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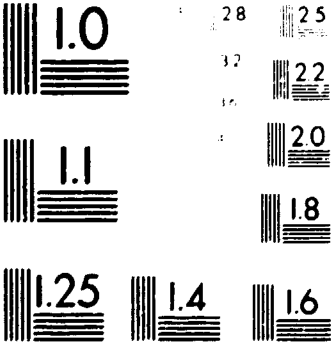

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ORIGINAL

FINAL REPORT

UNIDO CONTRACT No. 86/90

PROJECT No. XA/RAF/86/631

ACTIVITY CODE: XA/12/62.4

18433

Development and Introduction of Small-Scale Gari Processing Technology

SUBMITTED BY

Federal Institute of Industrial Research, Oshodi
Nigeria

20th November, 1989

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ACKNOWLEDGEMENT

The Federal Institute of Industrial Research, Oshodi, Nigeria gratefully acknowledges the contribution of the African Regional Centre for Engineering Design and Manufacture [ARCEDEM], Ibadan, Nigeria in the drawings of the various component machines of the UNIDO sponsored small scale gari processing plant.

SUMMARY OF REPORT,

CONCLUSIONS AND

RECOMMENDATION.

1. The gari processing plant which has been built for UNIDO is based on upgraded and modified existing basic designs of those component unit machines which are readily available and which were identified from a national survey of major gari producing areas. The gari-plant is made up of seven component machines that facilitate the operations of more than 10 different steps in gari processing from the cassava root.

2. The most critical machines in the plant are

   i. the grater - used for particle size reduction from peeled cassava tuber and dewatered (pressed) cassava cake;

   ii. screw press-for water removal from fermented cassava pulp;

   iii. garifier/dryer - this is a cylindrical cooker/dryer that first gelatinises (cookes) the pulp followed by water removal (drying), yielding ready - to-eat dry gari product; and

   iv. a sifter (shaker) for gari grading.

3. The layout of the plant is arranged in such a way that there is only one prime mover - a 6-horse power diesel engine - which drives all the moveable machines (i.e the grater, the sifter and the garifier/dryer). Performance tests on the gari plant showed that it is versatile in that it equally dries gari, cassava flour, lafun and starch, unlike other existing gari plants which produce only gari. The plant is therefore expected to be also suitable for use in various countries that have preference for cassava flour.

4. The design of the plant took into consideration the limitations of manufacuting facilities in many African states and avoided undue sophistication that might defeat the objective, that is, to produce a low technology, low cost gari processing plant. The drier can be fired with charcoal, coal, firewood, sawdust or gas, whichever is available, thus making tne plant suitable for rural areas.

5. The present output of gari is between 120-160kg in 8 hours, but this could be considerably increased by changing the present prototype from a batch to a continuous process. The plant was demonstrated in various international trade fairs, science exhibitions and rural areas all with favourable responses. It was also demonstrated for participants from Cameroon and Liberia.

6. Techno-economic analysis of the gari plant showed that a total investment cost of $33,323 will be required. It will employ 9 workers who will be expected to produce about 37 tons of gari per annum at a selling grice of $0.74/kg. This is about double the cost when processed by traditional methods. If however, the annual gari output could increase by better management, under moderate semi-commercial scale of production, the unit production cost should fall.

7. It is recommended that at least one gari plant should be manufactured for each of the African countries that consume gari, including Congo and Zaire where cassava flour is eaten.

CHAPTER 1

[PHASE 1]

BACKGROUND INFORMATION AND SURVEY OF SMALL SCALE GARI PROCESSING MACHINES AND METHODS

CHAPTER 1

1.0 BACKGROUND INFORMATION:

The United Nations Industrial Development Organisations (UNIDO) in August 1986 mandated the Federal Institute of Industrial Research Oshodi (FIIRO) to "develop a small-scale gari plant that is marketable, efficient, low cost and will improve the efficiency of gari production in rural areas".

The implementation of the project was divided into six phases, the first of which was the survey of the local areas to study and evaluate equipment being used for village scale gari production.

The national survey of major gari producing areas covered Ogun, Oyo, Bendel and Imo States. These visits brought us in contact with both manufacturers of the village scale gari processing plants and the users of the equipment. It was concluded that the most appropriate plants are those manufactured by two different companies in Ibadan namely - ELA Agricultural Machinery Manufacturing Company and Sahara Engineers Limited. Some units of this equipment were recommended to be upgraded and standardized for greater productivity and easy reproducibility of spare parts and maintenance considering the low technology in these areas. These included the grater, the sieve, the dryer and the introduction of a small milling machine to standardize the gari particle size.

1.1 INTRODUCTION:

Gari is a gritty gelatinized starch food processed from fermented cassava (Manihot esculenta, Crantz) and used as a staple in some countries of West Africa and Central Africa. It is estimated (FAO 1979) that global production of cassava was about 117 million metric tonnes with Africa contributing about 45 million tonnes. Nigeria seems to be a major producer and consumer of gari as a staple in Africa; its gari output being roughly about 2 million tonnes in 1976 (Ngoddy and Kaplingsky 1976).

Other products of cassava processing are cassava flour, starch, tapioca, "fufu" and "lafun". Gari is however most preferred because of its ease of preparation and relative storability. Basically, gari processing involves the peeling of the cassava tubers, the grating of the peeled tubers, the fermentation and dewatering stages, and the frying and packaging stages.

There are three recognized levels of gari processing in the country - depending on the extent of mechanization involved.

The first and the basic level is the traditional system where each unit operation is essentially manual, time consuming and tedious. The frying is carried out in a semi-spherical iron pot fired with wood. It is essentially a family system, with production capacity ranging from 20-50kg per day.

The second level is one in which some mechanisation or improvement have been introduced in some of the unit operations or/and processing equipment with production capacity ranging from 300 - 500kg per day. The mechanisation and improvement are generally in the areas of --

1) Grating - where a motorised grater is used to replace the hand grating. The graters are of different capacities and efficiency.

2) Dewatering process: - where either a screw press or a hydraulic jack is used to replace the heavy stone in traditional process.

3) Friers - here the semi-spherical pot is replaced by a semi-cylindrical metal which can be manually or mechanically paddled.

The third level is that using commercial plants with output of 3 to 10 tons a day. The unit operations are almost entirely mechanised. The FIIRO design which has been commercialized in over three African countries falls into this category. However the present assignment from UNIDO falls into the second category.

The United Nations Industrial Development Organization (UNIDO) realizing the expertise of the Federal Institute of Industrial Research Oshodi (FIIRO) in this area has mandated FIIRO in this contract "to develop a small-scale gari plant that is marketable, efficient, low cost (that) will improve the efficiency of gari production in rural areas".

1.2 WORK PLAN AND TIME SCHEDULING:

The work plan was divided into six phases for a time scheduled of 18 months starting from December 1986 as shown in Annexes 1 and 2. The Phase 1 involved a national survey of major gari producing states and villages.

1.3 OBJECTIVES:

The objectives of this survey were to -

(1) Visit selected intensive gari processing areas and review their processing methods;

(2) Identify the equipment being used presently by the different communities.

(3) Identify problems associated with each unit of the component gari equipment; and

(4) Identify units that are considered suitable for modifications and improvements.

1.4 THE SURVEY:

The survey was carried out by a team consisting of a food technologist, an economist and a design engineer to Ogun, Oyo, Bendel and Imo States which were identified as states with intensive gari production. In each state, visits were made to the Ministries of Agriculture, Agricultural Development Projects, Local Government Areas, towns and villages where gari is produced in substantial quantities. Local people in all the different states were met and the machines being used were evaluated and photographed. The places visited in each state are shown in Table 1.

Table 1: *Town and Villages Visited in Each State*

OYO STATE	OGUN STATE	BENDEL STATE	IMO STATE
Ibadan, Iyana	Ifo, Ilaro,	Benin, Sapele	Owerri, Orlu
Offa, Iwo,	Abeokuta,	Warri, Abraka	Umuahia,
Awe, Oyo	Ijebu Ode	Auchi, Ibilo	Umudike
Ogbomosho, Ikire	Ijebu Igbo	Igarra, Abudu	Oboro Etiti
Odo Ota	Shagamu, Makun	Ekpoma, Umunede	Mgbiriehi
Lanlate	Ogbere		

The extent of mechanisation varies from place to place. In some places only the grating is mechanised, in others two or more unit operations have been mechanised. In all cases the peeling of the tubers is still manual. In all places where mechanisation has been introduced, the equipment for each unit operation are similar and conventional, as discussed below:

Grating: The grater consists of an inverted perforated light gauge sheet wrapped round a wooden roller. This roller is connected to a motor which may be petrol; diesel-or electrically-operated. The machine is also being used as cassava cake granulator. (Figure 1).

Dewatering Process: The equipment used for this process consists of either a screw press or a hydraulic jack. The mash, packed in synthetic sacks, is stacked in layers and dewatered through the operation of the screw press or jack. (Figure 2)

Sifting: This is the removal of fibres from the granulated gari mash. This is generally done manually but some processors have mechanised this operation. The sieve is however made from vegetable fibres instead of having a metal mesh (Figure 3).

Frying Trays: These consist of either rectangular or semi-cylindrical metal sheets fired either with wood, diesel or gas. The number of frying trays varies from place to place - depending on desired capacity. In all cases the gari is manually paddled or turned round with wooden spatulas - usually two people standing by a tray of about 1x2.5m and 10cm deep (Figure 4 and 5).

Disc Mill: Only one of the places visited has a disc mill which is needed to mill the coarse gari particles to even sizes.

Sifter/Grader: The grader is a manual sifter or a mechanised one (Figure 6 and 7).

1.5 CONCLUSION:

The tour revealed that silent revolution has been going on at the grass roots level to mechanise gari production to the extent they can afford - assisted by local engineering companies. The ELA and Sahara type gari machineries seem to account for about 75% of the equipment used in gari production at the rural level - though standardization seems to be lacking.

It was concluded that though the equipment produced by both ELA and SAHARA are widely in use at the rural level, these equipment have to be upgraded and standardized for greater productivity and easy reproducibility for spare parts and maintenance. It was realized that a completely new and sophisticated design will not make any impact in these areas because of the complexity involved.

1.6 RECOMMENDATIONS:

(a) Grater: That the typical drum type be selected because of the advantage that it can be used as a granulator. Its parts should be standardized and galvanized sheets should replace the old tins used. An alternative could be the adoption of the FIIRO type grater which has a higher and more efficient production rate. However this was found to be more expensive.

(b) Dewatering: That the screw press type with flywheel be adopted since the maintenance problem involved is very small. This was considered more suitable over the system using the hydraulic jack, because of sealing problem and spillage of hydraulic oil into the mash.

(c) Granulator: It was also realized that the grater was used for this purpose. Therefore the design of the grater should take this into consideration.

(d) Sieve: A simple mechanical type with metal mesh be designed.

(e) Garifying: That the open tray non-continuous dryer system should be re-designed such that the toxic fumes from, the gari are channeled away from the operators while the energy efficiency be improved upon in the design. A maximum output of 500kg of gari per 8 hour working day was recommended.

(f) Milling: It was recommended that a simple milling unit be bought for integration into the plant. This was to standardize particle size of the gari.

(g) Packaging & Weighing: A simple system of packaging the gari in 2kg sealed polythene bags simiiar to that being used in FIIRO be used if necessary or required. It was however realized that this might not go well with the habits of the rural population who are used to tasting the gari before selecting their choice. This notwithstanding, its introduction will improve its hygiene, appearance, packaging and acceptability.

CHAPTER 2

[PHASE 2]

ARI MACHINE DESIGNS AND SPECIFICATIONS

CHAPTER 2

2.0 SUMMARY:

The gari machines most commonly employed by small scale-gari producers were earlier identified through a survey as a mechanical grater, a manual screw press, a garifier/dryer, a sieve (shaker), using a non-continous system. This report presents the designs of the various machines, suitably modified and upgraded for greater efficiency. The need to avoid undue sophistication and to reduce cost was paramount in the choice of design parameters.

The grater is built of mild steel frame and perforated galvanized steel sheet grating surface. The screw press is made from mild steel sections and plates, and a central square threaded screw of 12mm pitch. The garifier has three rotating arms with split wooden paddles and a vent system to safeguard operators from poisonous cyanide fumes whiles roasting cassava mash. The sieve is a mechanical shaker carrying a frame that can hold screens of various apertures. These units are coupled to a 6 h.p. diesel engine as the prime mover. The designed maximum capacity of the plant is 500kg of gari in an 8 hour working day.

2.1 INTRODUCTION

In the first interim report (chapter 1) it was recommended that a mechanised, non-continuous system, having a maximum output of 500kg of gari per 8 hour working day was desirable. Furthermore the machines to be adopted were to be those widely used at present but suitably upgraded and standardized for greater productivity, easy manufacture of spare parts and maintenance. While the garifier/dryer and the sieve (shaker) were built from a new design, the rest of the component machines, namely, the grater, screw press, disc mill and weigher were purchased locally and modified. Details of the individual machines and design specifications are given in this section.

2.2 OBJECTIVES:

The objectives of the second phase of the UNIDO gari machine project were to design, fabricate, improve upon and assemble the gari machines recommended from a previous survey.

The following gari machines are affected:
The cassava grater, the screw press, the garifier/dryer, the sieve (shaker) and the simple mill.

2.3 THE MACHINE DESIGNS AND SPECIFICATIONS

2.3.1 Cassava Grater: Schematic Figure 8

There are generally two types of graters used locally in Nigeria. These are the hammer type and the abrasive type. The former is used for large scale productions while the latter is for small scale operation. Because of its simplicity and cost-effectiveness, the abrasive type of grater was adopted for the project designs.

The abrasive grater was bought from a local fabricator (Addis Engineering Limited, Isolo, Lagos) and was made up of a rotating disc of cast aluminum clad with finely perforated galvanized plate around its periphery to form an abrasive disc. This disc was assembled within a stationary enclosure which has an abrasive, well perforated galvanized sheet close to it at the feeding end. Thus the quality and efficiency of the machine depended on:

i. the extent of abrasiveness of the disc and plate.

ii. the clearance between the disc and stationary wall.

iii. the limiting speed of rotation of disc which was 700-800 revolutions per minute.

MODIFICATIONS:

It was found that the quality of grating done by the machine was not standard when used as was purchased. Hence modifications were carried out on:

i. the main drive-by fixing pulleys and belts to make the speed of the disc 72 revolutions per minutes (r.p.m).

ii. the stationary plate-by creating an abrasive surface on it through scattered drillings.

FINAL SPECIFICATIONS OF THE GRATER:

Overall Dimension	-	714mm (L) x 618mm (B) x 565mm (H)
Designed capacity	-	300 to 350kg/hour
Actual capacity	-	300kg/hour
Power required	-	2h.p, if driven by electric motor
Actual arrangement	-	Belt and pulley drives coupled to a diesel engine drive

Materials:
i. Main frame - mild steel
ii. Shaft - mild steel
iii. Main rotors - cast aluminum
iv. Abrasive covers - galvanized steel
v. Pulleys - grey cast iron
vi. Belt - size B 930

vii. Bearing - MP 25 basic bearing size 1030

2.3.2 SCREW PRESS Schematic Fig. 9

Basically there are three types of cassava paste dewatering machines in practice, namely:

i. Basket Centrifuge - for large scale operation

ii. Hydraulic press - for medium scale operation

iii. Screw press - for small scale operation

Because of simplicity of construction and low maintenance cost, the screw press was considered for the project. This equipment initially purchased from the local market (Addis Engineering Limited, Isolo, Lagos) was made up of the following:-

a) Square threaded shaft fitted at the lower end on a ramming plate which could be raised or lowered by using the operating rod inserted into a hole made at the lower part of the threaded shaft.

b) A brass nut, square threaded, through which the screw shaft passed, which was fitted like a bush in a hole made at the centre of the upper horizontal frame.

c) Main frame of U-channel and angle iron structural mild steel carrying at the bottom a stationary plate of cast aluminum which was round for drainage when cassava mash is packed on it for pressing.

The loading capacity of the press when tested as purchased was a maximum of 80kg, which was considered too small. Modification was therefore made by providing structural steel covers at the sides so that it was able to accommodate material of about 240kg.

SPECIFICATIONS:

Overall dimensions - (L) 980mm x (B) 700mm x (H) 1690mm

Designed capacity - 80kg per batch

Capacity after modification - 240kg per batch

Maximum compressive load - 3 tonnes

Materials: i. Frame - Mild steel sections and plates

ii. Screw shaft - Mild steel rod.

iii. Nut - Brass

iv. Rams (top and bottom) - cast iron or cast aluminium or seasoned wood, depending on availability.

Thread type - Square with pitch 12mm

Installation - Bolt down on concrete base with drainage facility.

2.3.3 GARIFIER/DRYER: Schematic Fig. 10

The design and fabrication of the dryer unit was carried out completely from scratch at the Institute. It is made up of a mechanised but simple ventilated system, in which the poisonous cyanide fume is conveyed away from the operator, unlike the traditional open tray system, presently used in the villages.

The cooking drum is a cylinder made up of half lower base of mild steel and half upper base of aluminium plate cover which has windows that could be opened and closed at intervals as necessary. The cooking is done by a moveable charcoal fire tray ignited in an insulated chamber at the bottom part of the cylinder. Material mixing is carried out during cooking and drying stages by rotating wooden paddles scattered on the main shaft at three intervals and orientation of 120 degrees to one another. Each paddle is spring - loaded to maintain constant contact with the lower portion of the drum and rake up material from the drum and thus avoid burning of materials being processed.

The main drive is through chain and sprocket wheel coupled to a reduction gear box driven through belts and pulleys by a diesel engine.

IMPORTANT FEATURES:

From experiments it was found that continuous long paddles spanning the ends of the three arms of the central shaft produced messy cake instead of cooked separate granule gari. Further experiment was therefore performed by breaking the paddles into seven pieces on each shaft. It was discovered that the stirring of product became more turbulent with the result that cassava flour (i.e ungelatinised product) not gari was produced.

The third experiment was also performed with the number of broken paddles reduced to five pieces, and this gave desired result for gari. It was concluded that:

a) the unit could be used with five paddles to produce gari.

b) it could be used with seven paddles to produce other cassava products (cassava flour, fufu or starch).

FINAL SPECIFICATIONS FOR GARI FRYER:

Overall dimension - 1420mm (L) x 1100mm (B) x 1660mm (H)

Charge capacity designed - 150kg/batch

Operating capacity - 50kg of fiber free, fermented granulated cassava cake per hour.

Power requirement - 1.5 h.p

Material: i. Cooking drum - mild steel

ii. Drum cover - aluminium

iii. Support frame - mild steel

iv. Fire place - brick or mud (to be built in situ around frame or fiber

- insulating jacket of mild steel plate.

v. Paddles - seasoned wood on stainless steel pipe arm.

vi. Main shaft - mild steel rod bushed by stainless steel pipe.

Firing - Wood, material waste, cooking gas, fuel oil, charcoal, mineral coal, palm kernel shell. When the fuel is other than cooking gas and fuel oil firing tray of mild steel trolley can be used.

2.3.4 SIEVE (SHAKER): Schematic Fig. 11

This is a machine that can be used to sieve both the wet mash and dried gari-granules. It is made up of a simple vibrating system which uses an eccentric cam mounted on the main deriving shaft. The cam pushes an oscillating tray which holds a detachable screen under which is a discharge hood of aluminium or galvanized sheet. The screen is made in different sizes to be used as the case may be for fiber removal or gari sifting (3mm aperture) and 1mm for fufu, starch and cassava flour. The oscillating tray holding the screen is damped by means of two coiled springs at one end of the tray.

SPECIFICATIONS:

Overall dimension - 1160mm (L) x 500mm (B) x 1025mm (H)

Designed capacity - 70kg per batch

Operating capacity - i. 700kg per hour for granulated cake

ii. 500kg per hour for crude gari

iii. 650kg per hour for milled gari.

Power requirement - 1.5 h.p

Materials i. Main frame - mild steel

ii. Tray - mild steel and wood

iii. Screen - wood and metal welded mesh or drilled mild steel plate.

iv. Bearing - Bearing - pillow blook NP.30

v. Shaft - mild steel EN8A

vi. Cam - mild steel EN8 (case hardened).

2.3.5 WEIGHING SCALE:

This is a dial type having a maximum capacity of 200kg weight. It is hung on a structural steel frame of 1-beam during weighing.

2.3.6 MILLING MACHINE:

This is a disc attrition mill with grey cast iron disc, cast aluminium housing and structural steel stand. The drive capacity is 1.5 h.p and the drive system is belt and pulley arrangement.

MODIFICATION:

A structural steel stand was built for erecting the mill. Also the belt and pulley system was re-designed and arranged to connect the shaker pulley in series with the grater and diesel engine drive.

SPECIFICATIONS:

Operating capacity - 45kg of coarse gari particles per hour (dry milling)

Overall dimension - 500mm (L) x 500m (B) x 1300mm (H)

Power required - 1.5 h.p.

Materials - i. Grinding disc - grey cast iron

- ii. Grinding housing - grey cast iron or cast aluminium.

iii. Grinder base - grey cast iron or cast aluminium.

iv. Grinder stand - structural mild steel angle iron.

Maximum speed - 725 r.p.m.

Disc arrangement - One rotating, the other stationary.

Installation - Bolting down on concrete base.

2.3.7 DRIVE SYSTEM:

The layout of the plant (Figure 12) was arranged in such a way that there is only one prime mover - a 6 horse-power diesel engine.

A structural steel base was constructed upon which the units were installed to facilitate transportation and re-installation at demonstration sites, although the erection could be carried out as well on concrete foundations. The following are details of the drive system:-

i. SPECIFICATIONS FOR THE GRATER:

Drive ratio	-	1.67:1 (1500:900 r.p.m.)
Belt size	-	B 930
Pulley on grater	-	280mm Ø
Pulley on prime mover	-	170mm Ø
Power required	-	2 h.p.

ii. SPECIFICATIONS FOR THE REDUCTION GEAR BOX:

Speed reduction ratio	-	60 : 1 (725 r.p.m : 12 r.p.m.)
Belt (gear box to engine)	-	A 930
Pulley	-	315 p.c.d.

iii. SPECIFICATIONS FOR THE DRYER:

Chain drive (dryer/gear box)	-	pitch 3/4"
Driver sprocket	-	23 teeth on 150mm p.c.d.
Driver sprocket	-	57 teeth on 300mm p.c.d.
Type of sprocket/chain	-	Double link.
Power required	-	1.5 h.p
Speed reduction ratio	-	2:1 (12 r.p.m : 6 r.p.m.)

iv. SPECIFICATIONS FOR THE SIEVE:

Power required	-	1.5 h.p
Drive ratio	-	2:1 (725 r.p.m : 363 r.p.m)

Belt size - B 930

Pulley on sieve - 280mm Ø

v. SPECIFICATIONS FOR THE MILL:

Power required - 1.5 h.p

Speed reduction - 1:2 (363 r.p.m : 725 r.p.m.)

Belt size - A 85

Pulley size on mill - 200mm Ø

2.4 DETAILED DRAWINGS OF GARI PLANT:

Detailed drawings of the grater, sieving machine, screw press and garifier/dryer are available as shown in the annex. The garifier has as much as 20 component drawings as shown below

DETAILED DRAWINGS OF THE GARI PLANT

ITEM NO.	DESCRIPTION	QUANTITY
1	Cassava grater	7
2	Sieving machine	9
3	Screw press	7
4	Garifier/dryer	20

2.5 CONCLUSION:

The design has been carried out taking into consideration the limitations of manufacturing facilities in our African States as well as the availability of materials. In most cases, mild steel was used unless where the strength is affected and also where the food quality may be adversely affected. The design also took into consideration the objective of the project to have a mechanised low cost Gari Plant which could be used in rural areas. Therefore any sophistication that might defeat this objective was avoided.

CHAPTER 3

(PHASE 3)

PERFORMANCE TESTS ON THE PLANT WITHIN THE INSTITUTE

3.0 SUMMARY:

The seven component machines of the gari processing plant were test run separately and collectively to determine performance and to make improvements where necessary. The grater and garifier/dryer were found to be the critical components judging from the target of gari output of 200-500kg per day. The weight of wet cassava mash which the grater/granulator could handle after appropriate modification was approximately 1500kg in 8 hour working day, while that of the screw press was 240kg/batch within an hour processing period. These results were found to be satisfactory. The garifier's output was about 120kg of finished gari per day, or about 12kg of gari in a 30 minute frying time using batch methods. Higher outputs are desirable and possible provided a continuous plant is built. That should eliminate much handling and intermittent stoppages to load and clean up as was discovered in the present prototype plant, but it will no longer fall into a low-cost category.

3.1 THE MACHINE PERFORMANCE TEST RESULTS:

The spring balance was used to weigh tubers before and after peeling. It was found out that it could handle conveniently 50kg of roots within 5 minutes, although it had a maximum capacity load of 200kg. Since the gari plant was designed for a maximum capacity of 2 tons of roots in 8 hours, (assuming a yield of 1/2 ton of gari from 2 tons of unpeeled tubers), the weigher was considered suitable to handle the job.

The grater as it was purchased could grate about 675kg of peeled cassava in 1 hour or 5.4 ton in 8 hour continuous operation but the mash was discovered to contain pellets of ungrated portions which constituted about 30% of the mash. However after it was modified as indicated in section 2.3.1 the capacity was reduced to 90kg/hour or 1520kg in 8 hour day. This was considered satisfactory judging from the expected weight of 1500kg of peeled roots, assuming a peeling less of 25-35% from a ton of unpeeled cassava.

The screw press was manually operated. Initial tests showed that it could dewater a maximum load of 80kg of grated roots to about 50% water content in 48 hours. This load was deemed too small, but after providing a structural steel housing (covers) so that the packed bags of mash could be contained within the housing and a guttar round the edge, terminating in a hole at the bottom to drain the liquor away, a satisfactory capacity of 240kg of mash per batch per hour of loading, was achieved. Actually, the screw press was loaded fully at the end of the grating process and screwed reasonably down to avoid bursting the cloth bags. The mash was then allowed to drain gradually and to ferment in situ for 48 hours. The final water content was brought to about 50% (by weight) by further screwing down of the upper arm by means of the manual lever. Because the grated mash could not all be contained in the screw press, the excess mash was stored in aluminium vats, covered with lids to prevent discolouration of the top layer and allowed to ferment for 4 days.

Development of the sour flavour has been discovered to be fastest and optimum at 48 hours if the mash is gradually pressed and continuously draining as in the village method but it takes much longer (about 4 days) for the sour flavour to develop fully when the pulp is staying in vats without liquor draining away (Onyekwere et al, 1989). The fermented mash stored in the metal vats was dewatered in batches. The efficiency of the screw press is reportedly improved by the use of an ARCEDEM type which has a lever at the top and bottom of the central screw rod, rather than at the bottom only.

The dewatered cassava came out as cake which was then granulated (distintegrated) in the grater, thus using the latter for a dual purpose of grating and granulating. The capacity of the granulator was about 1440kg in 7 hours and was considered satisfactory.

The granulated mash was next sifted through the 3mm mesh wire sifter to remove fibre and was then hand loaded in 25kg amounts through the dryer vents into the charcoal heated dryer. (The vents at the upper portion of the garifier served a dual purpose as feeding chute for the dryer as well as a safety measure for the evacuation of toxic fumes from the roasting cassava mash). The vents were immediately closed and heating was continued to cook (gelatinise) the pulp for 15 minutes during which the maximum registered temperature indicated by the thermometer was 58°C. The vents were then opened to release steam (and toxic cyanide fumes) and for drying to commence. The two stages of gelatinisation and drying were completed in 30 minutes yielding about 12kg gari. Excessive condensation within the system caused sticky, messy cake to form along the central rotating axle and sides and upper lid of the garifier drum. Although sufficient steam was needed to cook the pulp when processing for gari, it was not so for other products, thus the vents were never closed at all for fufu, starch and cassava flour. Additionally, from experiments it was found that one continuous long wooden paddle spanning each of the three arms of the main rotating central shaft supposed to keep the pulp agitated produced unacceptable gelatinised cake instead of cooked separated granule gari. Further experiment was performed by breaking the paddles into seven or five pieces along the shaft, as discussed in section 2.3.3. It was therefore concluded that (i) the dryer unit should be used with five separate paddles on each arm of the main shaft to produce gari and (ii) seven paddle pieces to process other products (i.e cassava flour, fufu and starch).

It was also observed that with prolonged running of the garifier/dryer the upper parts that did not receive much direct heating grew rusty and brownish cake accumulated which fell back and contaminated the rest of the product. It is likely that a narrower dryer drum or stainless steel drum will eliminate this problem but the use of mild steel drum in the first instance was to reduce cost.

The roasted gari was allowed to cool overnight, milled in the disc mill and graded by sifting through the 3mm screen of the shaker/sieve and packaged in two kilogram polythene bags. The moisture content of the gari was approximately 9.3% while the cyanide content was 0.027kg cyanide per kilogram of gari. Both results were within acceptable limits. From experience gari having such low moisture content could retain its freshness for up to 9 months to 1 year if packaged in waterproof bags.

The dryer seemed to be the most important and critical single equipment. It was stated that a maximum charge of 25kg of sifted mash yielded about 12kg of gari within 30 minutes operating time. Allowing 1 hour for cleaning and lunch break, the maximum number of charges in an 8 hour period would be 14 and would yield 168kg of gari. In our experimental tests, because of intermittent stoppages of the lister engine to discharge and reload the garifier (including recharging the coal fire), the maximum number of charges was 9 and yielded 120kg of finished (sifted) gari while consuming 100kg of charcoal. This ouput could be markedly increased by changing the garifier into a continuous system which will not need to stop the dryer intermittently to load and discharge. However, the overall cost of the plant will not fall within the village scale level.

3.2 CONCLUSION:

All the gari machines were carefully evaluated in the Institute and it was discovered that the garifier/dryer was the single most critical component, followed by the grater. The garifier was found to be versatile in that it equally dried gari, fufu, cassava flour and starch unlike other gari processing plants which dry gari only. There was economical use of energy because a single diesel engine drove all the moveable component units, namely the grater, dryer, sifter and disc mill. However, the garifier's output of less than 200kg in 8 hour working period could be considered too small if up to 2 tons of cassava were available for processing. On the other hand, experience shows that village scale gari producers hardly have more than one ton of cassava per day. Thus this prototype gari plant could be ideal.

CHAPTER 4

[Phase 4]

DEMONSTRATION OF THE GARI PLANT IN TWO NIGERIAN VILLAGES INCLUDING OTHER EXHIBITIONS

4.0 SUMMARY:

Having obtained the necessary operational data and modifications in the Institute the gari plant was subsequently taken for processing demonstrations to two gari producing villages in two states of the country (Ilaro in Ogun State and Ibilo in Bendel State). The choice of the two places was deliberate. While Ilaro people consume well-fermented sour gari, Ibillo consumers prefer non-sour gari with very short fermentation time. The demonstrations were successful judging from the feedback from the villagers.

4.1 THE DEMONSTRATIONS:

Concrete floors for mounting the equipment were prepared previously with permission of the local government authorities before a two man team left for Ilaro on 27 May 1988, and later proceeded to Ibillo. The Chairmen of the Local Government Councils in those places motivated the cooperative farmers to bring their already peeled cassava tubers for processing. They also invited other villagers and pressmen to witness these demonstrations which lasted for 17 days. The demonstrations were deemed to have been successful judging from the favourable comments from, the villagers and samples of good gari that were brought back to the Institute. Several photographs were taken at the demonstrations and depicted the following activities:-

Figure 13 - Cassava peeling and (b) peeled cassava weighing

Figure 14 - Cassava grating demonstrations.

Figure 15 Bagging of grated cassava roots.

Figure 16 -	Dewatering/fermentation processes on the screw press.
Figure 17 -	Weighing of granulated fermented cassava mash.
Figure 18 -	Garification/Drying process: Firing of garifier with charcoal Dried gari collected from the dryer outlet spout being sampled by a spectator.
Figure 19 -	Milling and sieving operations.
Figure 20 -	A cross-section of the village people who watchedthe gari plant demonstrations at Ibillo.

4.2 EXHIBITIONS:

The plant was also exhibited in the Lagos State International Trade Fair of 1988 and the Federal Ministry of Science and Technology, Lagos, exhibitions in 1988 and recently (16-21 October 1989).

Additionally, UNIDO sponsored the international exhibition of the gari plant in the 5th All Africa Trade Fair held in Kinshasa (16-31 July 1988). It was not then possible to hold processing demonstrations because only three out of the seven components of the plant were airfreighted due to excessive air charges. Nevertheless, the few componments (grater, the central drive and dryer) exhibited aroused interest among local entrepreneurs who requested for further information on the equipment. A French/English interpreter who was engaged by UNIDO enhanced the success of the exhibition.

4.3 CONCLUSION:

The small scale gari processing plant aroused interest and enquiries following processing demonstrations in Nigerian villages and exhibitions in Lagos and Kinshasa. It is hoped that similar interest will be shown in other cassava consuming countries of Africa, particularly since the plant can virtually satisfy the preferences of a wide range of consumers, be they gari, fufu, cassava flour or even small scale industrial cassava starch processors.

CHAPTER 5

[Phase 5]

LOCATING AND TEST-RUNNING THE PLANT IN TWO OTHER SELECTED COUNTRIES IN AFRICA

5.0 S U M M A R Y:

The proposal to locate the gari plant in two other countries in Africa, namely Cameroon and Sierra Leone, failed to materialise because of very high cost of air-freighting of the plant to these places, which was unacceptable to UNIDO. Thereafter, UNIDO arranged and brought participants from Cameroon and Liberia to observe the gari demonstrations in FIIRO as a cheaper alternative. A two week long demonstration exercise was further reinforced with lectures and excursions to traditional gari processors, gari equipment manufacturers and research agronomists. The exercise was successfully carried out.

5.1 INTRODUCTION:

The contract terms included the demonstrations of the plant in two other African countries. Cameroon and Sierra Leone were earlier earmarked but UNIDO had to cancel these demonstration because they were not cost effective. UNIDO, on the alternative, decided to bring participants from both countries to Lagos to have the demonstration in FIIRO. Results of the demonstrations in FIIRO are now discussed.

5.2 OBJECTIVES:

To demonstrate and test the gari plant before participants from other countries and to collect their suggestion for improvements.

5.3 THE PLANT TESTS/DEMONSTRATIONS FOR FOREIGN PARTICIPANTS:

A two week (24 July - 4 August 1989) long demonstration of the gari plant was held in FIIRO for three participants coming from Cameroon and one from Liberia. (Those from

Sierra Leone failed to turn up). Several lectures were given to keep the participants busy during the period of cassava fermentation. Some of the lectures topics included:

i. The design and fabrication aspects of the gari plant

ii. Laboratory quality control of gari fermentation

iii. Safety aspects in cassava processing and

iv. Over-view of gari fermentation research and commercialisation in FIIRO.

The greater part of the time was devoted to practical sessions in gari and fufu processing and a two-day industrial visit to small scale gari producers in Ibadan, International Institute of Tropical Agriculture (IITA) in Ibadan and Addis Engineering Limited, Isolo, Lagos, which is a major gari plant manufacturer. The expenses were borne by UNIDO. All the participants took active part in the practicals.

From discussions with the participants, useful suggestions were collected on what improvements they would want to see in the plant.

5.4 CONCLUSION:

Judging from the feedback from the representatives from Cameroon and Liberia, the demonstrations were successful and they were particularly interested in what they saw in IITA, Ibadan and Addis Engineering Limited. The general areas of improvement as collected from the various other exhibitions and demonstrations is in the discharge aspect of the garifier. At present a long wooden spatula is being used to scoop the finished gari out but some suggested a tilted drum or screw conveyor means that could facilitate this discharge.

These modifications or improvements may appear in improved designs as envisaged in the continuous gari plant design now on the drawing board.

CHAPTER 6

TECHNO-ECONOMIC ANALYSIS OF THE GARI PROCESSING PLANT

6.0 SUMMARY

1. The gari processing plant has been fabricated and is available from FIIRO but detailed drawings are available to enable those wishing to build others to do so.
2. The total investment cost is estimated at $33,323 which is expected to be financed from the bank and to be repaid back within 6 years. The loan includes a working capital of $1905 which is normally provided in the form of over-draft.
3. The gari factory is expected to employ 9 workers and if they work for 300 days/year will produce 37 tons of gari, at the average rate of 120kg gari per day. Because this daily output is very small, the selling price of the gari will be nearly double that processed by traditional methods. If however, the designed capacity of 300-500kg of gari could be attained, unit price will fall. The profit and loss account is not included in this report.

6.1 GARI PRODUCTION PROCESS

The production process of cassava tubers into gari involves so many operations. Altogether the different operations will span between five and six days.

The operations are as follows:-

6.1.1 SORTING AND WEIGHING

After harvesting the cassava tubers, the good tubers should be separated from the bad tubers. The good quality tubers will then be weighed on the scale to determine the quantity of cassava tubers that will be used.

6.1.2 WASHING AND PEELING:

This process involves, first washing the good quality tubers. This is to remove the sand and other impurities from the tubers; they will then be peeled. Because of the irregular shape of the tubers, manual peeling is recommended, as it is more economical and less wasteful.

For this plant, about two peelers can handle the peeling operations successfully.

6.1.3 WASHING AND GRATING:

The peeled tuber should first be weighed again to determine the extent of loss as a result of the peeling operation. After weighing the tubers should be washed again before feeding them into the grater. The grating operations will then reduce the tubers into cassava mash.

The grater designed for this plant can handle 300kg of cassava in one hour. After satisfying the needs of this plant, the grater can be used by other gari producers in the neighbourhood for a fee. This can generate some revenue which can be used for the upkeep of this plant.

6.1.4 FERMENTATION:

The mash collected from the grater should be put in sacks for fermentation. The sacks should be kept for between 3 and 5 days depending on the desired acidity level one wants to achieve and the final taste of the end product required.

6.1.5 DEWATERING:

After fermentation, the sacks containing the cassava mash should then be transferred to the dewatering machine whereby the liquour can be pressed out.

The dewatering machine designed for this plant can press out water from about 240kg of cassava mash per batch of about 2 hours.

6.1.6 GRANULATED:

This is the process whereby the cake obtained after pressing out the water from the mash is further broken down in powdery form. The cassava grater has been designed to perform this function.

The grater has a capacity for granulating 1.44 tonnes of cassava cake in a day of 8 hours.

6.1.7 SIFTING:

This is the process whereby the fibrous materials are removed from the granulated cake. The fibrous materials so far removed can be used to produce another food called "LAFUN".

The sifting machine has been designed to handle up to 1.5 tonnes of granulated cake in a day of 8 hours.

6.1.8 GARIFYING:

This is the process whereby the sifted cake is fed into the fryer where the residual starch in the granules is first cooked and later dried to a moisture content of about 10%.

The present fryer can only handle 120kg of gari in 8 hours.

6.1.9 SCREENING AND MILLING:

Screening is the process whereby the coarse gari is first separated from the fine ones using the seiving machine.

The coarse gari will then be milled into finer particle size product called gari flour. Gari flour when prepared has good texture like semolina.

6.1.10 PACKAGING:

This is the process whereby the end product - gari or gari flour is packed into bags of different sizes and sealed up. The bags should be well labelled.

Sealing can be done by using heat sealing machine or by applying red hot knives on polythene bags.

6.1.11 PROCESS FLOW CHART:

The schematic diagram of lprocessing cassava intc gari is as shown below:

PROCESS FLOW CHART OF GARI PRODUCTION

SORTING AND WEIGHING OF TUBERS

WASHING AND PEELING

GRATING

FERMENTATION

DEWATERING

GRANULATION

SIFTING

GARIFYING

SIEVING AND MILLING

LABELLING AND PACKAGING

6.2 ECONOMIC ANALYSIS

6.2.1 CASSAVA TUBERS

The only raw material for gari production is the cassava tuber. The price of cassava varies with different seasons. It is most expensive in the dry season. Last year cassava reached an all high price of $131.5/tonne. During the harvesting season it can be as low as $26/tonne.

For our subsequent calculations we shall assume a price of $66.00 per tonne. This price includes transportation cost.

6.2.2 MANPOWER REQUIREMENTS:

To operate this plant, a total of about 9 workers will be required. About 2 peelers, preferably women will be needed to work on the factory floor to perform the different operations. A security man will be needed especially in the night.

All these categories of workers must have First School Leaving Certificate except the Supervisor who will be the overall head. The Supervisor must have Ordinary National Diploma in Food Technology.

6.2.3 OTHER REQUIREMENTS:

(a)	Charcoal	-	$5 or 100kg/day
(b)	Water	-	500 Litres/day
(c)	Diesel oil	-	$0.22 or 4 litres/day
(d)	Packaging	-	60 pieces/day
	bags (2kg)	-	$3.28 for 100 pieces
(e)	Cartons with labels	-	6 cartons/day

6.2.4 PROPOSED PRODUCTION PROGRAMME

For the operation of this plant we wish to make the following assumptions.

A Working Hours

No of working hours/day	-	8
No of working days/week	-	6
No of working days/year	-	300

B Quantity of Gari produced

Gari produced/day	-	120kg
" " /week	-	720kg
" " /year	-	37 tonnes

6.2.5 ESTIMATED PRE-PRODUCTION EXPENSES:

(a) Feasibility Report	-	$526.0
(b) Labour Expenses		
i. Supervisor (2 months)	-	$132
ii. 2 Peelers (1 week)	-	13
iii. 5 Factory Hands (2 weeks)	-	82
iv. 1 Security man (2 weeks)	-	10
(c) Stationery and Incidentals	-	40
TOTAL	=	$803.00

1. NOTE: 1 US dollar is equivalent to ₦7.6

6.3 THE TOTAL INVESTMENT COST

The total investment cost is the sum of the fixed capital cost and the working capital cost. The breakdown is as follows:

6.3.1 ESTIMATED FIXED CAPITAL REQUIREMENTS

(a)	Land	-	$658
(b)	Factory Building (shed with reinforced floor)	-	$6,579
(c)	Machinery and Equipment	-	20,000
(d)	Installation Commissioning & Training	-	1,579
(e)	2 water tanks (500 litres each)	-	40
(f)	Furniture	-	263
(g)	Pre-production Expenses	-	803
(h)	Sub Total	-	29,922
(i)	Contigencies (5% of h)	-	1,496
			$31,418.00

NOTE: No vehicle is recommended. It assumed that the plant will be located close to the farm and gari buyers will be coming to make the purchases on the farm.

