CHAPTER 7

COMMON LINE PLAN

CHAPTER 7

COMMON LINE PLAN

7.1 PROBLEMS

7.1.1 Map

A map with a scale of 1:25,000 prepared by enlarging a map with a scale of 1:50,000 was used for the present study. The map is contoured at 20 meter intervals but represents neither accurate landform nor altitude of small or local parts.

Although this comparatively old map on the 1:50,000 scale disagrees with the actual conditions in many points, the topography of the area was found accurate as a result of a plain levelling survey conducted between the points M and N (See Fig. 1) on the common line route. This survey was conducted to find out if the slurry can be transported by launder.

Consequently, it was thought that this map was reliable in all respects for the planning work. However, a more detailed map with a scale of 1:5,000 and route surveys are deemed necessary at the final stage of the study.

7.1.2 Location of the Portals of Tunnel and Division of Tunnel Length

As mentioned previously, a 15-km stretch of the tunnel must be constructed passing through the mountain area.

There are private houses, an elementary school, buildings of the Bureau of Forest Development and camping facilities around Camp 4 which should be avoided in the construction of the portal of the tunnel in the area. A small promontory (paddy field) downstream of Camp 4 is selected as the location of the tunnel portal. It is upstream of Bued River bridge and about 10 m above the Kennon Road. It is relatively easy to construct an access road from Kennon Road to this place. Besides, this place is sufficiently wide to afford spaces for excavating the tunnels (two extrances will be required as Philex's feeder line tunnel is also built here) for the junction facilities of the feeder lines and the common line.

The altitude of the tunnel portal is at 610 m SL based on contour lines of the map and the altitude of the Kennon Road Bench Marks.

The tunnel length is about 15 km from Camp 4 to the crossing point at Bued River near Dongon. It should be divided into several sections to reduce the term of construction work of the common line and several tunnel entrance are required. The mountain side area along the Kennon Road has a steep terrain making it difficult to provide any tunnel portal higher than the elevation of the road because construction and maintenance of the access roads leading to the tunnel mouths will cost very high aside from the difficulties of transporting personnel, machinery, materials, waste etc.

Therefore, the elevation of the tunnel portal should be as close to that Kennon Road as possible. Difficult problems will then arise due to the very limited location of the tunnel mouth because of steep terrain so that it is desirable to locate the tunnel portal at the same level with the Kennon Road to save the cost of tunnel development.

These problems could be solved by the adoption of an underground fall, which makes it possible to select a good location for the tunnel portal and provide adequate division of working sections as shown in Fig. 2.

7.1.3 Location of Underground Fall

As mentioned previously, it is planned that the slurry transport should be gravity and any excess head be taken care of by the underground fall.

The underground fall should be built in rigid rock. If vertical holes of the underground fall is opened through soft rock, concrete lining or steel walling is necessary to protect the walls of the hole from the falling slurry. This will make the total cost of construction very expensive.

Therefore, a rock location having a higher wear resistance than concrete must be selected for the underground fall under the limited conditions of tunnel level, landform and nature of rock.

As mentioned in Chapter 4, the area from Camp 4 to the crossing point at the Bued River consists of metavolcanics in the vicinity of Camp 4, over which there are layers of sedimentary rock of comparatively younger stage dipping toward the west at 15 - 25°. These layers of sedimentary rock are mostly conglomerate and partially limestone. At the western part are layers of sandstone and siltstone formed in the later stage.

The harder these rocks are, the older is the stage when they were formed. Rocks at various places were sampled and brought back for compressive strength tests. The field compressive strength tests using Schmidt Hammer (simplified device to measure the strength of concrete) were performed on rock beds along road cuts in the Kennon Road. The results shown in Table 4-3 show that the compressive strengths of rocks around the proposed location of the underground fall about 6 km away from the starting point of the common line (see Fig. 2) is sufficiently high (more than 500 kg/cm^2).

The vertical hole of the underground fall is cylindrical with a diameter of 550 mm. Two holes (one is spare hole) will be constructed at the depth of about 200 m.

Before the final study, check boring is necessary to determine rock alterations, strength, faults, spring water, etc. in the site of the underground fall.

7.2 ROUTE OF COMMON LINE AND SYSTEM OF SLURRY TRANSPORTATION

7.2.1 Outline of the Common Line Route

As mentioned in Chapter 5, the common line is divided into two (2) parts, the upstream part in the mountain area and the downstream part in the plain.

One plan for the tunnel route in the mountain area and two (2) plans for the north and south routes in the plain area included (See Fig. 1).

The features of the two (2) planes for the plain route are:

(1) The north route plan can employ either launder or pipe line. If the launder line is laid up to the seashore, pumping is necessary to transport the slurry to the reclamation area in the sea through the pipe line.

(2) The south route plan can only employ the pipe line as the plain has an average gradient of 0.7%. However, transport of the slurry by gravity is possible over a distance of more than 10 km from the seashore.

As a result of the overall review of the two plans on their economy, ease of maintanance and relation with the sea area, the following plan is recommended (Figs. 1 and 2):

"The north route plan should be adopted for the plain; the pipe line for crossing the Bued River, the launder line from the Bued River to the tunnel at the sea coast mountain (Fig. 2. between point M and point N), and the pipe line from the sea coast mountain tunnel to the sea area. The slurry flows to the sea area by gravity utilizing the head of the upstream pipe line".

7.2.2 Mountain Area

(1) Information from the tunnel civil engineer

Figs. 1 and 2 show the route in the mountain area. The results of the geological survey in this area and knowledge of the tunnel civil engineering are summarized as follows:

a. The upstream area of the tunnel route has a very steep terrain which is still being sharply eroded. The downstream sedimentary rock is comparatively recent and soft. Therefore, the terrain more than 10 km down Camp 4 is a little more gentle but weathering is faster than erosion and is vegetated.

b. The weak lines of the rock formation crossing the Bued River have been eroded and formed valleys which generally have a large water catchment area and retain water stream even during dry seasons.

Some upstream valleys of the Bued River have cascades owing to the steep terrain and the valleys usually have giant boulders in the stream. This means that large boulders flow down with the muddy torrent when it rains heavily. It will be difficult to construct the piers in the stream valley for any structure traversing it.

c. In the upstreams valleys, fresh rocks are exposed in the riverbed and the ones made of weathered rock increase in the downstream valleys. Therefore, the overburden above the tunnel passing under the riverbed valley should be more than 30 meters thick at the upstream portion and more than 50 meters thick at the downstream.

d. The Kennon Road has been constructed by cutting through steep valleys and its mountain side is mostly cliffs. Some steep, narrow paths are avilable from the Kennon Road into the mountain but if the tunnel portal is placed at a mountain slope far above the Kennon Road, construction and maintenance of access road from Kennon Road to the tunnel portal will be very expensive and toilsome.

e. The conglomerate around Camp 3 has many week joints which cross at right angle to the direction of the tunnel. The rocks at this area are weathered. The Kennon Limestone is exposed downstream of this area. The limestone is a chemically weak rock and is likely to have formed dorines or sink holes. Therefore, an adequate thick overburden is necessary for the tunnel development through this district.

f. As shown in Table 4-3, the compressive strengths of rocks are more than 1,000 kg/cm^2 for metavolcanic rocks near Camp 4, more than 500 kg/cm^2 for conglomerate within a range of about 10 km from Camp 4, 300 kg/cm^2 a comparatively soft conglomerate in the down stream area and 1,000 kg/cm^2 for the fresh limestone.

There are many fissures in the hard rock area, and comparatively few intrusive dykes, large faults, etc. in the mountain area which may cause obstacles when the tunnel is excavated. Generally speaking, the nature of the rocks in the mountain area is one where a tunnel can be developed easily.

g. From the conditions of faults and fissures in this area and the geological conditions of mines in the Baguio district, it is expected that the largest amount of underground water, about $1m^3/km$ in the tunnel will come from the metavolcanics. Water from the older conglomerate and limestone will be relatively small. Underground water is estimated to be little from the young rocks around Dongon.

(2) Selection of tunnel route and slurry transport system

The basic problem in the selection of the tunnel route is whether the tunnel should be detoured to pass under a valley encountered on the way of excavation or should be made to pass the ground surface by providing a tunnel portal on the slope of the valley.

Considering that the mountainous area is steep, undergoes conditnuous erosion and receive heavy rainfall, it is difficult to construct a causeway across the valley by the use of waste obtained from tunnel excavation and use the causeway as the passage of the transport line. To traverse the valley, the line needs a bridge constructed on piers with a comparatively wide span. In addition, the tunnel portal should be reinforced with concrete lining to protect it from rolling stones. A problem is posed since these works require another group of workers with different technical skills from those in the tunnel excavation group so that the latter group has to suspend the excavation while these works are being made.

In view of the foregoing, it is recommended that the tunnel be passed underground below the valleys though its length will be slightly increased.

The tunnel will have six curves. The radius of curvature is to be 100 m based from the requirements of the excavator used.

The tunnel route in the mountain area is divided into three parts: upper tunnel, underground fall, and lower tunnel. The scheme of the tunnel route is shown in Fig. 1 and 2.

The launder system is adopted for all the route within the tunnel which has a gradient that allows the slurry transport by gravity. Both top and bottom of the underground fall are open and the slurry drops by gravity. For the ground surface downstream, a drop box and launder are provided for the exit on the lower portion of the tunnel.

(3) Tunnel timbering

It is one of the basic policies in the selection of the route to avoid as much as possible the use of heavy supports such as concrete lining. Table 7-1 shows the timbering ratio and length of each working section which have been anticipated from the geological survey, rock strength tests and conditions of the selected route.

Before finalizing the design, it is necessary to make borings, exploration by seismic methods, geological survey, etc. in order to improve the accuracy of the estimated timbering ratios.

7.2.3 From the Plain to the Sea Coast

(1) Landform

The rock formation from Bued River to the seashore is younger than that of the mountain area and is referred to as the Rosario Formation which comprises of soft conglomerate, sandstone and siltstone.

Table 7-1: Extension and Proportion of Timbering

Working Section	Extension (proportion)	No timbering	Shotcrete	Steel Timbering	Concrete lining	Total
No.1	m (%)	2,110 (87.9)	120 (5.0)	120 (5.0)	50 (2.1)	2,400
No.2	m (%)	1,670 (72.8)	230 (10.0)	350 (15.0)	50 (2.2)	2,300
No.3	m (%)	1,390 (72.4)	190 (10.0)	270 (15.0)	50 (2.6)	1,900
No.5	m (%)	1,690 (68.0)	380 (15.0)	380 (15.0)	50 (2.0)	2,500
No.6	m (%)	1,630 (67.9)	360 (15.0)	360 (15.0)	50 (2.1)	2,400
No.7	m (%)	1,190 (48.0)	630 (25.0)	630 (25.0)	50 (2.0)	2,500
No.8	m (%)	540 (33.7)	480 (30.0)	480 (30.0)	100 (6.3)	1,600
No.11	m (%)	-	-	720 (60.0)	480 (40.0)	1,200
Total	m (%)	10,220 (60.8)	2,390 (14.2)	3,310 (19.7)	880 (5.3)	16,800 (100.0)

Note: The No.4 working section is underground fall

The area is folded along a north-south axis and weathered and eroded. The remainder of comparatively hard portions has formed a north-south ridge west of Apangat River. West of this mountain, there are hills and another north-south ridge 80 to 100 m above sea level along the sea coast.

West of Bued River is an alluvial fan which grandually descend to the southwest.

The ridge nearest to the Lingayen Gulf has east-west fractures which have been eroded near Rabon and about 4 km south from it and have become rivers.

(2) Selection of the route

If any route except that along a river is selected for the common line in the sea coast portion where the slurry can flow by gravity, a tunnel with a length of 600 - 800 m is necessary to cut across the coastal mountain. Construction, however, will be very expensive due to the soft ground.

The route by the river will pass along a fault. The major active fault which traverses Luzon Island can be avoided. As there have been no troubles in the past in railways and highways laid along or across these faults, it will be also safe for the slurry transport line to be laid there.

A comparative study has been made between the north route which terminates near Rabon and the south route which ends near a river about 4 km south of Rabon (See Fig. 1).

The advantage and disadvantage of the two routes are:

a. North route plan

(a) Advantages:

i) From Bued River to the sea coast, either launder or pipe line can be laid. It was confirmed by levelling made that the area between points M and N shown in Fig. 2 has an average gradient of 1.25%.

ii) This is the shortest route to the seashore.

(b) Disadvantages:

i) A 700 meters bridge thru paddy fields will be needed to cross Bued River.

ii) As the route passes substantially through central part of the plain, any trouble during operation would have a considerable effect on the surrounding areas.

iii) A tunnel passing directly below the paddy field west of the Apangat River is necessary.

b. South route plan

(a) Advantages:

i) An existing bridge can be utilized for the route to cross the Bued River. However, the bridge has little room for any additional loading that it will be necessary to build a new bridge along it.

ii) There are few problems in the excavation of a tunnel through the west ridges of Apangat River.

(b) Disadvantages:

i) Launder lines cannot be used as the gradient is only 0.7%

ii) This route is about two (2) km longer than the north route.

A big advantage common to both plans is that any rising gradient can be avoided.

If the pipe line system is adopted in both plans, the slurry can be transported by gravity to the sea area by utilizing the head at the upstream line portion. The construction cost will be slightly higher for the north route. In both plans, the length of time for construction in the plain is shorter than that in the mountain area.

The launder line is more favorable than the pipe line in both construction and operation costs. In the north route plan, the required gradient of 1.25% can be maintained over the entire length of the launder line. If the launder system is adopted for the plain in the north route plan, the construction cost is substantially equal to and the operation cost is cheaper than those for the pipe line in the south route plan. Further, the location of the line outlet in the north route plan is more convenient with respect to the reclamation area in the sea. Therefore, the north route plan is suggested to be adopted.

(3) Transport system of slurry

In the north route, the launder line can be used for slurry transportation over the entire route up to the sea coast. Pumps are however, needed to carry the slurry from the coast to the reclamation area in the sea. The required length of the pipe line from the sea coast to the offing to accomodate the volume of tailings to be dumped in 20 years is about 6.9 km.

Table 7-2 shows comparison of the construction and operation costs between the combined systems of launder, pump and pipe, and the pipe line system, laid from point N to the sea area (Fig. 2). It is clear that Table 7-2 that both construction (including the cost for making a emergency pond near the pump station) and operation costs are lower when the pipe line system is used from point N downward.

From point N toward the offing, the slurry can be transported by gravity 6.9 km or more at the maximum slurry flow rate which is the farthest distance of the dumping point.

Table 7-2 Comparison of Construction and Operation Costs between Combination of Launder, Pump and Pipe Line, and Pipe Line only

	launder, pump and pipe	Pipe line system
Construction cost	x 1,000 ₱ 23,300	x 1,000 ₱ 20,226
Operation and maintenance cost	x 1,000 ₱/year 2,691	x 1,000 ₱/year 2,472

The pipe line system is lower in both construction and operation costs. See Appendix A-7-1 for details of these costs.

Another plan is proposed to use of the pipe line for the entire route from the Bued River crossing downward. This plan however, will further lengthen the distance of slurry transport by gravity from the sea coast toward the offing and hence will be too expensive to be adopted.

It will also be necessary to consider meausres to prevent entry of any foreign matter into the launder line at the plain part.

The Bued River should be crossed by pipe line because it can be laid horizontally so that the height of the piers can be maintained approximately equal and because it has a smaller unit weight than the launder line so that piers with lower bearing strengths can be used.

For pipe line, each pier will be about 8 m high while for a graded launder line, a pier at the starting point to cross the Bued River will be about 16 m high and will be very expensive.

When the Bued River is crossed by a horizontal pipe line, the required head of the pulp column to send the slurry through this line section is 7 m. The 22-meter head at the point L (Fig. 2) is enough to meet the required head.

7.3 DESCRIPTION OF THE COMMON LINE

Fig.2 shows the arragement of the common line facilities. Of the total length of 26 km, horizontal tunnel and underground fall is 17.0 km (including 0.6 km of access tunnel), or about 65% of the total length.

The common line up to the sea coast of the Lingayen Gulf will include the launder line (19.7 km) and the pipe line (6.3 km), the respective ratios to the total legnth being 76% and 24%.

The facilities attached to the common line are summarized below:

The common sump is provided at the tunnel portal at point A in Camp 4 in order to connect the three (3) feeder lines (Philex's will be launder line and the others', pipe lines) with the common line. The flow meters, density meters and strainer to remove foreign materials from the slurry flow will be provided there including equipments to collect the valley water and spring water from the feeder line tunnel which are used for washing the launder and the facilities.

The tunnel is graded 1.25% and has a launder line laid therein. The underground fall will be constructed between points E and F, plus an additional tunnel from Point E to the mountain slope E'for ventilation and for discharging the underground water from the tunnel.

The facilities are provided upstream of Pellemell Creek (points G and H) to collect and supply water to the pipe line in order to maintain the critical flow speed when the slurry flow therein decreases. This valley has a wide catchment area and can supply a sufficient volume of water even during dry seasons.

A emergency pond with a capacity of 30,000 m^3 is provided near the tunnel portal at point J. The excess head of 40 m between points J and K will be absorbed by drop boxes.

