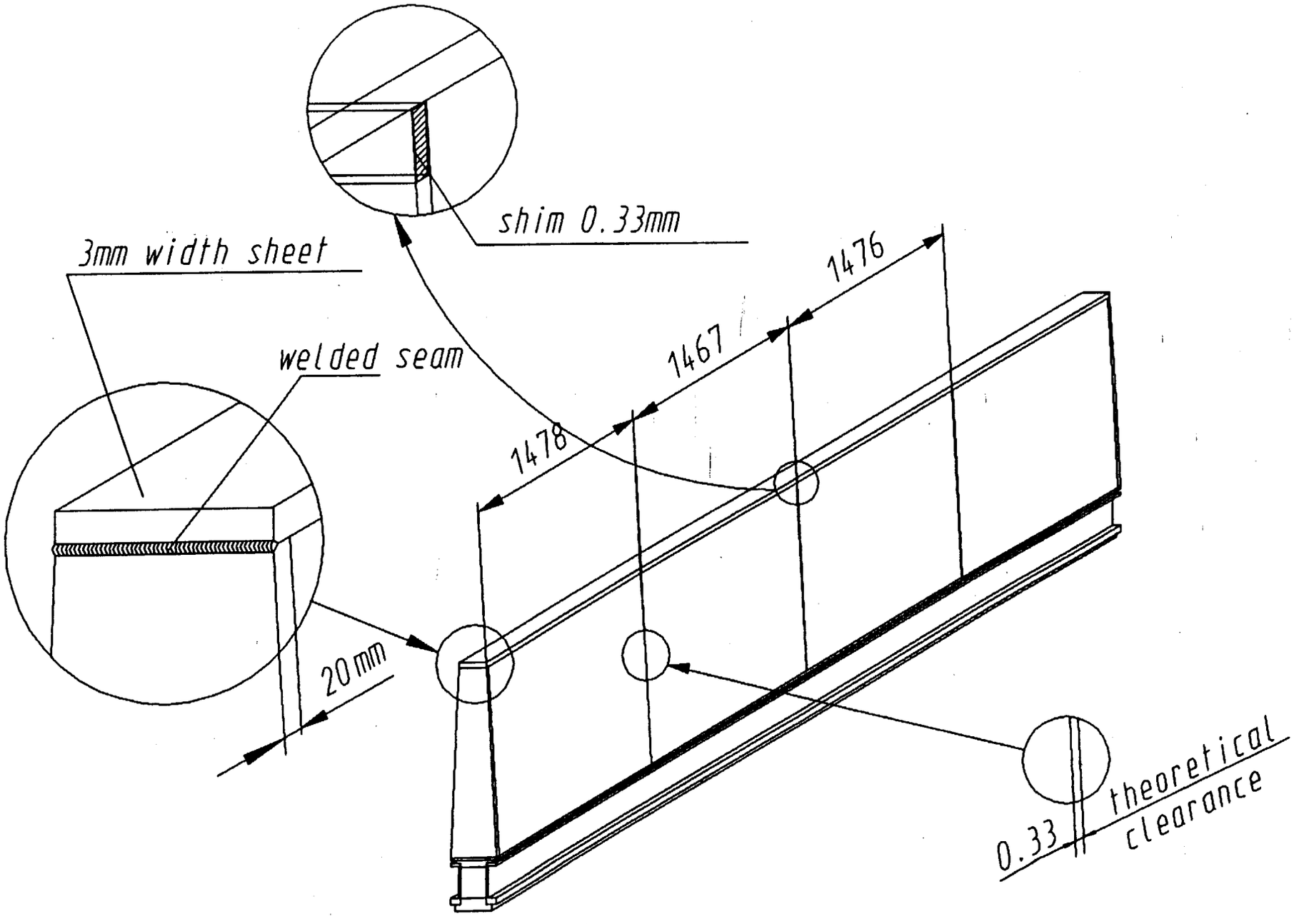
- The dividing of the supermodule by the single module:
  - provides the increasing of the accuracy for the coordinate matching of the each half-period on Z axis;
  - the expensive high-size stand isn't required for the supermodule assembly;
  - the transport problems are more simpler;

- the risk of the defect of the geometry for the assembled supermodules with the weight about 5T under the lifting and transportation is essentially lower than in the modules with the weight 20T and total sizes to 500mm;
- the proposed supermodule structure gives the opportunity to make the control assembly of the barrel end lids;
- the problems of the calibration for the PMT-s and modules on the beam are decided with more simple way.



Drawn by S.Wodwood
Chkr by A.Surkov

SUPERMODULE OF ATLAS HADRON CALORIMETER


shim 0.33mm
3mm width sheet
welded seam
1476
1467
1478
20 mm
0.33
theoretical clearance
Drow: Chernych S.

3. Module. Design Philosophy and assembly module.

- Individual module consists of periodic parts tied up with highstrength studs. From 12 to 15mm width plate is welded to a module along outer radius, 5÷10mm width plate can be welded by an intermittent scam on inner radius.

- To increase mechanical stability of a module its plates can be stressed, e.g., to pressure of 10÷15 kg/sm^2. The pressure can be maintained by use of stainless 0.1÷ 0.3mm width strips welded by spot-weld to plate ends.

- Use of tying strip's results in additional costs, but they allow to gain more stable geometry, scintillation plates and fibers gain additional proofing against possible mechanical damages.

- Trapezium's plates are leading components of the module. The plates (and hence module itself) can be made as symmetrical and asymmetrical ones about the axis on which tying studs are arranged.

It looks reasonable that modules are made with some asymmetry. Introduction of asymmetry allows:
- to eliminate possible loss of particles whose trajectories have radial direction in the zone of clearances between supermodules;
- to widen installation clearances between supermodules without loss of Hadron calorimeter resolving property. Moreover of widening of clearance results in reducing the price of supermodule construction simplification of assembly.

- Introduction of asymmetry seems to allow to increase resolving property of Hadron calorimeter. The question is in need of additional study.

- Assembly of module can be carried out on assembly jig that allows to change space orientation of the module during its assembly.

- Assembly of module is carried out from preliminary assembled metal plates, each of them is arranged with basing on two planes with making secure of designed position of scintillation plates by studs.

- Assembly jig allows to test of scintillation plates and fibers quality at given pressure of stress. As required imperfect scintillation plates and fibers can be replaced until complete assembly.

- Tension of tying studs and strips is maintained with hydraulic devices with a control system of given tension.

- At use of tying strips spot-weld of them is reasonable not only to end plates but to intermediate plates, this will increase stiffness and geometrical stability of module essentially.

The Estimation of Rod Stresses

The purpose of this study is roughly estimate the stresses of the rods clamping up the module structure of ATLAS Hadron Calorimeter.

1. Specs:

- number of rods $n_{rod} = 22$
- diameter of rod $d_{rod} = 6mm$
- compression in module structure $p = 0.5$ MPa.

2. The compression square is equal to half of the square of module shape plate due to the spacers between tiles.

$$S_{comp} = 0.5\, S_{plate} = 0.5 \cdot 0.5\,(0.373+0.222) \cdot 1.53 = 0.23\ m^2$$

3. Total force of compression

$$F_{tot} = S_{comp} \cdot p = 0.23 \cdot 0.5 = 0.115\ MPa$$

4. The tensile force of one rod (in assumption that the tensile force of all rods are the same)

$$F_{rod} = F_{tot} / n_{rod} = 0.115 / 22 = 5.2 \cdot 10^{-3}\ MN$$

5. Tensile stresses in the rod

$$\sigma_t = F_{rod} / S_{rod} = 4F_{rod} / \pi d_1^2$$

where $d_1 = 4.9mm$ – inner diameter of thread M6

$$\sigma_t = 4 \cdot 5.2 \cdot 10^{-3} / \pi\,(4.9 \cdot 10^{-5})^2 = 274\ MPa$$

6. The suggested material of the rod is alloy steel 38XH3MΦA (C-Cr-Ni-Mo-Va-Al) with properties:

yield strength	$\sigma_y = 880$ MPa
ultimate strength	$\sigma_u = 980$ MPa
hardness	227...352 HB
allowable tensile stresses	$[\sigma_t] = 450$ MPa

7. Safety margin for the rod

$$SM_{rod} = [\sigma_t] / \sigma_t = 450 / 274 = 1.6$$

8. During the assembly of tiles into module half of the rods are removed and replaced with tubes Ø6×1 for calibration purposes. So the rod tensile stresses may exceed the allowable stresses for the rod material.

FILE NAME: RODSTR BY BORISOV.E

In that case the steel strips may be added for remaining specified compression in module structure. The strips are lap spot welded to the module shape plates.

