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L* at SSC

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1) Introduction

The model adopted for the structures for the L* detector follows the model used for the L3 experiment at LEP. In this model a single long collision hall is constructed with its major axis along the collider beam line. The hall is designed and sized to allow space for construction of the detector in situ. Such an approach would be indicated if the detector components were too large to move off line for servicing. The approach would be viable if an alternate beam orbit (bypass) were provided to allow for moving the beam line away from the detector, or if the schedule for completion of detector construction were matched to that of the accelerator and adequate down time were provided during the annual operating cycle to maintain and upgrade the detector in situ. No special shielding is required in this model since there is no beam-level assembly area requiring access during operations.

2) General Description of Magnet Assembly

The main parameters of the L* detector are listed in Annex 1. The L* magnet (19 m free bore and 28 m free length) is now modelled as a huge 20 MW DC conventional aluminium coil with full iron shielding (Figs. 1 and 2). The main parameters are listed on Fig. 3 and compared to the L3 magnet. The enormous mass of the magnet (49000 tons) and the large dimensions involved (up to 27 m in diameter) have lead the L* Collaboration to propose the concept of manufacturing as far as possible complete units of large individual mass of up to 600 tons (Fig. 4). This option determines largely the dimensions and lay-out of the various halls. The Coil Pancakes, the Iron Crowns, and the Hadron Calorimeter will be assembled as complete units in near-by assembly halls, brought in the horizontal position over the head of the Construction Shafts by multi-rollers rigging jigs using wide gauge temporary railways (Fig. 5). Coil Pancakes and Iron Crowns will be rotated in the vertical position in the pit head (Figs. 6 and 7). In the Construction Shafts, special lifting equipment installed on a temporary basis (for example four 200 tons lifting towers Figs. 8 and 9) will allow the lowering of individuals loads up to 800 tons (including lifting jig). At the bottom of the Construction Shafts, the heavy loads will be deposited together with the lifting jig equipped with proper multi-rollers on side rails running along the Collision Hall to allow swift moving into the assembly position (Figs. 10–14). The bars for the magnet iron barrel will be lowered in the Construction Hall by a 300 ton mobile crane and installed in position by one of the overhead bridge cranes.

The same mobile crane will also be used to lower 50 ton fully pre-equipped counting rooms inside the Counting Room Shaft situated directly above the magnet.
Other parts of the L* detector will be handled in a conventional way by the various overhead bridge cranes installed in the Assembly Halls, the Construction Shaft Headhouses and the Collision Hall.

It is worth noting that the L* Collaboration is also looking, as an option, at a superconducting solenoid coil but this appears technically difficult. This superconducting magnet should be manufactured from pre-machined elements assembled on the surface. The same kind of heavy rigging equipment mentioned above could be use to lower complete sections of coils down in the Collision Hall. However, it is clear that building such a huge superconducting coil on the surface would have important implications for the assembly halls and services needed on the surface which are not considered here.

3) Collision Hall Complex Description

Taking into account the previous description key features of the Collision Hall Complex include (see Fig 15):

- The beamline is 217 ft [66.1 m] below the surface.
- The interaction point is located centrally in the Collision Hall, 13.5 m abovethe floor.
- A Collision Hall, 40 W × 108 L × 37.5 H m^3 where the width is transverse to the beam.
- Two 20 × 40 m^2 construction shafts from the surface to the hall roof.
- A Counting Room Shaft 20 × 29 m situated between the two Construction Shafts.
- Two 30-ft- [9 m] diameter personnel and utility shafts with tunnels.
- Two overhead cranes: 100/20-ton crane; hook height is 32.5 m.

3-1 Collision Hall

The width of the Collision Hall is determined largely by the detector 20 MW solenoid magnet and its assembly equipment where tracks would be laid out on each side to carry magnet parts of hundreds of tons. Adding to the overall width will be the space required to run hall and detector services. The length of the hall is defined as consisting of zones, the center part occupied by the magnet with adjacent detector assembly areas and component lowering and unloading zones.

The hall 108 m × 40 m × 37.5 m has a 40 × 20 m construction shaft at each end which is equipped with two 100/20 ton cranes. In the center there is the inclined concrete cradle to house the base of the magnet yoke. There are connecting tunnels to the utility shafts situated each side of the detector that permit the introduction of light equipment without opening the main shaft shielding plug. In the roof of the hall there are four chicanes feeding the Counting Room Shaft directly above the magnet.

In the model, two top-running bridge cranes are provided in the Collision Hall. Both cranes have a hook height of 32.5 m and a span of approximately 28 m, and run on a common set of rails. The hall crane hook height is 32.5 m above the floor. The crane hook is 5.5 m above the magnet yoke structure. The hall ceiling is 5 m above the hook, thus, the overall height of the hall is 37.5 m.

The cranes 100/20 ton are used for handling the large quantities of steel required for the magnet yoke assembly, most of which would be lowered down the construction shaft by a mobile 300 ton crane on the surface.

3-2 Shafts and Tunnels

Two rectangular construction shafts, one rectangular counting room shaft, two circular utility shafts, two hall access tunnels, and a utilities bypass tunnel were modelled. The dimensions and requirements of each are as follows:

3-2-1 Construction Shaft

The 40 × 20 m construction shafts are sized to allow the lowering of large pre-assembled pieces from the surface during construction (an example is a coil winding pancake weighing approximately 400 tons, 23 m in diameter by 1.2 m long.). After construction, the shaft would be plugged with shielding blocks and a mobile concrete cover for collider operation.

3-2-2 Counting Rooms Shaft

The counting rooms shaft 20 m × 29 m is sized to suit counting room modules (housing electronics dissipating to no more than 1.5 MW) that are pre-assembled on the surface (Fig. 16). The shaft situated above the magnet penetrates to within 8 m of the Collision Hall roof includes an elevator and stairwell complex with vent ducts. In each corner of the shaft there is a chicane 5 m × 3 m passing through the roof to the main hall creating detector services passages.

3-2-3 Utility Shafts

There are two 30-ft-[9-m] internal-diameter shafts that includes a equipment elevator of 3 m × 4 m with a capacity of 4 tons, a stairwell and vent duct. This shaft is 125 ft

[37 m] from the side of the hall away from the ring center, at both ends of the Collision Hall. The utility shaft extends to the surface and terminates at one end of the Construction Shaft Head Halls.

3-2-4 Bypass Tunnel

The bypass tunnel would have a width to match the main beam tunnel. The straight section of the tunnel is 45 ft [13 m] from the wall of the Collision Hall; this distance provides sufficient clearance from the Collision Hall to allow independent construction of the hall and its utility bypass.

3-3 Surface Halls

A large complex of surface halls is required for the assembly work of the detector (see Fig. 17).

The main features are:

- Two magnet coil assembly halls
- Two muon detector halls
- One hadron calorimeter hall
- One vertex/transition radiation hall
- One counting rooms hall
- Two construction shaft halls
- One magnet concrete slab
- Two coil element storage area

The main features of these surface halls are listed in Annex 2.

3-3-1 Magnet Halls

The Magnet Halls 62 m × 26 m complete with 100/20 tons cranes are for the manufacture of the coil windings and are foreseen to be established near the main Construction Shafts at a very early stage in the surface constructions in order to meet the schedule. They will be equipped with a wide gauge railway, large turntables and beam electron welding guns capable of joining the large slabs of aluminium to form the magnet coil turns.

3-3-2 Muon Chamber Hall

The Muon Chamber Hall 124 m × 26 m complete with a 20/5 ton crane is for the assembly of chamber parts and tests. There is an estimated minimum of 64 chambers that are assembled from manufactured parts delivered to site. The work of stringing the wires will be carried out in 8 very large clean rooms that can also be accessed by the crane. The assembled and tested chambers are mounted in frames shipped from the adjacent hall and mechanically tested, rotated and aligned. The units are then transferred to the vacant first Magnet Hall for storage.

3-3-3 Muon Frame Hall

The Muon Frame Hall 56 m × 26 m complete with a 20/5 ton crane is for the assembly of the frames that will house the muon chambers. Frame components are delivered to site and then assembled to create support structures approximately 5 m wide × 15 m long × 5 m high that are transferred to the Muon Chamber Hall.

3-3-4 Hadron Calorimeter Hall

The Hadron Calorimeter Hall 40 m × 26 m complete with a 40/3 ton crane is for the assembly of modules delivered to site. Each module can weigh up to 5 tons and may contain uranium as an absorber. The modules are formed into rings on turntables where the completed 40 ton 6 m diameter ring is stood vertically and transferred to the assembly point in the vacant second Magnet Hall.

3-3-5 Vertex/ Transition Radiation Detector Hall

The Vertex/ Transition Radiation Detector Hall 40 m × 26 m equipped with a 20/5 ton crane is for assembly of the detector parts and to house a light workshop that will give support to the L * detector as a whole.

3-3-6 Counting Rooms Hall

The Counting Room Hall 40 m × 26 m, covering the shaft housing the control room modules, is equipped with a 10 ton crane capable of handling full row of racks and smaller components such as air conditioners.

3-3-7 Construction Shaft Halls

The Construction Shaft Halls 80 m × 26 m equipped with a 100/20 ton crane are a function of the magnet assembly schedule. These halls contain the movable shielding plugs (Fig. 18).

3-3-8 Magnet Concrete Slab

A 70 × 40 concrete slab, situated in the proximity of the Construction Shafts, equipped with a wide gauge railway will be used to assemble by welding and store various iron crowns in the pole structure of the magnet. A 300 ton mobile crane will service the area and a mobile tent will be installed when the welding is in progress.

3-3-9 Storage Areas

The storage of the finished coil pancakes requires a total surface of 1400 m^2. These four area should be recessed in the ground by 8 m to limit interference between the stored pancakes and the movement of pancakes on the ground level. Another 1300 m^2 of storage area will be needed for storing the aluminium slabs before welding. The Magnet Concrete Slab must be adjacent to a 1700 m^2 of parking lot used as storage area for the iron bars and iron pieces before welding. Other storage areas for various materials will be required throughout the site.

4) Material Handling

4-1 Introduction

Special handling provisions will be required for assembly of the L* detector components, transporting them to the IR and installing them in the Collision Hall. Mobile cranes, forklifts and trucks will be used to handle the sub-components from the receiving/storage areas to the assembly buildings where further handling operations for assembly will be done by overhead bridge cranes or mobile cranes in the case of the magnet iron pieces. The special heavy rigging equipment needed for the large pieces during magnet assembly is described in Chapter 2. The bars for the magnet iron barrel will be unloaded on the storage area using a 300 ton mobile crane. The same crane will be used to later load the bars on flatbed trucks to move them near the head of the Construction Shafts and lower them through the Construction Shafts on the floor of the Collision Hall. From there they will be moved and installed in position by one of the overhead bridge cranes. The same mobile crane will also be used to lower 50 ton fully pre-equipped counting rooms inside the Counting Room Shaft.

Completed units of Muon chamber (10 ton each), will be moved from the Muon Chamber Hall to one of the Magnet Halls for intermediate storage, and later from this hall to the Construction Shaft Headhouses for mounting, using a low vibration flatbed trailer specially equipped with a tent for temperature control.

Other parts of the L* detector will be handled in a conventional way by the various overhead bridge cranes installed in the assembly halls, the Construction Shaft Headhouses and the Collision Hall.

4-2 Listing of Hall Requirements

In the Receiving/Storage area, the largest sub-component to be handled will be 12 meters long, by 6 meters wide, by 3 meters high and the heaviest sub-component will weigh 10 metric tons.

In both Magnet Halls, the largest sub-component to be handled by the overhead crane will be 32 meters long, by 25 meters wide, by 3 meters high and the heaviest sub-component will weigh 100 metric tons.

On the Iron Construction Slab, the largest sub-component to be handled by the mobile crane will be 12 meters long, by 3 meters wide, by 1 meters high and the heaviest sub-component will weigh 100 metric tons.

In the Hadron Calorimeter Hall, the largest sub-component to be handled by the overhead crane will be 6 meters long, by 6 meters wide, by 1 meters high and the heaviest sub-component will weigh 40 metric tons.

In both Muon Chamber Halls, the largest sub-component to be handled by the overhead crane will be 14 meters long, by 5 meters wide, by 8 meters high and the heaviest sub-component will weigh 20 metric tons.

In the Vertex Hall, the largest sub-component to be handled by the overhead crane will be 14 meters long, by 3 meters wide, by 3 meters high and the heaviest sub-component will weigh 20 metric tons.

In the Construction Shaft Headhouses, the largest sub-component to be handled by the overhead crane will be 14 meters long, by 5 meters wide, by 8 meters high and the heaviest sub-component will weigh 100 metric tons. The same overhead crane will handle the components used to build the fixed part of the radiation shielding plugs which are required for those shafts.

In the Utility Shaft, the largest sub-component to be handled by the equipment elevator will be 3.5 meters long, by 2.5 meters wide, by 2.5 meters high and the heaviest sub-component will weigh 4 metric tons.