6.3.2 ESTIMATED WORKING CAPITAL

(a)	Cassava (2 weeks)	-	$190
(b)	Operating supplies & Utilities (1 month)	-	210
i.	Charcoal	-	100
ii.	Diesel oil (1 drum)	-	5
iii.	Packaging bags	-	66
iv.	Cartons	-	26
v.	Water	-	13

(c)	Manpower Cost (1 month)	-	329
(d)	Overheads (1 month)	-	419
(e)	Marketing costs (1 month)	-	22
(f)	Finished product stock (1 week)	-	434
(g)	Sub Total	-	1814
(h)	Contigencies (5% of g)	-	91
			$1,905.00

THE TOTAL INVESTMENT COST

Fixed capital	-	$31,418
Working capital	-	1,905
TOTAL	=	$33,323.00

About $33,323.00 will be needed to operate this plant on a modest scale in the first year. If the production capacity is increased, the fixed capital cost will not increase. The little difference will be in the increase of the raw material cost and the cost of operating supplies and utilities.

OTHER COST ITEMS

6.4 ESTIMATED ANNUAL RAW MATERIAL COST

Raw material	cost/year		
Cassava tubers			
144 tonnes/year		-	$9,474.00

6.5 ESTIMATED COST OF SUPPLIES AND UTILITIES

	ITEMS	COST/ANNUM
(a)	Charcoal	$1,500.00
(b)	Diesel oil	67.00
(c)	Packaging bags	592.00
(d)	Cartoons	237.00
(e)	Water	197.00
	TOTAL =	$2,593.00

NOTE Cooking gas can be used instead of charcoal if gas is cheaper.

6.6 ESTIMATED ANNUAL FACTORY AND ADMINISTRATIVE OVERHEADS

	ITEMS	ANNUAL COST
(a)	Building, furniture, machinery and equipment etc. (Maintenance - 5% of cost)	$1,342.00
(b)	Building, furniture, machinery and equipment etc. (10% of cost for Insurance)	$2,684.00
		$40,262.00

(a)	Supervisor	$790.00
(b)	5 Factory Hands	1,974.00
(c)	2 women peelers	632.00
(d)	1 Securityman	237.00
		$3,633.00

6.9 PROPOSED FINANCE PLAN

The total investment outlay of $33,323.00 is expected to be financed by the Co-operative Society. As at now an interest of about 10% is charged on loans in Nigeria, while Commercial Banks charged between 27% and 30%.

The proposed repayment schedule is as presented below. The grace period of one year is assumed. Everything is also expected to be paid back by the end of the 6th year.

6.9.1 ESTIMATED ANNUAL DEPRECIATION AND AMORTISATION OVER 10 YEARS IN EQUAL AMOUNT

(a) Building, Furniture, machinery & Equipment	$2,684.00
(b) Land	66.00
	$2,750.00

6.9.2 CONCLUSION:

The present size of the fryer used for production can only produce about 120kg of gari in 8 hours. This has been calculated to be $0.74 per kilogramme. This is quite higher than the present selling price of the traditional gari which is about $0.26 to $0.39 per kilogramme depending on the location.

6.9.3 ESTIMATED ANNUAL PRODUCTION COSTS AT CONSTANT PR

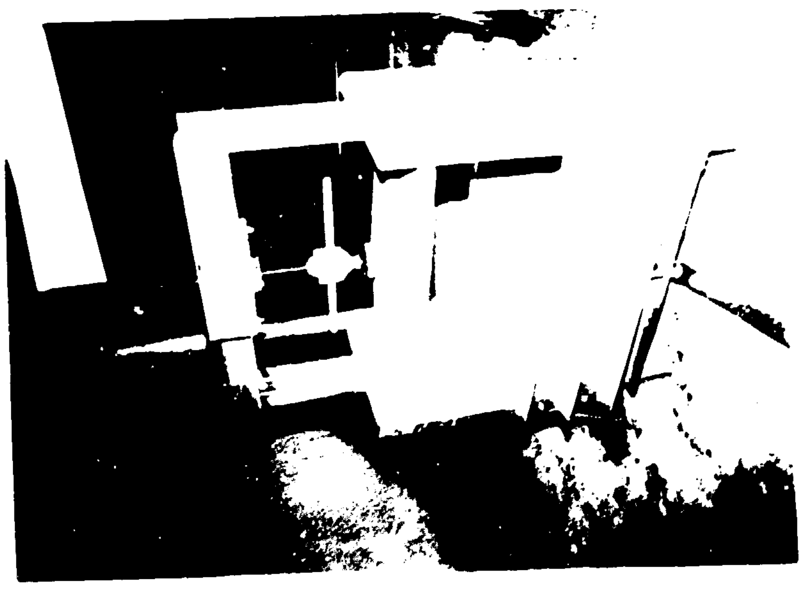
($ 00)

	YEAR	1	2	3	
1	Raw Materials	9.5	9.5	9.5	9
2	Supplies & Utilities	26	26	26	
3	Factory & Admin. Overheads	34	34	34	
4	Manpower Costs	37	38	41	
5	Marketing Cost	3	3	3	
6	Total Operating Costs	195	196	199	2
7	Contigencies [5% of 6]	9.8	9.8	10	
8	Financial Costs	29	29	24	
9	Depreciation and Amortisation	25	25	25	
10	Total Production Cost	263	259	258	2
11	Production C o s t / kg	0.71	0.72	0.71	0.

NOTE: 1 US dollar = ₦7.

56, International Technical Cooperation Centre, Tel Aviv, Israel.

ONYEKWERE, O.O; I.A AKINRELE; O.A KOLEOSO and G. HEYS (1989). Industrialisation of Gari Fermentation. In: Industrialisation of Indigenous Fermented Foods (Ed. K H Steinkraus) Marcel Dekker, Inc. New York, publishers, 439 pages.

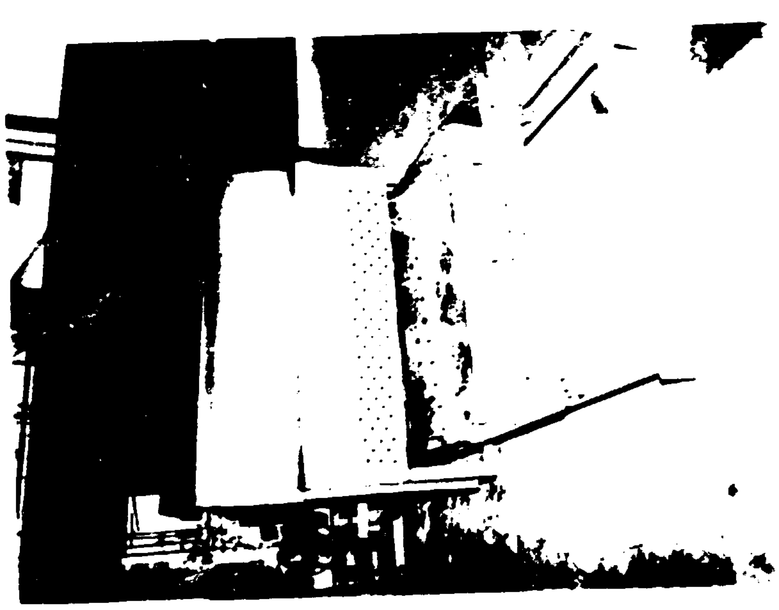


C. Various photographs (27 nos.)

D. Schematic drawings of FIIRO/UNIDO Gari Plant (Figures (8-12)

E. Detailed drawings of the Gari Plant:-

i.	Cassava grater	-	7 drawings
ii.	Sieving machine	-	9 "
iii.	Screw press		7 "
iv.	Garifier/dryer	-	20 "



tion of these phases is as shown in Annex B.

PHASE I: 2 months (December 1986-February 1987).

A survey of local areas to study the gari processing equipment being used and to evaluate the processing methods.

REPORTING TIME: 1 month (February-March 1987)

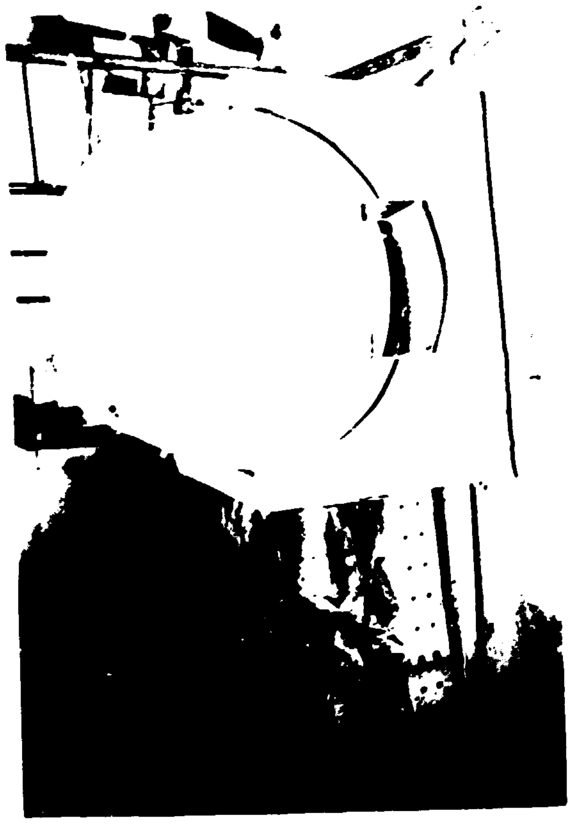
MONEY RELEASE:

PHASE II: 7 months (March - October 1987)

Selection of appropriate processes for use, followed by the designing, modification or adaptation and fabrication of new processes on the basis of existing models.

REPORTING TIME: 1 month (October - November 1987)

MONEY RELEASE:



PHASE V: 2 months (March - May 1988)

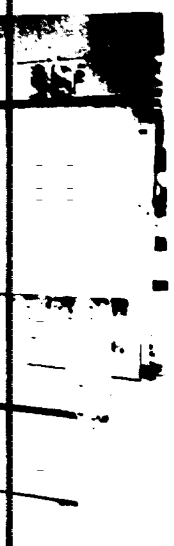
Locating and test running the plant in two other countries in Africa to be selected from the following: Ghana, Cameroon and Sierra Leone.

PHASE VI: 1 month (May - June, 1988)

Preparation and submission of final report, including techno economic analysis.

REPORTING TIME: 1 month (June - July 1988)

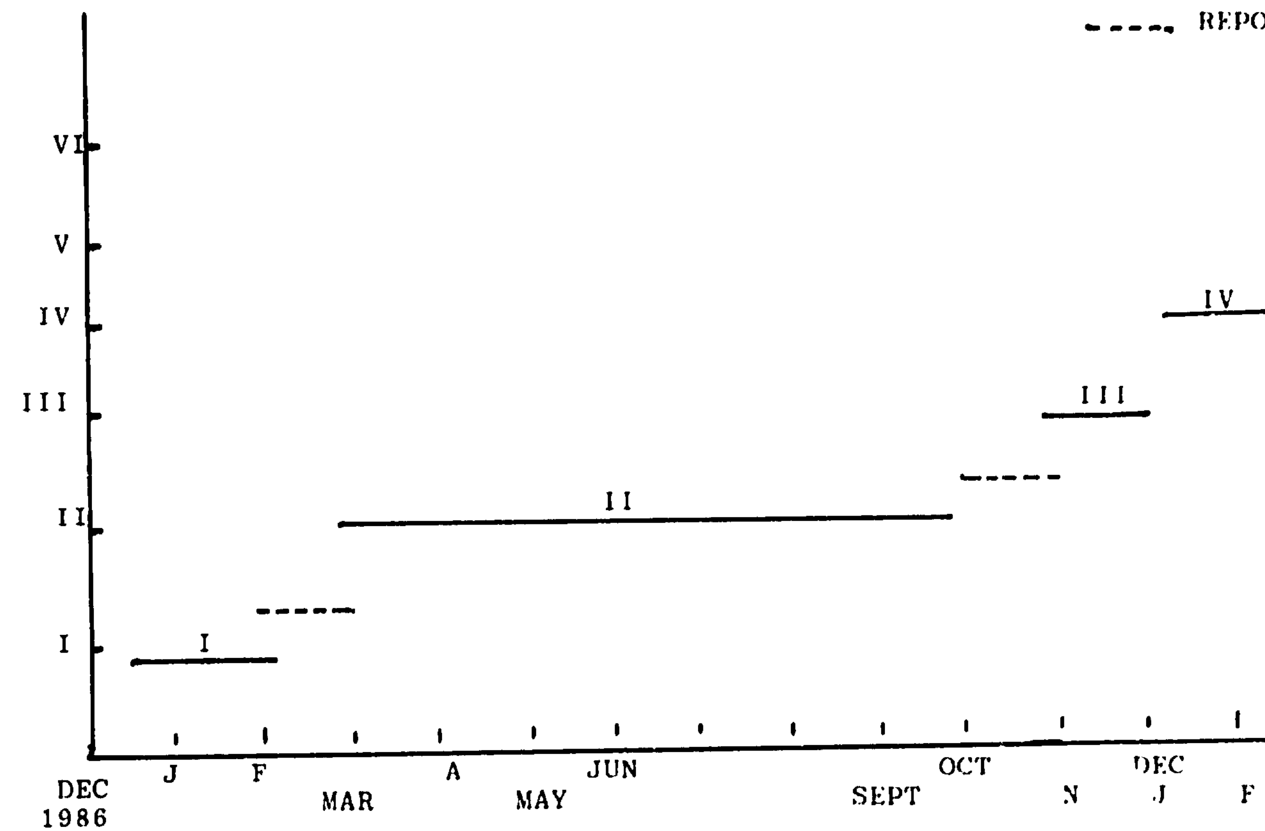
NOTE: These schedules could not be strictly followed because of some changes from UNIDO due to financial constraints.



ANNEX B

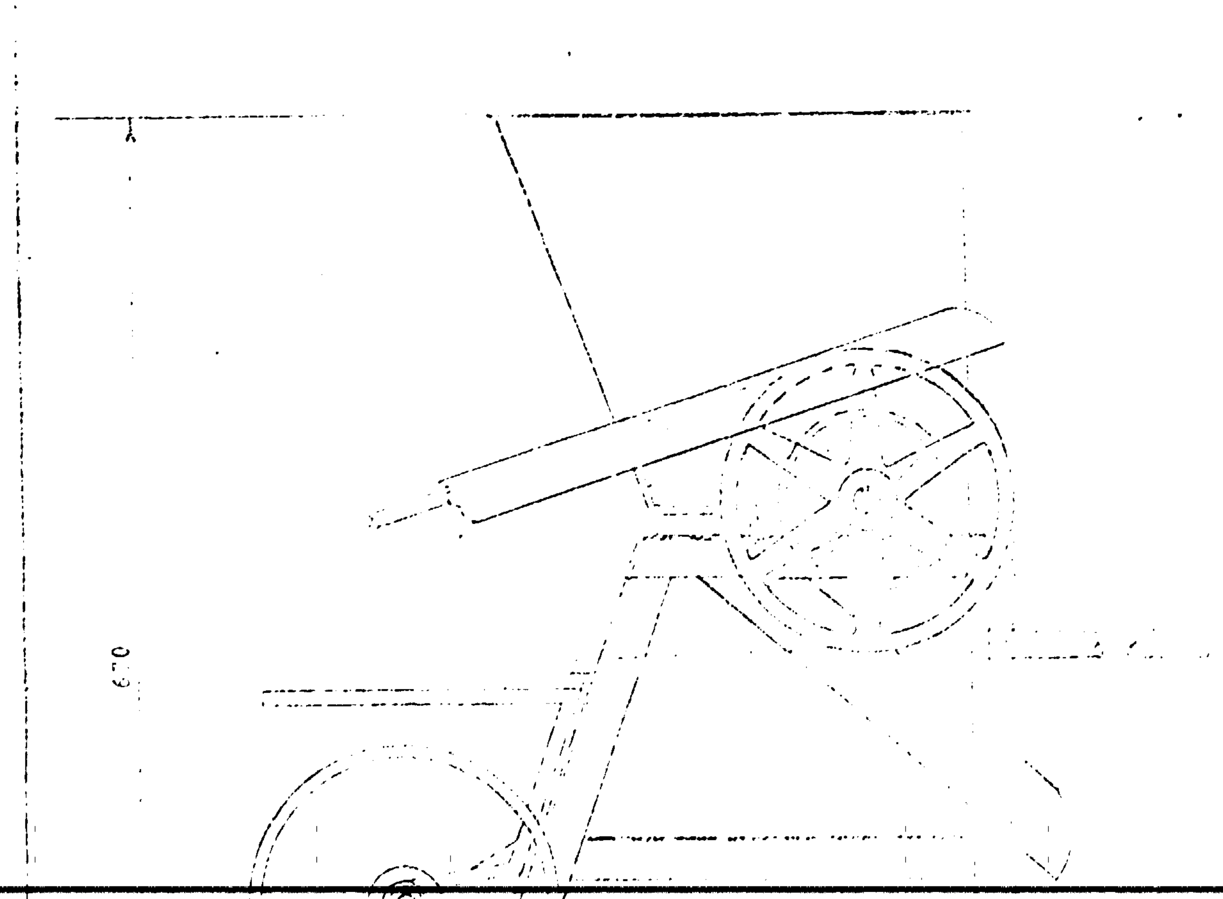
UNIDO XA/RAF/86/631 - CONTRACT 86/90

NEW TIME CHART

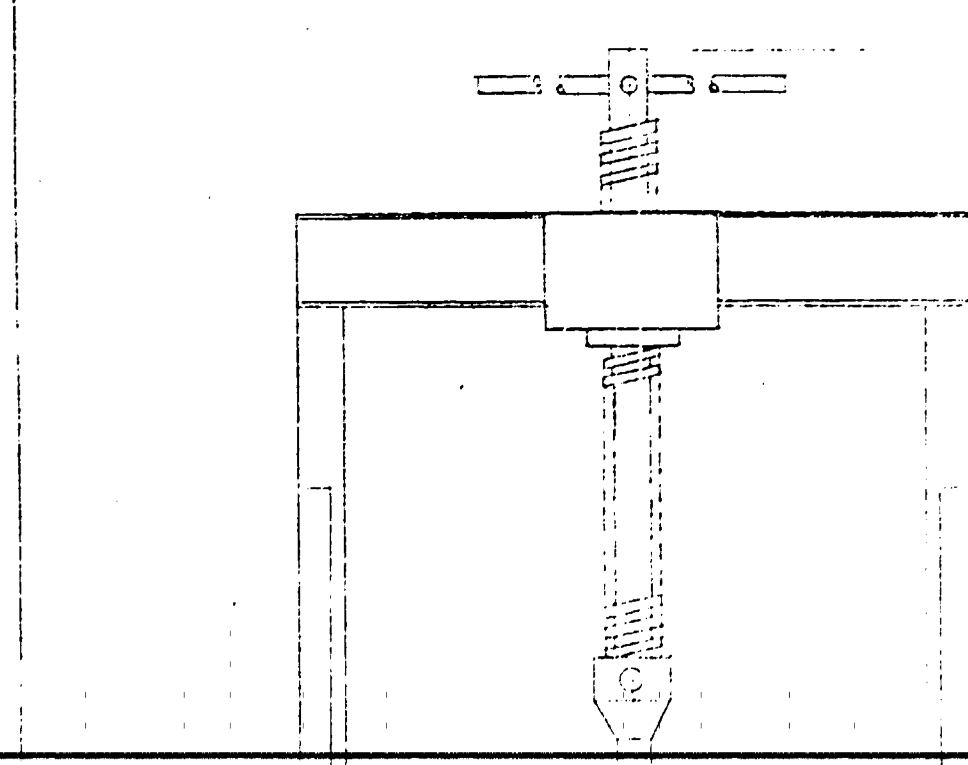


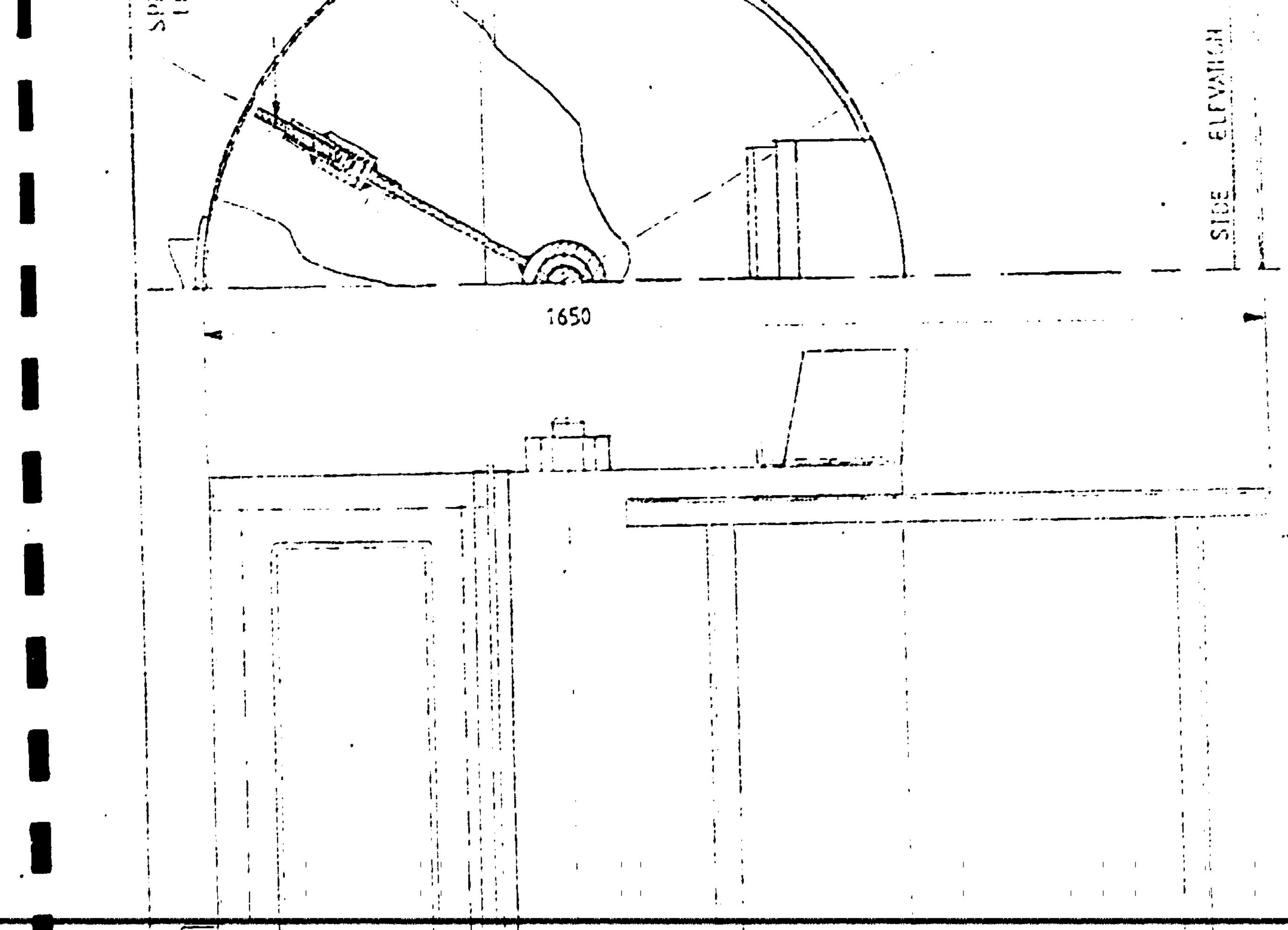
SCALE 1:5	TITLE	
DATE 25-10-87	DRG NO FIG 8	

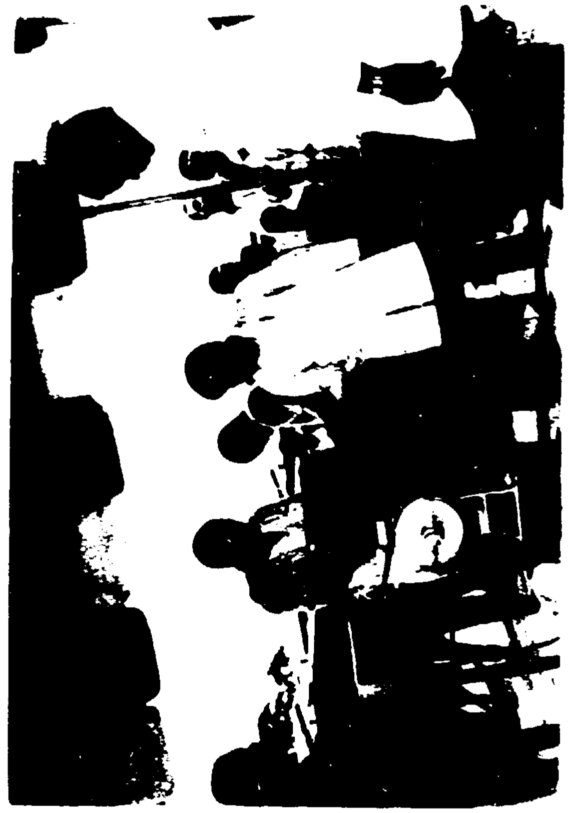
Annex D

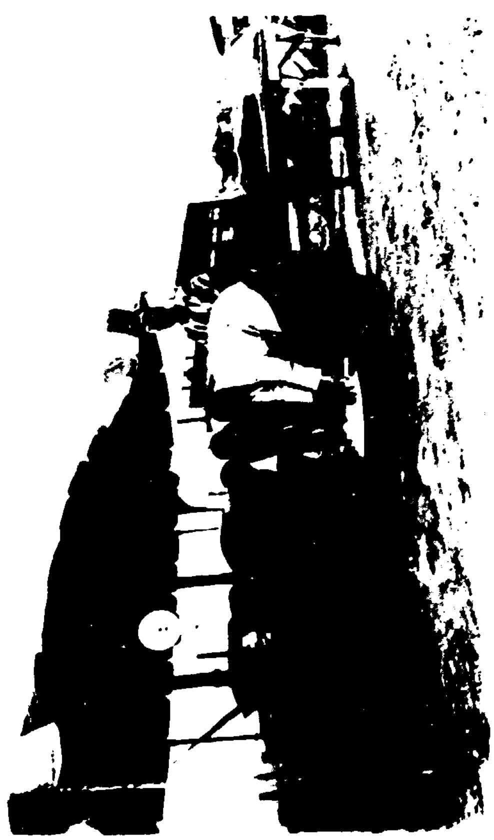


SCALE	TITLE	
DATE 25·10·77	DWG NO FIG 9	NO OF SHEETS

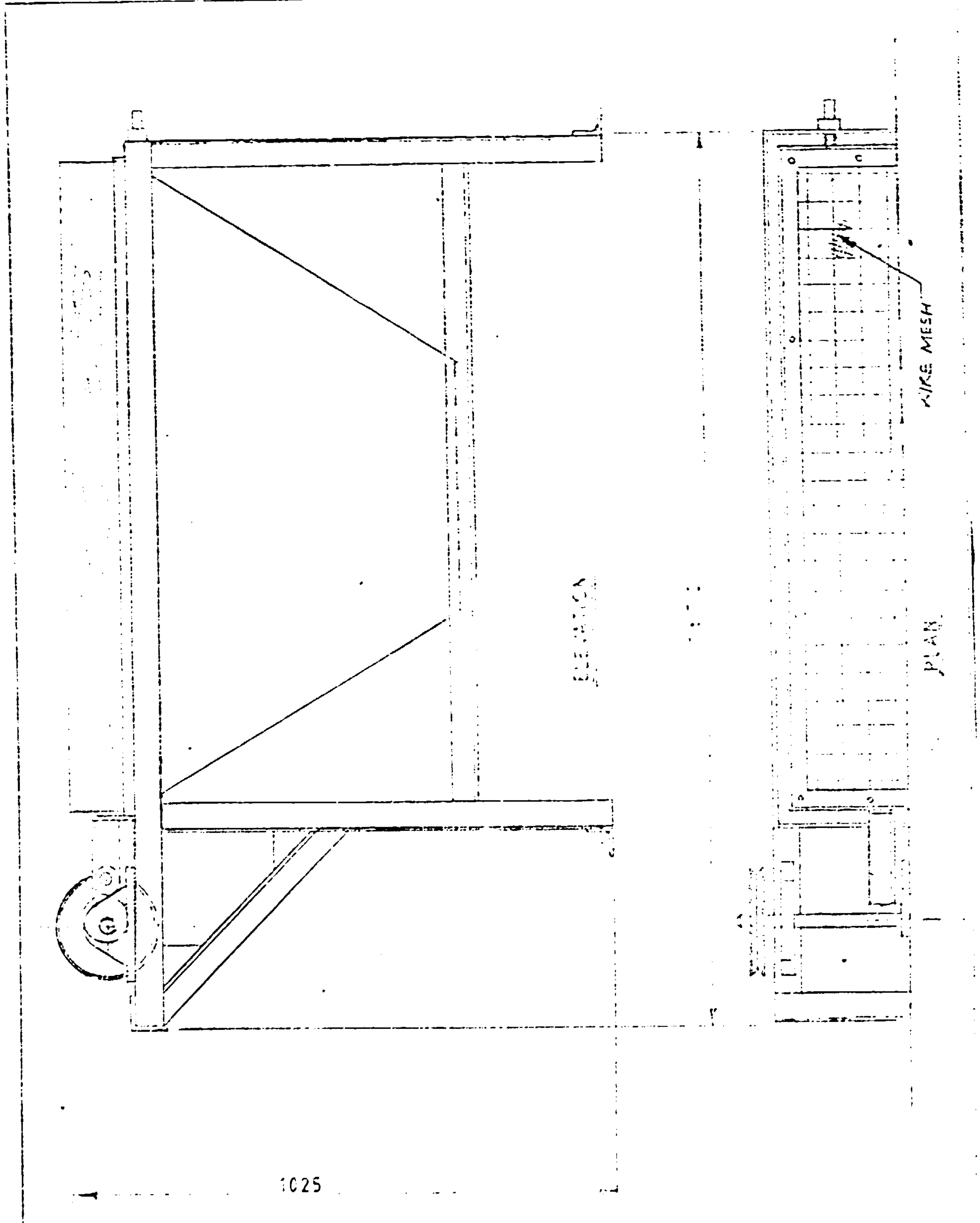



10
SPRING LOADED PADDLE
SIDE ELEVATION
1650

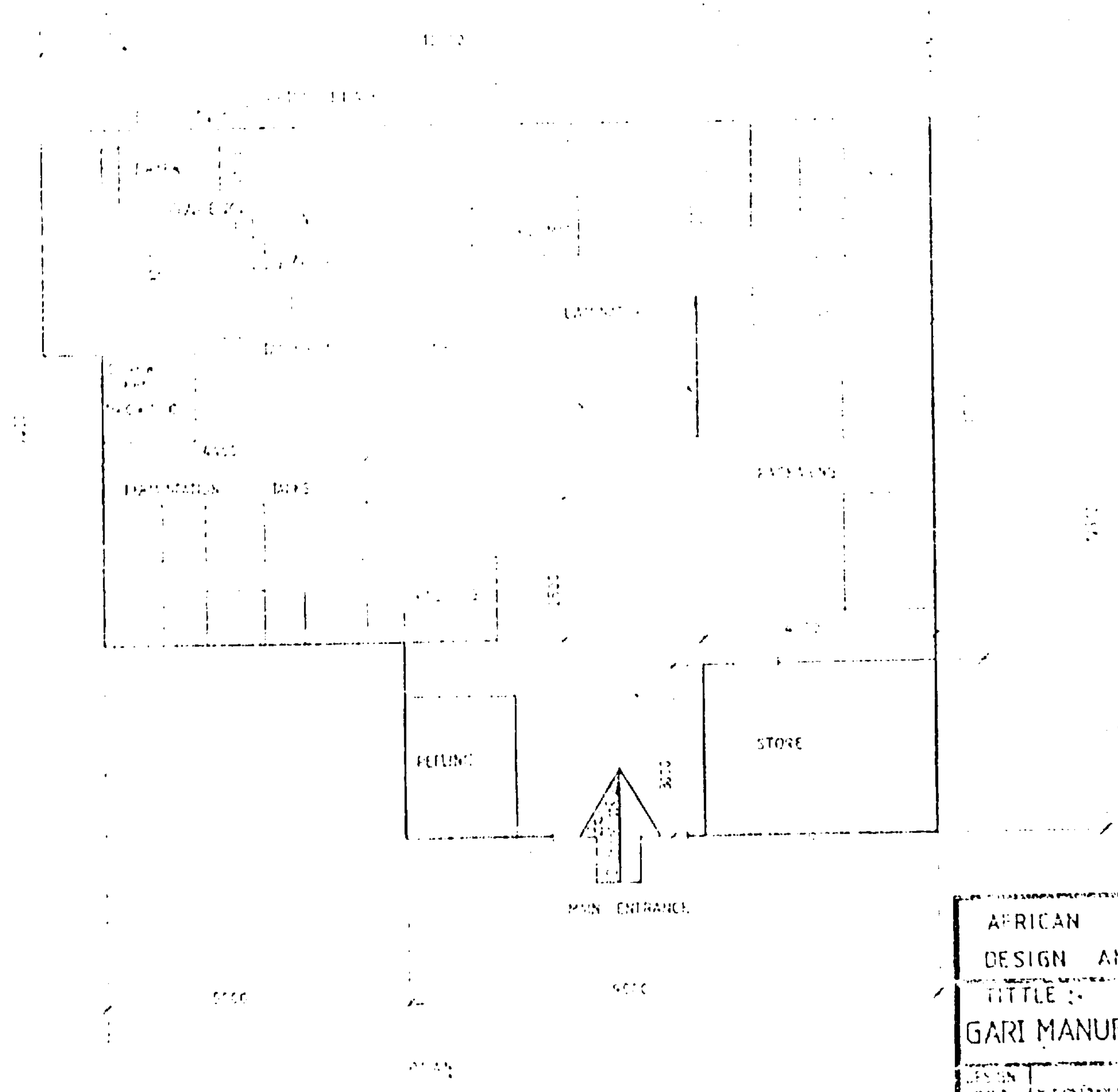




DATE 25 - 10 - 87 | DRWG NO FIG 11 | NO OF SHEETS



SIEVING MACHINE



AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING. (ARCEDEM)

TITTLE :-

GARI MANUFACTURING PLANT LAYOUT/ SCHEMATIC

DRAWING NUMBER

FIG 12

ANNEX E-1

GARI GRATER (Detailed Drawing)

TITLE	DRAWING NO.
Gari grater part	30013204
" " "	300130306
" " "	300130114
	300130312
	300130401
	300130402
	300130403
	300130404
Sub assembly	300130300
Land wheel	300130106
Front plate	300130301
Motor support bracket	300130105
Part detail	300130308
	300130003
	300130109
	300130307
	300130107
	300130108
Bracket	300130203
	300130115

ANNEX E-2

SIEVING MACHINE

TITLE	DRAWING NO.
Chute and frame	300110100
Chute sub assembly	300110200
Structural arrangement	300140200
Sieve sub assembly	300110300
Drive sub assembly	300110400
Frame sub-sub assembly	300110500
Part detail	300110303
" "	300110111
" "	300110101
" "	300110110

ANNEX E-3

SCREW PRESS (detailed drawings)

TITLE	DRAWING NO.
Part detail	300210110
	300210113
	300210115
	300210114
	300220112
	300210120
	300210104
	300210107
	300210108
	300210119
	300210103
	300210105

	300210101
	300210106
	300210111
Sub assembly	300130100
Hopper sub assembly	300130200
Sectional assembly	300210100
Gated control sub assembly	300140500
Sliding gate sub assy	300140600
Rod	300140153
Gate plate	300140155
Shaft	300140117
Bottom casing	300140147
Bottom end covèr	300140149

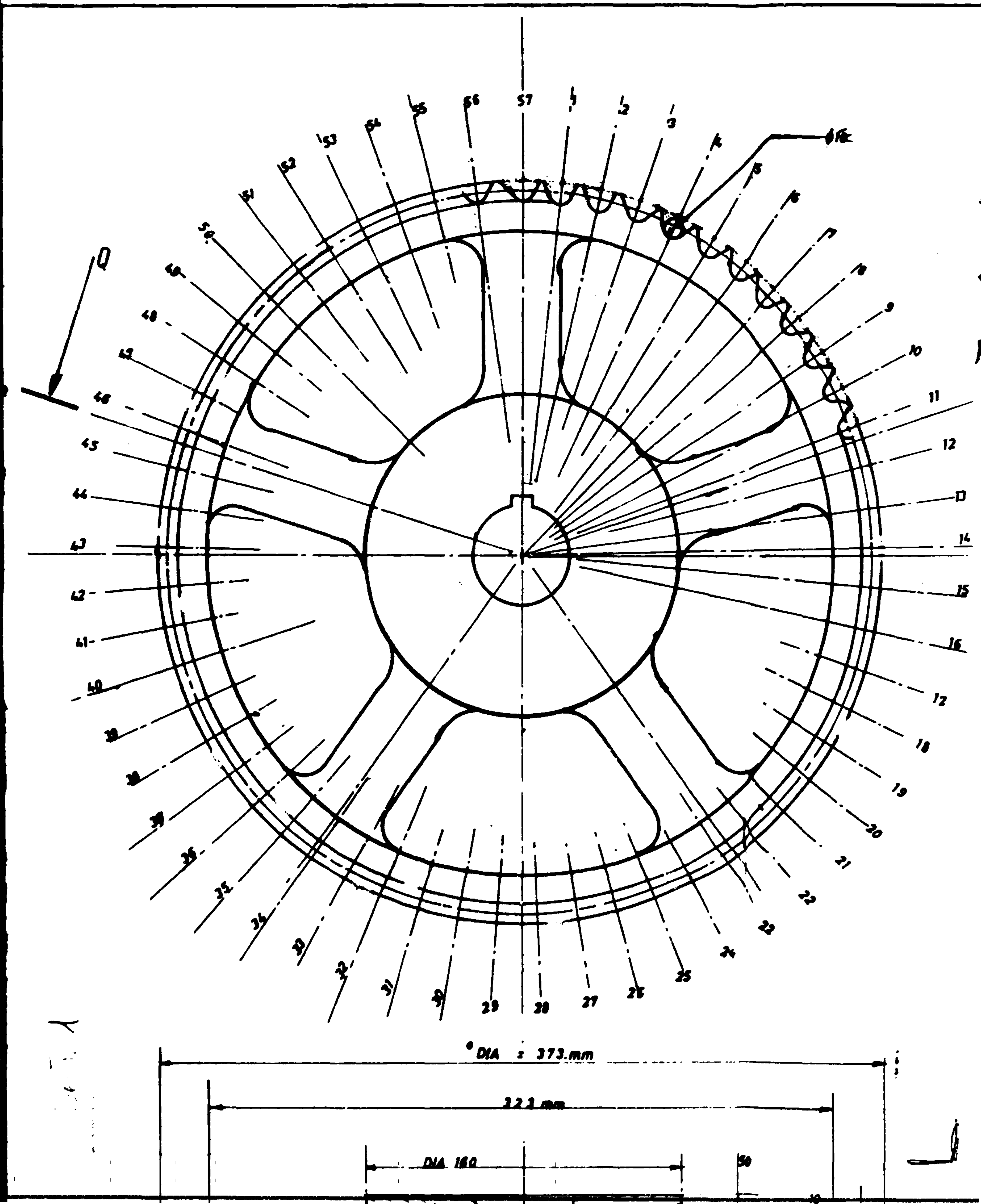
ANNEX E-4

GARI-FRYER (DETAILED)

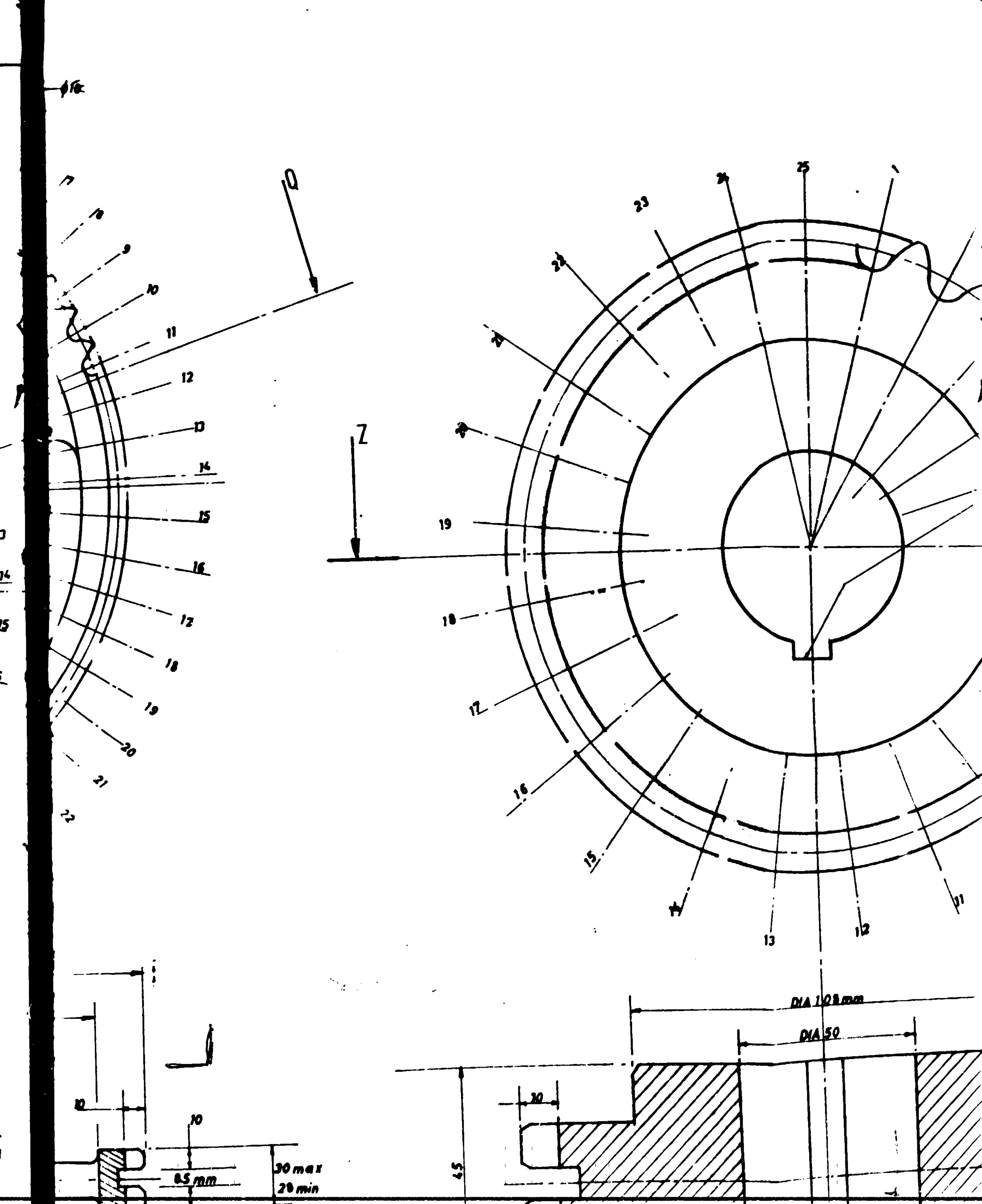
TITLE	DRAWING NO.
General assembly	1896/89-2
Drive and driven sprocket detail	5-1896/89-2
Gari paddle and arm sub assembly	2-1896/89-2
Drum support	300140143
Aluminium rust protector	300140121
Feeder gate	300140144
Gate control disc	300140111
Lifting handle	300140109
Bolting log	300140105
Top half casing	300140129
Paddle plate	300140138