9. In assumption that half of the compression force is maintained by rods and another half is maintained by strips the number of strips is defined as

$$n_{strip} = 0.5\, F_{tot} / F_{strip}$$

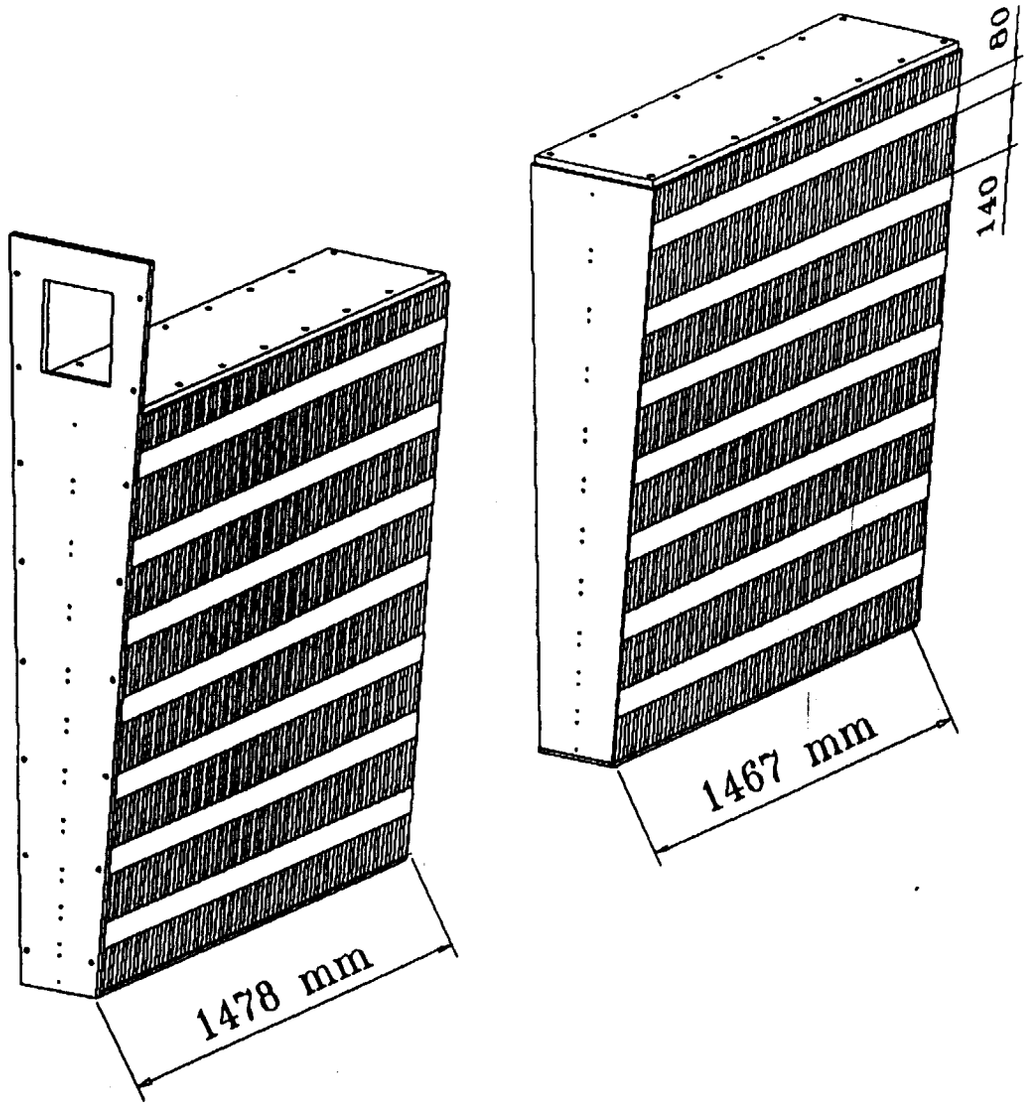
where $F_{strip} \approx 4...6$ KN is the bearing strength of welded strip. It was experimentally tested for stainless steel strip 80mm width and 0.12mm thickness.

$$n_{strip} = 0.5 \cdot 0.115 / 4 \cdot 10^{-3} \approx 14$$

10. The strips are smoothed out on both sides of module with ~140mm gap as shown on figure.

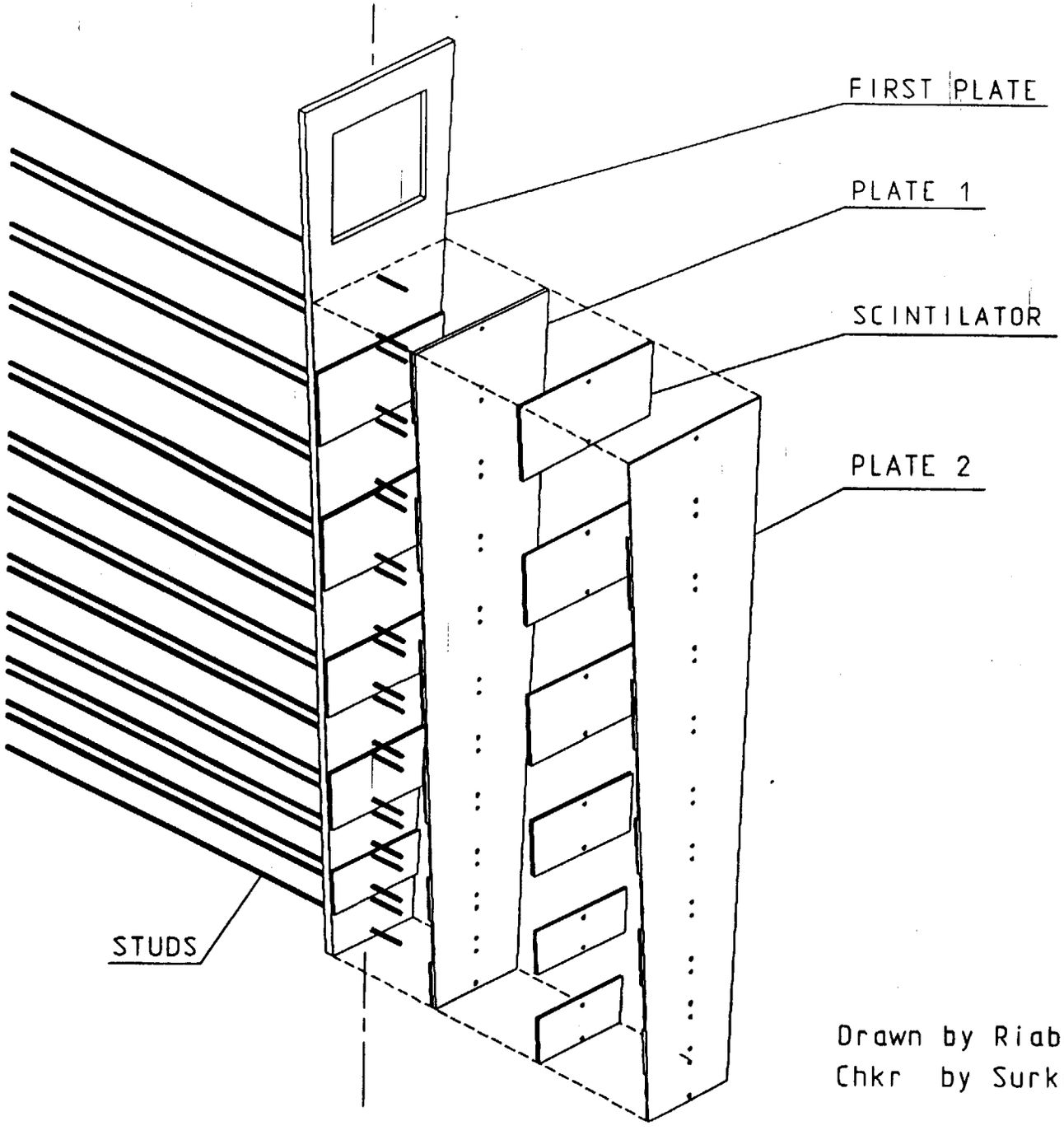
11. Conclusion:

- the rod safety margin when all rods are inserted is equal to 1.6;
- the rod safety margin when half of rods are inserted is equal to 0.8;
- the rod safety margin when half of rods are inserted and 14 stainless steal strips 80mm width and 0.12mm thickness are tighten with force 4KN each is equal to 1.6.