In the Counting Room Shaft, the largest sub-component to be handled by the equipment elevator will be 3 meters long, by 2 meters wide, by 2.5 meters high and the heaviest sub-component will weigh 2 metric tons, and in the Counting Room Shaft Hall the largest sub-component to be handled by the overhead crane will be 5 meters long, by 3 meters wide, by 3 meters high and the heaviest sub-component will weigh 10 metric tons.

In the Collision Hall, the largest sub-component to be handled by the overhead crane will be 14 meters long, by 5 meters wide, by 8 meters high and the heaviest sub-component will weigh 100 metric tons.

5) Services Requested for the Running of L*

5-1 Water Cooling

L* will require cooling for:

- The magnet and the bus bar system by a LCW system.
- The power supply by a LCW system.
- The racks and electronics by an industrial water system.

5-1-1 Magnet and bus bar system

The magnet and the bus bar system will be cooled by a dedicated Low Conductivity Water (LCW) system designed to remove the 20 MW DC dissipated by the magnet and bus bar system. This closed loop system will be cooled via a water/water heat exchanger by the industrial water general cooling system. As the main part of the magnet circuitry is in aluminium, this circuit must not be mixed with other LCW systems. For this particular LCW system all piping must be done exclusively in aluminium or preferably in stainless steel, copper and composites like bronze, and iron must be totally excluded. A secondary loop will be derived from the main circuit to maintain at a constant temperature the cooling shield of the magnet which is designed to protect the volume inside the magnet from heat influx coming from the coil. The requested parameters are the following:

– Water temperature at inlet of magnet	< 25 ° C
– Flow	800 m^3/h
– Pressure at inlet of magnet	25 bars
– Water conductivity	< 1 m Siemens

For the secondary circuit the requested parameters are the following:

– Water temperature at inlet of shield	20 (+0, -1) ° C
– Flow	30 m^3/h
– Pressure at inlet of shield	15 bars
– Water conductivity	< 1 mSiemens

5-1-2 Power supply

The power supply electronics will be cooled by a standard LCW system. The requested parameters are the following:

– Water temperature at inlet of power supply	< 25 ° C
– Flow	20 m^3/h
– Pressure at inlet of magnet	7 bars
– Water conductivity	< 1 mSiemens

5-1-3 Racks

Electronic racks will be cooled by forced flow of air through air/water heat exchanger situated at various levels inside the racks depending on how must power is dissipated in each rack. The water used in these heat exchangers can come from the normal chilled water system. The requested parameters are the following.

– Water temperature at inlet of racks	13 ° C to 15 ° C
– Total power dissipated	< 1.5 MW
– Pressure at inlet of racks	7 bars

The temperature of the cooling water must always be above the guaranteed dew point inside the Collision Hall and the Counting Rooms.

5-2 Ventilation

The ventilation of the L* Collision Hall is designed primarily to control air temperature and humidity around the detector and its electronics. However, in case of fire in the Collision Hall or in the detector proper, the ventilation system is a major part of the safety equipment.

In L* we can take advantage of the fact that the magnet iron provides an enclosure well separated from the Collision Hall. Its seems therefore appropriate to separate the ventilation system in two:

- The Detector Ventilation.
- The Collision Hall Ventilation.

5-2-1 Detector Ventilation

Air will be fed and extracted in various parts of the volume inside the magnet, in priority on the electronics boxes and flammable gas system (if any) to prevent creation of flammable gas pockets, to maintain a controlled atmosphere around individual detectors. The requested parameters are the following:

– Air temperature at outlet	20 ° C ± 1 ° C
– Dew point	< 12 ° C
– Flow (inlet and outlet)	20,000 m^3/h

In case smoke is detected inside the volume of the magnet (for example by sniffed air analyzed by a central station) nitrogen, or halon can be injected through the Detector Ventilation ducts to quench the fire by lowering the amount of oxygen for a suitable time.

The cooling of electronics situated inside the magnet is foreseen to be done by a forced liquid system and thus restricting the influx of power to the air inside the magnet to ~ 5 kW.

5-2-2 Collision Hall Ventilation

Air will be fed at the bottom of the Collision Hall in various places, and will be extracted at the top of the Collision Hall. In case of fire detected in the Collision Hall, the extraction ventilators will be of prime importance to extract smoke and leave a clear zone at the bottom of the hall for a longer period to allow intervention by the fire brigade. A renewal of one hall volume per hour seems adequate. The requested parameters are the following:

– Air temperature at outlet	18 °C ± 2 °C
– Dew point	12 C
– Flow (inlet and outlet)	140,000 m^3/h

The magnet will be insulated to prevent heat leaking inside the hall, and the various racks installed in the Collision Hall will be force cooled by water and thus the influx of power to the air inside the Collision Hall is not expected to exceed 30 kW.

5-2-3 Air Locks in Safety Stairwells and Lift

Stairwells and lifts, and their access zones at the top and bottom must be slightly pressurized to keep smoke out during the evacuation of personnel in case of fire. The needed flows and pressures depend how these safety accesses are constructed.

5-3 Heating and Air Conditioning

All halls which have not been mentioned in the Chapter 5 on ventilation must be heated and air conditioned to provide a reasonable working environment. Special cases are the air conditioning for the Counting Rooms which in addition to creating an "office like" environment must be able to remove the heat input from the non rack-mounted electronics equipment (computers, monitors etc.) and the heat leakage from the water cooled racks (a few percent of total rack power). Also the Muon Chamber Hall must be specially treated as the wiring of muon chambers requires a very stable temperature with controlled humidity..

6) Assembly of Major Components

6-1 Magnet

The assembly of the magnet has been described in Chapter 2.

6-2 Muon Chambers

The L* muon chamber assembly model is based on the method that was used in the L3 Detector at CERN.

Components manufactured in industry outside are brought to an interaction site surface hall. The hall is equipped with a large clean room area where the pre-assembled chamber frames are introduced for wire stringing and testing. The individual completed chambers (1.5 tons) are then placed into support frames, rotated, aligned, fully tested and stored on pedestals.

The units (10 tons) are then transported carefully in a controlled environment to the shaft head. Next they are lifted from the truck and lowered down below onto an awaiting insertion frame suitably positioned under the Collision Hall crane hook.

The frame is suitably designed to match the slope of the beam line and then adjusted and placed onto the assembly and access tube ready for rotation to its final position. The rails of the magnet and the frame are then coupled and the unit is then inserted into its position inside the magnet, aligned and surveyed.

6-3 Hadron Calorimeter

The hadron calorimeter assembly model is based on the method that was used in the L3 Detector at CERN.

Calorimeter modules containing uranium plates and active detector layers are brought to the surface assembly hall storage area and checked. Each module (5 tons) is then lifted and placed onto a turntable where the assembly of horizontal calorimeter rings is made and then stood vertically with a special tipping device.

The rings are assembled together on a cradle designed to carry the full weight of the calorimeter and stand on rails having a suitable length to allow the completed unit to be pulled outside the surface hall to a convenient position for handling. However, prior to this action, the calorimeter barrel would be equipped with services and electronics and tested.

The completed tested unit would then be moved on rails to the shaft head and lowered using the same equipment as used for the magnet and positioned on an infrastructure that would enable the calorimeter to be moved to the interior of the support tube inside the magnet.

7) Planning of Operations

The assembly of such a detector is a complex operation where success depends on many other tasks to be finished on time. *Particularly important is the beneficial occupancy dates of the Magnet halls to allow the manufacture of the coil to proceed.*

Also locating these Magnet Halls and the Magnet Concrete Slab (required for the magnet iron work) close to the Construction Shafts to avoid costly and time delaying complex transport operations is of prime importance.

Then the beneficial occupancy date for the Collision Hall is the next key date as it marks the start of the magnet assembly. A full planning of operation has been modelled and is shown in Annexes 3 and 4.

L* MAIN PARAMETERS

	Total Weight (t)	Inner Radius (m)	Outer Radius (m)	Length (m)	Z1 (m)	Z2 (m)
Inner Vertex Chamber		0.05	0.17	1.00		
Transition Radiation Detector		0.17	0.48	2.00		
Calorimeter Barrel	1000	0.50	6.0	4.20		
Calorimeter End Cap (2)	500	0.10	1.54		1.27	4.27
Forward Calorimeter (2)	400		0.10		16.75	19.25
Muon Chamber Barrel (2)	320	3.50			0.10	13.5
Muon Chamber End Caps (2)	192	0.45	7.75		4.85	13.65
Magnet Coils (2)	6800	9.50	11.50		0.30	13.50
Magnet Iron	49000	11.36	13.50	16.25		

ANNEX 1

PROPOSED PARAMETERS OF L* SURFACE HALLS AND EXTERIOR STORAGE AREAS

FUNCTION	No.	DIMENSIONS m	AREA m2	CRANE t	HOOK HEIGHT m	ELEVATORS	HVAC*	EXT STOR AREA m2
Magnet coil constr assy test	2	62x26x14	1612	100/20	8		H AC	2700
Magnet iron constr.	1		(mobile)	300	8			2800 (+ 1700)
Magnet power								
Muon constr assy test	1	124x26x18	3224	20/5	12		HVAC	
Muon module frames	1	56x26x14	1456	20	8		H AC	
Calorimeter assy test	1	40x26x14	1040	40/3	8		H AC	
Vertex/TRD/Shop assy test	1	40x26x14	1040	20/5	8.		H AC	
Cryogenics inst.test	1		500	5	8		HVAC	
Main shaft	2	80x26x14	2080	100/20	8	1	HVAC	
Control Room shaft	1	40x26x8	1040	10	5	1	HVAC	
Offices	1	56x26x14	1456(x3)			2	HVAC	
Gas	1							
Cooling								
Ventilation								
Electrical								

