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CANOES IN GHANA

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by

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Programme de Développement Intégré des Pêches Artisanales en Afrique de l'Ouest - DIPA

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With financial assistance from Denmark and in collaboration with the Republic of Benin, the Fisheries Department of FAO is implementing in West Africa a programme of small scale fisheries development, commonly called the IDAF Project. This programme is based upon an integrated approach involving production, processing and marketing of fish, and related activities ; it also involves an active participation of the target fishing communities.

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Mr. Oyvind Gulbrandsen is a naval architect from Norway. This is the report of a mission to Ghana, undertaken on 6th May through 2nd June 1990.

This report was presented and discussed at the IDAF/FAO Sub-regional workshop on alternatives to the large dug-out canoe for use by small-scale and artisanal fishing communities, 26 - 29 November 1990 at Accra.

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1. Terms of Reference

Following the outlines as set out in the Canoe Replacement Programme, and in cooperation with IDAF, the consultant will prepare a feasibility study on the replacement of the large Ali/Poli type dugout beachlanding canoes and on less wasteful construction methods for the small dugout canoe in Ghana.

In particular, the consultant will assess the technical and economic viability of other boatbuilding methods and materials, including all forms of timber, GRP and aluminium construction, estimating the cost of setting up new construction facilities and the required training at both village and commercial levels of production.

2. Background

2.1 Number and size of canoes

According to Ref. 1 the composition and average sizes of the dugout canoes utilized in the marine fisheries are as follows : (1986 census)

	Average length overall m	Number
Ali/Poli/Watsa canoes	12,7 - 14,1	3,969
Beach seine canoes	9,4 - 11,9	797
Set net canoes	6,6 - 9,7	1,852
Seine canoes	-	1,004
Drift gillnet canoes	8,0 - 12,3	450
	Total	8,072

Broadly speaking there are two groups of canoes. The large Ali/Poli/Watsa canoes of 13-14 m constitute 50% of the fleet. Since the 1986 census canoes in this group have grown to 14-16 m length with an increase in net size. The remaining canoes doing beach seine, drift net, set net, line fishing are 7-12 m long.

2.2 Replacement need of canoes

The average service life of the Ghana dugout canoe made from Wawa (Triplochiton scleroxylon) has been given in Ref. 2 as 4-10 years, with an average of 6 years.

Assuming 6-7 years as average age, the replacement need would be as follows :

	No. of canoes	Replacement per year
Ali/Poli/Watsa canoes 14-16 m	3,969	600
Beach Seine/Drift net/ Set Net/Handline canoes 7-12 m	4,103	600

2.3 Timber for canoe replacement

From one large Wawa tree of 1.6-1.8 m (5-6 ft) diameter, and 30 m (100 ft) bole length, it is usually possible to make one large canoe 14-16 m and one small canoe 7-12 m. Drawing GHA-1 No. 5 shows the manufacturing process. The number of trees of this size to cover the replacement need for the Ghana canoe fleet is therefore 600 trees per year. In addition some canoes are exported to other countries in the region. The number of these canoes is estimated to 600 of 14-16 m and 700 7-12 m. These would require about 100 trees per year for replacement. The total replacement need is therefore around 700 trees. However, not all the trees that are felled can be utilized. Some trees have heart rot which is not discovered before the tree is felled. Ref. 3 gives a figure of 3 out of 10 trees felled that cannot be utilized and which are therefore left in the forest. Therefore the total number of trees felled to cover the replacement need is about 900 per year.

A tree of 1.8 m (6 ft) average diameter and a length of 30 m will contain 76 m^3 of timber. 900 Wawa trees per year give a log volume of 68,000 m^3. About 93% of this timber, or 63,000 m^3, is left in the forest as wood chips from carving out the canoe or discarded trees due to heart rot.

In addition to the timber for the dugout canoe comes the sawn Wawa timber needed for topsides and thwarts. This is approximately 1.2 m^3 for the 15 m canoe and 0.6 m^3 for the 9 m canoe. For 700 canoes per year of each size, the requirement would be 1,600 m^3 yearly of sawn planks, assuming 25% waste. With a saw conversion factor of 0.55 this gives about 3,000 m^3 of logs. Total timber requirement for canoe replacement is therefore in the region of 70,000 m^3 of Wawa logs per year.

2.4 Cost of canoes

The cost of the canoes is as follows, based on average figures from several villages :

	15 m canoe	9 m canoe
	¢	¢
Cost in forest	500,000	300,000
Tractor forest-road	70,000	50,000
Lorry to coast	180,000	150,000
Cost of dugout at coast	750,000	500,000
Planked up topsides + thwarts	150,000	100,000
Total cost of canoe	900,000 (US$ 2,400)	600,000 (US$ 1,700)

Assuming 1,400 canoes are produced each year, half of 15 m and half of 9 m, the total value of the completed canoes would be :

7-12 m canoes	¢ 420 million	(US $ 1,2 million)
14-16 m canoes	¢ 630 million	(US $ 1,7 million)
Total value	¢ 1,050 million	(US $ 2,9 million)

2.5 Alternative use of Wawa timber

Fig. 2 shows alternative use of a Wawa log. If the 70,000 m^3 of Wawa logs used yearly for making dugout canoes were converted into sawn timber, the value would be as follows, assuming a conversion rate of 55% into planks, 32% into small sizes and firewood and 13% into sawdust (Ref. 15):

Local market :

Sawn timber, 37,000 m^3 at ¢ 35,000 = ¢ 1,300 million (figures rounded off)

Small sizes, 22,000 m^3 at ¢ 15,000 = ¢ 300 million " " "

Total ¢ 1,600 million " " "

(US $ 4.4 million)

Export market :

