

A RO-RO RAMP WITH SOME SPECIAL FEATURES

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1 General

Increasing commercial traffic between Ireland and England resulted in the decision to enlarge the Dublin Harbour with 60.000 m² new loading/unloading facilities and a new Ro-Ro ramp. Merchant Ferries is the operator of the terminal with Ove Arup as their Engineer. Ascon, the Irish main contractor, subcontracted the Ro-Ro ramp to HSM, which in its turn subcontracted the design to Delta Marine Consultants. In June 1994 the contract was awarded, under the condition that the ramp would be operational in December 1994. Only about seven months were available for the design, the construction of the 350 ton ramp with mechanical installation in The Netherlands, the transport [in winter season] to Ireland and the commissioning. Planning showed that construction had to start immediately, leaving no time to finish the detailed design before start of construction. So concurrent engineering had to take place with design and construction as two parallel activities.

2 Description of the Ro-Ro Ramp

The Ro-Ro ramp is located at the far end of a new dock quay, allowing ships to berth along mooring dolphins. It consists of a bridge part, supported at the shore by a hinge and integrated at the sea side with a pontoon. The width of the bridge is 10 meters and the shipside of the pontoon is 20 meters, allowing a wide range of Ro-Ro vessels to berth.

The allowable length of the total structure was limited, due to the available length of the harbour and the dimensions of the vessels to be expected. This resulted in a bridgelength of 22.5 m and a pontoonlength of 12.5 m.

At the shore side, the hinge allows changes of inclination of the ramp and small rotational movements in the horizontal plane. At the sea side, the ramp is supported in horizontal direction by a fenderpile and floats up and down with the tide [Appendix A, figure 1].

The ramp is fitted out at the sea side with a large ballast tank with submersible pumps, located in the pontoon, to adjust the freeboard of the ramp in relation to the draft of the vessel and the changes in freeboard of the pontoon due to the tidal movement.

We refer to Appendix A, Fig.1 Ro-Ro Ramp

3 Performance Specifications

The Ro-Ro ramp has to cater for the following principle operational conditions:

3.1 four different types of ferries, each characterized by:

- * the beam of the ferry, which determines the difference between the centerline of the ship and the centerline of the Ro-Ro ramp, due to the fact that the ferries are always moored alongside the mooring dolphins. It results in asymmetrical traffic loading on the Ro-Ro ramp.
- * the stern ramp length of the ferry, which influences the slope of her own ramp during operation. The dimensions vary between 8.50 m and 12.30 m.
- * the stern ramp width of the ferry, which influences the a-symmetrical traffic loading on the Ro-Ro ramp. The dimensions vary between 7.60 m and 11.54 m [App. A, figure 2].

We refer to Appendix A, Fig. 2 Ro-Ro Ramp with several ferry layouts

- * the structural dimensions of the ramp of the ferry, which requires careful attention to the nose design of the Ro-Ro ramp, to prevent [non acceptable] structural contact.
- * the changes in freeboard of the ferry during loading and unloading. The lowest level is L.A.T. + 1.45 m and the highest level L.A.T. + 4.00 m, while for each individual ferry the freeboard varies during loading/unloading about 1 meter in respectively 1.5 or 2 hours [App. A, fig. 3].

We refer to Appendix A, Fig. 3 Transitions and inclinations

3.2 Loading and unloading must be able to take place in between waterlevels L.A.T. + 0.00 m and L.A.T. + 4.50 m.

3.3 Because this Ro-Ro ramp is intended to be used for heavy commercial [lorry] traffic transport only, special design load cases were defined:

- * to allow quick loading and unloading, double lanes of HA traffic loading, according to the British Standard. The HA load represents a lane full with cars.
- * a special transport defined as a 45 unit HB load. This represents a single 180 ton transport with wheel basis defined in the British Standard. This can be e.g. factory equipment.
- * a single 100 tons MAFI trailer. This is a theoretical future trailer, based on the existing 45 tons MAFI trailers. Besides the high load and special wheel layout, it is characterized by a very small 'bottomclearance'.

3.4 Besides these specific criteria, the Ro-Ro ramp has to cater for standards like:

- BS MA 97, which defines details of ramps and the allowable slopes and gradients.
- Numerous British Standard [steel] codes for the bridge section.
- Lloyd's Rules for the pontoon section.

To allow the Ro-Ro ramp to operate under all these criteria, an adjustable freeboard is required. For this purpose a waterballast tank is foreseen, which can adjust the freeboard, according to the requirements during [un]loading periods.

Besides the operational conditions, the Ro-Ro ramp has to be capable of surviving certain non operational local environmental conditions. This is a maximum waveheight of 1.2 meters and 3 second period.

4 From idea to final Design

The initial idea of the operator was, to make a structure with an internal freshwater ballasting system. For this purpose tanks were foreseen at the seaside of the pontoon and at the landside of the bridge. Pumping water from one into the other tank should adjust the freeboard of the ramp sufficiently. However, the very short allowable length, about 35 meters [comparable structures under these conditions are about 75 meters], made it impossible to get this idea realised. Finally, a seawater ballast system, which means a seawater ballast tank only in the pontoon, operated by a pumpsystem for ballasting and deballasting, was designed.

Up till now, often one of the compartments of the pontoon is outfitted as pumphroom and another as intake. However the allowable dimensions of this Ro-Ro ramp made it unattractive and difficult to design an independent pumphroom and intakeroom, because it would result in extra torsional forces in the structure.

It was decided, unconventionally, to locate the pumphroom in the ballasttank itself and to omit the intakeroom. This by itself very simple solution avoided the aforementioned difficulties [App. A, figure 4].

We refer to Appendix A, Fig. 4 Location of ballast tank and pumps

Another important interaction between Ro-Ro ramp and expected Ro-Ro ferries is the shape of the ferryramp. Several types of ferryramp structures with different dimensions exist and they differ significantly. Although it is the intention to standardize the ferryramp layout, this is not always the case with existing ships.

5 Operational Conditions

First a preliminary design was made to establish the expected selfweight and center of gravity. With these figures all loading combinations were calculated and checked. This resulted in the conclusion that a sea waterballast tank of 525 m³ was required, which could be located inbetween the framework spacing of the pontoon.

One of the important items for the operational conditions - and especially for the very heavy trailers - is the waterplane area of the pontoon. At the moment the trailer passes the pontoon, its weight will increase the draft of the pontoon, resulting in a change of the gradient and the transition angle. A small waterplane area will have a larger impact on these values. It is not possible of course, to adjust the waterballast quickly during passage of the trailer, so the design has to take care, that the trailer cannot touch the Ro-Ro and ferry ramp.

To fulfil all criteria for this structure, such as ramp shapes, gradients, transition angles, combination of structure length and special trailer dimensions, was impossible. In cooperation with the owner, the best fit pontoon deck geometry to accommodate the foreseen ferries was designed [figure 5].



Fig. 5 Deck geometry

6 Design/Construct

The fact that the total design/construction time was minimal and critical, it was necessary to implement in the design production friendly aspects, allowing construction to start long before the total final design was ready.

To minimize interference between design and construction and to allow flexibility in time, both for the design and for the construction, the following actions were taken:

- The layout of the structure was set-up in a standard grid, avoiding adjustments in overall dimensions.
- The structure was divided in parts, to allow parallel design by several engineers, reducing the design period and allowing the construction to start with several items at the same time.
- The bridge part was designed as an independent bridge, with its own girders and supports.
- The pontoon was designed independently.
- The pumpsystem was designed independently.
- Especially for steel structures, complicated details or connections cause often delays. Therefore one of the first actions was to design, establish and agree a number of standard [weld]connections for the total structure. These were the preferable connections of the contractor and were checked by the designers [App. A, fig. 6]. So production could not be delayed by details.
- The amount of steelplate thicknesses and qualities was minimized.
- Directly after the preliminary design, the contractor investigated the availability of steelplates and profiles, because there was hardly time available for delivery of special materials. Construction had to take place with direct available materials.