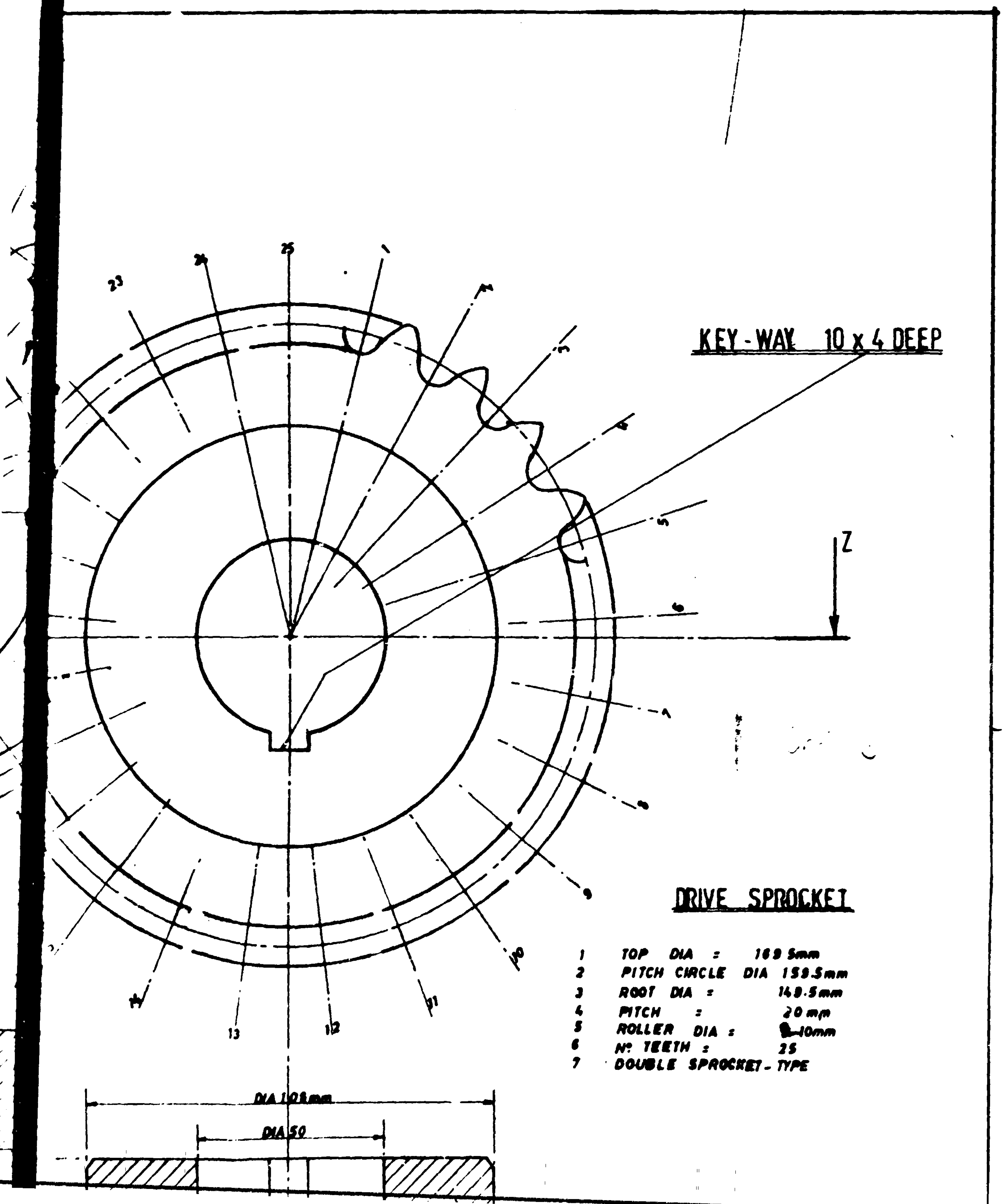
Top drum re-inforcement	300140128
Plate	300140134
	300140148
	300140130
	300140133
Paddle arrangement	300140300
Gari fryer	300140100
Paddle arm	2B-1896/89-2
Housing support	3-1896/89-2
Housing side cover	1B/C-1896/89-2
Housing sub assembly	1-1896-89-2
Shaft detail	2A-1896-89-3
Housing detail	1A-1896-89-3
Charcoal trolley to fryer	4-1896-89-3
Back cover supports	3C-1896-89-3
Supporting frame parts	3A-1896-89-3
Sides cover detail	3E-1896-89-3
Front cover and development	3B-1896-89-3
Cover detail	E-1896-89-2

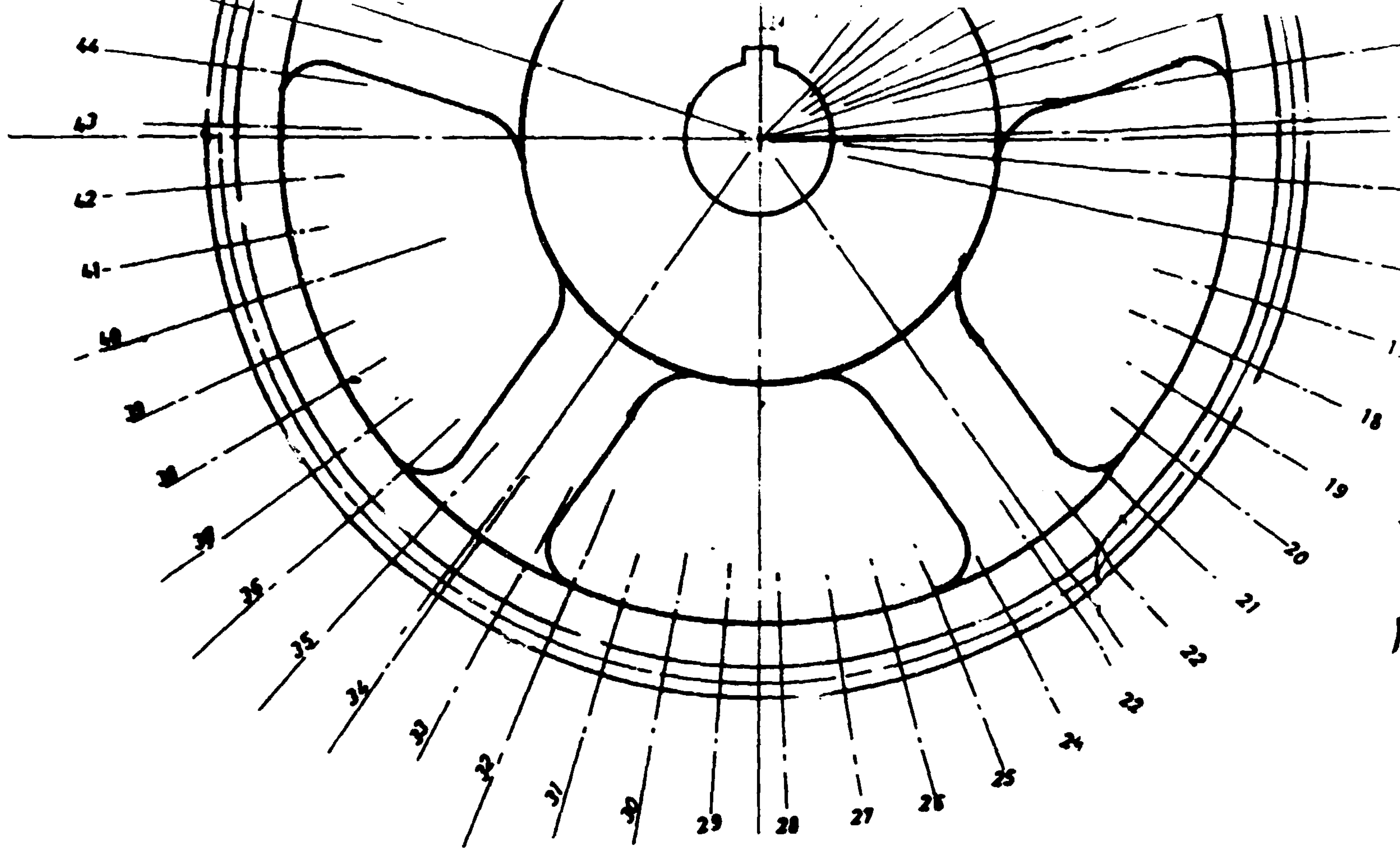
DESCRIPTION	DRAWING NO.
FIIRO/UNIDO Gari fryer	300140100
Main Assembly	030013000
Main "	300210000
Main "	300110000

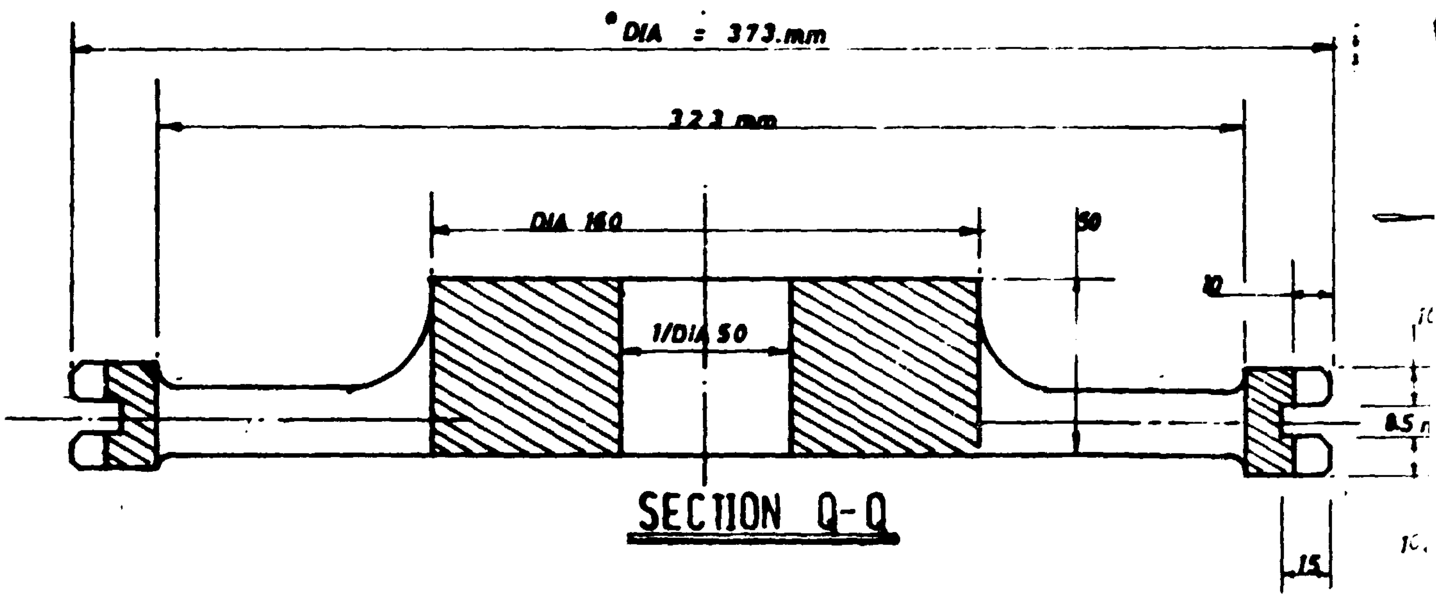


Q
DIA : 373.mm
323 mm
DIA 160


Q
Z
DIA 108 mm
DIA 50
30 max
20 min
8.5 mm
45
10
20


KEY-WAY 10 x 4 DEEP
Z
DRIVE SPROCKET
1 TOP DIA : 169 5mm
2 PITCH CIRCLE DIA 159.5mm
3 ROOT DIA : 149.5mm
4 PITCH : 20 mm
5 ROLLER DIA : 10mm
6 Nº TEETH : 25
7 DOUBLE SPROCKET - TYPE
DIA 109mm
DIA 50



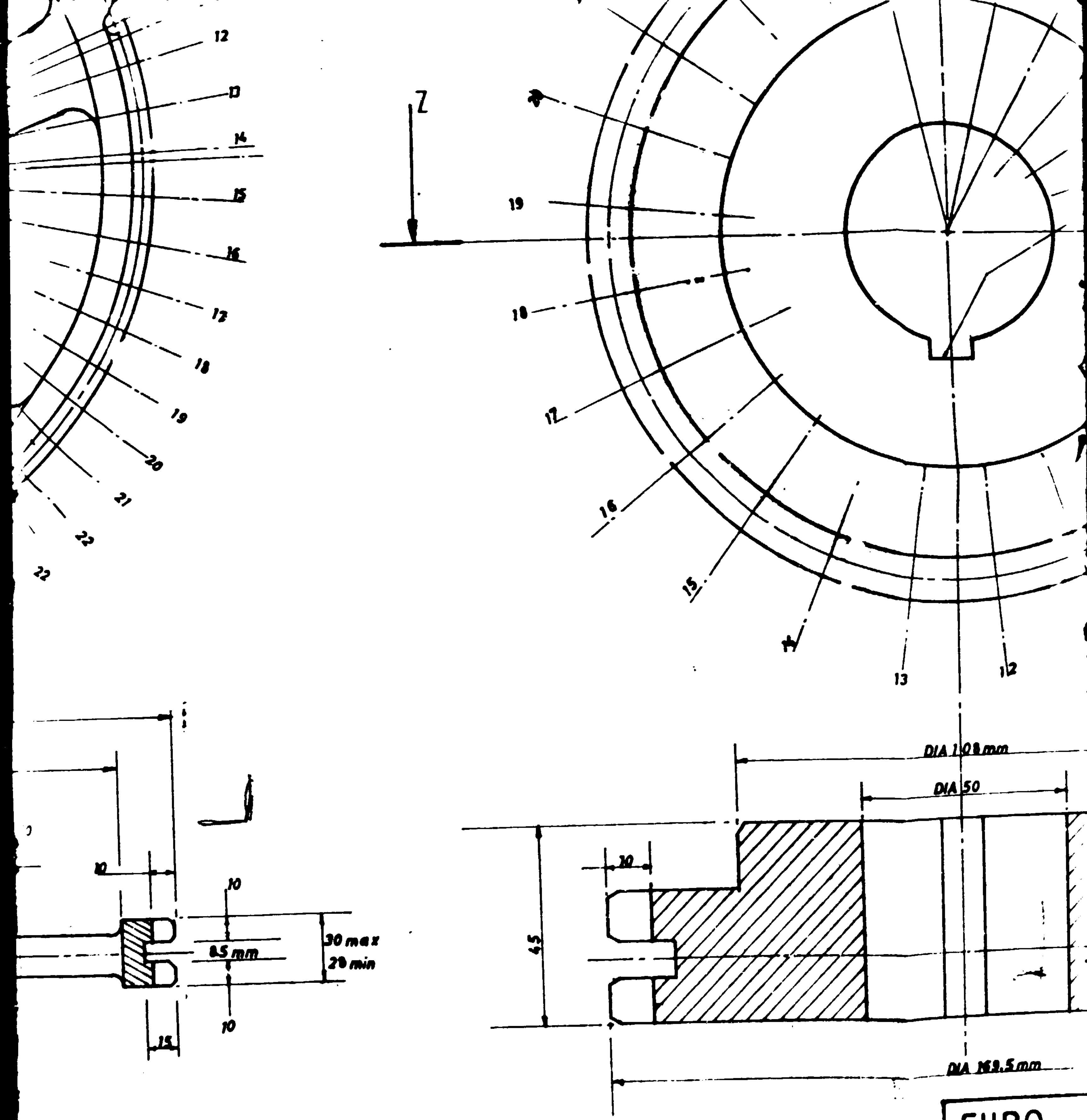


SECTION Q-Q

FRYER MAIN SHAFT SPROCKET

1 PITCH CIRCLE DIA METER : 363mm
2 ROOT - DIA : 353mm
3 TOP DIA : 373 mm
4 TOOTH HEIGHT : 10mm
5 DOUBLE - SPROCKET OR TWIN SPROCKET TYPE.

SECT 4

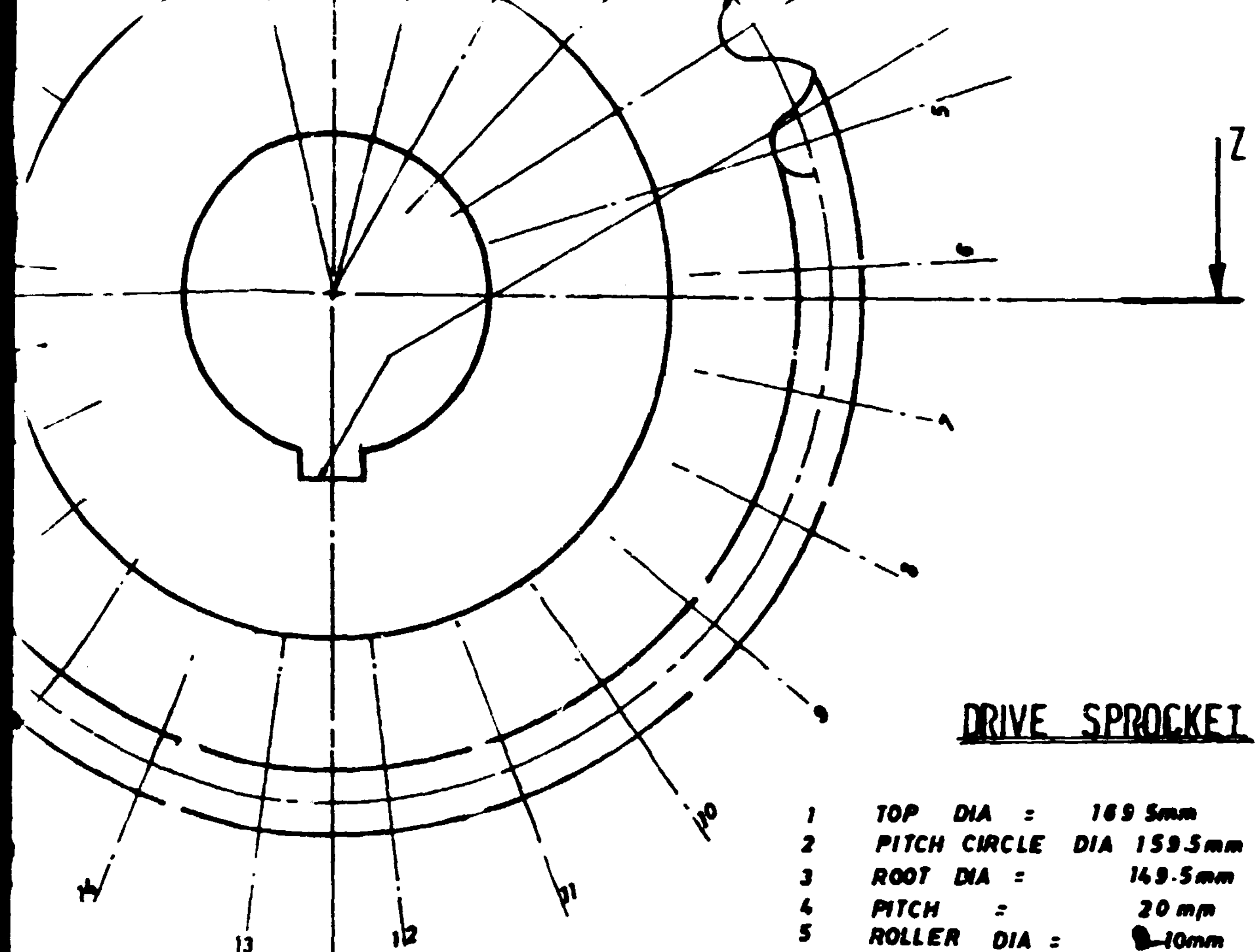


FIIRO.

MIL:

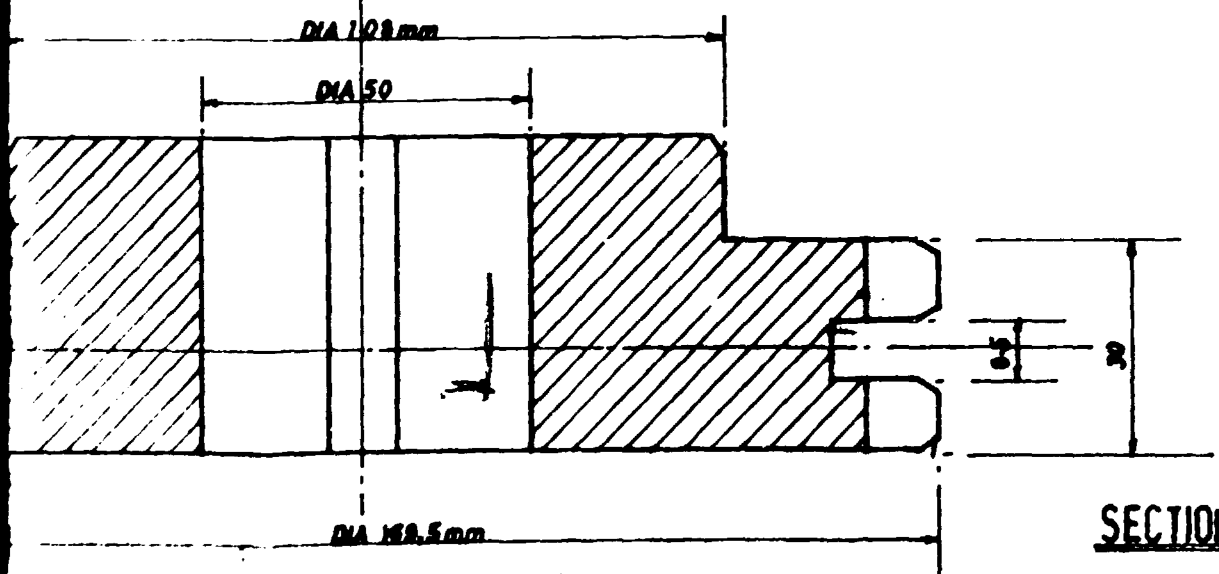
STOCK SIZE

TITLE UNIDO
DRIVE & D



DRIVE SPROCKET

1. TOP DIA : 169.5mm
2. PITCH CIRCLE DIA 159.5mm
3. ROOT DIA : 149.5mm
4. PITCH : 20 mm
5. ROLLER DIA : 9-10mm
6. Nº TEETH : 25
7. DOUBLE SPROCKET - TYPE

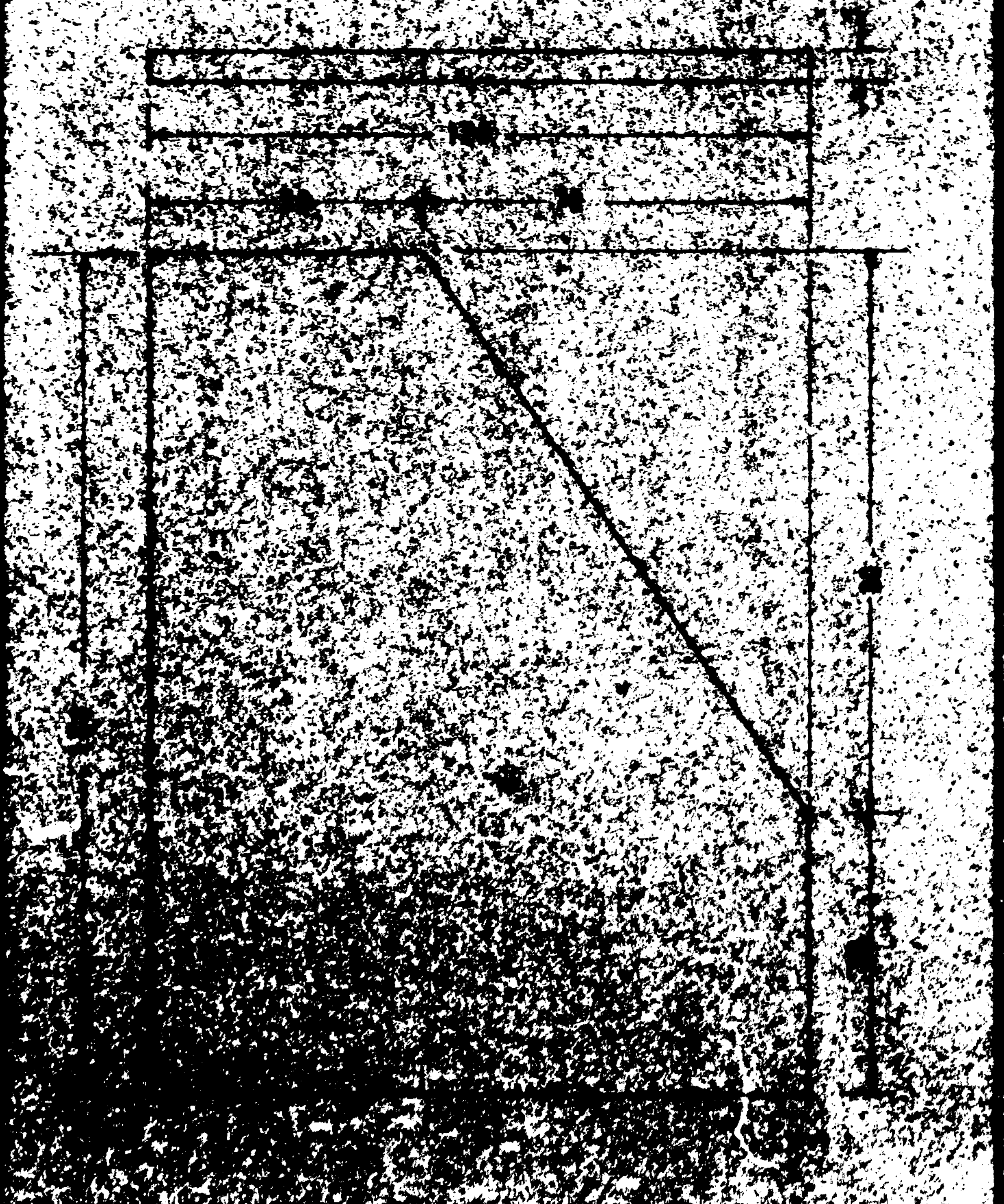


SECTION Z-Z

FIIRO.	FEDERAL INSTITUTE OF INDUSTRIAL RESEARCH OSHODI. P. M. B. 21023 IKEJA. OSHODI. LAGOS.			
MTL:	SCALE	1:1 & 1:2	DESIGNED	FIIRO
	DATE	21 6 89	DRAWN	[illegible]
	QTY	1 EACH	TRACED	[illegible]
STOCK SIZE	REPLACES DRG [illegible]		CHECKED	
			APPROVED	
TITLE UNIDO/FIIRO GARI FRYER DRIVE & DRIVEN SPROCKET DETAIL			5-1896/89-2	

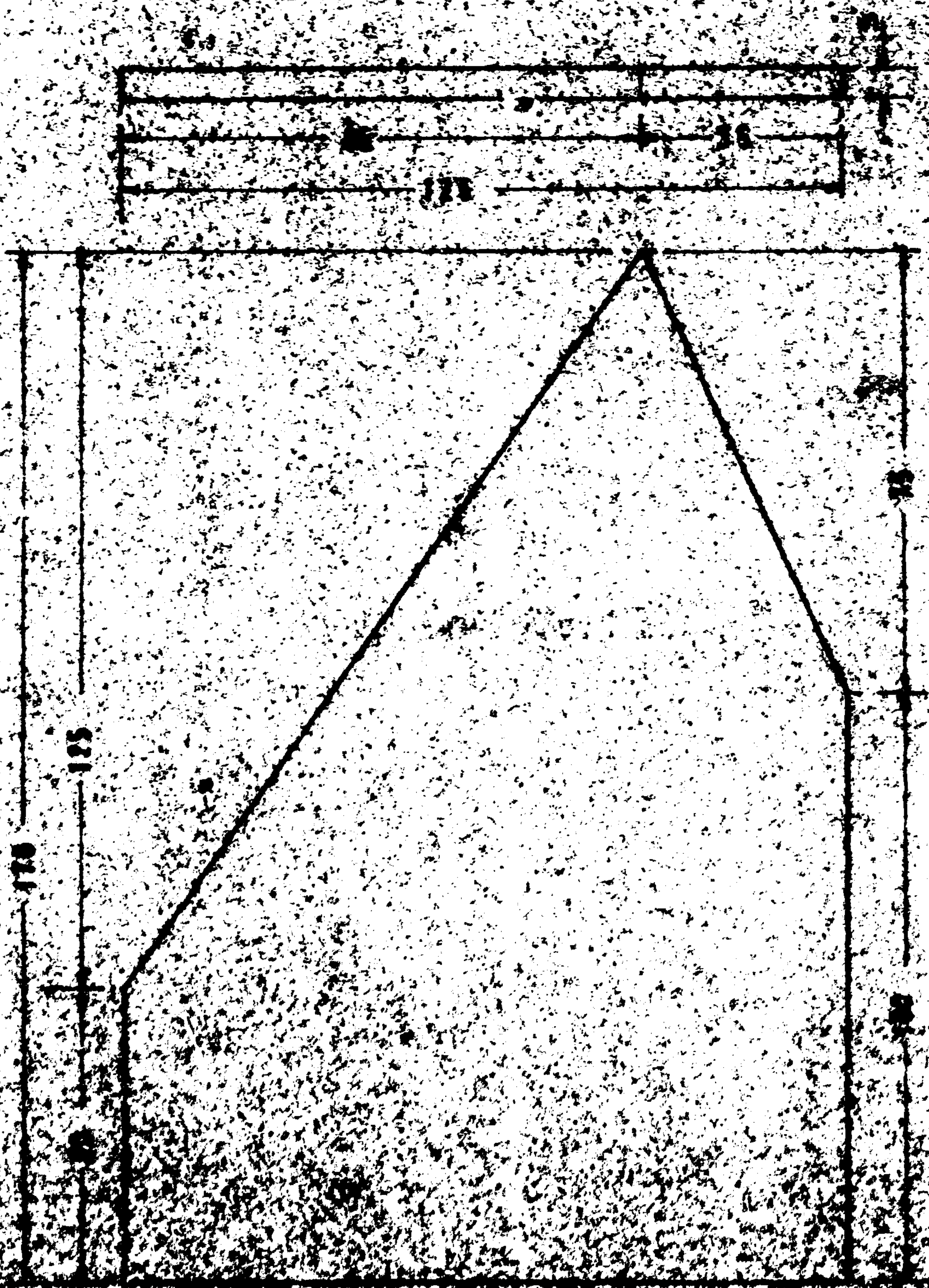
SET 6

ARCEDEM	PROJ REF FIIRO UNIDO GARI SIEVING MACHINE	
SCALE 1:1	TITLE [illegible]	SHEET NO 2
DATE	DWG NO [illegible]	NO OF SHEETS



	DESCRIPTION	QTY	MAT'L

ARCEDEM	PROJ REF E1188 UNIDO GARI SIEVING MACHINE	
SCALE 1:1	TITLE BASE DETAIL	SHEET NO
DATE	DWG NO	NO OF SHEETS



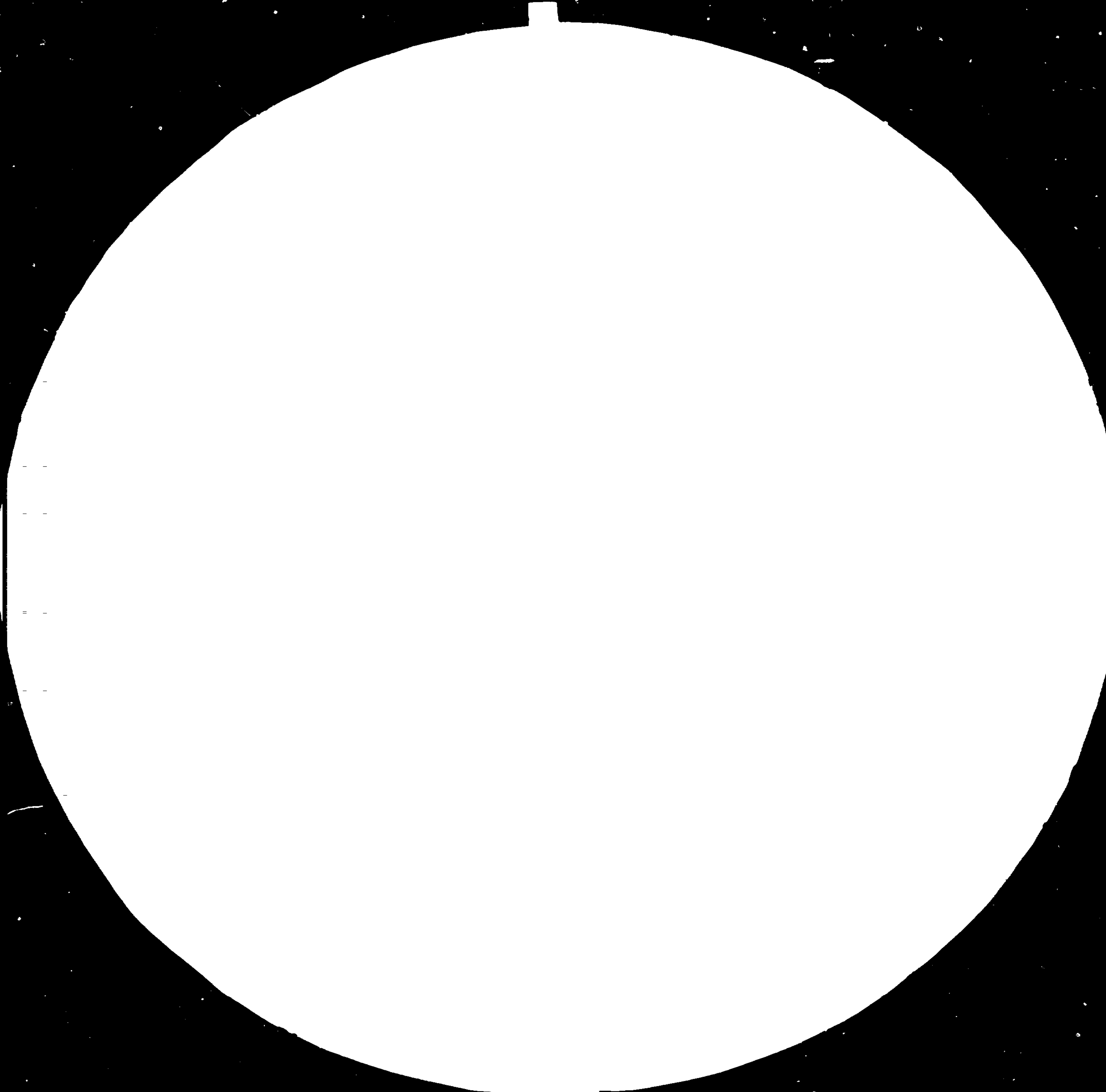
107 R 5 x 125 x 175 L 6 1 MS

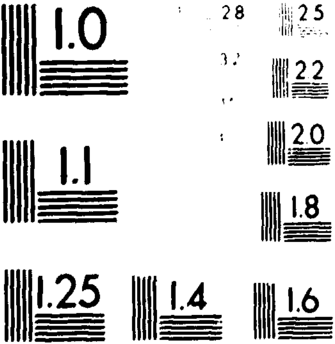
ARCEDEM | [illegible] FIBER WIND [illegible] MACHINE

SCALE 1:1 | [illegible] | SHEET NO 3

DATE | [illegible] | NO [illegible]

91 06 03





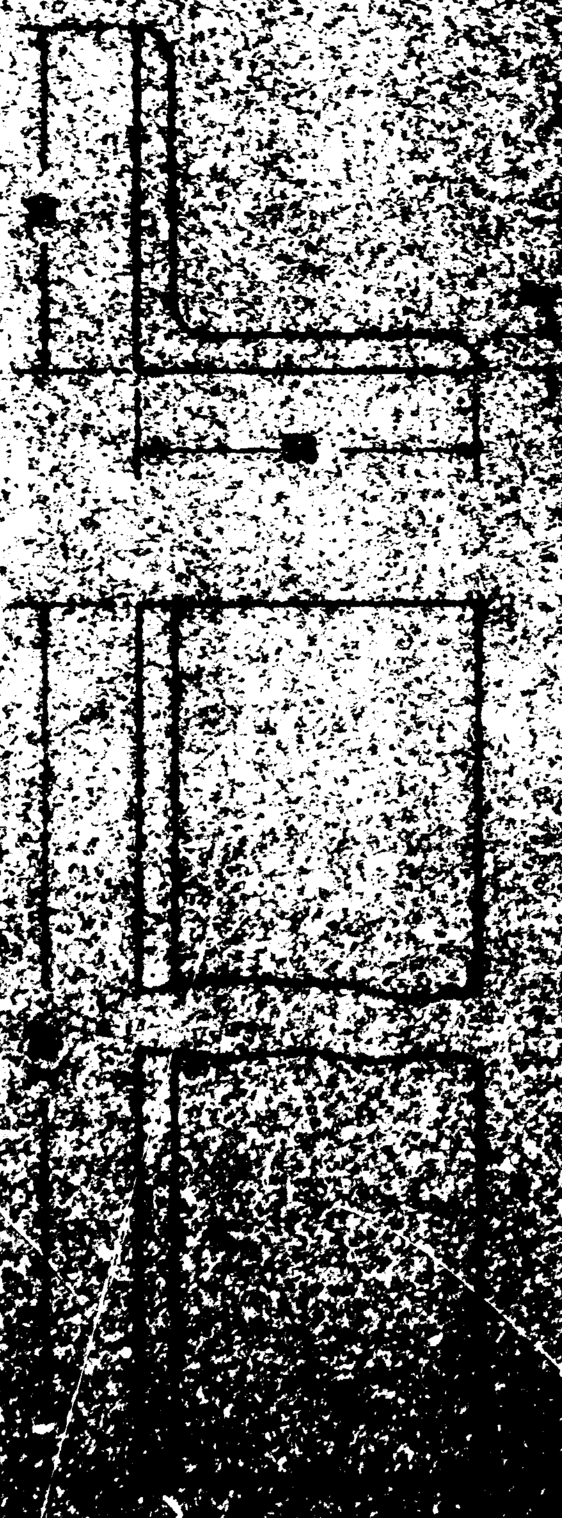
MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

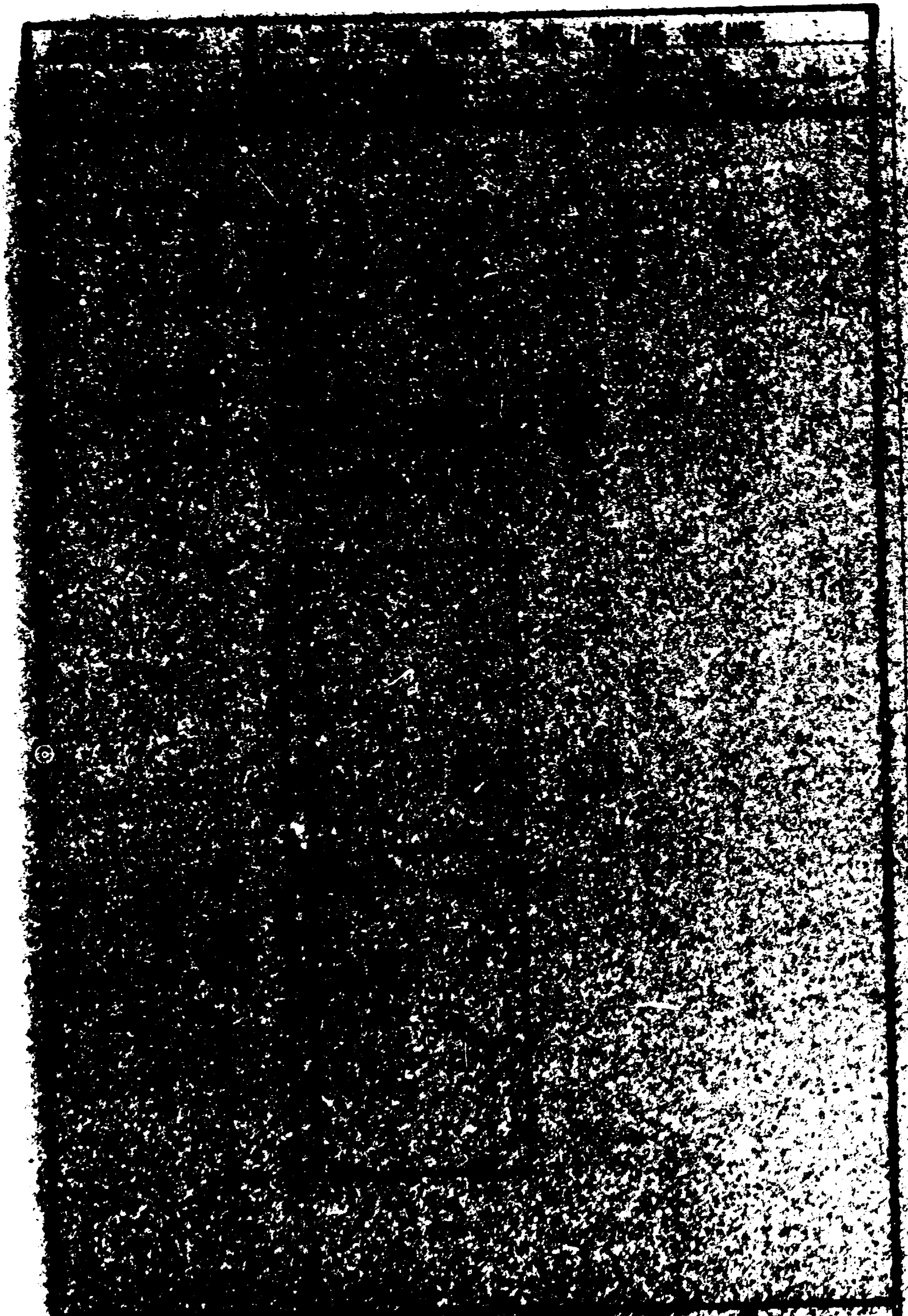
STANDARD REFERENCE MATERIAL 1010a

(ANSI and ISO TEST CHART No. 2)