Sawn timber, 37,000 m^3 at ¢ 85,000	= ¢ 3,100 million	(figures rounded off)
Small sizes (local), 22,000 m^3 at ¢ 15,000	= ¢ 300 million	" " "
Total	¢ 3,400 million	" " "
	(US $ 9,4 million)	

If the Wawa log now used for making canoes were converted into planks, the canoes would have to be built in another way. A cost estimation of making the equivalent to a 15 m canoe in other materials is given in Section 9. In calculating the total cost, it is assumed that a 9 m canoe would cost 50% of a 15 m canoe:

	15 m canoe	Total value of 700 canoes 15 m and 700 canoes 9 m
Wood:	¢ 1,0 million (US $ 2,800)	¢ 1,100 million (US $ 2,9 million)
GRP:	¢ 2,4 million (US $ 6,700)	¢ 2,500 million (US $ 6,9 million)
Aluminium:	¢ 2,3 million (US $ 6,400)	¢ 2,400 million (US $ 6,7 million)

The yearly gain or loss in value by building the canoes in another method and converting the Wawa to sawn timber would be :

Alternative canoes uilt in :	Sawn Wawa sold on local market	Sawn Wawa sold on export market
Wood:	Gain = ¢ 500 mill.(US$ 1,4 mill.)	Gain = ¢ 2,300 mill.(US$ 6,3 mill.)
GRP:	Loss = ¢ 900 mill.(US$ 2,5 mill.)	Gain = ¢ 900 mill.(US$ 2,5 mill.)
Aluminium:	Loss = ¢ 800 mill.(US$ 2,2 mill.)	Gain = ¢ 1,000 mill.(US$ 2,8 mill.)

If wood is used as an alternative construction method, there is a gain even if the sawn Wawa is sold on the local market. If the sawn Wawa is exported, there is a gain for all construction methods. From a national economy point of view, it would therefore even pay to import GRP or aluminium materials if the Wawa now used in dugout canoes could be exported. According to the "Ghana Timber Marketing Board" there is a good market for Wawa abroad. However, since the cost of logging and conversion is the same for all species, the timber companies prefer to export higher value species.

3. Considerations in Design of a New Canoe

3.1 General

The problem of finding an alternative to the dugout canoe is most pressing for the larger Poli and Watsa canoes because of the size of log required.

In the following considerations a size of canoe has been selected close to the 15.1 m GHA-1 design shown in drawings Nos. 1-5. This canoe was measured at Chorkor near Accra. According to the fishermen it represents a good average size of a Poli canoe. The question of alternatives for the smaller dugout canoes should be fairly easy to tackle after a workable solution has been found for the larger canoes.

3.2 Fishing method

The general arrangement of the present large canoes is mainly determined by the operation of the two main fishing gear.

The Poli purse seine (Appendix 4 and Drawing GHA-1, No. 4) is a fine mesh net, mostly 13 mm, which, in 1984, was recorded (Ref. 19) to be 450-540 m long and 35-45 m deep. According to Ref. 1 this net has now increased in size to 700 m length and 90 m depth. This increase in size of net has led to an increase in size of dugout canoes from 12-14 m to 14-16 m length. The Poli net is operated in fairly shallow water where the net touches the bottom. The crew required is 12-15 men. Purseseining with this net is a year-round fishing operation, October-December being the peak season. The main catch is anchovy (*Engranlis encrasicolus*) and juvenile *Sardinella spp.* and small fish like grunt (*Brachydenterns auritus*).

The Watsa purse seine (Appendix 4) has 18-50 mm mesh netting. It catches little tunny (*Euthynnus alleteratus*), *Sardinella spp.*, European Anchovy (*Engranlis encrasicolus spp*) and Chub mackerel (*Scomber Japonicus*). The size of the net is 400-500 m long and 35-50 m deep and is operated by a crew of 10-12 men. Its operation is the speciality of fishermen from Ada, Nungo and Kpone. A typical decked canoe for Watsa net is shown in drawing GHA-2, No. 1.

3.3 Dimensions

The long length and narrow beam of the existing canoe is determined by the shape of the log. Even with a different construction method, a drastic change in dimensions to a shorter and wider boat should not however be made, for the following reasons :

- The long length is required for the crew of 12-15 men to be spaced along the canoe for hauling of the purseline and for hauling of the net. See Drawing GHA-1, No. 4.
- A long length gives higher speed with the same engine. Speed is especially important when setting the Watsa net.
- Some beaches are so crowded with canoes that a large increase in beam might create problems of space.
- A longer canoe is easier to manhandle on the beach in that the ends can be more easily lifted for placing

rollers under the bottom

For these reasons a new canoe should be close in dimensions to the present one. A slight increase in beam and a small reduction in length can be accepted:

		GHA-1 Traditional canoe	Proposed New Canoe
Length overall	LOA	15.1 m	14.0 m
Beam moulded	BMD	1.90 m	2.18 m
Depth moulded	DMD	1.10 m	1.05 m
Cubic number	LOA x BMD x DMD	32 m^3	32 m^3

The proposed dimensions for a new canoe are indicative and have to be modified for different construction materials to give satisfactory stability.

3.4 Shape

The keel must be shaped so that the canoe will sit upright on the rollers when being hauled on the beach. This means a flat keel about 600-700 mm wide, or alternatively with two shallow keels. The keels must be shallow to give as little lateral resistance as possible. The ability to side slip is very important in a surf-crossing canoe. When hit by a breaker with the beam to the sea, the canoe should react by sliding away rather than tripping over a deep keel. This is best achieved by rounded sections, but experience from surf boats in India shows that also flat panels, as with plywood and aluminium, are acceptable, provided the requirement of a flat keel and low resistance to side slip is met.

