EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

ATLAS

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TILE CALORIMETER MODULE ASSEMBLY.

JINR-DUBNA GROUP PROPOSAL.

Abstract

An approach to constructing and assembly of TILECAL module is proposed. The basic idea is to use the hot-rolled steel with some selection criteria to fabricate good supermodule assembled from 1 meter long modules.

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2 MANUFACTURING OF STEEL.

2.1 Steel manufacturer choosing in RUSSIA.

Using our very recent (SDC/SSL connected) direct contact with different RUSSIAN steel producing plants, basing on our detailed knoweledge of their official (state) standards as well as on our direct experience with these producers and their steel quality we have choosen as a main steel producer the NOVOLIPETSK METALURGICAL COMBINATE, - the NLMK at the LIPETSK - city.

This world wide known gigantic plant has necessary technical possibilities to roll **all** hadron calorimeter steel during **one** shift on **one** rolling mill.

Technology proposed here is based on NLMK hot rolled steel using. Such a steel is an ordinary, regulary produced steel with no special or additional demands needed to be mentioned.

2.2 Material specification.

As a main hadron calorimeter structural steel we propose a hot rolled steel sheets : this is Russian standard "CT-10" steel, indicated in state standard as "ГОСТ 1050-78".

The CT-10 parameters are the following ones:

- The chemical composition (max. allowed):

$$C = 0.14\%; \ P = 0.035\%; \ S = 0.04\%$$

QUALITY CONTROL PROGRAM . At current stage we do not consider this problem (comment: Dubna and NLMK have accumulated significant Q/A and Q/C experience including measurements stages when fabricating steel plates for SDC/SSC-Lab). We would add that we do not limit ourselves with Q/C and Q/A requirements at this moment.

2.4 Conditions of steel plates storage and of their transportation to modules manufacturer.

On all stages of material transportation from its manufacturer to final product producer all steel sheets must be surely protected from moisture, water acces to sheet surface.

When sheets transportation one must follow strictly slinging scheme, use slinging fixturings and use sheets packing fixtures as well as pack transportation fixturings.

Sheets must be stored stricktly horizontally. Storage place must be dry, warm and with no dangerous for steel admixtures in air.

To avoid overloading of storage it will be usefull to order that amount of steel which is corresponding to the hadron calorimeter components production schedule.

The final list of items under control could be later described in quality control programme.

When sheets or packs transporting one must follow item 2.4 demands.

3.2 Master plates production.

For 5th hadron calorimeter prototype module fabrication we have obtained from NLMK $5^{+0.14}_{+0.10}\,mm$ thickness steel sheets for master plates.

These tolerances were valid for the full ordered set of metall with total weight of 8 tons.

In order to satisfy the shop-drawing requirements of thickness [$5 \pm 0.05\ mm$] we have decided to remove extra-thickness by chemical etching. After etching in SAVELOVO the NLMK steel sheets obtained the necessary thickness, indicated on drawing.

We have observed the following negative features of this method:

- some degradation of surface quality: we had $R_a \simeq 3.2$ microns and obtained $R_a \simeq 12.5$ microns.
- some increasing of of thickness nonuniformity of one masterplate precutted sheet ... The etching process is not going uniformly due to very large precutted plate area.
- it was necessary to clean chemically the plate surface to remove rust (ortophosphor 50% concentration acid was used).
- plate production time was increased.

Master plates production technology we propose here is based on use of the all purshased rolled metal with no plates thickness mechanical

1. Billets marking "on sheet".

Before starting sheets precutting each sheet will obtain (by electric pencil) its identification number. In a special log-book we indicate to what purchasing (delivered) party of metal is given precutted sheet belonging to... To make marking simpler we use template.

2. Sheet blank lay-out.

To obtain precutted plates we use Guillotine shear. Scheme of original plate cutting is given on FIG.1. Template is used to contour the cutting lines... Some other (then Guillotine shears) methods are possible to obtain precutted plates.

3. Sheet rolling (straightening) if necessary.

Guillotine shear usually gives some flattness violations of precutted plate. Therefore such a plate needs to be straightend. Usually it can be achieved by additional rolling which is necessary before moving plate for further machining... When laser or gas cutting is used such a distortion does not appear, so there is no need to straighten precutted plates. What cutting procedure will be in reality used must be determined by master plates producer.

3.2.2 Precutted plates (billets) preparation for machining.

We propose master plates machining when they stacked in pack. Amount of plates in pack corresponds to quantity of plates in 1-m module plus some technological reserve. If this figure is fixed to be equal 120 (as in 5th prototype module), then each pack will contain plates numbers

- 40×10 key ways in narrow wedge side
- satisfy the $1550_{-0.3}$ dimension.

3.2.6 Holes drilling with drill jig.

We drill the plate holes using the drill jig. This operation is done with whole pack with 2÷5 plates/pack. When placing of pack into drill jig the plates locating is done with use of $50mm \times 10mm$ and $100mm \times 10mm$ key ways. Drilling precission is illustrated by FIG.5.

3.2.7 Quality control.

The kinds, methods and amount of controls as well as report-forms can be described in special "Quality control program". At current stage the above mentioned operations are not prescribed.

3.2.8 Interoperational storage.

Master plate billets, plates under machining, when storaging between operation and ready plates must be kept in hiorizontally on solid support. Storage conditions for plates must be satisfied as item 2.4 indicated.

3.3 Spacers production.

When fabricating of 5th prototype module of h-cal we obtained the NLMK steel for spacers: $4^{+0.10}_{+0.01} mm$.

These figures (tolerances) were valid for the all ordered (4 tons) metal. Spacer's thickness tolerances indicated on drawing were ± 0.1 mm.

2. The sheet lay out.

To obtain billets one could use the Guillotine shears. The sheet thickness is allowing the horizontal knife cutting and it does not cause the billet's edge curving. The lay out scheme is given on the FIG.6. Some other methods of billets obtaining are possible provided they conserve the billets flatness.

3.3.2 Billets preparation for machining.

For machining the spacer plates are packed. When 5th prototype spacer producting pack had 5 billets. This figure could be noticably larger provided necessary technological preparation is done.

3.3.3 Holes drilling.

Originally in the pack of billets we drill two ⌀ $8mm$ base holes. These are holes which will be used for speacer clamping when assembling.

3.3.4 Contour machining.

The billets pack locating is achievedd by 2 holes in fixturing device. A possible spacer contour surface machining sequence see on FIG.7. Machining: by milling or planing.

3.3.5 Quality control.

The kinds, methods and amount of controls as well as report-forms can be described in special "Quality control program". At current stage the above mentioned operations are not prescribed.

4 MODULE ASSEMBLING.

4.1 Reference information.

Weight of one rolle of steel sheet .... $15t$

Weight of one meter of $5mm$ sheet $1520 \cdot 5 \cdot 1000 \cdot 7.8 \cdot 10^{-6}$ .... $60kg$

Weight of one meter of $4mm$ sheet $1520 \cdot 4 \cdot 1000 \cdot 7.8 \cdot 10^{-6}$ .... $48kg$

Length of $5mm$ sheet roll .... $250m$

Length of $4mm$ sheet roll .... $312m$

To fabricate $1m$ long module master plates

the needed amount of steel is $\frac{1.6m \cdot 120}{4}$ .... $48m$

To fabricate $1m$ long module spacer plates

the needed amount of steel is .... $25m$

One steel roll is enough to fabricate

master plates for .... 5 modules

spacer plates for .... 12 modules

Each roll (for master and for spacer plates) will be cutted and stacked in 5 packs each $3t$ heavy.

From one pack (with $5mm$ steel sheets) will be cutted 120 master plates for one 1 meter long module.

From one pack (with $4mm$ steel sheets) will be cutted the amount of spacers necessary for 2.4 module of 1 meter length.

4.2 Stacking.

After machining 120 ready master plates are stacked in one pack. As to spacer plates they also are stacked: 60 plates in one pack. Then for all

By combining in this manner the packs of master plates and of the spacer plates we will get modules heights all equal to $1068mm$. In reality, due to some gaps between plates, the module's height could be bigger.

By having spacer plates of different height one can correct the module's height with $\pm 0.3mm$ precision (spacer plates thickness difference is within the $0.02 \div 0.1mm$ range).

To achieve necessary flatness of new period external surface when stacking of period into module, it is important to stack master and spacer plates accordingly their labeling (marking).

4.3 Module assembling in fixturing tool.

For 1-meter module assembly we use fixturing tool (FIG.9). This fixturing tool has two datum (base) surfaces. These surfaces are used for module master plates locating. Spacer plates necessary positioning in module will be determined by slotted bushings. Module assembling with using of hard base surfaces allowes one to achieve the module side surface nonflatness equal to $0.15mm$ (see APPENDIX 1).

After the necessary amount of master plates and spacers were stacked they must be compressed by studs acting through $20mm$ thick plate. The following action is module thickness measurement. If looks necessary, to obtain desirable module height and plates flatness some corrections could be undertaken with spacer plates exchanging. Studs then is placed on module and clamp it.

After necessary module height is achieved the two base surfaces must

5 SUPERMODULE ASSEMBLING.

Assembled module is rolled over its narrow side up and then placed on girder with help of rather special auxillary equipment able to move the module (FIG.12).

The module transverse positioning on to the girder is determined and fixed by module's key (was welded earlier). The key must be inserted in girder's key way.

Second module will be placed on girder close to first module. First/second modules distance is determined by module moving auxillary equipment.

Modules load on girder is transfered through key.The gap between girder and master plates surfaces is equal 0.5mm. Second module is moved towards the first one by jack.

By special auxillary tools the modules will be straped tightly. Then third module is positioned and same (as with 2nd module) operationes are repeated. Procedure is continued with IV,V,VI modules.

In the narrow wedge side key way will be inserted 5980mm long key. Key is fixing the modules relative positioning. Next step: all studs are inserted into supermodule and tightend. Temporary connecting (clamping) equipment removed.

Key (located in wedge narrow side) is welded to master plates. Wide wedge side master plates also were welded to the girder.

Now supermodule is prepared for the tiles to be inserted in.

The technology proposed allows one to achieve the assembly precision (along the supermodule length) equal to $\pm 2mm$; supermodules side

Then all six 6mm studs are removed out of modules

6 CONCLUSION.

One of the realistic option of hadron calorimeter manufacturing in RUSSIA is considered here. The leading principles when (technology) choosing were the following ones:

- achievement of the required module and supermodule design parameters
- using of the ordinary, widely used equipment
- the most cheap steel using for the main components production
- module and supermodules assembly on the master and spacer plates production area
- achievement of the necessary modules and supermodules assembly rate.

