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ATLAS BARREL HADRON CALORIMETER 0-MODULE ASSEMBLY TECHNOLOGY

1997

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1 Introduction

On 16 – 19 April in Dubna according to the 0-module production schedule the ATLAS Barrel Hadron Tile Calorimeter 0-module was assembled.

The module assembly was done on ⌀6 *m* **rotary table** of the **milling machine** using the **main tool** for the module assembly and a few **additional tools**.

These added tools permitted to simplify and to make easier to us the module assembly.

The mounted module elements position control (horizontality and verticality) was performed with the help of the **Minilevel**. The Minilevel scale graduation value when horizontality and verticality determination was 0.01 *mm* per 1 *meter*.

All the module assembly tools and the module assembly technology were developed by *LNP JINR* designers.

The main tool for the module assembly was fabricated by "*Nuclear & Vacuum*" Corporation (Bucharest, Romania).

All the added tools for the module assembly, the **traverse** for the module lifting and the **angular brackets** were fabricated by the *LNP* Experimental Machine Shop.

The module assembly was done by the LNP JINR team.

2 0-module assembly technology

2.1 The incoming inspection of module elements

The module assembly was done using the following elements:

- the girder;
- 19 submodules (we have 19 submodules arrived to Dubna from ANL (Argonne, USA), CERN, IFAE (Barcelona, Spain), INFN (Pisa, Italy), Charles Un-ty and IP of Acad. Scie. (Prague, Czekh), IHEP (Protvino, Russia); 4 submodules were glued in Dubna;
- strip clamping (front plate);
- 2 end plates;
- 22 tubes, $\oslash D = 8\ mm$;

- set of steel gaskets (0.02 – 0.8 *mm*);
- screws **M16**;
- washers.

Before module assembling the incoming visual inspection of elements arrived for assembling was done and also their main dimensions were checked to make sure of drawing conformity.

The Girder. All the girder dimensions correspond to the shop drawings. The main interest of us was focused on the planarity of the contact surface of the girder's key projection and on that surface twisted angle along the girder length. The planarity measurements were done just before the submodules installing. The girder was placed on the equally distributed along its length supports of the module assembly main tool. The deviations from the horizontal plane were measured by Minilevel in the support zones for two directions: for the longitudinal direction and across it. The measurement data were used to define of the locations and the thickness of the first gaskets between the girder and supports of the main tool for the module assembly.

Submodules. Before assembling all the submodules were visually inspected. The special attention was paid to weld quality, to the glue absence and to the absence of appearing bushes in the slots for scintillators inserting. Moreover all the slots were checked if scintillators could be easily inserted. Sometimes (in the rare cases) the slots were too narrow because some of the arrived master plates have too large excess deformation.

All the submodules obtained from collaborating Laboratories were checked if they are replaceable. For that check they were installed — one by one — to Dubna press-tooling used for submodules gluing. We found that we can make the submodules installing in an arbitrary order.

Dubna, Protvino, and Prague submodules were covered by CORTEC-protection at JINR. The remaining submodules have been protected by CORTEC at CERN or in the places where they were glued.

Strip clamping (the front plate). Strip clamping overall dimensions correspond to the drawings ones. However the plate straightness in the 124 *mm* dimension plane (which was not indicated at drawing) was about 4mm, but it didn't affect on the assembly quality as this non-straightness looked as one half-wave.

End plates. The end plates geometric forms are quite simple and therefore the plates didn't undergo incoming inspection procedure. However during assembling procedure it was found that two holes at each plate (for fastening screws) were based about 5 mm away from the drawing indicated position. The plates were remilled on the milling machine in Dubna.

Other elements. When the incoming inspection of the fastening details, of 8 mm tubes and of the gaskets we had checked their quantities and the completeness of the type/set.

2.2 The list of auxiliary and tackle equipments for module assembling

To do the assembly works successful the additional assembling tools were designed and fabricated besides the main assembling tool.

To provide the manipulation possibilities with the ready module the traverse and the angular brackets were also designed and fabricated.