The Bued River will be crossed by horizontal double pipe lines. Drop tanks will be for the head of 22 m between the tunnel exit and the river-crossing pipe in order to give the pipe line gravity head. Another strainer will be provided near point L to remove foreign substances. A water tank with a capacity of 150 m^3 will be provided at the point L to wash the pipe line during emergency.

The pipe line will cross the highway at the final section crossing Bued River. A culvert made of reinforced concrete will be put under the highway to pass the line. The launder line will pass between points M and N on the plain and will be supported mostly by stands about 6 m high from the ground.

An emergency pond with a capacity of 15,000 m^3 will be provided before the Apangat River.

A tunnel will pass in the section represented by points N-O-P. A small under,round fall with a depth of about 40 m is provided at points N-O. The reasons for providing the vertical head are the high construction cost for a horizontal tunnel driven under the eastern low slope (used as paddy field) of the mountain and the relatively convenient position of the tunnel portal on the west side of the mountain. The vertical head provides the head to the pipe line. The underground fall provided at pints N-O is made of concrete and consists of three (3) sections: two vertical head works to communicate with the two (2) pipe lines, and one as manway equipped stairs (See Fig. 18).

A strainer will be provided at point N to remove foreign matter. From point O downeard is the 10-km pipe line extending up to the sea area.

The required volume of water used for washing this pipe line will amount to 10,000 m^3 at one time. A considerable expense will be needed to construct a water tank of this size to accommodate this volume of water. Therefore, pumps from Apangat River will supply water to the pipe line. The pump used for this water supply will have a capacity of 0.6 m^3/sec. x 12 m x 130 kw.

A pair of pipe line will be laid through the tunnel O-P. The tunnel section will be similar in shape and dimension as that in the mountain area and its gradient will be at least 0.5% to discharge the spring water therefrom.

From point P to point Q, are pairs of horizontal to -0.5% gradient pipe lines, provided with drop tanks at curved points. It is planned that the pipe line passes under bridge of highways and the National Railway.

Recommendations

During the route survey, it was noticed that areas along the common line route have poor irrigation facilities. Tobacco and other dry field crops appear to be cultivated on a large portion of the area during dry seasons. Some fields are left uncultivated. Considering that the Philippines has recently been importing rice from abroad and her land is most productive when rice is cultivated, it is suggested to add to the common line some irrigation facilities so that rice can be cultivated at these fields during dry season. In providing such irrigation facilities to the farmers the Government will obtain more cooperation from them in purchasing the site required for the Project.

The pump provided at the Apangat River for washing the pipe line and the 5-inch diameter pipe line used for excavating the tunnel from point G to point N can provide water at intakes at the required points along the pipe line. Calculations show that water in this line up to 1,000 ton/day could be taken and utilized for irrigation.

7.4 SPECIFICATIONS OF MAIN FACILITIES

7.4.1 Tunnel Section and Equipment Arrangement

Fig. 7-1 shows the arrangement of equipment within the tunnel section. A launder line is laid in the tunnel on the left side viewed downstream because spring water easily discharges from the tunnel. The clearance between the launder line and the left side wall is 25 centimeters. This part serves as the drain passage of the spring water. Drain pipes are laid under the launder line from this drain passage to the main spring water ditch on the opposite side at intervals of 50 meters.

The launder is placed 164 cm from the right-hand side wall. The rail used for excation is shifted to this space and used for a 0.6 ton mini-battery locomotive for patrol use. The size of the 0.6 ton mini-battery locomotive is approximately 90 cm wide, 100 cm high and 120 cm long which will be suitable for patrolling. This is also available for carrying light materials for repair work.

Two locomotives are necessary during the operation of the common line, one to patrol a 6-km distance from the portal of tunnel (point A) at Camp 4 to point E' and the other for about 7-km distance from point J to Point F.

If the spring water in the tunnel is excessive, a side ditch may be provided. A5" pipe shown at the lower right-hand part of Fig. 7-1 is suggested for tapping irrigation water.

A pair of pipe lines is laid through the tunnel in the sea coast (points O-P). The arrangement is shown in Fig. 9-4. A monorail is provided on the tunnel ceiling for use changing of pipes, etc.

The tunnel measures 1.1 km and partrol within the tunnel will be made by foot.

7.4.2 Launder Line

Based on the following computations, the launder should be 0.65 m for inner width, 0.9 m for depth, 0.3 m for the bottom thickness, 0.13 m for side wall thickness and made of reinforced concrete.

(1) Flow rate

Average flow:	0.78 m^3/s
Max. flow:	1.05 "
Min. flow:	0.5 "

0.225 m^3/s (average flow of tailing slurry from the other 5 mines) when PHILEX has shut down their mill plant.

(2) Gradient: -1.25%

(3) Shape of launder section

Semi-cricle bottom shape is desirable so that slurry can easily flow when velocity of flow decreases. Having a large thickness against wear, the bottom will be shaped into a quasi-semicircle so as to be easily repaired (See Fig. 7-2).

(4) Dimensions of launder section

Among the various formulas to determine the flow though the launder, the Manning's Formula is used. It was also used by Marcopper during their design work of their launder line. The coarseness coefficient used by Marcopper is n = 0.014 and was also adopted in this deisgn.

Manning's Formula:

$$Q = \frac{1}{n} AR^{\frac{2}{3}} I^{\frac{1}{2}}$$

Q : Flow rate, m^3/s

n : Coarseness coefficient, 0.014

A : Fluid sectional area, m^2

R : Dynamic water radius, m

I : Gradient, 0.0125

Width of the Launder

The width of the launder is 0.61 m in Marcopper (maximum flow rate: 1.0 m^3/s). The value 0.6 - 0.7 m appears appropriate from past performance records. The width of 0.65 m is adopted in this design.

Using Manning's Formula, the average flow speed and fluid depth are calculated as follows:

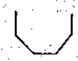
	Flow rate (m^3/s)	Average flow speed (m/s)	Fluid depth (m)
Mean	0.78	2.75	0.49
Maximum	1.05	2.9	0.60
Minimum (1)	0.5	2.5	0.36
Minimum (2)	0.225	1.9	0.21

Depth of the launder

The total depth of the launder is 0.9 m (the depth of fluid at maximum flow plus 0.3 m allowance).

(5) Considerations on wear, material and thickness of launder.

The measures against the wear of launder will be considered as the launder wall suffers a strong abrasion from particles of tailings with sliding, rolling and jumping movenents when the slurry flows through the launder. The launder is made of reinforced concrete which is generally used for this kind of system.

Marcopper has past performance data about the launder in a  shape and with a gradient of 1.0%.
A 50-mm wide zone at the middle portion of the bottom surface is worn more than the other parts about 20 mm annually. The side wall is worn about 1 mm annually. In this proposed project, the launder has a gradient of - 1.25% which results in faster flow and faster wear. The wear resistance of the launder may be raised by adopting some quality control system in the construction of the concrete launders which will be manufactured in a factory. With the same wear extent as being experienced in Marcopper, the launder bottom is specified to be 300 mm thick from structural reason so that operation may not be suspended for long hours due to repairs after 10 years from start of the operation. If a systematic repair work (padding of the bottom surface) is executed for all the launder sections after 10 years, about one month suspension of the slurry transport operation will be necessary for the repair of the launder. Each mine will then dump their tailings into their own dam or pond.

Examination of the wear-proof materials for the launder should be made before the definite study. The following materials should be studied:

Schmelzbasalt: It has higher wear resistance than a high manganese steel and is also comparatively economical. It is also used for the launder for hydraulic transtation of the high abrasive blast furnace slag of iron works. The construction cost for supports of launder line can be reduced by using light weight launder which is, for example, made of this material for lining the launder made of steel plate. Only the launder already lined with this material in the factory can be laid and care will be exercised in handling and transporting the launders so that their liners may not be damaged.

Fibre Concrete: If steel fibre is mixed with the concrete, toughness, bending strength and wear resistance will increase. The steel fibre is 0.2 - 0.8 mm diameter and 10-60 mm long, and mixed with concrete at a ratio of about 2% (volume). Its wear resistance against such tailing slurry like this project will fully be examined in advance.

7.4.3 Pipe Line

The pipe should be specified as API 5LX - X52 or equivalent, 762 mm in diameter and 11.13 mm in thickness because of the following:

(1) Selection of flow speed in pipe and pipe calibre

Since this Project can utilize natural gravity head, the problem of pipe wear by abrasive tailings is more important than that of pressure loss. The flow speed should be the critical velocity plus some safety allowance. Although various theoretical and experimental formulas for calculating the critical velocity are known, they cannot apply to all physical properties so that the bench test and field test should be conducted before the final design in order to confirm their feasibility. In Marcopper, where they are transporting their slurry similar to this Project, it is said that the critical velocity within the pipe is 1.5 m/s at pulp density of 35% (inner diameter of pipe is 610 mm). At Atlas where slurry transportation is done in similar manner, the flow speed is said to be 1.8 - 2.1 m/s at present. The designed figure is 1.83 m/s since no sedimentation of sand was observed at the flow speed of 1.62 m/s or more (pulp density 45%) with 510 diameter pipe in the field test.

The most practical way is to consult these two (2) examples. In view of the pipe diamter difference in this Project, no sanding will occur even when the slurry has a pulp density of 35%, if the in-pipe flow speed is 1.8 m/s at the average flow volume. When the inner diamter of the pipe is calculated using this figure, it is 743 mm. From the API standard, that one with 762 mm (30") outer diameter is available which is closest in inner diameter to this value. It has an inner diameter of 740 mm at thickness of 11.13 mm. Accordingly, the relation between flow and flow speed is as follows:

When average flow is 0.78 m^3/s (pulp density 39%), the flow speed is 1.82 m/s.

When maximum flow is 1.05 m^3/s (pulp density 35%), flow speed is 2.45 m/s.

When minimum flow is 0.50 m^3/s (pulp density 43%), the flow speed is 1.16 m/s.

When the flow is minimum, and the in-pipe flow speed is smaller than the supposed critical velocity of 1.5 m/s, a sufficient volume of water should be supplied to maintain at least the flow speed of 1.5 - 1.6 m/s.

(2) Quality of material and type of pipe

A pipe lining made of anti-wear material and centrifugal cast iron pipe would be more suitable but are expensive. Further, there are no data available for economic comparison of these and other materials used for transporting similar slurries with the one used in this Project. Therefore, API Standard Grade 52 or equivalent should be used in this Project. In the case of steel pipe, seamless pipe is best (welded pipe has inferior wear resistance at welded part) although expensive. In this project, the welded steel pipe having a longitudinal welded line is used. When this pipe is laid with this welded portion positioned apart from the bottom part which has the largest possibility of wear, no trouble due to abrasion will occur because of the high caliber of this pipe. Any spiral steel pipe cannot be used as it has weldlines on the whole circumference.

(3) Thickness of pipe

a. Minimum thickness

The slurry pressure in the pipe is highest in the pipe line to be laid at No.12 section from the sea coast mountain to the sea area. The altitude of the top of the underground fall at point N where this line begins is 94 m and the highest possible static water pressure is 12.5 kg/cm^2. The thickness calculated to withstand a pressure twice this pressure is 3.5 mm (allowing for a pressure rise by water hammer, etc.) by using the formula below. The thickness of 4 mm is adopted.

The formula for calculating pipe thickness is:

$$t = P \cdot D/(2S)$$

Where t : Thickness (inch)

D : Outer diameter (inch)

P : Maximum designed pressure (psi)

S : Allowable stress (37,450 psi in the case of X-52)

b. Wear allowance of inner pipe wall

The inner pipe wall particularly the bottom part which shares one-third of the total circumference is much worn by slurry particles. Therefore, the life time of a pipe can be prolonged by turning it one-third of a full turn.

At Marcopper, the steel pipe is worn about 5.5 mm for every 5 million tons tailings transported. A pipe with an inner diameter of 610 mm and thickness of 10.5 mm can last three (3) years when it is turned 120° every year and used until all circumferential wall is worn to a uniform 4 mm thickness. At Atlas, the pipe is worn about 6 mm annually. The wear has many factors such as in-pipe flow speed, particles in slurry, slurr density, quality and size of pipe and it is difficult to clarify the cause of wear in a simple manner. The most practical way is to consult these examples because they deal with slurry similar with the one in this Project, the rate of pipe wear is expected to be 6 - 7 mm a year.

c. Pipe thickness

A thickness of 11 mm (the minimum thickness plus wear allowance of 7 mm) is adopted. The pipe with a thickness of 11.13 mm should be selected from API pipe Standard.

(4) Number of pipe lines to be installed

The pipe will be rotated one-third of a full turn every year and replaced after three (3) years of use. One spare line should be provided so that the slurry transport operation may not be hindered by these maintenance works. In conclusion, a total of two pipe lines should be laid.

<u>Alternative plan of two (2) pipe lines system</u>

An alternative plan is conceived such that a triple pipe line with each pipe having an outer diameter of 558 mm two (2) lines for ordinary use and one (1) for spare is used instead of a double pipe line with each pipe having an outer diameter of 762 mm. But the required thickness will also be about 11 mm considering the wear allowance. The proposed triple pipe line of 558 mm. outer diameter and thickness of 11.3 mm (the pipe is 150 kg/m) will have a heavier weight than those of the double pipe line of 762 mm outer diameter. In this case, the frequency of line maintenance, number of drop tanks connected with the line and space for their installation also increase and therefore the cost becomes expensive. No cost calculation for purpose of comparison is made here.

(5) Joint of pipe

It is economical to construct the pipe line by welding. But the pipe will be rotated one-third of a full turn over every year. For this purpose, flange joints should be used in the necessary portions. It should be provided at intervals of 12 m within the tunnel where the efficiency of the rotation work is rather low, at intervals of 18 m on the bridge of the Bued River and at intervals of 24 m for the line at the other area.

(6) Gradient of pipe line

The gradient of the pipe line should be horizontal or less than -0.5% toward downstream so that the inner wall of the pipe may be worn as little as possible. For this purpose, a drop tank is provided where a high supporting stand is necessary in order to pass the pipe line along the profile of the land.

7.4.4 <u>Underground fall</u>

Fig. 7-3 shows the arrangement of the underground falls. A chamber with a length of 5 m and a width of 4 m is excavated from both sides of the upper tunnel. The floor of each chamber is dug 3 meters used as the boring chamber....At each chamber, a vertical hole with a diamter of 550 m and a length of about 200 m is excavated. It is planned that the two (2) vertical holes be spaced 8.8 m apart from each other. A chamber from the bottom portion of which is lower than the tunnel floor serves as a sump for the slurry flowing into the underground fall. As shown in Fig. 7-3, a ditch of 1.5 m x 1.0 m connecting both chambers is provided at the end of the launder so that the slurry may be led into either underground fall by means of a barricade.

The lower tunnel has almost the same structure as the upper tunnel as shown in Fig. 7-3. Each chamber floor is dug 3.3 m down lower than the tunnel floor and is used as the basin to absorb the energy of the tailings slurry. Water depth at this basin during operation of the line is about 4 m.

A cable hole with a diameter of 250 mm is excavated connecting both tunnels.

7.4.5 Common Sump (See Fig. 7-4)

A common sump is provided at the starting point of the common line at Camp 4 which accepts slurry flowing from three (3) feeder lines and discharges it into the launder of the common line.

The common sump is provided with a flow meter and a density meter to measure the flow volume and density of the mixed slurry collected from the feeder lines and control the flow in the common line. Furthermore, two sets of 5 mm mesh strainers (one is spare) are provided to remove the foreign materials which enter into the slurry flow on the feeder line. For this purpose, two (2) sets of switch valves are therefore provided.

(1) Common Sump

Material:	reinforced concrete
External Dimensions:	4 m wide x 13.5 m long x 7.9 m high

Structure:

Chamber to receive influent slurry: Inner dimensions - 3.2 m wide x 3.0 m long x 2.5 m deep. The depth of the sump at the bottom surface is 0.3 m to prevent the wear of the bottom concrete by influent slurry.

Valve chamber: Inner dimensions - 3.2 m x 2.5 m x 2.2 m. 2 plug valves (steel made) each with a calibre of 610 mm are provided. The valve seat is made of high Mn and replaceable.

Strainer chamber: Inner dimensions - 1.4 m wide x 6.9 m long x 1.5 m deep. A sump is provided under the valve chamber so that strainer may not directly attacked by slurry. The strainer is made of the highly wear resistant urethan rubber with built-in steel wires, and have 5 mm mesh.

Chamber to discharge slurry: Inner dimensions - 3.2 m wide x 2 m high. A sump with a depth of 0.3 m is provided to protect the bottom concrete.

Others: Deck, step, etc. for use of common sump valve operation are provided.

(2) Measuring instruments

The specific gravity of slurry is measured by a differential pressure transmitter and the volume of slurry by a electromagnetic flow meter. The dry metric tons of tailings are obtained by setting true specific gravity and then automatic calculation of the specific gravity and flow volume of slurry.

Thickness of concrete: The thickness of the part contacting with slurry is 400 mm or more to cope with the wear by slurry.

The flow meter is used in combination with a dummy meter in order to save the cost. The variations are indicated on the instrument panel or recorded or integrated, if necessary.