To keep all activities under control, both in time as in money, coordination is of utmost importance. Communication lines were very short, mostly directly between the designer and the production staff.

Although the reality is always more complicated, it was possible to accomplish the design and construction of the Ro-Ro ramp in time.

We refer to Appendix A, Fig. 6 Connection details

7 Structural

The structure is characterized by a very straightforward design.

The bridge consists of two main girders in longitudinal direction and in transverse direction each 5 meter a truss, supporting the deck.

Due to the fact, that during high water the underside of the bridge crosses the waterlevel, a box type structure has not been designed. It is important to prevent extra uplift by floating of the bridge part. This would result in increased gradients and extra forces in the ramp. The advantage of a box structure is the torsional stiffness.

The deck of the bridge and pontoon is of a special design. It consists of a steel plate supported by troughs in longitudinal direction. The dimensions of these troughs are larger than usual. This is a typical matter of a design/construct. These troughs were available, while other dimensions would enlarge the production time. By designing the total bridge section based on these troughs, the allowable construction time could be met [App. A, figure 7].

We refer to Appendix A, fig. 7 Steel deck with troughs

The torsional forces in the bridge are taken by the bracings between the lower web and the bridge deck. The usual large torsional forces in asymmetrical layouts were minimized by the symmetrical layout of the Ro-Ro ramp. Only traffic can cause significant torsion.

The pontoon is designed according to Lloyds rules, Ship to Shore Ramps and Link Spans [App. A, fig. 8,9,10]. The waterballast tank is located in the two seaside spans. In the landside span 3 small permanent waterballast tanks are located as provision to trim the Ro-Ro ramp with the middle tank in longitudinal direction and to correct with both outside tanks the transversal direction.

These measurements are foreseen, because the operational criteria are so critical and construction had to start long before the final design was ready and the final center of gravity was sufficiently accurately known. This is one of the important things in design/construct projects with insufficient time for the design. By including in the design such type of flexibilities, small adjustments are possible during construction, allowing the construction to start early. It appeared, during commissioning, that no permanent waterballast was required.

We refer to Appendix A, fig. 8 Horizontal crosssection pontoon

We refer to Appendix A, fig. 9 Longitudinal crosssection pontoon

We refer to Appendix A, fig. 10 Transversal crosssection pontoon

8 A new solution within a code

As mentioned above, the pontoon is designed according to Lloyds Rules and the deck according to British Standards, as required in the specifications.

Designing a deck of a floating structure, supported by troughs is never done before. This resulted in discussions with and explanation to the certifying authorities, but was finally approved. The advantage of the through is the simple design without many connection details and the fast construction method, which can be done completely by automatic welding. This type of structure is used regularly in bridge constructions. The main reason that marine authorities do not like the through is the fact, that corrosion control cannot take place at the inside. This is an understandable reason, but by welding the through completely and pressure testing the welds, the inside is fully sealed from the outside.

9 Discrepancies between codes

Another point of interest is the ever increasing amount of codes and the increase in discrepancies between them. Codes are not always compatible and do not always fit to each other. The connection between deck and pontoon is one of those examples. Designing it according to the Lloyds Rules would result in a more complicated solution than according to the British Standards. Contractually it was not defined which code had to be used for this connection. Because the pontoon had to be certified according to Lloyds Rules and time was running out, the Lloyds solution was finally adopted.

Another important matter to be mentioned is, that most construction codes are self explanatory and selfregulatory documents. They can be used by every engineer, without consulting the authors, and can be checked by other fully independent engineers. However, for Lloyds codes this is different. Because they are based partly on empirical experience, different interpretations are possible. Because certification is only allowed by the Lloyds organization, the experience and interpretation of Lloyds need to be consulted.

10 Hinge

At the shoreside, the bridge is supported by a hinge. The hinge allows three motions:

- a vertical movement of the pontoon, due to the tide, the waterballast and the traffic loads
- a longitudinal movement, to allow the berthing energy on the ramp to be taken by the fenders behind the hinge. No soft fenders are foreseen at the seaside. The load is transferred through the ramp to the hinge and dissipated by two fenders.
- a small horizontal rotation, caused by the allowed deflection of the mooring pile at the seaside of the ramp.

To allow all these movements, the shoreside of the ramp is shaped as a small box structure with at each side a sliding/rotating support.

For this purpose curved Mehanite plates are mounted to the ramp, which can rotate due to there shape and glide inbetween steel plates. At the seaside a restraint is foreseen to prevent sliding of the ramp into the water after the fender expands.

To prevent uplift of the ramp during loading at the pontoon side, an upside blockage structure is foreseen [App. A, figure 11].

We refer to Appendix A, fig. 11 Hinge

Between ramp and concrete abutment flaps are foreseen. Detailing of these flaps is complicated, because of the heavy load and gradient/transition angle criteria. Provisions need to be taken to prevent accidental uplift of these flaps [App. A, fig. 12].

We refer to Appendix A, fig. 12 Hinge detail

11 Ballast system

The ballast system consists of a ballast room at the seaside of the pontoon, two inlet and two outlet submersible pumps and an operator cabin with control equipment on deck.

To avoid a torsional moment in the structure, one inlet and one outlet pump is located at each side of the ballast room.

A hatch at each side allows access to the room and pumps and if necessary removal of the pumps.

The pumps are designed for 215 m³/h and need to operate under rather varying conditions. Due to the changing gradient of the Ro-Ro ramp, the internal and outside waterplane varies, changing the head of each pump.

In this case also the construction height off the pontoon is very important. The larger the height, the easier it is to locate the pumps. However, the larger the height the more permanent [water]ballast has to be taken into account. This is an undesirable situation, both from operational point [maintenance] as from cost.

For construction reasons it was favourable to have a flat bottom.

Optimisation of the height and all other operational conditions resulted in a height of 5.78 m. This allows sufficient head for the inlet pumps located at the bottom of the ballast room.

However locating the outlet pumps at the bottom would result in insufficient waterheight at the inlet of the pumps and consequential suction of air during certain load combinations. For this reason each outlet pump is located in a small bun, 750 mm below the bottom of the pontoon.

12 Outfitting of the ramp

The Ro-Ro ramp is equipped with a small control room on deck, a walkway alongside the bridge, rubbing strips in the landing area of the ferryramp, roadsurfacing on the bridgedeck and lighting. Watertight doors, inspection ladders and platforms allow for access to the inside of the pontoon. Lifting points are foreseen for transport and installation.

13 Construction of the ramp

The ramp is constructed in two parts, the pontoon and the bridge and finally assembled [App., fig. 8].

The baseplate and sides of the pontoon were provided with stiffeners by automatic welding before assembling [App. A, figure 11].

The bridge was made upside down, because that allowed the troughs to be welded automatically. When this section was ready, it was turned, lifted and connected to the pontoon.

All these activities took place in a sheltered construction hall, providing good working conditions during wintertime.

When the ramp was ready and provided with the necessary inside and outside coating, it was moved out of the hall by multiwheel lorries, lifted by two floating cranes and placed on the transport barge [App. A, fig. 13].