ANNEX 2

ANNEX 4

Name	Earliest Start	Latest Finish	Slack	Actual Start
Letter of Intent	5/15/90	5/15/90	0	5/15/90
Magnet pre-study	5/15/90	5/17/91	11.90	5/15/90
Proposal	5/15/91	5/15/91	0	5/15/91
Magnet study contract	5/15/91	5/16/91	0.00	5/15/91
Acceptation of Experiment	1/1/92	1/1/92	0	1/1/92
Magnet final study	5/15/91	5/20/92	0.00	5/15/91
Order coil tooling	5/19/92	4/23/93	4.00	5/19/92
Order Al plates	5/19/92	10/21/92	0.00	5/19/92
Order Bars for Barrel	10/20/92	2/22/93	0.00	10/20/92
Order Crowns	10/19/92	10/22/92	0.00	10/19/92
Beneficial occupancy Hall MA1	10/1/93	10/1/93	0	10/1/93
Manufacture welding tooling	12/21/92	2/25/94	4.00	12/21/92
Beneficial occupancy of μ Frame Hall	5/1/94	5/1/94	0	5/1/94
Beneficial occupancy of Underground area	2/1/95	2/1/95	0	2/1/95
Beneficial occupancy Hall MA2	4/1/94	4/1/94	0	4/1/94
Manufacture 3/8 of bars	2/19/93	3/2/95	0.00	2/19/93
Manufacture Rigging Tooling	12/21/92	5/30/94	5.00	12/21/92
Equip Hall MA1	10/25/93	5/30/94	4.00	10/25/93
Manufacture first plates	10/20/92	5/30/94	7.00	10/20/92
Beneficial occupancy of μ Chamber Hall	5/1/94	5/1/94	0	5/1/94
Beneficial occupancy of VE Hall	8/1/94	8/1/94	0	8/1/94
Equip Hall MA2	4/1/94	5/30/94	1.90	4/1/94
Install surface pit and underground rigging tools	2/1/95	5/3/95	0	2/1/95
Manufacture crowns in factory	10/20/92	10/31/94	0.00	10/20/92
Start coil manufacture in Hall MA1	1/24/94	5/31/94	4.00	1/24/94
Beneficial occupancy Iron Slab	8/1/95	8/1/95	0	8/1/95
Assembly and Test of First μ Frames	5/2/94	8/3/95	2.90	5/2/94
Beneficial occupancy of HC Hall	5/1/94	5/1/94	0	5/1/94
Beneficial occupancy of Electronics Shaft	2/1/96	12/10/96	22	2/1/96
Start coil manufacture in Hall MA2	7/1/94	5/31/94	1.90	7/1/94
Assembly of bars in first 3/8	5/4/95	5/2/95	0	5/4/95
Manufacture middle crown on site	10/28/94	5/3/95	0.00	10/28/94
Assembly and Test of First μ Chambers	5/2/94	8/3/95	2.90	5/2/94
Coil manufacture in Hall MA1	1/25/94	9/4/95	4.00	1/25/94
Remove Tooling from Hall MA1	5/2/95	10/4/95	4.00	5/2/95
Manufacture 3/8 of bars	3/1/95	9/4/95	0.00	3/1/95
Assembly of Middle Crown	5/5/95	9/4/95	0	5/5/95
Installation of light workshop	8/1/94	12/30/94	2	8/1/94
Manufacture Crowns of Side 1 on Site	5/2/95	10/4/95	0.00	5/2/95
Mount Electronics Counting Rooms	2/1/96	2/7/97	22	2/1/96
Assembly and Test of First μ Chamber Unit	5/5/95	10/4/95	2.90	5/5/95
Hall MA1 used for μ chamber storage	7/5/95	10/5/95	2.90	7/5/95
Assembly of bars in second 3/8	9/5/95	10/4/95	0	9/5/95
Coil Assembly and Crown on side 1	10/5/95	3/5/96	0	10/5/95
Manufacture 3/8 of bars	9/1/95	3/6/96	0.00	9/1/95
Assembly and test of HC Modules	5/2/94	1/4/96	1.90	5/2/94
Storage of μ Chamber Unit	7/6/95	11/12/97	2.90	7/6/95
Assembly and test of μ Chambers and Frames Assembly and test of remaining μ Chamber Units	7/6/95	11/7/96	3.90	7/6/95
Construction of Electronics Head Shaft Building	4/4/95	5/12/97	22	4/4/95
Coil manufacture in Hall MA2	7/4/94	12/5/95	1.90	7/4/94
Cover Side 1 of magnet with 3/8 of bars	3/7/96	4/5/96	0	3/7/96
Complete services	10/5/95	2/12/98	22	10/5/95
Side 1 of Magnet Finished	4/5/96	4/5/96	0	4/5/96
Manufacture Crowns of Side 2 on Site	10/3/95	5/7/96	2.00	10/3/95
HC Hall ready for Scintillators	11/6/95	10/14/97	22.90	11/6/95
Remove Tooling from Hall MA2	10/9/95	1/4/96	1.90	10/9/95
Rigging Tools Moved to side 2	4/8/96	5/7/96	0	4/8/96
Hall MA2 used for HC Barrel Assy	11/7/95	1/6/96	1.90	11/7/95
Coil Assembly and Crown on side 2	5/8/96	10/8/96	0	5/8/96
Manufacture 3/8 of bars	3/5/96	10/8/96	1.00	3/5/96
Construction Hall Shaft 1	5/8/96	9/11/97	10	5/8/96
Assembly of HC Rings	11/6/95	11/7/96	1.90	11/6/95
Cover Side 2 of magnet with 3/8 of bars	10/9/96	11/7/96	0	10/9/96
Testing of HC Sections	9/11/96	2/7/97	1.00	9/11/96
Mount Service Tube on Side 1	11/8/96	10/13/97	10	11/8/96
Assembly and test of μ Chambers and Frames Assembly and test of remaining μ Chamber Units	7/10/96	11/12/97	3.90	7/10/96
Side 2 of Magnet Finished	11/7/96	11/8/96	0	11/7/96
Storing Scintillators for Side 1 in HC Hall	11/6/95	10/14/97	22.90	11/6/95
End of Magnet Assembly	11/7/96	11/8/96	0	11/7/96
Mount Scintillators on Side 1	12/10/96	11/12/97	10	12/10/96
Storing Scintillators for Side 2 in HC Hall	11/6/96	10/14/97	22.90	11/6/96
Assembly and wiring of Vertex and TRD	11/1/94	7/8/96	2	11/1/94
Magnet Testing	11/8/96	12/9/96	0	11/8/96
μ chamber Mounting on Side 1	8/14/97	2/12/98	2.90	8/14/97
Prepare Rigging Tools for HC Mounting	12/10/96	1/8/97	0	12/10/96
Test and calibration	5/8/96	1/8/97	2	5/8/96
Lower HC, fit vertex/TRD and HC end caps	1/9/97	2/7/97	0	1/9/97
Mount HC in Position Remove tooling	2/10/97	3/11/97	0	2/10/97
Start Cabling Detectors/Counting rooms	4/8/96	2/13/98	22	4/8/96
Construction Hall Shaft 2	3/12/97	8/11/97	0	3/12/97
Mount Service Tube on Side 2	8/12/97	10/13/97	0	8/12/97
Cabling of HC	3/12/97	7/16/98	13	3/12/97
Mount Scintillators on Side 2	10/14/97	11/12/97	0	10/14/97
Cabling of μ Chamber Side 1	11/14/97	7/16/98	2.90	11/14/97
Cabling of TRD and Vertex	4/8/96	5/16/98	24	4/8/96
μ chamber Mounting on Side 2	11/13/97	2/12/98	0	11/13/97
Cabling of μ Chamber Side 2	2/13/98	7/15/98	0	2/13/98
Connect Machine Vac pipe	6/7/98	7/16/98	24	6/7/98
Detector Ready for Physics	7/16/98	7/16/98	0	7/16/98

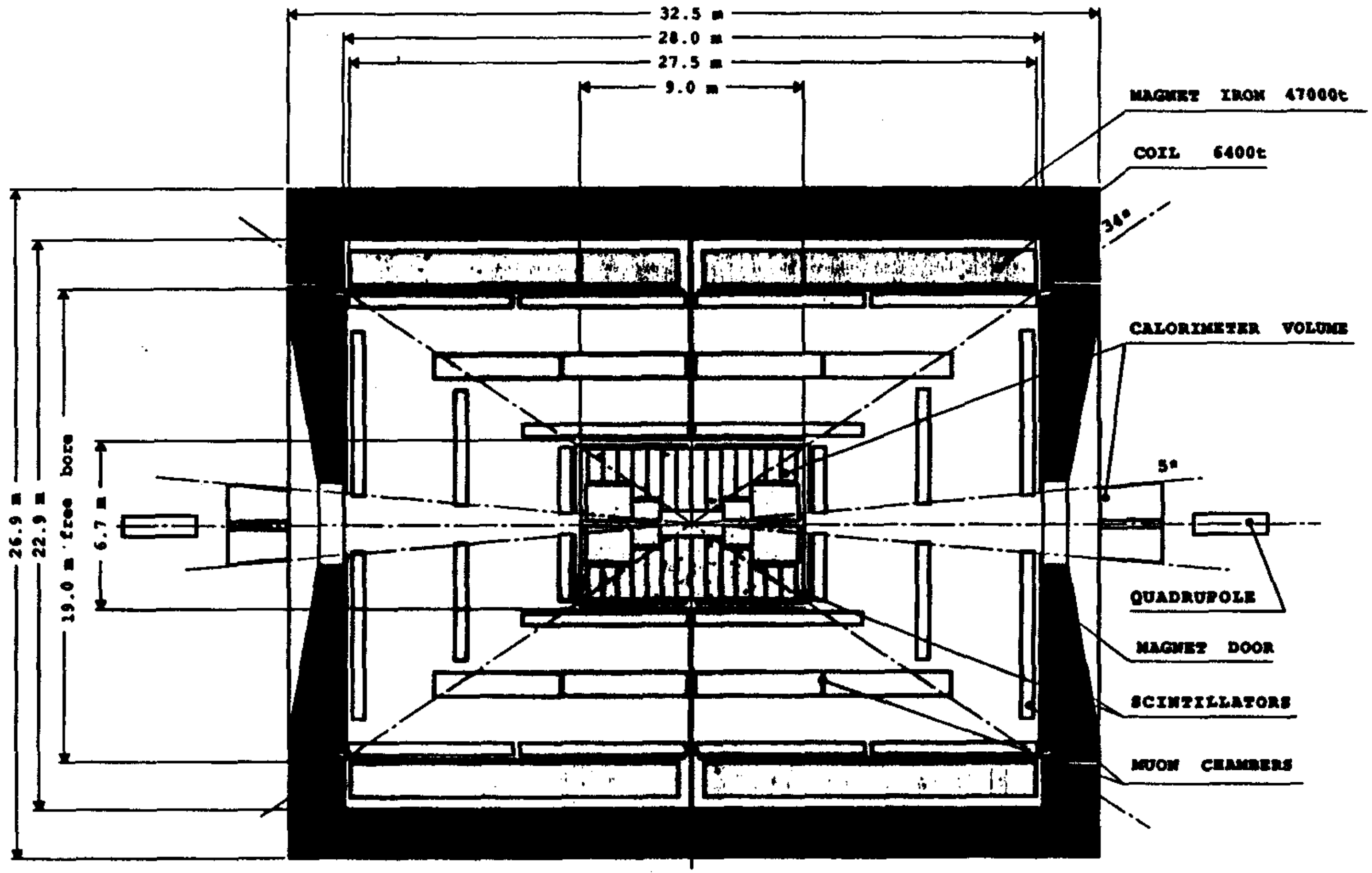
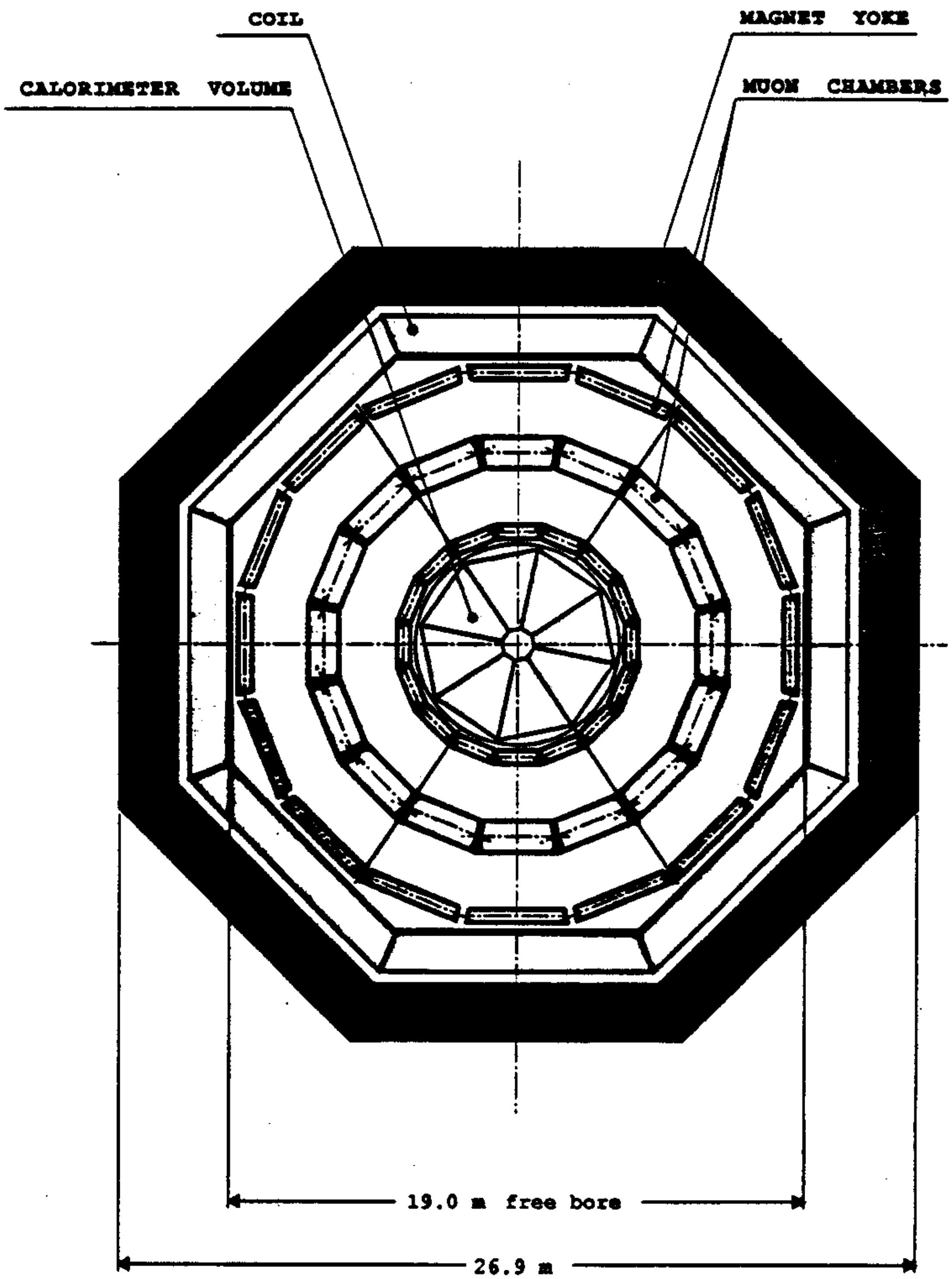