Main specifications of measuring instruments are below:

Specific gravity of slurry:

Differential pressure transmitter:	Span	0-500 mm H_2O
	Signal	4-20 mA DC
Indicator:	Graduation	1.00-1.50
	Signal	4 - 20 mA DC

Flow volume of slurry:

Electromagnetic flow meter.	Calibre	400 mm
	Range	0 - 4,000 m^3/h
Dummy:	Calibre	400 mm 3 units
Indicator:	Graduation	0 - 4,000 m^3/h

Dry metric tons of tailings:

Calculator:	Signal	4 - 20 mA DC
Integrator:	Signal	4 - 20 mA DC
	Number of figures	6

Common:

Recorder:	Graduation	1.00 - 1.50
		0 - 4,000 m^3/h
	Signal	4 - 20 mA DC

7.4.6 Supporting Frame and Bridge for Launder

The total length of the launder supporting frames is 4,840 m, those between points K and J at the mountain area are about 140 m and about 4,700 m between the points M and N west of the Bued River at the plain part. The total length of the launder bridges is 100 m, 60 m between points G and H at the mountain area and about 40 m crossing the Apangat River.

See Figs. 1 and 2 for division symbols.

(1) Common specifications of the launder supporting frame and bridge.

a. The foundation is made of reinforced concrete.

b. The lower and the upper structure are made of steel. The shaped steel less than 5" in size is mainly used and can be procured in the Philippines.

c. The upper structure is of a truss structure on which are provided the launder, tracks for battery locomotive for patrol (mountain area part) or a gallery for patrol (plain part), and handrails.

d. The launder installation surface is graded at -1.25% from the upstream of the common line toward the downstream.

e. The upper structure is of a structure in which expansion and contraction by temperature are taken into account.

f. Loading conditions in design:

The total long-term unit load is 2 tons (launder: 1.4 t, slurry: 0.6 t). 2.3 t/m is adopted as the designed load considering movable loads of battery locomotive and carrier which are applied during installation of the launder. Seismic coefficient is 0.15.

g. The upper and the lower structures are coated.

(2) The supporting frame between K and J

Height (m)	Length (m)
10	100
5	40
Total	140

- The dimension of the upper structure is 2.8m x 1.5m (See Fig. 6-7 B section)
- The 15 kg rail for use of battery locomotive is attached.

(3) Supporting frame between M and N (See Fig. 7-5)

Height (m)	Length (m)
under 2	500
2 - 4	400
4 - 6	900
6 - 7	2900
Total	4700

- The dimension of upper structure is 1.6m x 1.5m
- A projecting floor of 0.6m on one side is provided for use of corridor.
- A handrail is provided

(4) Bridge between G and H (See Fig. 7-6)

It is dangerous to construct piers in the stream between G and H because boulders and a large volume of valley water flow into the Bued River when it rains heavily. On the other hand, because of surface conditions, a bridge which could be used for tunnel development is necessary. Therefore, a bridge of two spans of 40 m and 20 m is to be constructed between points G and H and this is used when the tunnel is excavated. The piers which are made of concrete and provided at both ends of the 60 m span and at the side of point H.

a. Bridge at the side of point G

Span - 40 m : 1 unit

Special load: A 4-ton battery locomotive and Granby type loaded mine cars (6 units)
about 25 tons (about 17 m in length)

Width and height of the upper structure: 2.8 m x 3 m

b. Bridge at the side of point H

Span - 20 m : 1 unit

Width and height of the upper structure: 2.8 m x 1.5 m

(5) Bridge across the Apangat River (See Fig. 7-7)

Span - 40 m : 1 unit

Concrete piers are provided at both sides of the Apangat River, and a 40 m truss bridge is constructed.

The truss is 1.6 m wide and 3 m high and provided with a projecting floor of 0.6 m on one side for the corridor which is also provided with a handrail.

7.4.7 Pipe Supporting Frame and Bridge

The total length of the pipe supporting frame is about 1,400 m at No. 12 section west of the sea coast mountain. The bridges for pipeline consist of one (about 600 m) across the Bued River and six ones (each span about 25 m) in the No. 12 Section.

(1) Pipe supporting frame at No. 12 section

About 140 units of gate type pipe supporting frames 2 - 3 m high made of shaped steel are provided on the concrete foundation. They are for the common use of two pipes.

(2) Bridge across the Bued River (See Fig. 7-8)

The longest bridge in the common line which carries a double pipe line.

a. Main dimensions

Span : 40 m

Total Length : 600 m

Height from riverbed to the upper part of the structure: 8 m

b. Structure

The foundation is made of concrete.

The upper structure is a steel truss structure and the shaped steel of less than 5" which is locally available is mainly used. The upper structure is constructed horizontally to accommodate the double pipe line. At both sides of the pipe line, a corridor and handrail are provided for use of patrol, pipe installation work or pipe replacement work.

The truss is 2.8 m wide and 3 m high. Projecting floors are provided on both sides, hence the upper width is 3.7 m. The upper structure is a structure where expansion and contraction by temperature are considered.

The lower structure is made of steel pipe or concrete.

Rails are provided at both sides of the pipe installation for use of a manually operated crane with chain block in order to facilitate the installation work of the pipe on the bridge, its replacement and rotation works.

c. Loading conditions for the upper structure

Long-term live load: The load when the slurry flow will have increased in the future to fill up the two pipe line is assumed.

Weight of the pipe: 0.5 t/m. Weight of slurry: 1.2 t/m. Additional weight at the time of replacement and rotation of pipe: 0.2 t/m. The total weight: 2 t/m

Seismic coefficient is 0.15.

d. The steel parts are coated.

(3) Bridges for No. 12 section

Bridges for the double pipe line at the No. 12 section are to be constructed.

a. 25 m span 6 units

b. The piers are made of concrete and provided at both sides of the river to be crossed.

c. The upper structure is the same as the bridge across the Bued River but, it is 1.5 m high.

d. Loading conditions for the upper structure are also the same as the Bued River bridge.

7.4.8 Drop Box (See Figs. 7-9 and 7-10)

It is an open-top box type reinforced concrete tank to absorb the excess head in the launder line outside the tunnels. Five drop boxes are provided between points J and K at the mountain part and one at point L.

(1) As the excess head is 35.6 m between points J and K, the uppermost drop box has head of 7.5 m and the other four have 7 m each. The passage between the two drop boxes is made of steel pipe.

a. The uppermost drop box (See Fig. 7-9)

Launder to pipe type:	1 unit
Head:	7.6 m

Three chambers are provided. Two chambers are provided as there are two pipe lines connected with the outlet. Another chamber is provided as the junction box to the launder which leads to the emergency pond. A switch valve is provided at the upper part of each chamber. Deck, handrail and steps are provided for valve operation. The valve is of a plug type and have the valve seat replaceable and made of a highly wear-resistant high manganese steel. The calibre of valve is 610 mm.

b. Intermediary drop box

Pipe to pipe type	3 units
Head	7 m Two-chamber type (See Fig. 7-10)

The feed pipe for the drop box is T-shaped and the pipe end is vertically inserted about 2.5 m into the drop box toward its center so that slurry may not directly attack the inner wall of the box. The rubber lined pipe is used for the T-shaped pipe and insertion tube as they are worn faster by turbulent flow.

c. The lowermost drop box

Pipe to launder type	1 unit
Head	7 m
	One-chamber type as a single launder line connected with the outlet.

(2) Drop box for point L (See Fig. 7-11)

Launder to pipe type	1 unit
Head	7 m Two-chamber type

This drop box is connected with the drop tank which leads to the pipe line across the Bued River. A 50-mm mesh strainer (made of urethane rubber) is provided to prevent entering the foreign materials into the pipe.

(3) Measures against wear of drop box

The following structures and materials are to be used in order to reduce wear of the drop boxes.

a. The bottom of the box has a sump 1.2 m deep to avoid any direct attack by influent slurry.

b. The method mentioned in (1)-b is adopted to prevent the wear of the side wall by influent slurry.

c. Rubber-lined tube is used as the slurry feed tube as mentioned in (1)-b.

d. A replaceable insert with an anti-wear rubber lining is attached to the discharge nozzle as it is worn faster by the turbulent slurry flow.

e. A rubber-lined tube 6 m long is used for the piping portion connected with the discharge nozzle, because of an unstable flow over a distance about 7 times the inner diameter of the pipe and a 10.5 mm thick steel pipe can only last three (3) months like that of Marcopper.

7.4.9 Drop tank

This is a cylindrical closed type tank made of steel plate to absorb any excess head or maintain pressure in the pipe line. It is provided in pairs. In this Project, three(3) units in pairs are provided in the No. 9 section upstream of the pipe line across the Bued River and 21 units in pairs including the ones with samller heads in No. 12 section at the sea coast area.

(1) Drop tank for No. 9 section (See Fig. 7-13)

Head: 5.3 m   Inner diameter: 1.5 m   3 units in pairs

(2) Drop tank with head of more than 3 m for No. 12 section (called drop pipe) (See Fig. 7-14)

Head: 4 m   Inner diameter: 1.5 m   1 unit in pairs

Head: 3 m   Inner diameter: 1.5 m   7 units in pairs

(3) Measures against wear of drop tank:

a. Countermeasure against wear

This is just the same as in 7.4.8 - (3): Drop Box.

b. Air escape and vacuum breaker

A pipe with a diameter of 50 - 80 mm for air escape is installed with its height as high as topographical conditions permit to give large hydraulic gradient because air entering in the pipe line has an adverse effect on the slurry flow conditions and wear resistance of the inner wall of the pipe, and may also cause water hammer. This pipe also functions as a vacuum breaker to eliminate any vacuum when the flow stops at the upper line portion.
A vacuum produced within the pipe is likely to cause collpase of the pipe and drop tank.

c. Anti-external pressure strength of tank

In case vacuum occurs in spite of the countermeasure mentioned in item (b), the tank should have a sufficient strength to withstand the atmospheric pressure.

d. Drip trap and manhole

These are provided for repair and cleaning of tanks.

(4) Drop tanks with head of less than 2.5 m in No. 12 section (See Fig. 7-14)

There are many drop tanks with small heads in the No.12 section. They are also used to curve the pipe line.

These drop tanks with inner rubber-linings with the same calibre as the slurry transport pipe are used.

Number of this type of drop tanks is:

Head (m)	Number
2.5	6 units in pairs
2	2 units in pairs
1	5 units in pairs

Like that of the drop box, the rubber-lined tube is used for the inlet T-shaped pipe and the pipe connected to the outlet nozzle.

7.4.10 Emergency Pond

Each emergency pond is installed in the valley of point J and near the terminal of the launder. The former is called No. 1 emegency pond and the latter No. 2 emergency pond.

(1) No. 1 Emergency pond

Main specifications of this pond are: Capacity of slurry storage: 30,000 m^3. Top width of bank: 5.0 m. Top length of bank: 66.0 m. Height of bank: 30.0 m. Effecitive height of bank: 20.0 m. Slope gradient: 1:1.5 (inner side) and 1:1.8 (outer side). Banking: 25,000 m^3 (clay: 7,000 m^3 and waste: 18,000 m^3). The length of the bottom closed conduit is 230 m.

The slurry storage capacity is not very much larger than the volume of banking because of the topographic conditions and also because waste produced from the excavation of the tunnel is planned to be used. The bank is covered with qualified clay at the inner side 8.0 m wide (horizontal) and 4.4 m thick in order to interrupt the leakage of water (See Fig. 7-15).

There will be no need for a passage for rain water on the mauntain slope as the water catchment area is small.

Slurry flows into the pond from the drop box via the launder. The rain-water and the supernatant water of slurry are promptly discharged away from the site. For this purpose, a bottom closed conduit and a water collection closed conduit (partially open) are provided (See Fig. 7-15). The water flows into a small river which joins the Bued River near Dongon.

It is assumed that about 7,000 m^3 of slurry flows into the emergency pond from the feeder lines and the common line in every emergency. The slurry stored in this pond is dredged by a simple dredge pump with a capacity of 68 m^3/H and sent to the launder of the common line via a booster pump installed at the right side of the bank. For this purpose, a pipe 80 mm in diameter, is laid (dredge piping: 100 m and land piping: 100 m).
A 30-KVA diesel powered generator supplies power to the pump.

(2) No. 2 emergency pond (See Fig. 7-16)

The designed slurry storage volume is 15,000 m^3. It is constructed by excavation as no suitable basin is available in the neighborhood. The depth from the top of the bank is 4.0 m. The soil obtained from the excavation is utilized for constructing a bank with slope of 1:2.0, width of 7.0 and height of G.L. + 1.5 m. The volume of excavated soil is 14,000 m^3 and the banking volume is 4,500 m^3. The bottom area is 70 m x 80 m or 5,600 m^2. The bank is 392 m long.

Slurry flows into the pond from the junction box via a launder. The water within the pond is discharged into the Apangat River through a launder.

The dredging facilities and their operation method are similar to those of No. 1 pond.

7.4.11 Facilities to Supply Emergency Water

(1) Emergency water tank (See Fig. 7-17)

The installation place is near point L.

Size: 6.0 x 6.0 x 5.0 mH = 180 m^3

Effective storage volume: 150 m^3

The tank is a box structure and made of reinforced concrete. The side wall is 30 cm thick to prevent leakage.

(2) Water lift equipment at the Apangat River

This is the equipment to replenish the common line with water when the slurry flow has decreased as well as to supply water for washing the pipe interior.

Water lift pump:	36 m^3/min. x 12 m lift (with automatic water absorber)	1 unit
Motor:	130 KW	1 unit
Absorption tube:	Foot vale	1 set
Discharge pipe	600 mmø and 200 m long	
Discharge valve:	Check valve	1 set
Power source:	200 KVA diesel power generator	1 set
Electricity building:	5 m x 5 m	1 unit
Operation:	Manual	

7.4.12 Communication Facilities

(1) Basic policy

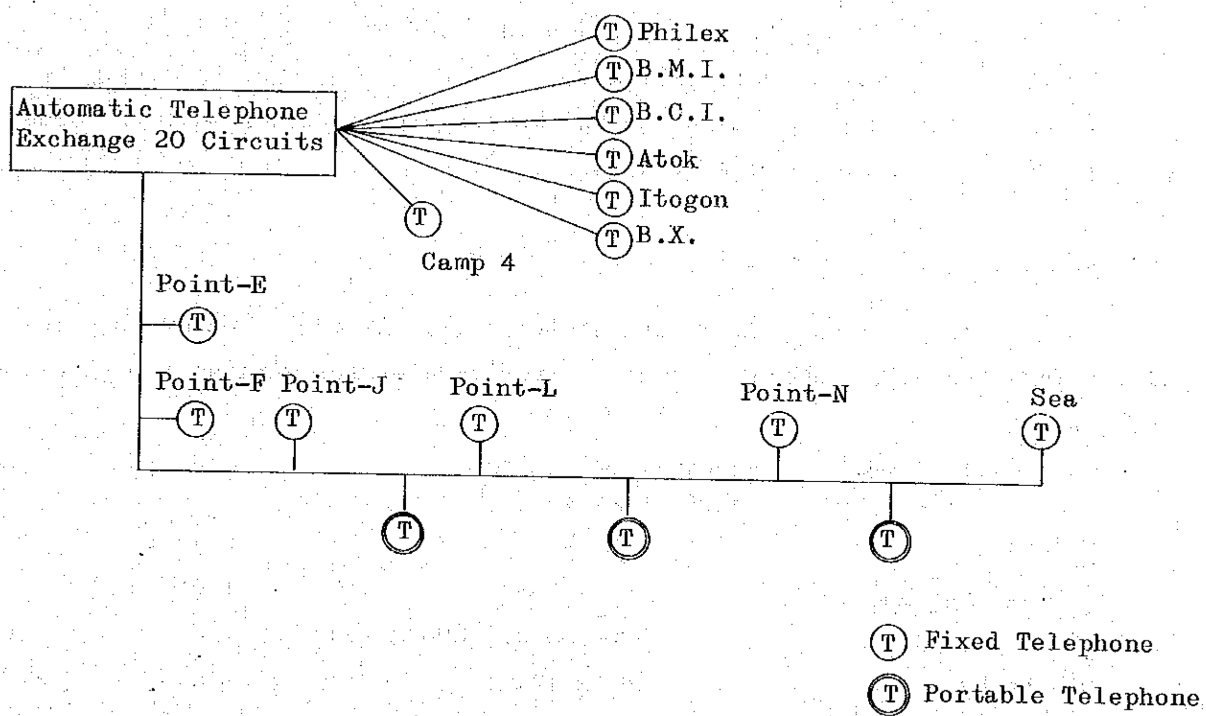
The communication facilities required for control and operation of the TLP System are installed according to the following plans:

(a) Wire telephone system with a high communication reliability is provided as the communication facilities.

(b) Total number of fixed stations is 13 (6 for mines, 1 for Camp 4, 1 for sea, and 5 for important places along the common line).

(c) Three movable stations are provided for the common line. The plug socket is installed at intervals of 1,000 m.

(d) Twenty circuits are selected for the capacity of the exchanger. The above conditions are shown in the drawing below:



Note) The construction cost shown in this Feasibility Study includes these for communication facilities for the common line but does not include these for the communication facilities which connect Camp 4 with each mine.