Because at the same time HSM was also building the new Linkspan for Cork, both the Linkspan as the Ro-Ro pontoon were transported by the same seagoing barge.



fig. 13 *Loadout of the Ro-Ro pontoon*

After 5 days sailing, the barge arrived in Cork, where the Linkspan was offloaded. After arriving in Dublin, the Ro-Ro pontoon started its floating life by submersing the barge and supporting the landside of the bridge by a floater. The ramp was towed to its destination in the harbour and with the support of a landbased crane placed in position. After some final installation activities and commissioning, the Ro-Ro ramp was transferred to the owner.

APPENDIX 'A'

1/1

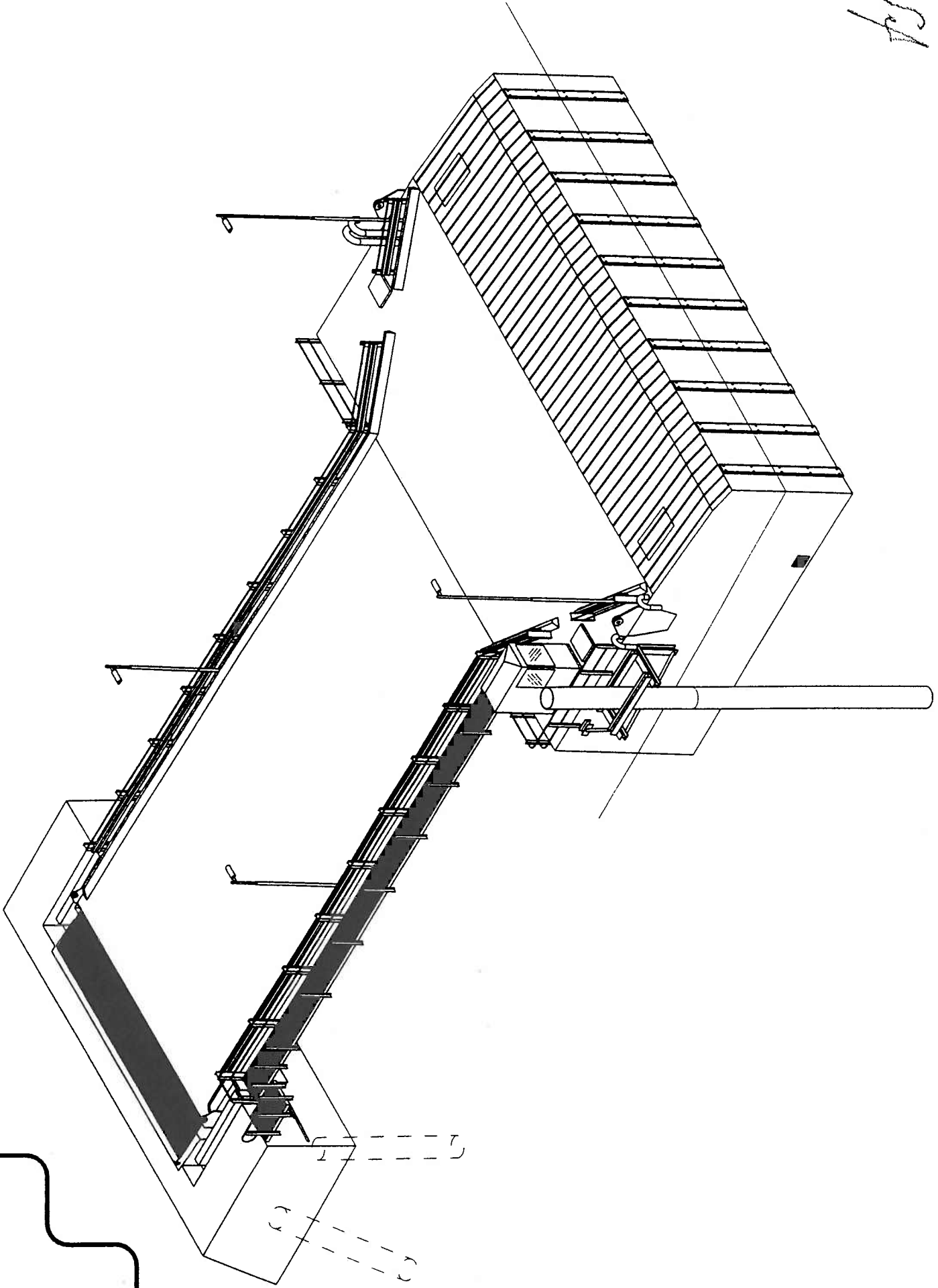
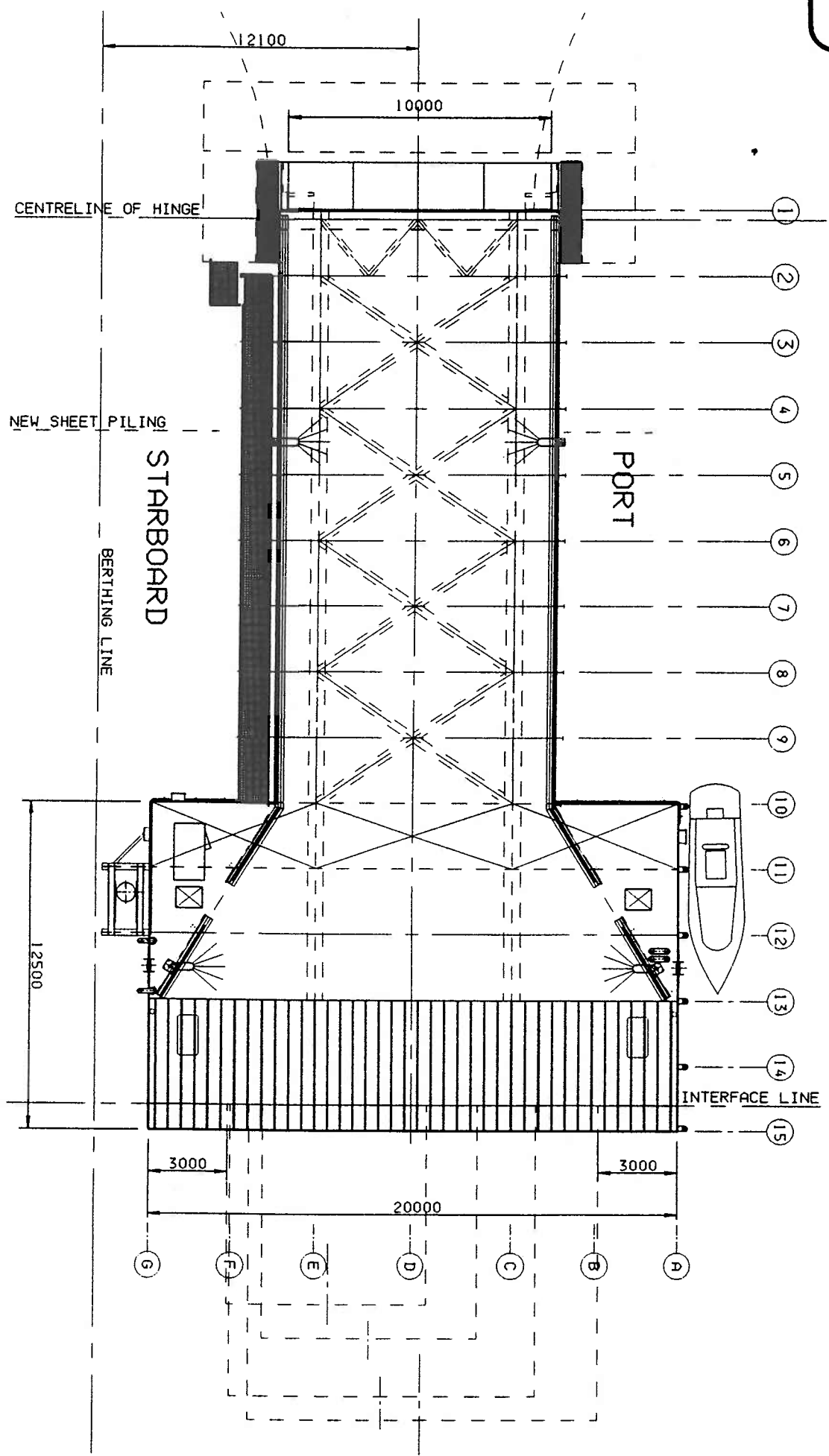