FIGURE 1

DETECTOR LAYOUT
20MW VERSION/4
0.75 Tesla

Scale 1:200
18 August 1989



CROSS SECTION

FIGURE 2

DETECTOR LAYOUT

20MW VERSION/4

0.75 Tesla

L* Ref:CD/DO

CERN/LHC-067/M4A

Scale 1:200

18 August 1989

Main parameters of L* magnet compared to L3 magnet

Parameter	L3	L*
Free internal diameter	11.4 m	19 m
Free length	12 m	28 m
Magnetic induction	0.5 T	0.75 T
Width of conductor	90 cm	150 cm
Weight of coil	1000 tons	6800 tons
Electric power DC	4 MW	20 MW
Induction in iron	1.6 T	1.8 T
Thickness of barrel	84 cm	196 cm
External diameter	15.8 m	27 m
Thickness of crown	100 cm	229 cm
Total weight of iron	6000 tons	49000 tons
Axial coil packing factor	0.9	0.91
Total radial distance for insulation	31.5 cm	40 cm
Conductor thickness	6 cm	9 cm
Number of turns	168	273
Current	30 300 A	66 100 A
Coil inductance	0.3 mH	1.2 H
Coil resistance	4 mΩ	4.6 mΩ
Voltage across coil	125 V	300 V
Ampere-turns factor	1.058	1.08
Cooling water flow	160 m^3/H	800 m^3/H