The forward and aft sections should be rounded as on the existing canoe, except that some sharpening of the bow's waterline is of advantage to reduce the slamming of the present canoes in a head sea.

Experience with surf craft in India and Africa shows that the most critical phase is when approaching the beach. If the craft starts to broach it must immediately be brought back on course by the helmsman. This can only be done with a craft having a good rudder response. The Ghana canoe has an excellent shape for high manoevrability with a rocker in the keel and well rounded bow and stern sections. The steering oar gives a good leverage, but requires much skill in handling. In India the steering oar is not used on the Bay of Bengal Programme (BOBP) craft for surf crossing due to excellent manoevrability with a large rudder placed directly behind the propeller of the inboard diesel engine. An outboard engine mounted far aft should give a good steering movement, provided the propeller is not sucking air. Different positions of the outboard engine should be tried to improve manoevrability.

3.5 Stability

Drawing GHA-1, No. 3, shows the stability of the present type of canoe in the most critical condition : the crew of 12 men standing on the thwarts and hauling in the net. The maximum righting moment at 30° heel is 400 kg m. The maximum pull from the net is 370 kg before the canoe capsizes.

The stability curve shows that the metacentric height GM = 0.29 m. This is less than the minimum required by Nordic Boat Standard (NBS), Ref. 12 : Minimum GM = 0.35 m. For decked boats at 30° heel, the NBS minimum GZ = 0.20 m. The GHA-1 has GZ = 0.11 m at 30°. Beyond 40° heel the open canoe swamps. The conclusion is that the traditional Ghana canoe has less stability, measured in GM and GZ, than is considered minimum by NBS. The question of capsize at sea was raised but few fishermen thought it to be a problem. No statistics exist to quantify this problem. A staff member of the IDAF project participated in a fishing trip from Axim where the canoe capsized during night fishing at sea when hauling in the last part of the Poli purse seine. After capsize the canoe could not be righted again. There was nothing to hold onto on the bottom of the canoe. Only by chance were they spotted by another canoe and rescued. The canoe and the net were also recovered.

There is a need to go deeper into the question of safety of the canoes. What type of accidents happen and how often?

A watertight deck is a definite advantage from a safety point of view, both when crossing the surf, to prevent swamping, and to prevent flooding and capsizing when the fish suddenly dives while the net is being hauled on board.

The canoes used for Watsa purse seining to the east of Great Ningo have a deck (Drawing GHA-2, No. 1). The deck and bulkhead however, are not watertight and of limited benefit from a safety point of view. The reason that Watsa canoes in the east have a deck was said to be that the Watsa net had to be set at high speed to encircle the fast swimming tuna and that the net on top of the deck could be set quicker than if stacked in the bottom of the canoe between the thwarts, as on the Poli canoe. A reason for stacking the Poli net inside the canoe is the greater weight of this net compared with the Watsa net.

There is no doubt that a watertight deck with watertight bulkheads separating the net bin and the lead bin from the rest of the canoe would increase the safety of the canoe. At present there is also a bailing compartment in the canoe. This could possibly be replaced by a simple bilgepump made locally from a plastic pipe. The disadvantage of a watertight deck would be higher cost and more cumbersome retrieval of the fish when unloading.

The question of a longitudinal bulkhead in the fishhold to stop the fish/water mixture from decreasing the stability, due to a free surface effect, needs to be considered especially with an increase in beam.

3.6 Other safety aspects

The canoes do not carry any navigational lights, nor radar reflectors. Since most of the Poli fishing is carried out at night, the possibility of being run down by a ship or another fishing boat is high. Here again, not enough information exists to determine the need for and practicability of introducing navigational lights.

The International Maritime Organization (IMO) guidelines recommend that a lifejacket is carried for each crew member. One can question whether this is practical on a canoe. There is the problem of storing the jackets so that they cannot be stolen, whilst still being easily accessible in an emergency.

The present dugout canoe is unsinkable. This should also be top priority with a new construction method. Preferably some kind of handgrips should be incorporated for the crew to have something to hold onto when the canoe is in a bottom up position, but this might be difficult to include in a beachlanding canoe. Appendix 5 shows that additional buoyancy of about 0.4 m^3 has to be added to a 14 m wooden planked canoe, 1.8 m^3 to a GRP canoe and 2.0 m^3 to an aluminium canoe, to give flotation according to Nordic Boat Standard, NBS Ref. 12.

3.7 Engine

The standard outboard engine at present used on the Poli and Watsa canoes is the 40 Hp Yamaha Enduro. It develops 40 Hp at an engine rpm of 5,500. The weight is 65 kg. Cost is ¢ 840,000 from the dealer Japan Motor in Accra. This includes a 10% import duty. The service speed on a 15 m canoe loaded with net and crew, having a displacement of 4.2 tonne, is about 8.0 knots. Fuel consumption at service speed (3/4 throttle = 30 Hp) is about 16 litres per hour. Fuel consumption per nautical mile is 2.0 litres.

The fuel cost in Ghana is as follows :

Petrol	¢ 400 per gallon = ¢ 88 per litre
Oil, SAE 40	¢ 2,500 per gallon = ¢ 550 per litre

Oil is mixed with petrol in a ratio of $^1/4$ gallon oil to 5 gallons of petrol. This is an oil petrol ratio of 1:21 which is much richer than recommended by the manufacturer (1:50). However, the fishermen insist that running on this ratio has led to breakdown and therefore prefer the richer 1:21 mixture. The cost of this mixture per litre is :

petrol	∅ 88 x $\frac{20}{21}$ =	∅ 84
oil	∅ 550 x $\frac{1}{21}$ =	∅ 26
Total		∅ 110

Fuel consumption per trip varies a lot, but figures between 45-68 litres (10-15 gallons) were mentioned. Taking 55 litres (12 gallons) as an average per trip, and estimating 200 trips per year, the yearly fuel consumption is 11,000 litres (2,400 gallons).