Fig 2



Form: A31297x420mm

Fig 3

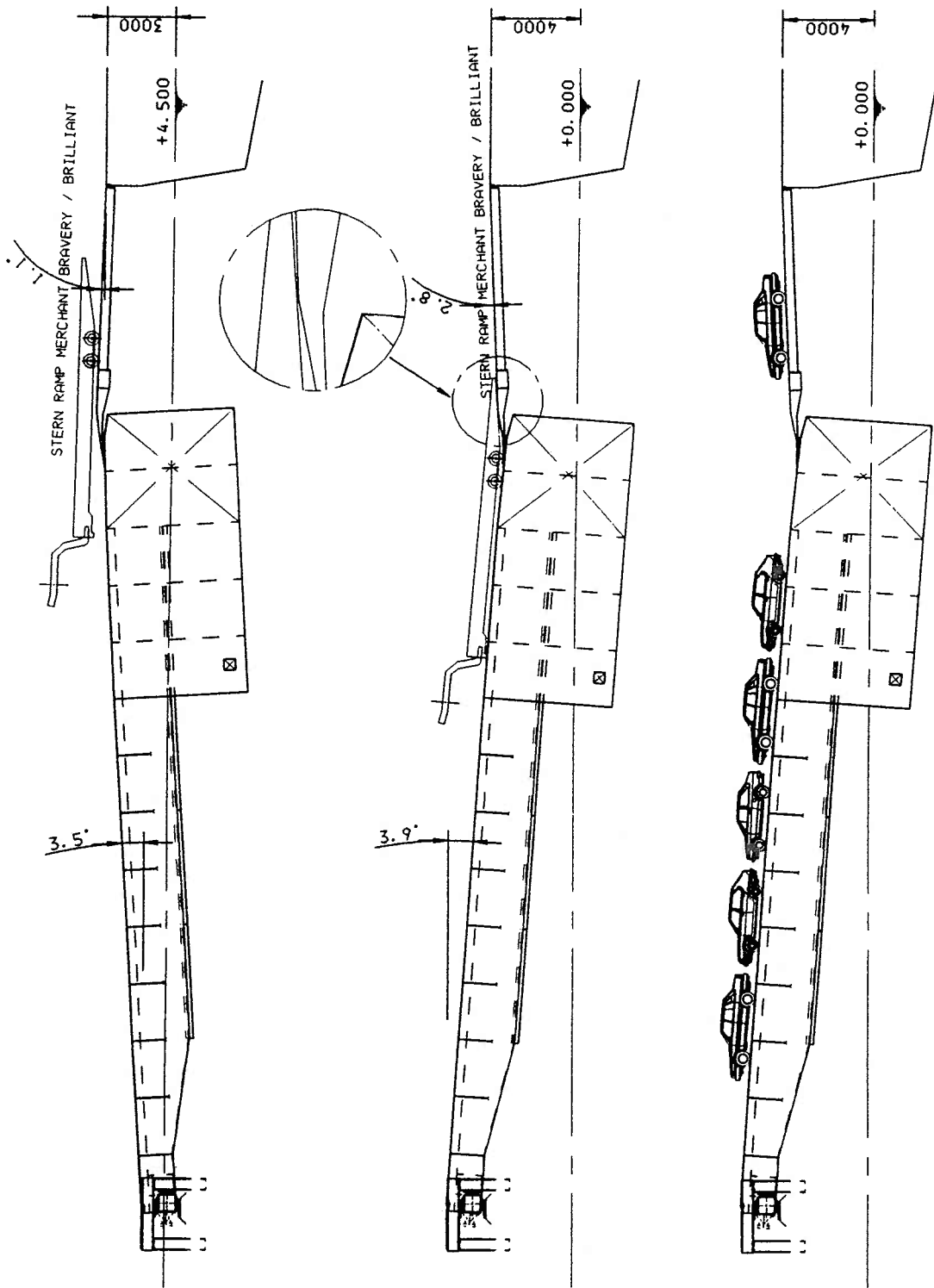
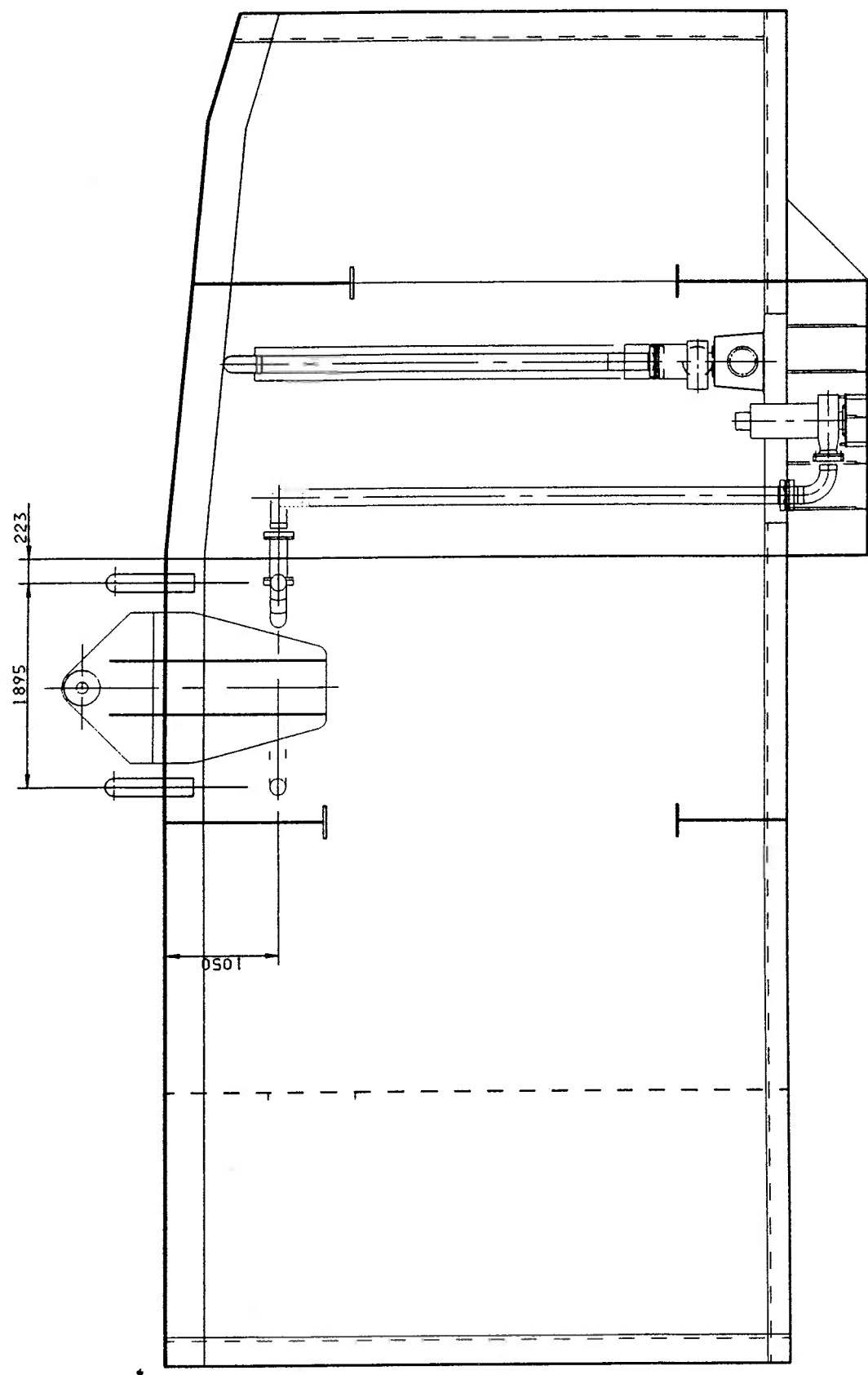
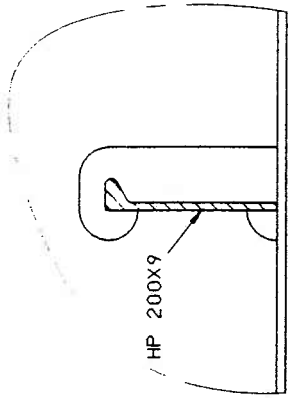