(2) Sepcifications of Main Equipments

(a) Automatic exchange			Quantity
	Type:	Cross bar system	1
	Circuit:	20	
(b) Battery			
	Type:	Alkali battery	1
	Voltage:	48 V	
	Capacity:	36 AH	
(c) Telephone unit			
	Fixed:		13
	Movable:		3
(d) Plug socket box			
	For out-door use:		30

(e) Cable

2C	2 mm^2	Shield		37 km
12C	2 mm^2	Shield		6 km
14C	.2 mm^2	Shield		6 km
16C	2 mm^2	Shield		2 km
18C	2 mm^2	Shield		7.5 km
20C	2 mm^2	Shield		6 km
20C	2 mm^2	Shield	Pit cable	300 m

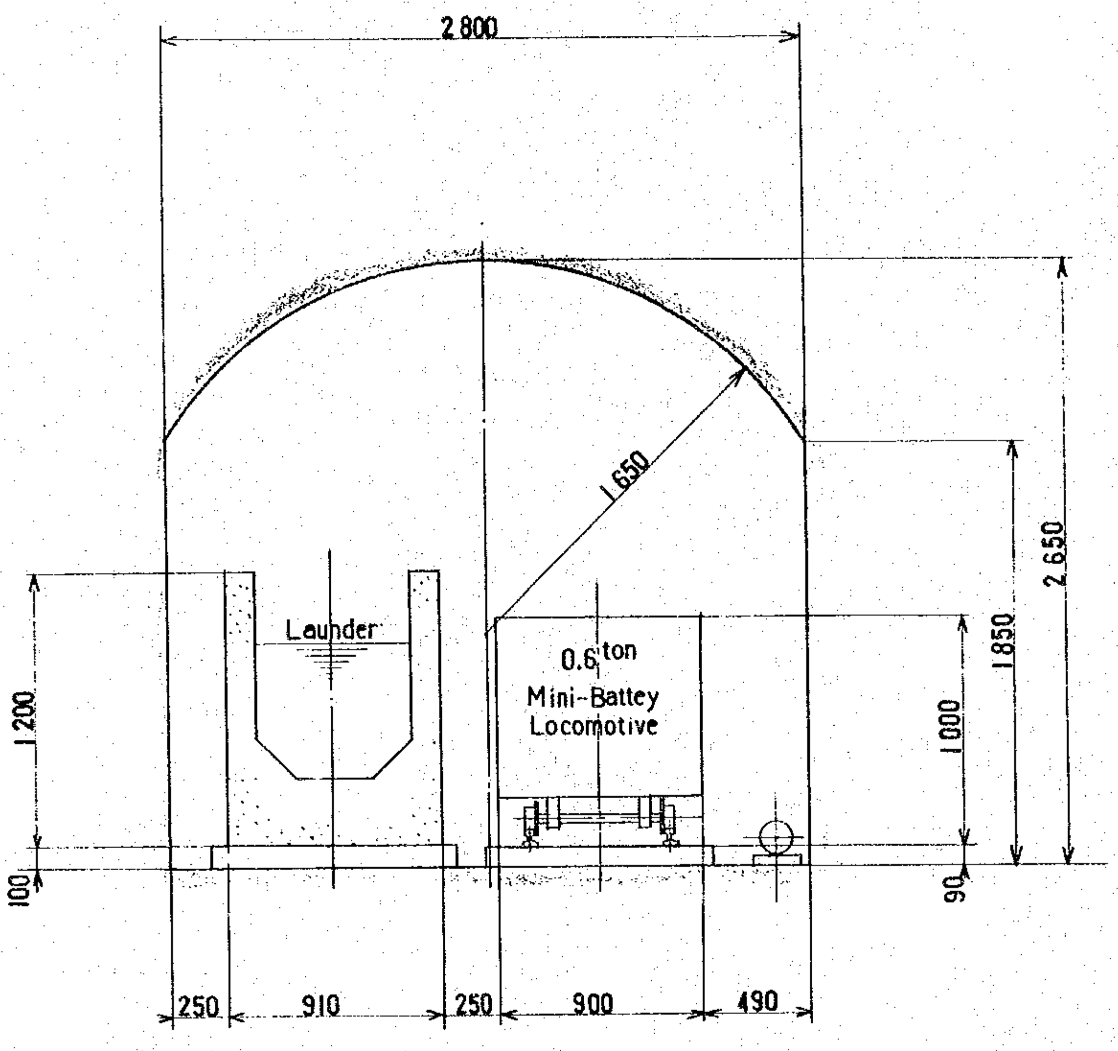


Fig. 7-1

Unit : mm

TUNNEL SECTION

DRAWN BY ET DATE 3/29/'78
CHECKED BY ... DATE 3/30/'78
SCALE 1 : 30

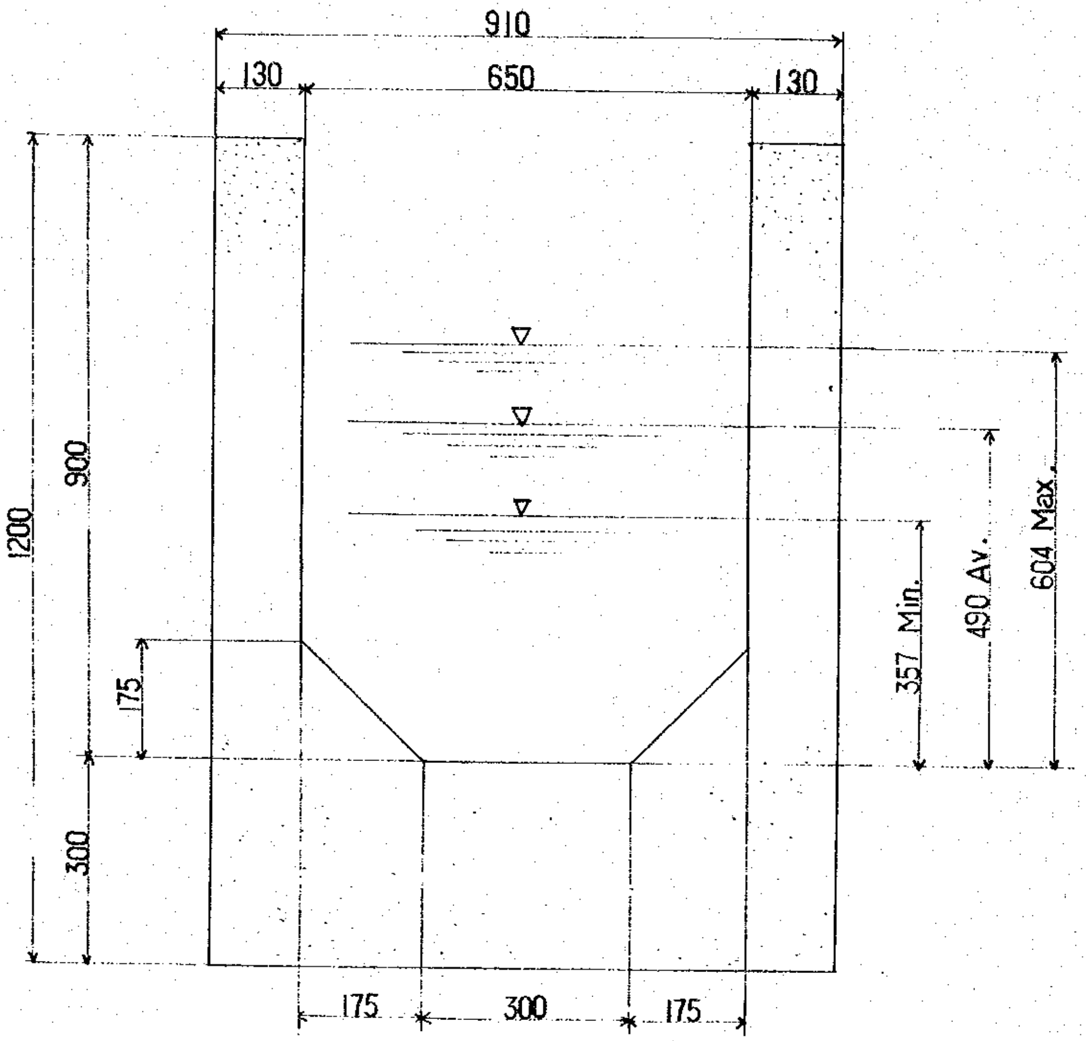
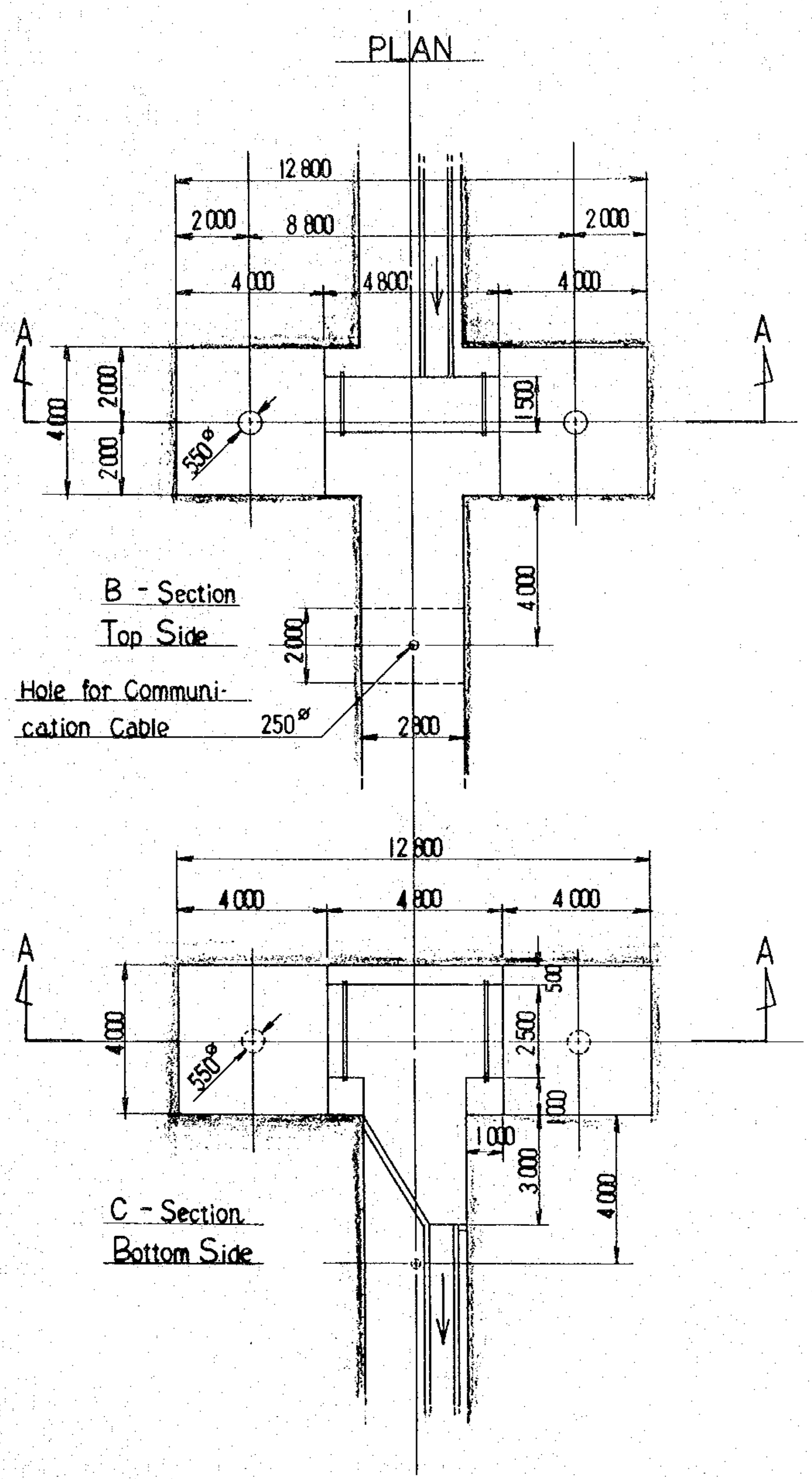