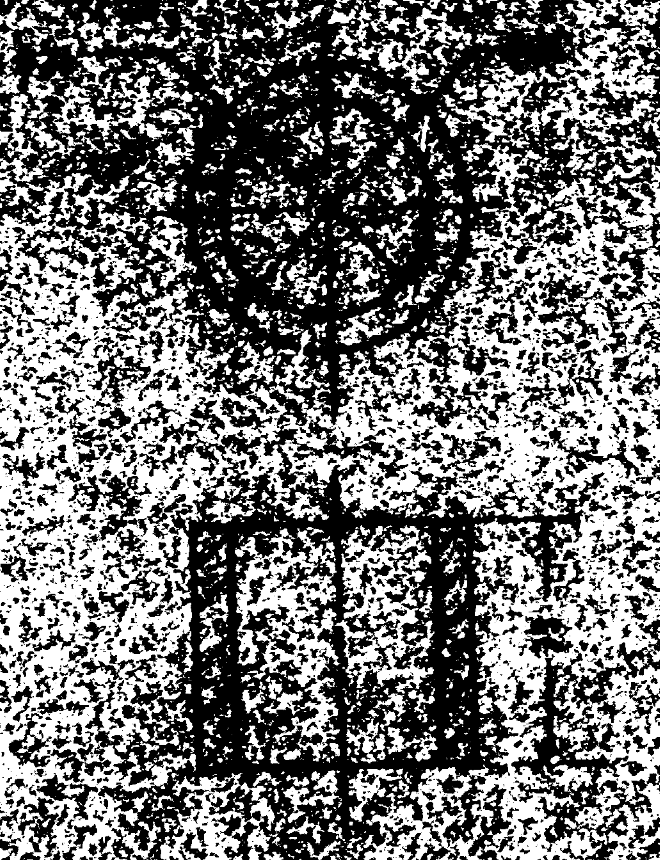
ARCEDEM	[illegible]	
SCALE [illegible]	[illegible]	[illegible]
DATE	[illegible]	[illegible]



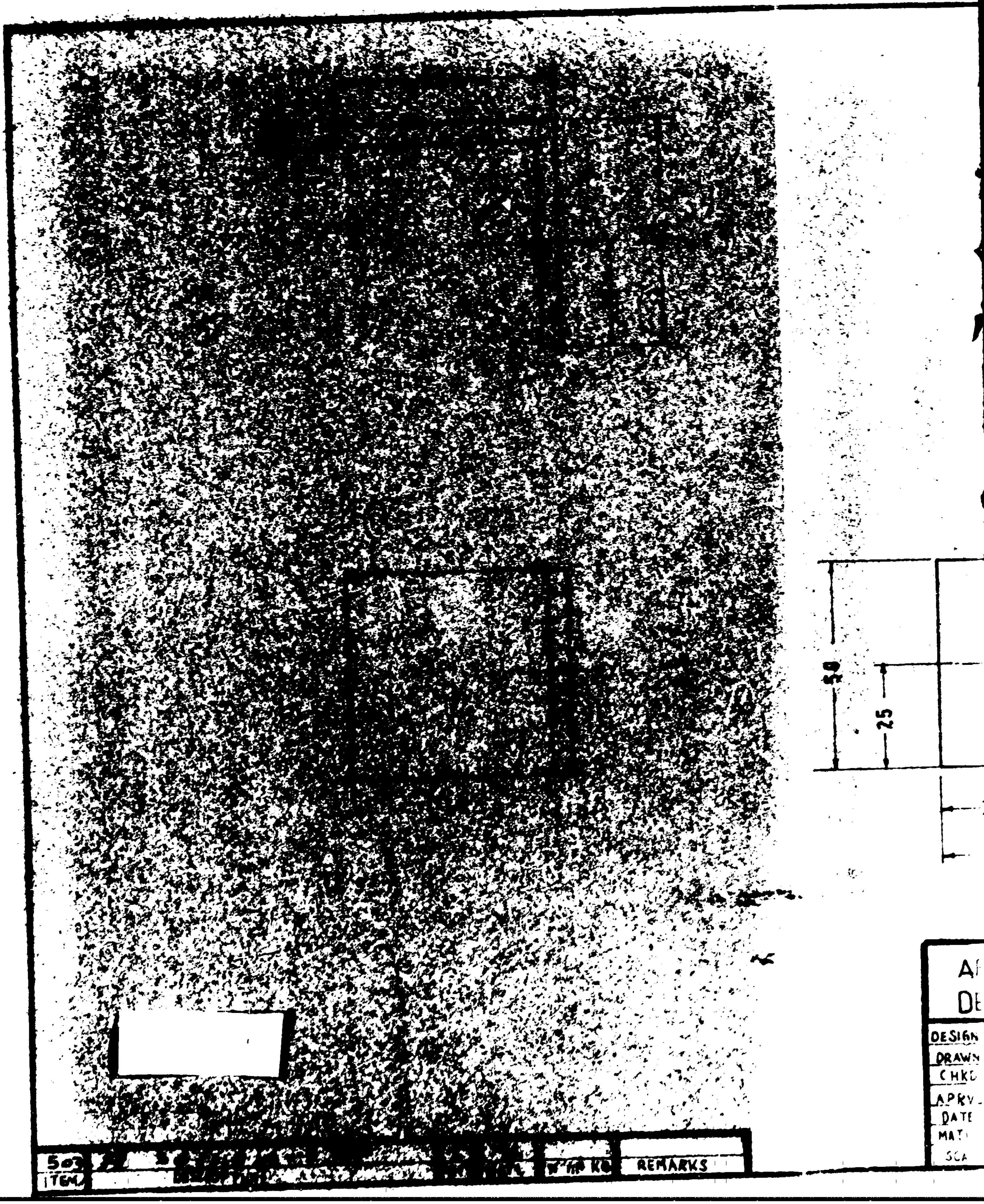
112	ANGLE 50×50×5×270 L[illegible]	1	[illegible]	[illegible]



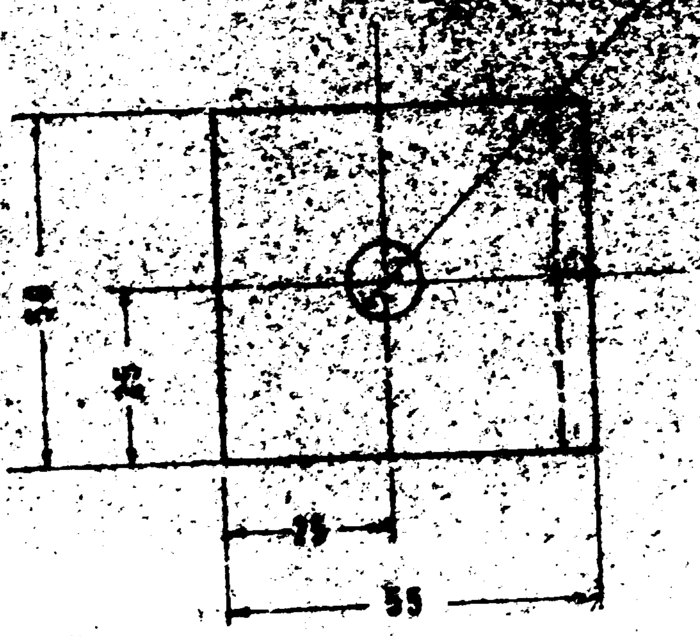
ARCEDEM



ITEM	DESCRIPTION	QTY	MAT'L	WT IN KG	REMARKS
[illegible]	[illegible]	[illegible]	[illegible]		



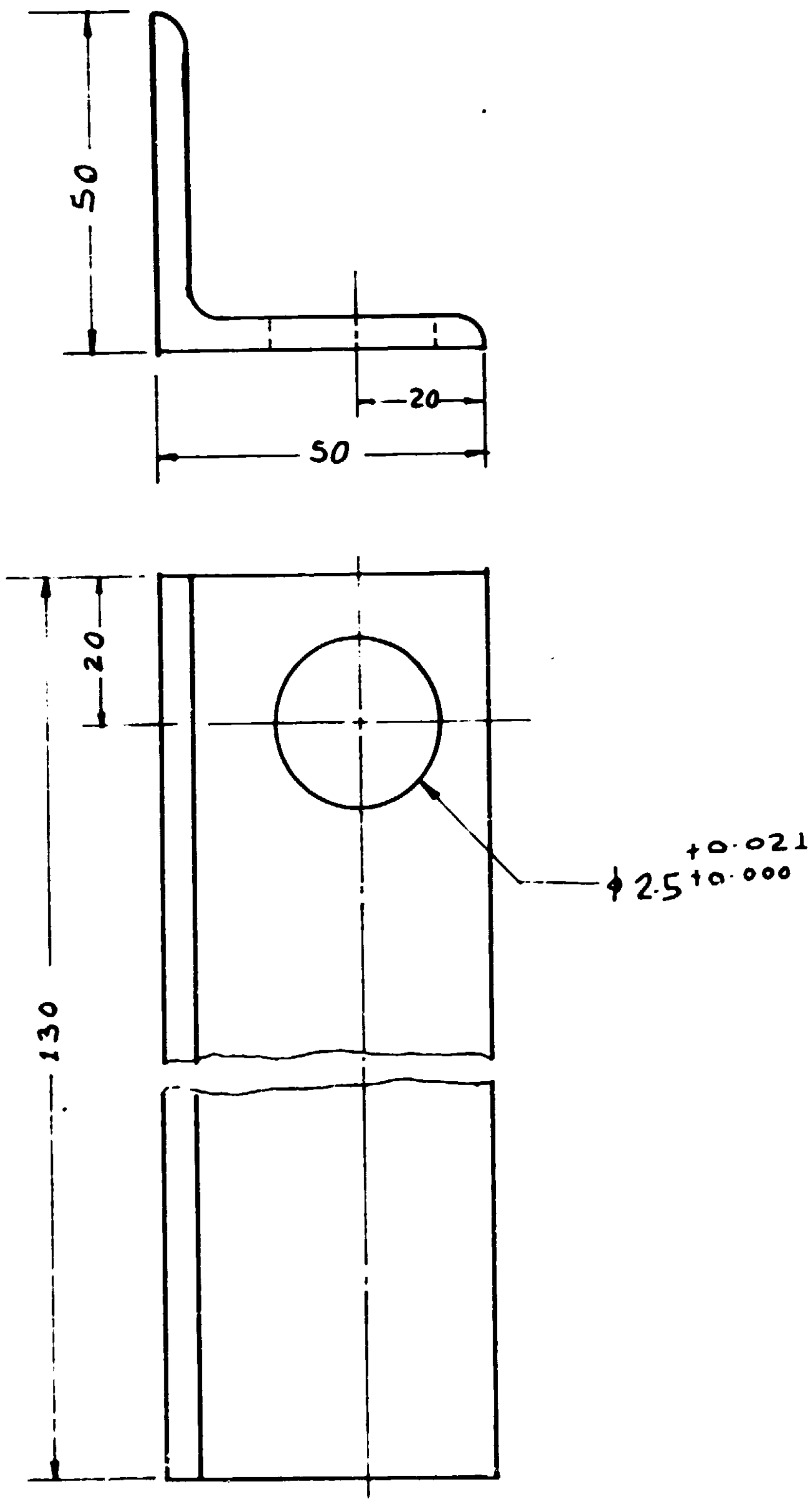
50
25
REMARKS
ITEM
DESIGN
DRAWN
CHKD
APRV
DATE
MAT
SCA



OUT 348

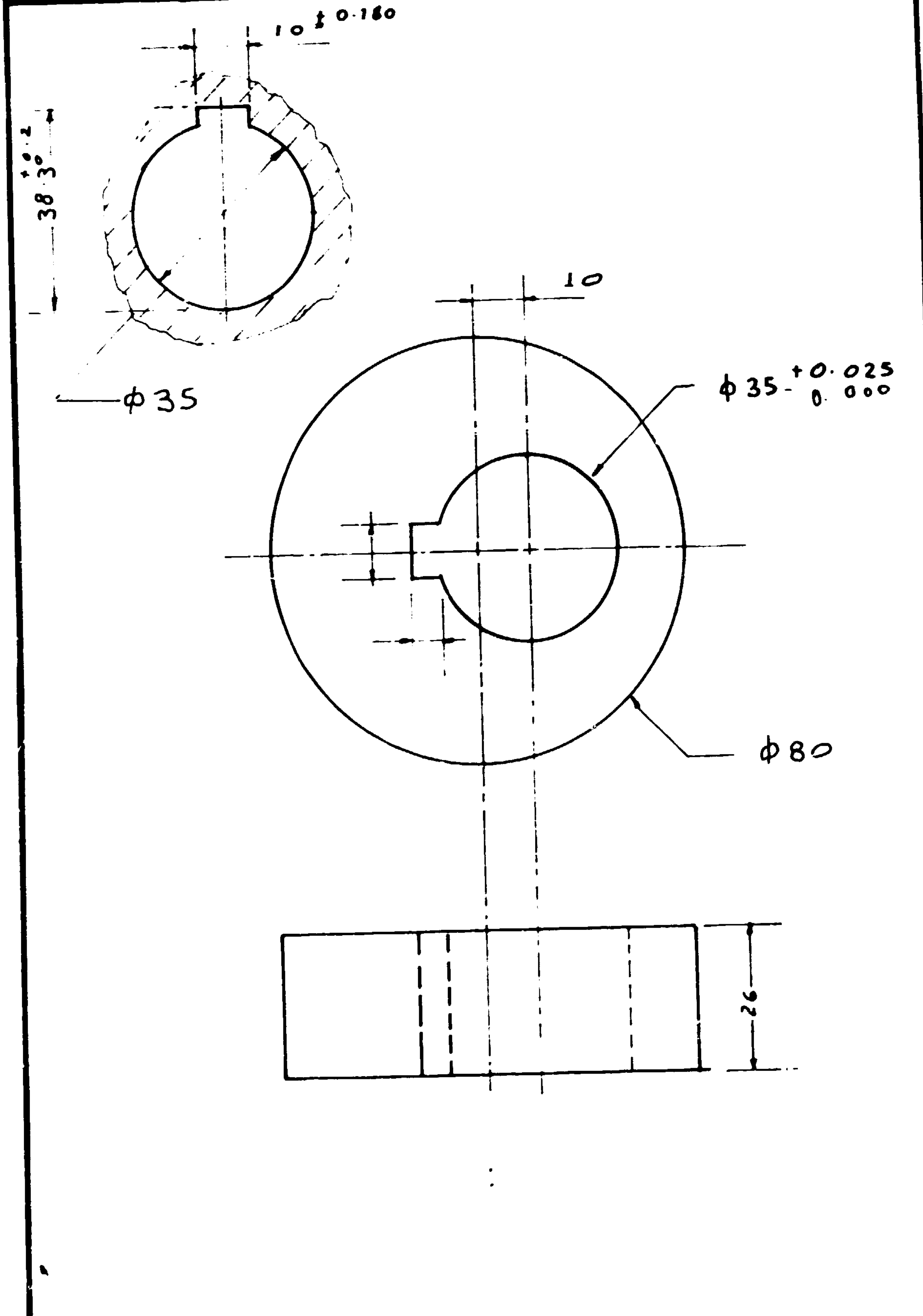
AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)		
DESIGN		TITLE [illegible] MACHINE PART [illegible]
DRAWN	[illegible]	
CHKD		
APRVD		
DATE		
MATL		DRG NO 300110503
SCALE	1 : 1	

ARCEDEM	PROJ REF F11RO/UNIDO GARI SIEVING MC.	
SCALE 1 : 1	TITLE PART DETAIL	SHEET NO 1
DATE AUG 87	DRG NO 300110312	NO OF SHEETS



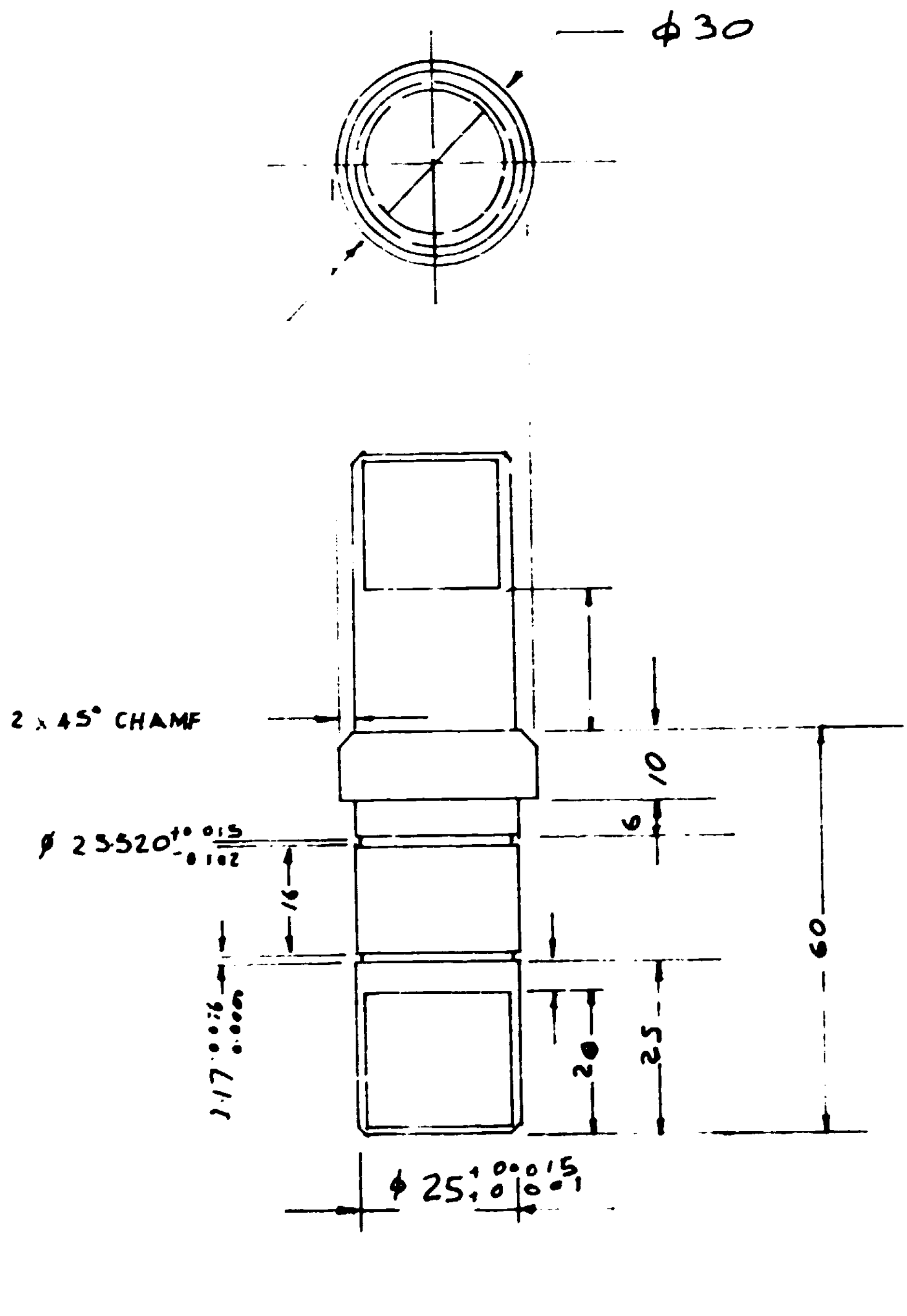
	ANGLE 50 X 50 X 5 X 130 LG	2	M.S		

ARCEDEM	PROJ REF FIIRO / UNIDO GARI SIEVING MS	
SCALE 1 : 1	TITLE PART DET	SHEET NO 2
DATE AUG 87	DRG NO 300110402	NO OF SHEETS



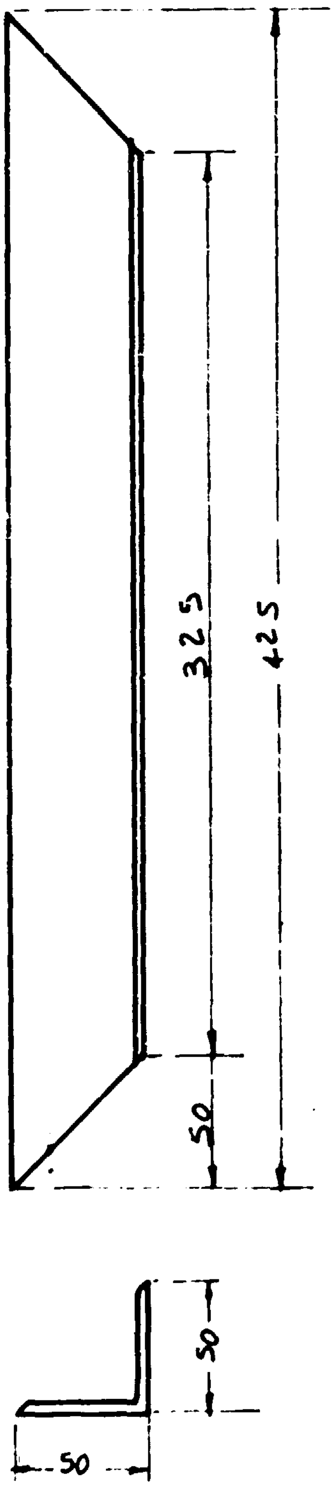
402	ECC CAM ϕ80 × 26	1	EN 8		

ARCEDEM	PROJ REF F I IRO/UNIDO GARI SIEVING MG	
SCALE 1 : 1	TITLE PART DET	SHEET NO 3
DATE AUG 87	DRG NO 300110313	NO OF SHEETS



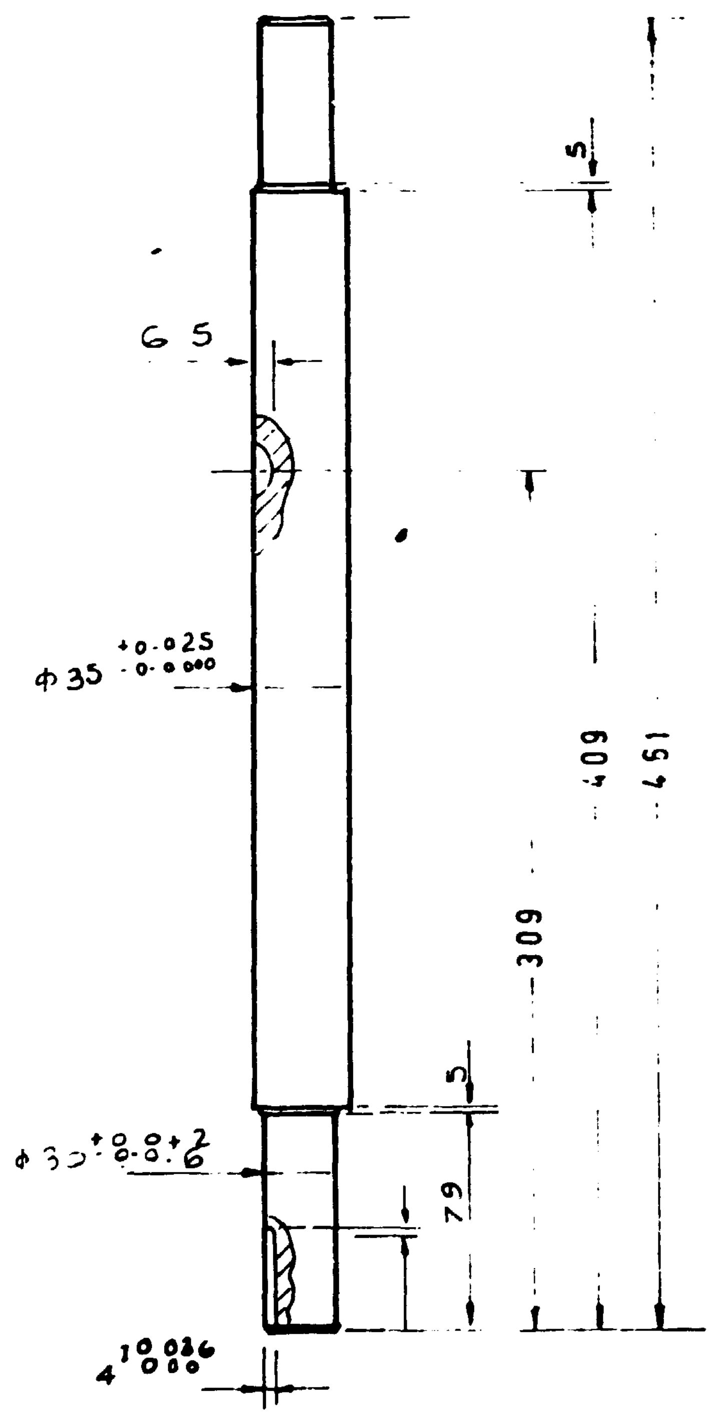
PIN Φ30 × 60 LG	1	M.S	

ARCEDEM	PROJ REF F11 RO/UNIDO GARI SIEVING	
SCALE 1 : 2 : 5	TITLE PART DETAIL	SHEET NO 4
DATE AUG 87	DRG NO 30011 0108	NO OF SHEETS



108	ANGLE 50 × 50 × 9 × 425 16	2	M.S		

ARCEDEM	PROJ REF FIIRO/UNIDO - GARI SIEVING MC.	
SCALE 1:2.5	TITLE PART DETAIL	SHEET NO 5
DATE AUG 87	DRG NO 300110401	NO OF SHEETS

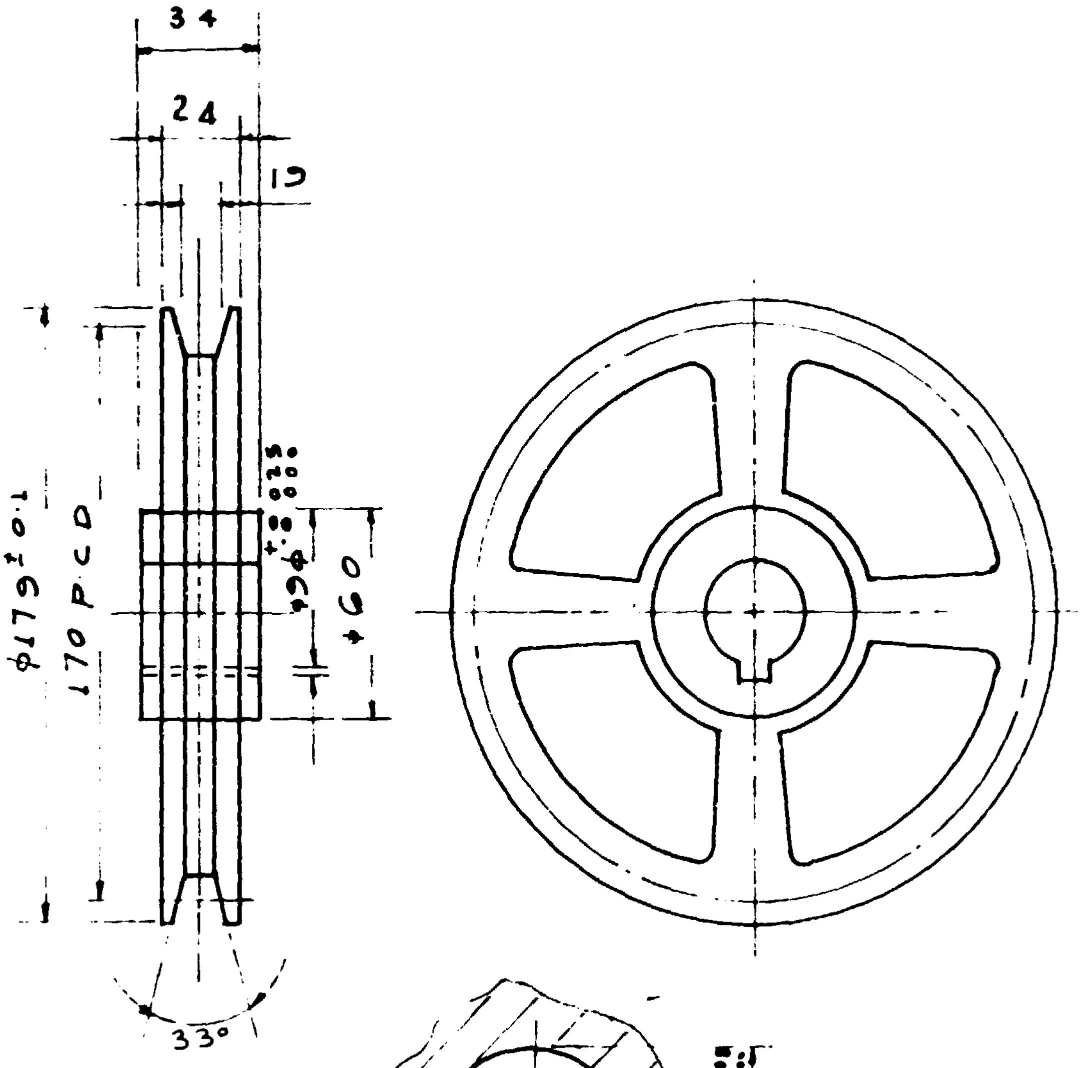


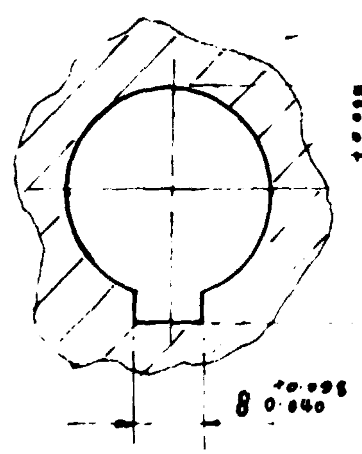
NOTES

1 USE KEY AND CUTTER NO 1210 FOR KEYWAY ON SHAFT (BS 4235 PART 2
DEPTH OF KEY 1 13.89 (0.547")
WIDTH OF KEYWAY 9.5MM

401	SHAFT Φ35 x 461 LG	1	ENG		
ITEM	DESCRIPTION	QTY	MATL	WT IN KG	REMARKS

ARCEDEM	PROJ REF FIIRO./ UNIDO. GARI PROJ	
SCALE 1 : 2	TITLE PART DET	SHEET NO 6
DATE AUG 87	DRG NO 300110403	NO OF SHEETS



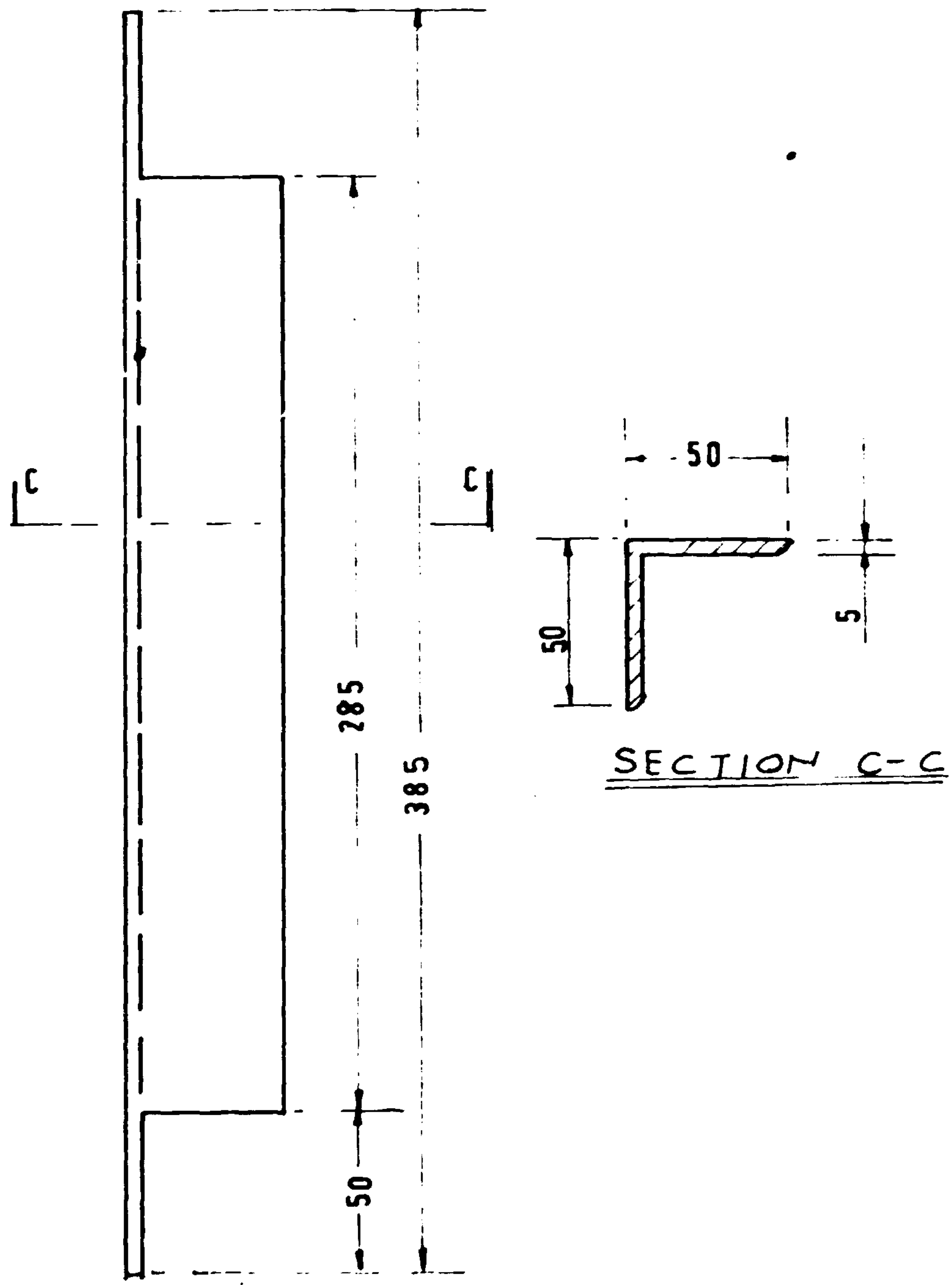


NOTE USE PARALLEL KEY BS 4238 PART 1

DETAIL OF KEYWAY

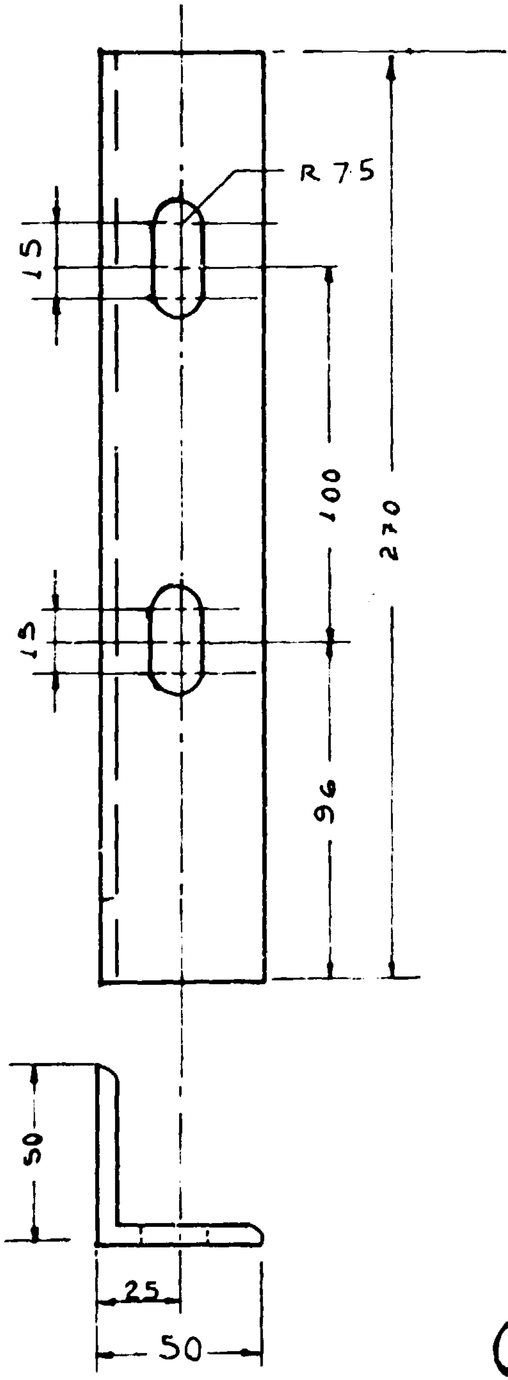
403 ITEM	PULLEY ϕ179 x 24 THK DESCRIPTION	1 QTY	N5 MAT'L	WT IN KG	REMARKS

ARCEDEM	PROJ REF FIIRO/UNIDO GARI PROJ	
SCALE 1 : 2	TITLE PART DET	SHEET NO 7
DATE AUG 87	DRG NO 300110109	NO OF SHEETS



109	ANGLE 50x50x5x385 LG	1	M.S		
ITEM	DESCRIPTION	QTY	MATL	WT IN KG	REMARKS

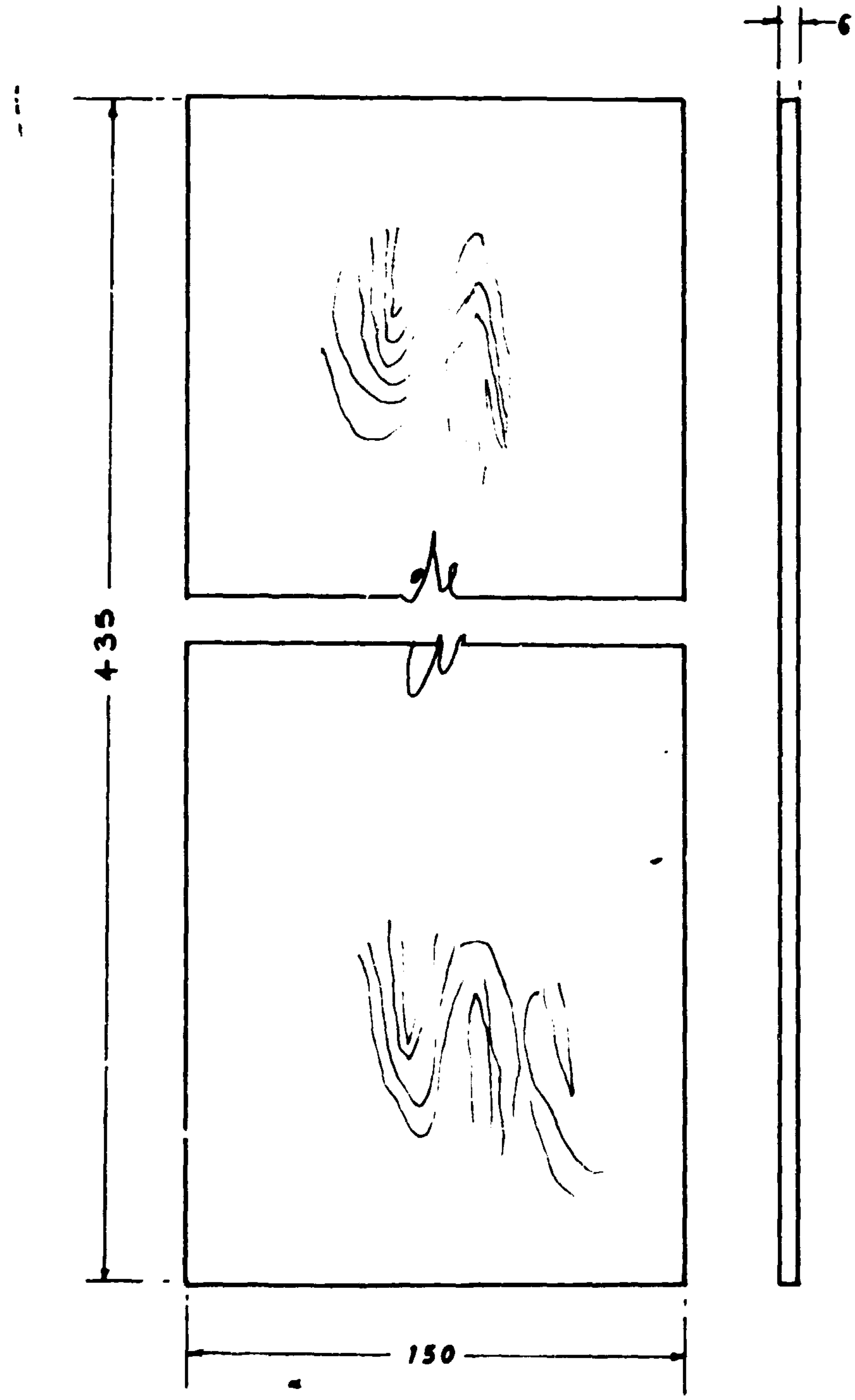
ARCEDEM	PROJ REF FIIRO/UNIDO GARI PROJECT		
SCALE 1 : 2	TITLE PART DETAIL	SHEET NO 8	
DATE AUG 87	DRG NO 300110110	NO OF SHEETS	