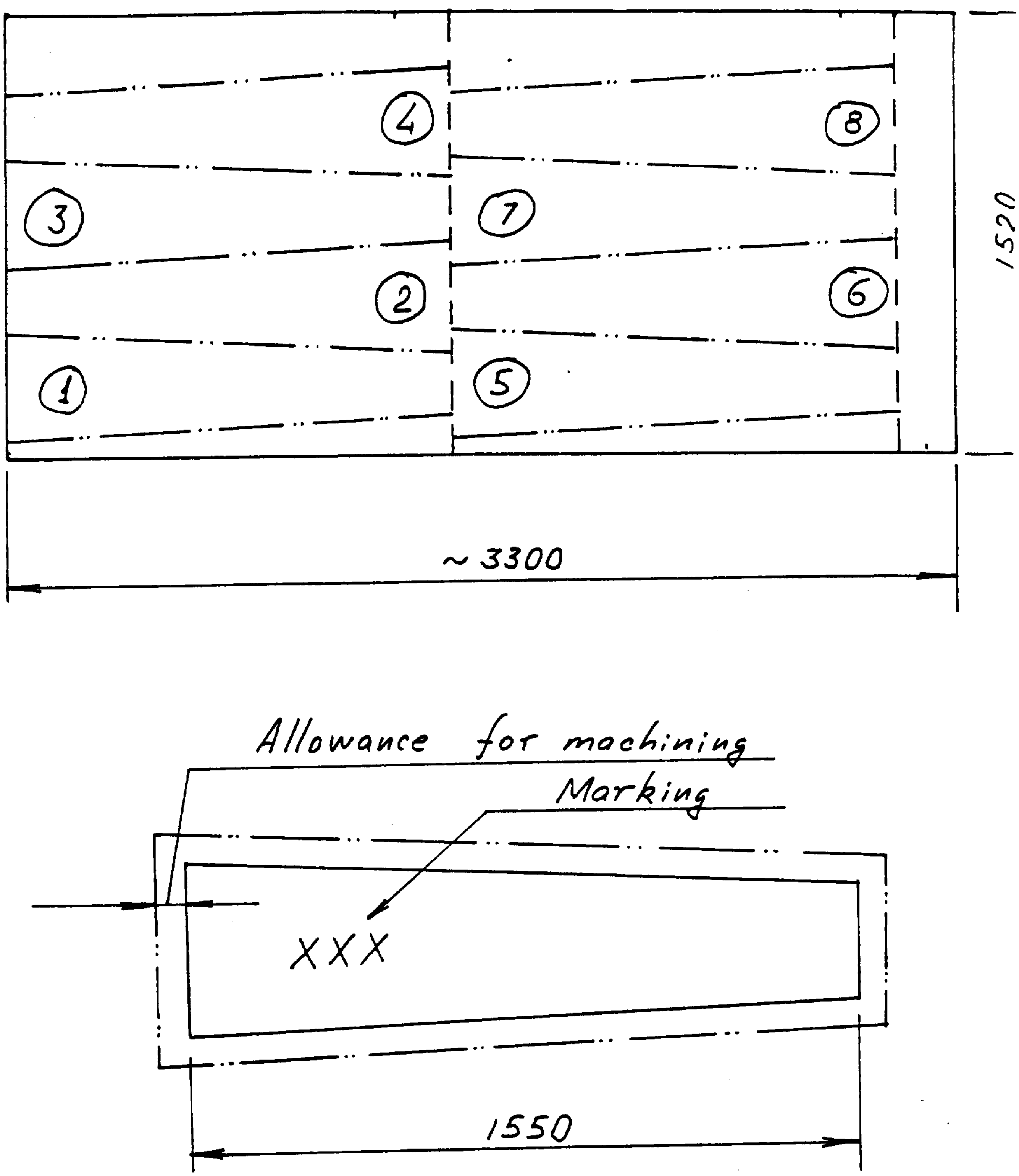

4
8
3
7
2
6
1
5
1520
~ 3300
Allowance for machining
Marking
XXX
1550

Fig. 1

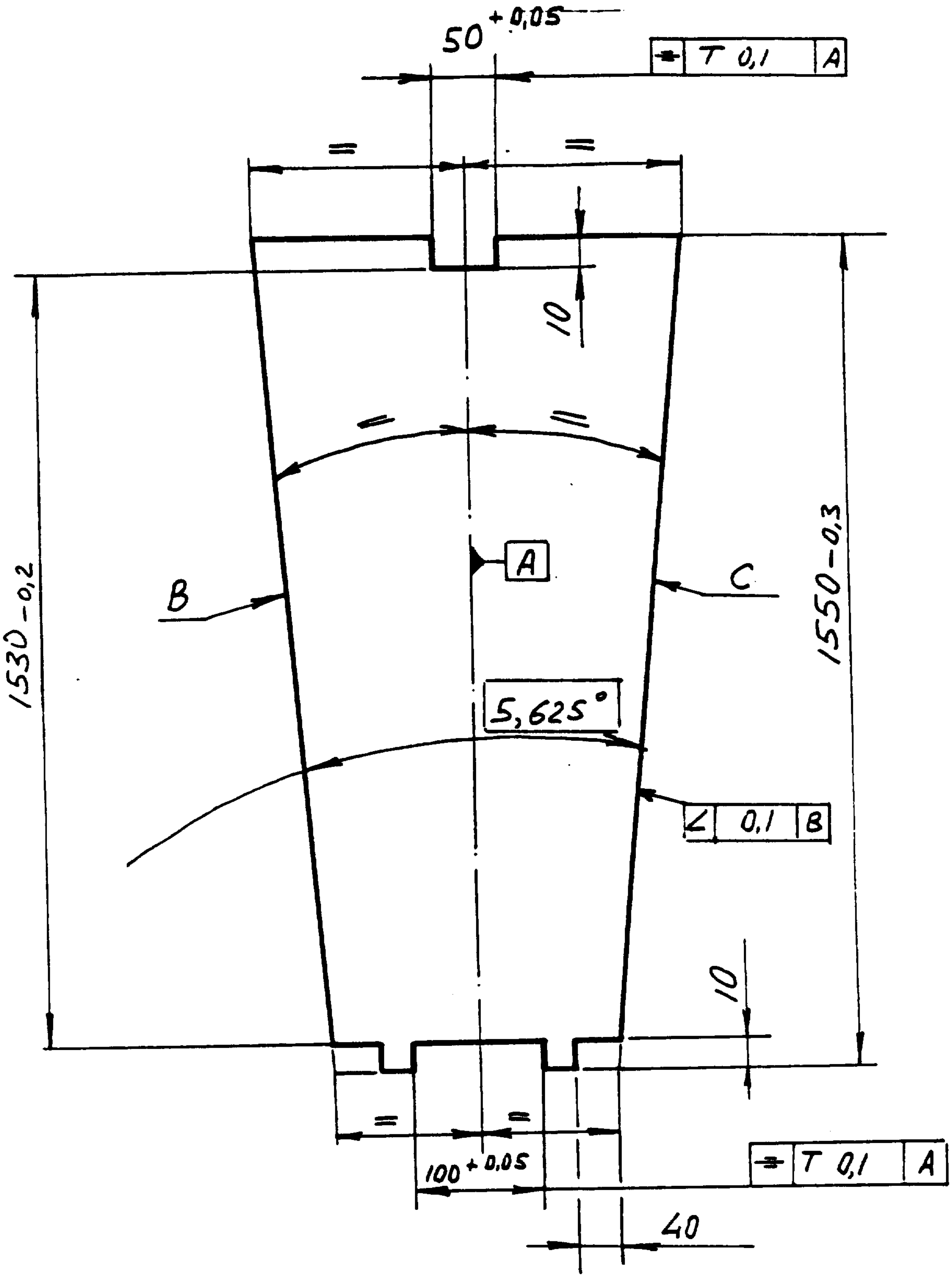


Fig. 3.

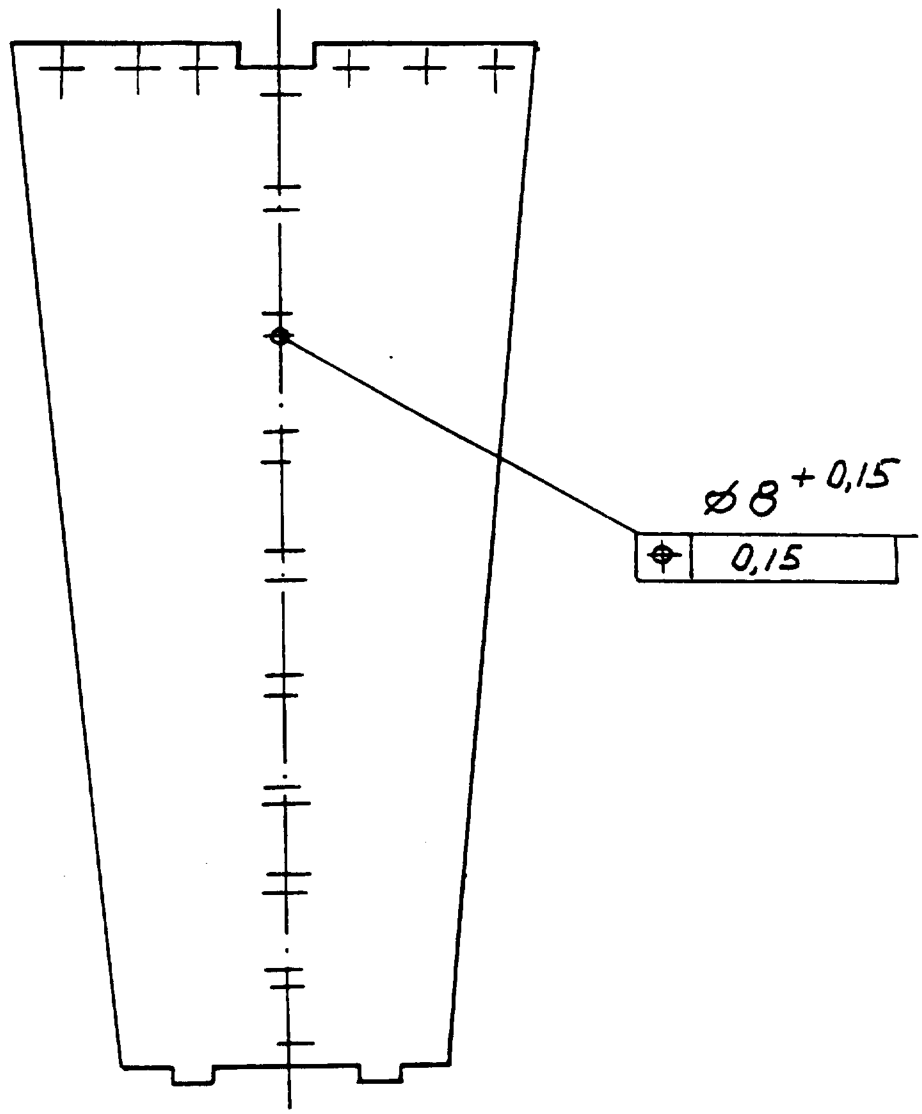


Fig. 5.