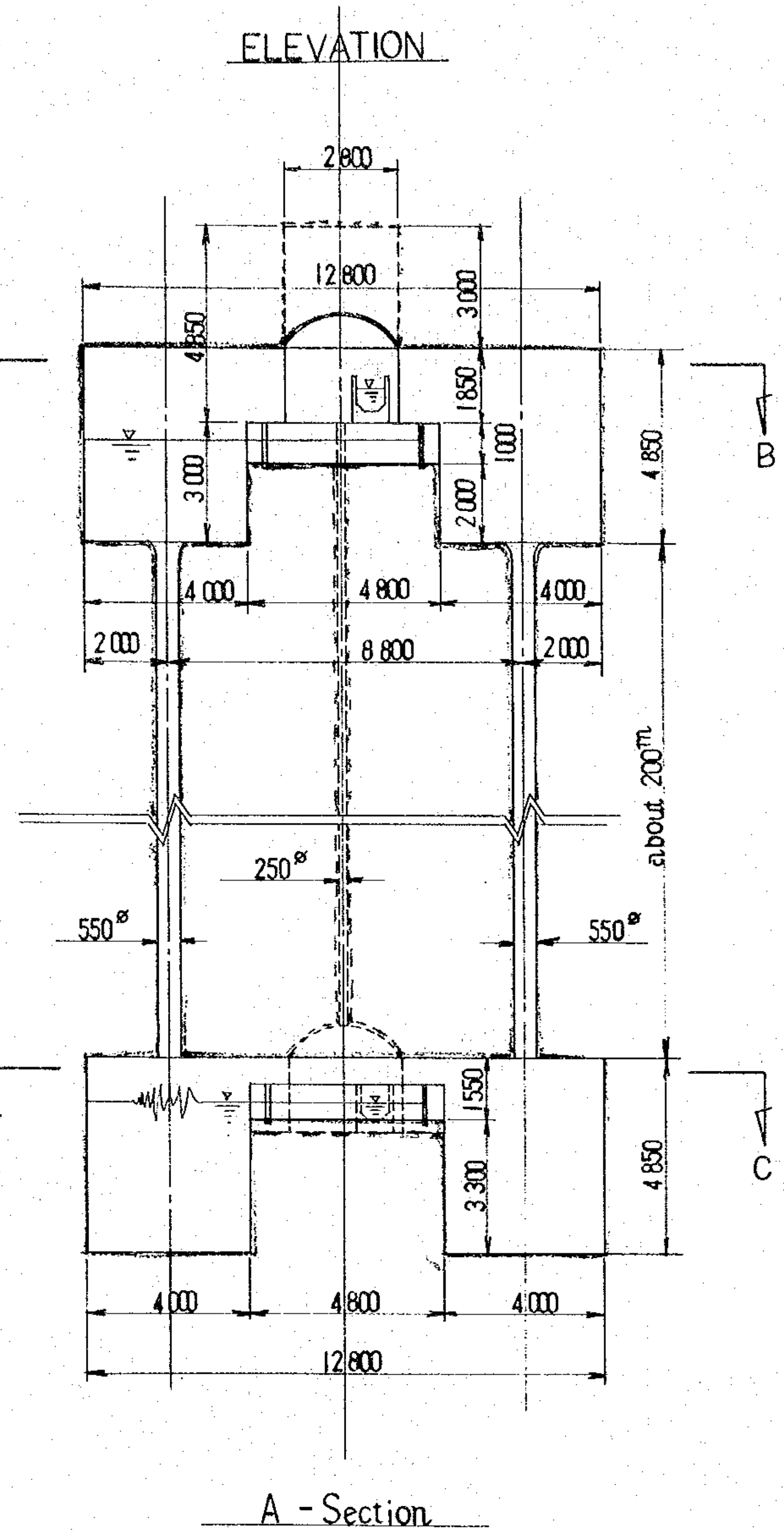
Fig. 7-2

Unit : mm

LAUNDER

DRAWN BY ET DATE 3/10/'78
CHECKED BY K.S DATE 3/12/'78
SCALE 1:10



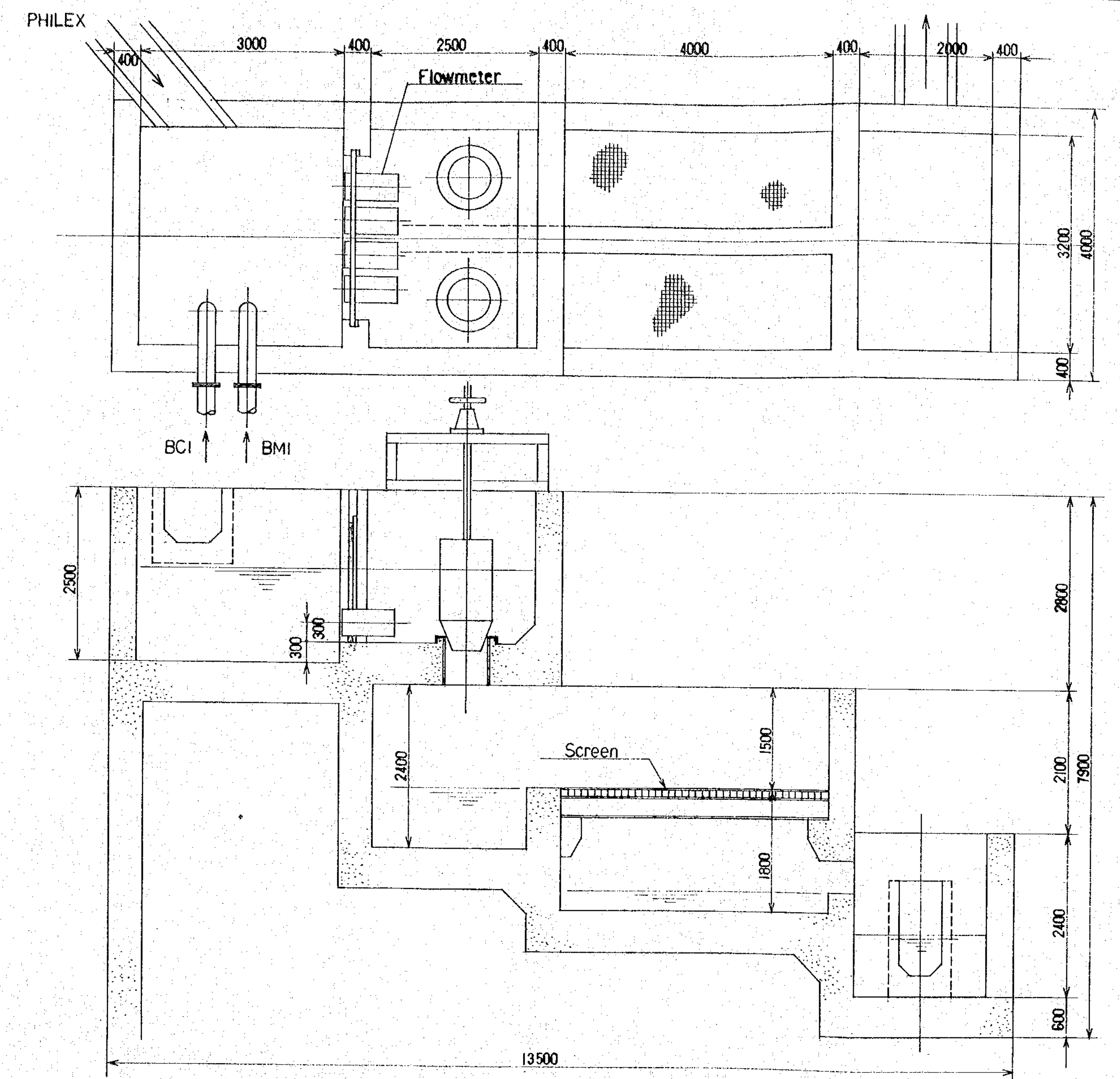


Location : Point E F
Q'ty ; 1Set

Fig. 7-3

Unit : mm

UNDERGROUND FALL			
DRAWN BY	S. I	DATE	4/6/'78
CHECKED BY	N. K	DATE	4/6/'78
SCALE	1:150		



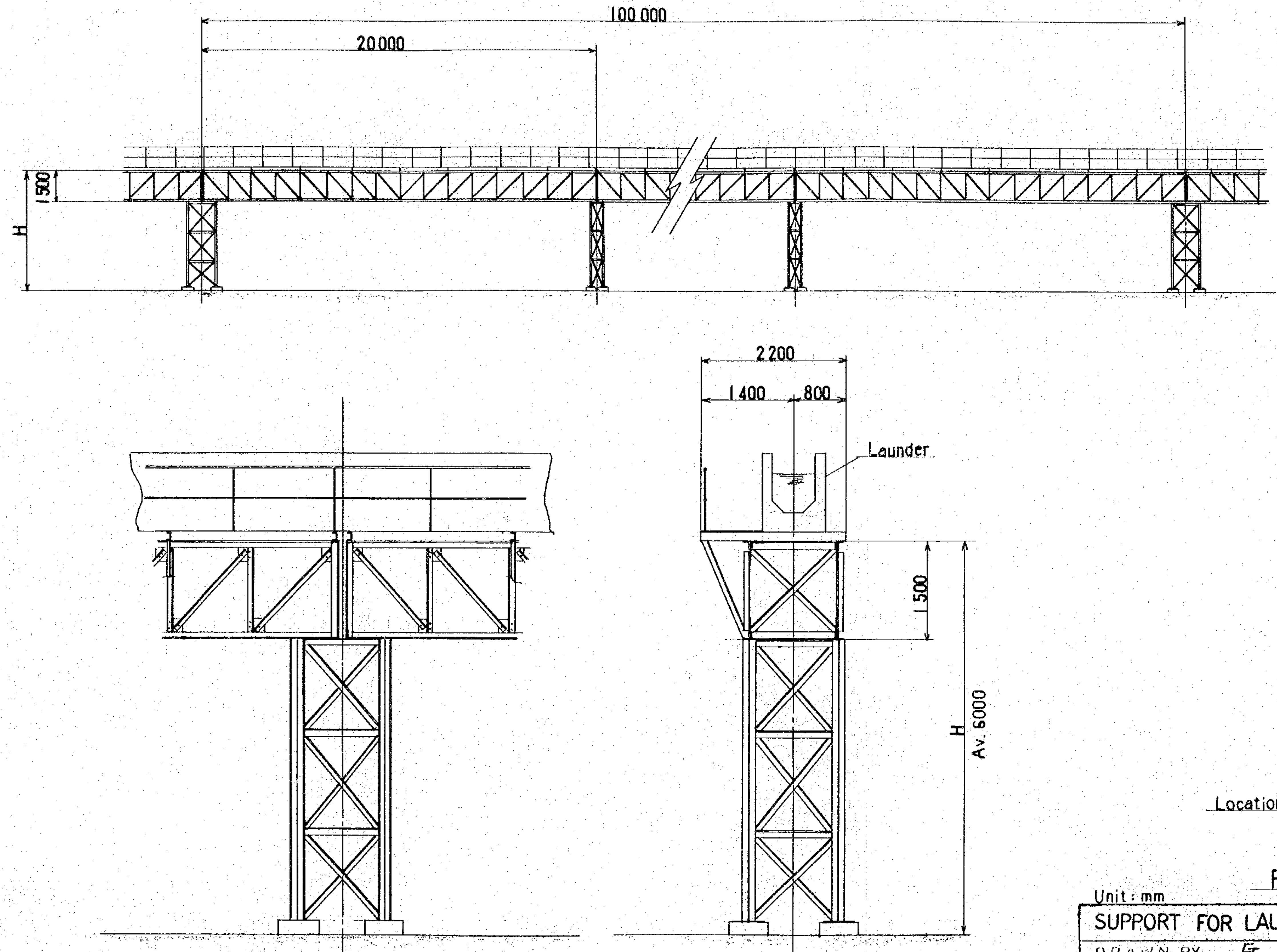
Q'ty ; 1 Set

Fig. 7-4

Unit : mm

COMMON SUMP

DRAWN BY ___ DATE 3/17/'78
CHECKED BY M.S DATE 3/18/'78
SCALE 1:60



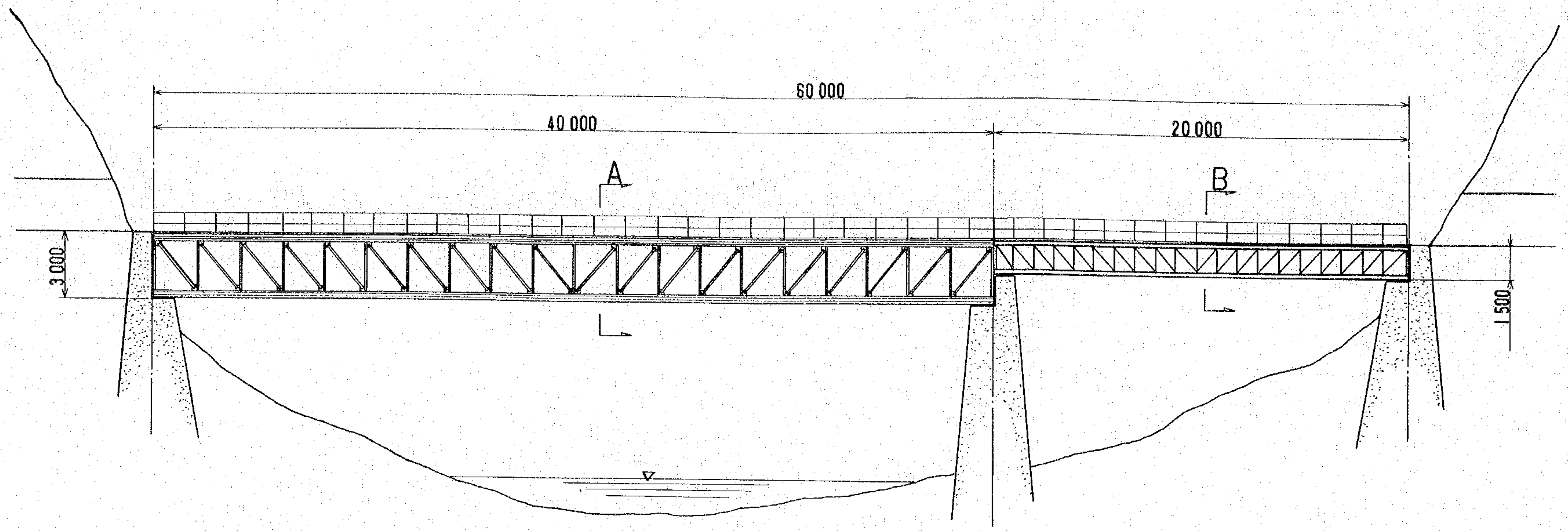
Location ; WS -10

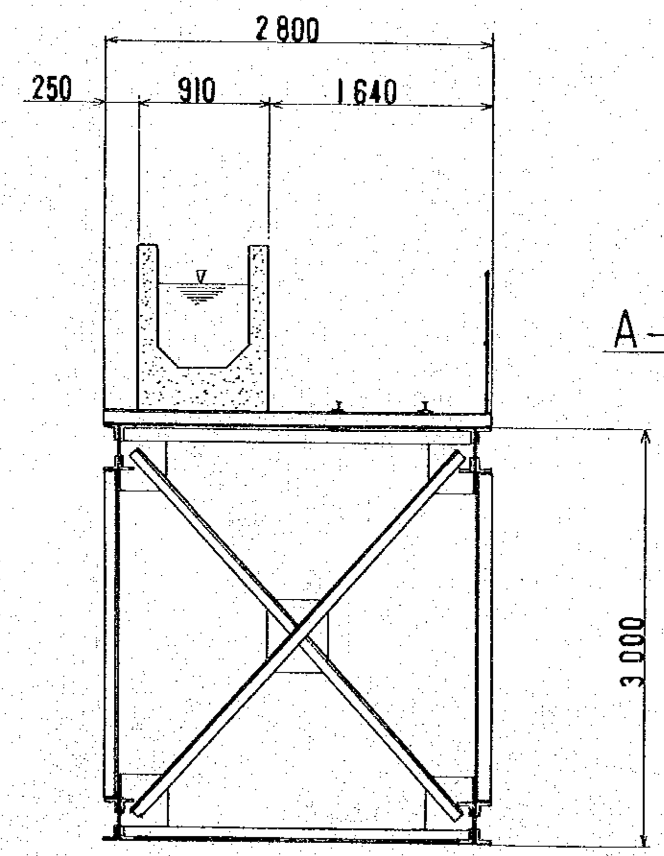
Fig. 7-5

Unit : mm

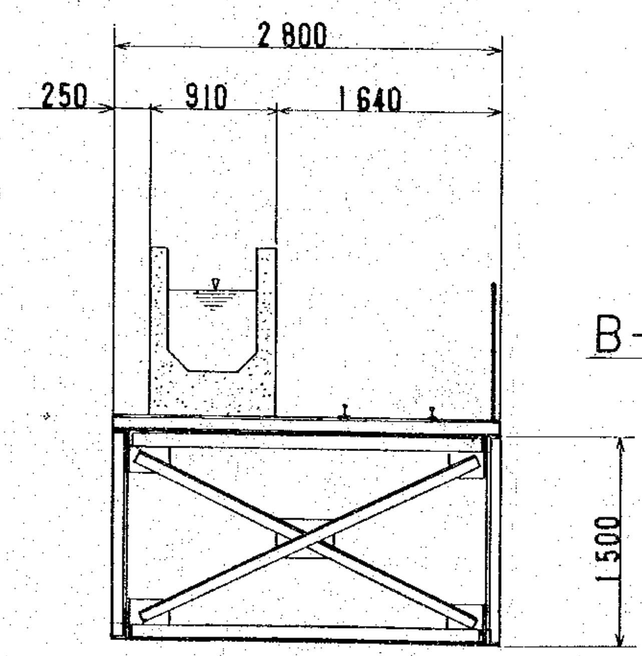
SUPPORT FOR LAUNDER

DRAWN BY DATE 3/21/'78
CHECKED BY K.S DATE 3/23/'78
SCALE 1:200 1:60





A – Section



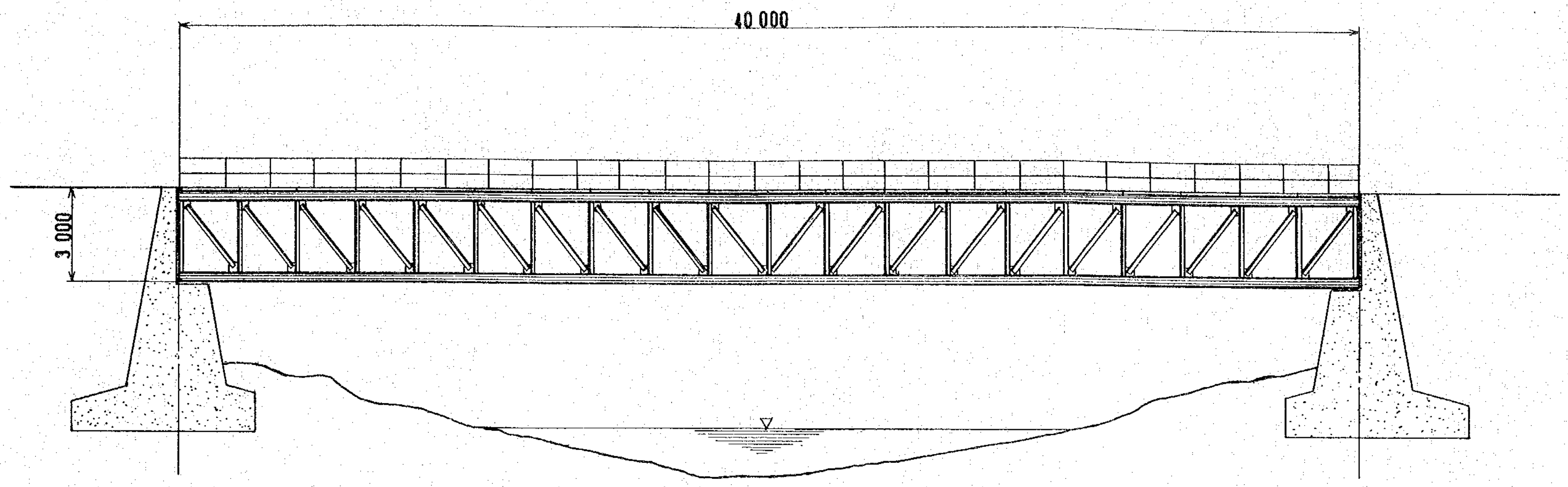
B – Section