Drawn by Riaboshapko
Chkr by A.Surkov

FIRST & SECOND MODULES OF SUPERMODULE



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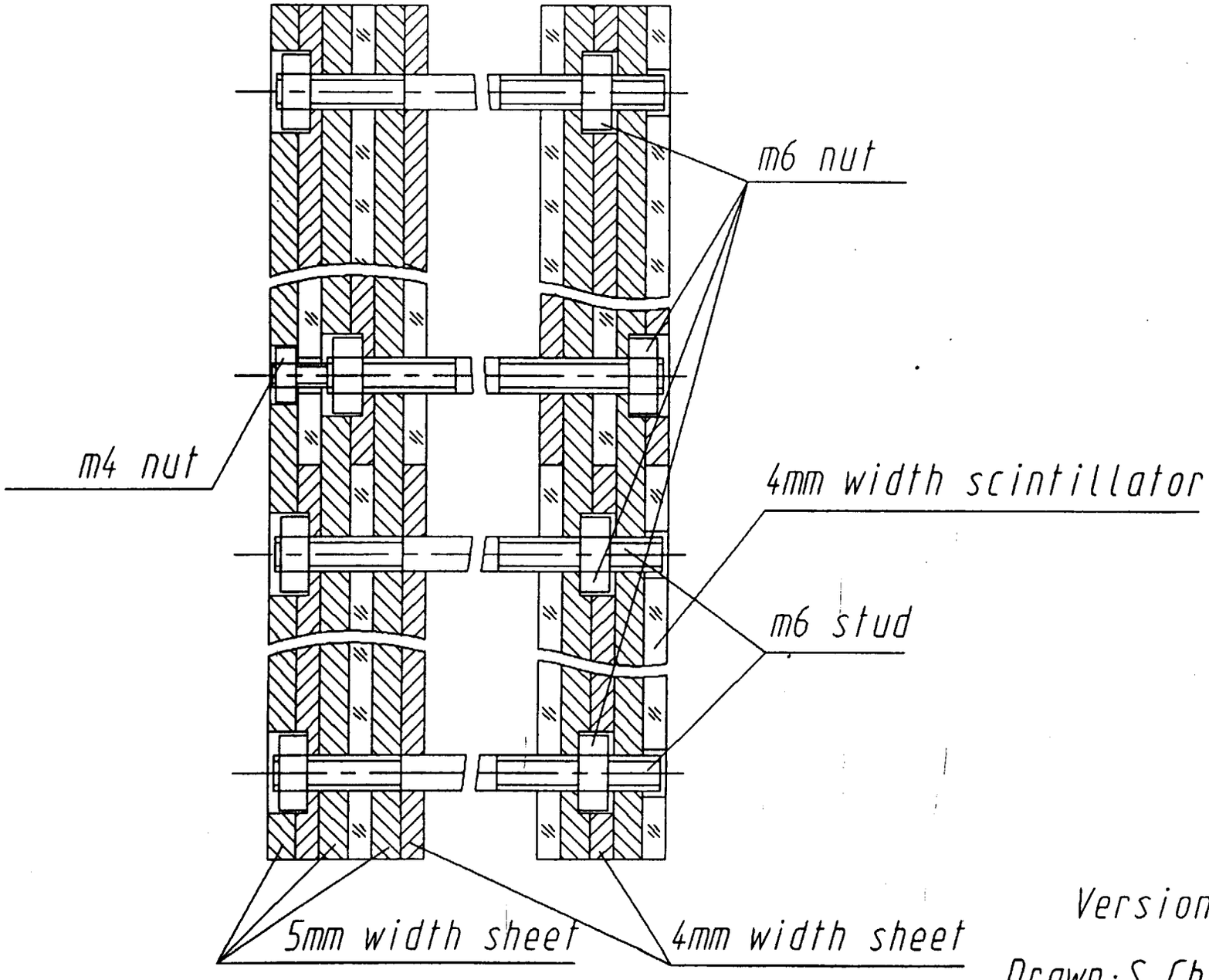
Chkr by Surkov

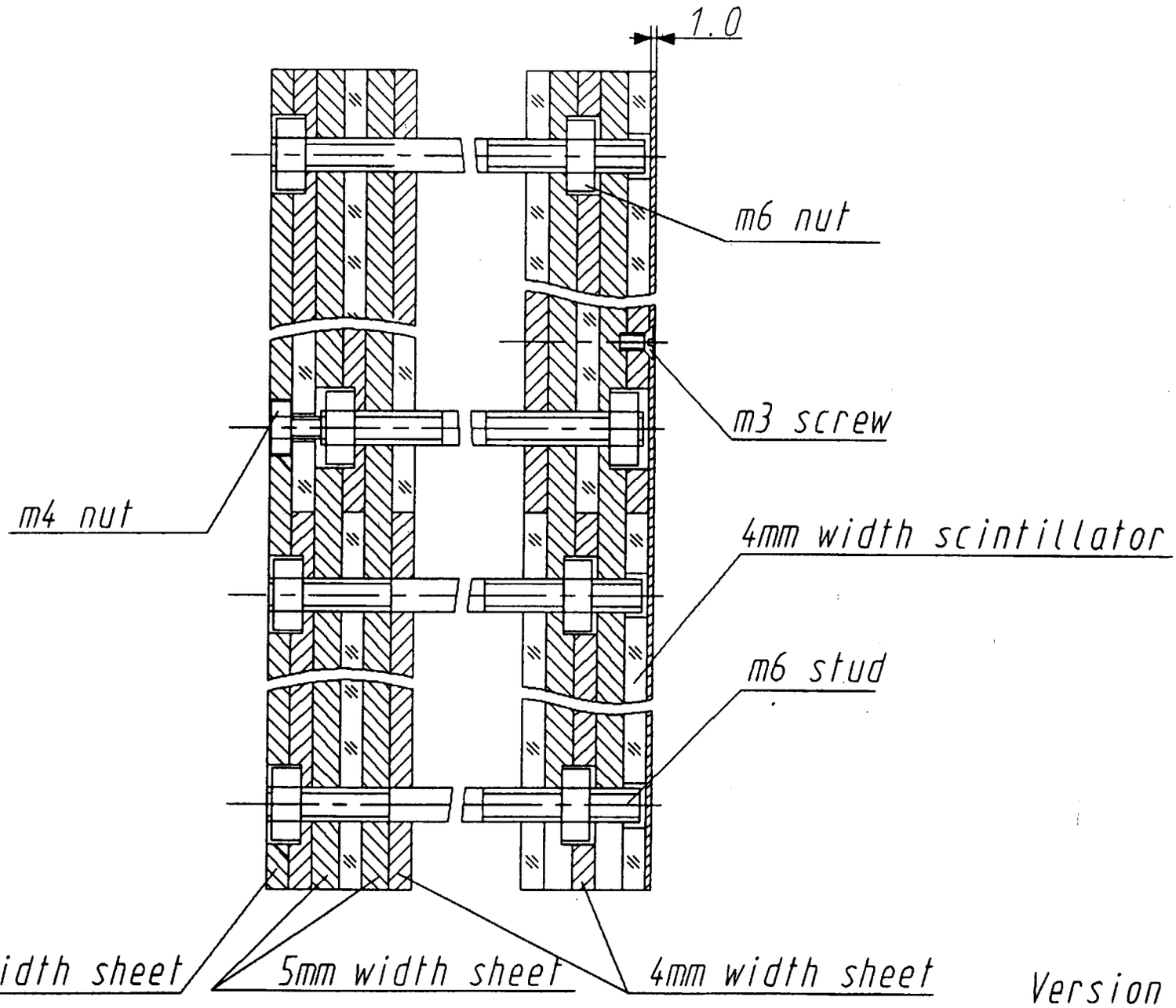
Assembly of first half-period.