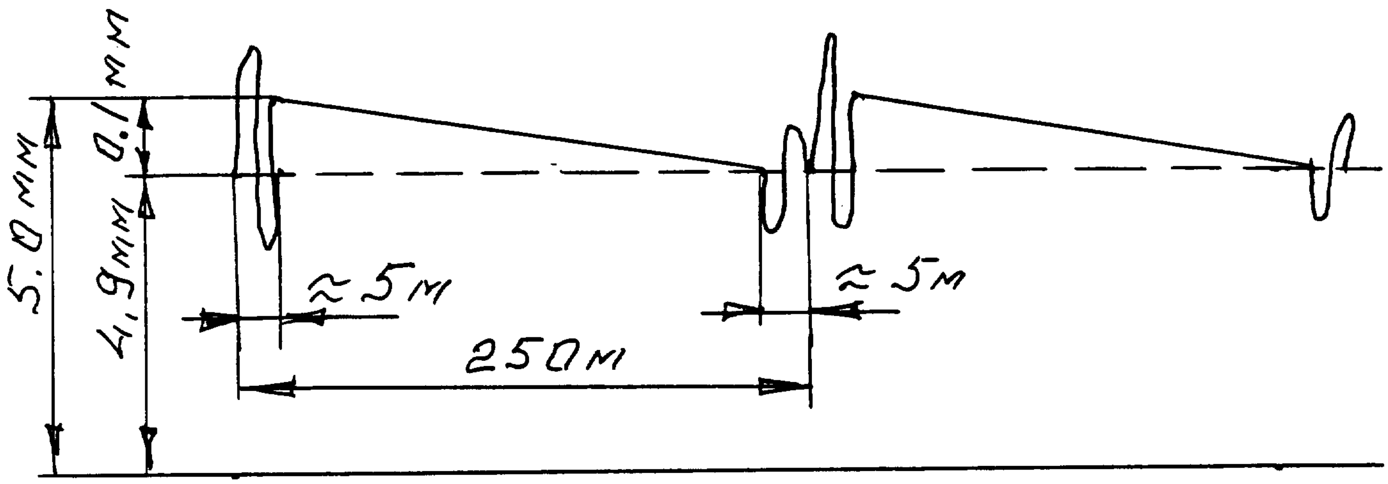


Fig. 8

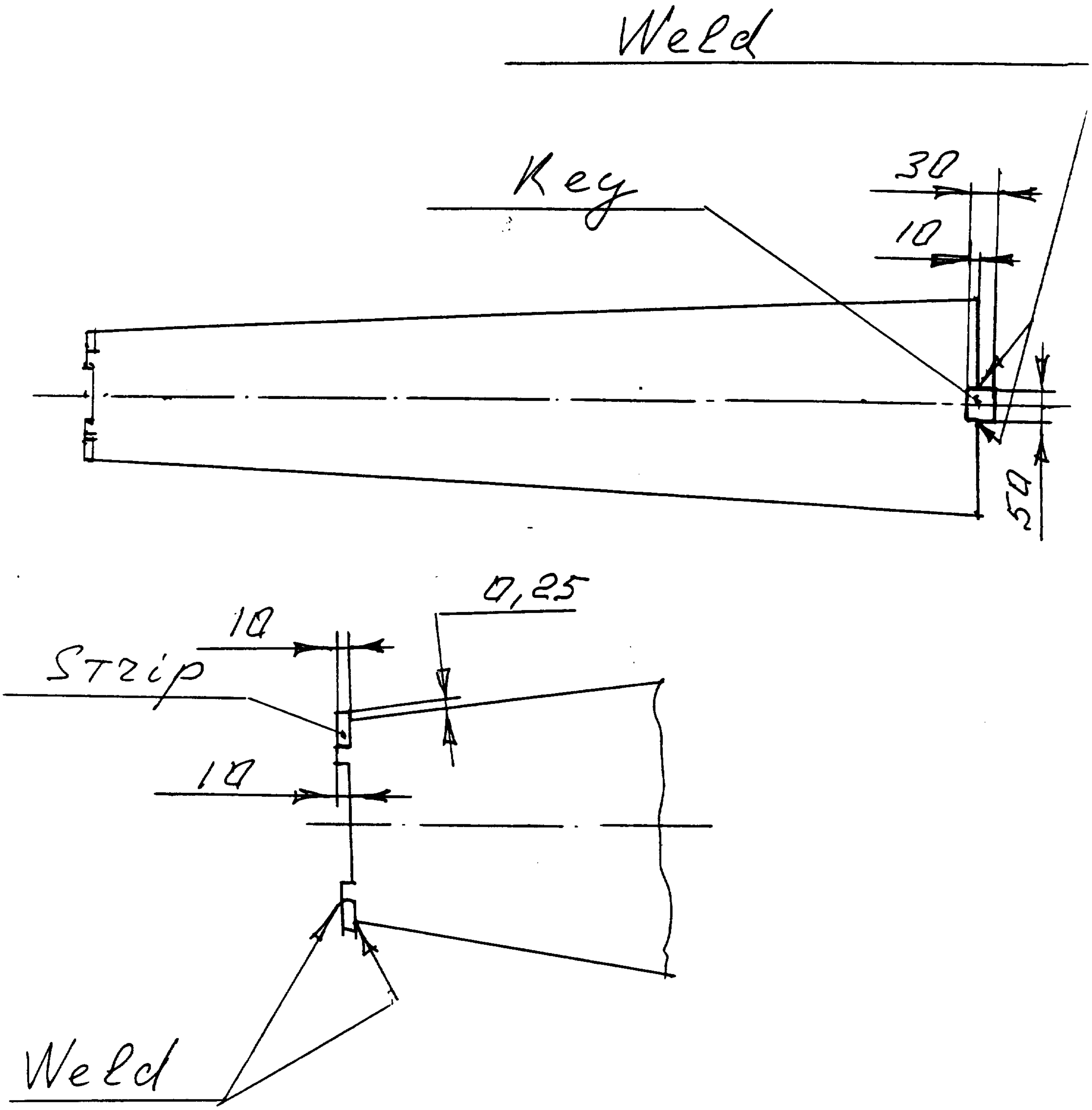


Fig. 10

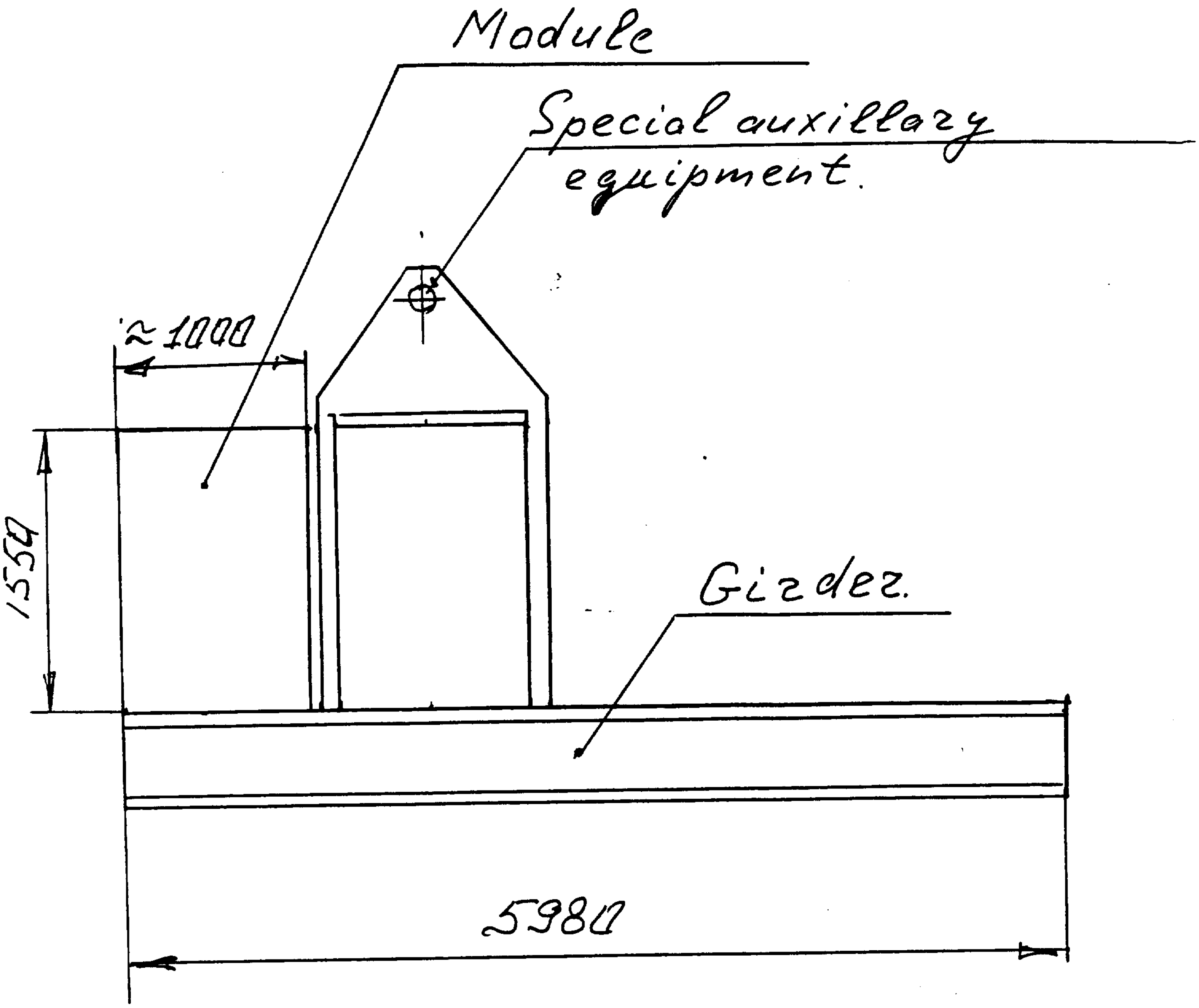