The following estimate will indicate the relative importance of the engine and fuel in the total cost picture :

YEARLY COST

		∅
A.	Engine valued at ∅ 840,000 depreciated over 3 years	280,000
	Fuel cost 200 trips at 55 litre/trip, ∅ 110 per litre	1,250,000
	Engine repair	200,000
	Total cost engine + fuel	1,730,000
B.	Canoe valued at ∅ 900,000 depreciated over 6 years	150,000
	Repair cost	20,000
	Total cost hull	170,000
C.	Fishing gear valued at ∅ 4,000,000, depreciated over 8 years (replaced piece by piece)	500,000
	Total yearly cost, A + B + C excluding crew cost	2,400,000

From the above it will be seen that the engine and fuel contributes about 72% of the yearly cost, excluding the crew cost.

The only alternative to the petrol outboard engine that could be envisaged is the diesel outboard or inboard engine.

The Yanmar 27 Hp diesel outboard engine has been tested for some years in Senegal and Sierra Leone. It has not yet been sold commercially, but the trials are encouraging.

Another alternative would be a diesel inboard engine fitted with a retractable propeller and rudder for beachlanding, such as tested by FAO in Benin. The tunnel installations tried in Benin would be unsuitable for beachlanding because of reduced manoevrability. The experience in Benin and in other African countries shows that only an inboard engine of proven performance on fishing boats in developing countries should be utilized.

The criteria would be :

- Power = 25-35 Hp
- Hand starting as main starting method
- Watercooled with keel cooling
- Medium speed, 1,800-2,500 rpm
- Removable cylinder liners

Such an engine would be robust and have an estimated service life of 6-8 years. Fairly few engines in the 25-35 Hp range are today made according to the above heavy duty specification :

Engine	Power Hp	Rpm	Weight kg
Sabb, 2 JRG	30	1,900	375
Yanmar 2TDG	26	2,100	330
Lister STW34GR	30	2,300	320

For comparison of the various engines, the table in Appendix 6 has been compiled. The fuel cost is based on 200 trips per year and a distance of 28 nautical miles/trip (3.5 hours at 8.0 knots) = 5,600 n. mile/year.

The table shows that a saving of ¢ 750,000 (US $ 2,000) per year would be realized if the canoes could be fitted with either a diesel inboard or a diesel outboard engine.

Several questions need to be answered however, before this large saving potential can be realized :

(a) The service experience with diesel outboard engines in Senegal and Sierra Leone has been on canoes operating in moderate or no surf

(b) The service experience with diesel inboard engines in Senegal, Sierra Leone and Benin has been on canoes working from beaches or harbours with no surf problem

(c) The higher investment of a diesel engine will require some kind of a credit scheme to enable the fishermen to buy it. This is especially true for the diesel inboard engine which has an investment value almost three times the petrol outboard engine.

(d) The inboard diesel engine requires a permanent installation with watertight bulkheads.

(e) The diesel engines require specialized diesel mechanics for repairs.

(f) The diesel engines require clean fuel for satisfactory operation. Fuel contaminated with water and dirt is a major source of problems with diesel engines.

In spite of these major disadvantages, and the dismal record of earlier attempts at fitting diesel engines to canoes in West Africa, the potential fuel saving is so great that further trials are justified both with diesel outboard and diesel inboard engines.

3.8 Engine installation

At present the outboard engine is fitted to a bracket outside the starboard side. The advantage of this position is that there is little chance of the purse seine getting entangled in the propeller while setting the net. The disadvantage is that the engine is very exposed to spray and waves and the damage can be quite extensive in the case of a capsize when surflanding.

Two alternative outboard engine installations exist :

(a) Inside well offset to the side as used on large purse seine canoes in Sierra Leone

(b) Inside well centrally mounted, as used on large purse seine canoes in Senegal.

In both these cases the correct positioning of the engine in relation to the waterline is critical.

Fig. 3 shows a sketch of the two alternatives. Both these alternatives should be tried on prototype canoes, together with the conventional side installation, to assess differences in speed, steering, lifting or tilting when landing.

3.9 Handling on the beach

The canoes are usually hauled out of the water after each fishing trip. It is considered too risky to leave the canoe at anchor. Permanently installed moorings could reduce the chance of the canoe being lost, but these moorings might interfere with beach seine operations.

The susceptability of Wawa to attack by marine borers would also be a problem with a canoe moored too long in the water.

The handling on the beach is done by manpower only. Usually two ropes are attached to the stem with about 15-20 people pulling on each rope. In addition 4-8 people are lifting and pushing with their backs on the stern. Planks and rollers are placed under the canoe. Rollers are usually made from a heavy wall steel pipe of 114 mm diameter and 1,8 m length. The canoe is prevented from rolling back between each heave, by placing a wooden wedge between the pipe and the plank.

Beach slopes in Ghana vary between a steep beach of 1:5 after a storm often associated with a "cliff" of up to 1 m height near the crest. In calm surf the beach slope could be 1:10 and even as flat as 1:20. Drawing GHA-3, No. 1 shows that a force of around 1.0 tonne will be required to pull a 3 tonne canoe on rollers and planks up a beach slope of 1:6. Assuming each man pulls 30 kg in short rythmic hauls, a 3 tonne canoe on rollers would require about 35 men.

The force required to pull the canoe is directly related to the weight of the canoe. If the weight is reduced to 1,500 kg, as is possible with aluminium or GRP, the pull required is reduced to 500 kg, and this would require only about 20 men.

One improvement on the present system would be to get the fixation for the pulling rope to the canoe lower down. The pull would then be more in the direction of the movement of the canoe.