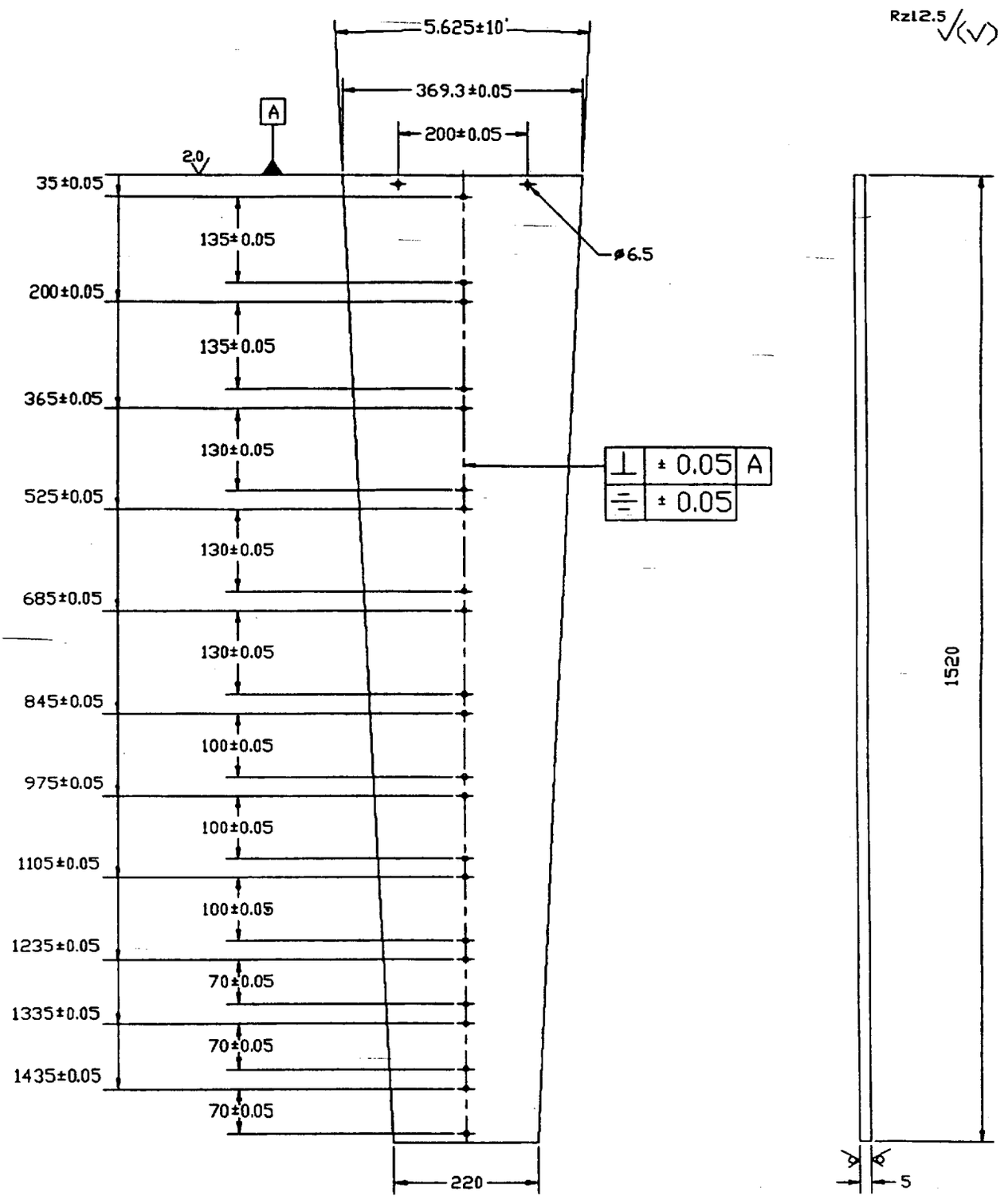
Version 1

Drawn: S. Chernych

Chkr: A. Surkov



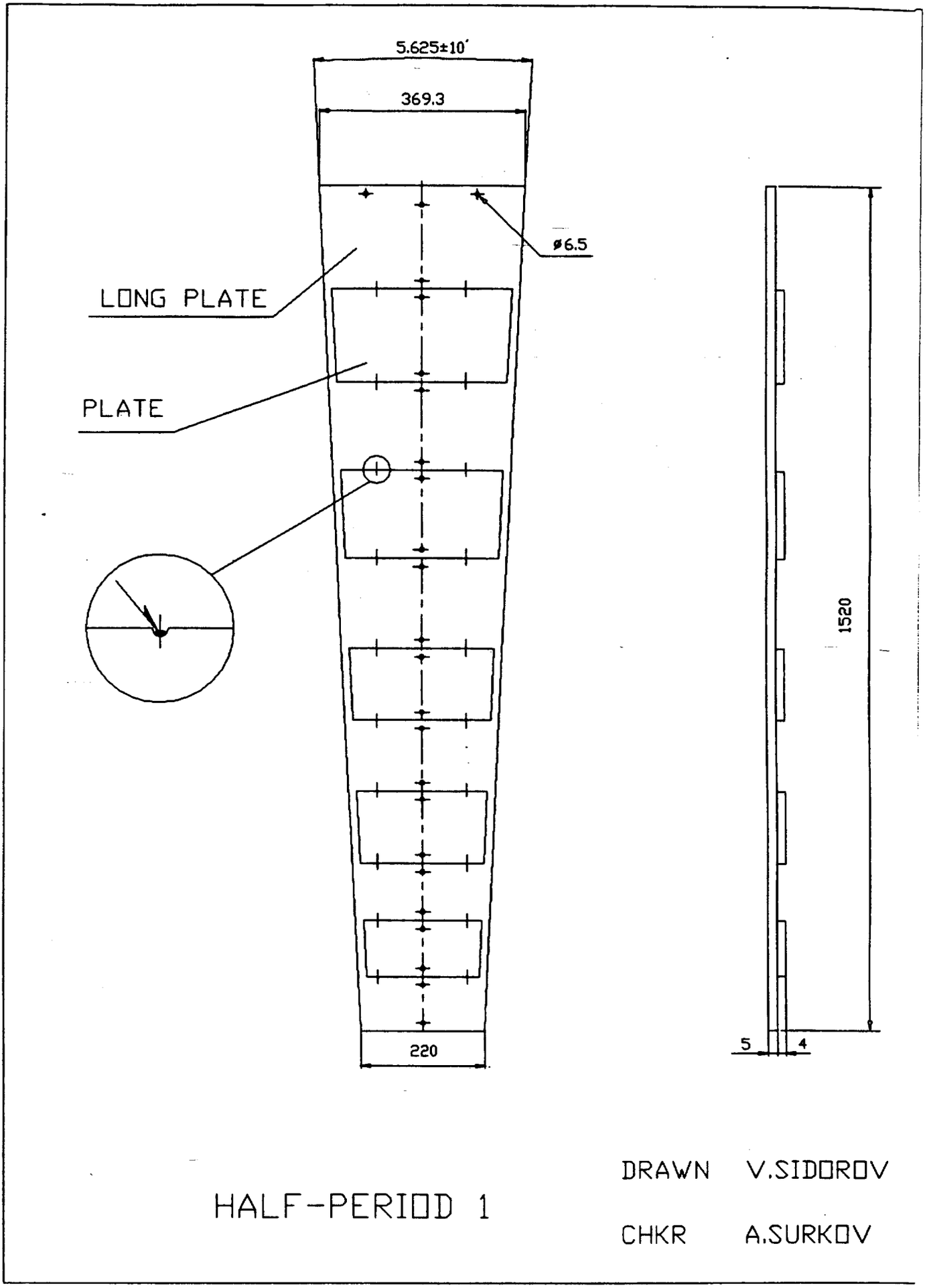
Version 2
Drawn: S. Chernych
Chkr: A. Surkov



LONG PLATE

DRAWN V.SIDOROV

CHKR A.SURKOV



HALF-PERIOD 1

DRAWN V.SIDOROV

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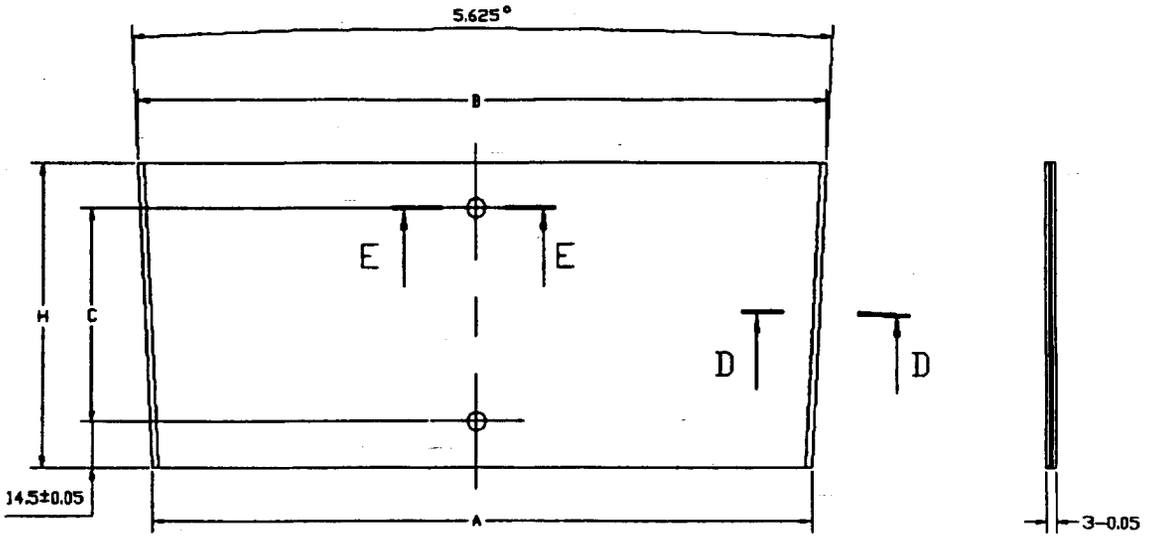
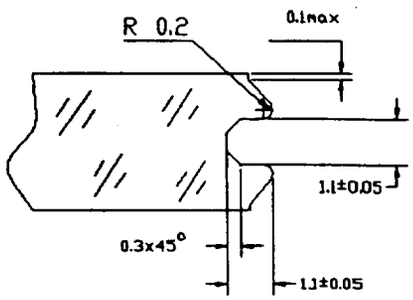
0.032