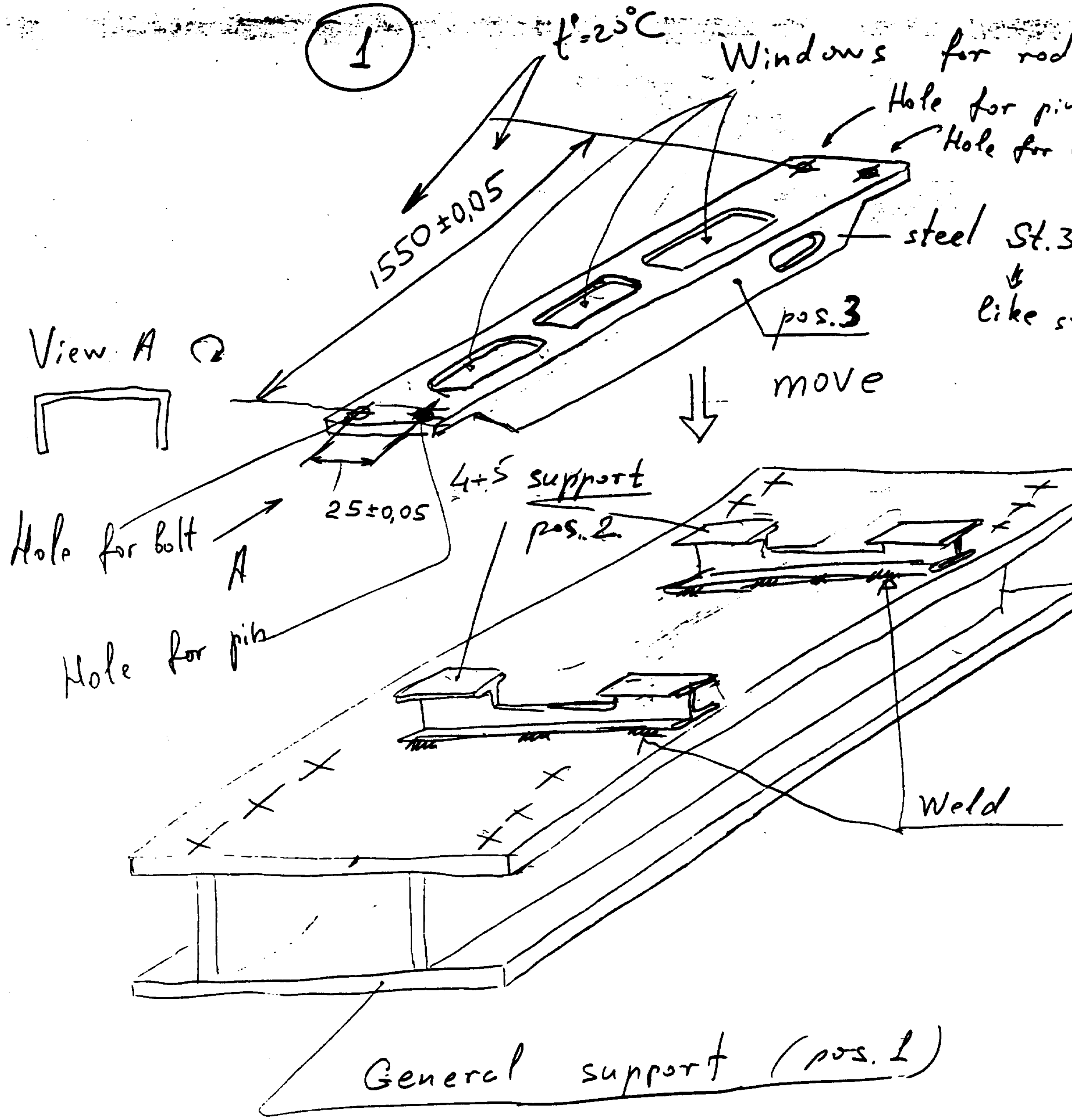
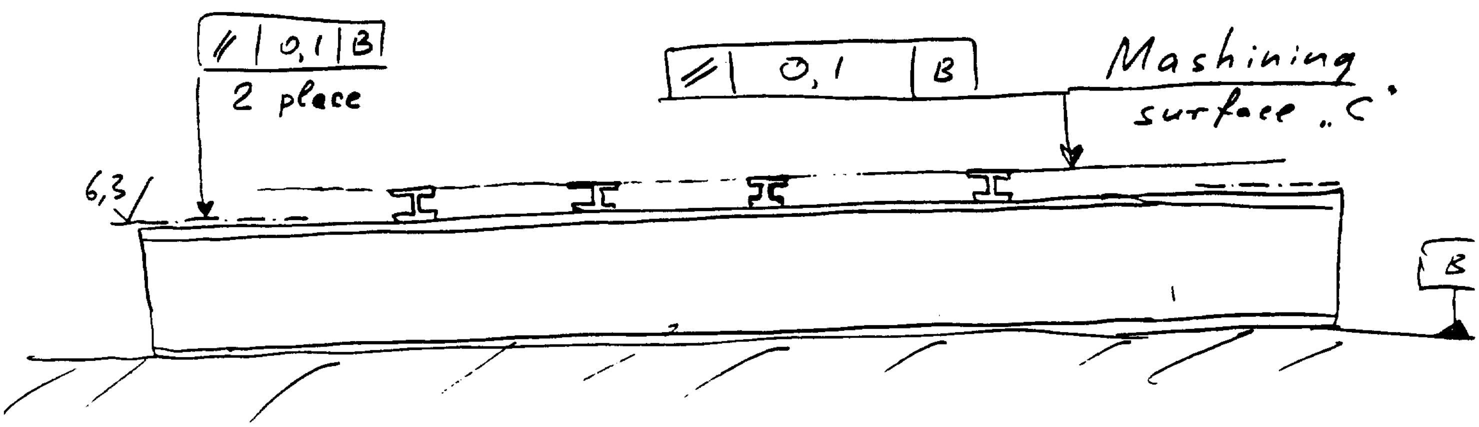


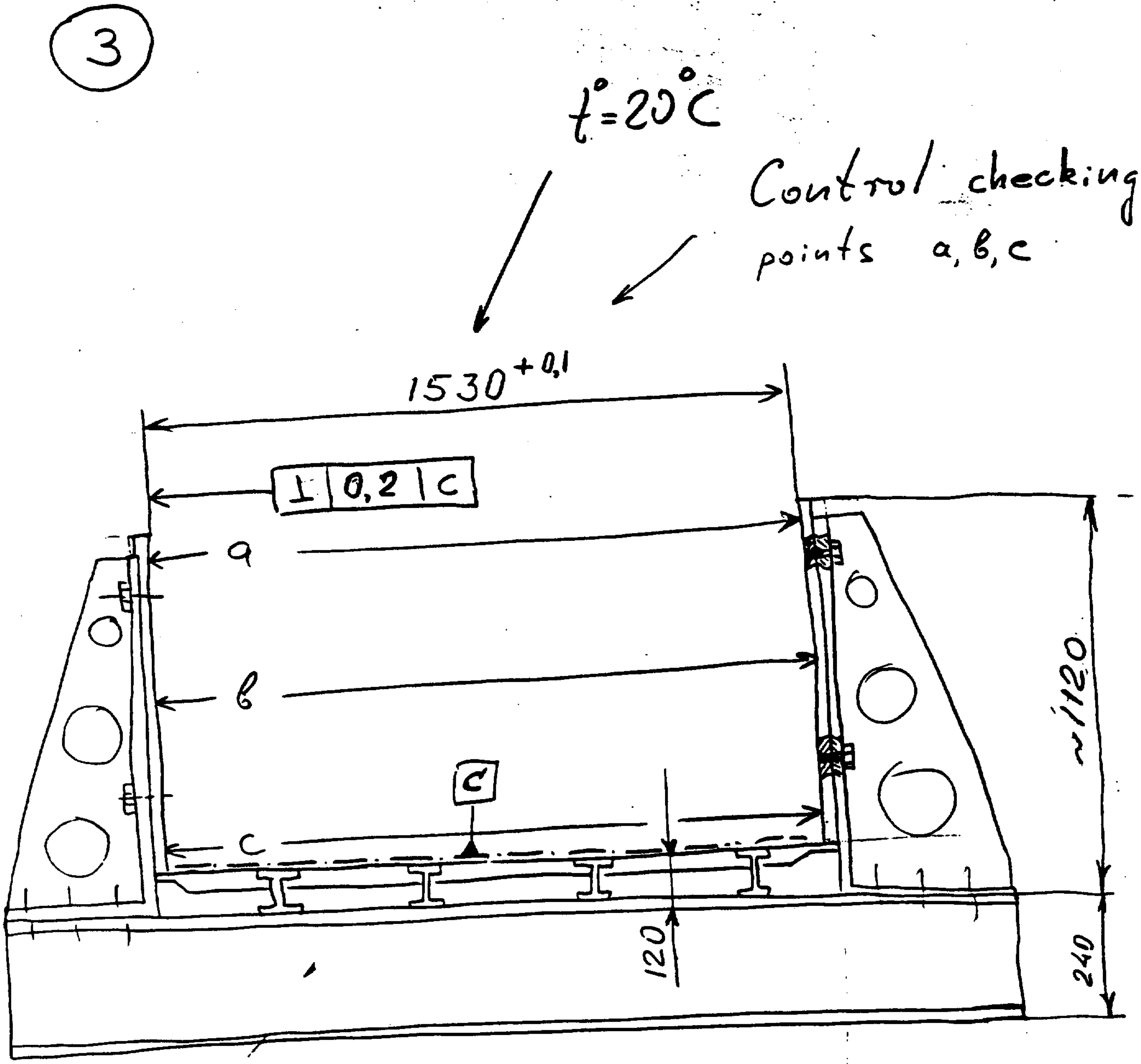
Fig. 12.