FIGURE 3

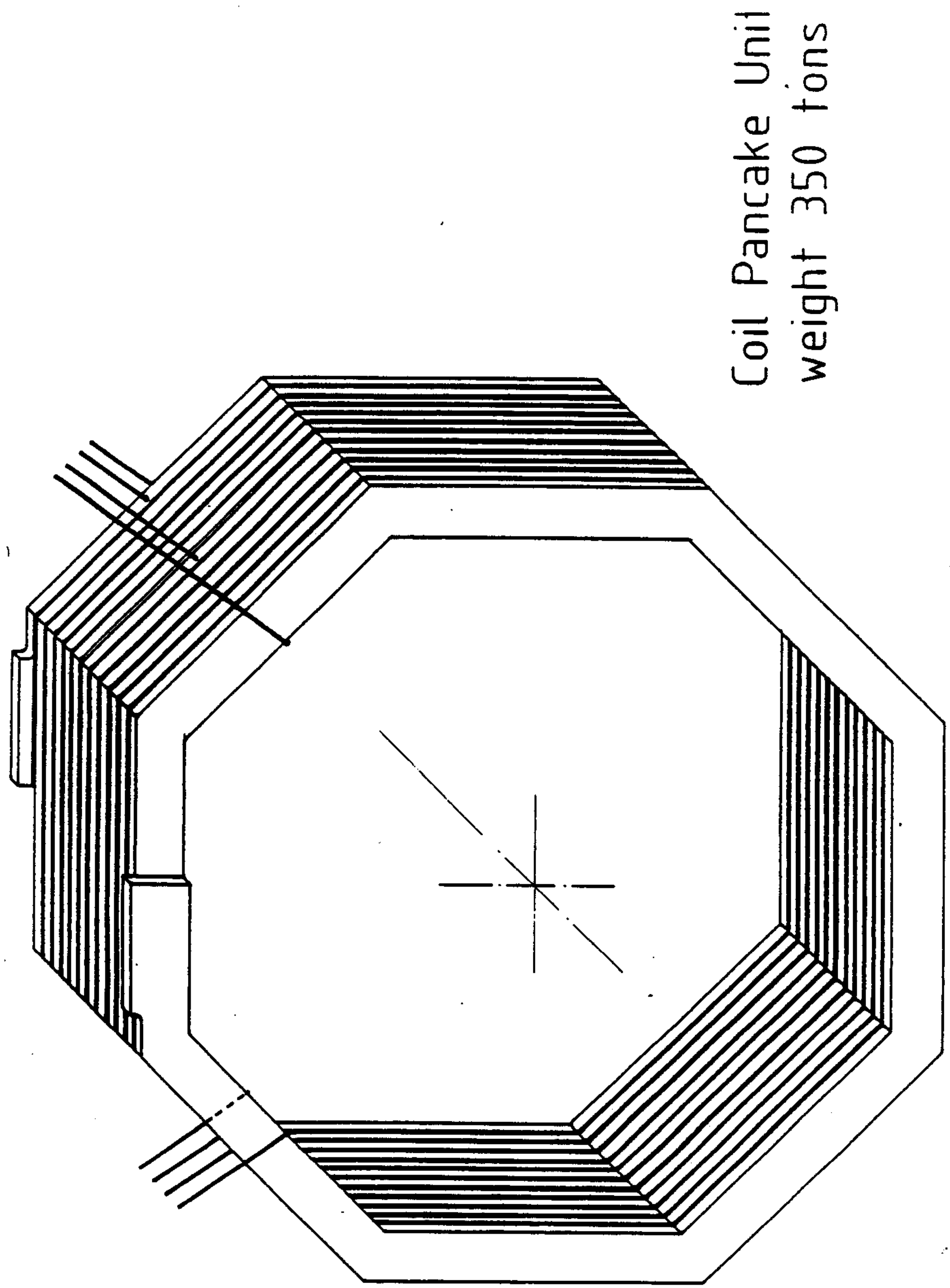


FIGURE 4

L3* at SSC during magnet assembly

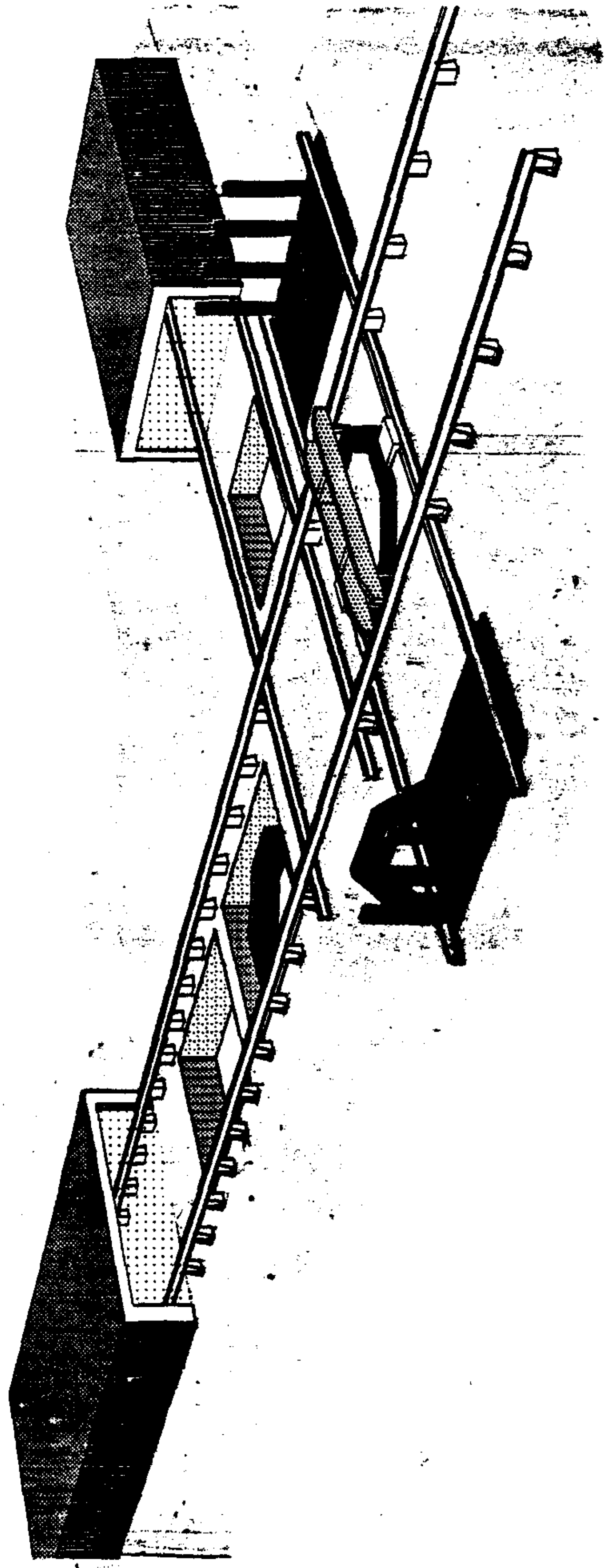


FIGURE 5

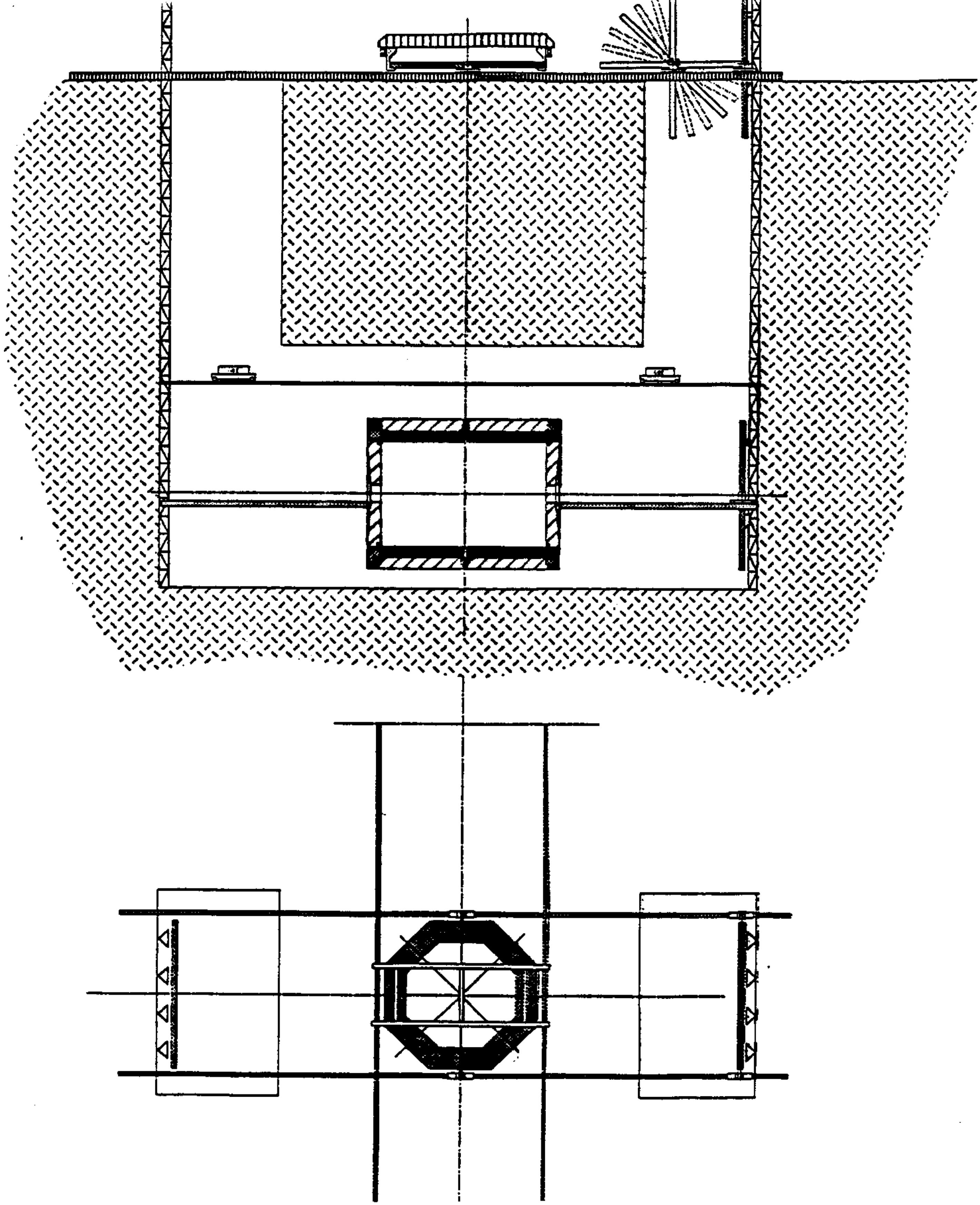


FIGURE 6

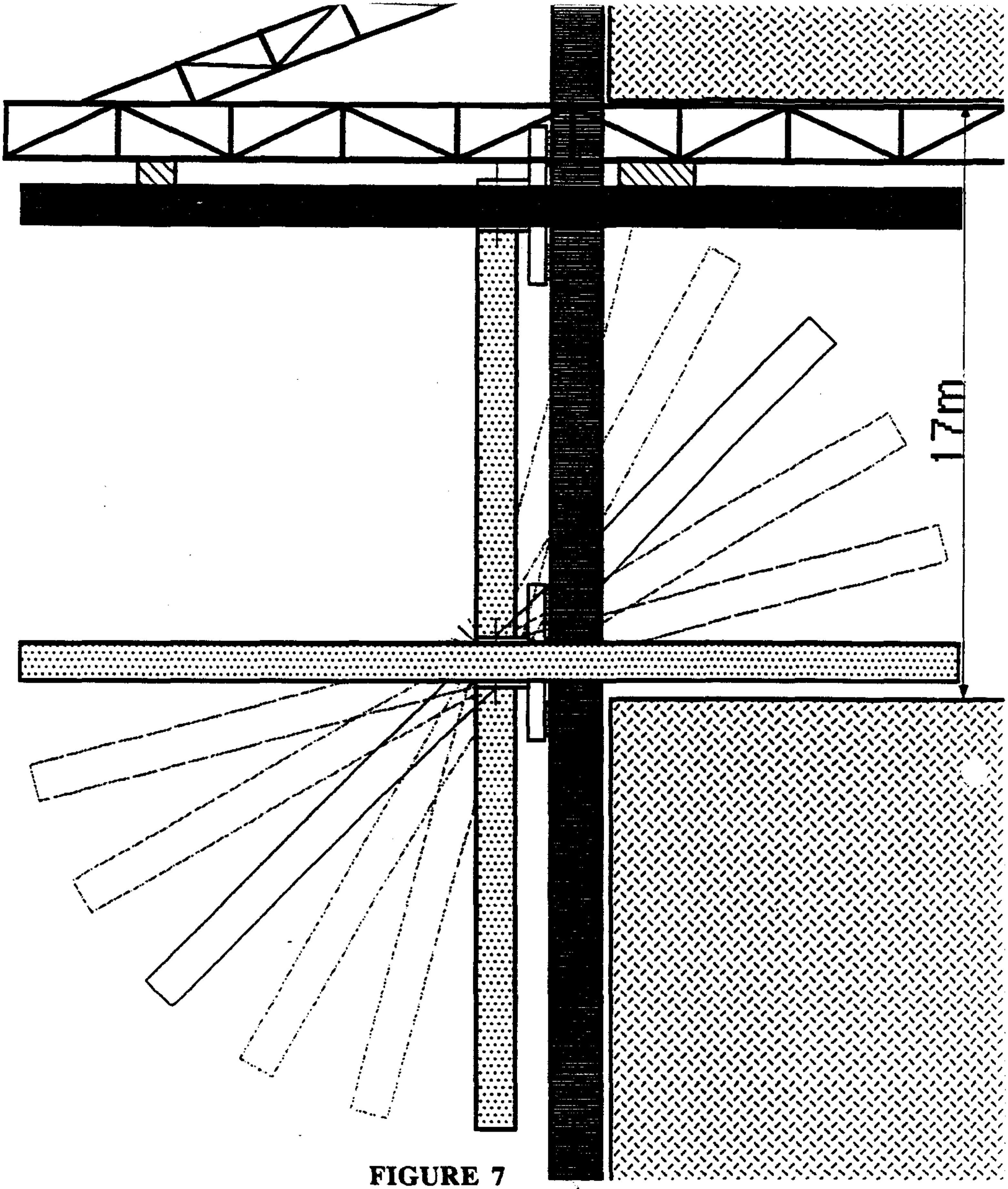


FIGURE 7

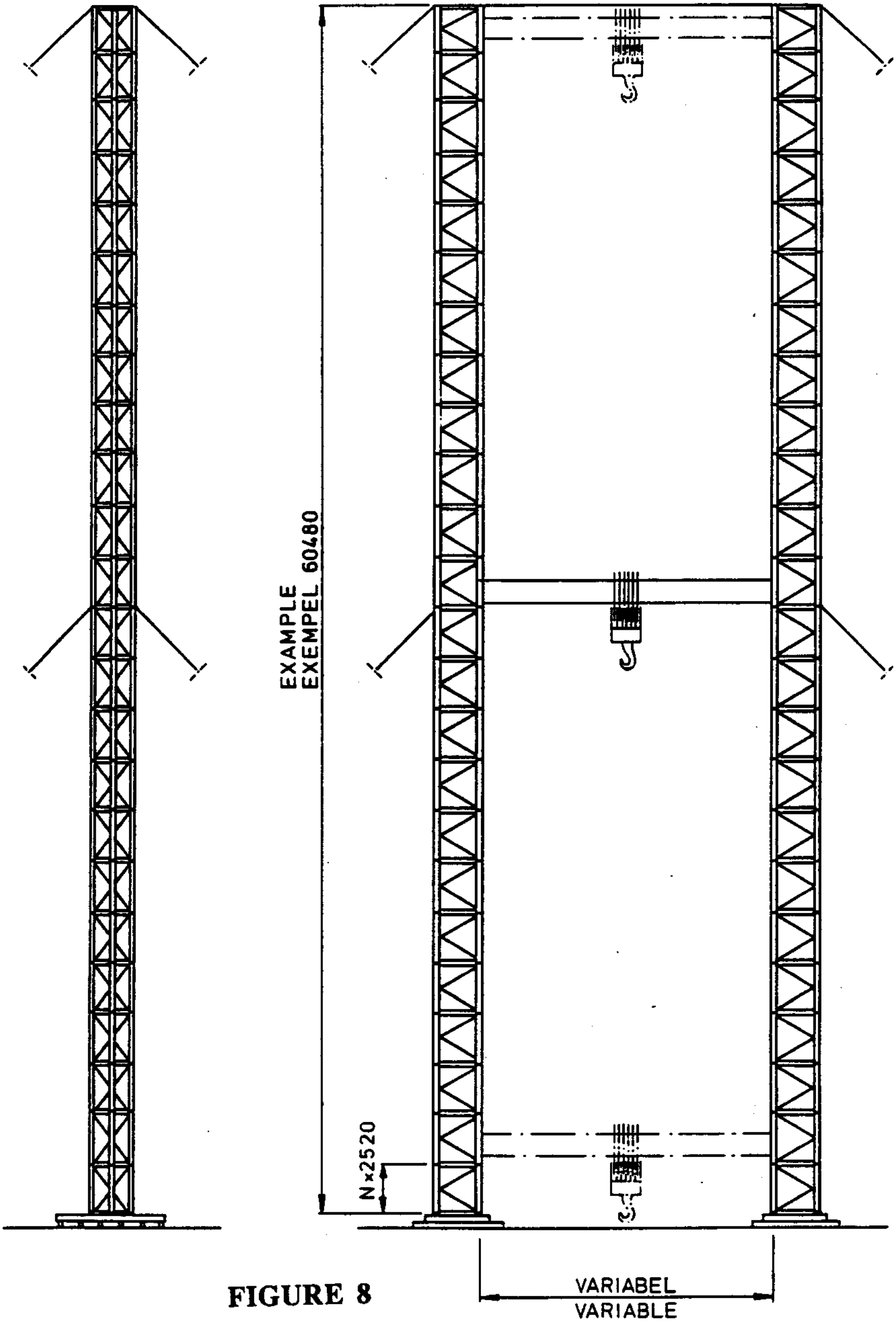
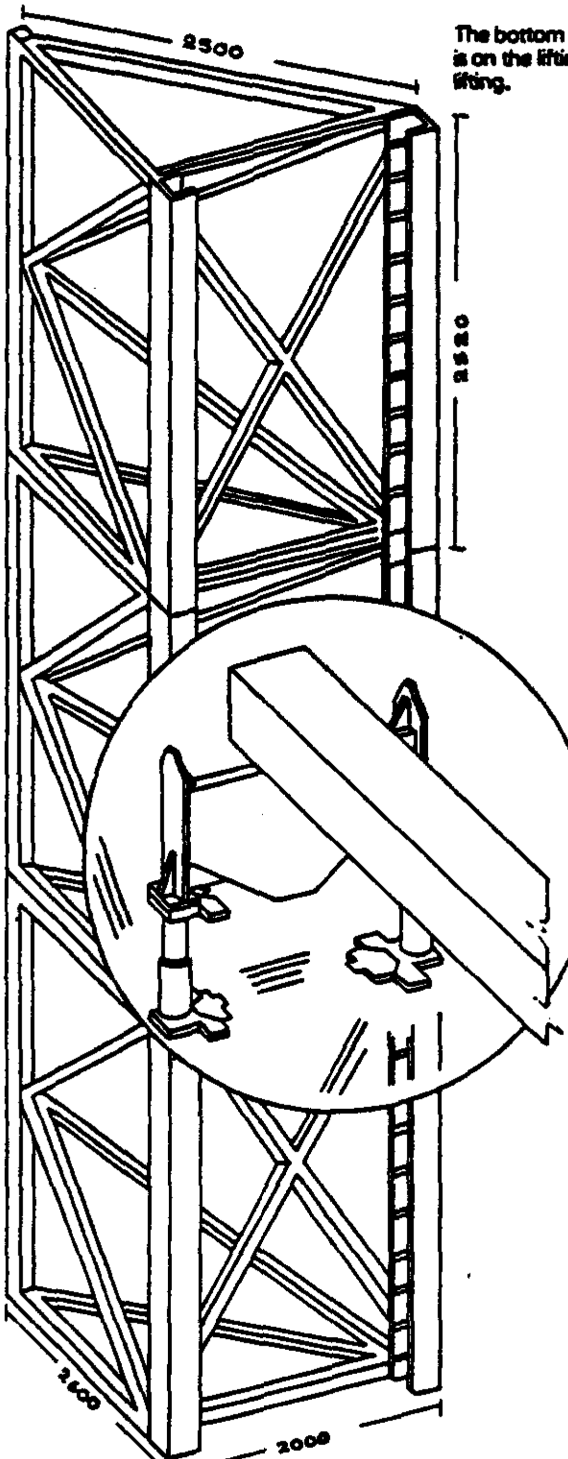


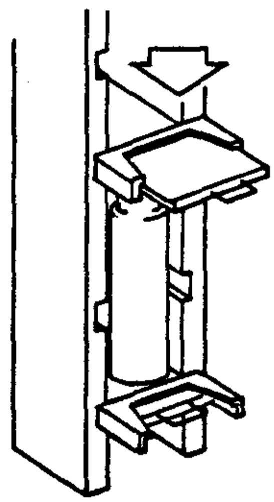
FIGURE 8

703

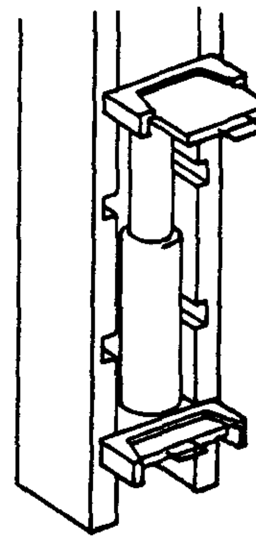


Individual tower sections have a capacity of 200T. Two or more towers, combined can lift loads from 400T upwards. Tower heights of 50 metres are typical although greater heights are possible.