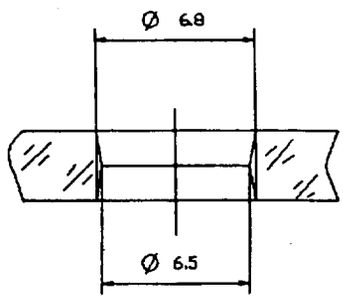


N	A	B	C	H
1	218	227.7	70 ± 0.05	99
2	227.8	237.5		
3	237.6	247.4		
4	247.5	260.1	100± 0.05	129
5	260.2	272.9		
6	273	285.7		
7	285.8	301.4	130± 0.05	159
8	301.5	317.1		
9	317.2	332.8		
10	332.9	349	135 ± 0.05	164
11	349.1	374.2		

D-D



E-E

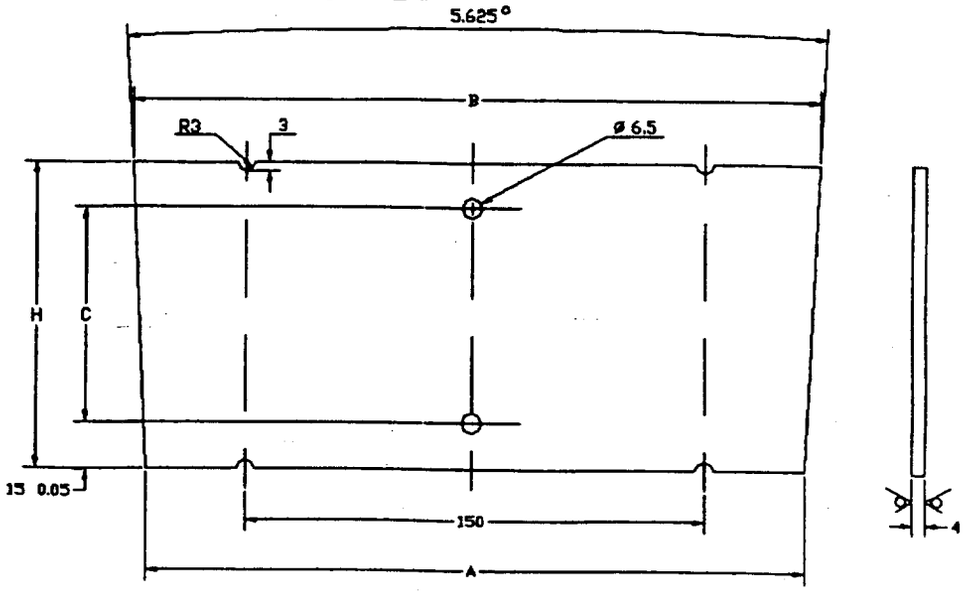


TUILE

DRAWN V.SIDOROV

CHKR A.SURKOV

Rz12.5

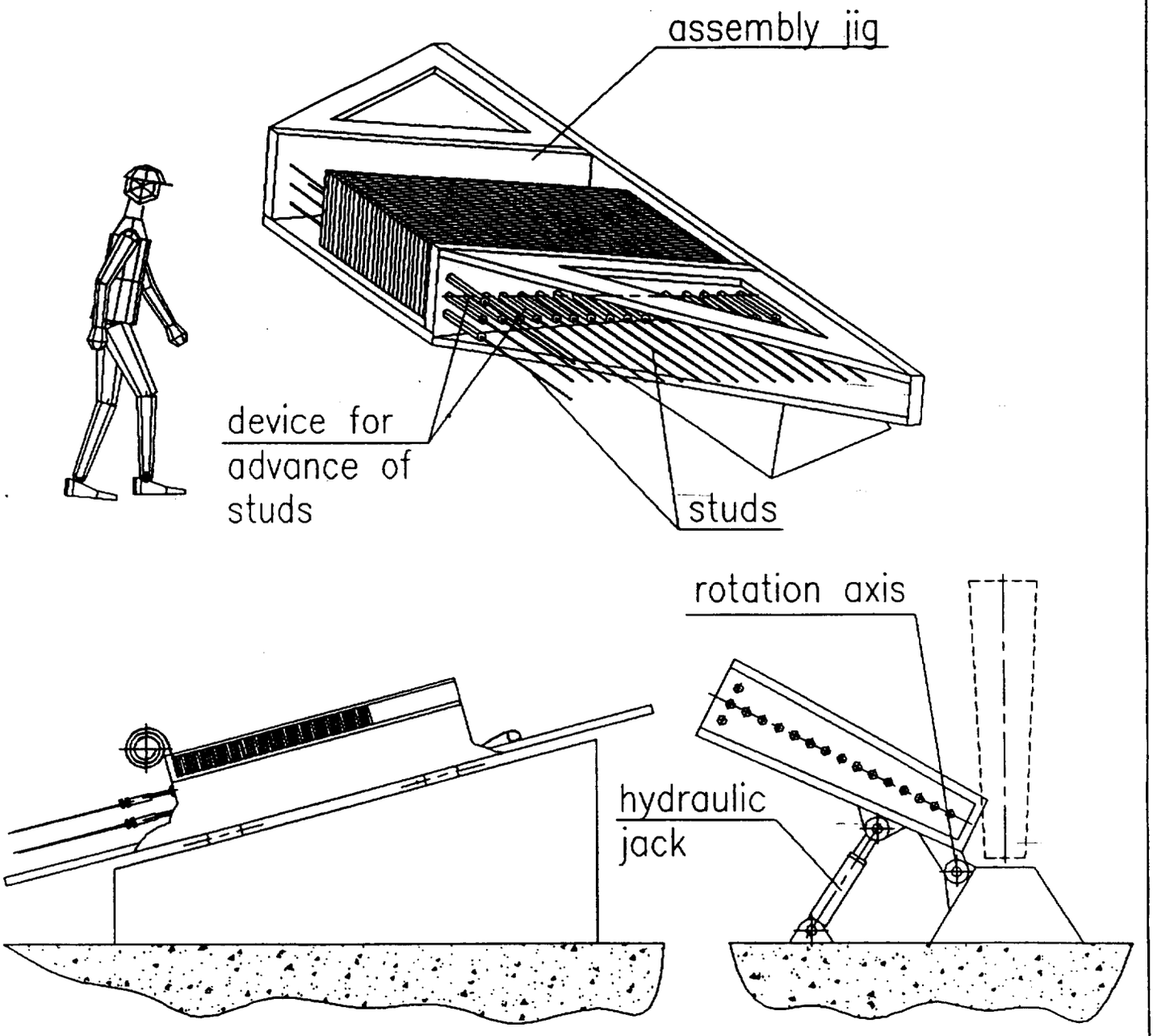


N	A	B	C	H
1	215	224.8	70 0.05	100
2	224.8	234.6		
3	234.6	244.5		
4	244.5	257.2	100 0.05	130
5	257.2	270		
6	270	282.8		
7	282.8	298.5	130 0.05	160
8	298.5	314.2		
9	314.2	329.9		
10	329.9	346.1	135 0.05	165
11	346.1	371.3	135 0.05	165

PLATE

DRAWN V.SIDOROV

CHKR A.SURKOV



Installation of metal plates into assembly jig, advance of studs.