There exist several methods to reduce the amount of manpower required :

(a) Block and tackle

Using two blocks with two sheaves each. One block attached to a palm tree or a log buried in the sand, the other block to the canoe. The pulling force is then reduced to about $^{1}/_{3}$ of a straight pull on the canoe. Eleven men would then be able to pull the 3 tonne canoe in the above example.

The disadvantage of this system is the amount of rope required, the problem of sand in the sheaves and the need for a fixation point.

(b) Manpowered capstan

The BOBP has developed a capstan where 4 men can pull a 3 tonne canoe. It is made of steel, hot dipped galvanized. A galvanized steel wire is required for pulling the canoe. A rope has too much stretch and can give a dangerous whiplash if it breaks.

The disadvantage of this system is the space required on the beach for the men pushing the capstan bars, and the need for a good fixation point.

(c) Engine driven winch

The BOBP has also developed a beach winch driven by an 8 Hp diesel engine, Ref. 18. Due to the weight it cannot be shifted from place to place. Hauling of several canoes can be achieved by having a snatch block attached to strong fixation points along the beach.

(d) Unconventional hauling devices

Two ideas could be worth exploring further :

- A winch pulled by a lever action
- A lift and pull gantry (Drawing GHA-3, No. 1)

Trials of the most promising hauling devices should be made to determine their suitability in Ghana.

4. Alternative Canoe Types

The easiest solution to the problem of finding an alternative construction method to the Ghana dugout canoes would be to adopt another proven design. The following is a survey of canoes that have been tried in Ghana and other West African countries.

4.1 Alternative canoes - Ghana

There have been some attempts at producing a planked version of a Ghana canoe :

- GIHOC, Tema. This is a carvel planked 12.0 m canoe which suffered from structural problems due to weak framing. The shape is a good approximation of a Ghana canoe.

- Winneba boatyard. A planked canoe with inboard diesel engine and propeller in a tunnel. The canoe is flat bottomed with a very different shape from the local canoes. The engine had a breakdown and the canoe is not in operation.

- Woodwork Marine, Takoradi. Flat bottomed "Dory" type boats of 8 m and 9 m length made of plywood. The 9 m canoe was powered with a 30 Hp inboard diesel engine. The hull shape is very different from a traditional canoe.

- A 10.8 m catamaran of Gifford type which was tried out for one year (1977-78) from a beach near Elmina and Kromantse.

None of the above alternatives has succeeded in entering the market. Experience in other developing countries shows that it is difficult to gain acceptance for a new craft if it is radically different in proportions and shape from the traditional craft. There have to be very good reasons for changes.

Before the construction of Tema harbour, planked surfboats were used to bring merchandise between the ships and the shore. These surfboats were about 7.6 m (25 ft) long and of carvel planking copper fastened to closely spaced transverse bent frames. The timber used in planking and framing was Danta. The construction leaves a very cluttered interior with frames and stringers, and this is a definite disadvantage in a fishing canoe where the catch is loaded in bulk in the canoe. It is also doubtful whether the construction would be strong enough for a craft 14-15 m long.

4.2 Alternative canoes - West Africa

(a) Traditional canoes

Fig. 4 shows types of canoe construction used in West Africa. Types A, C and E are planked constructions. Type A, from Senegal, (Fig. 5) is an almost frameless construction, the strength of which is dependent on the thickness of the keel plank and the drift bolted connection between the various members. The lack of framing gives a rather flexible hull and watertightness is achieved by a strip cut from a firehose nailed in place with tar under. The advantage of this construction is a clean inside without obstructions. The main disadvantage is the problem of strength of the drift-bolt joints and the need to dismantle most of the canoe when a plank has to be changed. The pronounced V in the transverse section of these canoes is important in distributing the load from the keel plank into the sides when the canoe is resting on one roller midship on the beach. A flatter bottom would need transverse framing. The V-shape means that the stability is low in light condition, but improves with loading.

Type C is the 15-17 m planked canoe used in Sierra Leone, modelled on the large Ghana canoes (Fig. 6). These canoes are of conventional carvel construction. They are not strong enough for surfcrossing and the plank seams would open up when left to dry on the beach.

Type E is a construction method used in Nigeria for 7-8 m canoes. There are no frames and the planks are held together by staples on the outside. Watertightness is achieved by nailing a strip of galvanized iron + caulking over the joint.

Types A, C and E represent three different methods of building a wooden boat. None of them are satisfactory for direct transfer to conditions in Ghana. They could however provide a starting point for further development, and should be included in the investigation proposed into various ways of achieving transfer of stresses and watertightness between planks.

(b) Introduced planked canoes

FAO has introduced two new canoe types in Senegal and Guinea Bissau. The 14.8 m SEN-1 of which a total of six have been built in Senegal and Guinea Bissau, and the 9.0 m canoe GBS-1 of which two have been built in Guinea Bissau. The construction method used is seambatten planking which solves some of the problems with watertightness and transfer of stresses between the planks. The seambattens on the inside are a disadvantage when the fish is loaded directly into the canoe, as when purse seining, since it becomes difficult to clean the boat.

The two SEN-1 built in Dakar are still afloat, when inspected in June 1990, five years after launching. The boats have not been operated in surflanding condition. The inboard aircooled diesel engines originally fitted have, however, broken down and been replaced by a diesel outboard engine in one case, and a second-hand diesel inboard engine in another case.