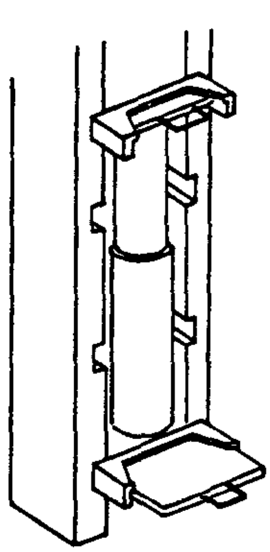
The bottom keep plate is in position, the load is on the lifting beam and the jack is ready for lifting.



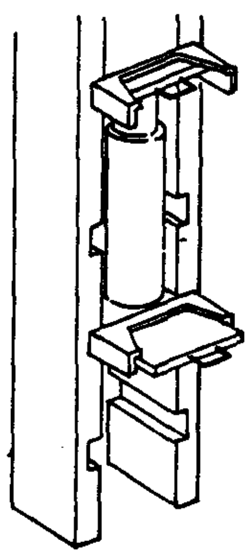
The hydraulic jack operates and 18cm of lift is effected to the next channel slot.



Optimum lifting speed 2.5 metres/hour.



The top keep plate is inserted, the load is taken up on the top plate and the bottom plate is extracted.



The power pack operates, the jack retracts up one step and the procedure repeats.