Below follows the list of tools used when the module assembling:

- *the traverse* (see Fig. 1) is used for the lifting and the transportation of submodules in the horizontal position. It permits to rotate the submodule along longitudinal axis (for example, before drop of submodule in to the bath to cover it by CORTEC).
- *turn over* tooling is used together with brackets to transfer the submodule from the horizontal position to the vertical one;
- *the vertical jack* (2 pieces): they are used for submodule lifting on the girder to insert the gaskets between the submodule strip and the girder;
- *the horizontal jack* (2 pieces): they are used for pressing one submodule to the preceding one;
- *the bracket* is used for vertical lifting and the transportation of the submodule;
- *the traverse* together with 18 brackets is used for the ready module lifting at 6 o'clock position; together with the two brackets, connected to the girder the traverse is used to transfer the module from the vertical position to the horizontal one with the help of the support;

- *the angular bracket* (10 pieces) together with 10 brackets and the traverse are used for module lifting at 3 o'clock position and (if it is necessary) at 1, 2, 4, 5 o'clock positions;
- *the supports* (2 pieces) serve for the ready module installation in the vertical (6 o'clock) position;
- *the support* serves to transfer the module from the vertical position (6 o'clock) to the horizontal one (3 o'clock) and also for the module transportation by the car.

2.3 The step-by-step consequence of the works when the module assembling

2.3.1 Installation of the main tool for the module assembling

The base of the main tool for the module assembling is the rotary table of the milling machine with the two $400 \times 550 \times 3500$ *mm* beams belonging to that machine. The rotary table diameter is 6 meters. The beams were both put along the table diameter with a gap between them in order to obtain 7500 *mm* long basis. The full set of the main tool drawings in the electronic form (*.eps*) is at **WWW** (ATLAS).

All parts of the main tool for the module assembling (see Figs. 2, 3, 4) were fabricated by the "*Nuclear&Vacuum*" Corporation (*Bucharest, Romania*) and were delivered to the Laboratory of Nuclear Problems (*JINR*) for final assembling.

On the beams (placed on the rotary table) the supports for the girder, the face brackets and one horizontal platform with the fence were successively installed.

The face brackets have been arranged to be symmetrical relatively to the tool longitudinal symmetry axis. For the left face bracket the perpendicularity of its vertical surface to the basis was kept within 0.11 *mm* per 1 *meter*. To define the verticality (or horizontality) of the surfaces the 2 *m* precision straight-edge ruler and the digital minilevel were used. The scale accuracy of that minilevel is 0.01 *mm* per 1 *meter*.

2.3.2 Installation of the girder.

The module assembling starts with the installation of the girder on the main tool for module assembling. In the longitudinal direction the girder is installed firmly (closely) to the bracket left face. In the cross direction the girder is installed firmly to two datum surfaces on of the main tool supports.

The horizontality of the girder's key projection surface has been checked for two directions (see *item* **2.1**) without fixing of the girder by the clamps to the main tool supports.

Further, taking into account the girder twisted angle the gaskets between the girder and the utmost left support of the main tool on two girder's sides were installed. On this support the clamps was also installed and fixed. After that the gaps between the girder and supports of the main tool for the all points of support were measured. Following to the measurement results the shims were inserted to the appropriate places. The shim thickness was 0.05 *mm* larger than measured gap value. After that the girder was fixed to the main tool supports by clamps. Further the surface horizontality of the girder key projection for two directions was measured again as it was mentioned above. That surface horizontality for the longitudinal direction was generally not more than 0.2 *mm* per 1 *meter*.

2.3.3 Submodule mounting

Submodules are coming to the assembly shop area in the horizontal position. To mount them on the girder and for conveyance of premounting visual inspection before assembling all the submodules have been transfered in to the vertical position. For this operation the special manipulation tool and the bracket are used. After submodule transferred to its vertical position the bracket remains attached to the submodule. This bracket is used for submodule lifting when submodule transporting to the location of mounting.