(c) Glassfibre reinforced plastic (GRP) canoes

Several attempts have been made to introduce GRP canoes:

- 9.75 m "Super pirogue" Ghana type in the Ivory Coast (Fig. 8)
- 9.12 m beachlanding canoe by FAO in Nigeria
- 9.1 m Yamaha canoes in Senegal and Sierra Leone
- 12.0 m Yamaha and Yanmar canoes in Nigeria, Senegal and Mauritania
- 12 m GRP pirogues of Italian manufacture in Mauritania
- 8.4 m GRP pirogue SOSACHIM, Senegal, produced locally at a cost of US $ 7,200 (1990)

The only success reported is in Mauritania where the inboard diesel powered 12.0 m Yamaha and Yanmar canoes have been well accepted by the local fishermen. There has, however, been a substantial subsidy involved. A modified version of these 12 m canoes has been built by an FAO supported boatyard (Fig. 7). The price in 1988 was US $ 4,300 for the hull only. A comparable size traditional Senegal canoe costs about US $ 1,500.

The main difficulty in introducing GRP canoes has been the high cost compared with traditional canoes.

5. Alternative Construction Methods - Wood

5.1 Wooden boat construction in Ghana

Ghana is the most important country in West Africa for wooden boatbuilding. It is the main supplier of dugout canoes to Benin, Togo, Ivory Coast and Liberia, and it has been the biggest producer of wooden planked, harbour-based boats of 9 m to 22 m length. These boats are of the FAO V-bottom type, introduced in 1970. Due to a drop in trigger fish catches, and a ban on more trawlers, new construction has come to a halt and most of the boatyards are now closed down. The facilities and the trained staff exist and could relatively easily be converted to construction of wooden canoes. The main commercial boatyards are :

Tema :	GIHOC Boatyard
Winneba :	Winneba Shipyard
Elmina :	Yartel Boatyard
Secondi :	GIHOC Boatyard
Takoradi :	Woodwork Marine

Other boatyards did exist but have been closed down.

The above boatyards are equipped with woodworking machinery such as circular saws, bandsaw and thicknesser/planer.

The quality of work seen on fishing boats in Ghana is quite variable. In some cases the scantlings and fastenings are insufficient and the workmanship ranges from good to poor. Any new design would require supervision from an outside consultant boatbuilder to ensure good quality in the prototypes. Only boatyards with a good reputation for quality of work should be selected.

5.2 Timber species

A summary of the properties of Ghanaian timbers is given in Ref. 14. At present only three species are widely used in Ghana for boatbuilding, see next page :

The main difference between the Wawa (Obeche) at present used for canoes and the Odum (Iroko) used in harbour-based boats, is the weight and durability, Odum being 70% heavier but of much greater durability. Odum can be expected to last at least twice as long as Wawa, that is 12-15 years against 6-7 years.

Durability is often linked with high weight, and, while this is acceptable for framing and keel, a less durable but lighter timber is often selected for planking.

The main criteria when selecting a timber for planking are :

- Little movement in service. A beachlanding craft is subjected to great variation in humidity; wet at sea, dry on the beach. It is important that a timber for planking has little movement in service, that is when the moisture content (MC) varies between 15% and 25%.
- Weight of maximum 700 kg/m^3 at 15% MC. A lighter timber will give a lighter canoe.
- Medium or high durability.
- Not prone to splitting when driving nails.
- Good long term availability.

Wawa satisfies all the above requirements, except for durability. Regarding availability, Appendix 7 gives an indication of estimated resource life of commercial species. Odum, the timber now extensively used in boatbuilding, is likely to be exhausted in 2-3 decades with the present rate of felling, whilst Wawa approaches sustainability.

The Consultant Timber Specialist will prepare a list of potential species of Ghanaian timbers suitable for boat construction. Appendix 8 gives particulars of timber used for boatbuilding in other West African countries.

BOATBUILDING TIMBER AT PRESENT USED IN GHANA

	Species		
	Wawa (Obeche) Triplochiton sclerozylon	Odum (Iroko) Chlorophora excelsa	Kusia (Opepe) Nauclea diderichii
Density at 12% MC	384 kg/m^3	652 kg/m^3	758 kg/m^3
Natural durability	non-durable	Very durable	Very durable
Movement in service	small	small	small
Use	Dugout canoes	Frames, planking above waterline, deck. Less resistant to marine borers than Opepe.	Keel, planking under waterline. Checks and cracks over the waterline.
Price/m^3 Local market 1)	₵ 30,000-50,000 US $ 80-140	₵ 70,000-90,000 US $ 190-250	₵ 80,000-90,000 US $ 220-250
Price/m^3 Export market	₵ 90,000 US $ 250	₵ 190,000 US $ 530	

1) The lower price is the one obtainable from small local sawmills. The higher price from larger commercial sawmills.

5.3 Impregnation to increase durability

Dupaul Woodtreatment GH Ltd. has a CCA treatment plant near Takoradi mainly for treating teak poles used in telephone and power transmission lines. The cost of treatment is Ø 49,000 per m3 with a retention of chemicals of 24 kg per m^3. The high cost of treatment makes it less attractive at present for use in boatbuilding but, as timber prices continue to escalate, it could be an interesting alternative in the future, permitting a great increase in durability of species with low natural durability. Care must be used in disposal of the offcuts from pressure treated timber as they should not be used for firewood due to poisonous fumes.

5.4 Marine plywood and veneers

Ghana has a substantial production of plywood and veneers. The plywood is produced as Water Boil Proof (WBP) with Phenol glue. Marine plywood according to ISO or British Standard BS 1088 is not produced due to problems of inspection. The WBP plywood is produced with mixed redwoods in the veneers, Mahogany and Sapele. However, plywood can be ordered from companies such as African Timber and Plywood (Ghana) Ltd. with a specified very durable timber, such as Makore, in all veneers and no splicing of veneers.