FIGURE 9

704

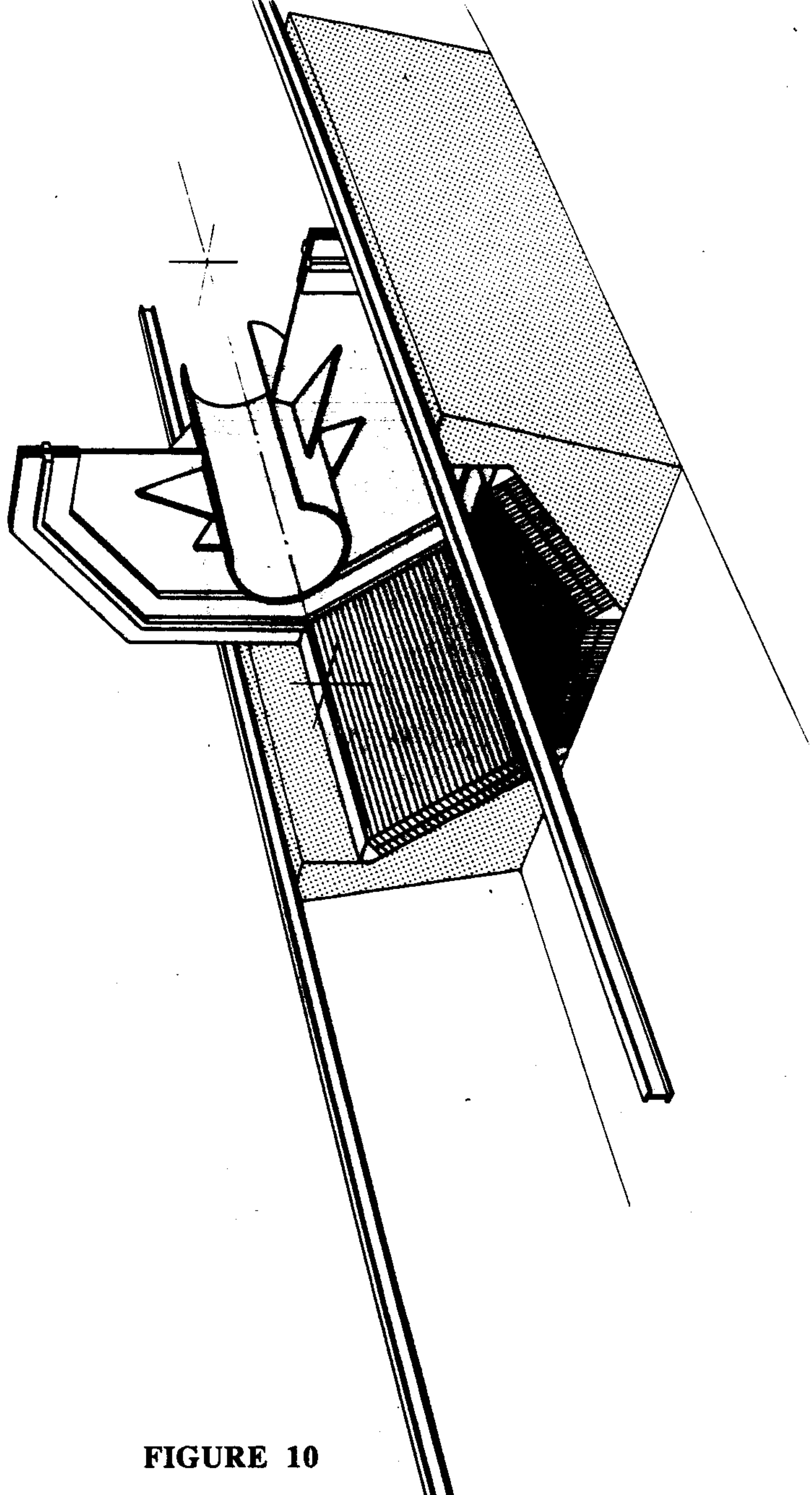


FIGURE 10

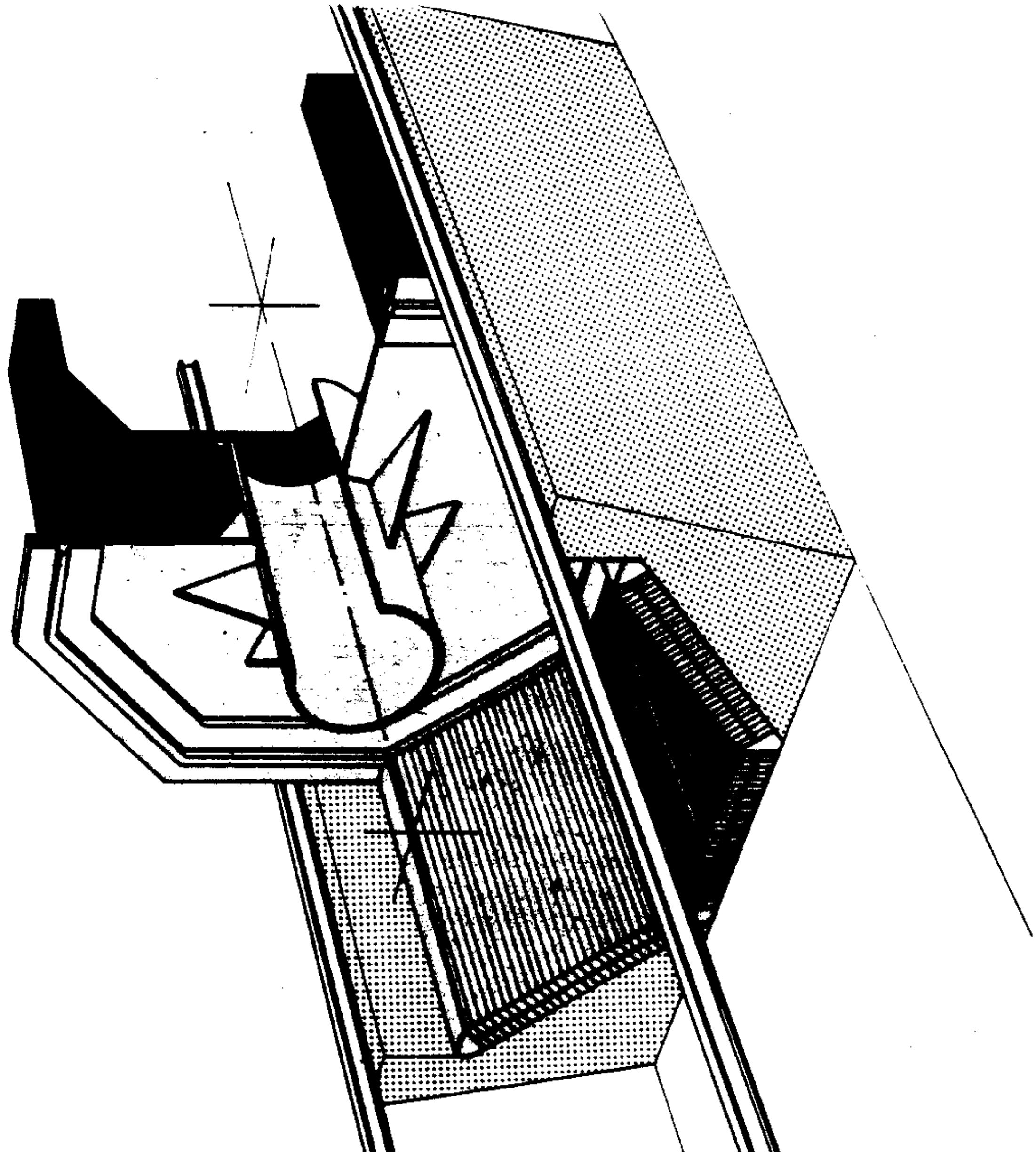


FIGURE 11

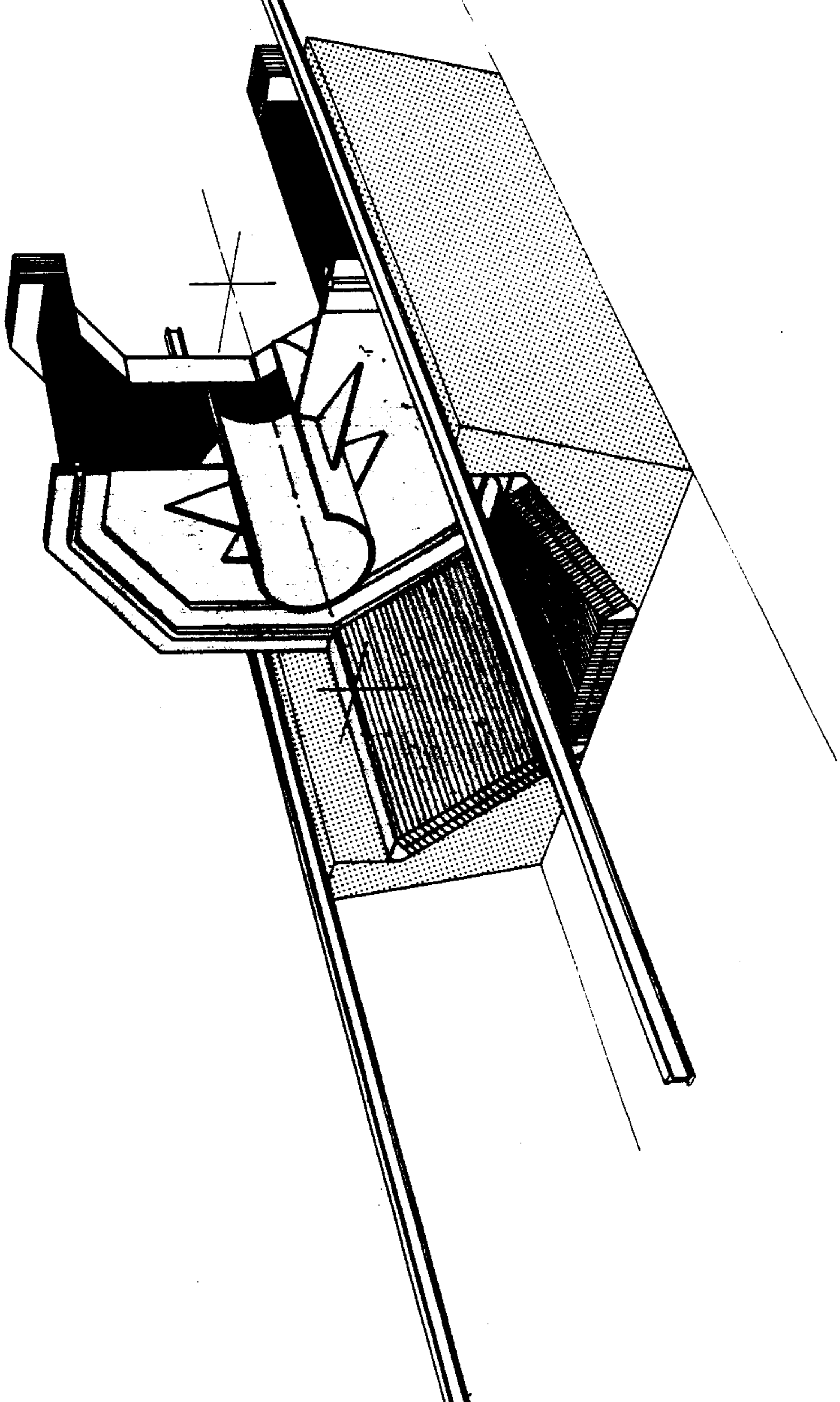


FIGURE 12

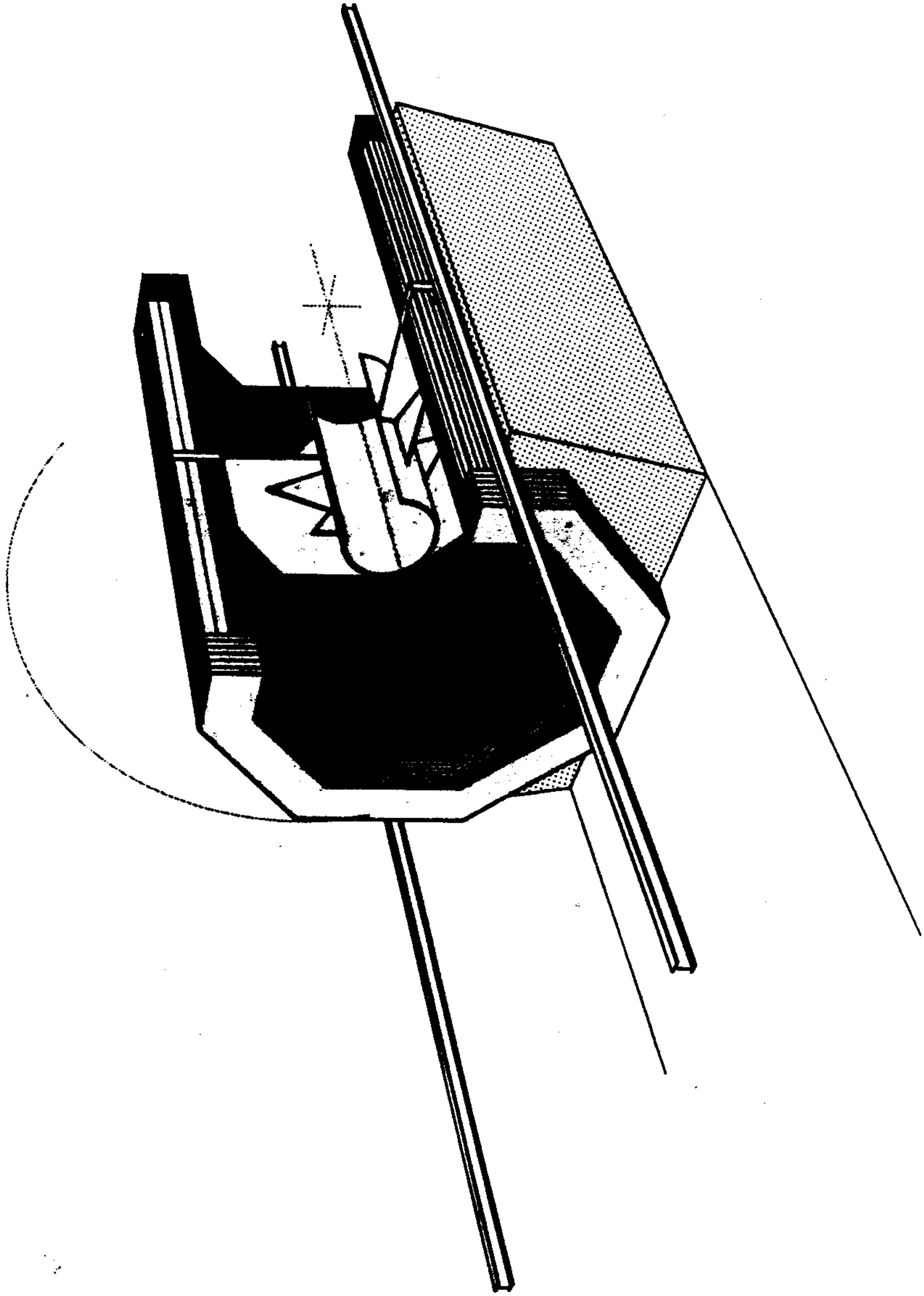


FIGURE 13

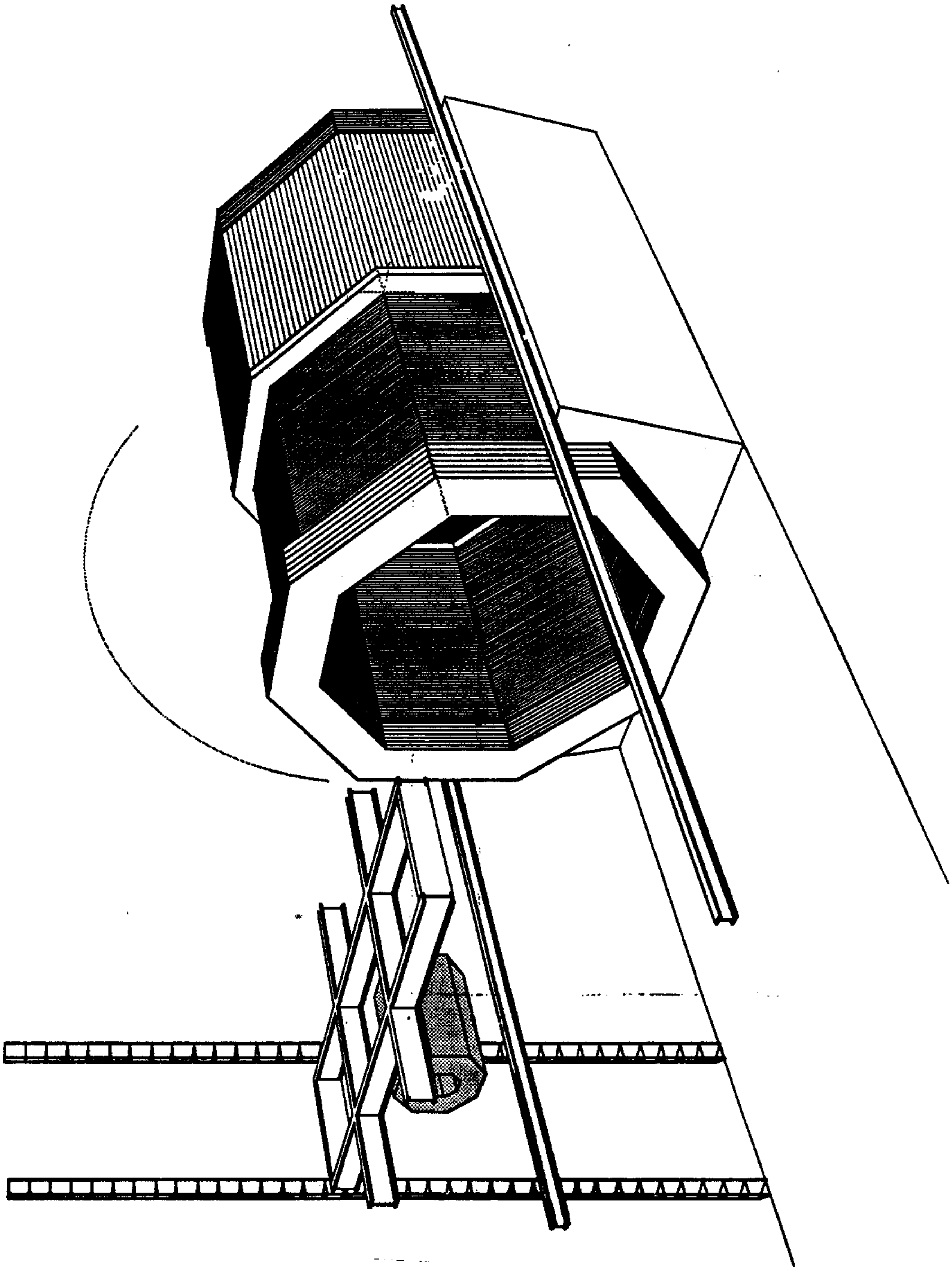
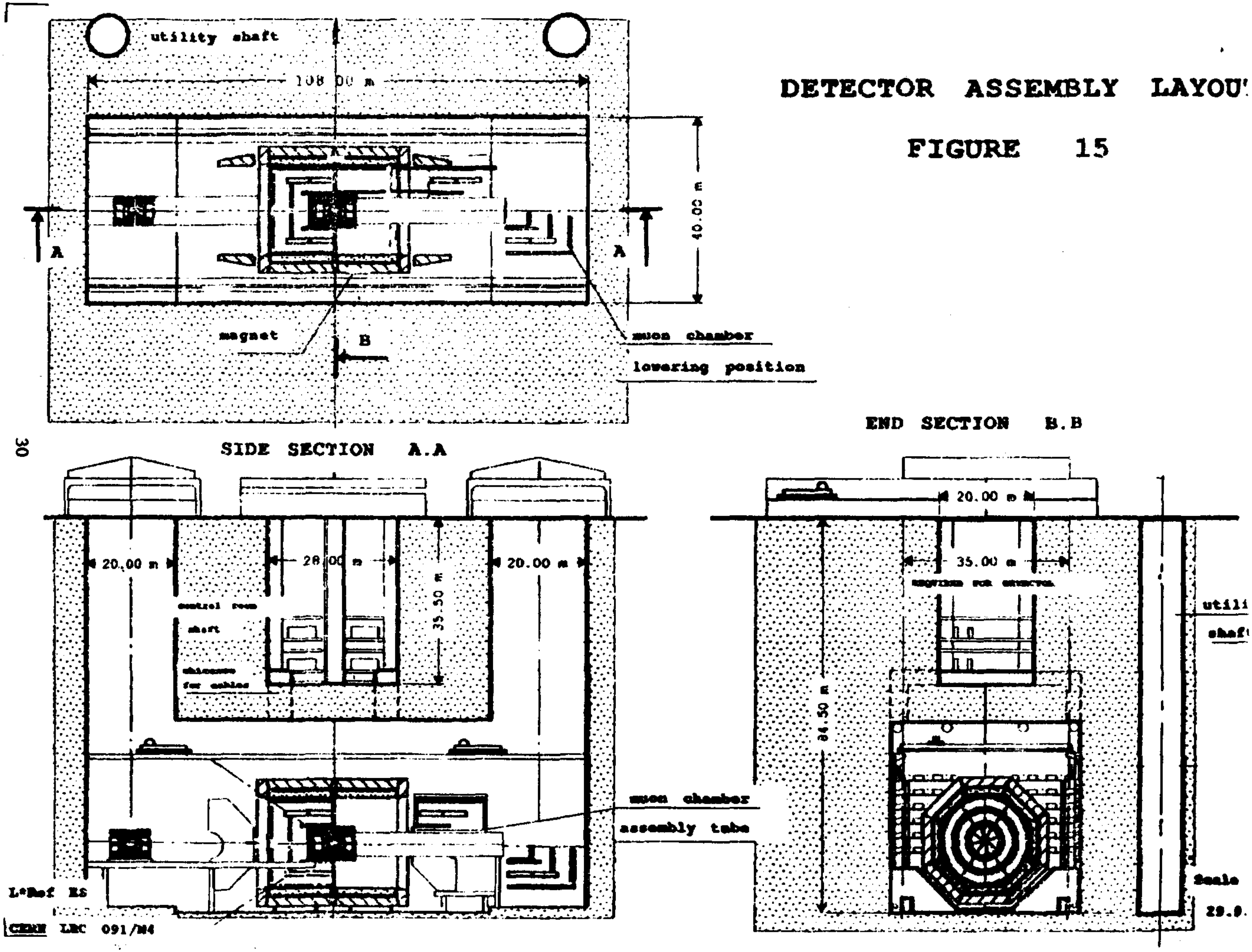