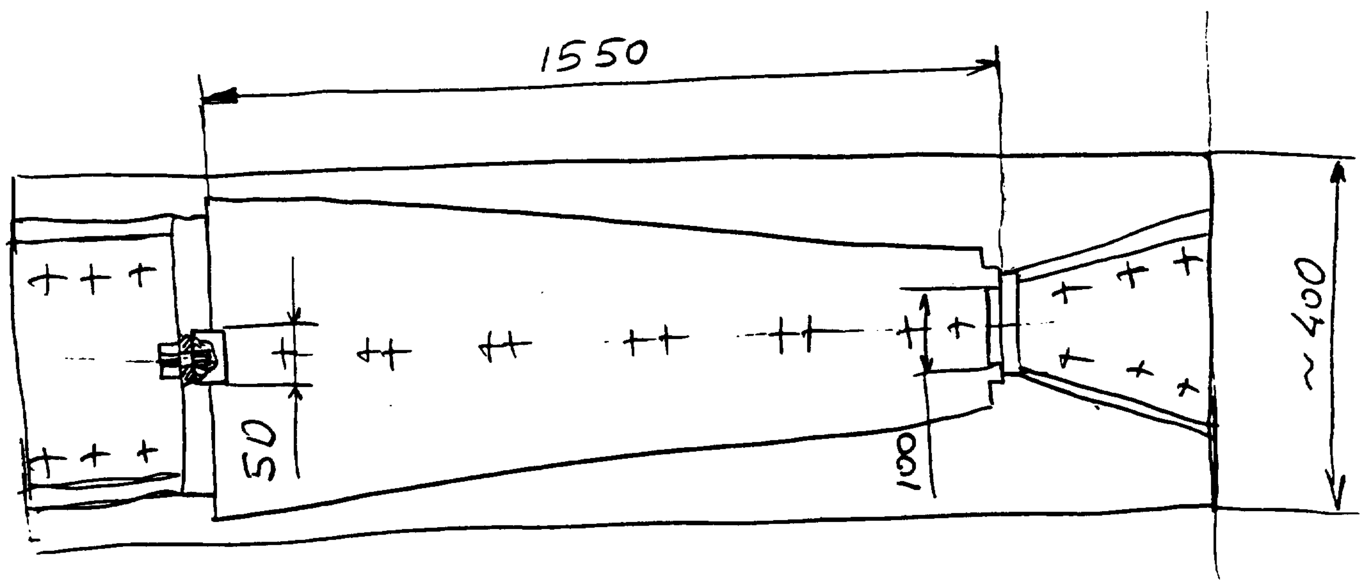
1
t°=25°C
Windows for rods
Hole for pin
Hole for
1550±0,05
steel St.3
pos.3
View A
move
4÷5 support
pos. 2
25±0,05
Hole for bolt
A
Hole for pin
Weld
General support (pos. 1)



// | 0,1 | B
2 place
// | 0,1 | B
Mashining
surface „C"
6,3
B

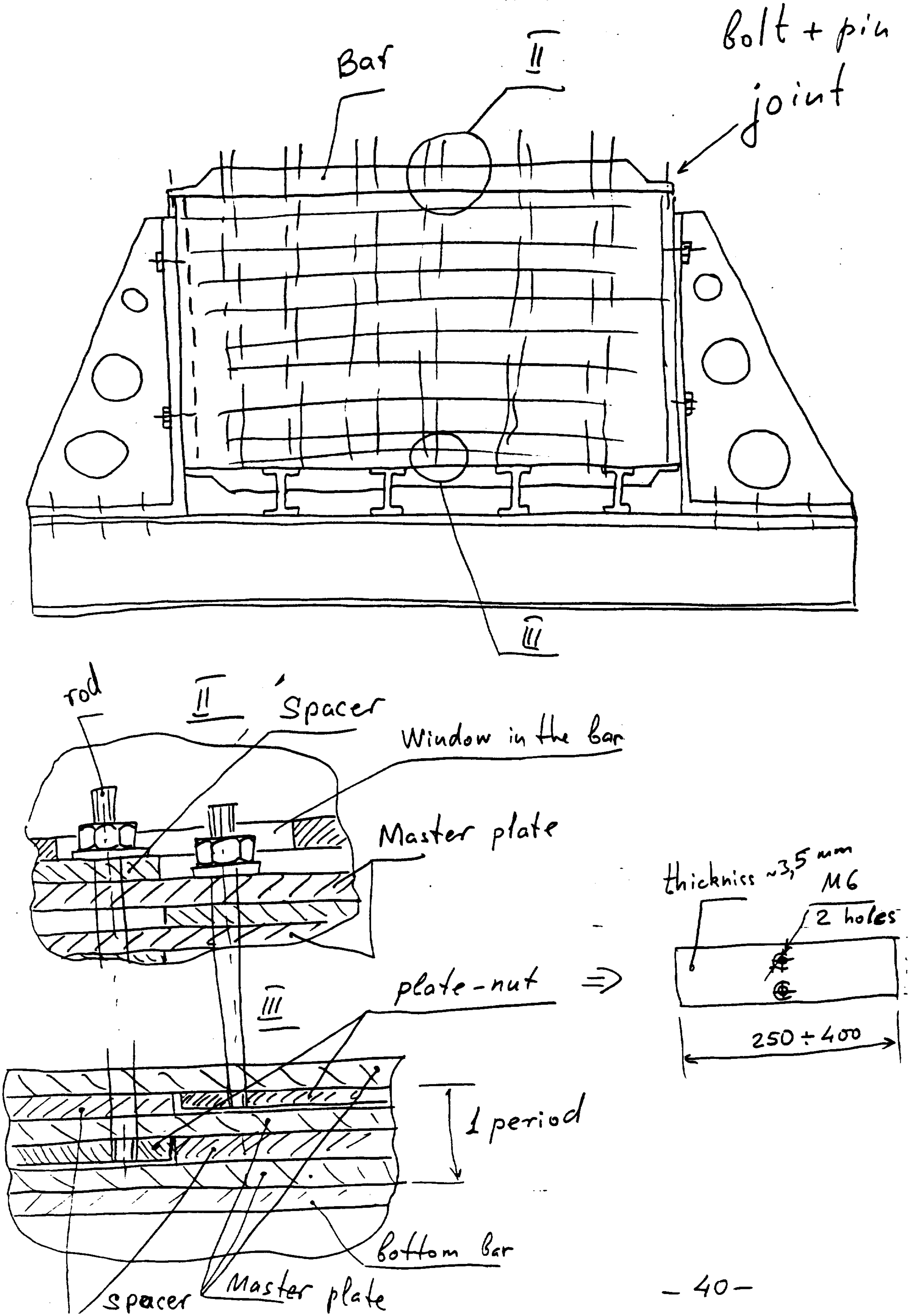


3
t°=20°C
Control checking points a, b, c
1530 +0,1
⊥ 0,2 C
a
b
c
C
~1120
120
240