The submodule mounting consequence is:

- to transport the submodule to the installing place on the girder;
- to turn in two guide studs M16×100 in the submodule bottom on the diagonal direction;
- to let down the submodule on its place, to turn out the guide studs;
- to press the submodule to the preceding one using the horizontal jacks;

- to set and to tighten uniformly the 6 bolts M16 in order to fix the submodule to the girder;
- to measure the gaps in the submodule corners between the submodule strips and the girder;
- to measure the submodule position nonperpendicularity for two directions (instruments are 2 meter precision straight-edge ruler, the pattern, the minilevel);
- to calculate — following the measurement results — the necessary shim thickness for each corner of the submodule;
- to compose the shims of the necessary thickness from the calibrated shims set of (the composition accuracy is 0.01 *mm*);
- to release the bolts, to lift slightly the submodule using 2 vertical jacks, to set shims;
- to tighten the submodule fixing bolts, to repeat the perpendicularity measurements and — in case of necessity — to correct the shim thickness; the allowed nonperpendicularity is not more than 0.1 *mm* per 1 *meter*;
- to measure the distance from the left face bracket (in the submodule bottom strip zone) to the end of the last submodule; to compare the measurement result with the drawing figure; to calculate the necessary thickness of the gasket to be inserted between submodules;
- to glue the necessary thickness gasket to two sides of the submodule in the zone between the submodule bottom strip and the girder key projection.
  (Comment: when the first submodule mounting the 0.8 *mm* thick gaskets were inserted between the left face bracket and the submodule);
- to transport the next submodule to the installing place on the girder.

When the mounting of all submodules is finished the $\varnothing 8\times 6000$ *mm* tubes we reinserted into all face holes of the module. In order to keep the elastic bushes in the submodules in the right position the needle was put on the tube end. (Here we mean the tubes for ^{137}Cs sources).

2.3.4 Installation of the strip clamping and the end plates

The strip clamping plate is put symmetric relatively to the outer surfaces of the utmost submodules. Strip clamping plate welding to submodules starts from the middle of the central submodule to the edges.

The weld seam is alternatively imposed on each side with the seam full cross section and the length up to 50 *mm* for one step.

When one needs to pass over from one submodule to another one then in the gap between submodules it is necessary to set the technological cross-bar in order to prevent the decreasing of the submodule-submodule gap and/or even their touching at the top parts with following (possibly) binding when welding their part. Before welding the strip clamping plate is closely pressed to the submodules key way by the technology clamps.

When the welding of the strip clamping plate to the submodules is finished then the horizontal platform and face brackets of the main tool for the module assembly are taken out and positioned near the assembled module on its one side.

The end plates are clamped to the module faces. At the bottom the plates are fixed by bolts, in the top the are welded to the front strip clamping plate.

2.3.5 The module geometry control

The precision of the module external dimensions depends:

1. on the production accuracy of the elements used for module assembly;

2. on the precision of these elements relative positioning.

The important geometry parameter which is depending on the assembly quality is the module side surface nonplanarity.

This parameter was measured twice: before welding of the strip clamping and after that. The nonplanarity of the module was defined with the help of the one meter rangle ruler and the set of the feelers. The maximum nonplanarity measured before the weld works was equal to 0.4 *mm/meter* and after the weld works — 0.45 *mm/meter*.

The module length was controlled by the ruler for the different cross sections of the module. The measured lengths were the same and it equal to 5641 *mm*.