The cost of the Makore WBP plywood would be Ø 1,1 million for a minimum order of 5 m^3. This gives a price per m3 of Ø 220,000. The ordinary WBP plywood costs about Ø 120,000 per m^3. See price list and Lloyds specification for veneers in Appendix 9.

5.5 Main problems in planked construction

A dugout canoe has no joints and no fastenings. It is a construction method found all over the world where large trees are still available. Pressure on forest resources has forced a development towards planked construction in many places. Building a craft from planks introduces two major problems that have to be overcome :

- watertightness in the joints between the planks
- sufficient strength in the connection between the planks.

The solutions to these two problems are extremely varied (Fig. 11).

Basically there are two methods of joining wood together:

- Mechanical fastenings (nails and bolts)
- Waterproof glue

When selecting alternative wood construction for Ghana canoes, the advantages and disadvantages of these two fastening methods have to be considered:

Mechanical Fastenings (Appendix 10)

Advantage: Suitable for village construction
Does not require well dried timber
Has flexibility for changes in humidity of timber
Repairs generally easy at the village level.

Disadvantage: Does not give the same strength as glued construction, therefore weight is heavier
Watertightness in joints is more difficult to achieve.

Glue (Appendix 11)

Advantage: Strength in all directions can be achieved and thereby a reduction in weight
Joints can be made completely watertight.

Disadvantage: Requires well dried timber and construction under cover, therefore less suitable for village construction
Cost of imported glue can be high, but amount of glue is dependent on construction method
Repair is generally more difficult than when using mechanical fastenings.

6. Alternative Construction Methods - GRP

At present there is no company making GRP boats in Ghana. Japan Motors did establish a boatyard in Tema some years ago with a view to producing the Yamaha type of GRP beachlanding craft. However, this venture was abandoned due to the high cost of the GRP canoe versus the traditional canoe. No local company could be located that make other objects from GRP such as bathtubs or basins. The local cost of the raw materials polyester resin and fibreglass mat, have to be estimated on the basis of cost in Europe as of June 1990 (minimum 10 tonne/year):

Polyester resin:	US $ 3.00 per kg
Gelcoat:	US $ 5.18 " "
Chopped Strand Mat (CSM) "E" glass:	US $ 3.65 " "

Transport cost Europe-Tema is assumed to be US $ 0.30 per kg.

Local cost CIF Tema is therefore:

Polyester resin:	US $ 3.30	= ¢ 1,200	per kg
Gelcoat:	US $ 5.48	= ¢ 2,000	" "
Chopped Strand Mat:	US $ 3.95	= ¢ 1,400	" "

The most appropriate construction method in Ghana would be single skin with hand lay-up of the laminate. To increase impact strength, the use of woven roving alternate with chopped strand mat should be considered. GRP must be protected against abrasion when the canoe is hauled up on the beach. Experience from Sri Lanka indicates that this is best achieved with a 10 mm layer of sand-resin mixture along the keel. Wooden abrasion keels are difficult to fix to the resin hull in a way that will facilitate replacement.

Lloyds (Ref. 8) recommend that the resin is stored at a temperature not exceeding 20°C and not below 0°C. In Ghana this would mean storage in a chilled room. It is then important that the resin is allowed time to rise to the temperature of the moulding shop before it is used.

The temperature and humidity in the moulding shop should be monitored. Variations that will lead to moisture condensation on moulds and materials must be avoided. As long as these precautions are taken, no major difficulty is foreseen in moulding GRP boats in Ghana. The existing commercial boatyard could fairly easily be converted to GRP construction.

7. Alternative Construction Methods - Aluminium

Ghana Aluminium Products Ltd. in Tema are producing various articles in aluminium, such as corrugated roofing sheets, watertanks and also a few aluminium boats of 5-9 m length. An unfinished fishing boat of 11.5 m length was seen in the workshop. An 8.5 m (28 ft) passenger transport boat was quoted at ¢ 5 million, excluding engine. The company is well equipped with tools and equipment for welded aluminium production. The question of cost of an aluminium alternative to the Ghana canoe can only be determined by obtaining a quotation from the company and from aluminium boatyards in Europe, but an indication can be had based on material prices.

The cost of aluminium plates was given as ¢ 1,200-1,500 and extrusions at ¢ 2,000. Import duty on aluminium is 10%. The quotations obtained in Europe, inclusive 10% tax, indicate a price per kg CIF Tema:

Plates	US $ 4.10	¢ 1,500
Profiles	US $ 4.70	¢ 1,700

Plates and profiles must be of an alloy approved for boat construction.

Although Ghana is a large producer of aluminium ingots, only plates up to 2.4 mm are rolled locally. All materials for building aluminium canoes therefore have to be imported.

Construction of the aluminium canoe would be on a jig, preferably a turnable jig that allows MIG welding in the most convenient position.

8. Scantlings

8.1 General

To perform a cost estimation it is necessary to know the scantlings, that is the dimensions of frames, frame distance and skin thickness of the bottom and side.

There are no existing comparable craft to the Ghana canoe working in the same arduous condition of surflanding in any part of the world. As shown under 4, we are not in the position that a craft of proven construction can be transferred from another country to Ghana.

Three approaches to determining scantlings are considered below.

8.2 Scantlings determined by external forces

There are three main types of loads that have to be considered:

(a) The canoe resting on the beach with one roller midship. This case is fairly well defined with a known load being the weight of the canoe with fishing gear.

(b) Hydrostatic and dynamic loads on bottom and sides. The determination of these loads can be made either on the basis of Ref. 9 or Ref. 12.

(c) Impact loads when the canoe is thrown broadside on to a sandy beach where the load is distributed over a larger area, or towards a rock where the load acts on a limited area. These latter loads are the most difficult to assess.