OUT 349

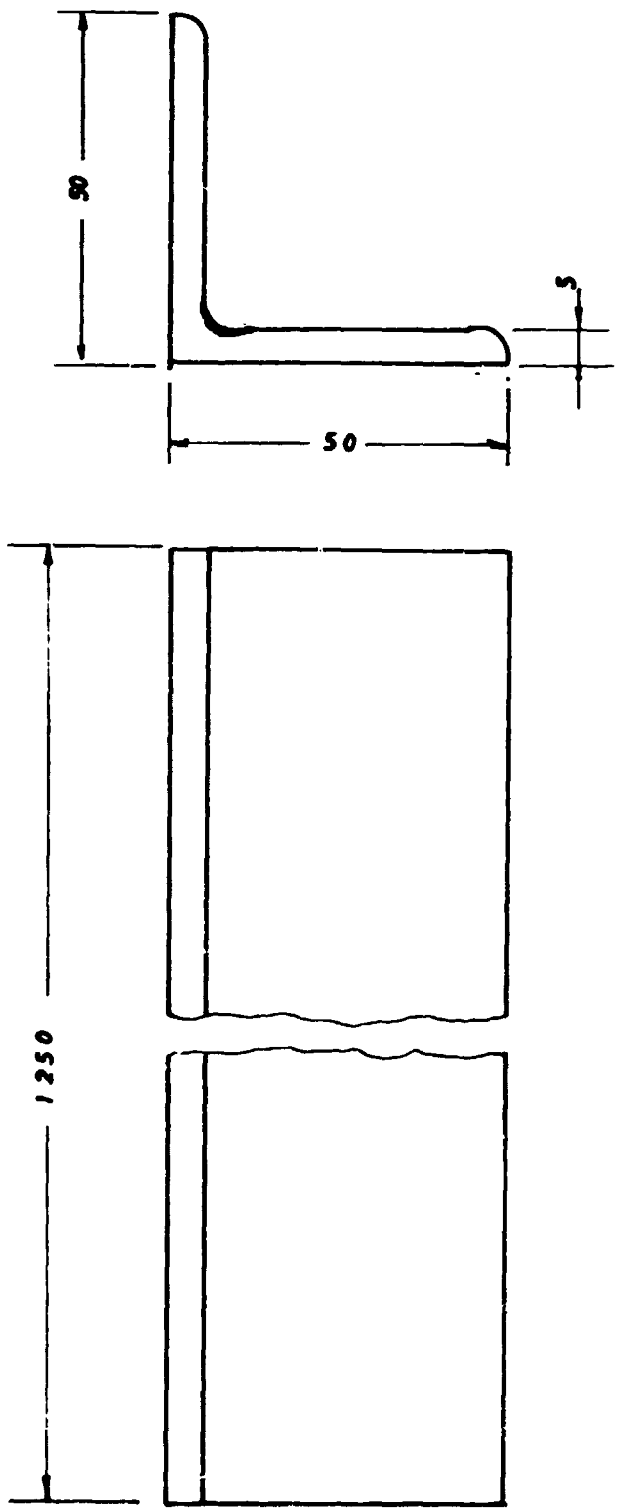
110	ANGLE 50x50x5x 270 LG	2	M.S		
ITEM	DESCRIPTION	QTY.	MATL	WT N KG	REMARKS

ARCEDEM	PROJ REF FIIRO / UNIDO GARI SIEVING MACHINE	
SCALE 1 : 2	TITLE PART DETAIL	SHEET NO 1
DATE AUG 1987	DRG NO 380110303	NO OF SHEETS



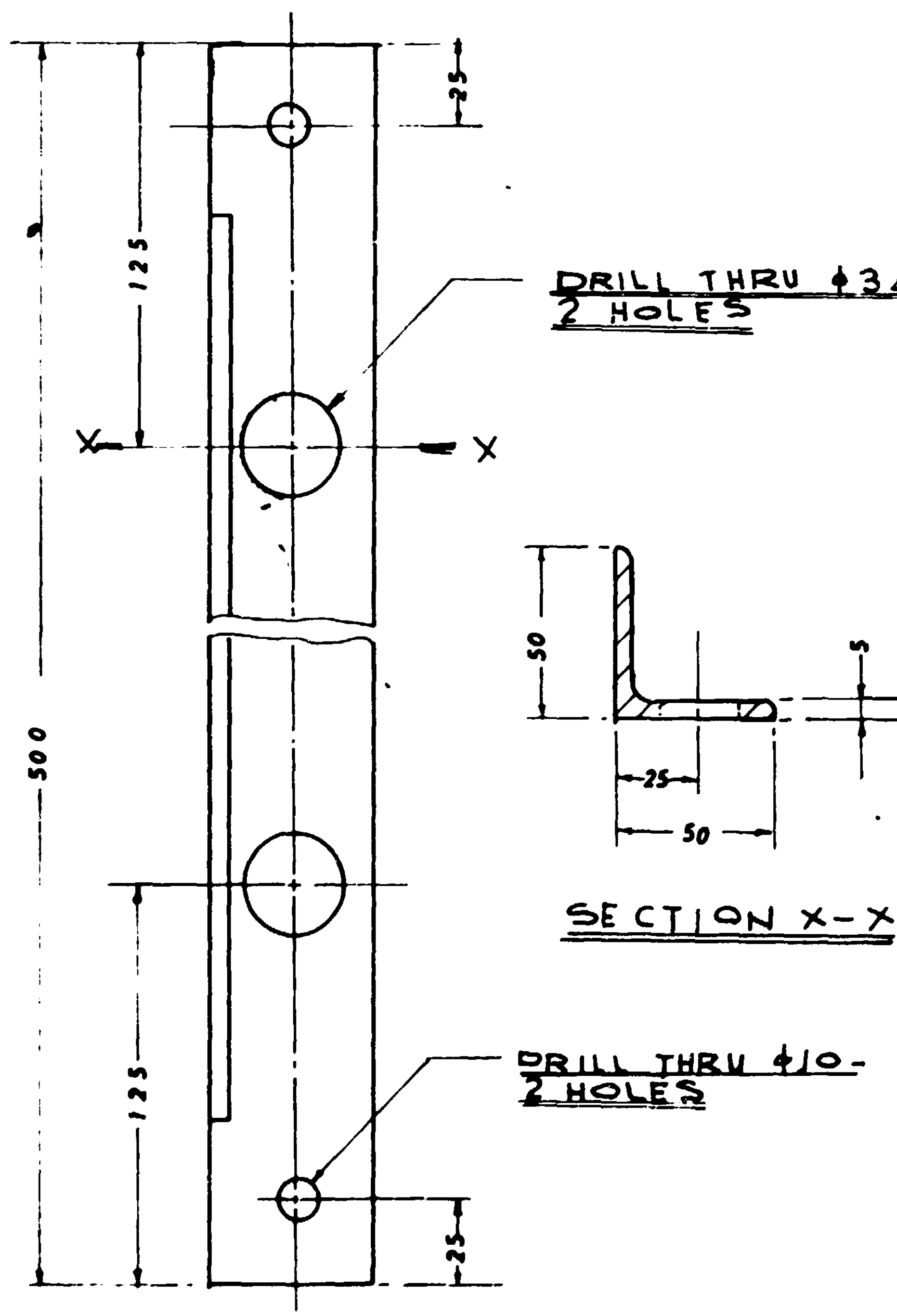
303	PLYWOOD 50150 × 435 × 6 THK	2	WOOD		

ARCEDEM	PROJ REF FIIRO/UNIDO GARI SIEVING MACHI...	
SCALE 1 : 1	TITLE PART DETAIL	SHEET NO 2
DATE AUG 1987	DRG NO 330110102	NO OF SHEETS



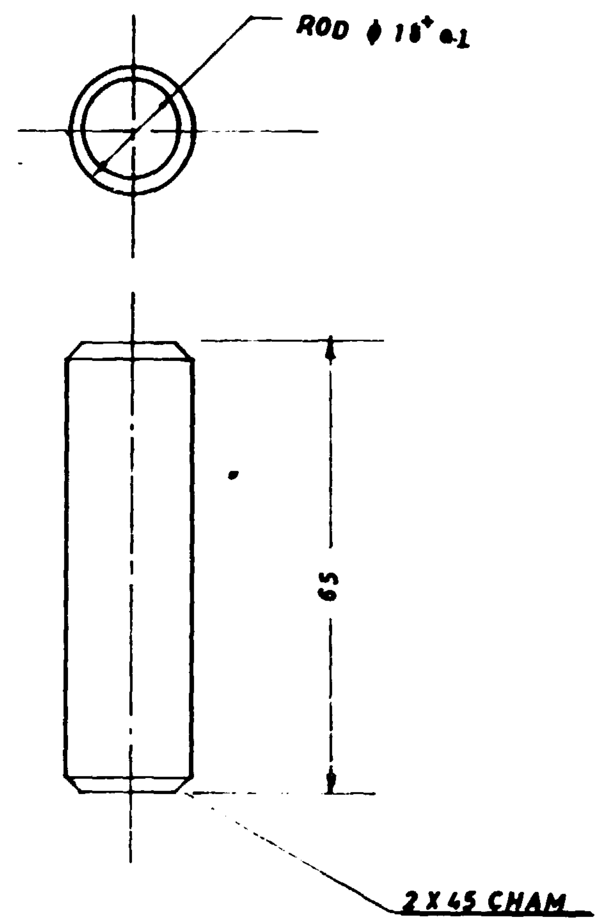
102	ANGLE 50 x 50 x 5 x 1250 LG	2	M.S	
ITEM		QTY	MATL	WT IN KG

ARCEDEM	PROJ REF FIIRO/UNIDO GARI SIEVING MACHINE	
SCALE 1 2	TITLE PART DETAIL	SHEET NO 3
DATE AUG 1987	DRG NO 300110104	NO OF SHEETS



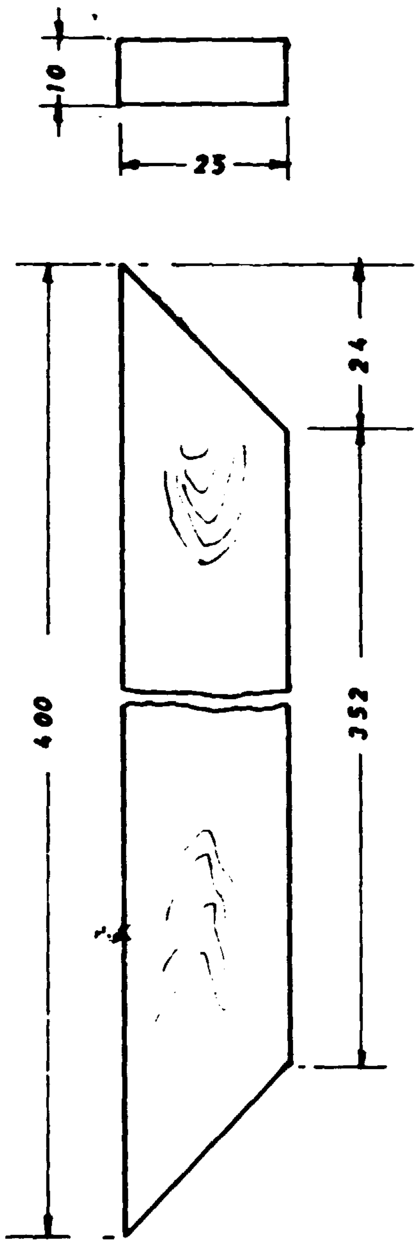
104	ANGLE 50 x 50 x 5 x 500 LG	2	MS		
		QTY	MATL	WT IN KG	REMARKS

ARCEDEM	PROJ REF FIIRO / UNIDO GARI SIEVING MACHINE	
SCALE 1 : 1	TITLE PART DETAIL	SHEET NO 4
DATE AUG 1987	DRG NO 300110301	NO OF SHEETS



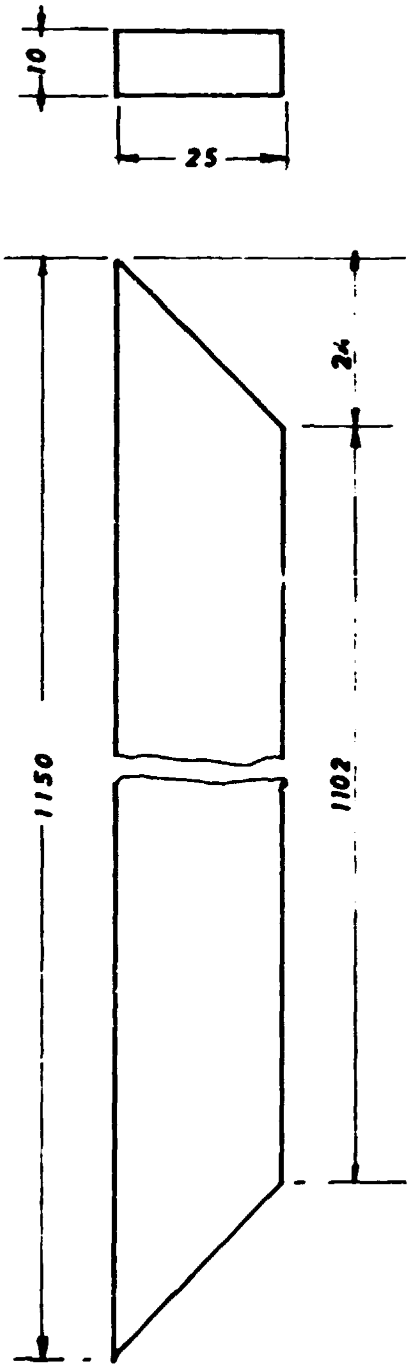
301	ROD ϕ 18 × 65 LG	4	M.S	

ARCEDEM	PROJ REF FIIRO/UNIDO GARI SIEVING MACHINE	
SCALE 1 1	TITLE PART DETAIL	SHEET NO 5
DATE AUG 1987	DRG NO 300110307	NO OF SHEETS



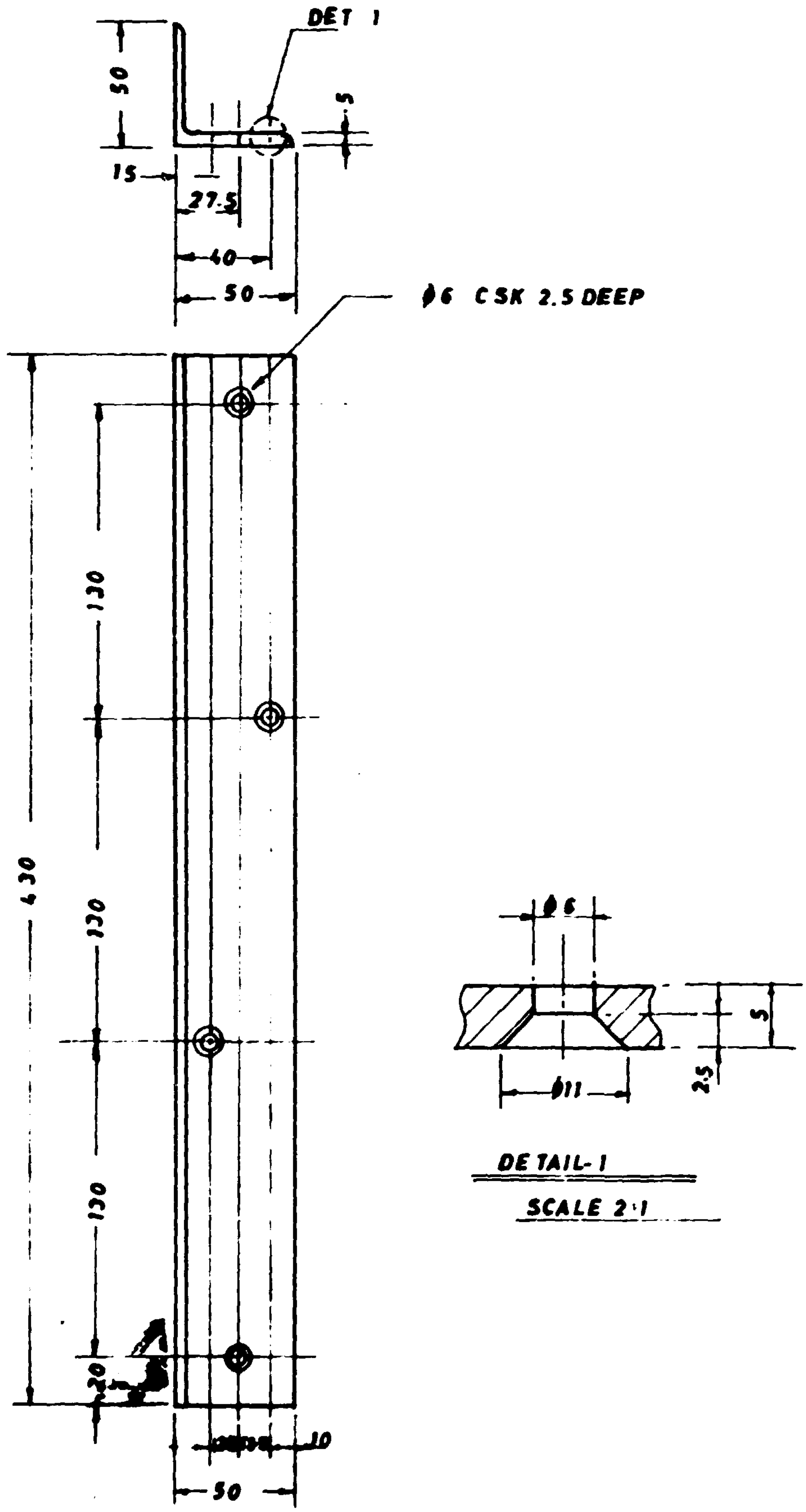
307	PLYWOOD BP 25 x 400 x 10 THK	4	WOOD		
ITEM	DESCRIPTION	QTY	MATL	WT IN KG	REMARKS

ARCEDEM	PROJ REF FIIRO./ UNIDO GARI SIEVING MACHINE	
SCALE 1 : 1	TITLE PART DETAIL	SHEET No 6
DATE AUG 1989	DRG No 300110306	NO OF SHEETS



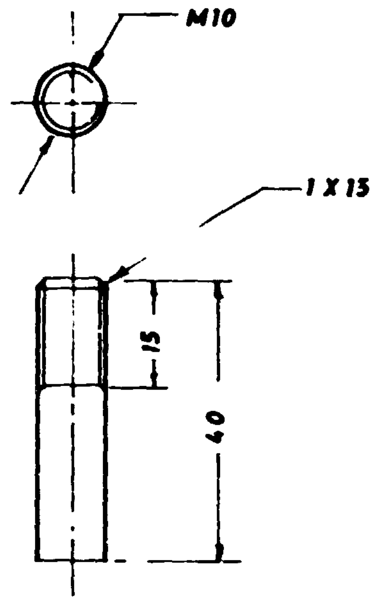
ITEM	DESCRIPTION	QTY	MATL	WT IN KG	REMARKS
306	PLYWOOD BP 25 × 1150 × 10THK	4	WOOD		

ARCEDEM	PROJ. REF. FIIRO. / UNIDO. GARI SIEVING MACHINE	
SCALE 1 : 2.5	TITLE PART DETAIL	SHEET NO 7
DATE AUG 1987	DRG No 300110302	NO OF SHEETS



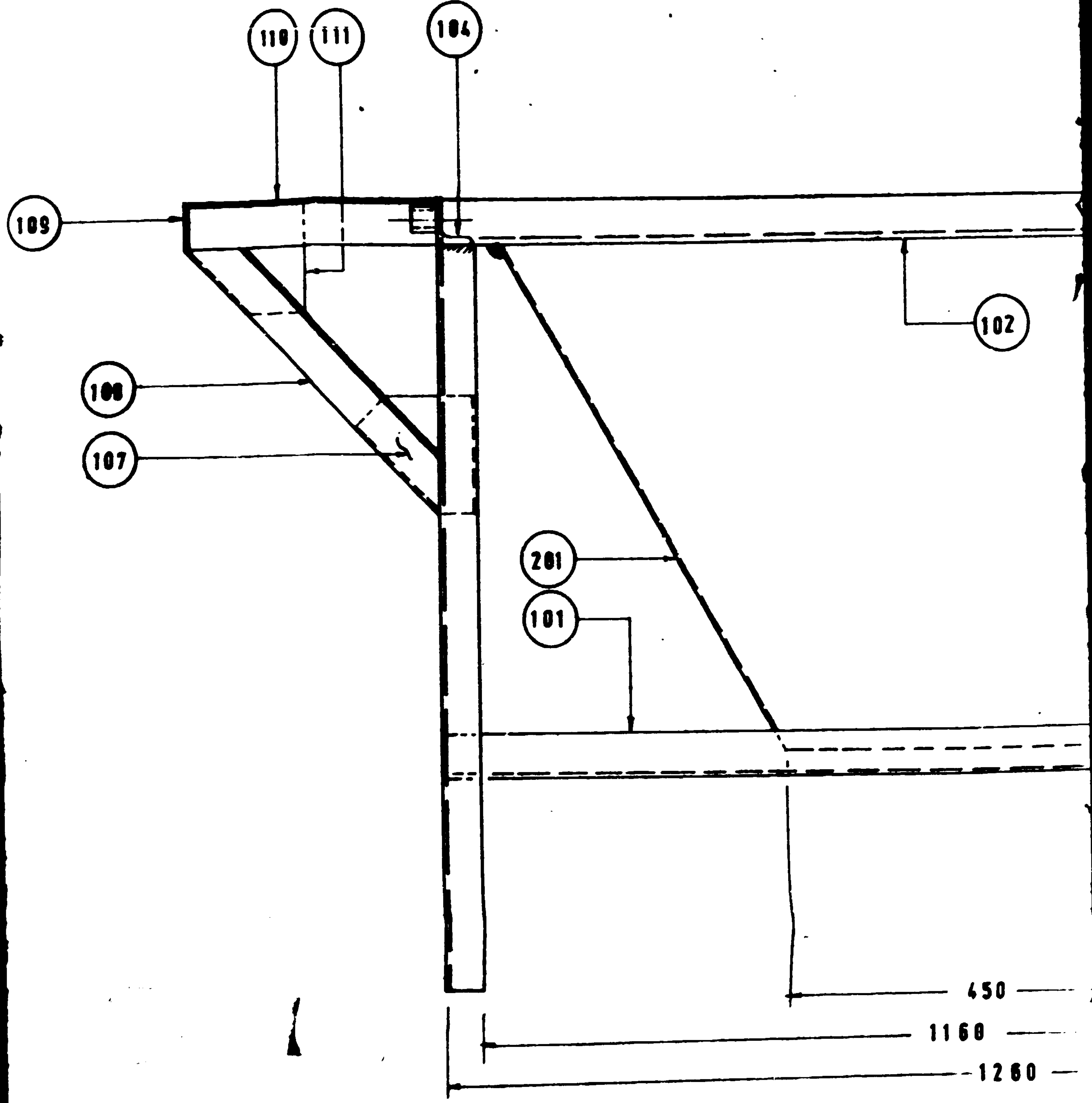
ITEM	DESRIPTION	QTY	MATL	WT IN KG	REMARKS
302	ANGLE 50 50 × 5 × 5 × 430 LG	2			

ARCEDEM	PROJ. REF. FIIRO/UNIDO GARI SIEVING MACHINE	
SCALE 1 : 1	TITLE PART DETAIL	SHEET NO 1
DATE AUGUST 1987	DRG NO 300110305	NO OF SHEETS

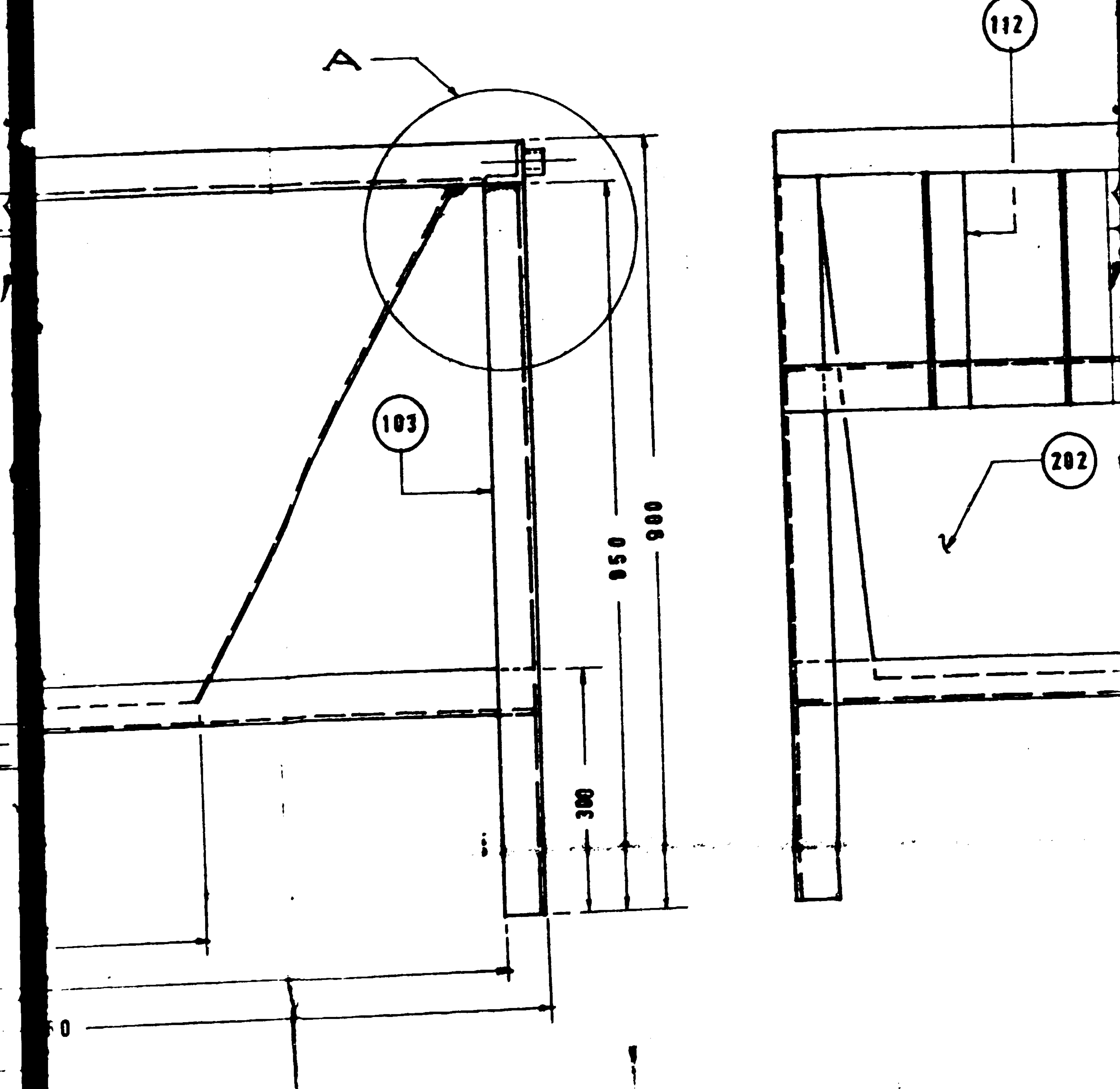


OUT 347

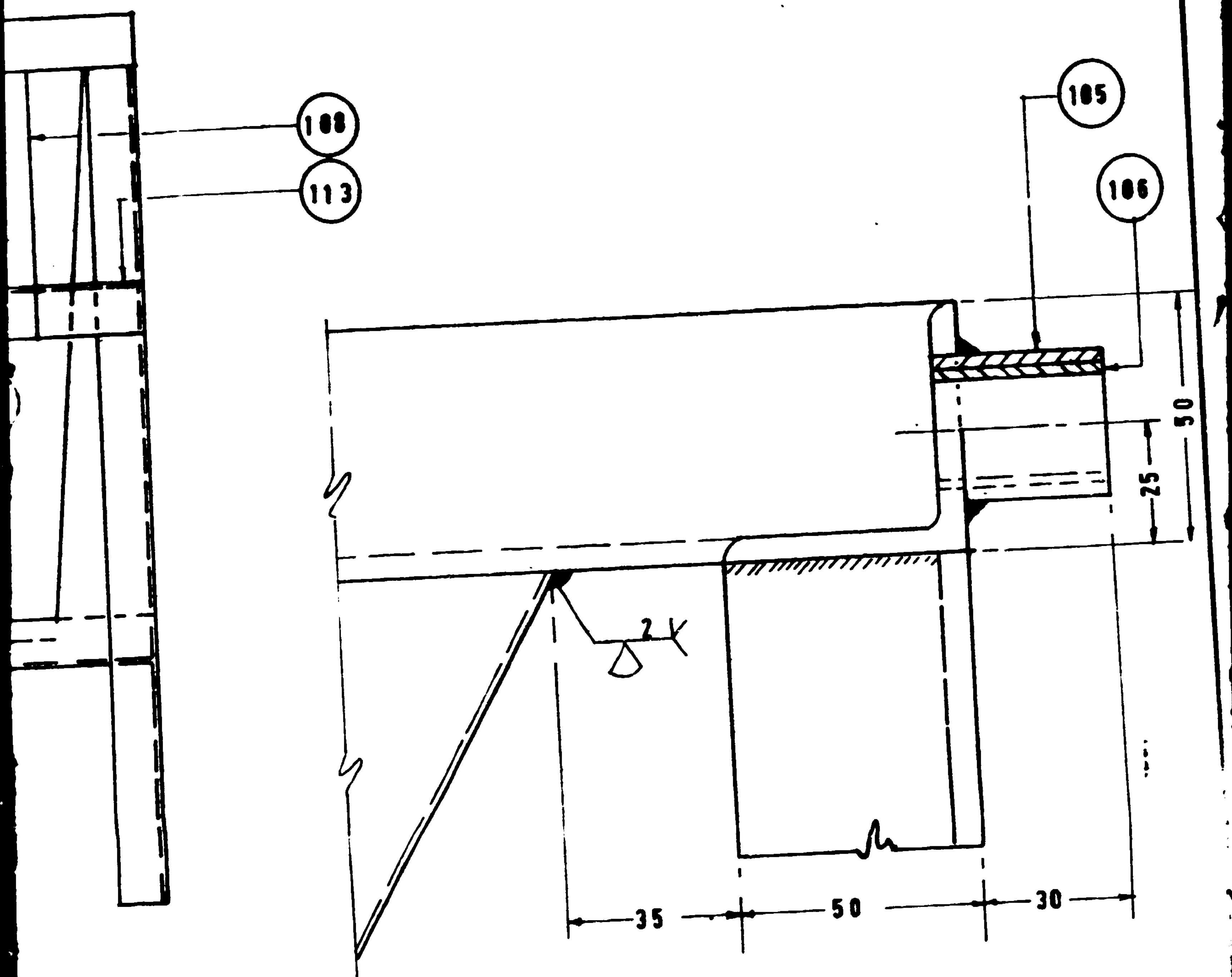
ITEM	DESCRIPTION	QTY	MATL	WT IN KG	REMARKS
305	STUD ϕ10 x 40 LG	4	M.S		