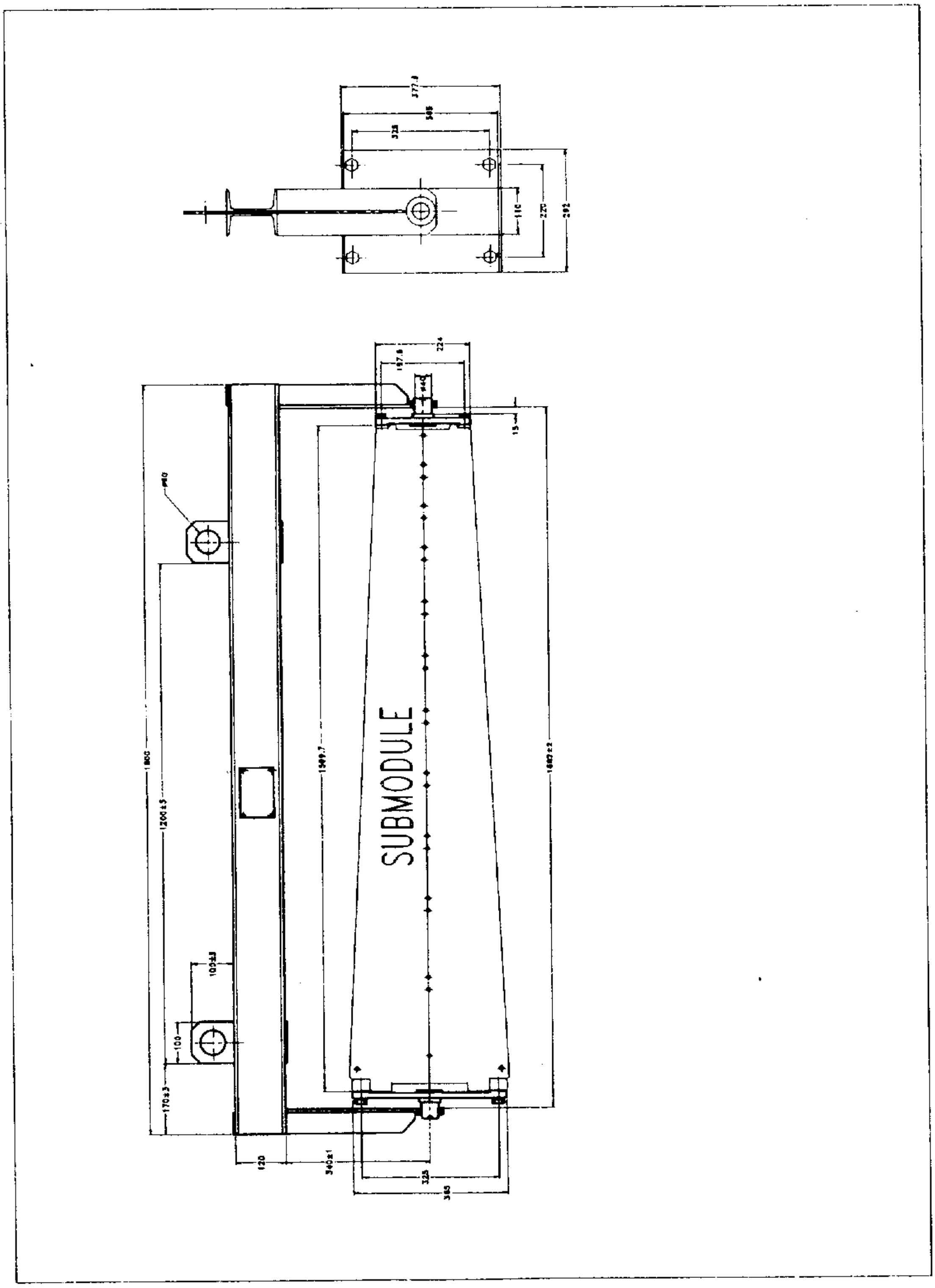

Figure 1

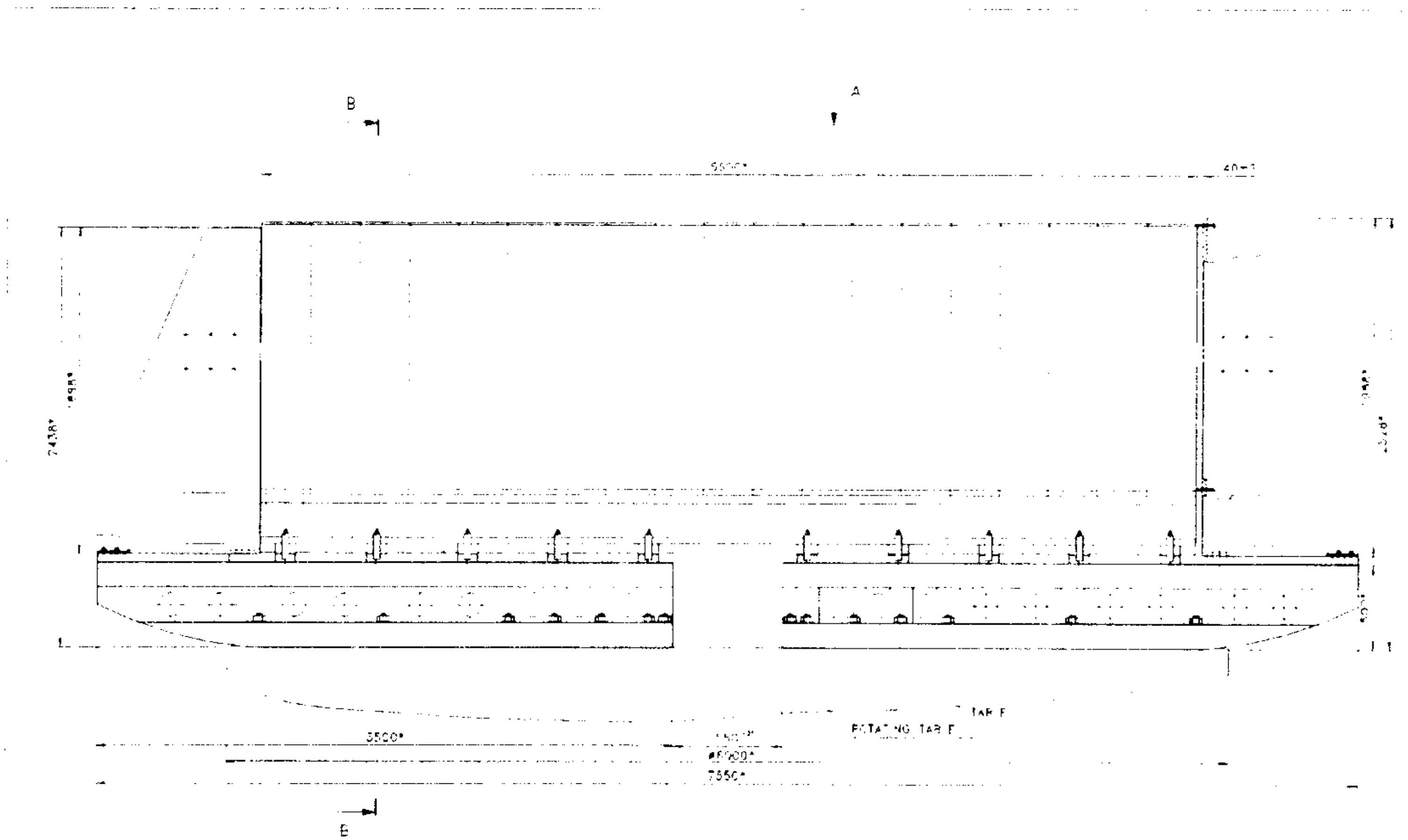