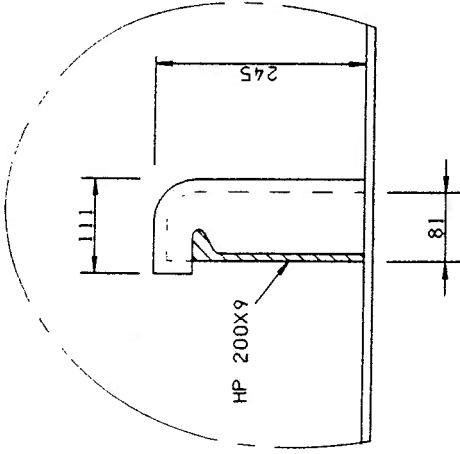
Fig 4



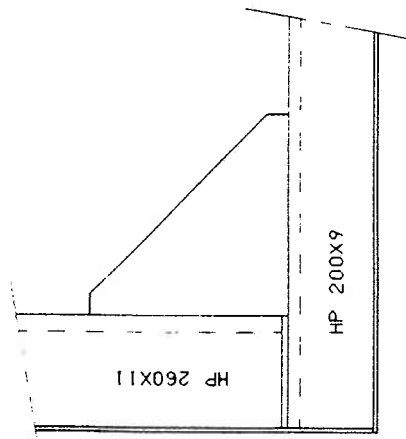
TYP. DETAIL
BULB THROUGH
WEB FRAME



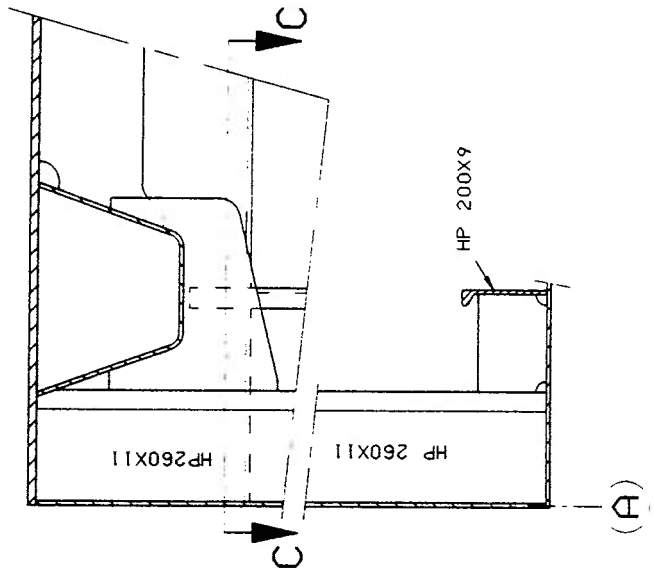
TYP. DETAIL
BULB TROUGH
W. T. BULKHEAD FRAME



TYP. DETAIL BULB-BULB



TYP. DETAIL SIDE WALL



SECTION C-C
(TYPICAL)

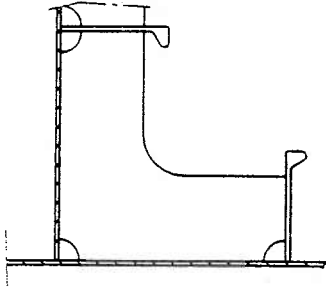
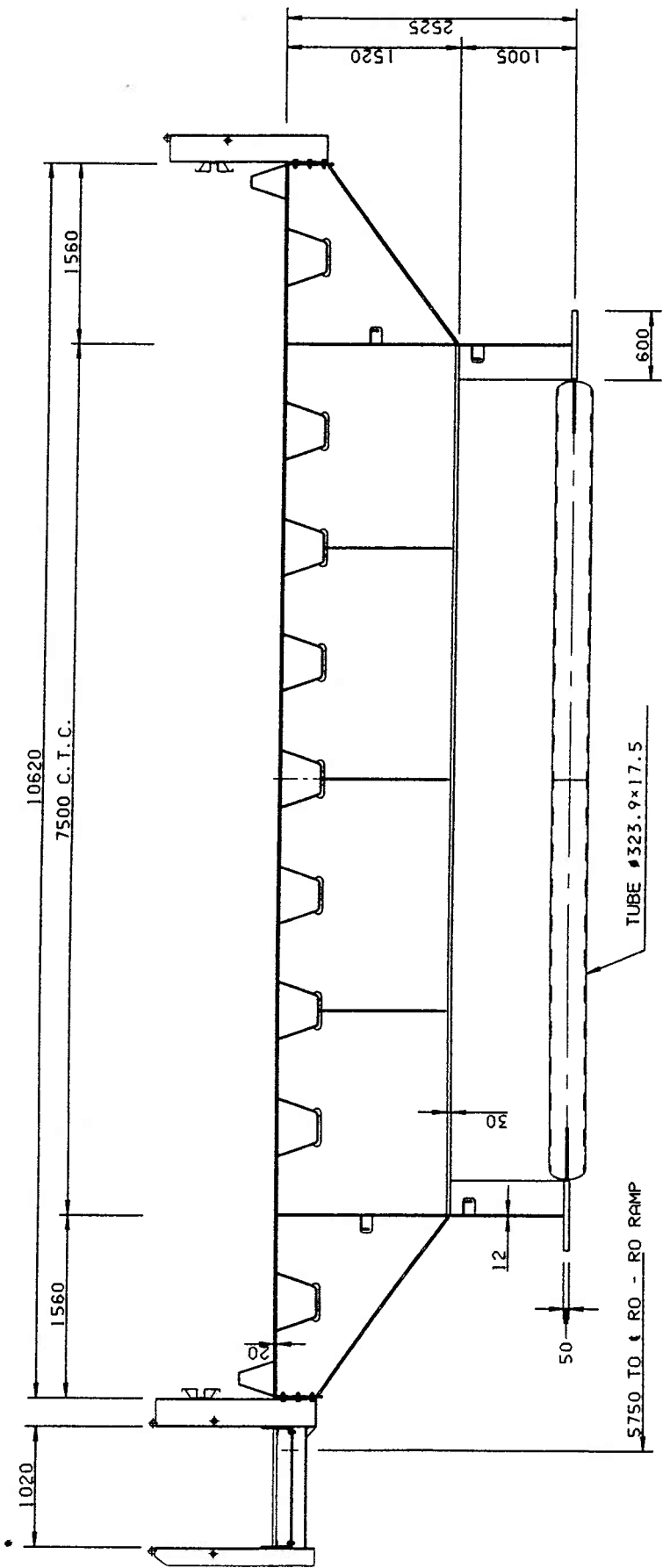