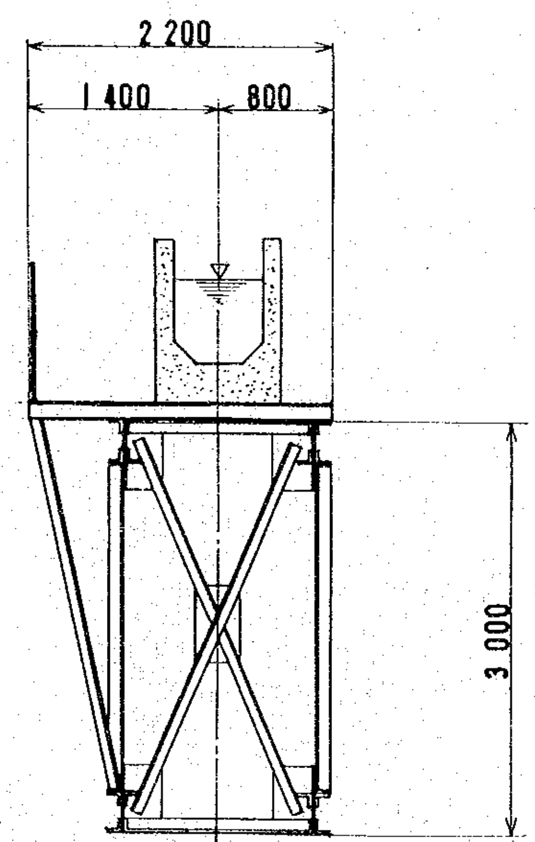
Location : Point G-H

Fig. 7-6

Unit: mm

BRIDGE FOR LAUNDER			
DRAWN BY	K.H	DATE	3/28/78
CHECKED BY	K.S	DATE	3/29/78
SCALE	1:200		1:50

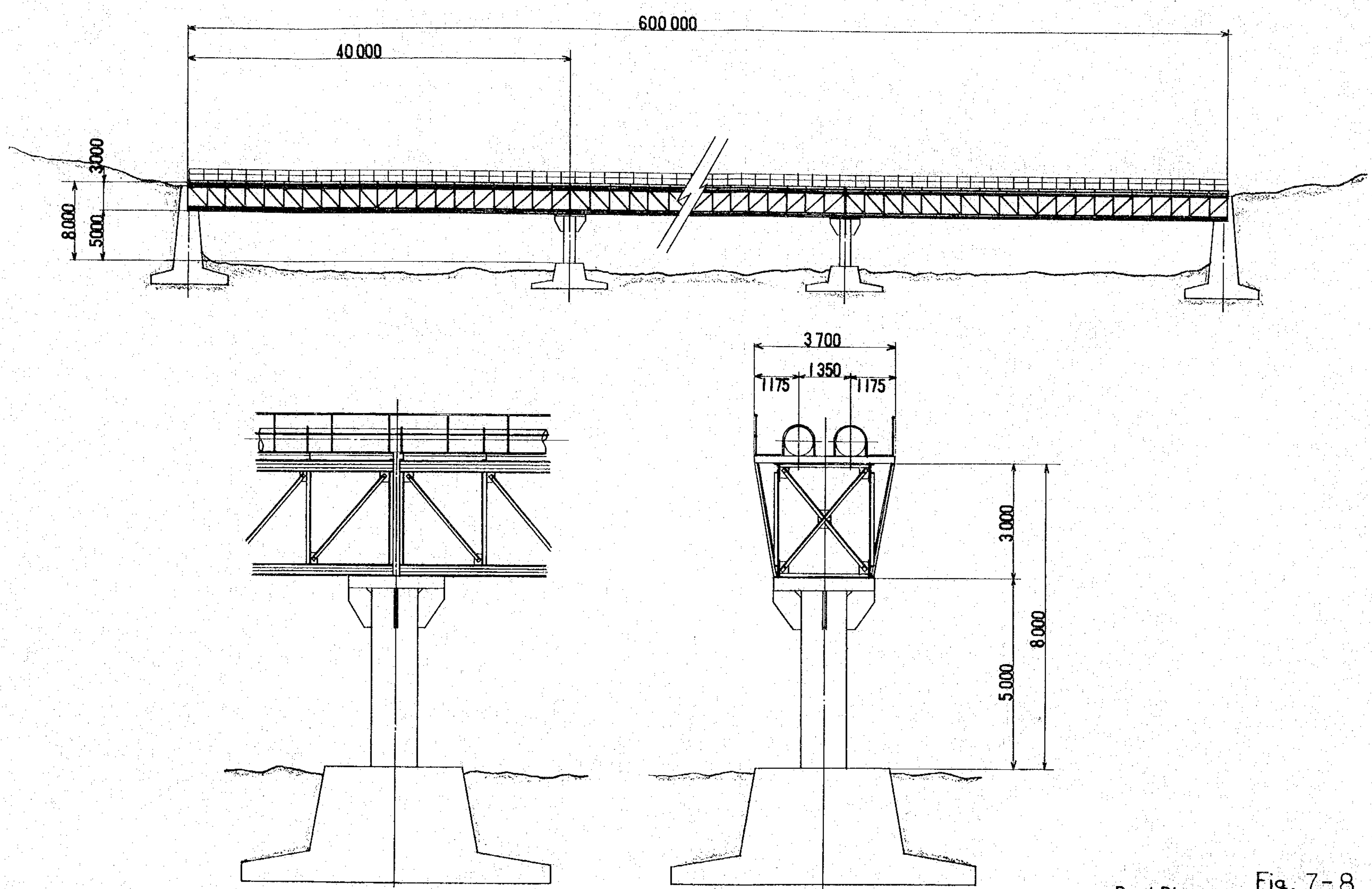




Unit: mm

Fig. 7-7

APANGAT RIVER BRIDGE			
DRAWN BY	K.H	DATE	3/28/'78
CHECKED BY	K.S	DATE	3/29/'78
SCALE	1:150		1:50



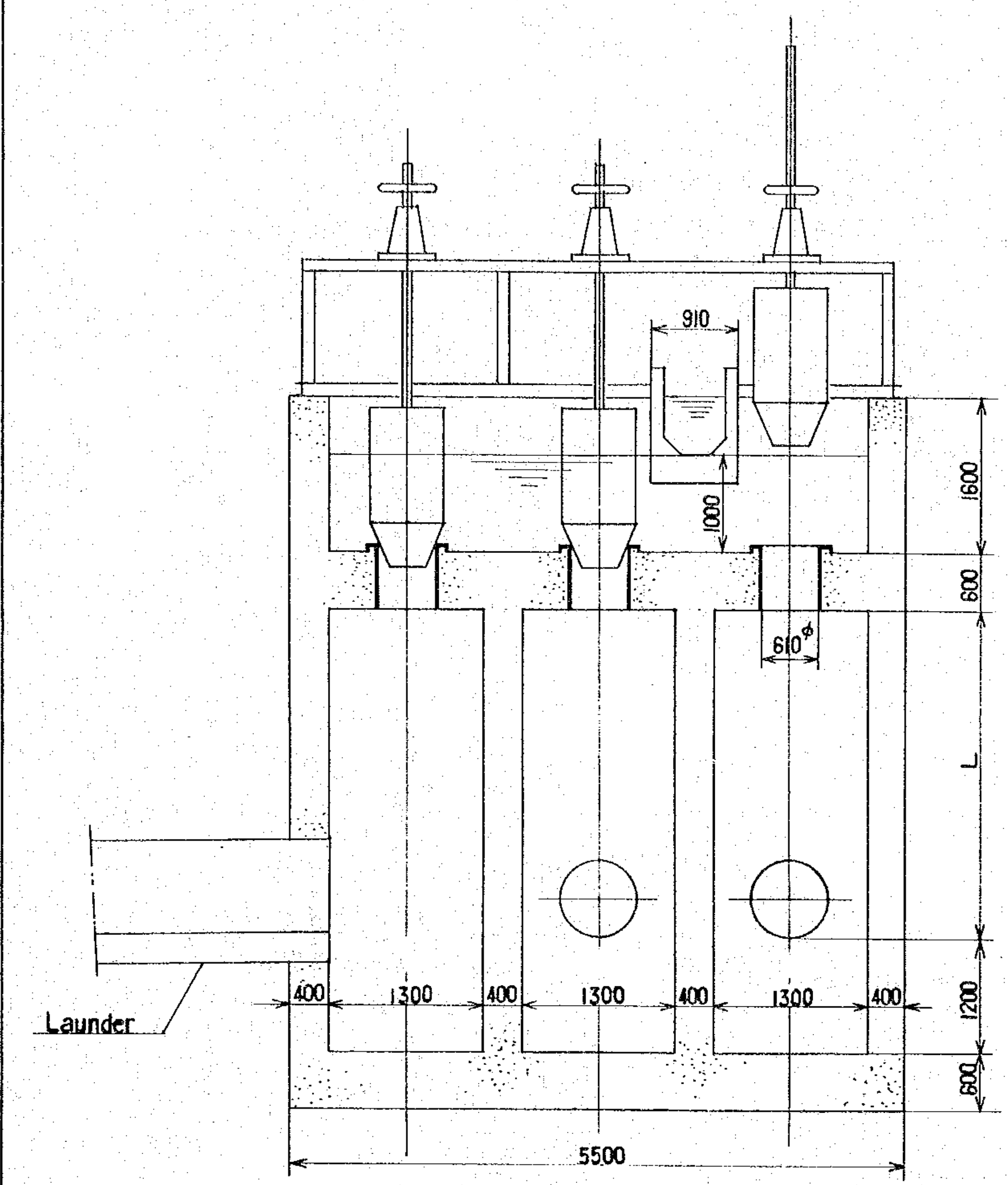
Bued River

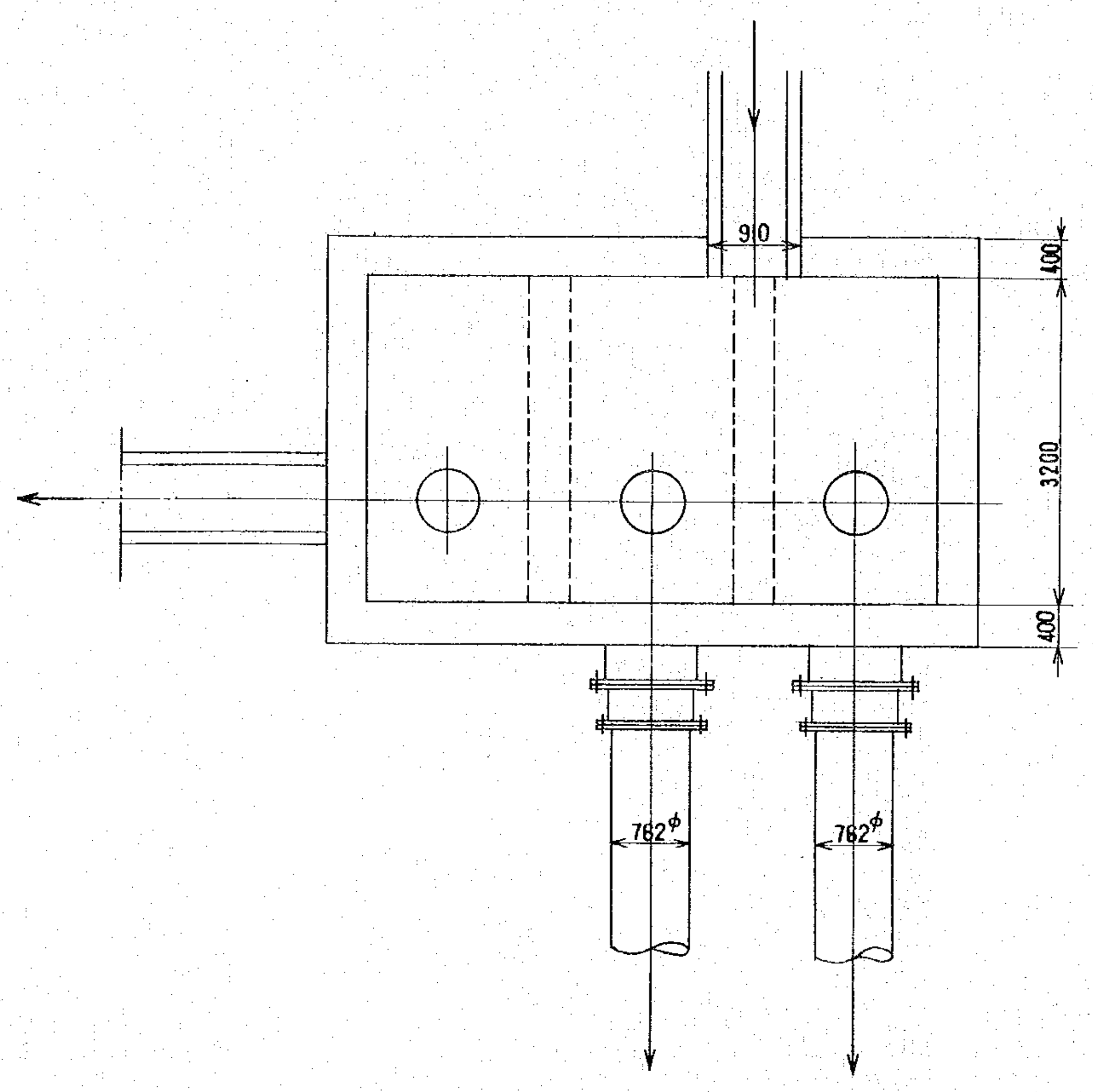
Fig. 7-8

BRIDGE FOR PIPELINE

Unit : mm

DRAWN BY		DATE	
CHECKED BY		DATE	
SCALE	1:400		1:100





Location : Point K-J

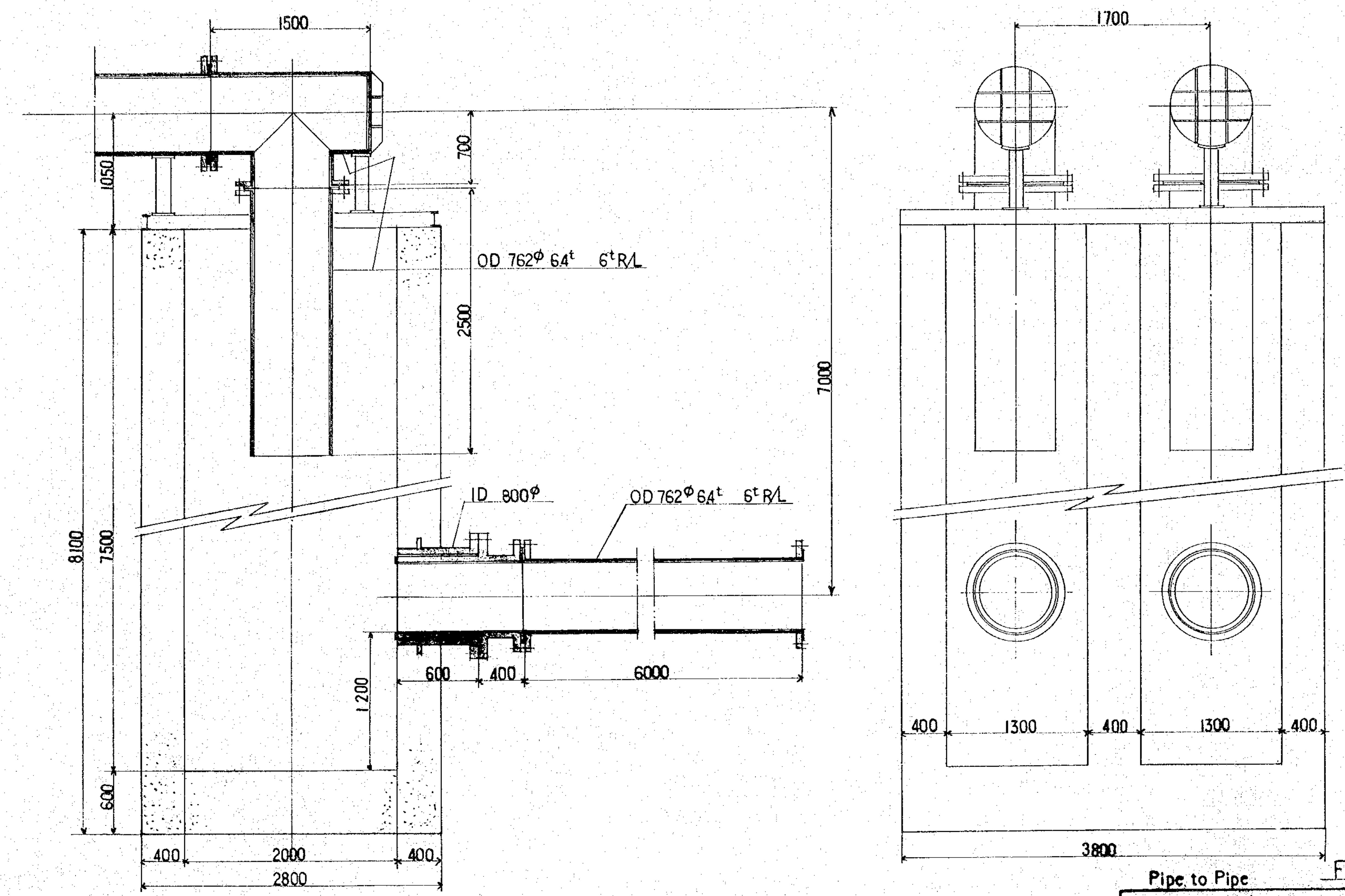
Q'ty : 1 Set

Launder to Pipe

Fig. 7-9

Unit : mm

DROP BOX			
DRAWN BY	G	DATE	3/24/'78
CHECKED BY	K.S.	DATE	3/27/'78
SCALE	1:60		



Pipe to Pipe

Fig. 7 – 10

Location ; Point K-J

Q'ty ; 6 Sets

Unit : mm

DROP BOX