FRONT ELEVATIO

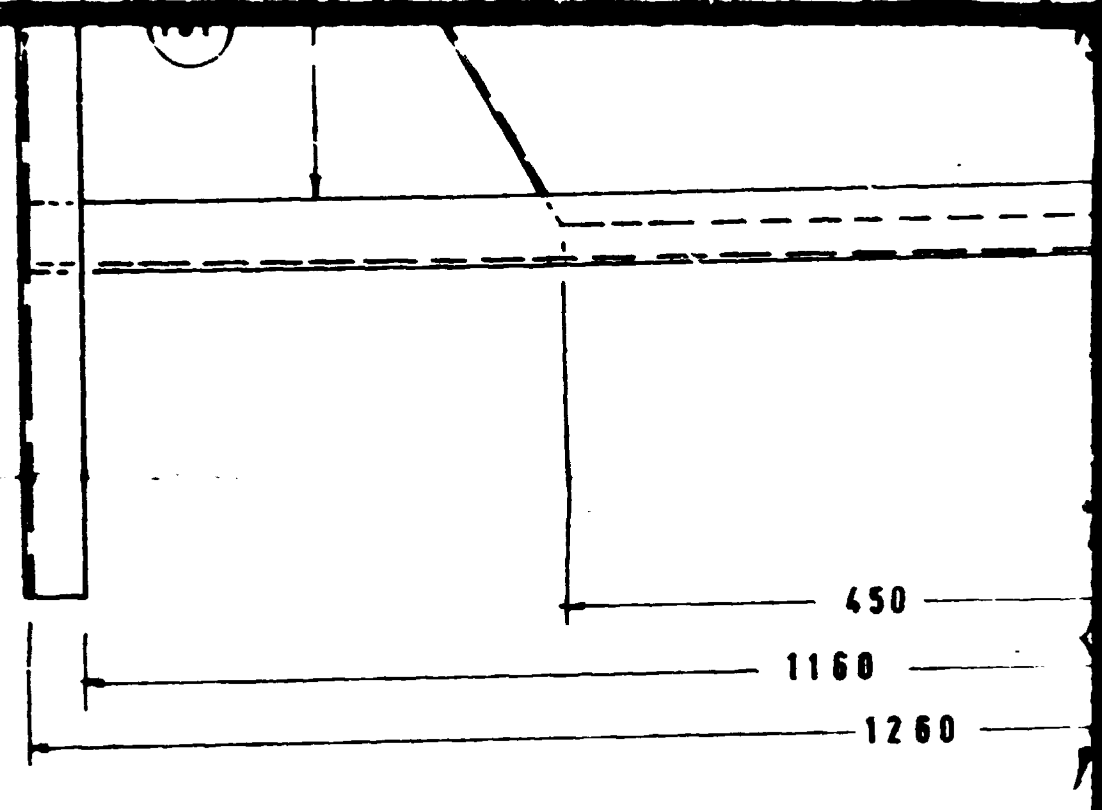


VATION

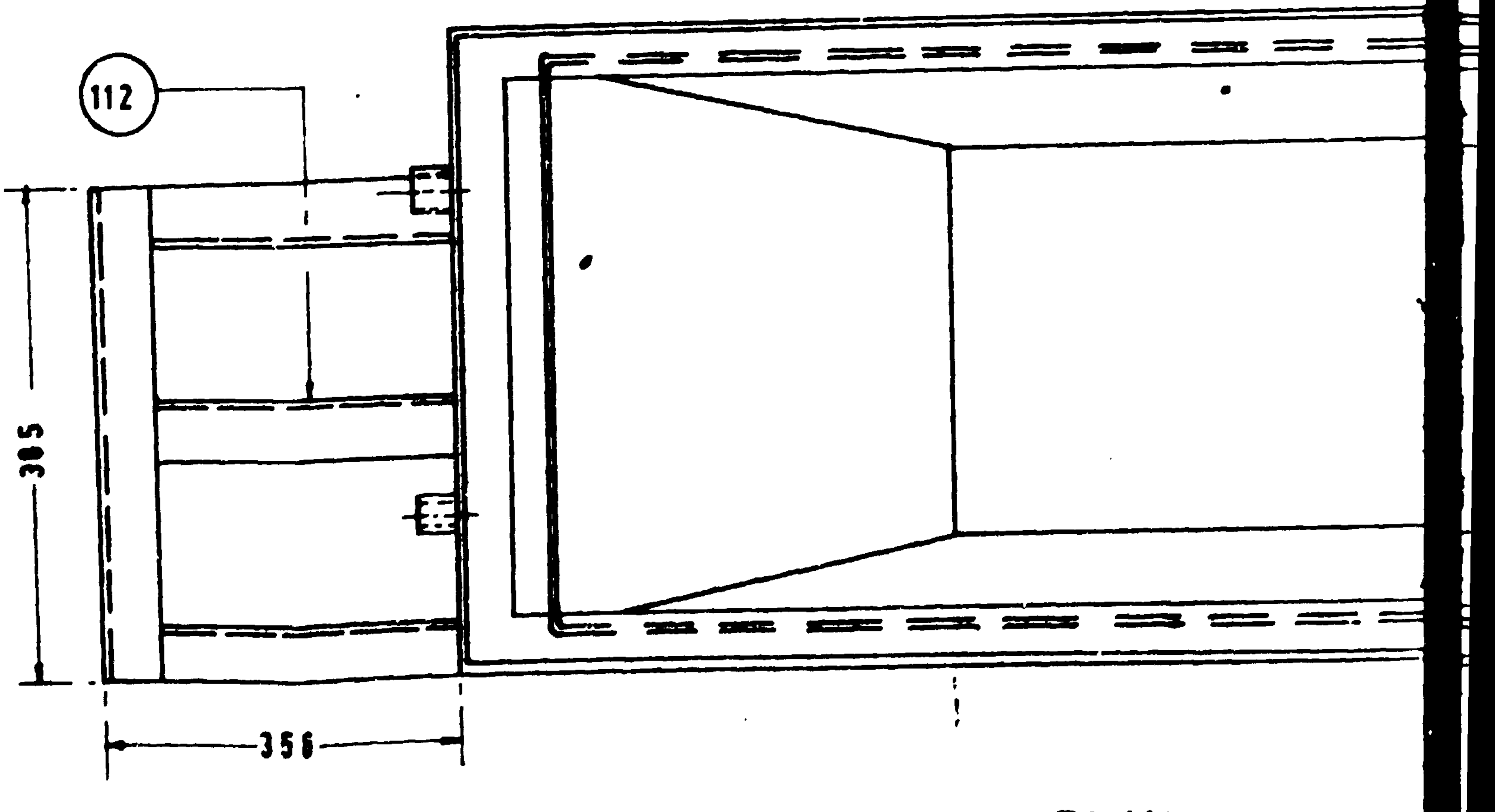


DETAIL A

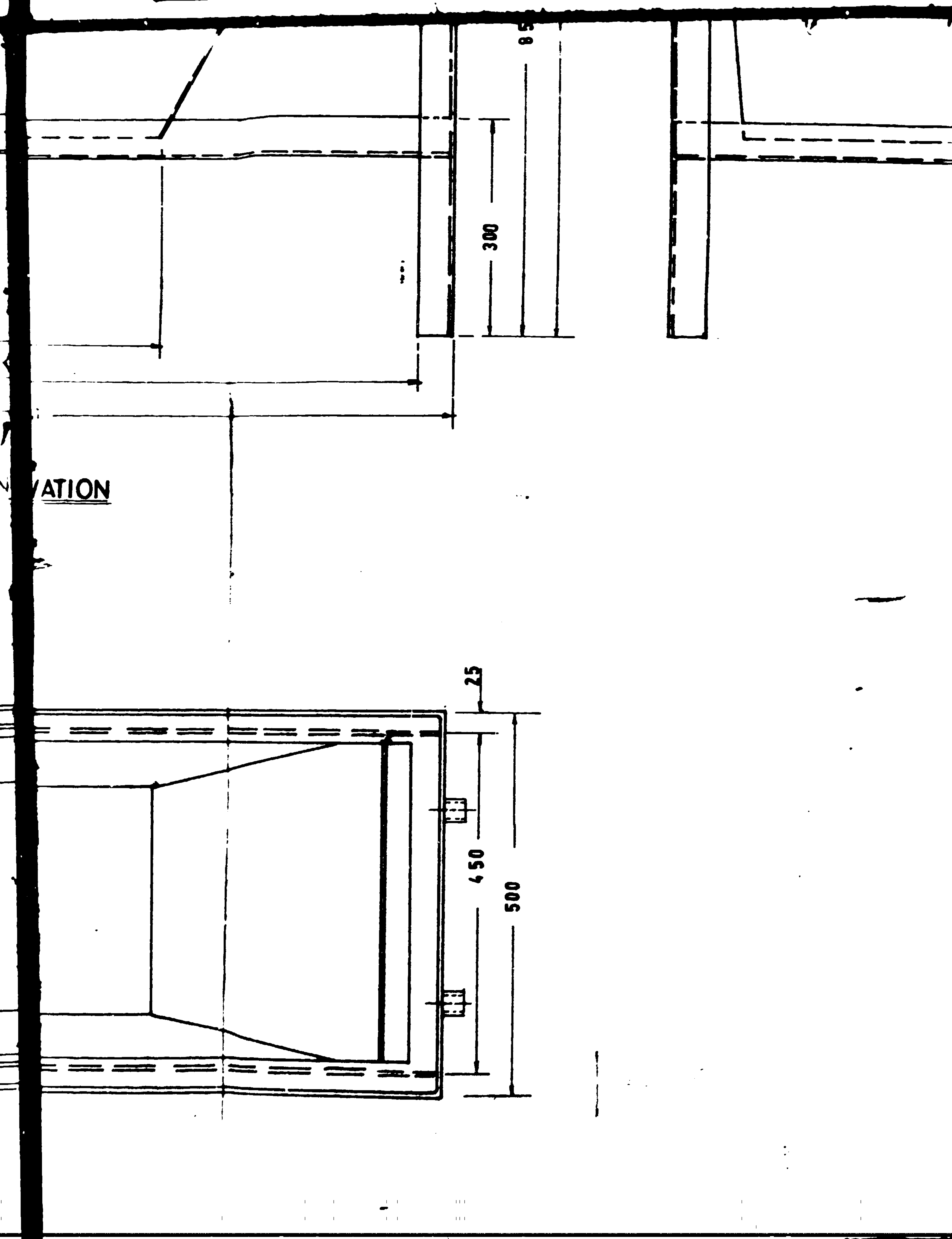
SCALE 1:1



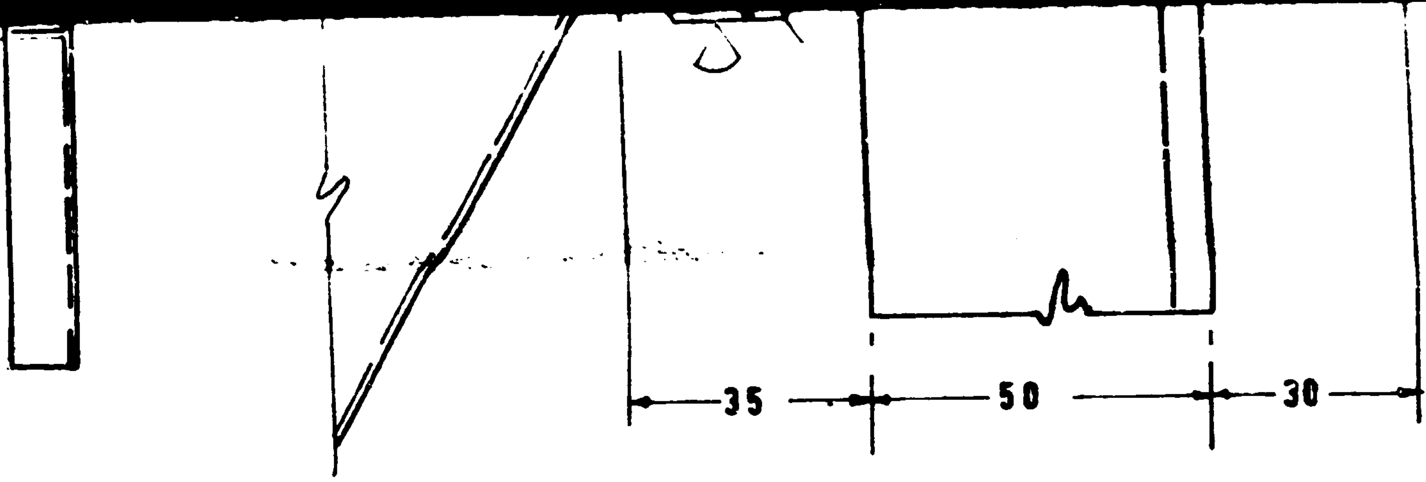
FRONT ELEVATION



PLAN



85
300
VATION
25
450
500

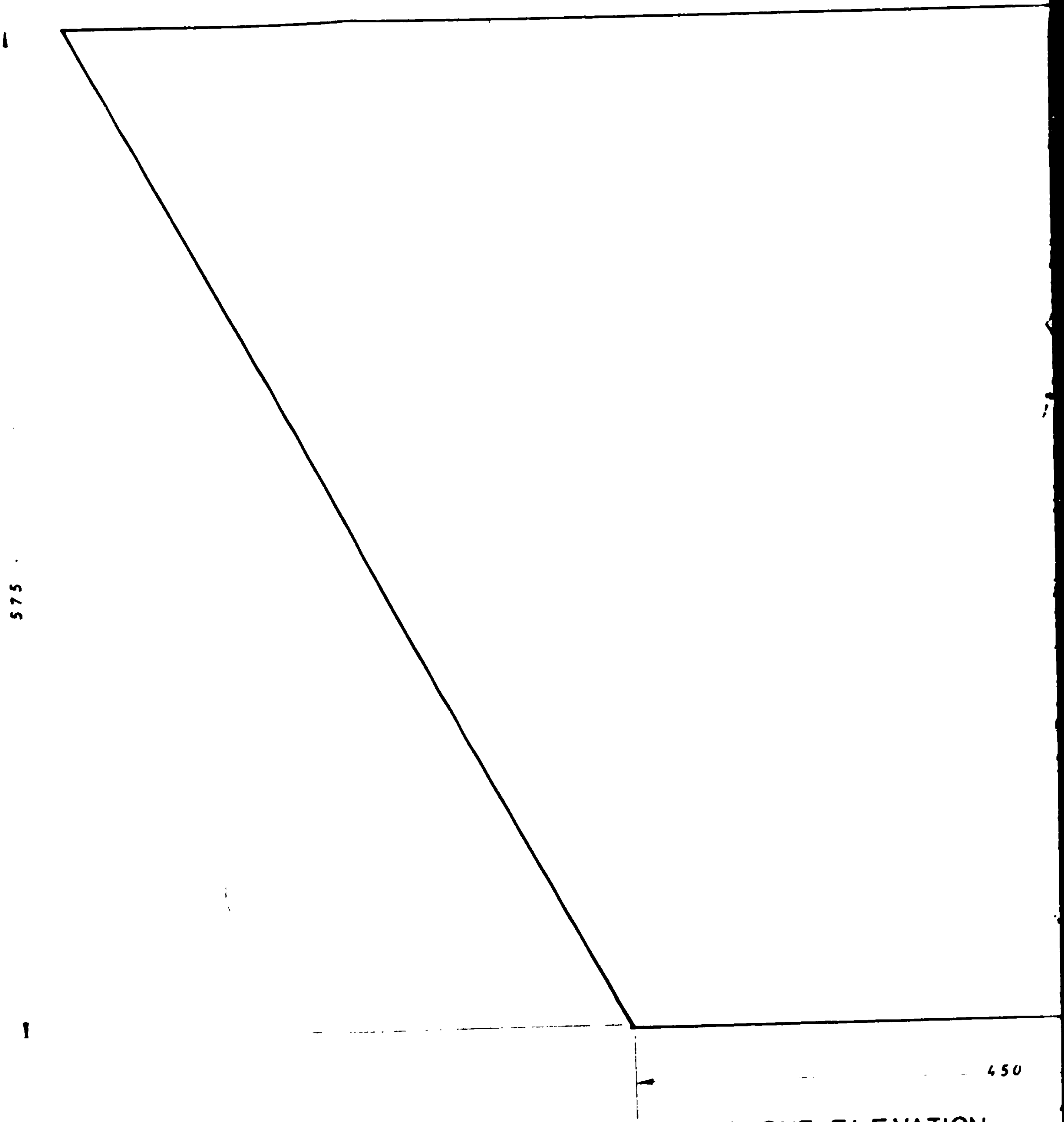


DETAIL A

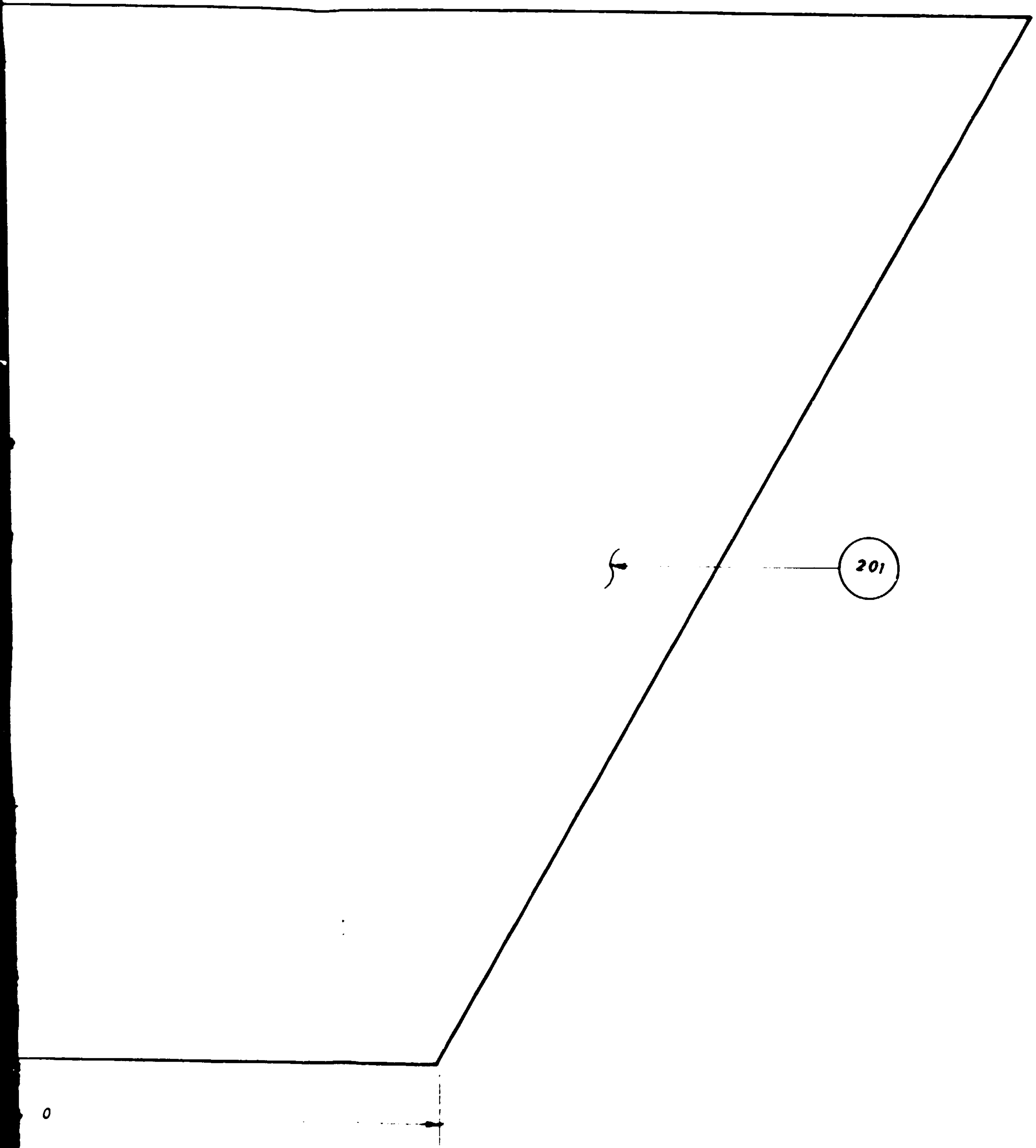
SCALE 1:1

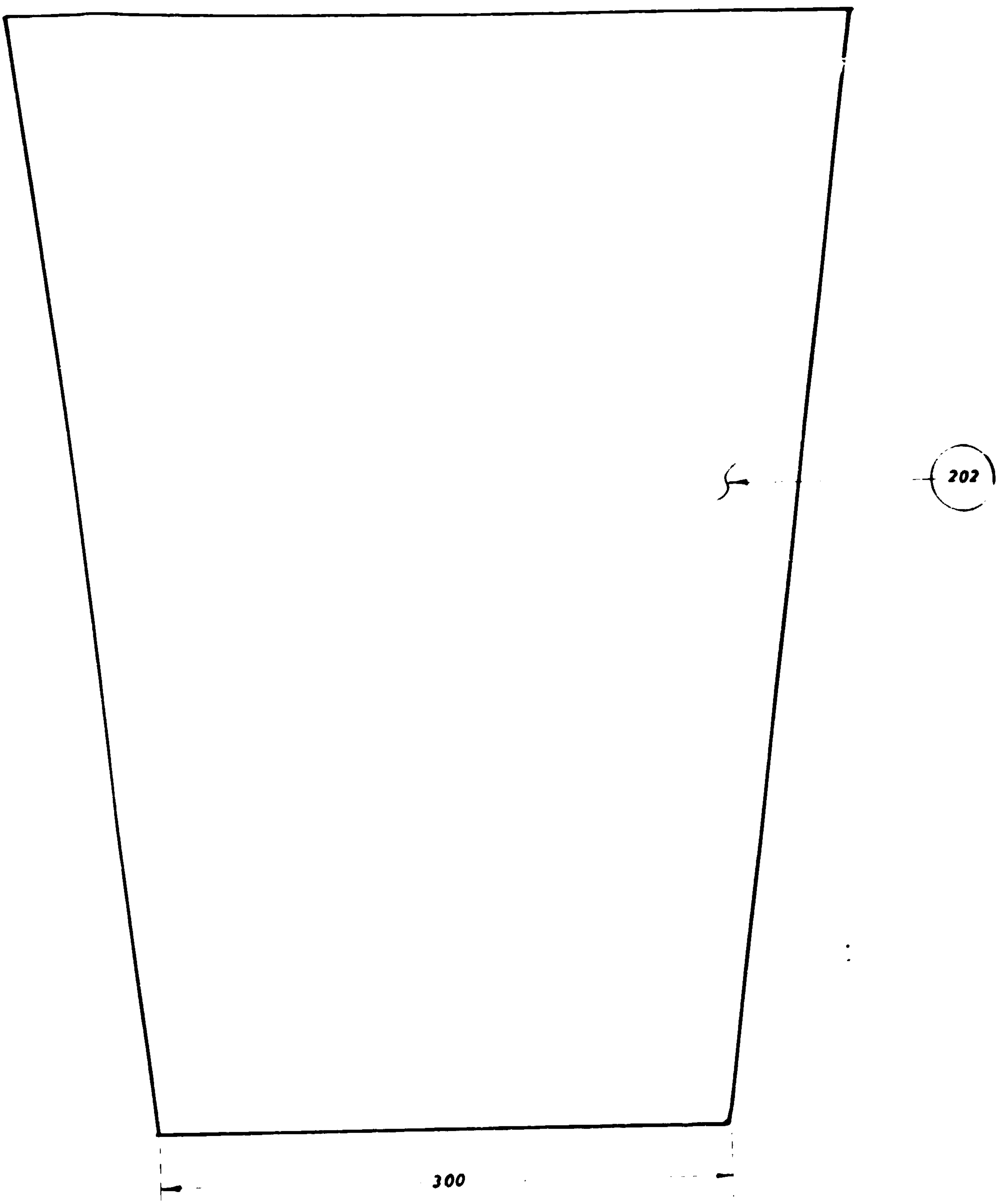
AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)

ASSY DRG REF NO	TITLE: CHUTE AND FRAME SUB-ASSY
DRN [illegible]	PROJ REF: FIIRO UNIDO GARI SIEVING MACHINE
CHKD	
APPRVD	
DATE	
MATL	DRG NO: 300110 100 OUT 324
SCALE 1:5	REV 0

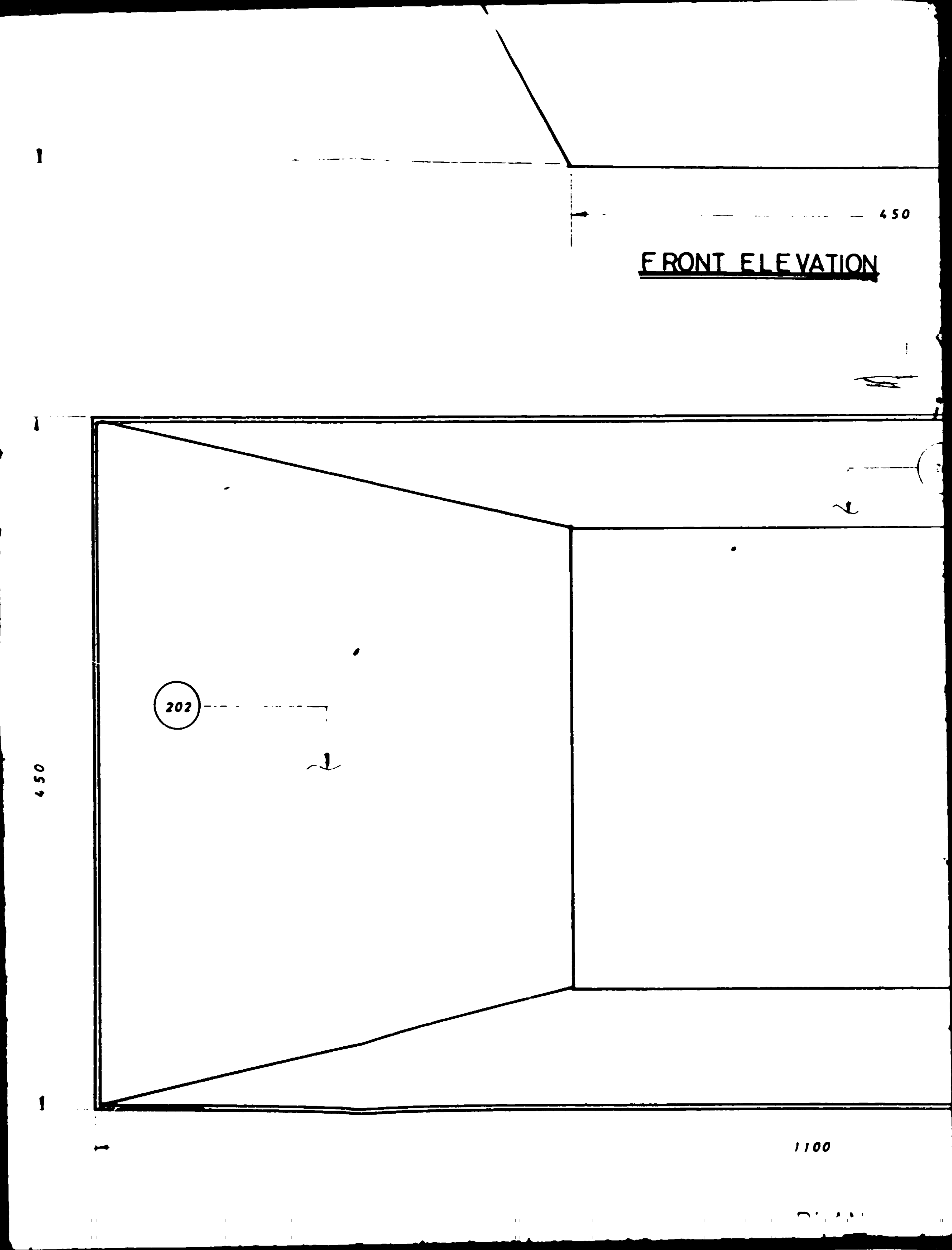


FRONT ELEVATION

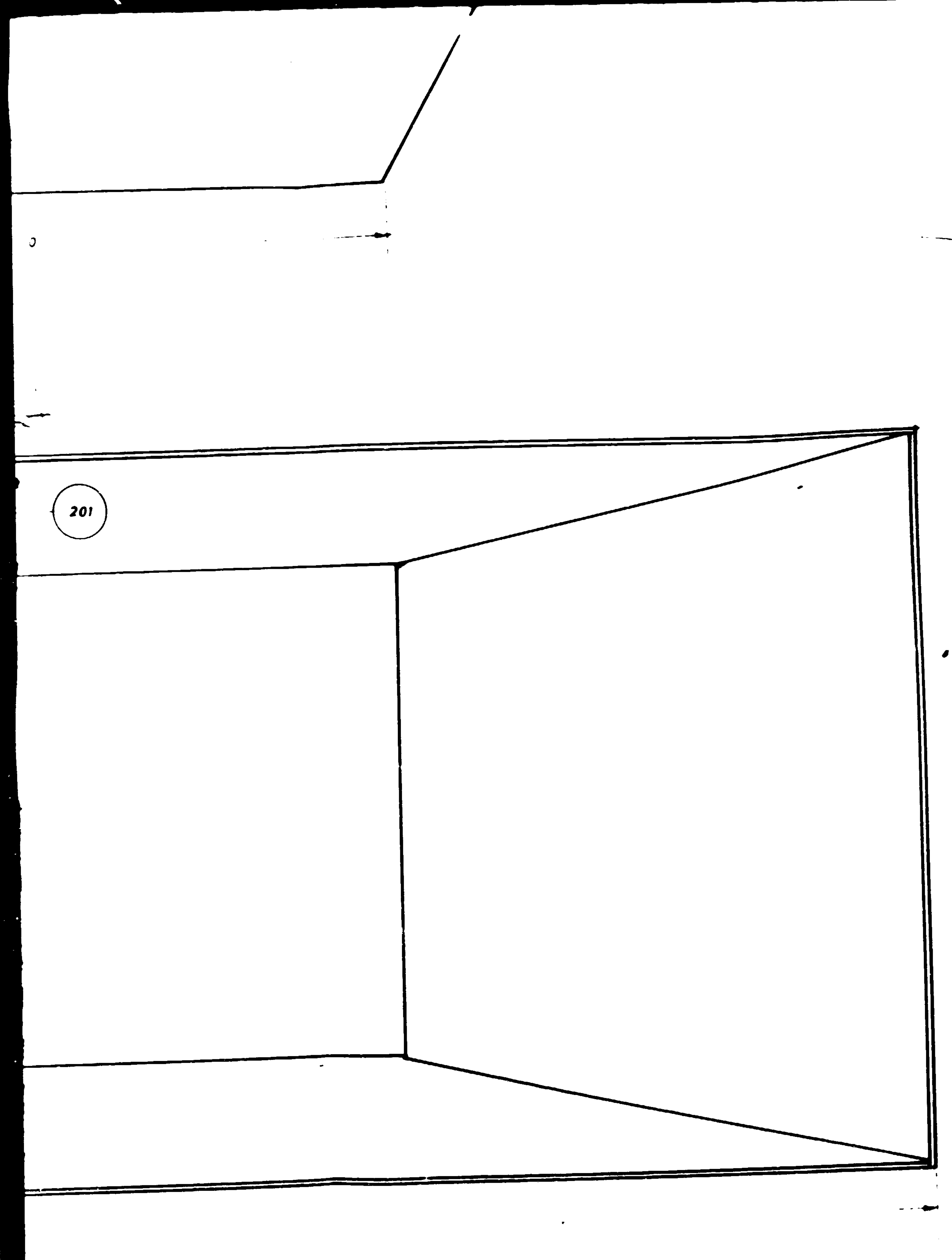

201



END ELEVATION



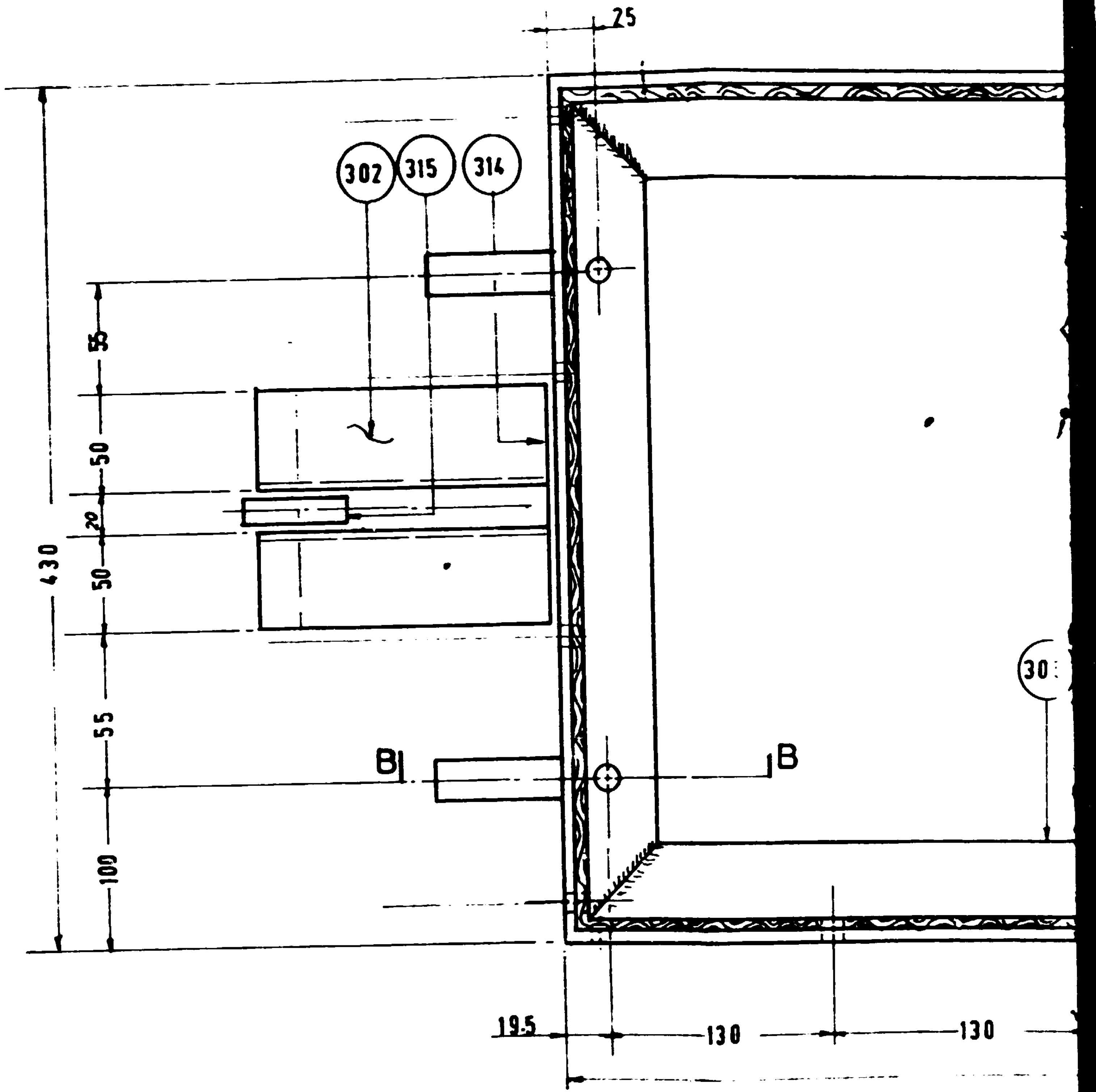
FRONT ELEVATION


201

300

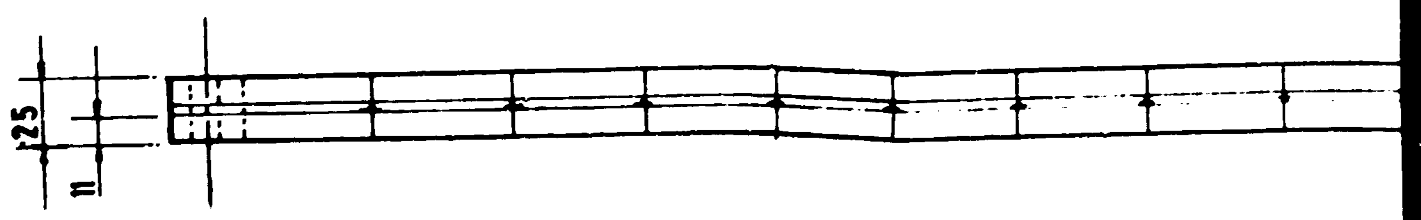
END ELEVATION

AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)	
ASSY DRG REF NO	TITLE CHUTE SUB ASSEMBLY
DWN A A ELUBE CHKD APPRVD DATE MAT L	PROJ REF FIIRO / UNIDO GARI SIEVING MACHINE
	DRG NO 300110200 OUT 325 REV