fig 6

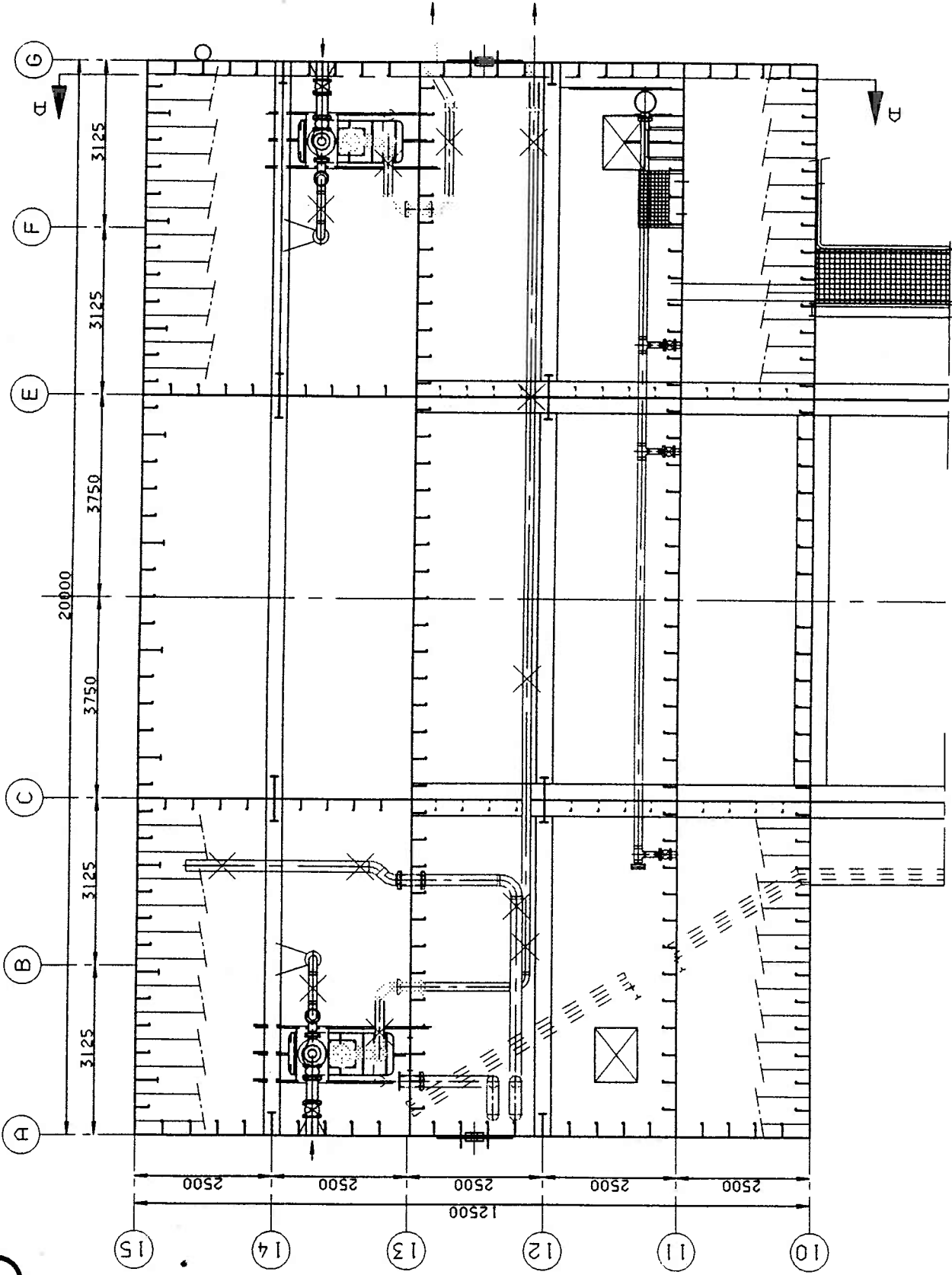
Fig 7



TYP. CROSS SECTION

fig 8

Form 141 (97-420mm)