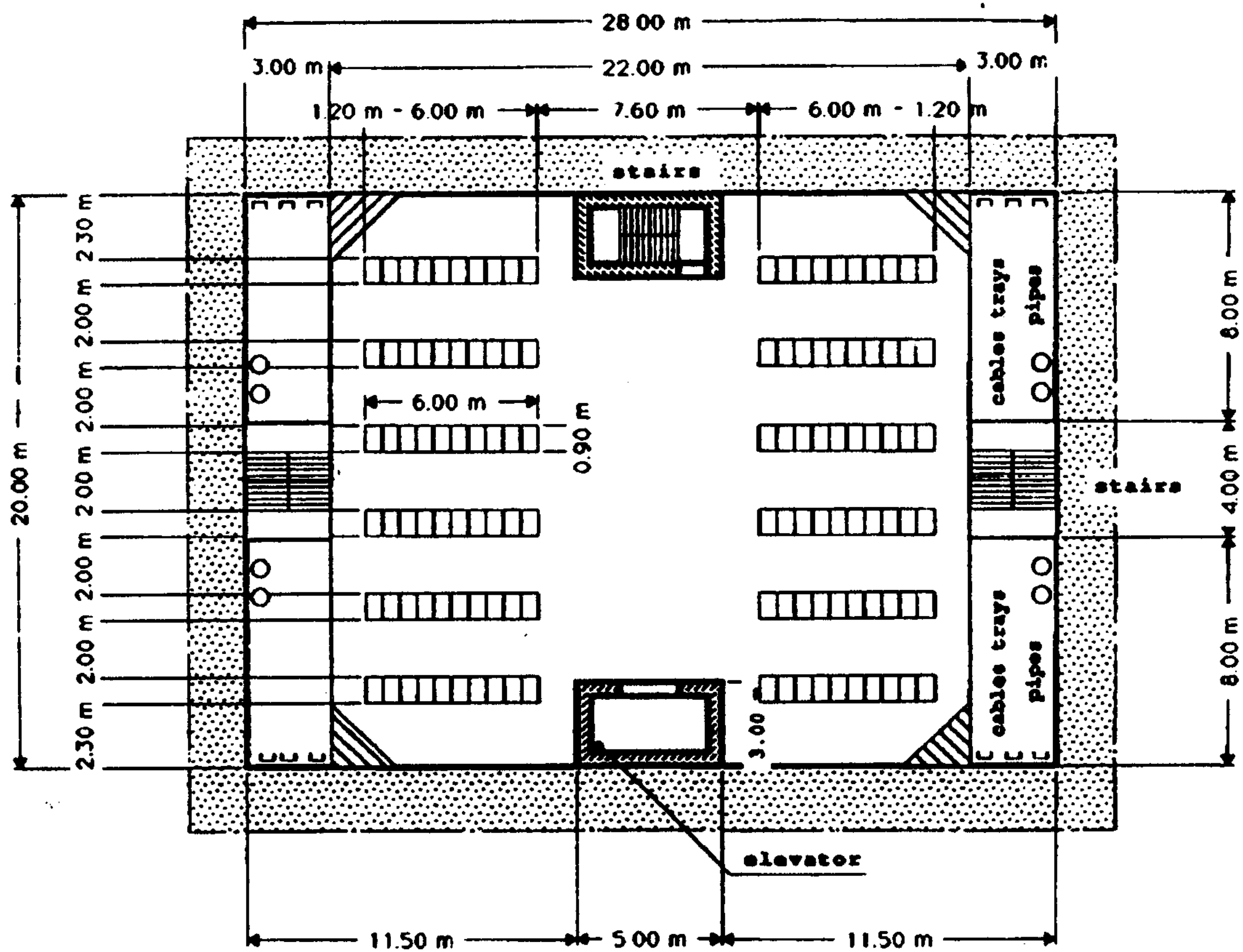
FIGURE 14

DETECTOR ASSEMBLY LAYOUT

FIGURE 15



COUNTING ROOM LAYOUT



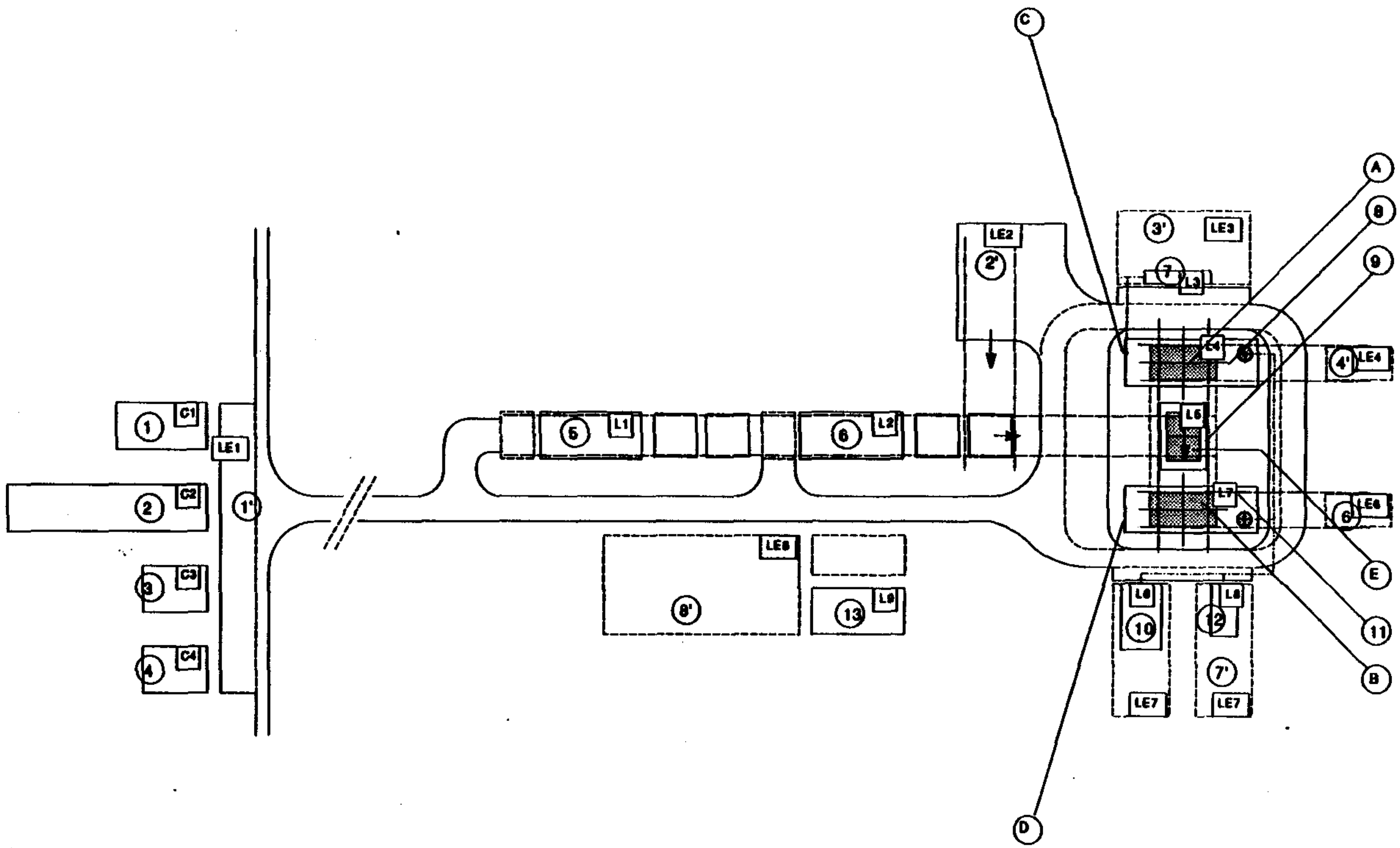
L• Ref ES

CERN/LHC 092/M4

Scale 1/20

29.9.1989

FIGURE 16



Buildings: 1. C1 Muon assembly 1 (28*56*12) 2. C2 Muon assembly 2 (28*124*16) 3. C3 Hadron calorimeter modules assembly (28*40*12) 4. C4 Vertex / TRD / Shop (28*40*12) 5. L1 Coil / muon chambers assembly (28*62*12) 6. L2 Coil / HC (28*62*12) 7. L3 Gas mixing / storage (8*40*6) 8. L4 Access building 1 (28*80*12) 9. L5 Electronics building (28*40*8) 10. L6 Utilities (40*24*12) 11. L7 Access building 2 (28*80*12) 12. L8 Electrical power rectifiers / transformers (16*32*8) 13. L9 Office building (28*56*12)

Outside areas: 1'. LE1 Unloading area (22*174) 2'. LE2 Iron assembly (40*70) 3'. LE3 Gas storage (44*80) 4'. LE4 Shielding beams storage area (20*40) 5'. LE5 Utilities outside area (29*12) 6'. LE6 Shielding beams storage area (20*40) 7'. LE7 Power transformers (34*80) 8'. LE8 Office parking (6-*120)

Access shafts: A. C1 Construction shaft 1 (40*20) B. C2 Construction shaft 2 (40*20) C. E1 Equipment shaft 1 (ø 9) D. E2 Equipment shaft 2 (ø9) E. EL 1. Electronics shaft (29*12)

FIGURE 17

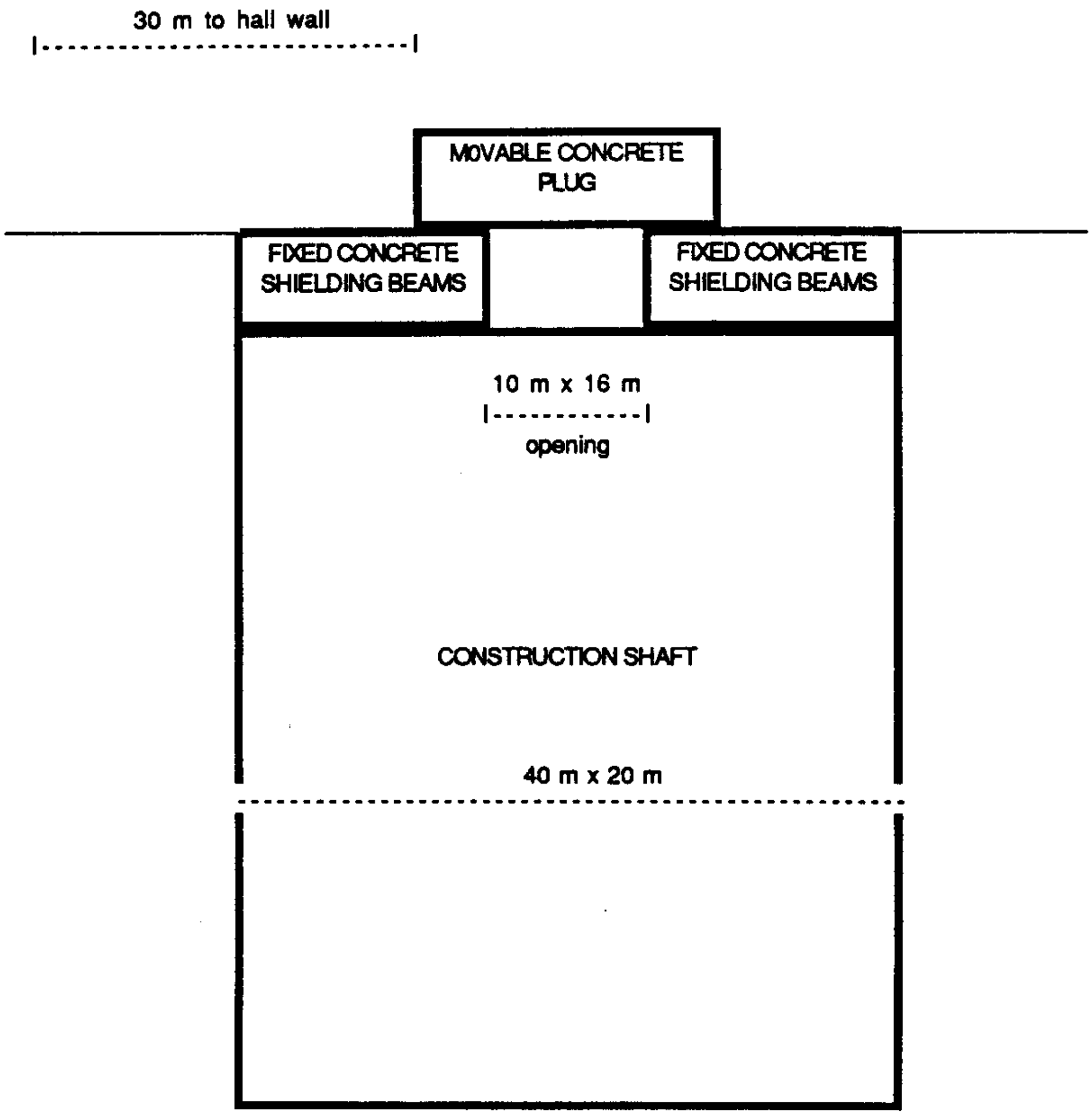
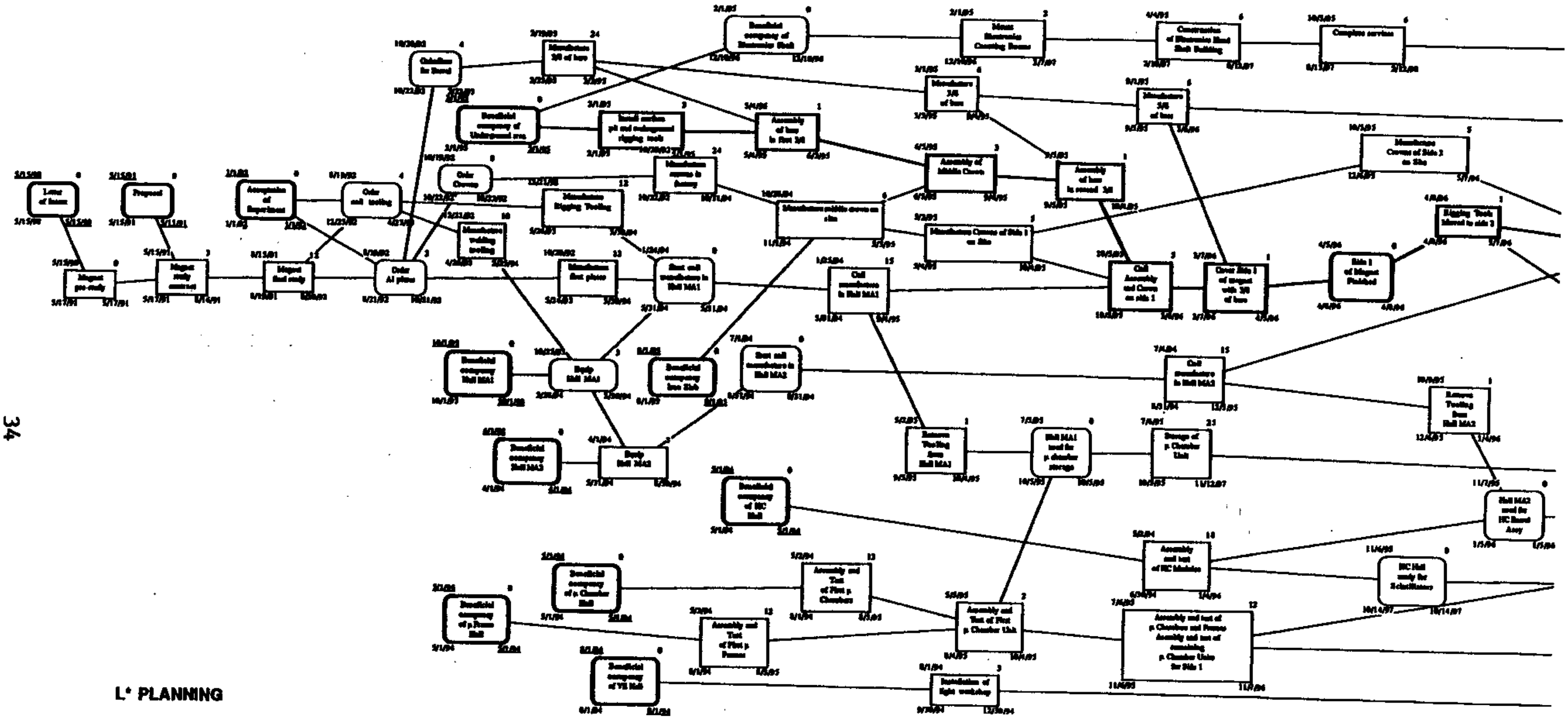

30 m to hall wall
MOVABLE CONCRETE PLUG
FIXED CONCRETE SHIELDING BEAMS
FIXED CONCRETE SHIELDING BEAMS
10 m x 16 m
opening
CONSTRUCTION SHAFT
40 m x 20 m

FIGURE 18



L* PLANNING

DURATION IN MONTHS
27 SEPTEMBER 1989 AH/MH

ANNEX 3