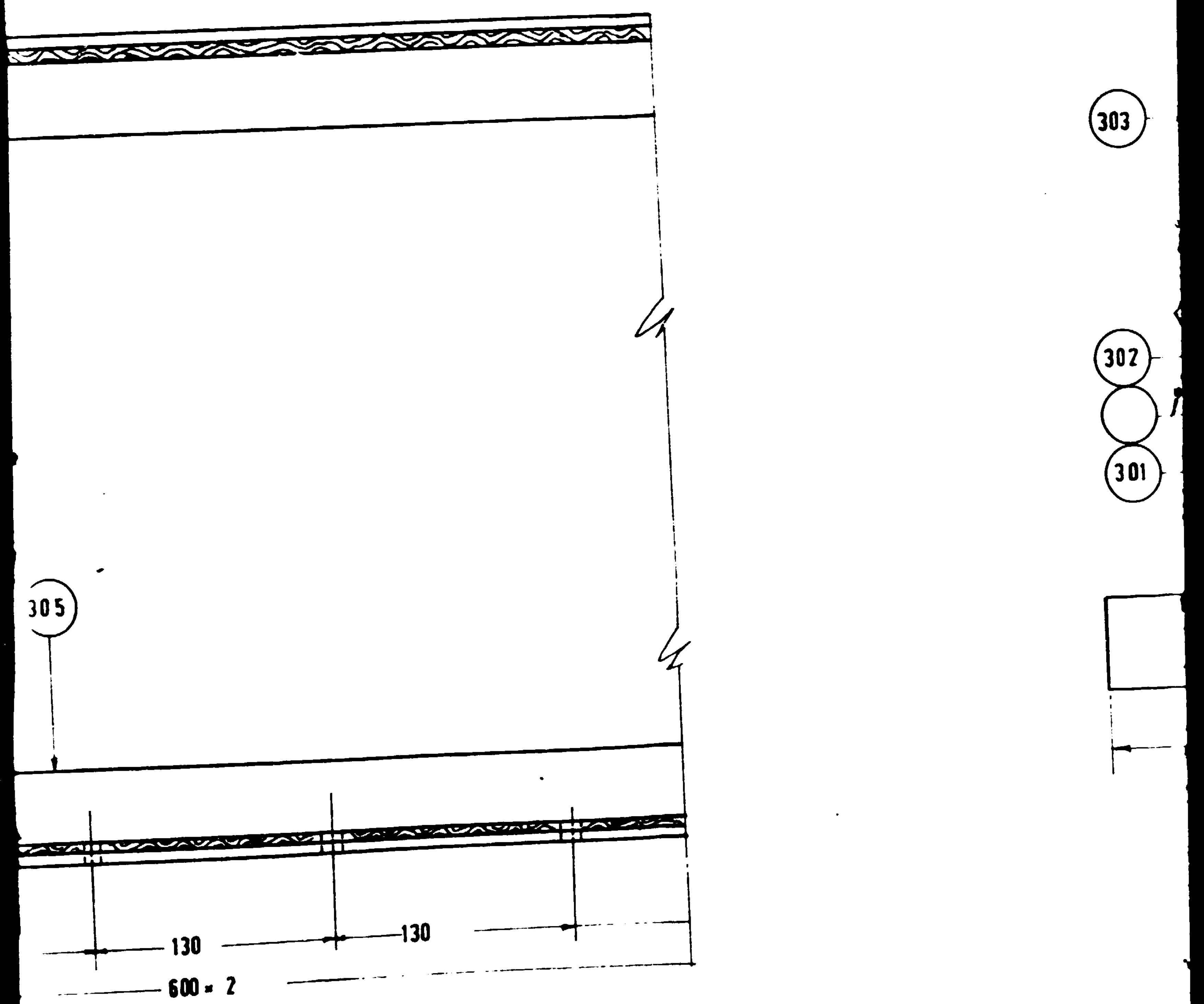


PLAN

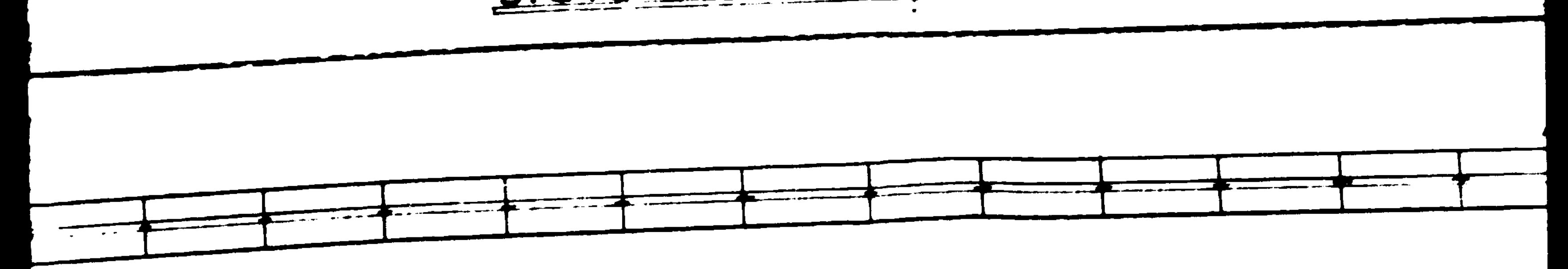
SCALE 1:2.5



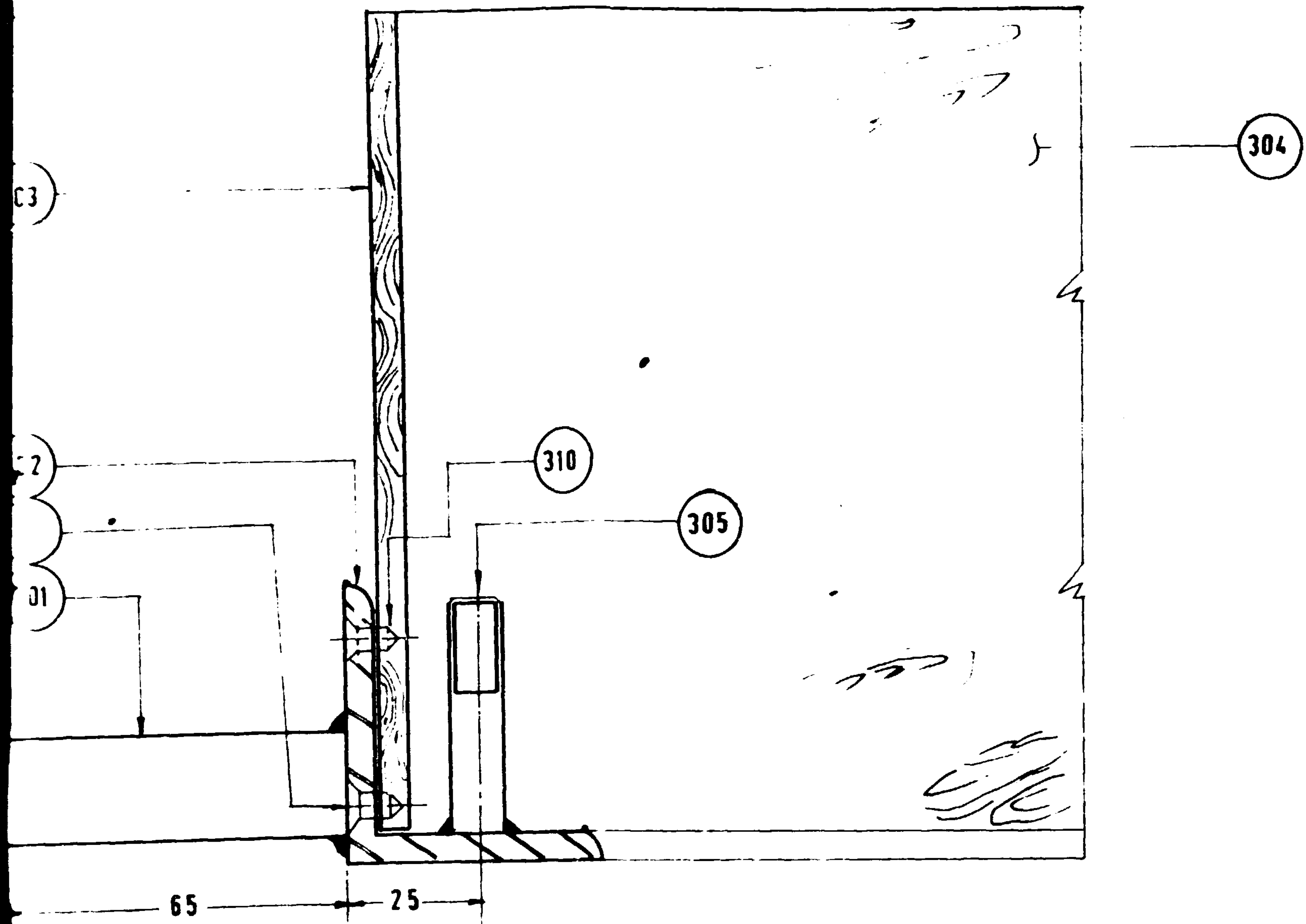
FRON



SIEVE BED ASSEMBLY



ONT ELEVATION

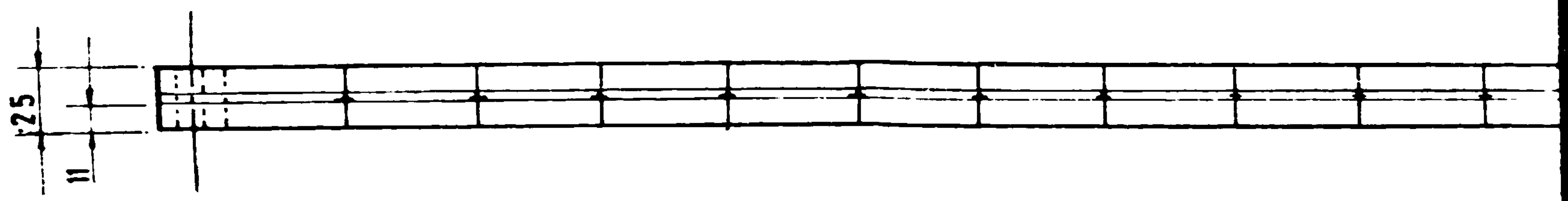


SECTION B-B

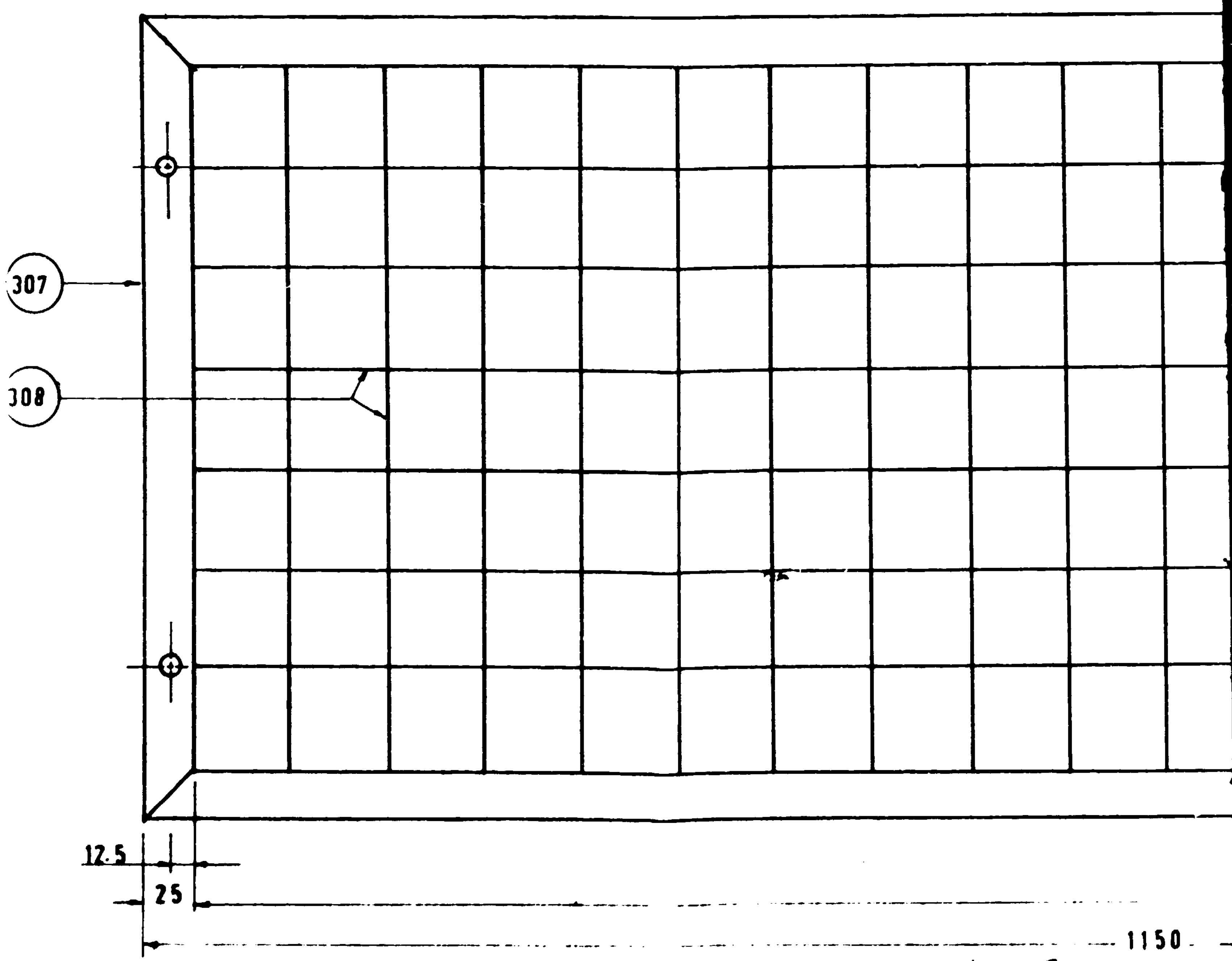
SCALE 1:1

PLAN

SCALE 1:2.5

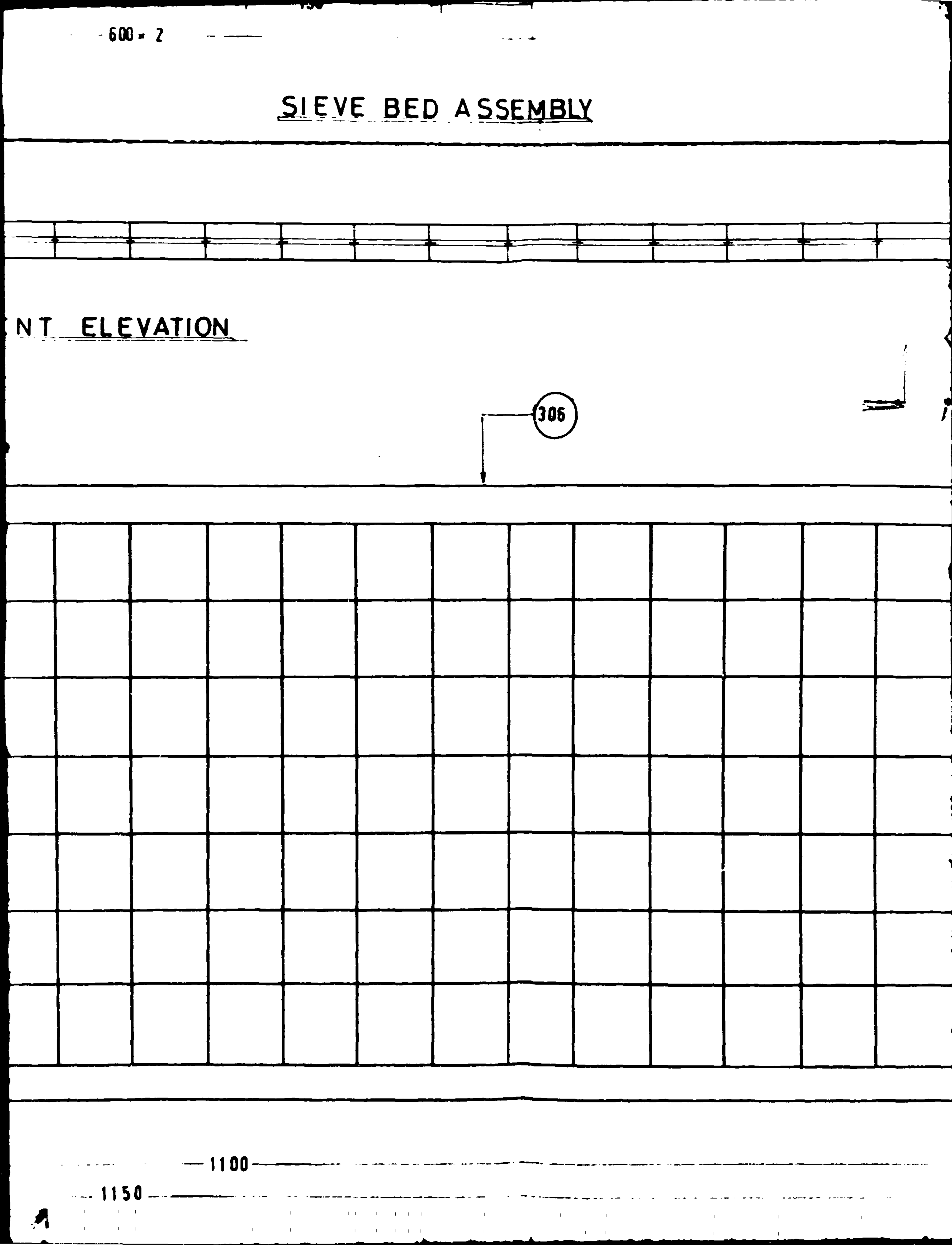


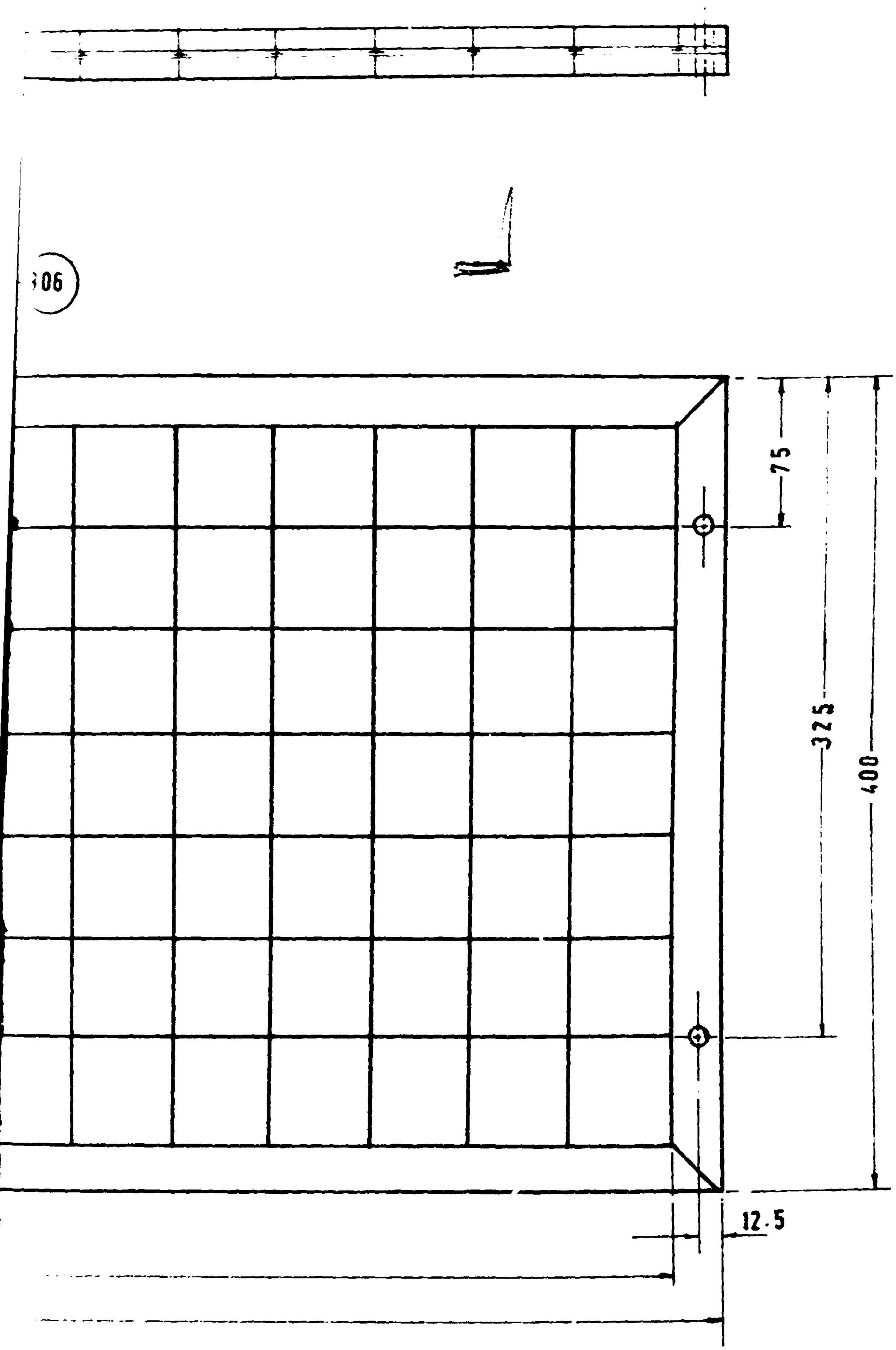
FRONT ELEVA



PLAN

SIEVE BED ASSEMBLY

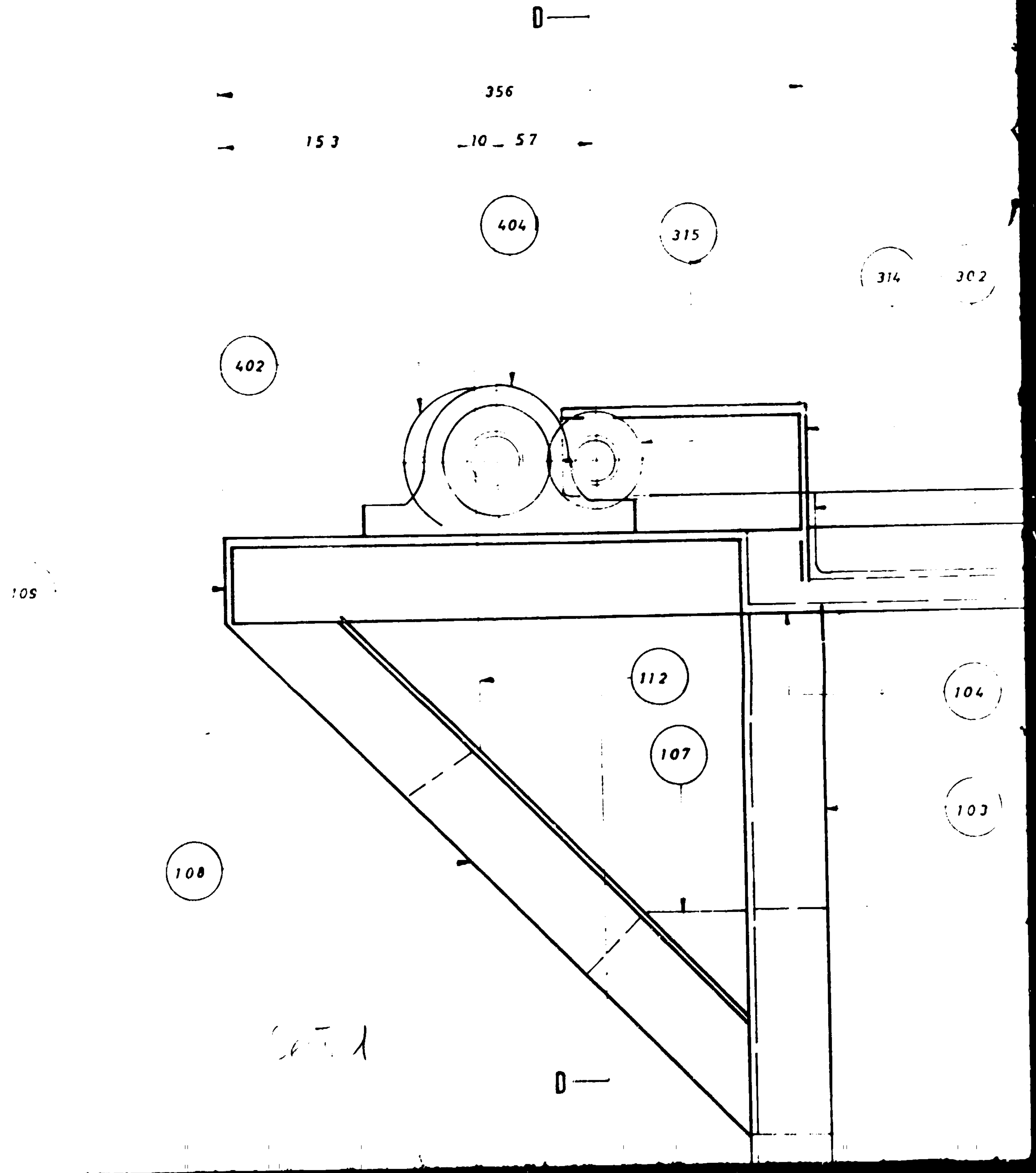


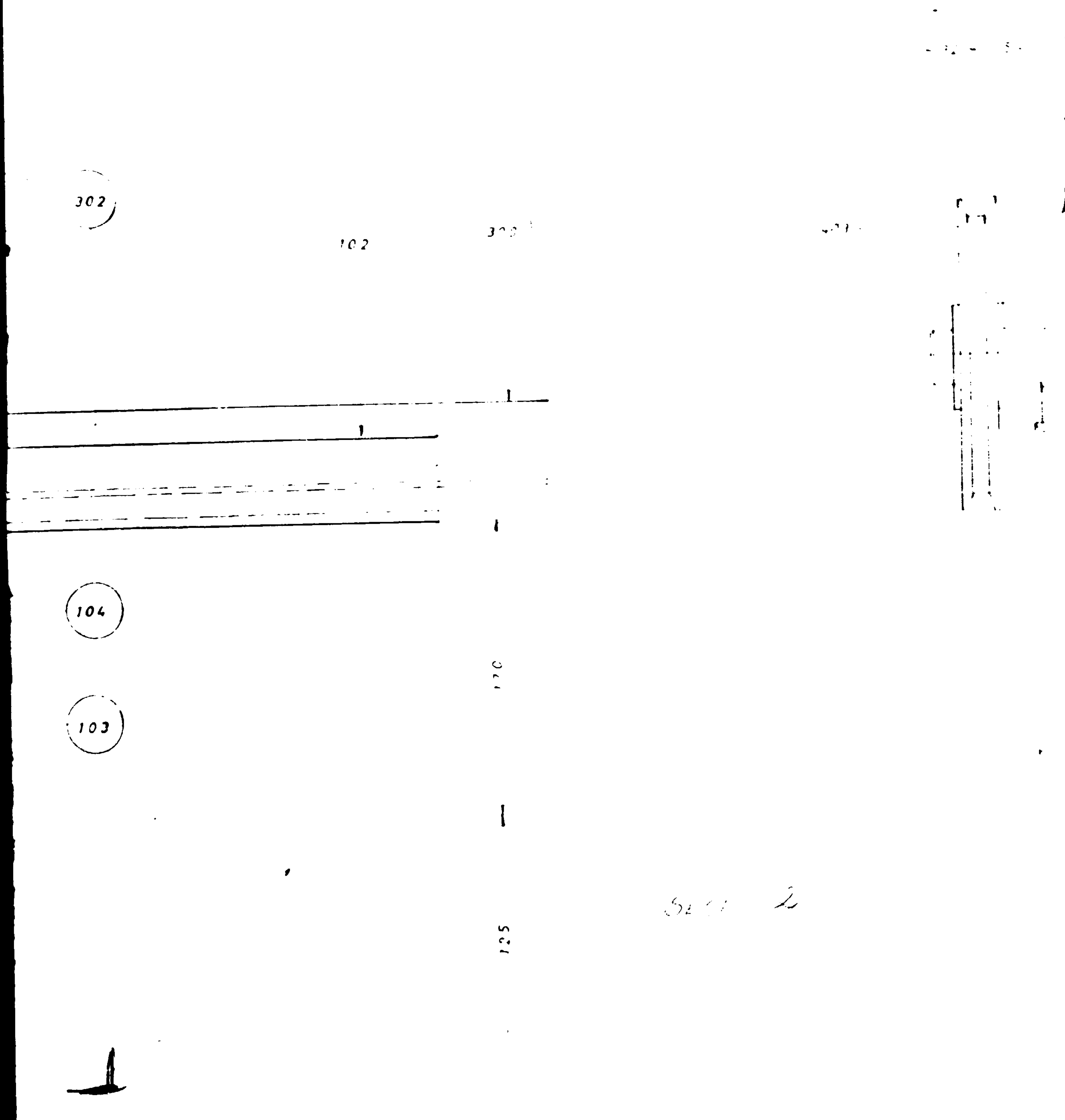


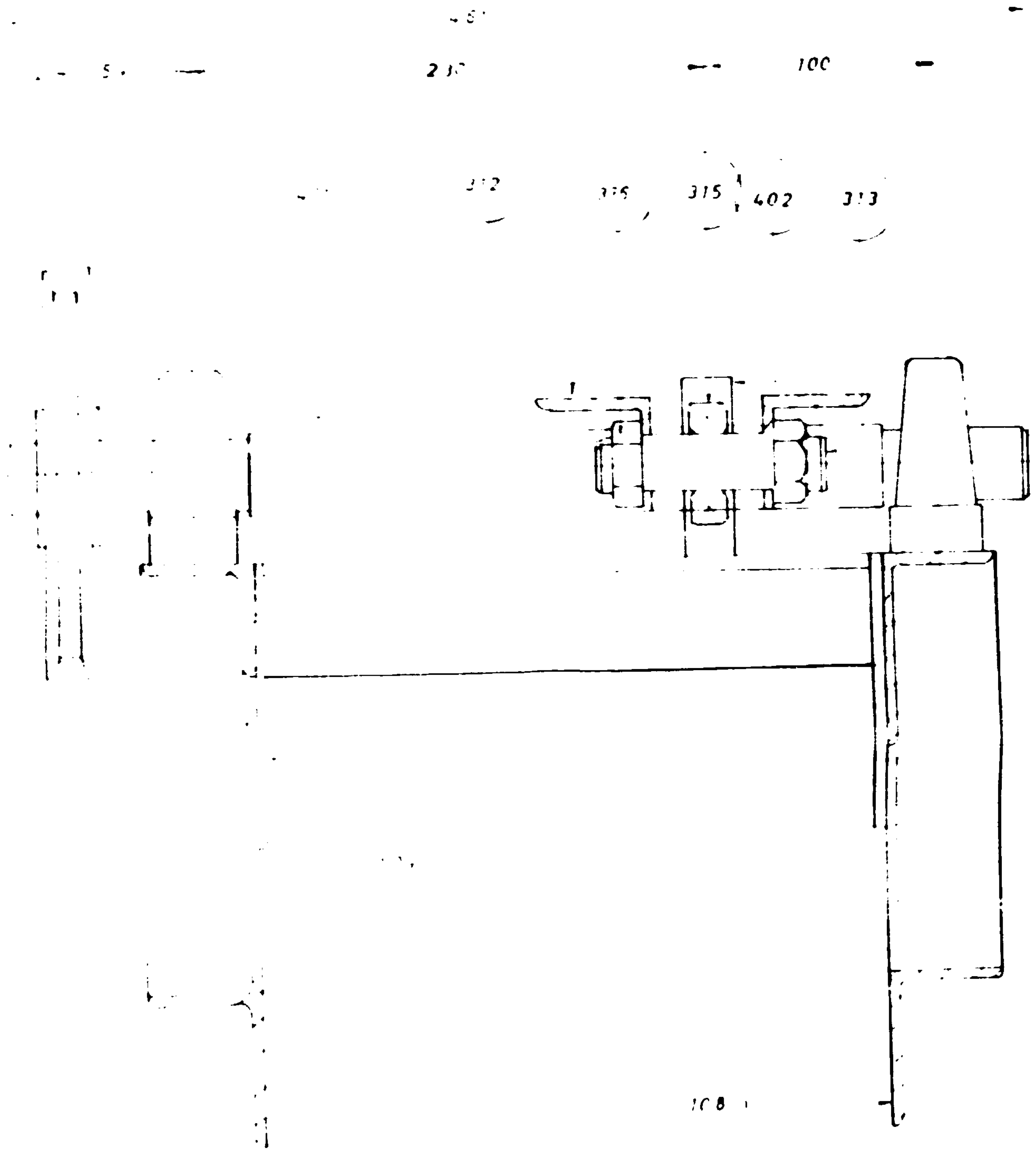
EMENT ASSEMBLY

AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)

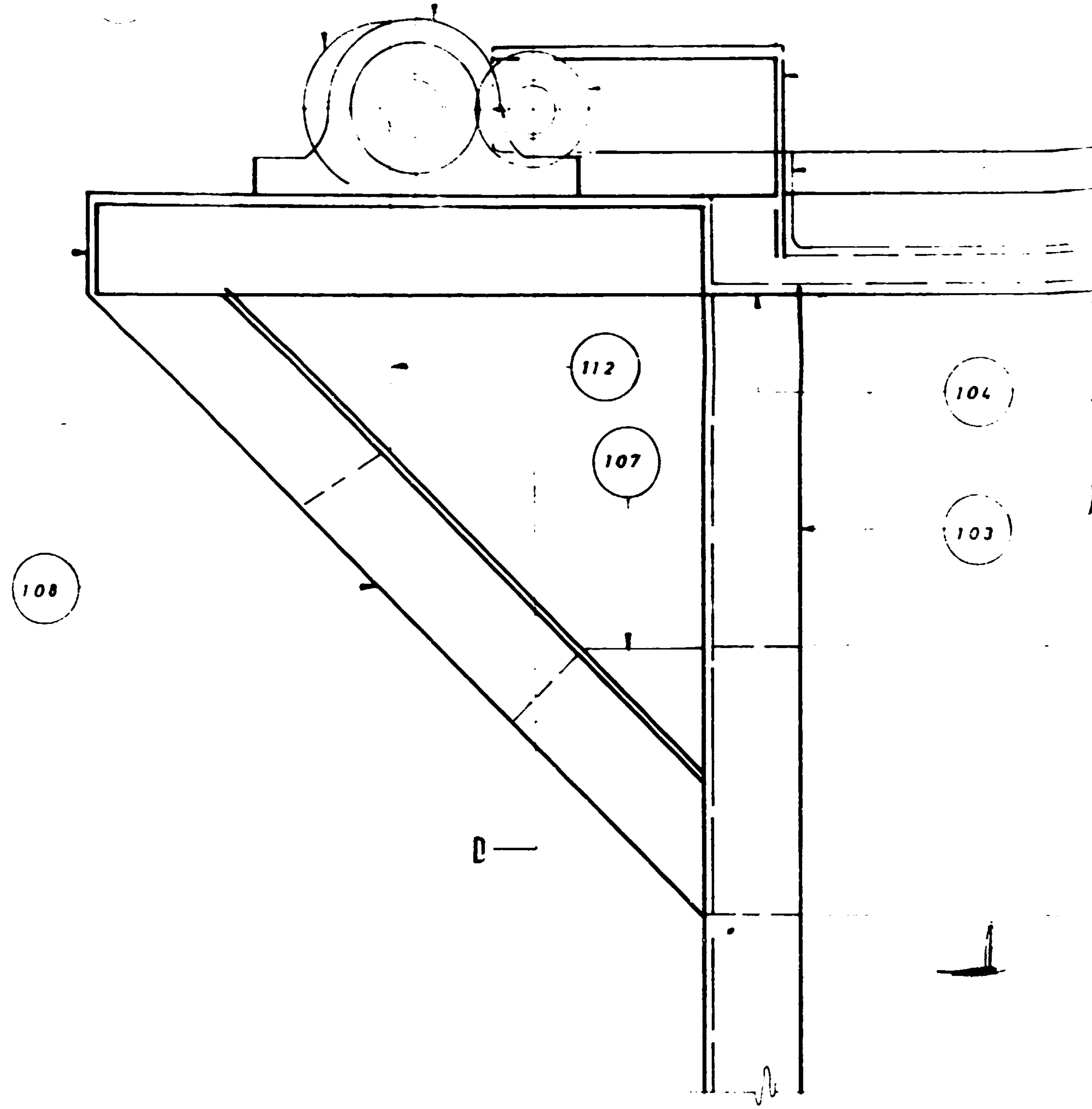
ASSY DRG REF NO		TITLE	SIEVE SUB ASSEMBLY
DWN	AA ELUBE	PROJ. REF.	FIIRO/UNIDO. GARI SIEVING MACHINE
CHKD			
APPRVD			
DATE			
MAT.		DRG NO	[illegible]
SCALE			


D
356
153
10
57
404
315
314
302
402
105
112
104
107
103
108
D


302
102
104
103



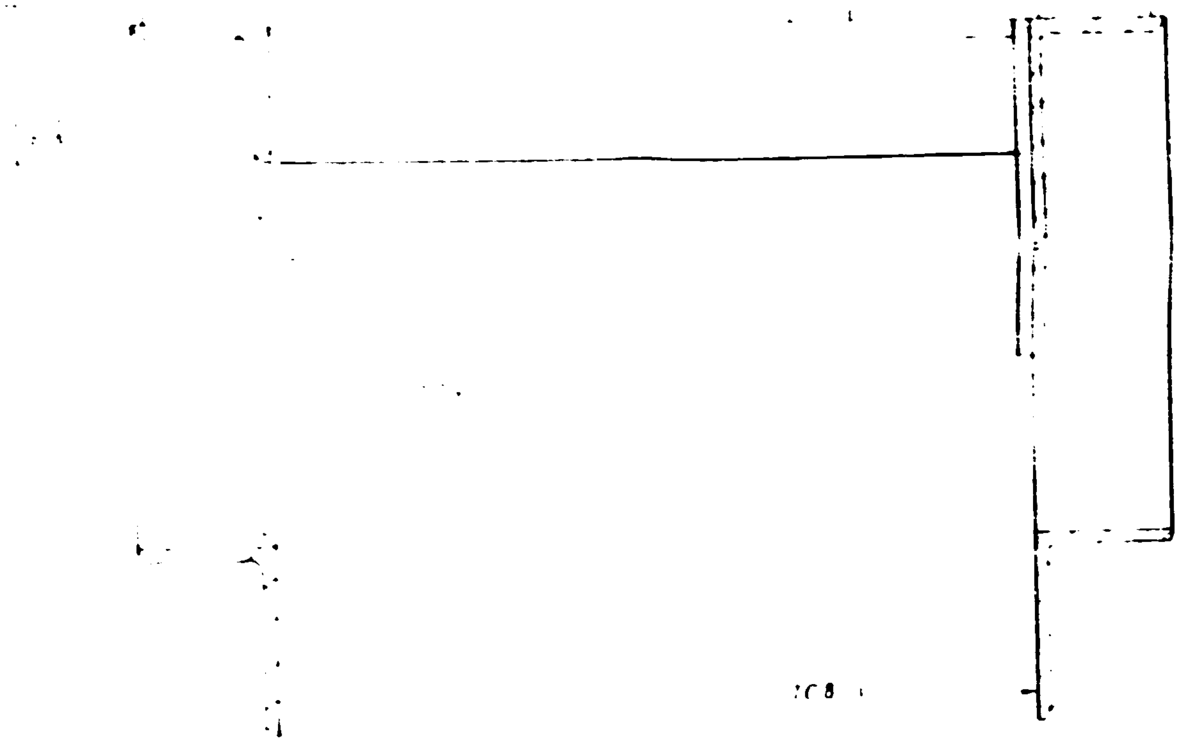
SECTION D D



FRONT ELEVATION

SECT 4

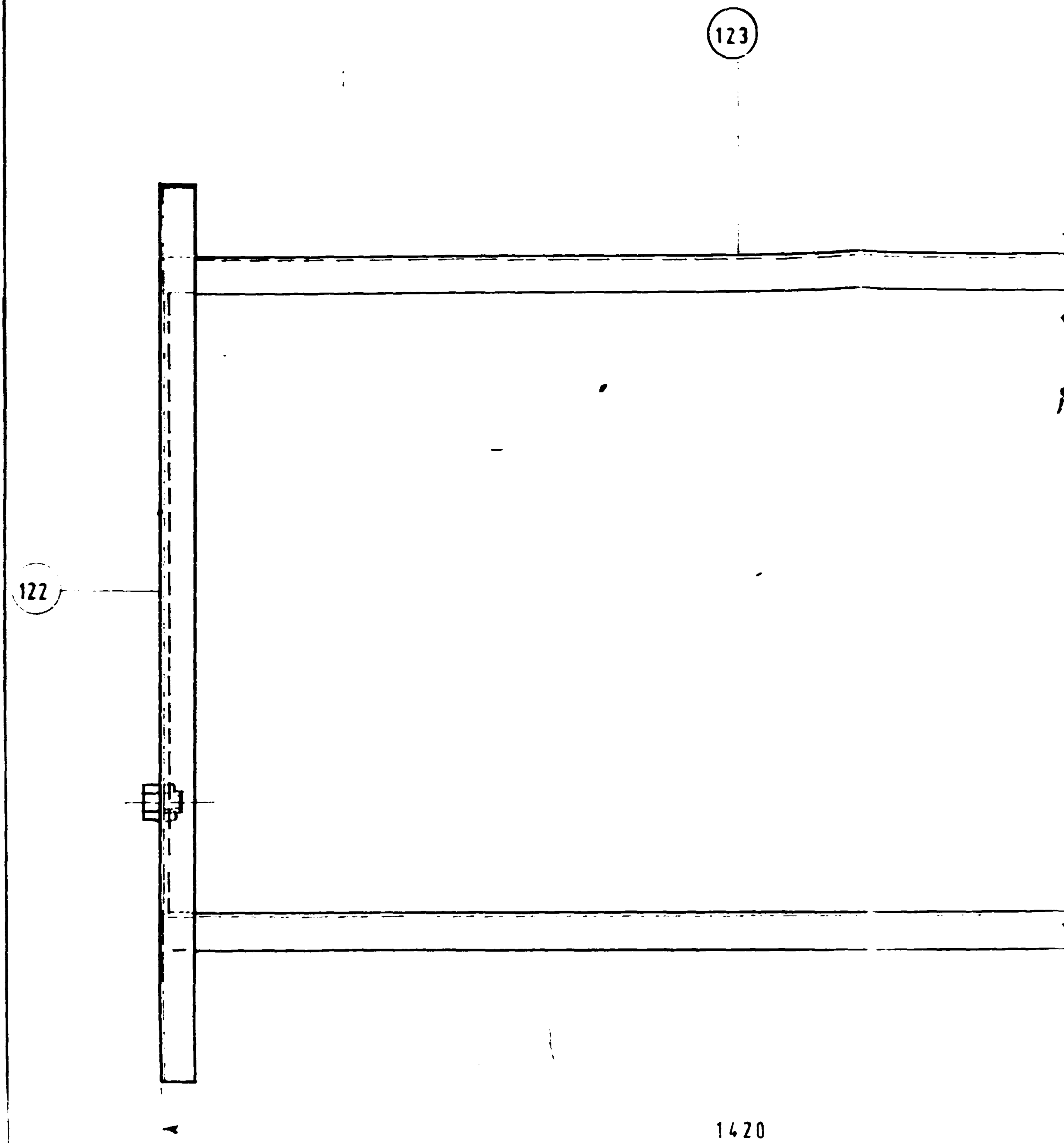
SECT 5

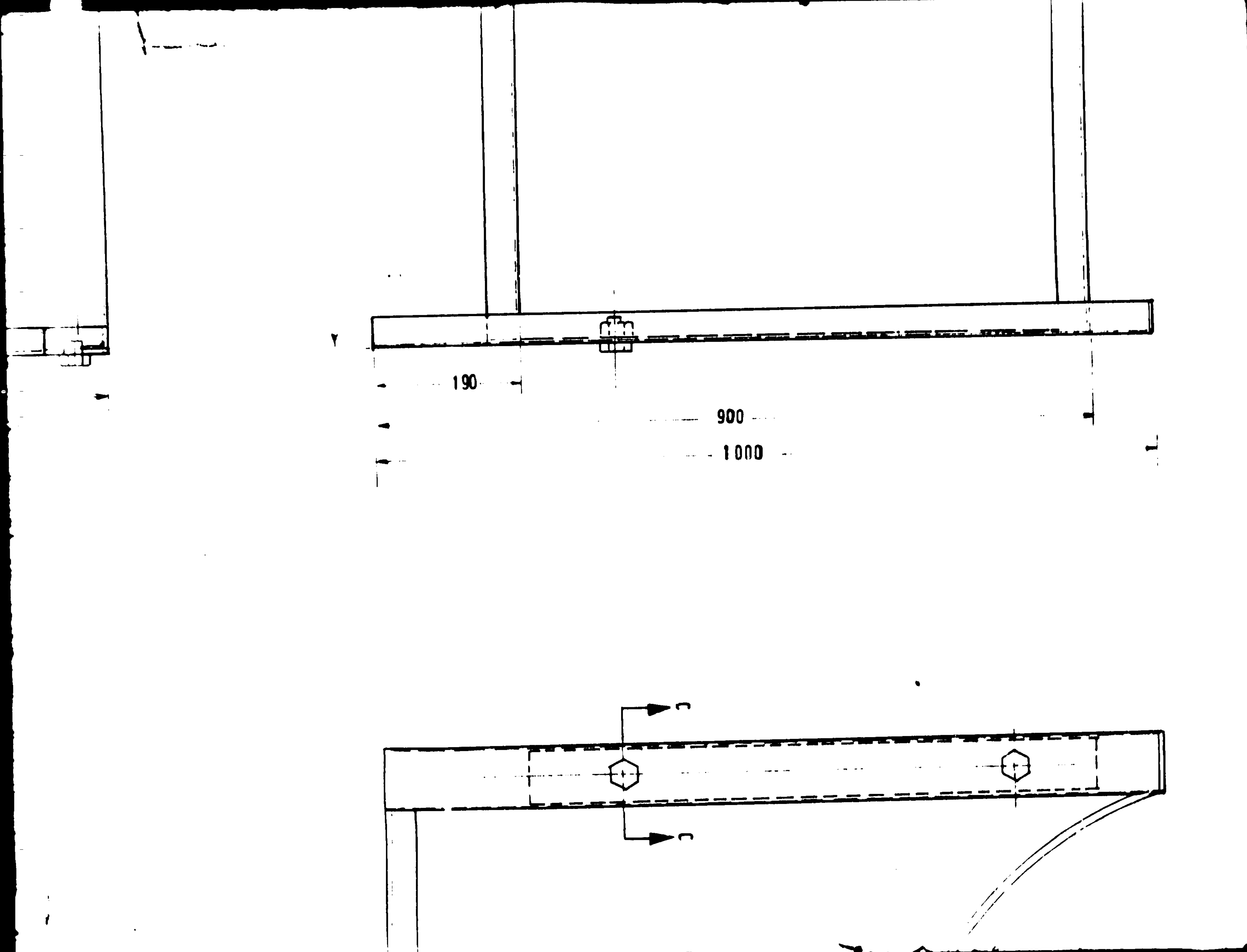


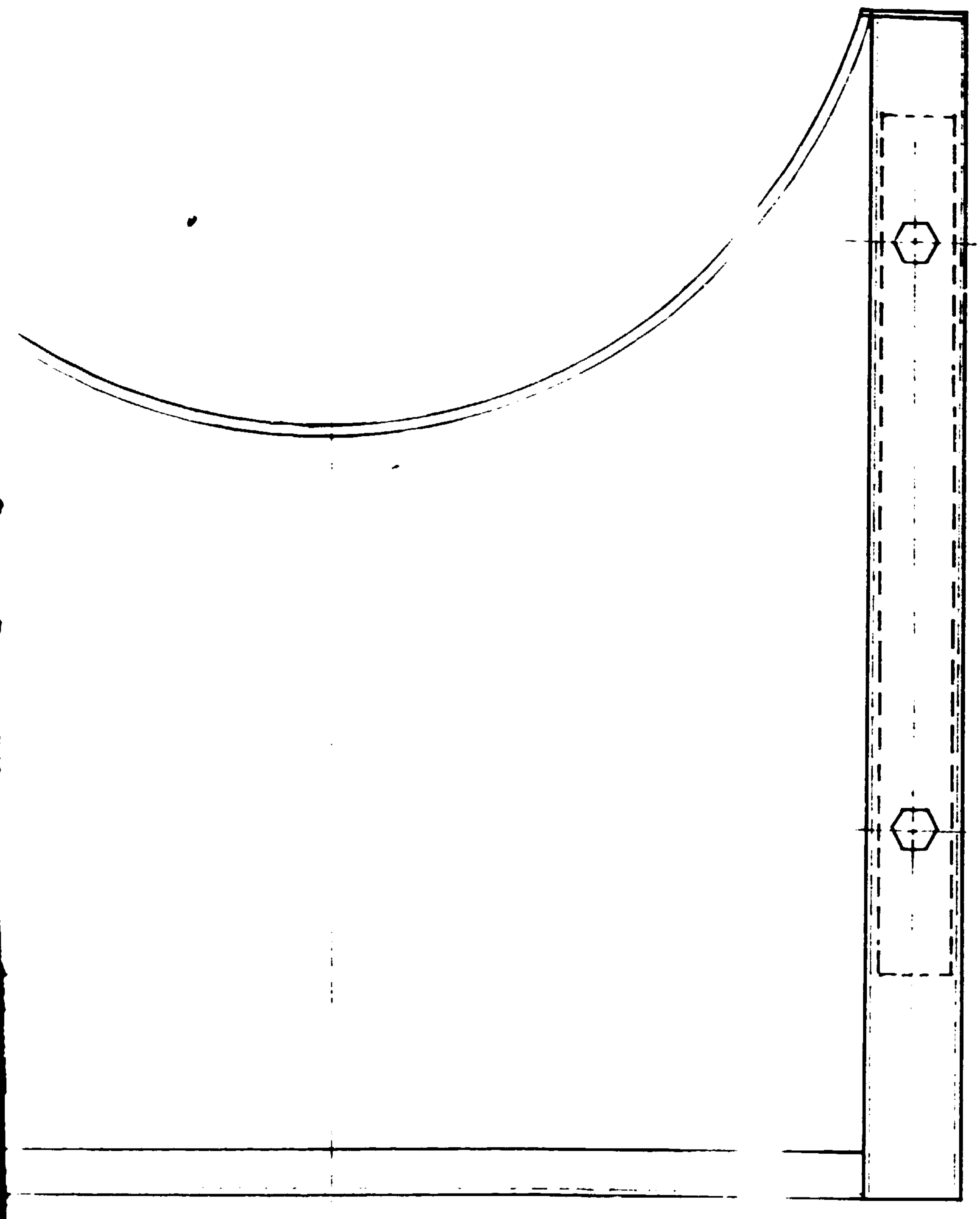
SECTION D D

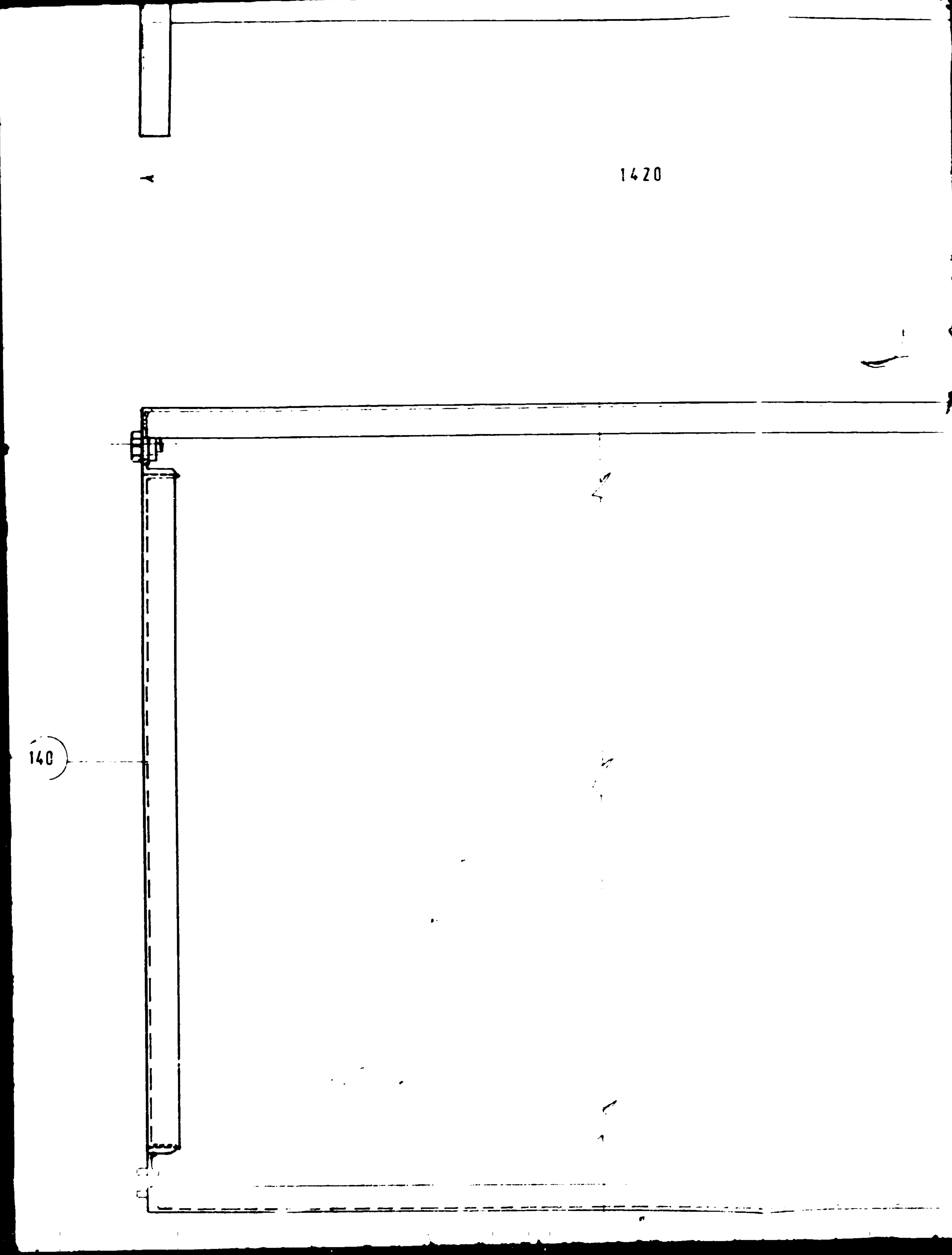
Sect 6

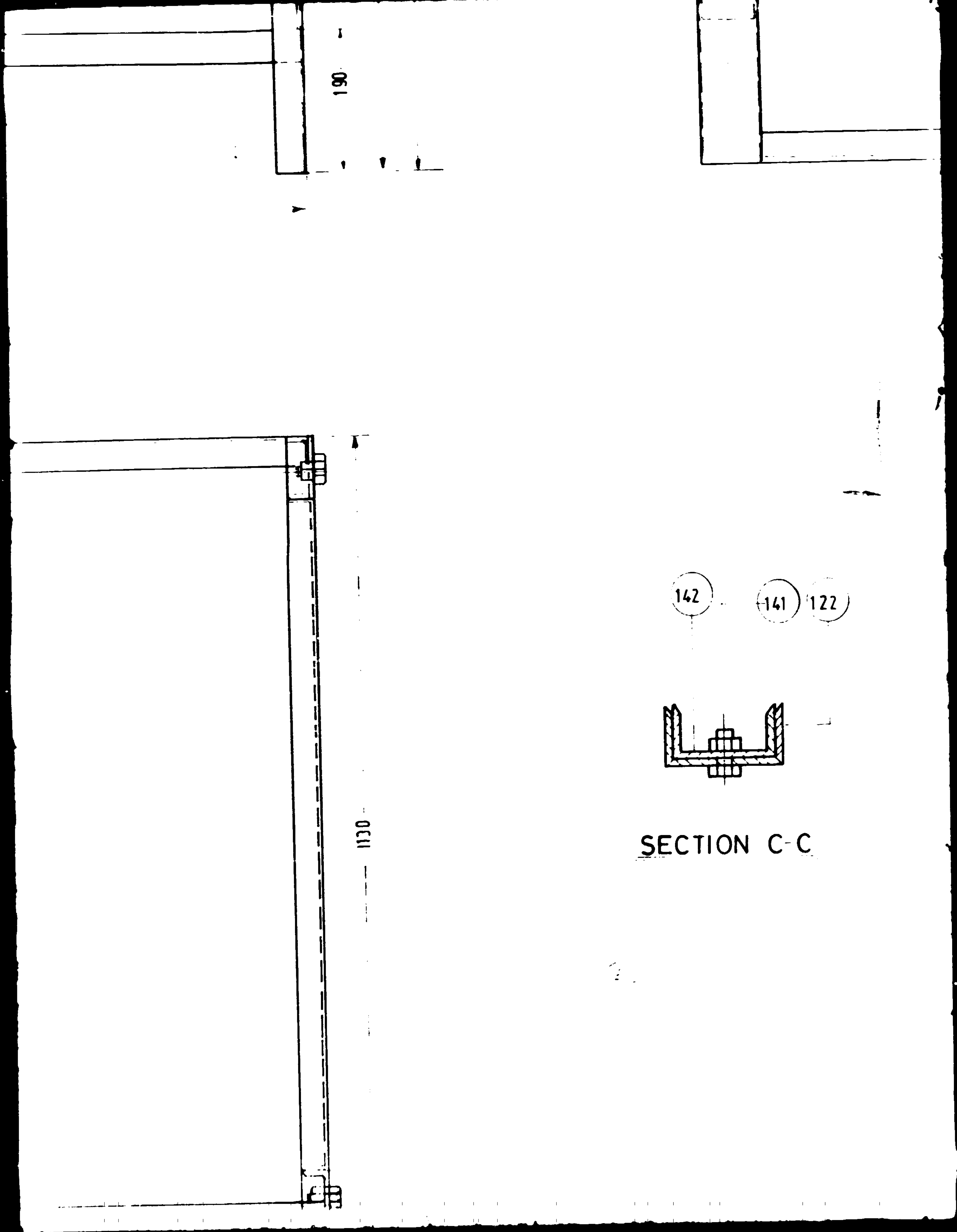
AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)