STARBOARD

TOP VIEW

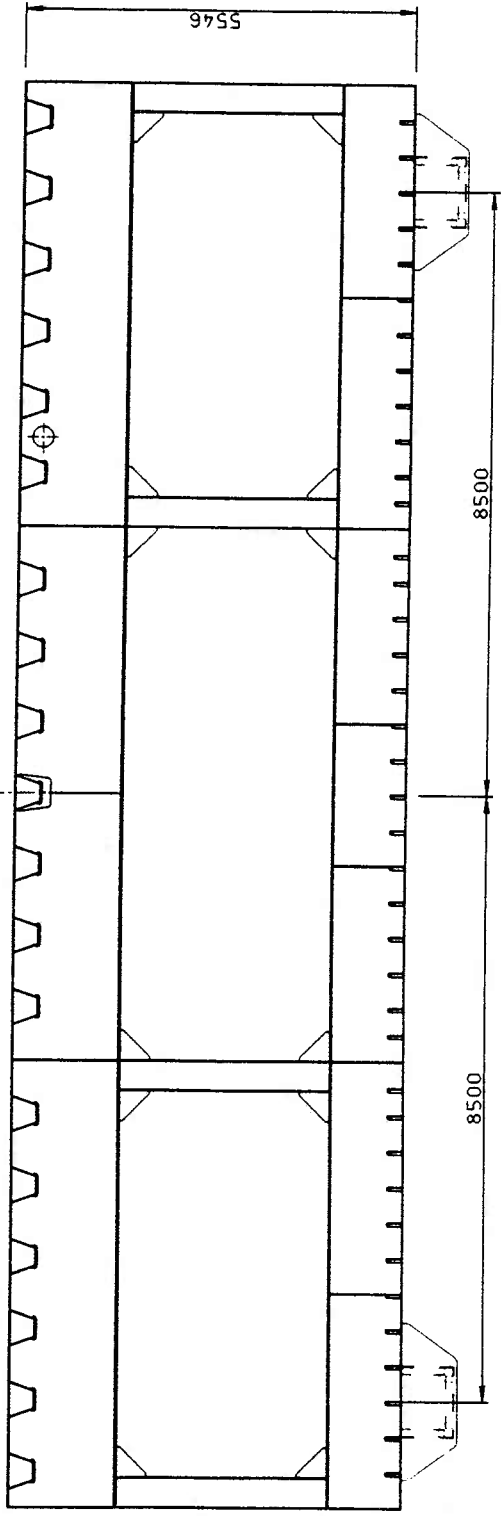
PORT

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WEBFRAME 14

STARBOARD

PORT



FRONT PLATE 15

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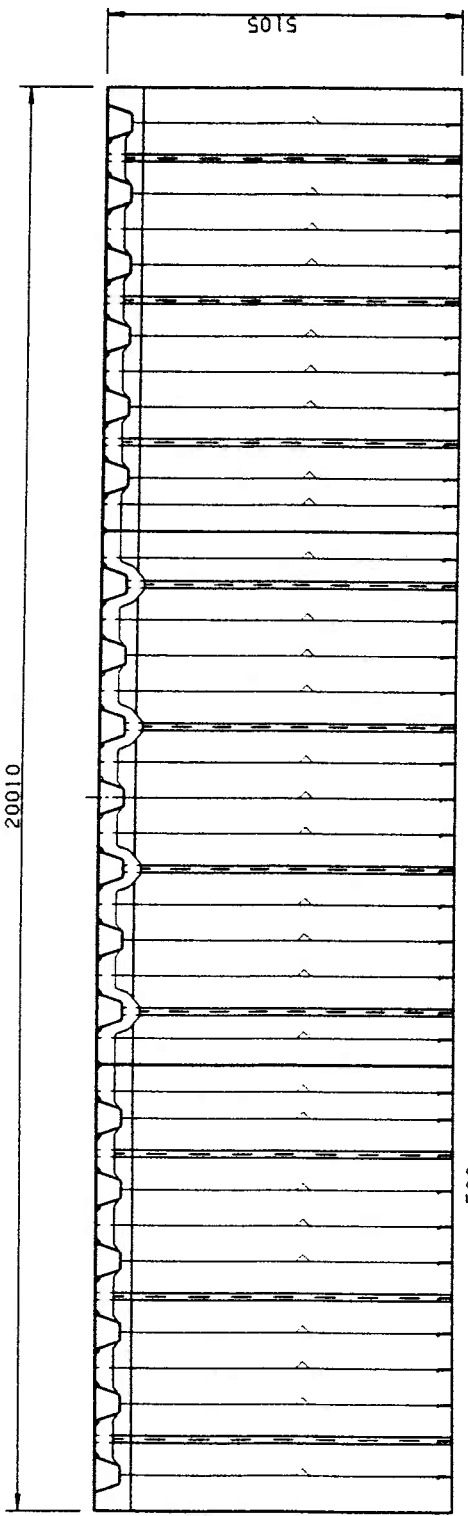
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PORT

STARBOARD

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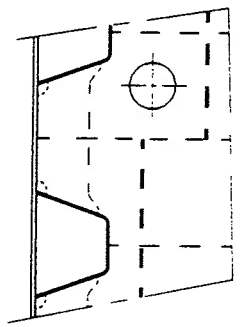
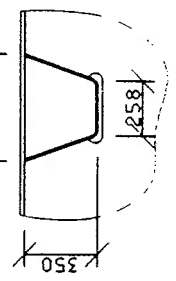
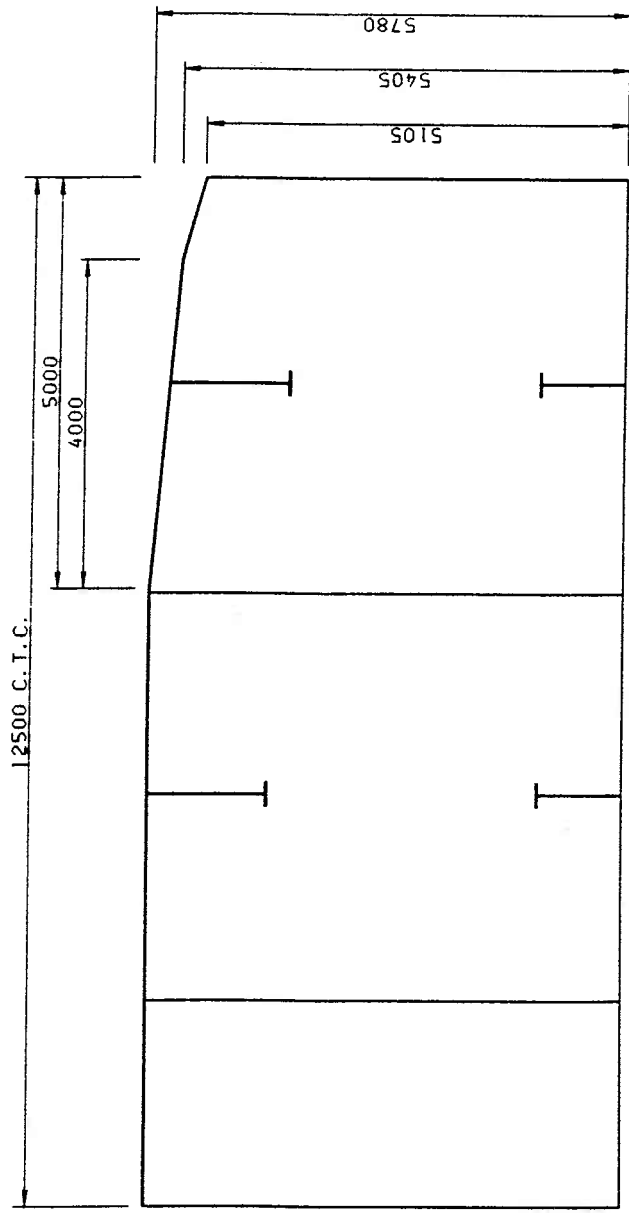
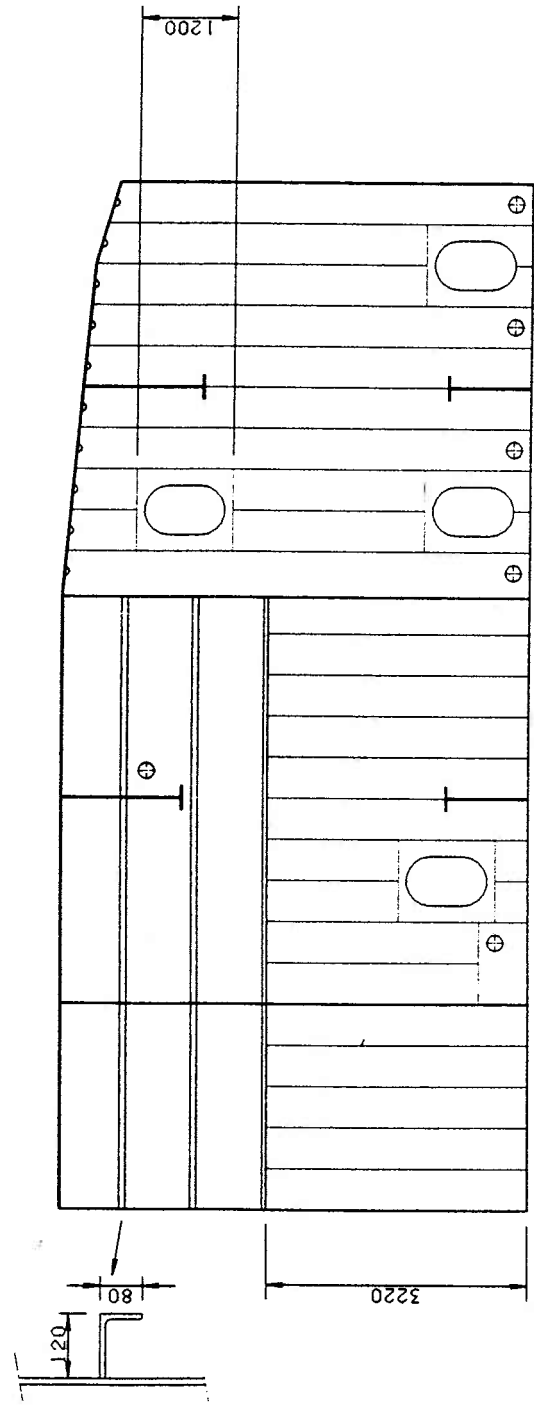