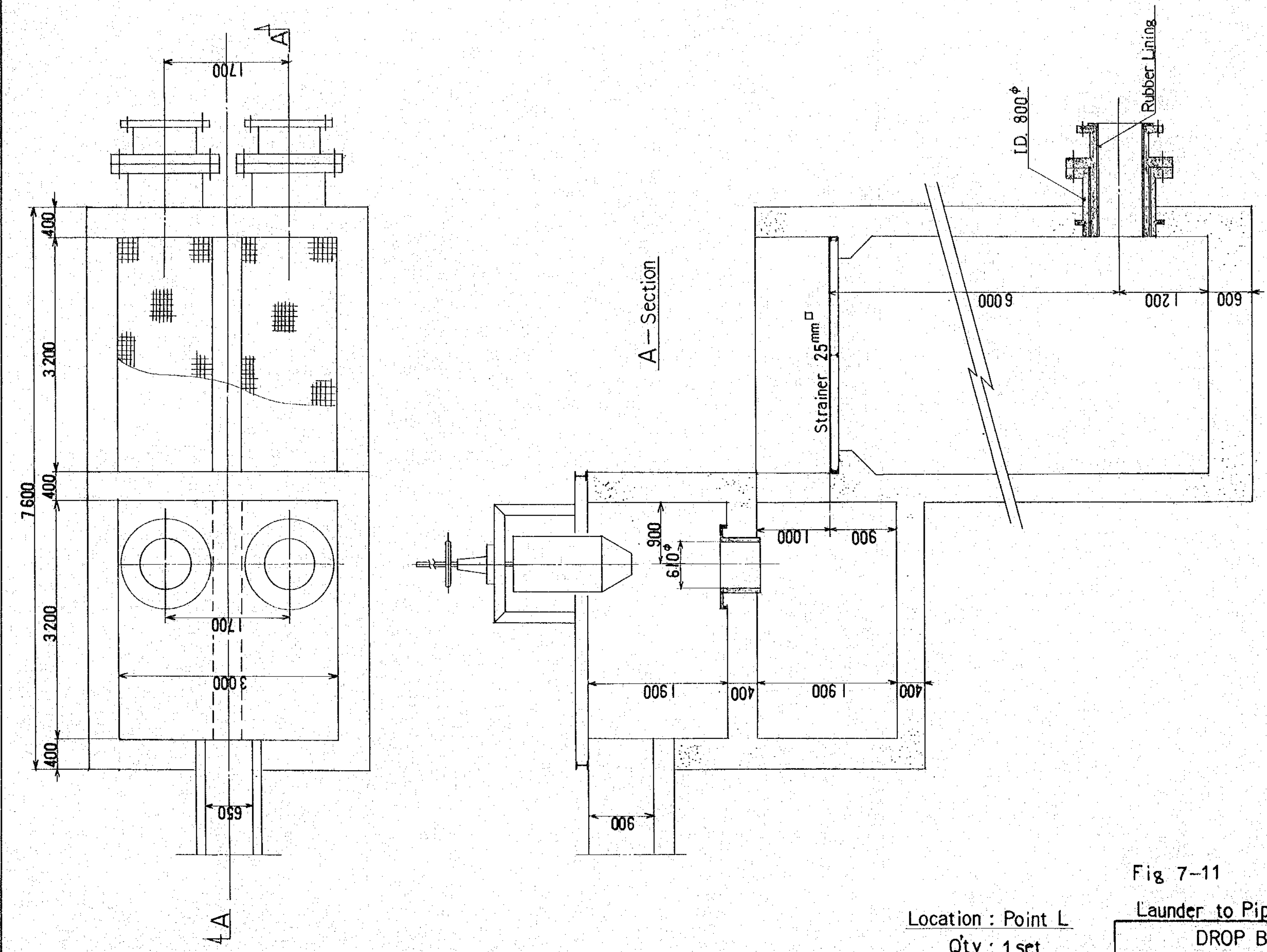
DRAWN BY

DATE

CHECKED BY

DATE

SCALE



Location : Point L

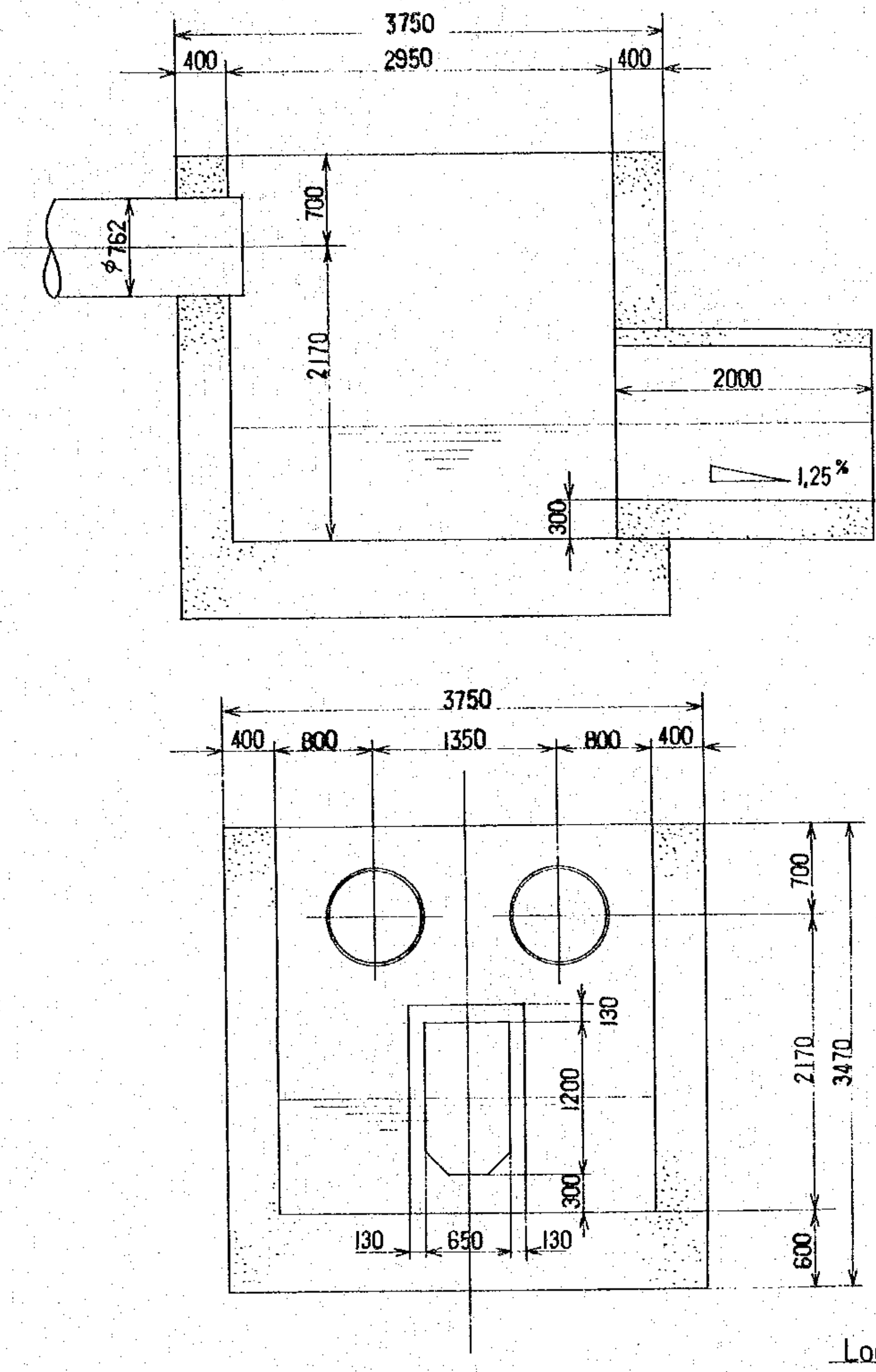
Q'ty : 1 set

Unit : mm

Fig 7-11

Launder to Pipe

DROP BOX	
DRAWN BY E.L	DATE 5/2 '78
CHECKED BY K.S	DATE 5/10 '78
SCALE 1:50	



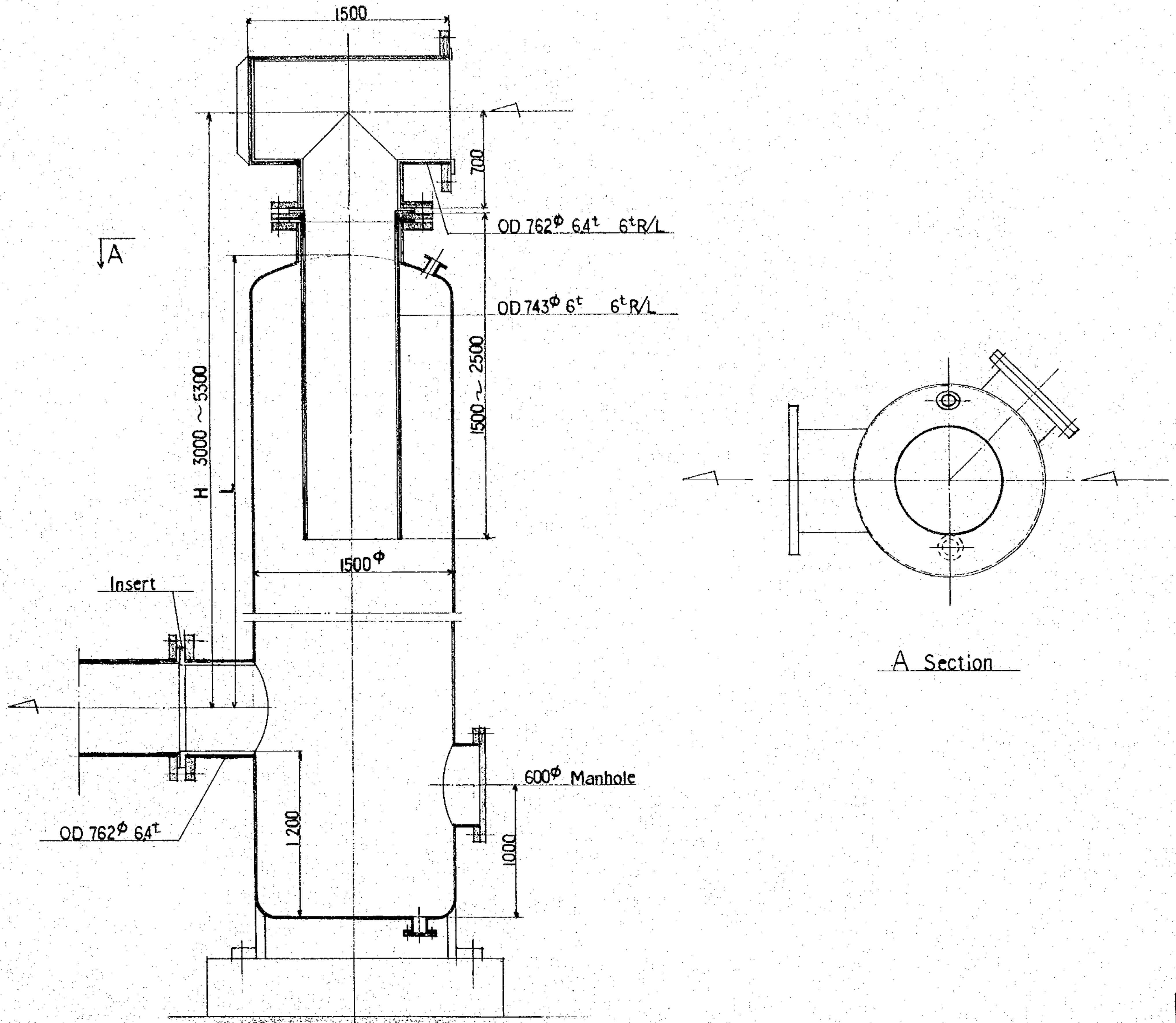
Location ; WS-10

Q'ty ; 1 Set

Pipe to Launder Fig. 7-12

JUNCTION BOX			
DRAWN BY	ET	DATE	3/11/'78
CHECKED BY	H.S	DATE	3/15/'78
SCALE	1:50		

Unit : mm



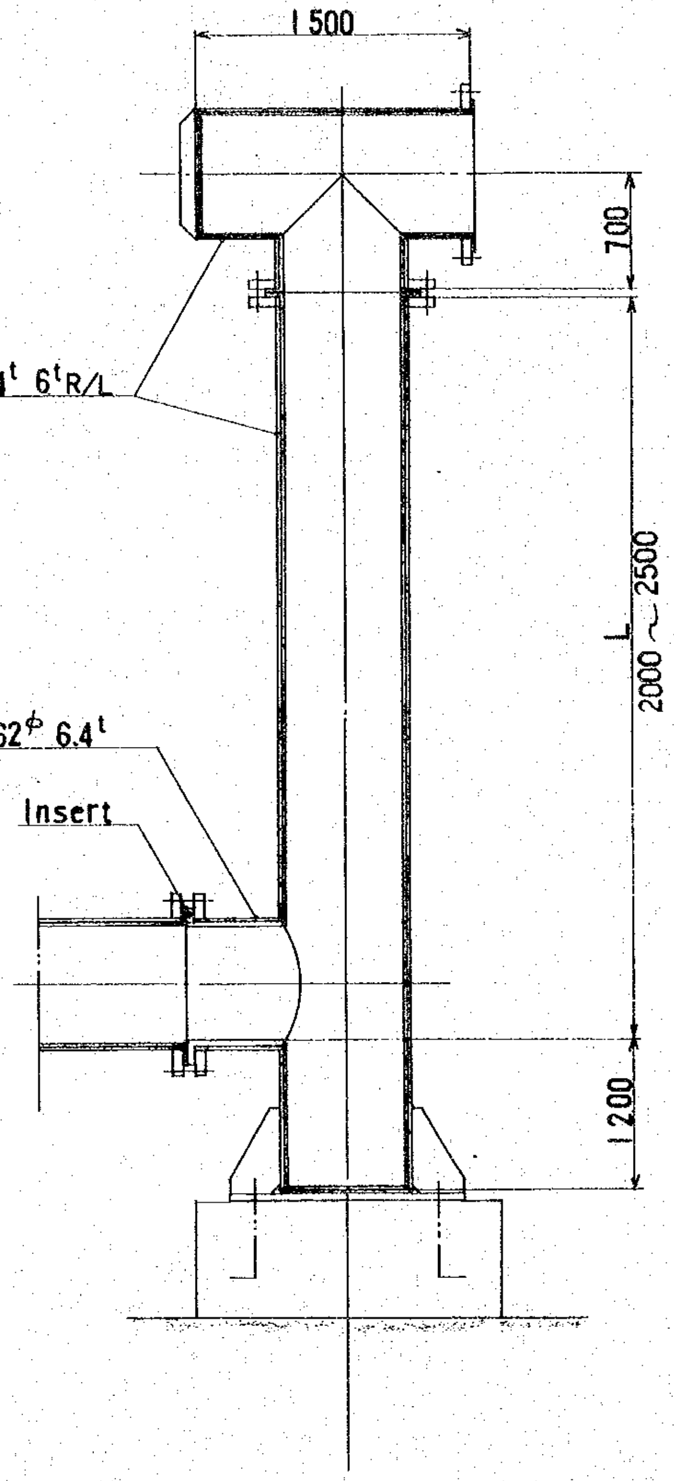
Location ; Point L , WS-11

Q'ty ; 22 Sets

Fig. 7-13

Unit : mm

DROP TANK			
DRAWN BY	G	DATE	3/15/'78
CHECKED BY	K.S	DATE	3/17/'78
SCALE	1:30		



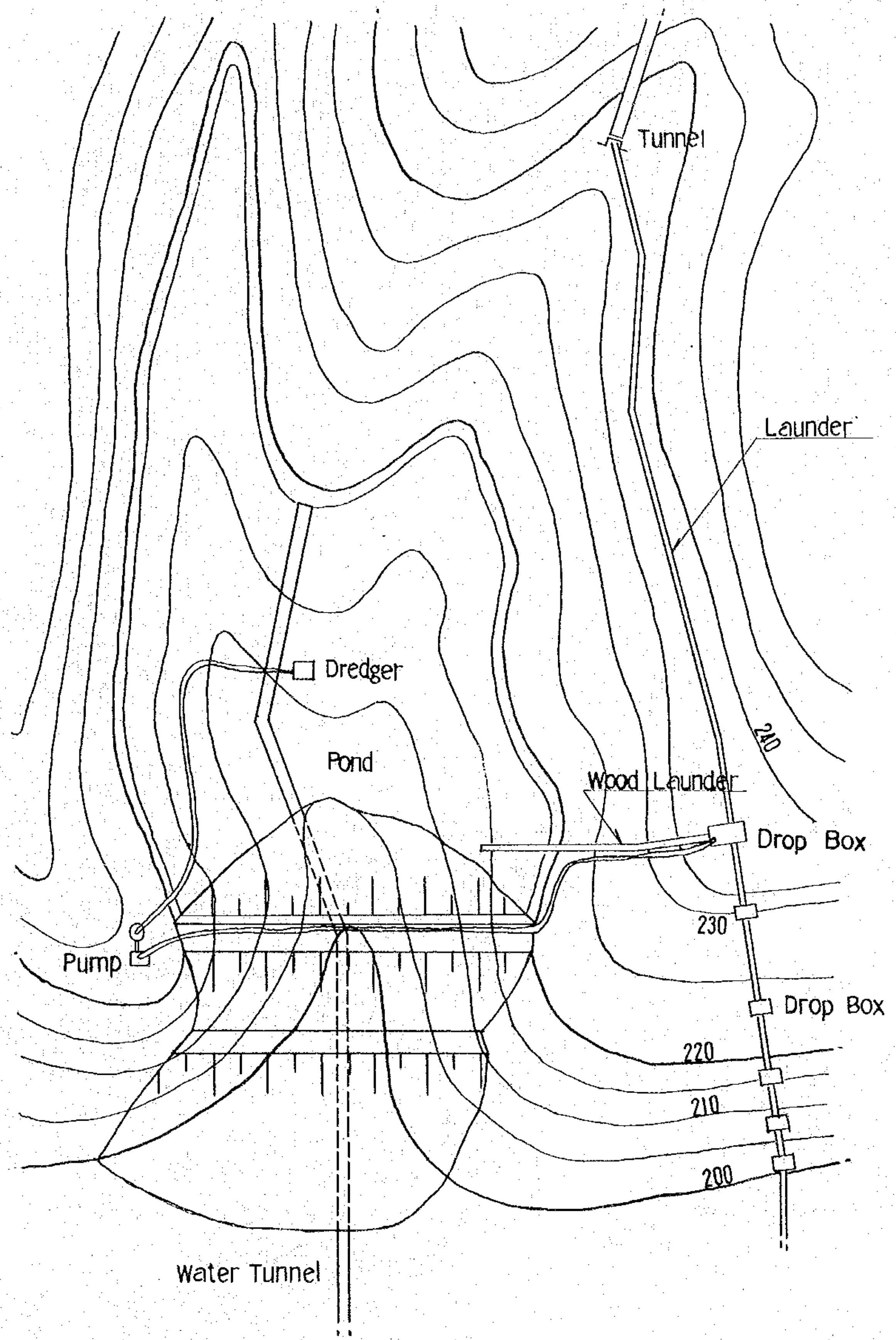
Location ; WS-12

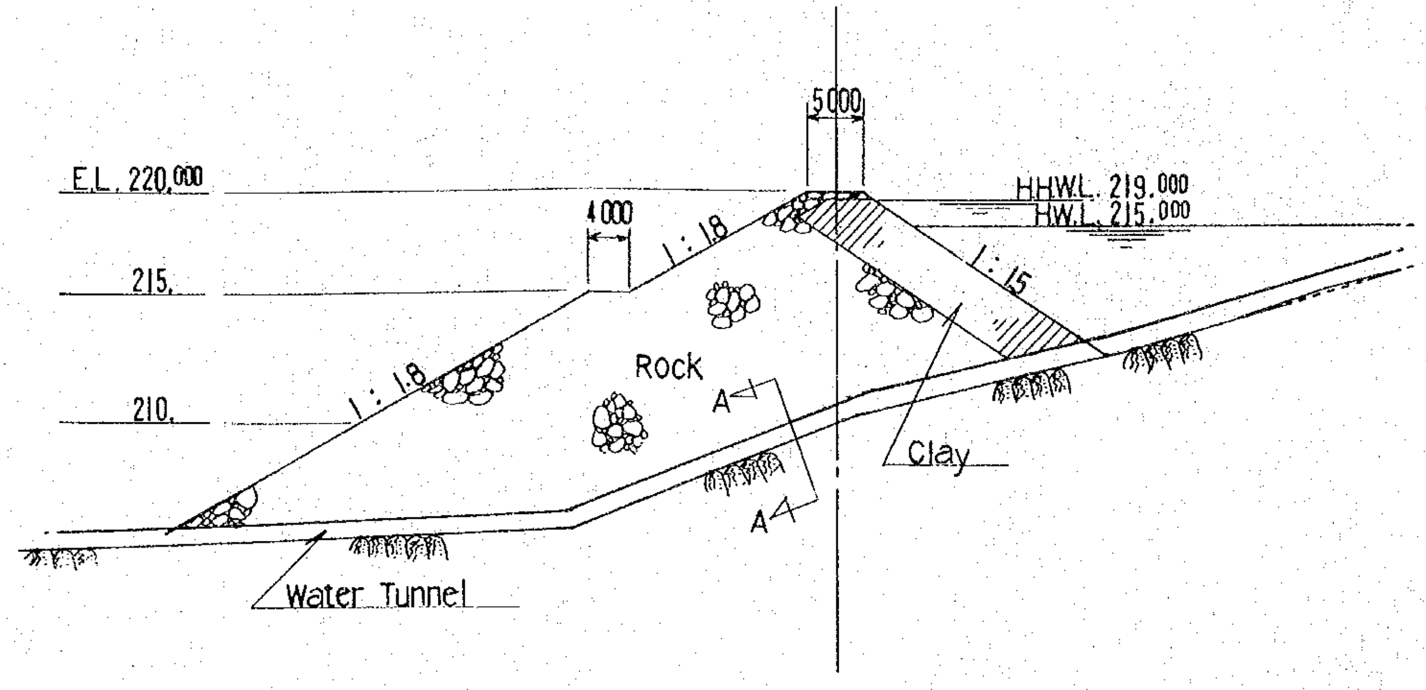
Q'ty ; 26 Sets

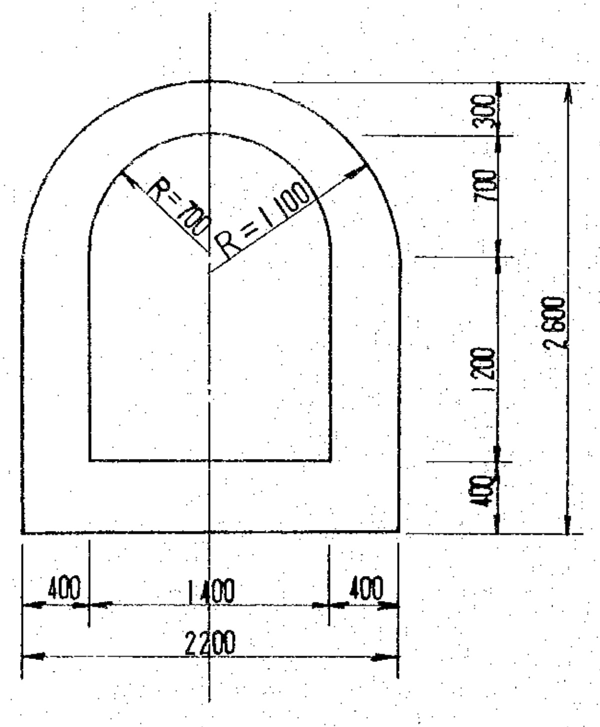
Fig. 7-14