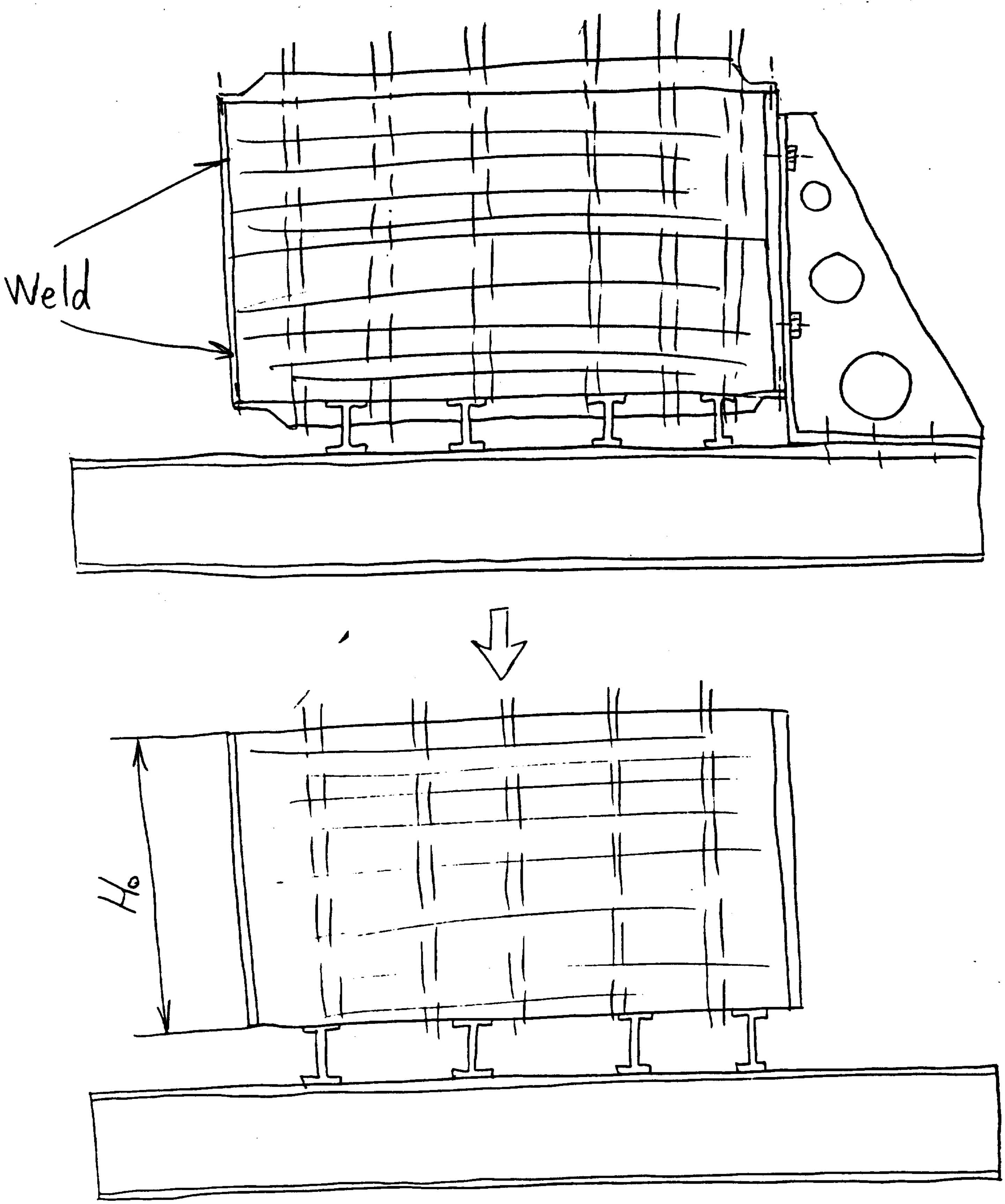


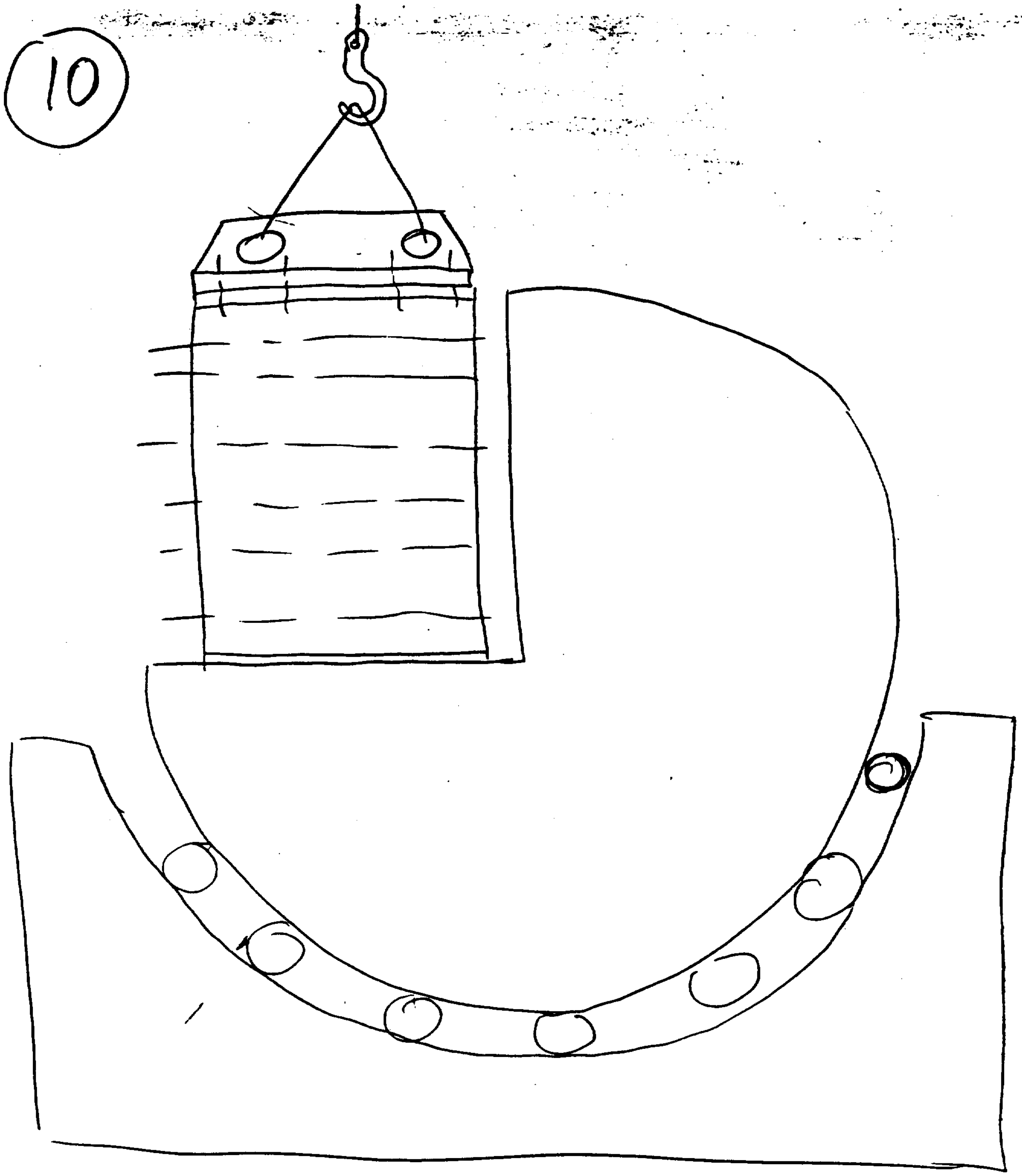
1550
50
100
~400

5

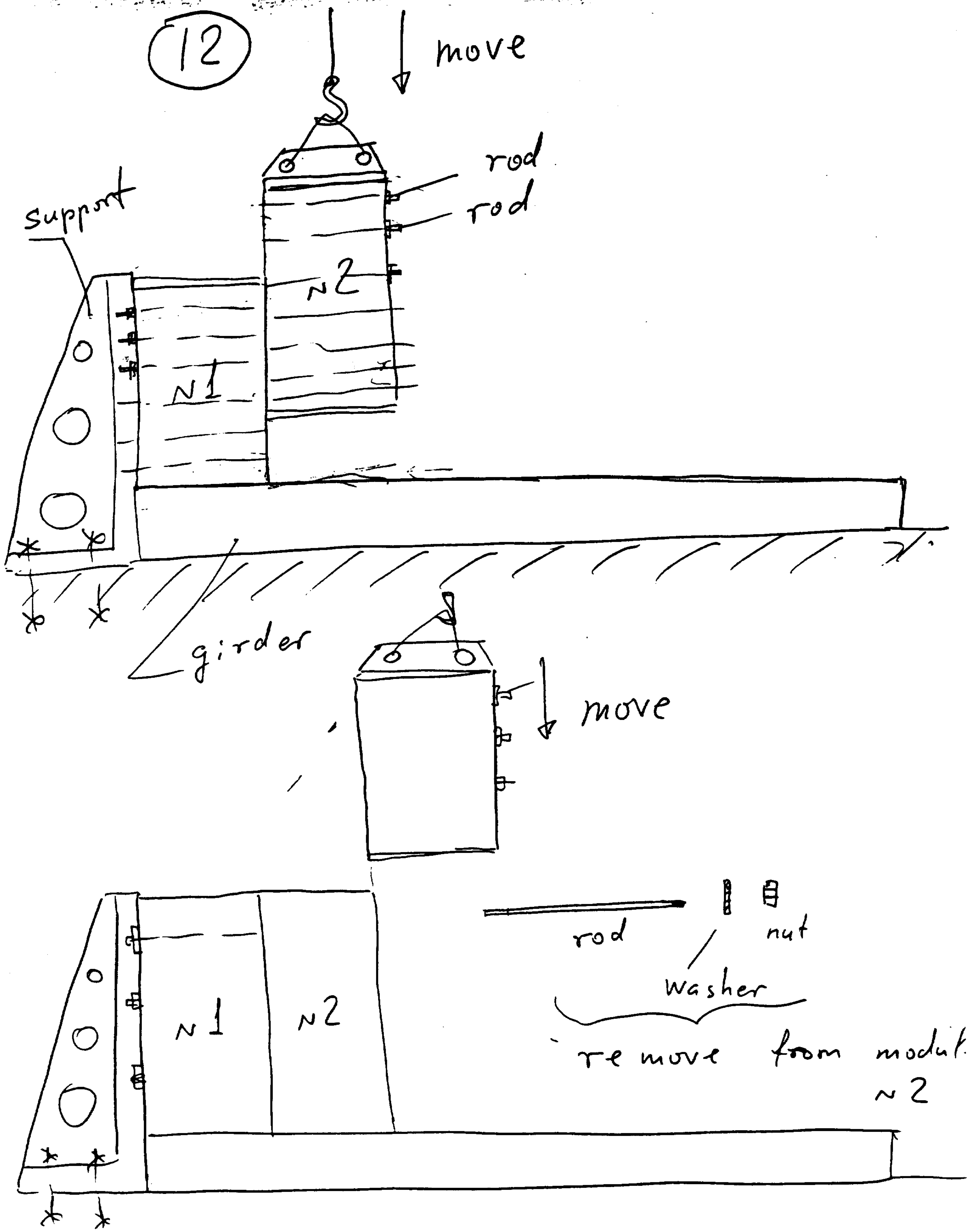

Bar
II
bolt + pin joint
III
rod
II
Spacer
Window in the bar
Master plate
thickniss ~3,5 mm
M6
2 holes
plate-nut
III
250 ÷ 400
1 period
bottom bar
spacer
Master plate