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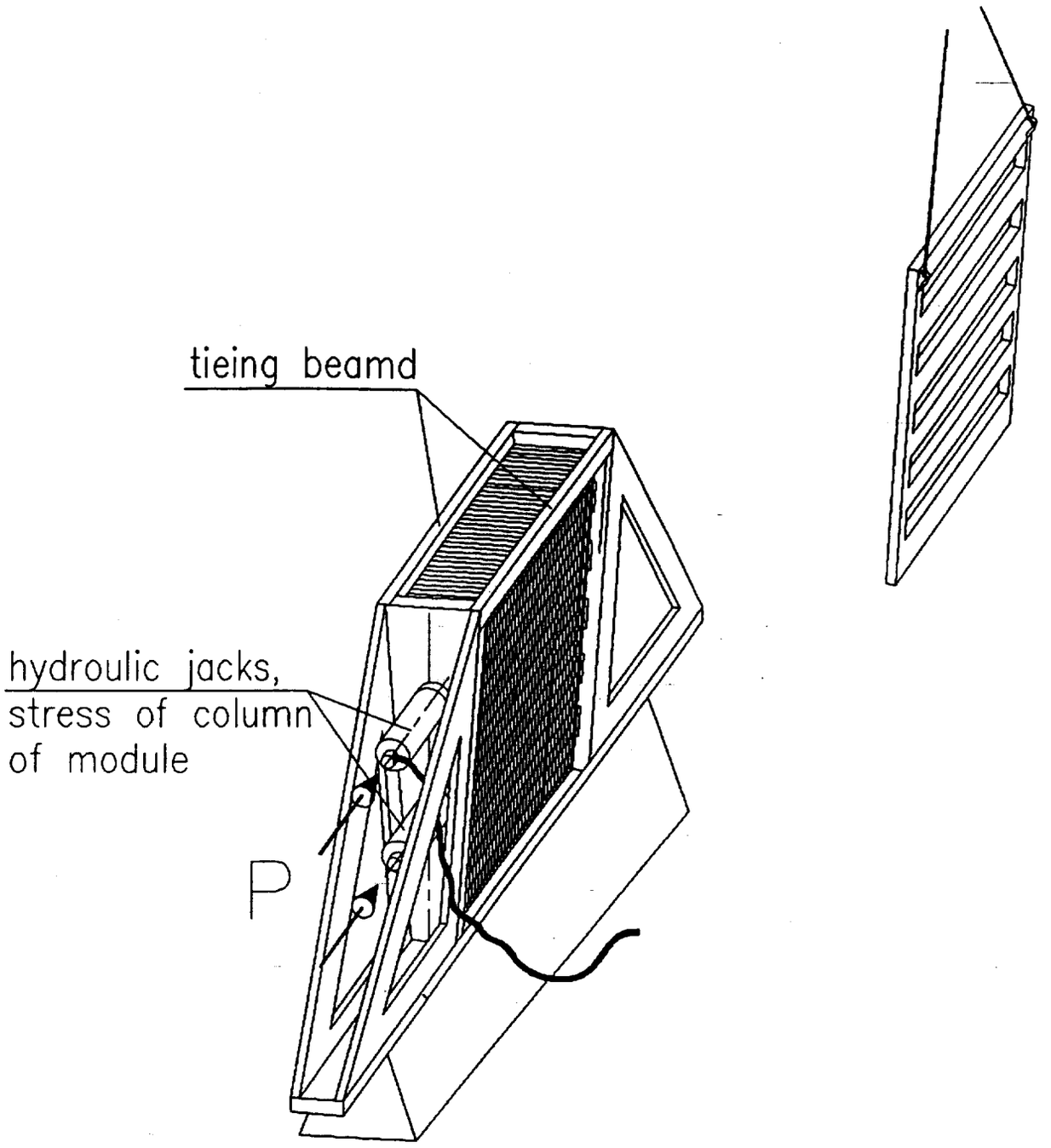
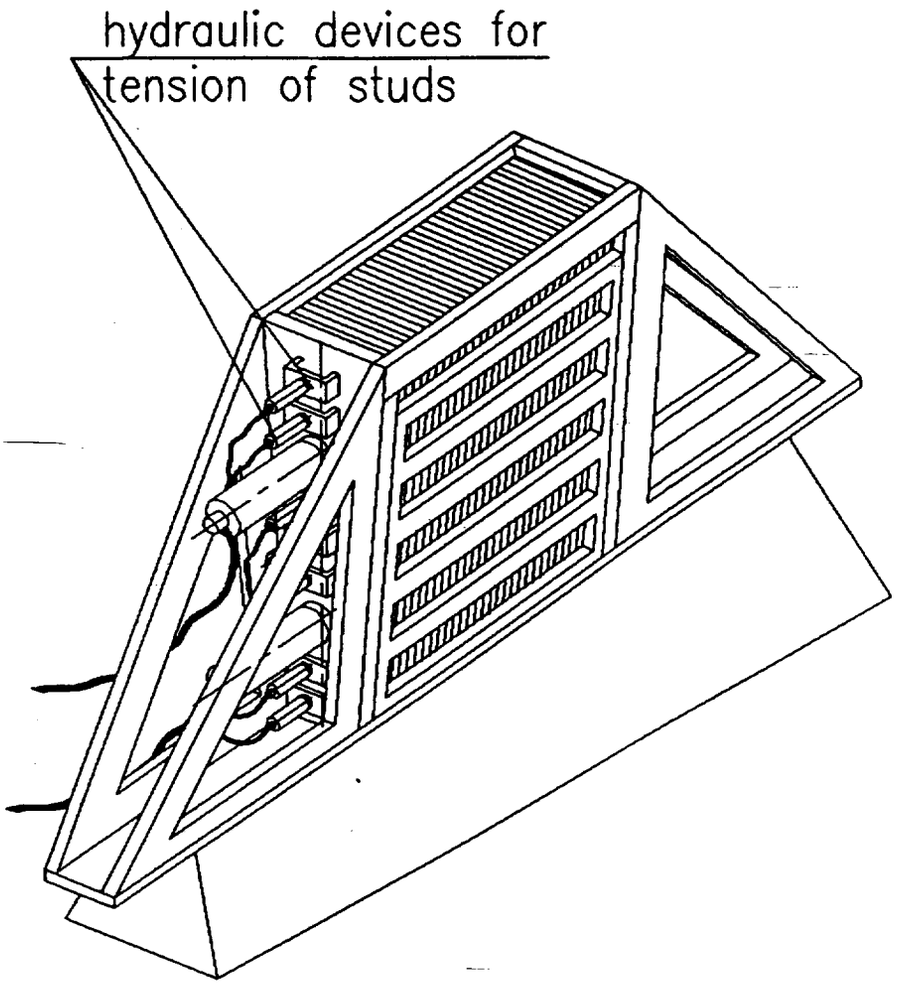
Chkr by A.Surkov



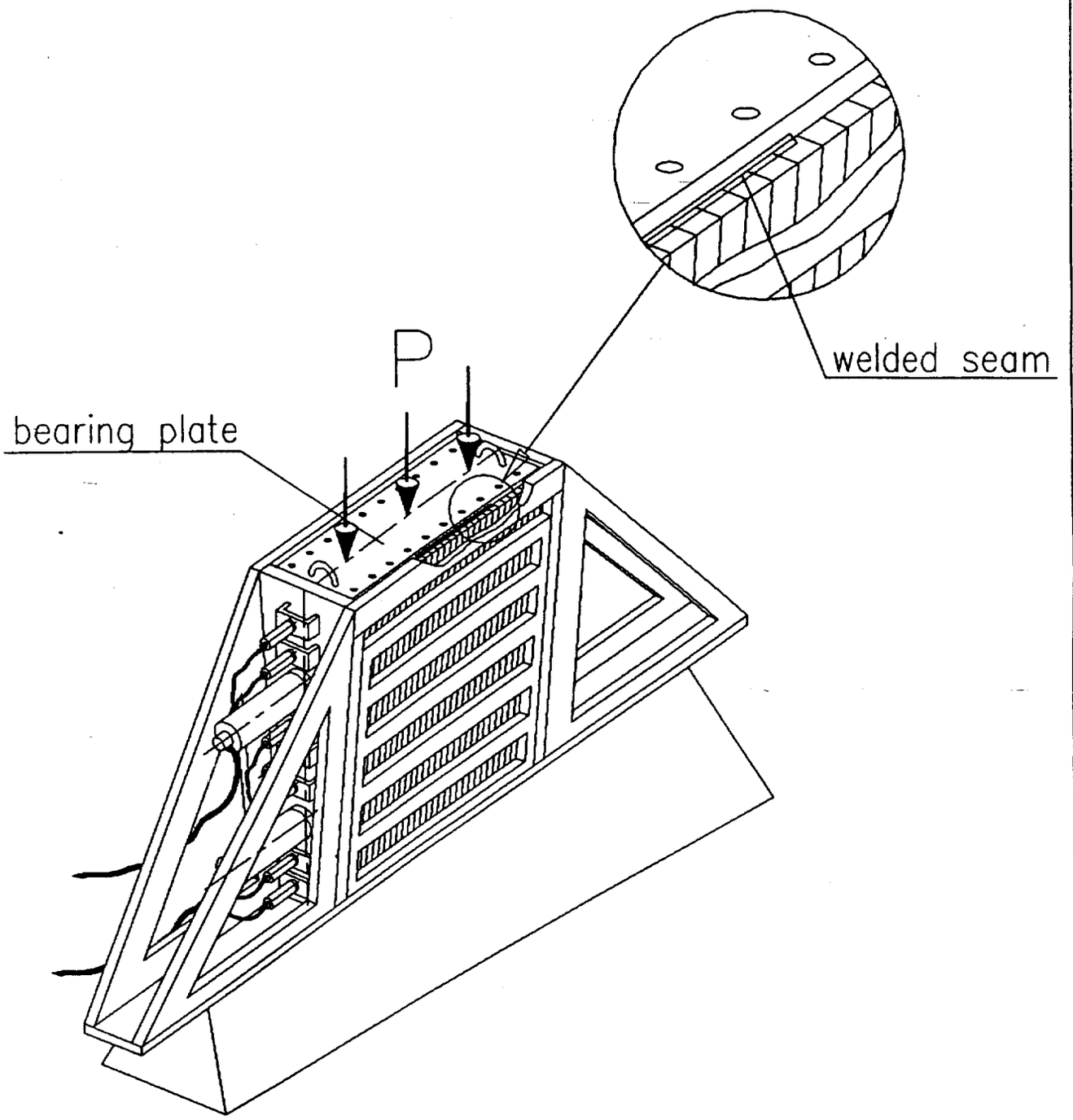
1. Finish of module assembly, installation of tieing beams, rotation of jig to the vertical position.
2. Installation of sides.
3. Strees of module column.