DROP PIPE			
DRAWN BY	G	DATE	3/19/'78
CHECKED BY	K.S	DATE	3/21/'78
SCALE	1:40		

Unit : mm







Section A – A

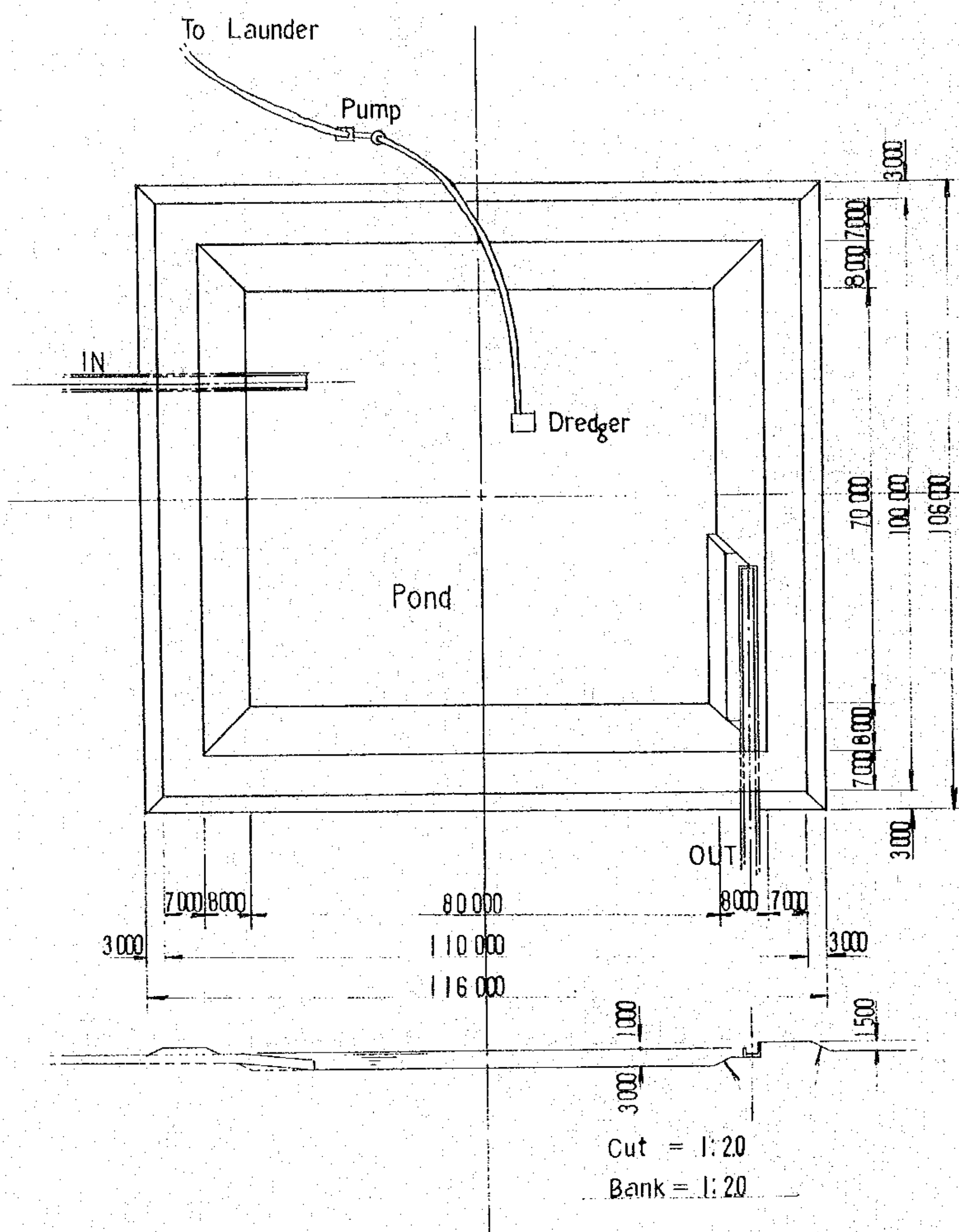
Q'ty : 1 Set

Fig. 7-15

Location , Point K-J

Unit : mm

EMERGENCY POND NO.1	
DRAWN BY	DATE
CHECKED BY	DATE
SCALE	



Location : near Point N

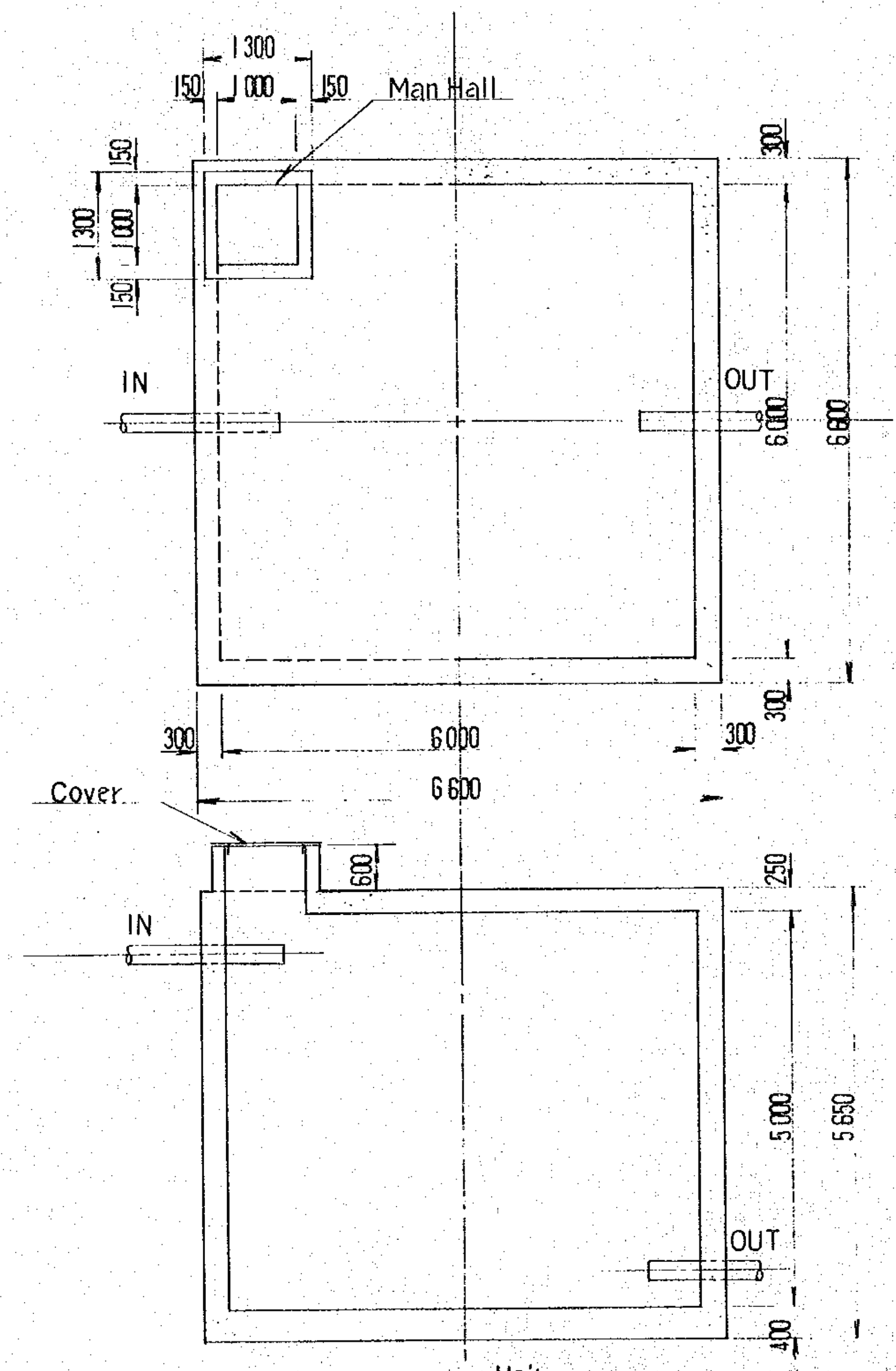
Qty : 1 Set

Fig. 7-16

Unit : mm

EMERGENCY POND NO. 2

DRAWN BY S.T. DATE 3/30/'78
CHECKED BY F.H. DATE 3/30/'78
SCALE 1:1100



Unit : mm

Fig. 7-17

Location ; Point L

Q'ty ; 1 Set

EMERGENCY WATER TANK	
DRAWN BY S. T.	DATE 9/29/'78
CHECKED BY F. H.	DATE 9/30/'78
SCALE 1:80	

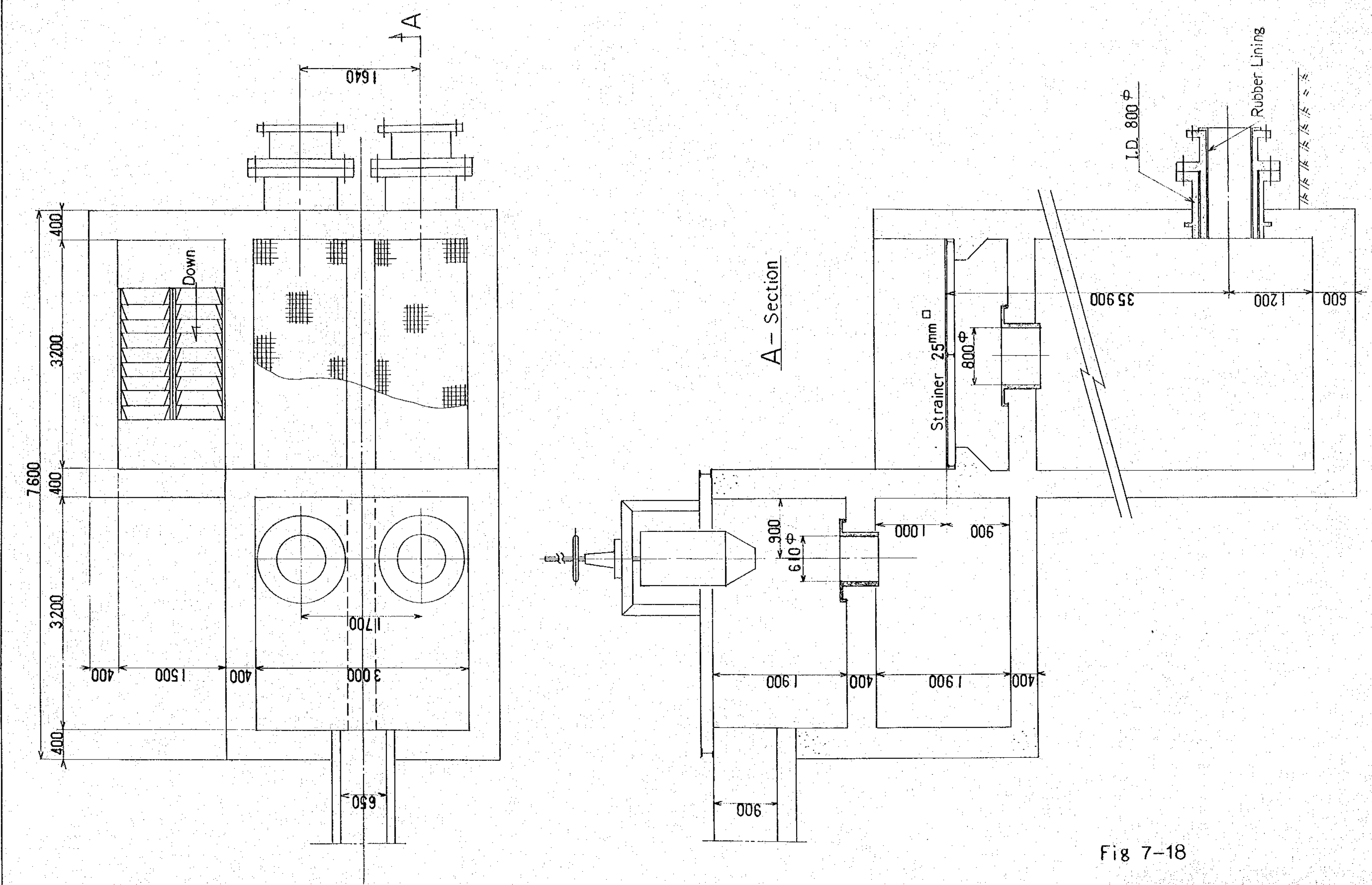


Fig 7-18

Location : Point N-O

Qty : 1 set

Unit : mm

UNDERGROUND FALL AT THE POINT N-O

DRAWN BY	E.T.	DATE	5/3 /'78
CHECKED BY	K.S.	DATE	5/10/'78
SCALE	1:50		