123
122
1420


190
900
1000
C
C



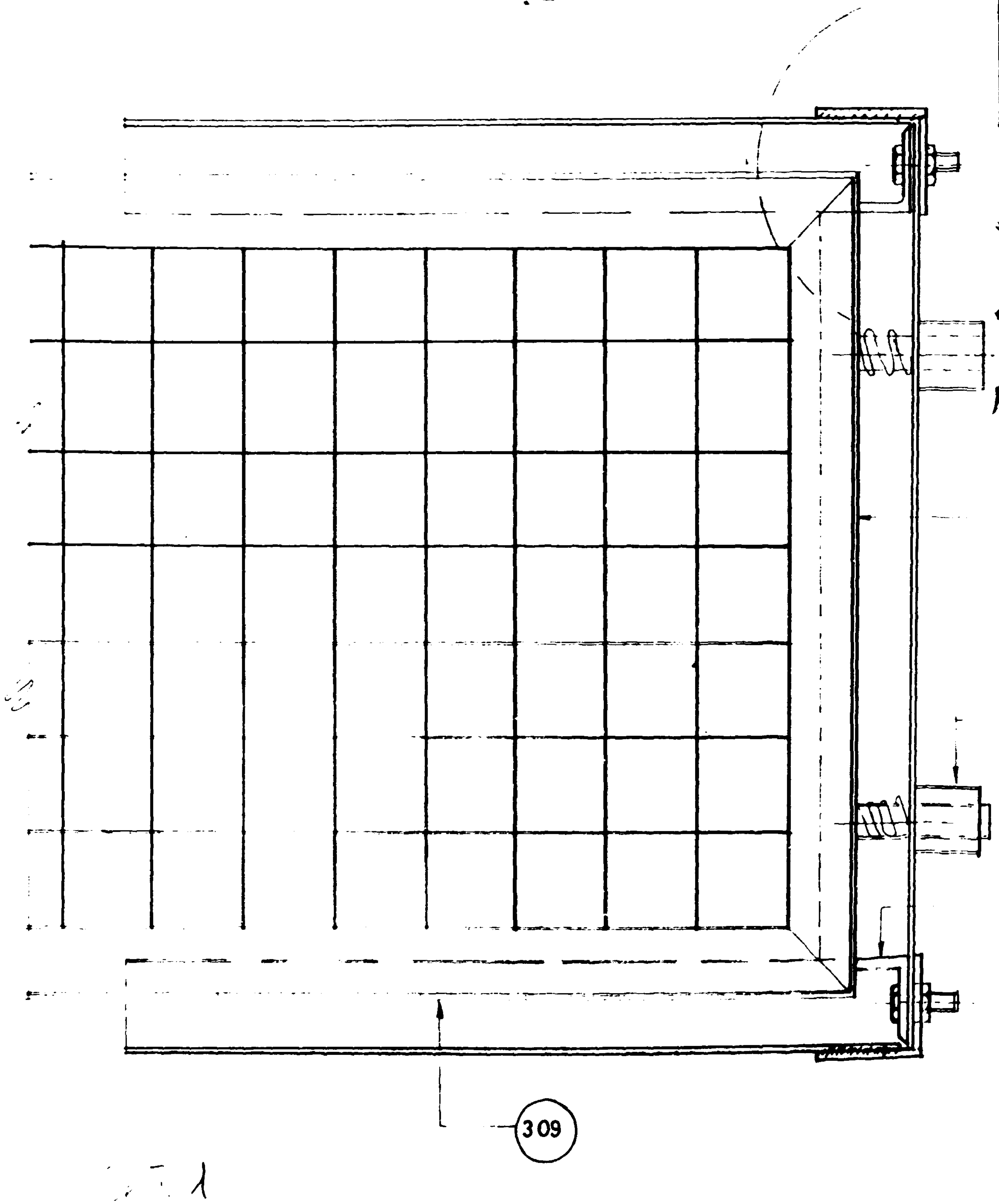

1420
140



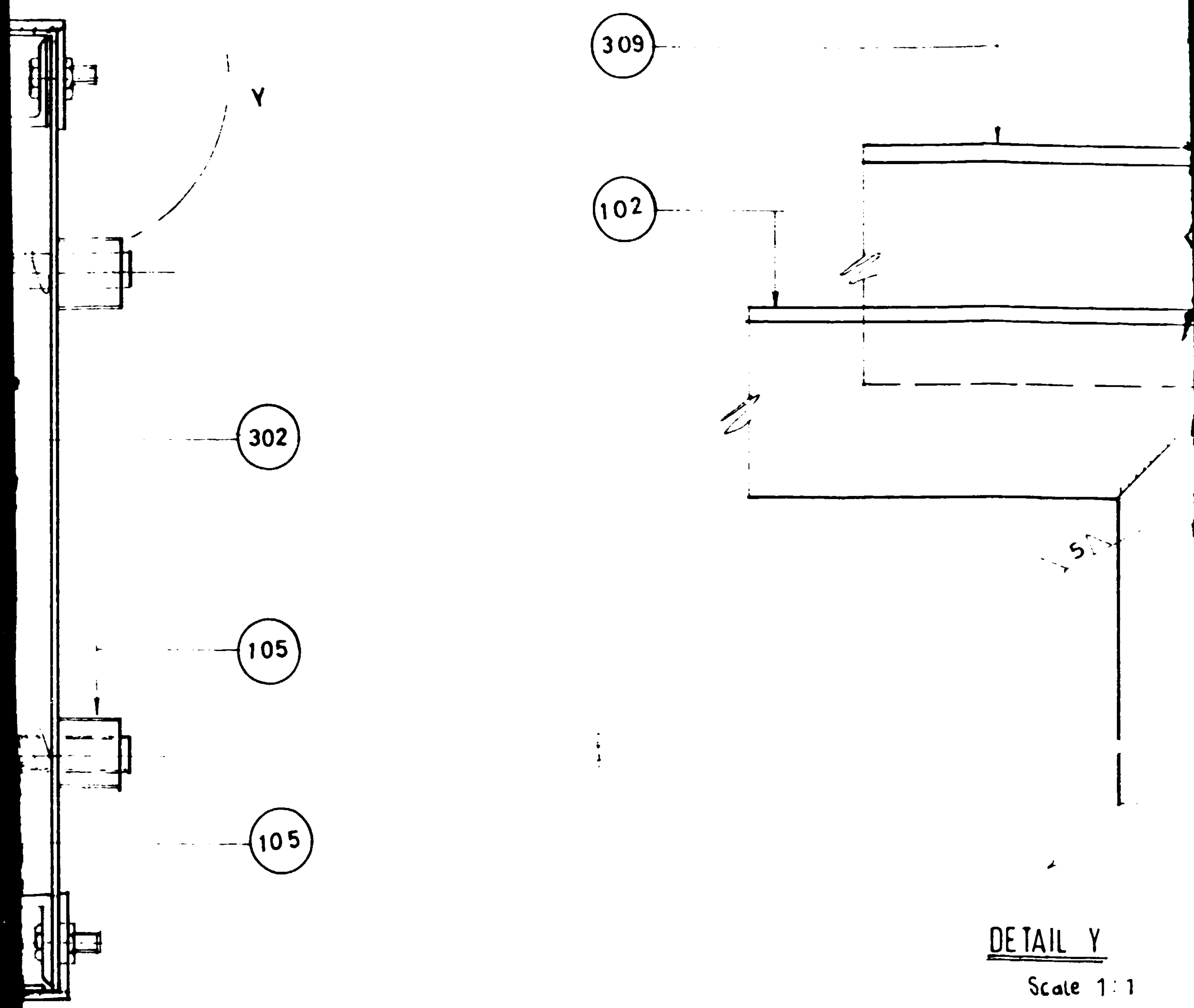
SECTION C-C

AFRIGAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)

AUST DRG REF NO	TITLE
	STRUCTURAL ARRANGEMENT
DRAWN 3/4/88	PROJ REF FIRE

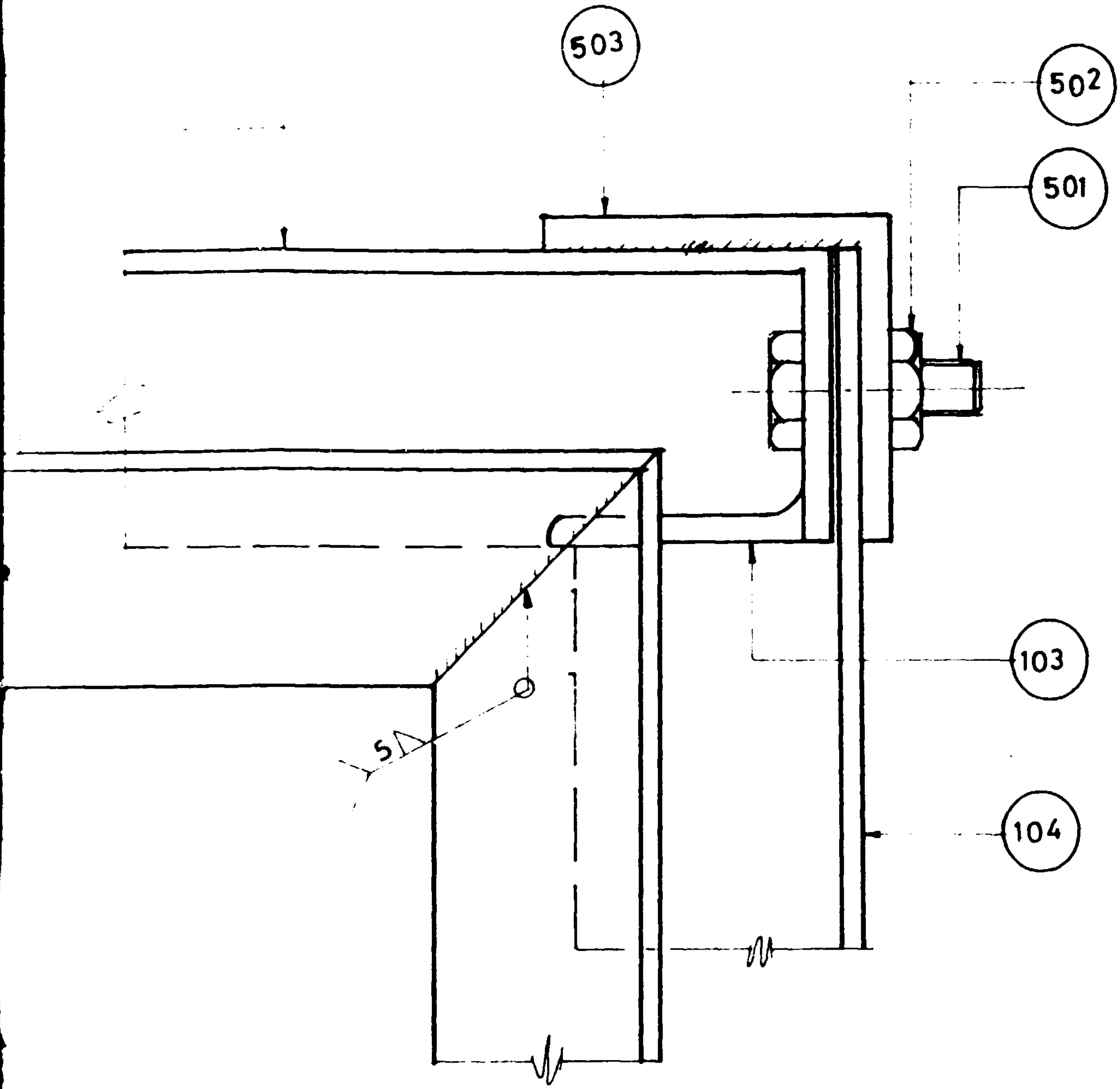


PLAN



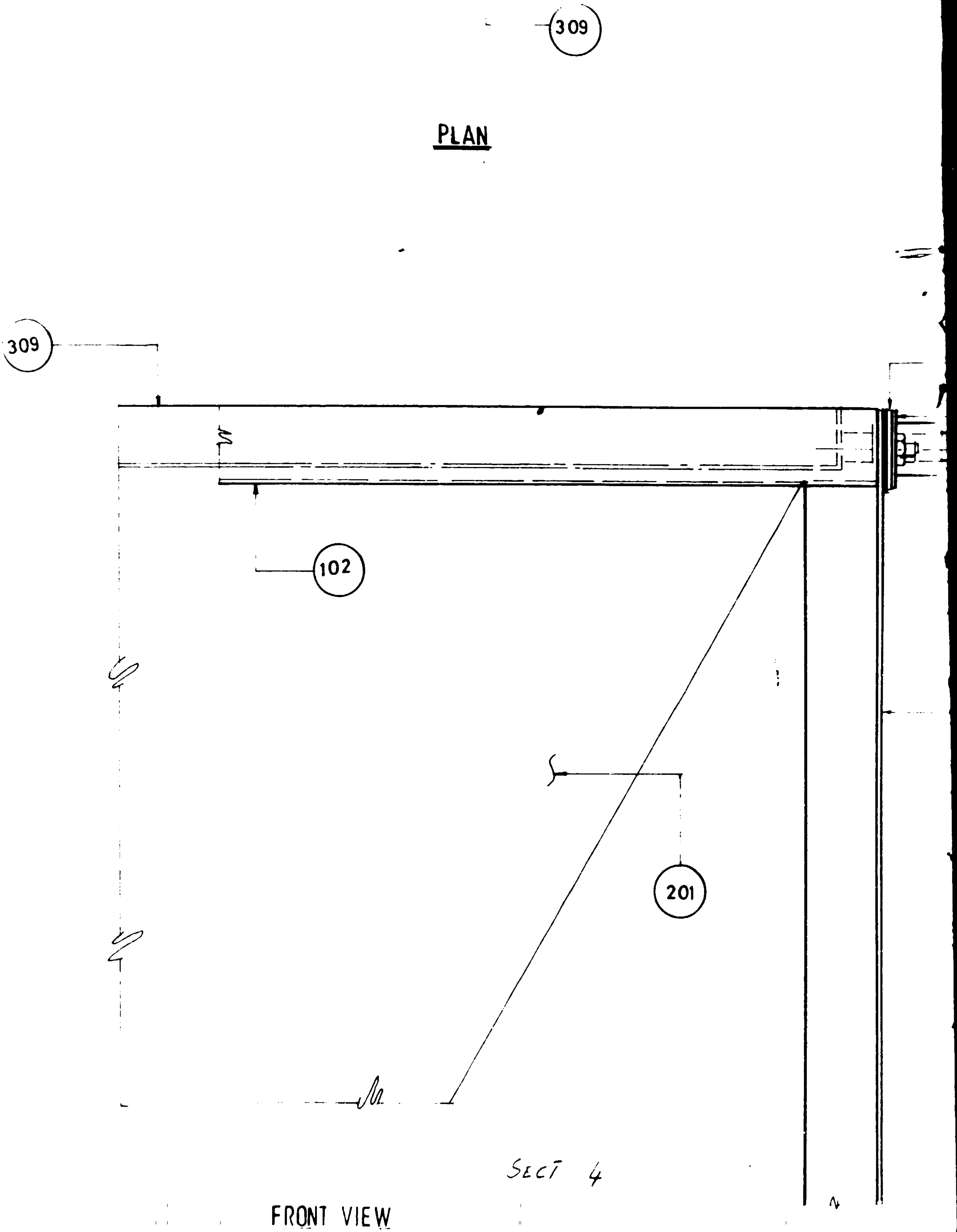
DETAIL Y

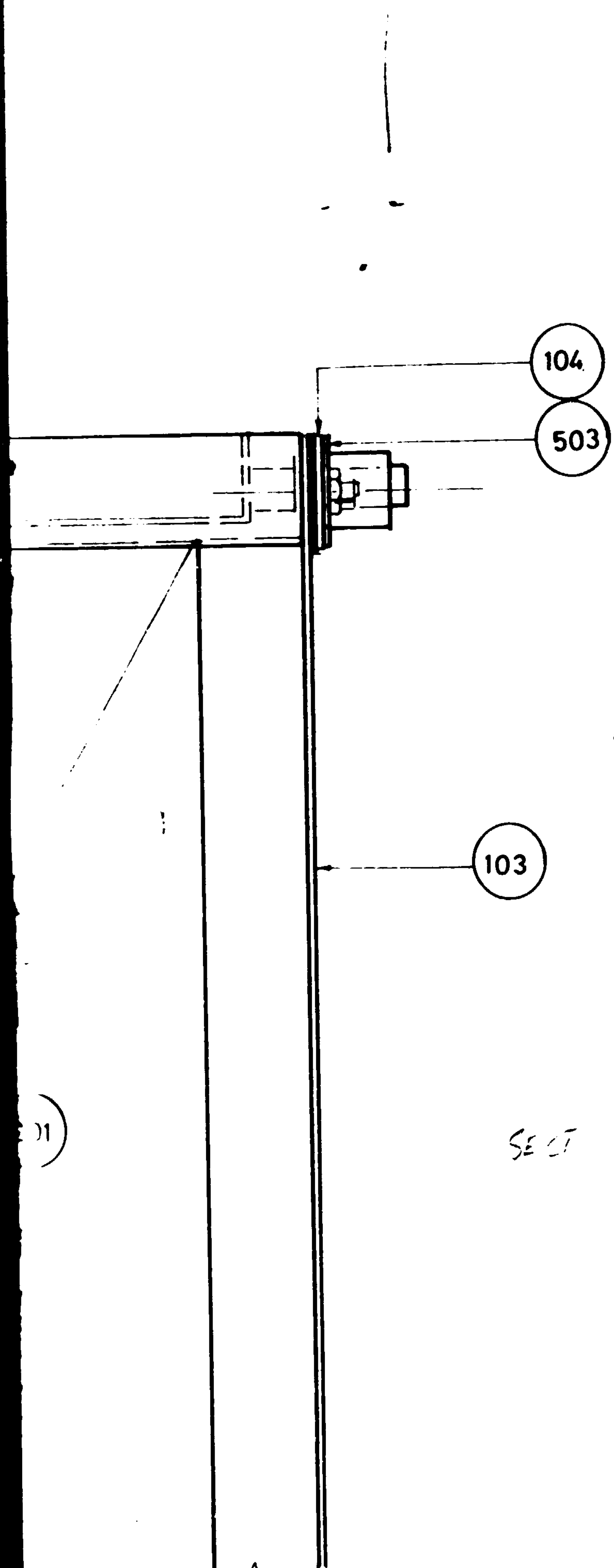
Scale 1 : 1



DETAIL Y

Scale 1 : 1


309
PLAN
309
102
201
SECT 4
FRONT VIEW

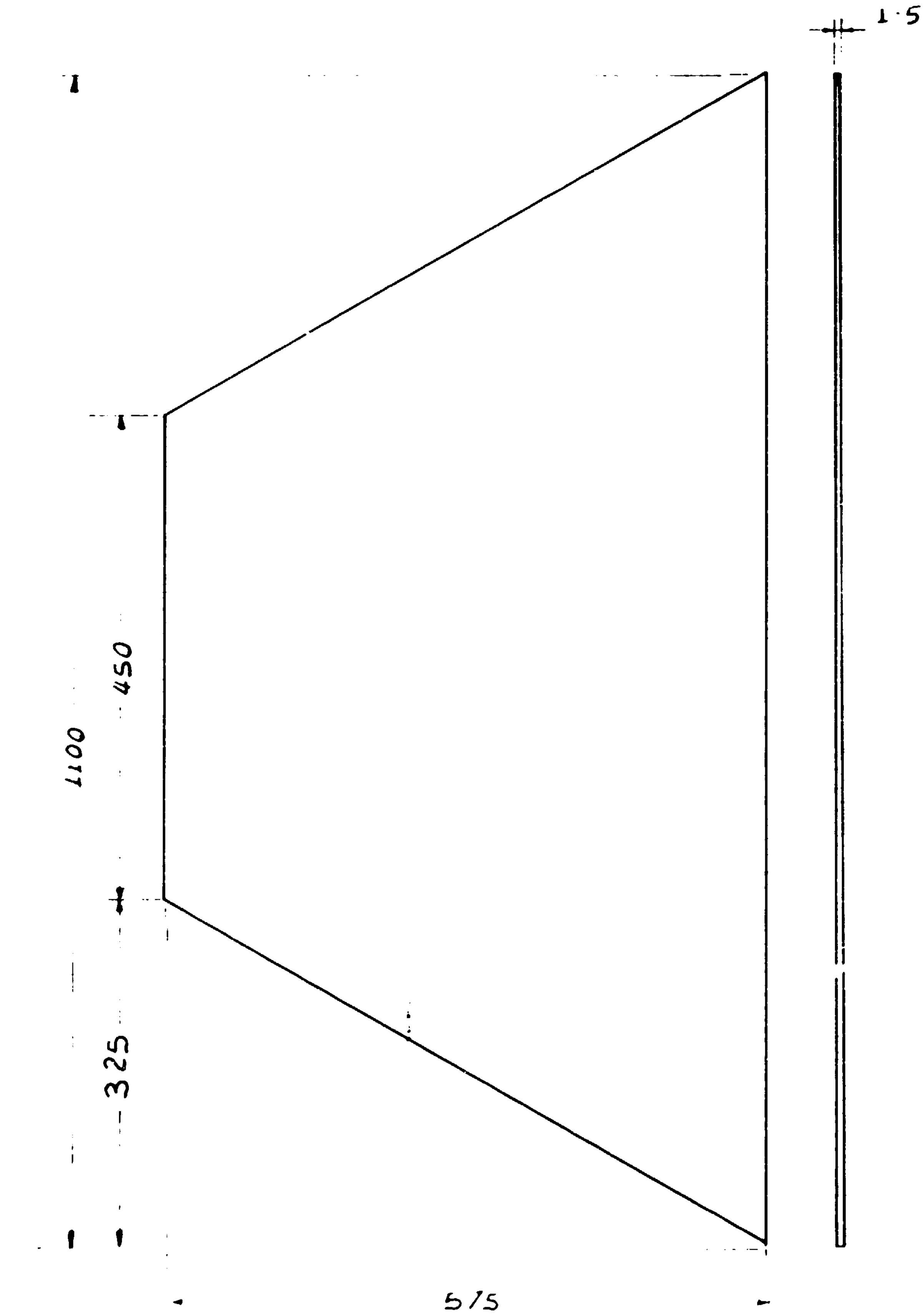


SECT E

SECT 6

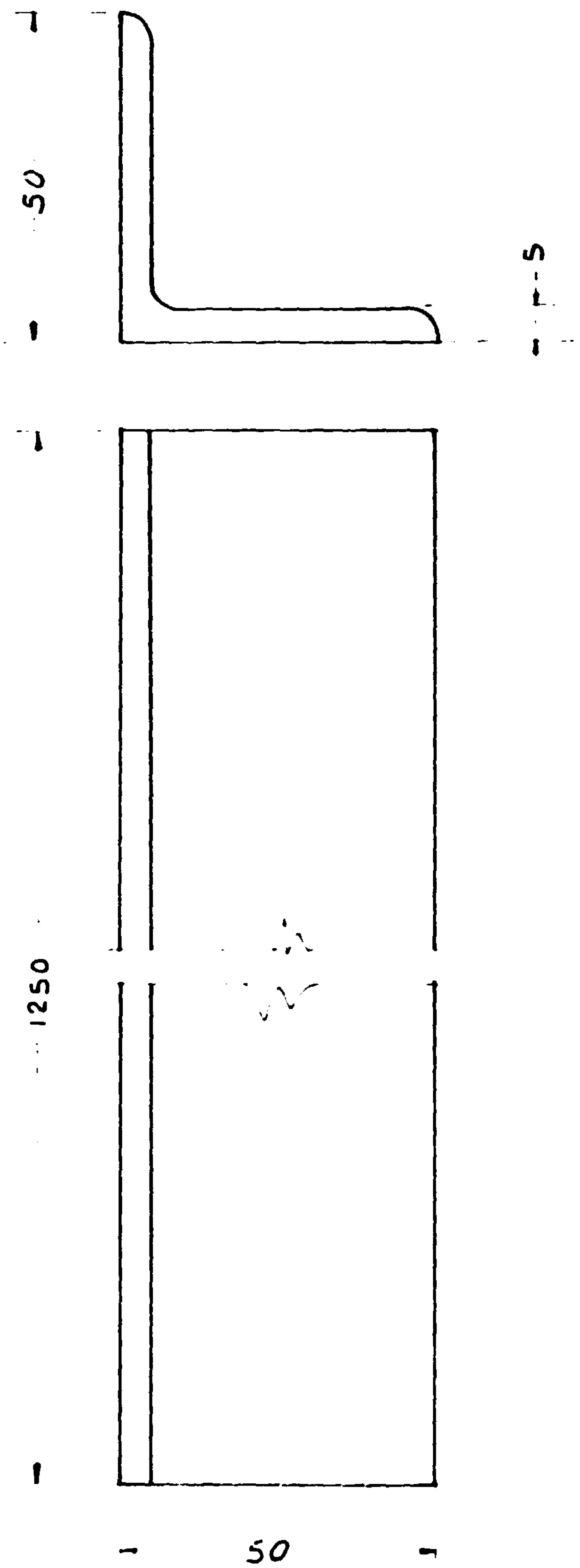
AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)			
ASSY DRG REF NO		TITLE FRAMING SUB-SUB ASSEMBLY	
DWN	A ELUBE	PROJ REF GARI SIEVING MACHINE	OUT 346
CHKD	30/11/88		
APRVD			
DATE	30-3-87		
MATL		DRG NO 300110500	REV 0
SCALE	1:2.5		

ARCEDEM	PROJ. REF	FIIRO, UNIDO GARI SIEVING MACHINE	
SCALE 1 : 5	TITLE	PART DETAIL	SHEET NO 1
DATE AUG 1987	DRG. NO	300110201	NO OF SHEETS

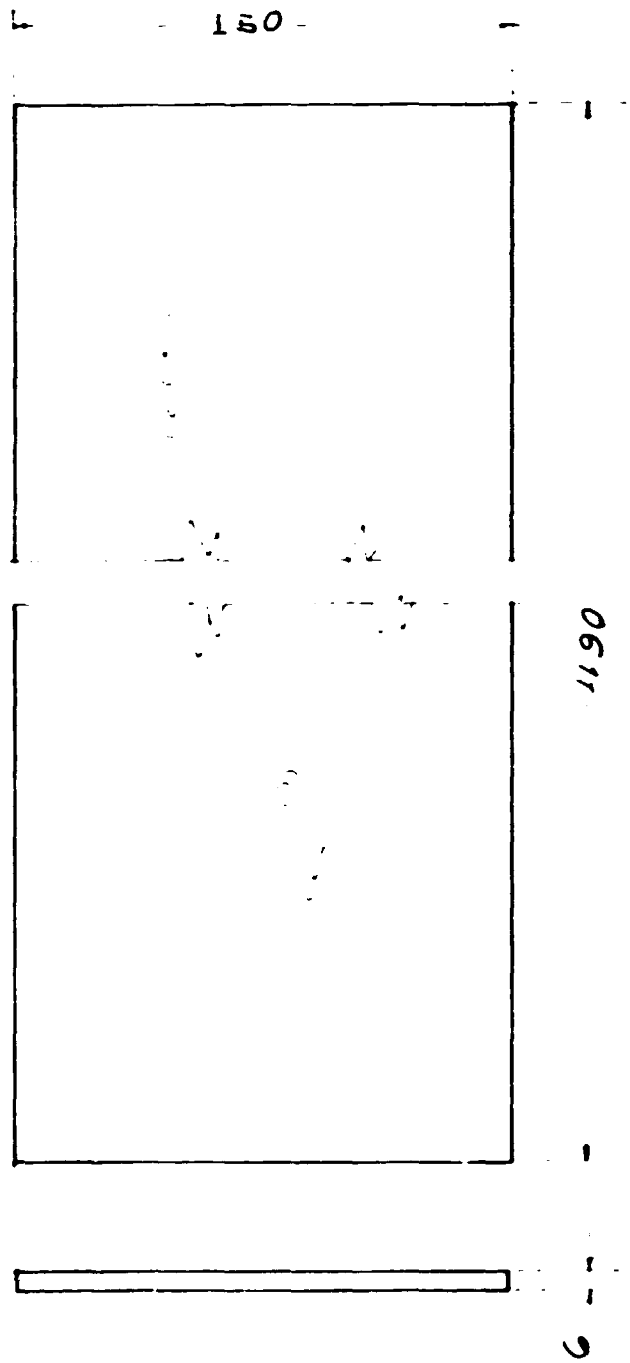


201	PLATE 1·5 × 575 × 1100 LG	2			

ARCEDEM	PROJ REF FIIRO/UNIDO GARI SIEVING MACHINE	
SCALE 1 : 1	TITLE PART DETAIL	SHEET NO 2
DATE AUG 1987	DRG NO 300110101	NO OF SHEETS

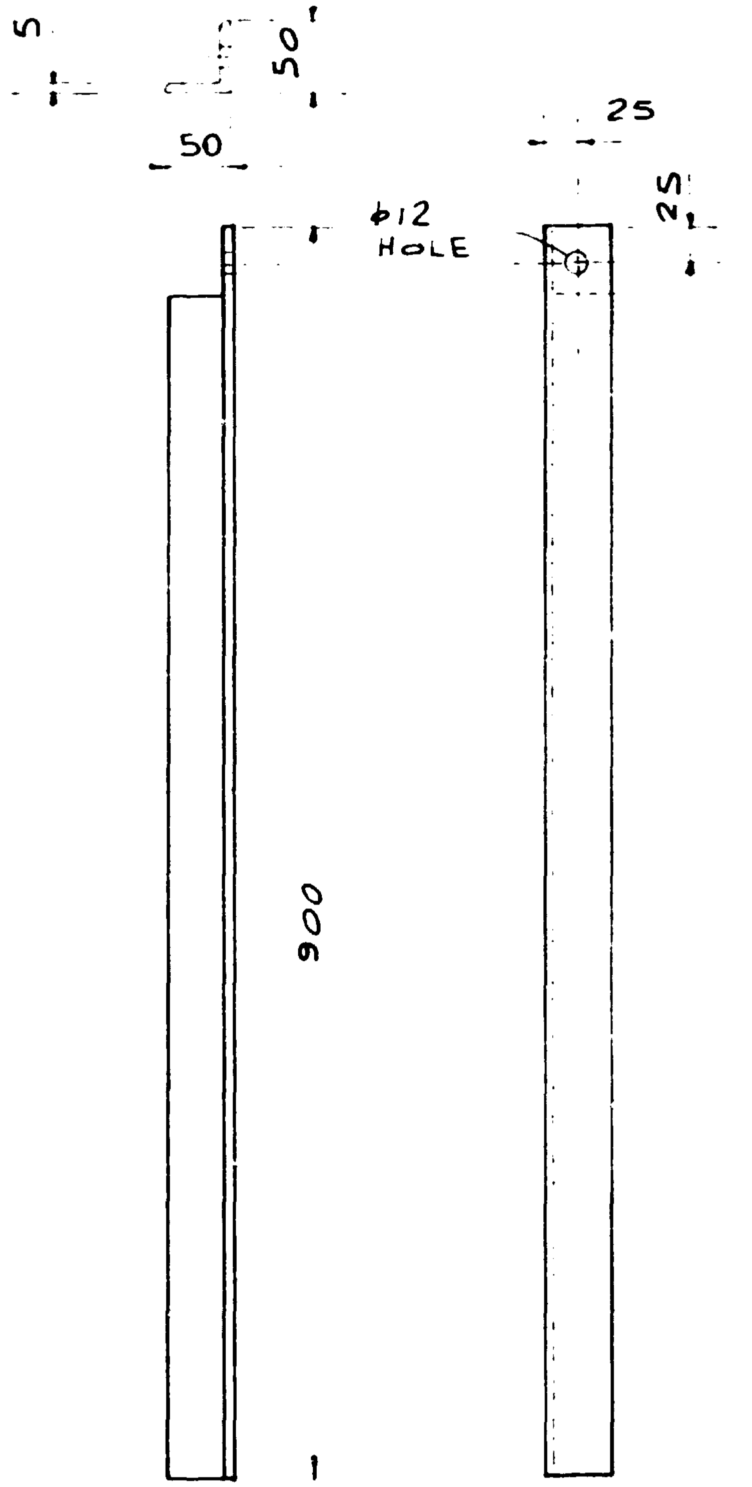


ARCEDEM	PROJ REF FIIRO / UNIDO GARI SIEVING MACHINE	
SCALE 1 : 2	TITLE PART DETAIL	SHEET NO 3
DATE AUG 87	DRG NO 300110304	NO OF SHEETS



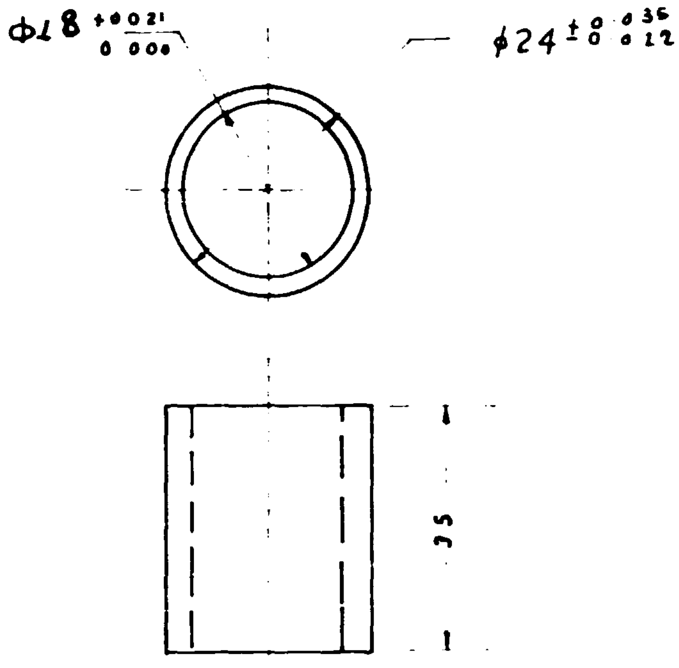
304	PLYWOOD BD 150 x 1190 x 6 THK	2	WOOD			

ARCEDEM	PRJ. REF	FIIRO / UNIDO GARI SIEVING MACHINE	
SCALE 1:5	TITLE	PART DETAIL	SHEET NO [illegible]
DATE AUG 8	DRG NO	300110103	NO OF SHEETS



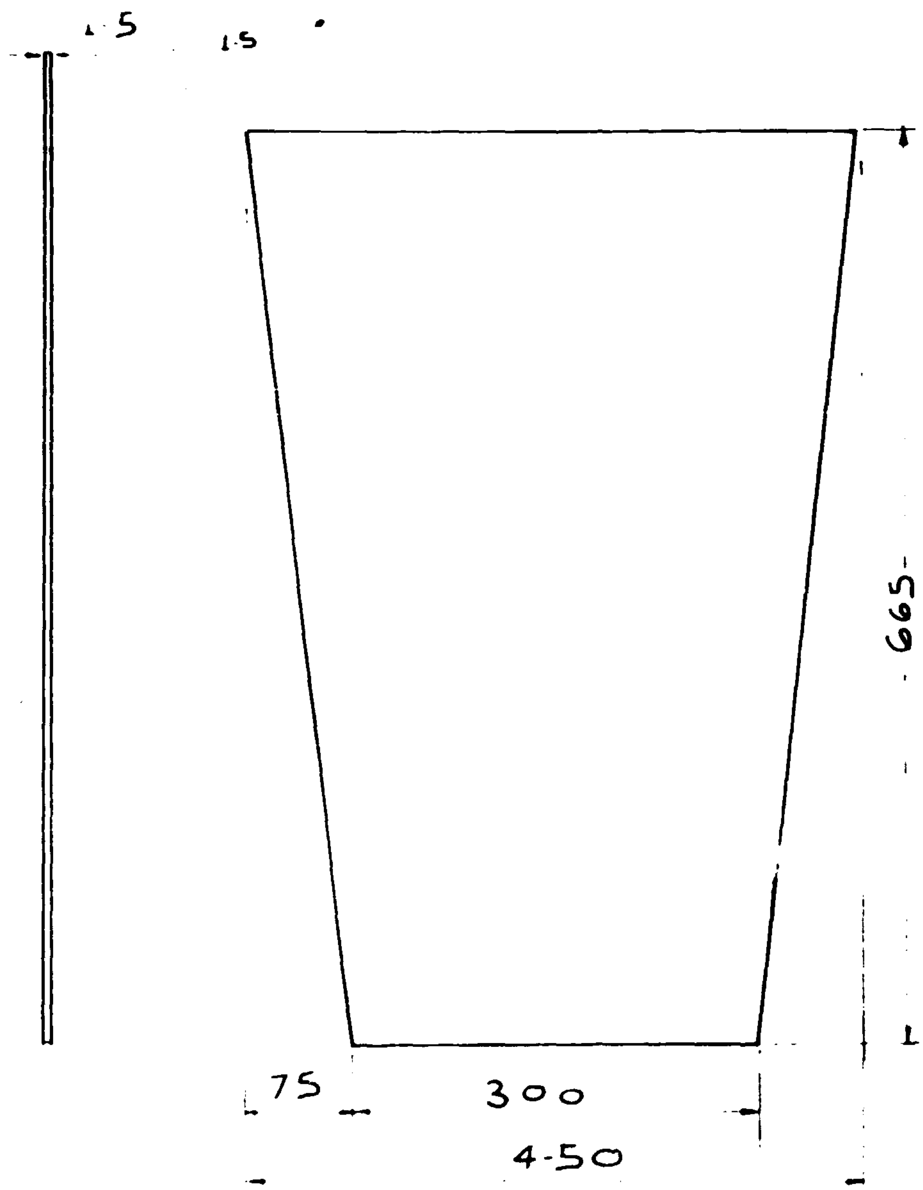
103	ANGLE 50x50x5 x 850LG	4	M.S		
ITEM	DESCRIPTION	QTY	MAT	WT IN KG	REMARKS

ARCEDEM	PROJ REF FIIRO/UNIDO GARI SIEVING MACHINE	
SCALE 1 : 1	TITLE PART DETAIL	SHEET NO 5
DATE AUG 87	DRG NO 30011 0106	NO OF SHEETS



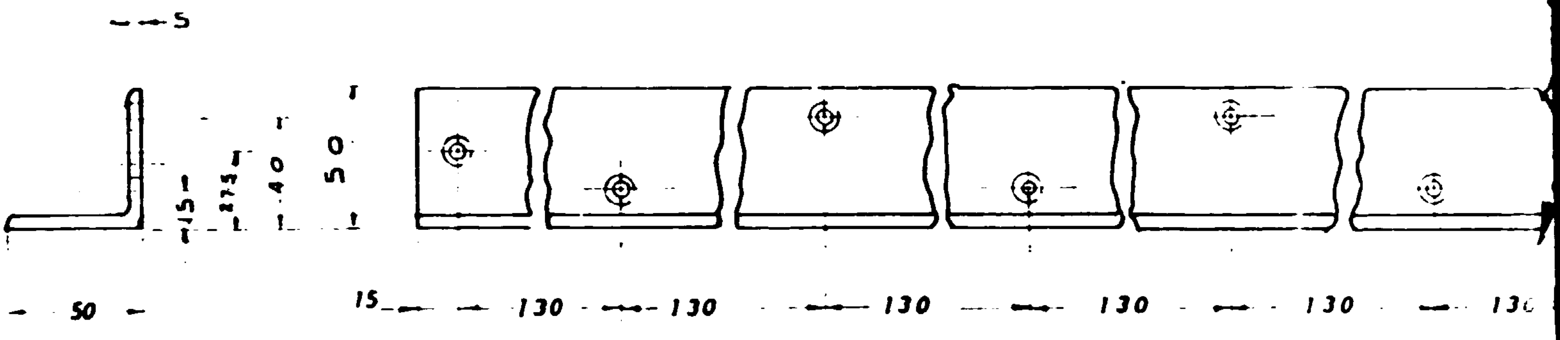
106	BUSHING O D 31 × I D 25 × 35	4	BRASS		
ITEM	DESCRIPTION	QTY	MAT.	WT IN KG	REMARK

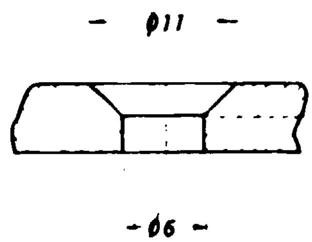
ARCEDEM	PROJ. REF FIIRO/UNIDO GARI SIEVING MACHINE	
SCALE 1 : 5	TITLE PART DETAIL	SHEET NO 6
DATE	DRG NO 300110202	NO OF SHEETS



DEVELOPMENT OF ITEM 202

ITEM	DESCRIPTION	QTY	MATL	WT IN KG	REMARKS
202	PLATE 1.5 x 450 x 665 LG	2	M.S		

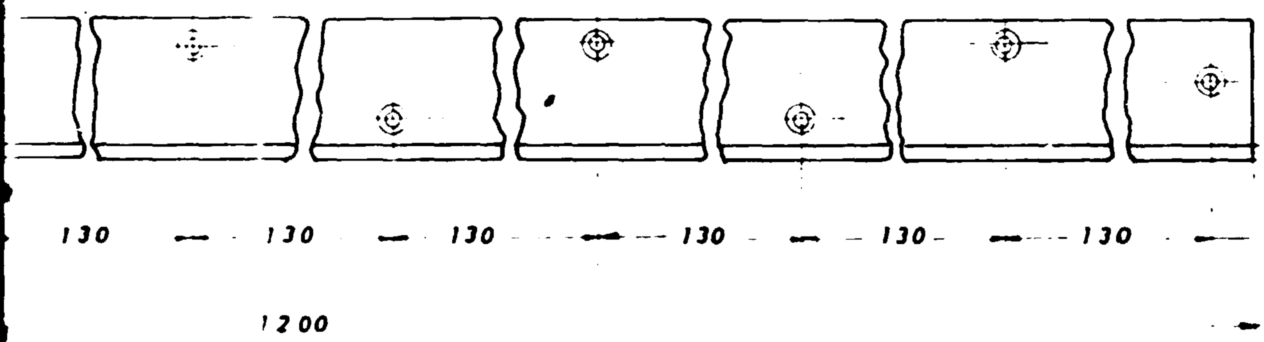


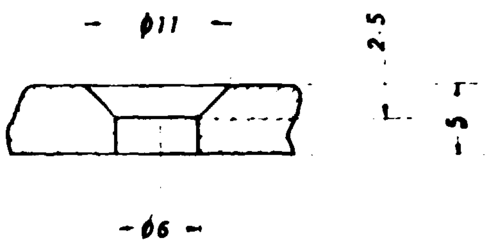


NOTE: ALL TOL. = + 0.1

SCALE 2 :1

		2			
	DESCRIPTION	QTY	MAT'L	WT IN KG	REMARKS





SCALE 2 :1

AFRICAN REGIONAL CENTRE FOR ENGINEERING DESIGN AND MANUFACTURING (ARCEDEM)

DWN CHKD APRVD	J. EGWERENDU	TITLE FIIRO UNIDO/ GARI SIEVING MACHINE (PART DETAIL)
		OUT 348