Fig 9

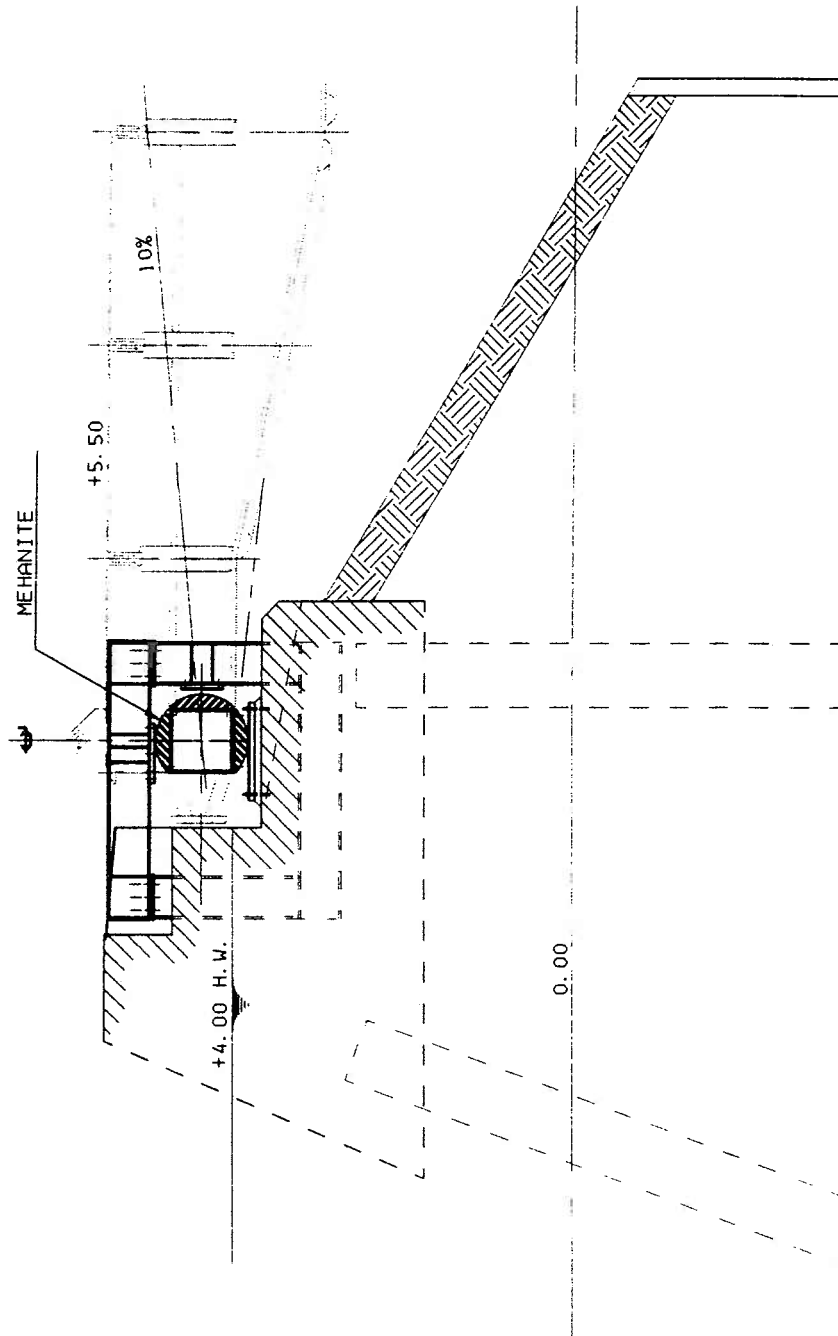


LONGITUDINAL SECTION F AND B



LONGITUDINAL WEB FRAME E AND C

Fig 10



11 G4

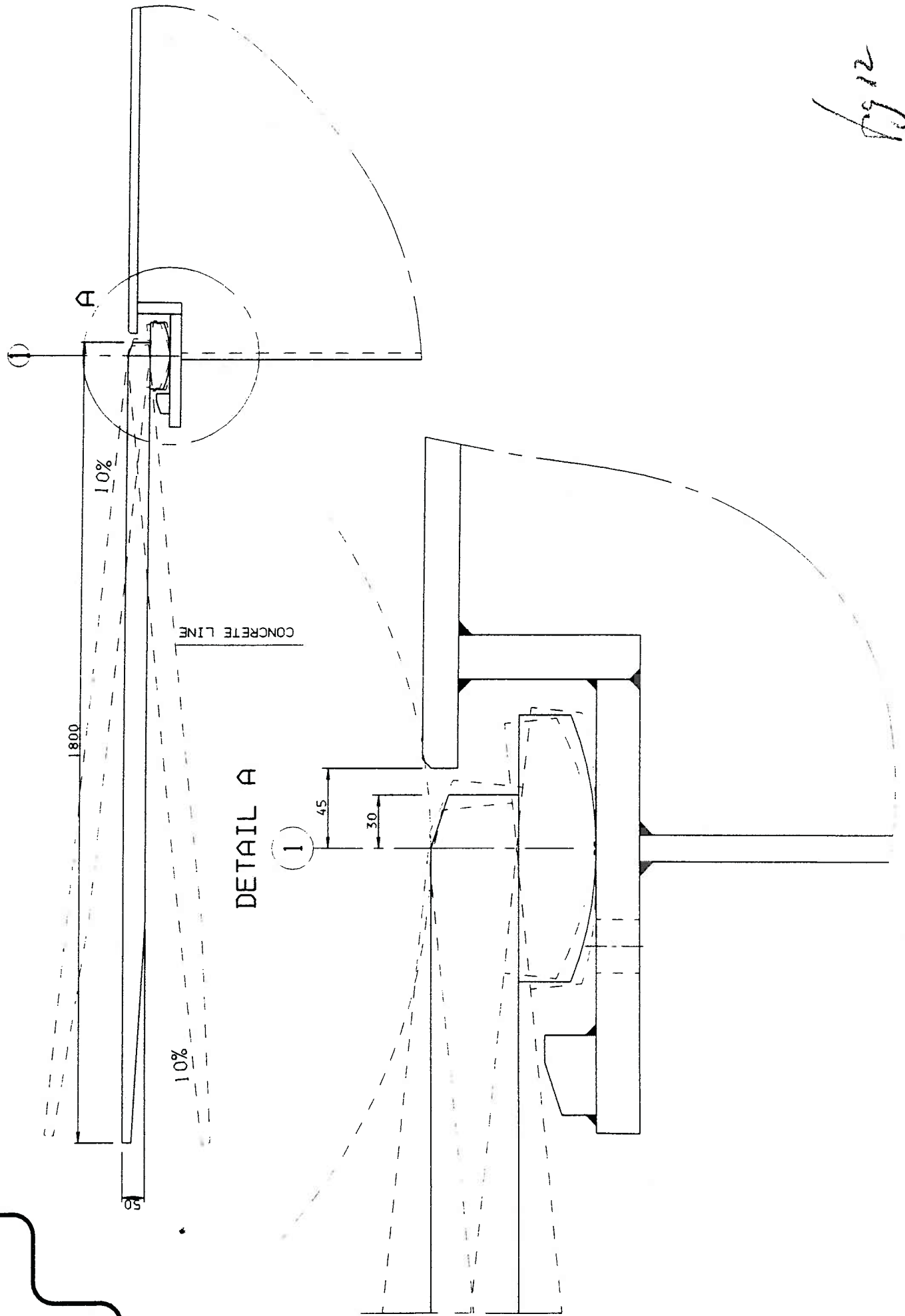


fig 12