Figure 2

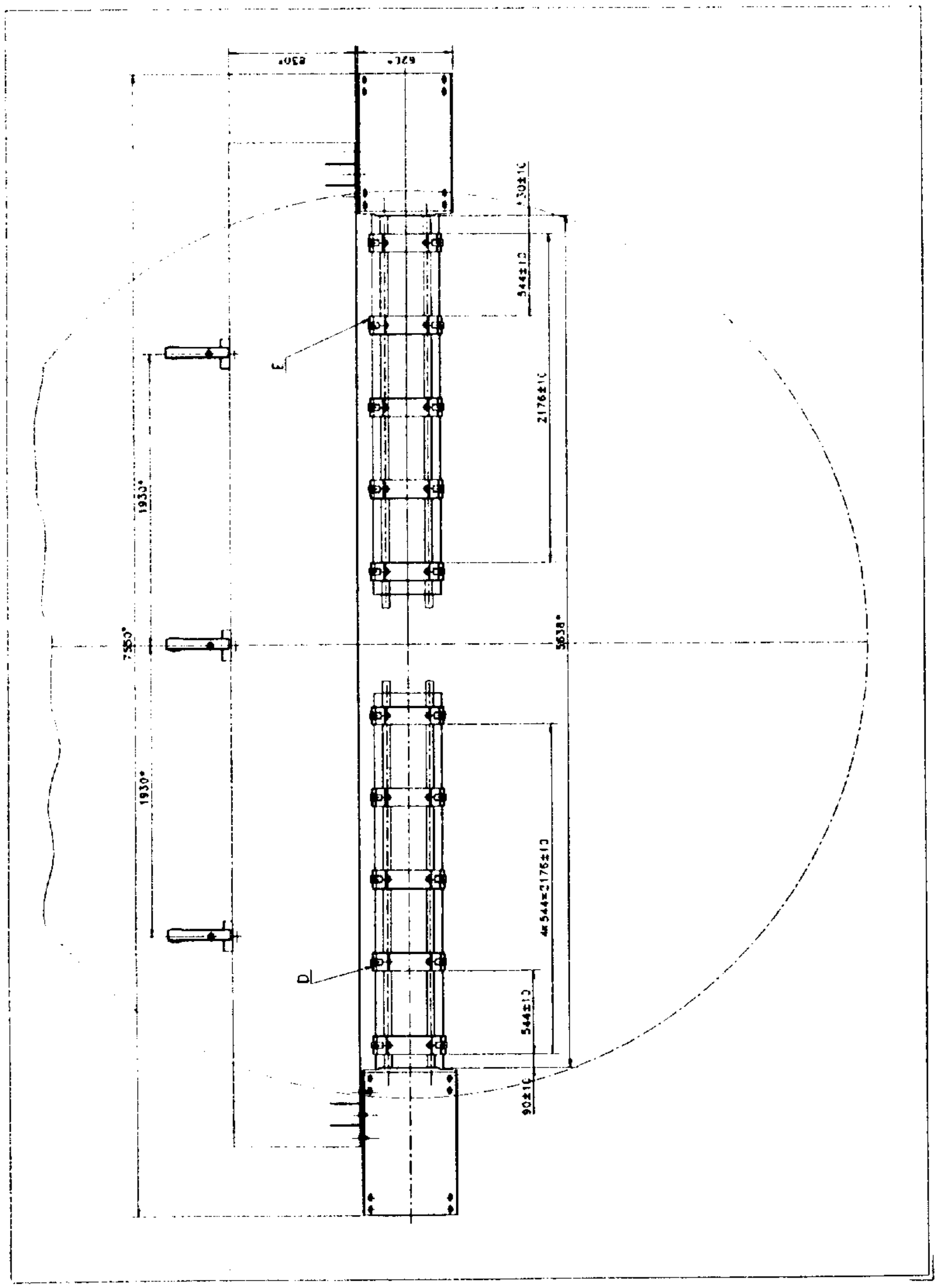
830*
820*
130±10
544±10
2176±10
1930*
7580*
5638*
4x544=2176±10
90±10
E
D