7

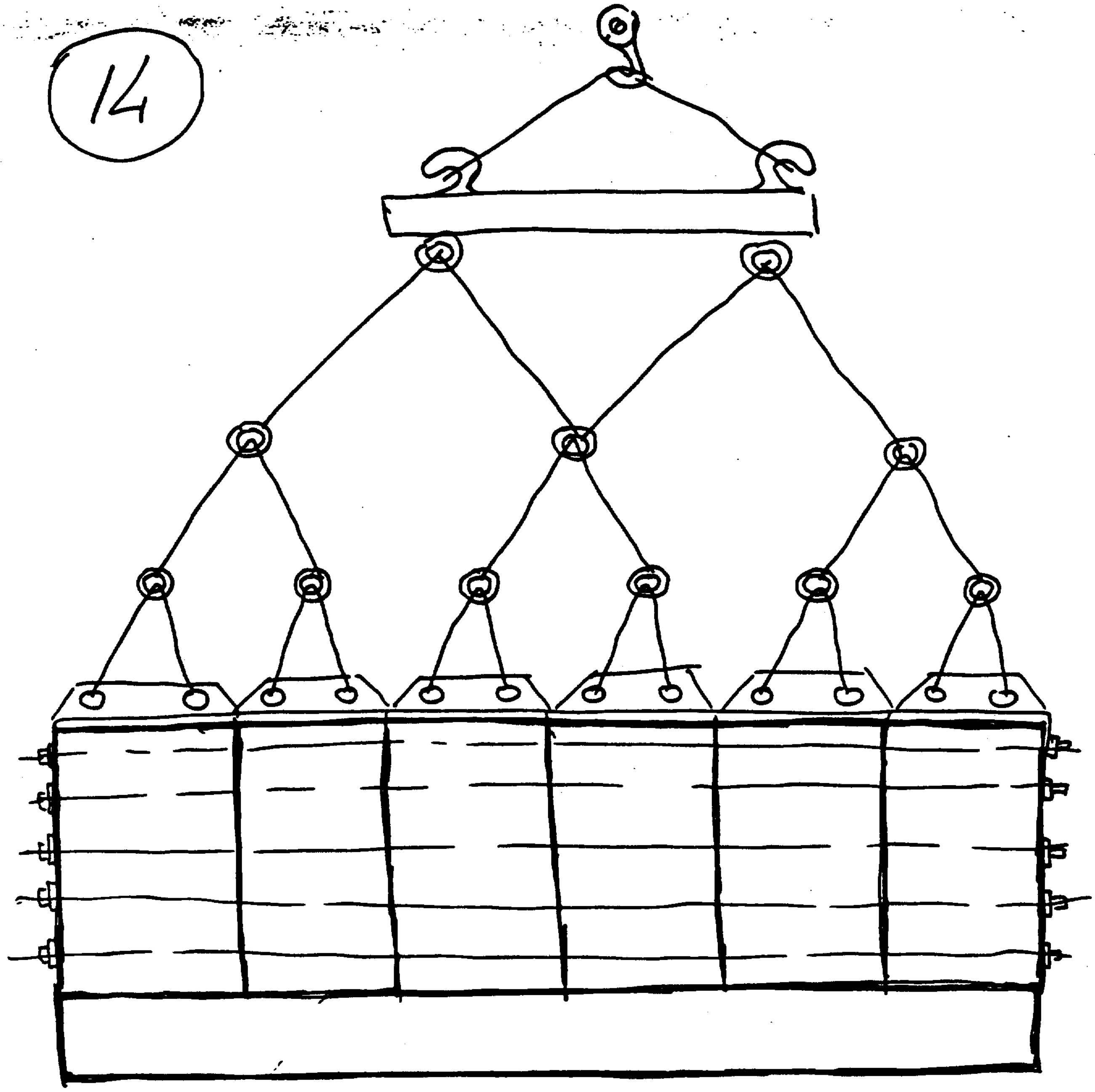




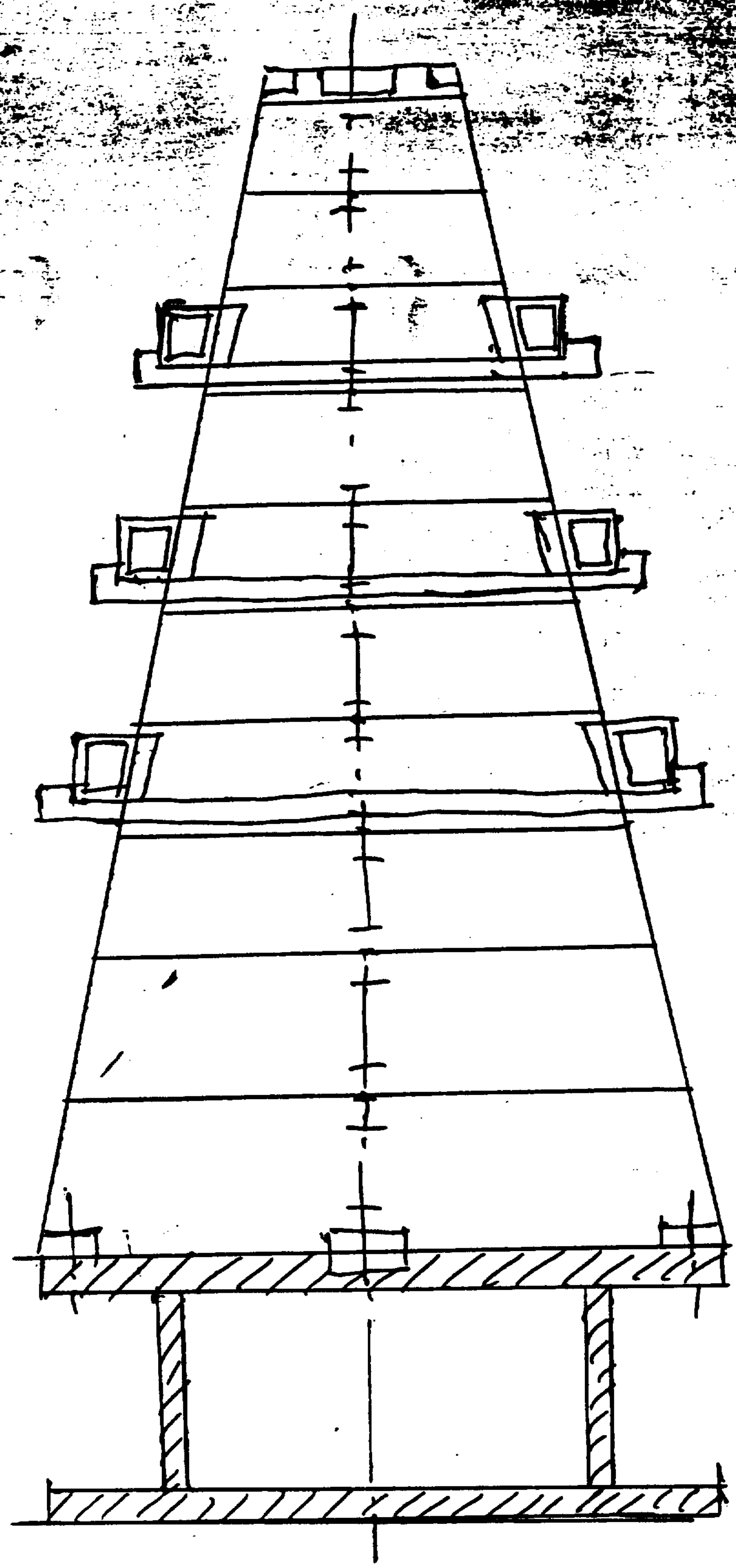
(12)


move
rod
rod
support
N2
N1
girder
move
N1
N2
rod
washer
nut
remove from module
N2

14



16



DESIGN: CRITERIA & STEPS

Report 28 June 94 1

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Level 1

Cooperative production by particip. institutes a b

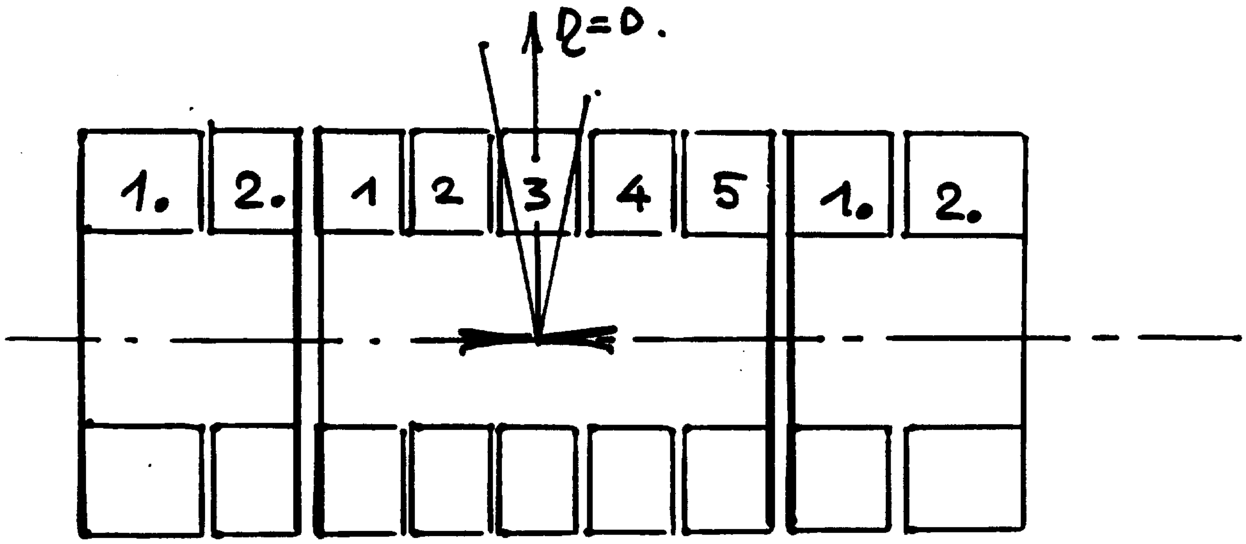
Production by compatible (additive) components

„High" components identity /by diff. manufacturers/

Identical modules structure

φ cracks ≤ 0.5mm (design param) (wedges self support)

Possibility of assembly at „destination point" (CERN,



COMMONLY ACCEPTED STARTING COND's TO FABRICATE IDENTICAL MODULES (1M?)

1.	Ready module dimensions meet design tolerances	TB
2	" " is stiff and ∴ transportable	T.
3	" " studs (strips) not overloaded	TB
START. 4	Originally purchased st.sh DO meet tolerances	agr. ed

Comm. a: independent manufacturing of (1/M) modules

Comm b: production cooperation is foreseen: exchange by toolings, auxil. equipment, dies, ...

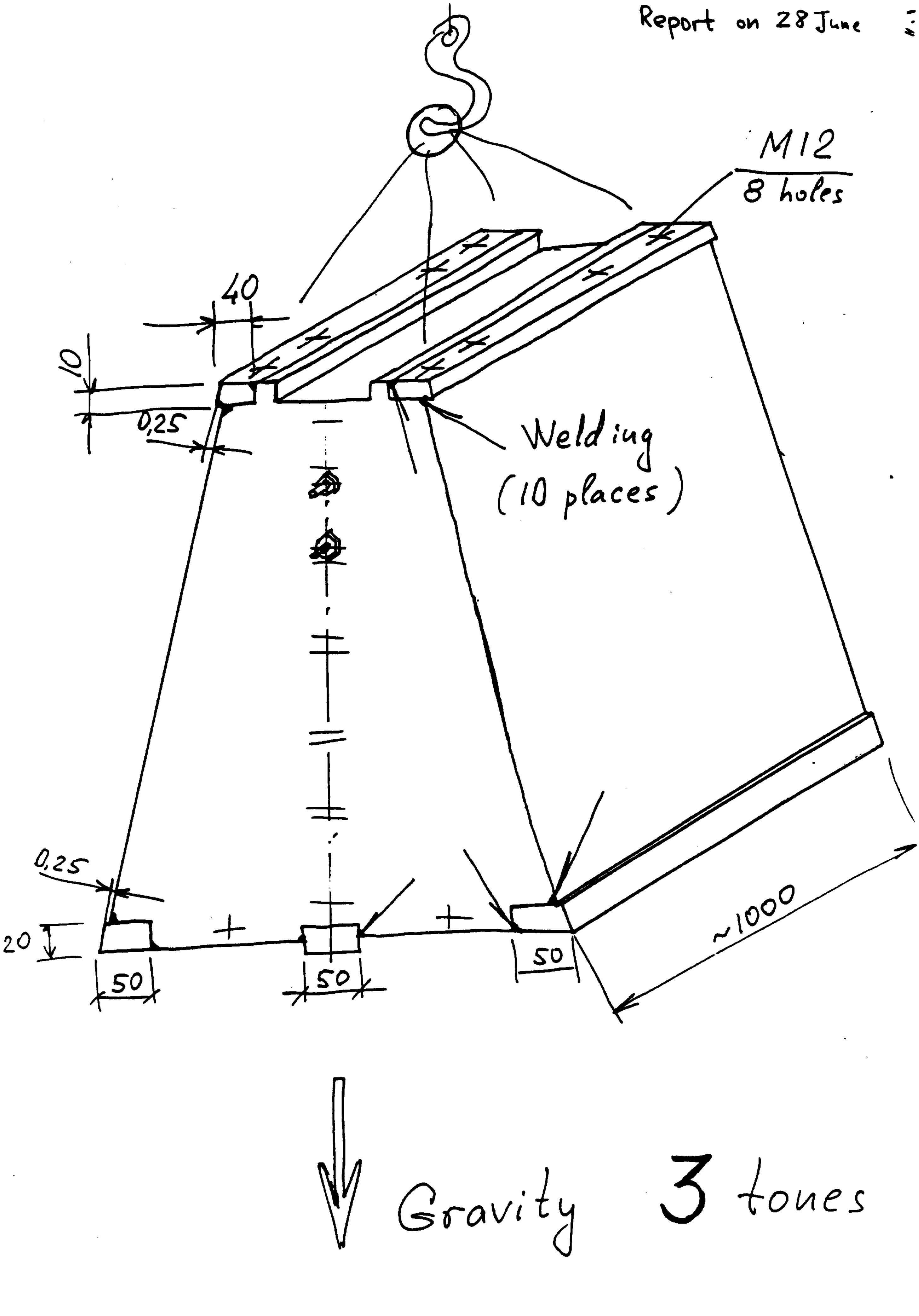

M12
8 holes
40
10
0,25
Welding
(10 places)
0,25
20
50
50
50
~1000
Gravity 3 tones

Fig. 1.