Drawn by S.Trifonov
Chkr by A.Surkov



1. Installation of hydraulic device for tension of studs.
2. Carrying out of tension.

Drawn by S.Trifonov
Chkr by A.Surkov



Installation of bearing plate, weld of it to plates.

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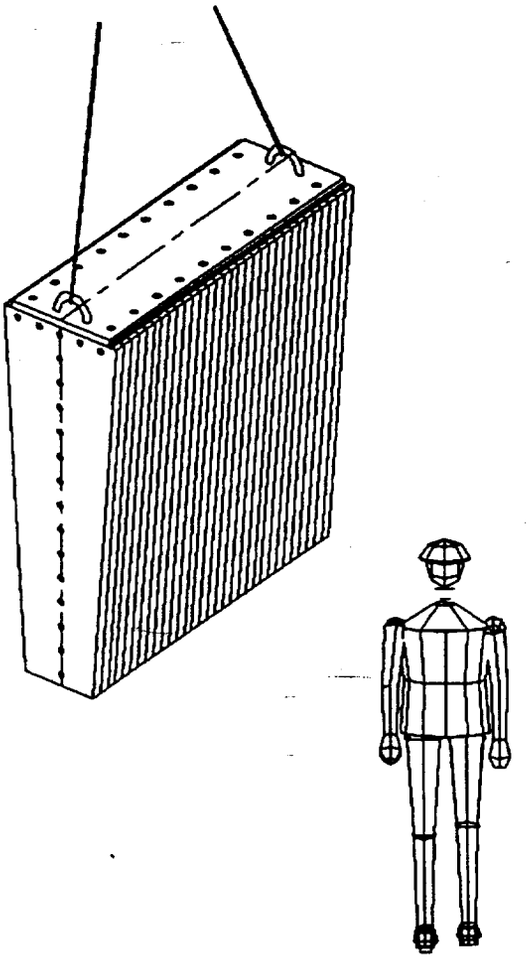
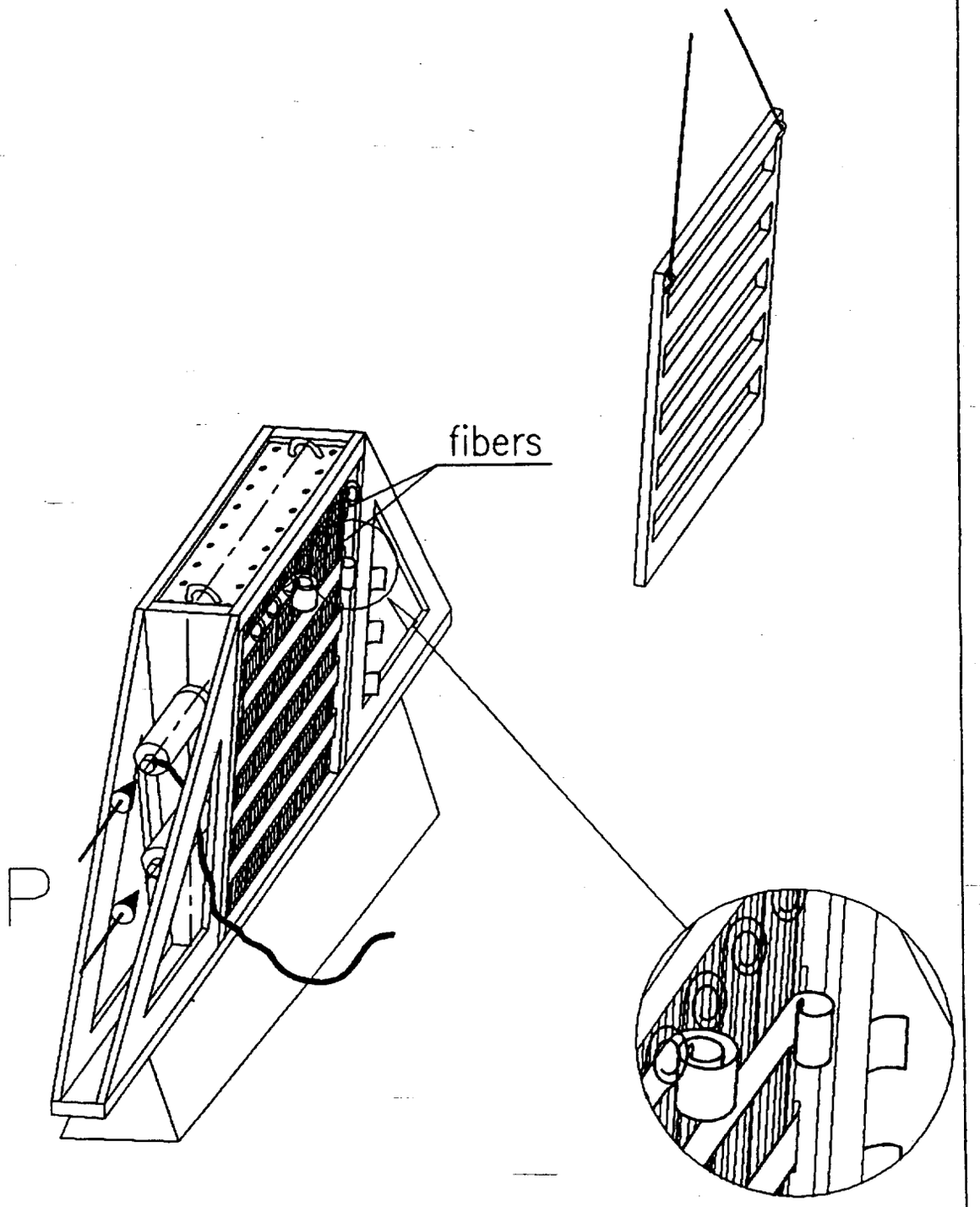
Chkr by A.Surkov



Transportation of module to machining of bearing plate.

Drawn by S.Trifonov
Chkr by A.Surkov



1. Mounting of module into assembly jig.
2. Installation of scintillators, fibers, proofing shields, fastening of strips, installation of sides.