Figure 3

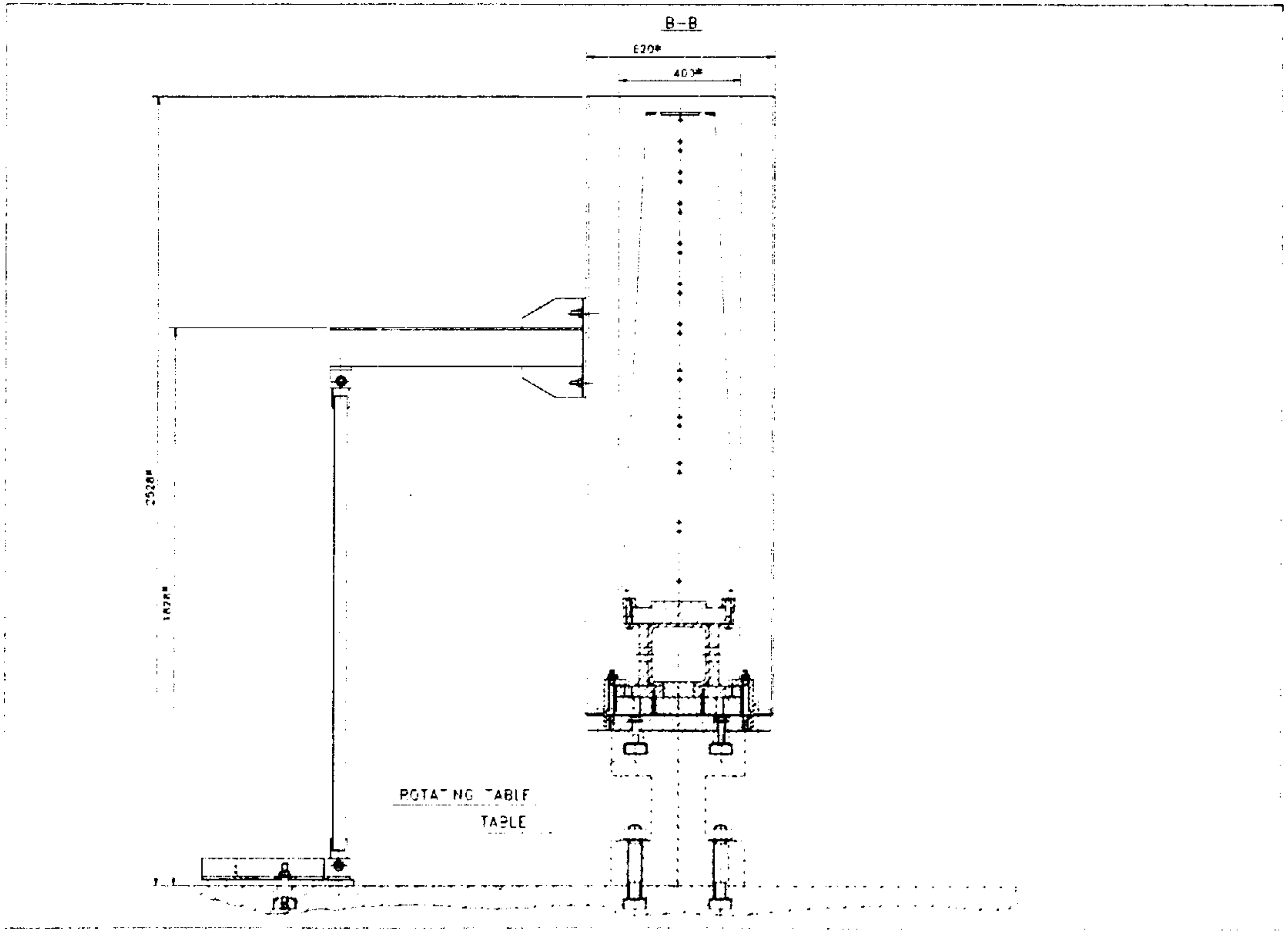

Figure 4

3 Conclusions

0-module was delivered to CERN in the beginning of May'96. Then the scintillator plates (tiles), fibers and drawer with electronics were installed into the module and in August-September it was successfully tested on the north beam area at CERN.

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Технология сборки модуля-0 барреля адронного калориметра
установки АТЛАС

Представлены результаты завершающего этапа в создании модуля-0 адронного калориметра установки АТЛАС. Создание модуля-0 стало возможным благодаря совместным усилиям в течение длительного периода специалистов из Дубны, Барселоны, ЦЕРНа, Праги, Пизы, Аргонна, Бухареста, Протвино.

Работа выполнена в Лаборатории ядерных проблем ОИЯИ.

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ATLAS Barrel Hadron Calorimeter
0-Module Assembly Technology

The «last step» of the 0-module production of the ATLAS Barrel Hadron Calorimeter is described. This «last step» became possible due to long period Dubna, Barcelona, CERN, Prague, Pisa, Argonne, Bucharest, Protvino collaborative efforts.

The investigation has been performed at the Laboratory of Nuclear Problems, JINR.

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