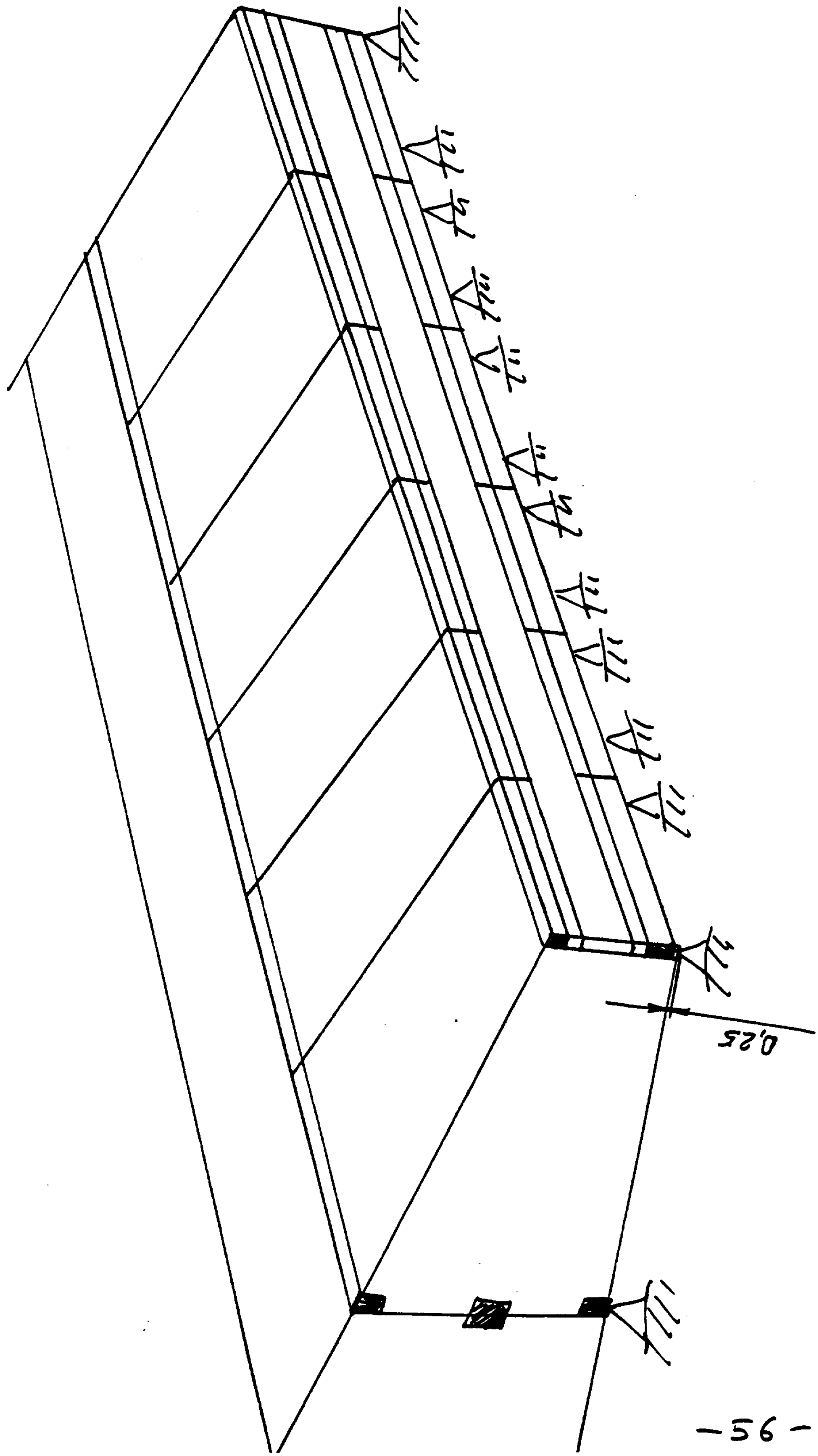
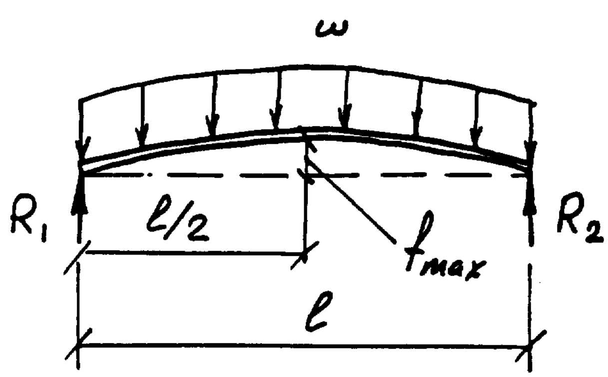
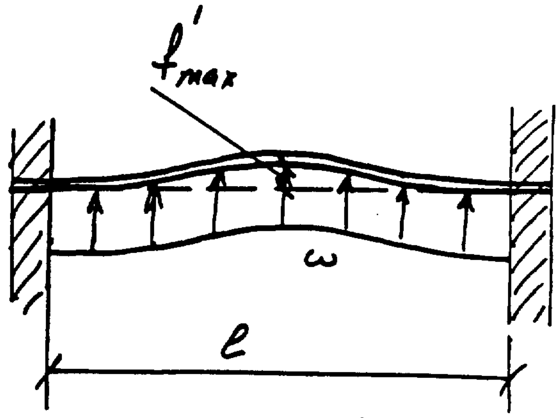


Fig 3



$$W = \omega l$$

$$f_{max} = \frac{W}{EI}\,\frac{5l^3}{384}$$



$$W = \omega l$$

$$f'_{max} = \frac{W}{EI}\,\frac{l^3}{384}$$

$$f'_{max} = \frac{1}{5} f_{max}$$

Fig 5

Report on column 94. 9

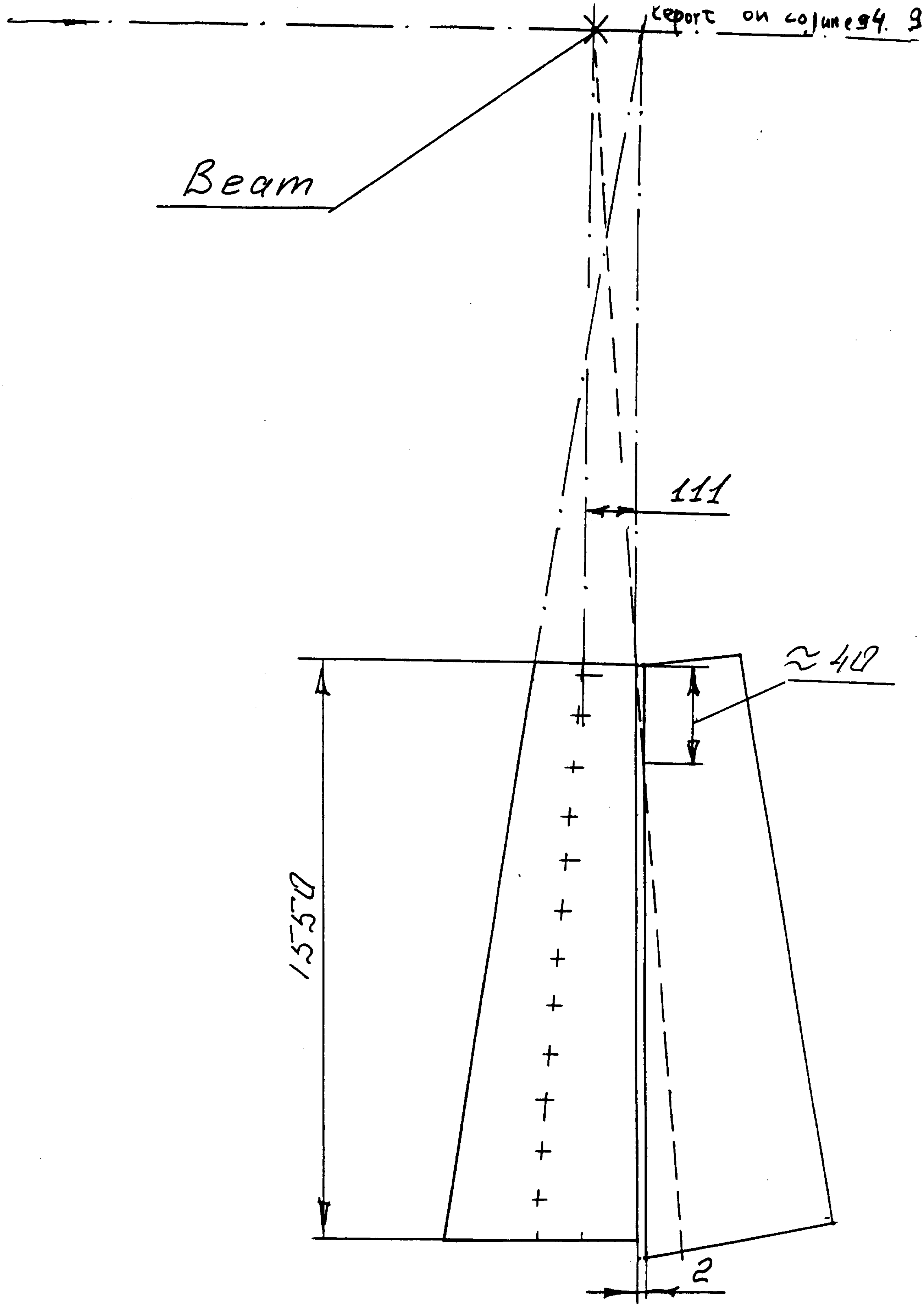


Fig 7