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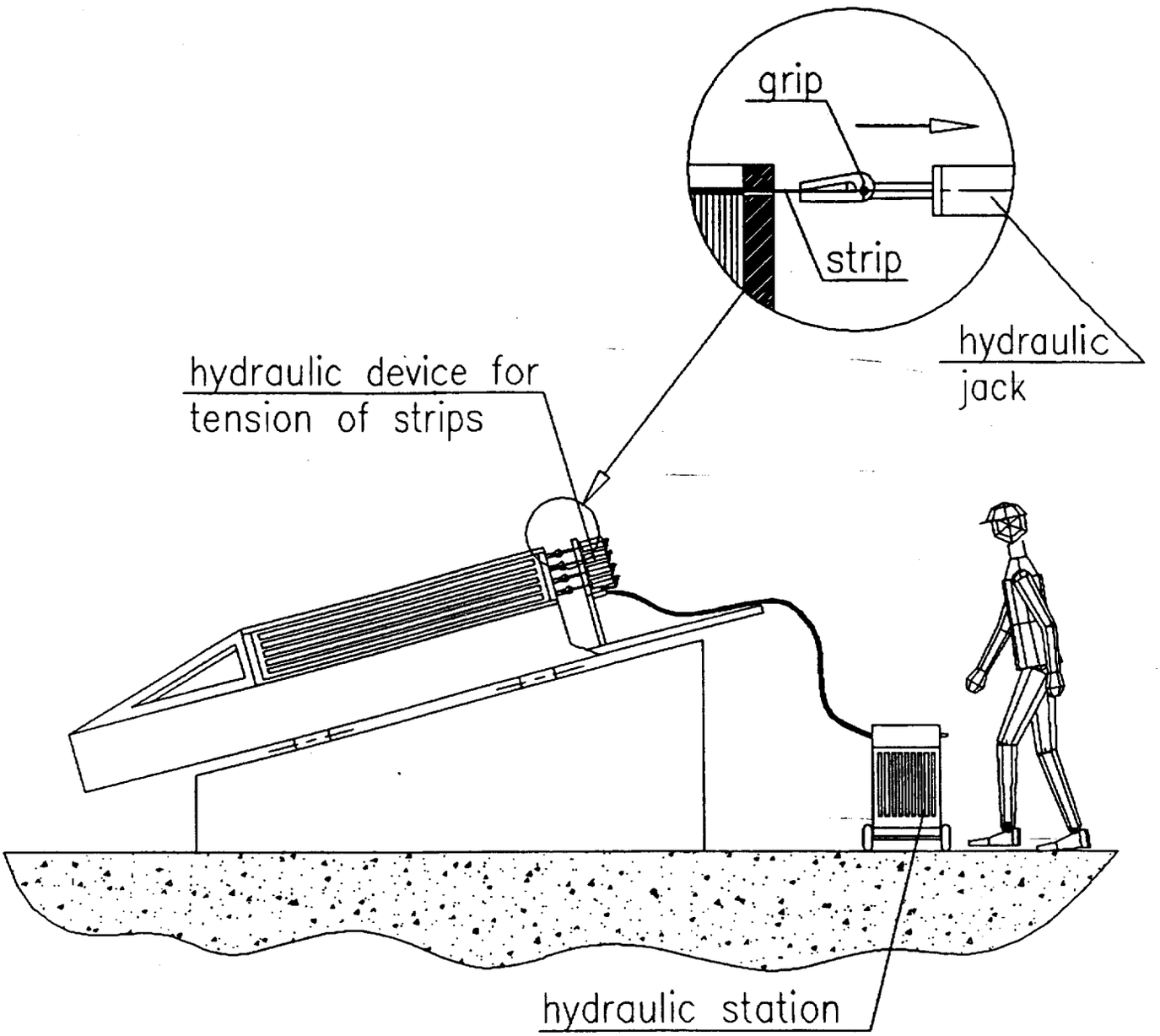

1. Installation of hydraulic devices for tension of strips.
2. Carrying out of tension.

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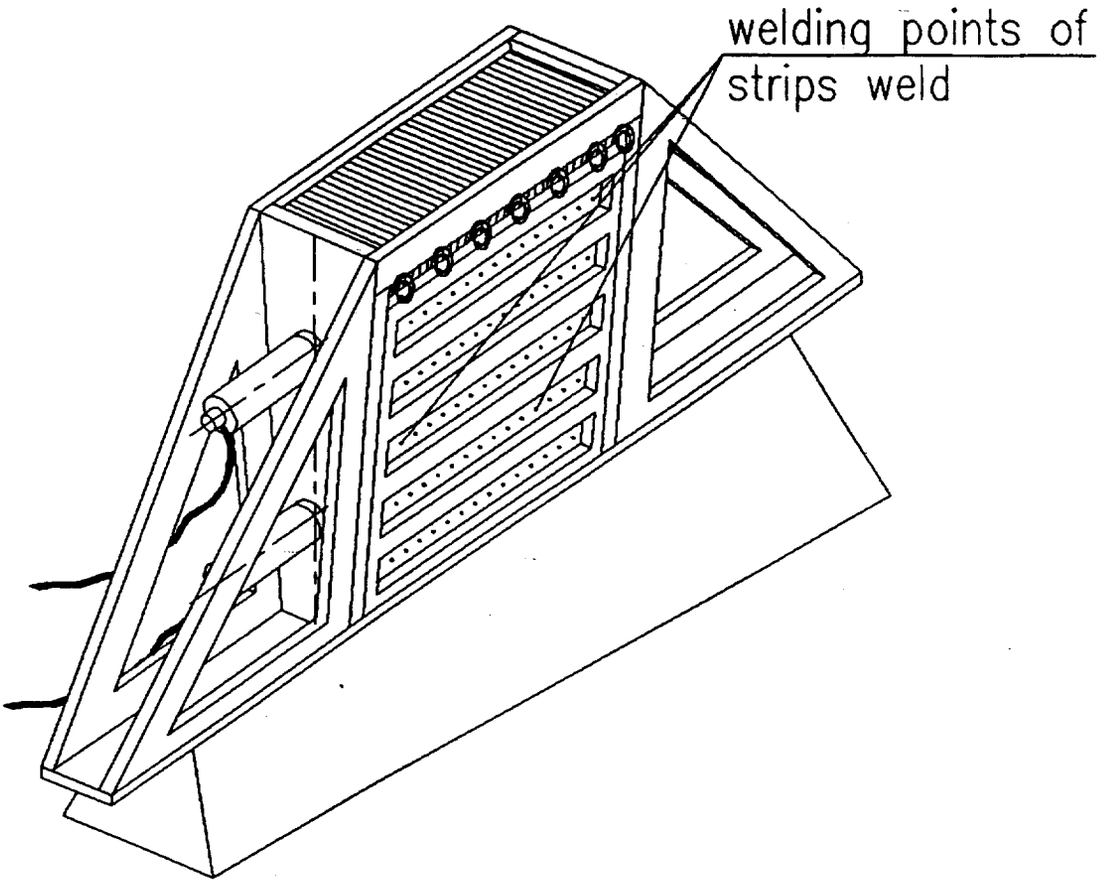

Weld of strips to plates.

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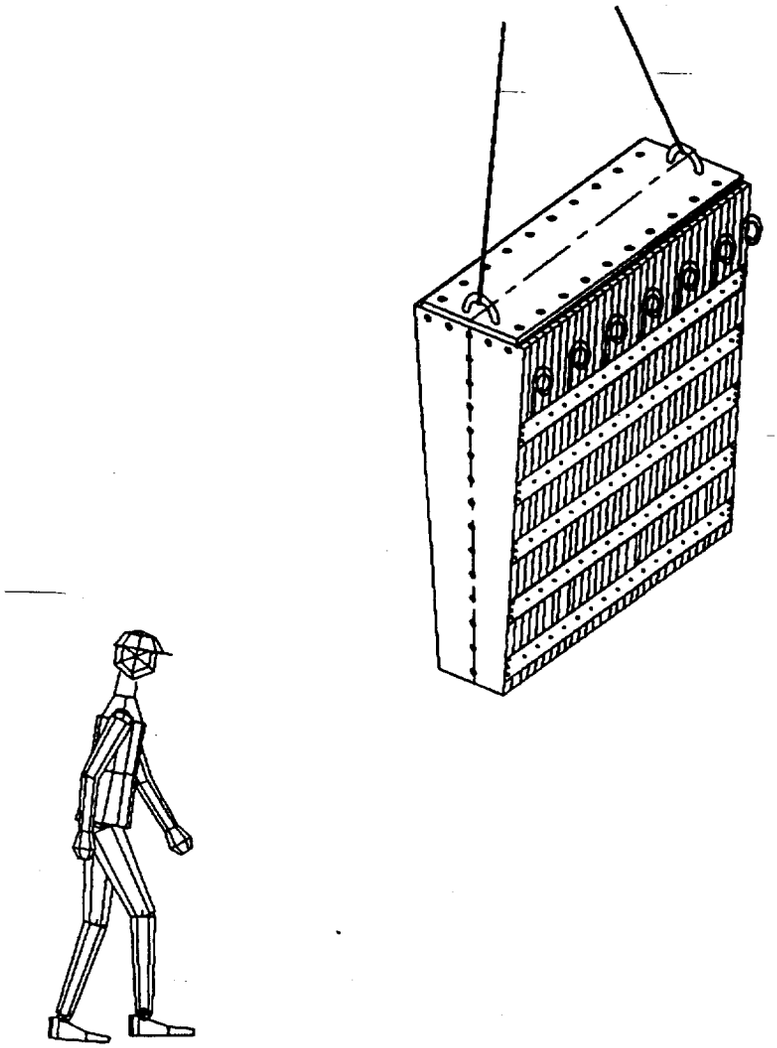

Transportation of finished module.

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Chkr by A.Surkov