It will be necessary to make a thorough investigation of the loads that can be expected and what thickness of planking is required with various construction methods. This investigation should be made by an institute with experience in theoretical and practical analysis of wooden structures. The target would be to give a rational basis for determining scantlings for wooden craft under 15 m length.

The investigation should focus on two aspects critical to wooden boats subjected to the rigours of beachlanding :

- Fastenings
- Watertightness under wetting and drying cycles.

Conventional carvel construction is unsuitable for beachlanding because the method gives low shear strength between the planks and poor watertightness under wetting and drying cycles. Methods of improving the shear strength and watertightness should be investigated and drawing GHA-3, No. 2 gives some ideas. Watertightness can be achieved by double planking with a watertight membrane between, but the weight of this planking will be 40%

higher to maintain the same strength in bending assuming no shear is transmitted between the two plank layers. Also, from a repair point of view, single planking is preferable.

8.3 Scantlings based on the existing dugout canoe

One approach to determine the scantlings of a new canoe is to base it on the existing canoe made from Wawa. If the new canoe was a dugout made from a stronger timber, the thickness could be reduced to maintain the same strength in bending. For example, taking a plank simply supported with a uniform loading q it can be shown that the thickness of the plank is

$$t = 0.86 \times S \sqrt{\frac{q}{f}}$$

where

S = distance between the supports
f = modulus of rupture of the timber

From Ref. 14

Wawa $f = 53\ ^{N}/mm^2$

Odum $f = 86\ ^{N}/mm^2$

It can be shown that for the same bending strength, Odum can have 0.79 x thickness of Wawa.

Assuming a bottom thickness of the dugout canoes from Wawa is on the average 170 mm. A canoe made of Odum would then be 135 mm thick. The canoe of Odum would however, be 34% heavier than the one made of Wawa. This approach is clearly not feasible. It does not take into account the reason why the canoe made of Wawa has to be so thick:

- Deterioration of the timber because of low natural durability. This means that the modulus of rupture diminishes drastically over the years

- Low abrasion resistance on the bottom leading to reduction in thickness and eventually cracking.

In both these respects Odum would be much better. Assuming that after 5 years the modulus of rupture of Wawa has been reduced from 53 $^{N}/mm^2$ to 10 $^{N}/mm^2$, and the strength of Odum unaffected, the Odum planking would be 0.34 x thickness of Wawa and the bottom thickness reduced to 58 mm. The canoe of Odum would then be 42% lighter than the Wawa canoe.

Another important aspect when considering the strength of a dugout canoe is that timber has very little strength in tension across the grain, in fact, only $^{1}/40$ of the strength along the grain.

Transverse frames in a planked hull will effectively take care of these stresses and thereby permit a reduction in hull thickness.

The conclusion is that using the existing dugout canoe as a basis for determining scantlings is of limited use when changing radically the construction method.

8.4 Scantlings based on classification societies rules

The thickness of the bottom skin has been determined for various stiffener spacing according to the rules of the following classification societies:

Lloyds Motorboat (Lloyds), Ref. 8
American Bureau of Shipping (ABS), Offshore Racing Yachts, Ref. 9
Sea Fish Industry Authority (SFJA), UK, Fishing Boats, Ref. 10
Nordic Boat Standard (NBS), Fishing boats, Ref. 12

The scantlings have been calculated for a canoe of the following dimensions. The size in cubic number is equivalent to the GHA-1, 15.1 m canoe, but the beam has been slightly increased and the length reduced:

Length over all	:	14.0 m
Beam moulded	:	2.18 m
Depth moulded	:	1.05 m
Cubic number	:	32 m^3

The classification societies give a choice between a closely framed boat with a thin hull planking and a boat with wider frame spacing and thicker planking. ABS and NBS also make modification for curvature of the shell and ABS for the aspect ratio of the unsupported skin panel in moulded and plywood construction.

Generally for greater local impact resistance it is better to have a thick skin with wider frame spacing.

(a) Wood

BOTTOM PLANKING THICKNESS (mm)
up to 150 mm above waterline

		Stiffener spacing	
		400 mm	800 mm
Carvel Planking	Lloyds ABS NBS SFJA	36 37 47 27	
Plywood or Cold Moulded	Lloyds ABS NBS	27 17 18	39 26 35
Strip Planked	NBS	33	66

From the above table one will note that the different classification societies give very different thickness of bottom planking. NBS require carvel planking of 47 mm thickness, whilst SJFA give 27 mm for the same fishing boat. Nobody can say that boats built according to SFJA rules are too weak. One reason is that Lloyds, ABS and NBS base their scantlings on length, while SJFA use Cubic Number = Length x Beam x Depth. Lloyds, ABS and NBS assume a craft of "normal" Western type where Beam/Length ratios are fairly constant. For a long narrow craft such as the Ghana canoe, this gives unrealistic figures. Scantlings must be related to the size of the craft and the Cubic Number is a much better measure for size than length only. It therefore seems that the SFJA approach is the more rational.

One can conclude that there is limited help in utilizing the present classification rules in determining the scantlings of a new wooden Ghana Canoe.

For cost estimation however, it is necessary to make some assumptions.

The material dimensions given in Appendix 12 must not be considered final, but they will be sufficiently accurate to give an indication of cost. The types of wooden construction selected are thought to cover the most suitable ones. The single plank skin construction in 12 A and B would require new solutions to stress transfer and watertightness between the planks. The construction methods selected are (Appendix 12):

- A Longitudinal planking
- B Cross planked
- C Strip planking
- D Plywood,
- E Strip planking + cold moulded,

Alternatives A, B and D would be fairly easy to repair compared with C, and E. For weight and cost calculations Odum has been selected both because it is well known locally and represents the upper limit in weight and cost. The weight is 650 kg/m^3 at 12% MC. In the calculations 700 kg/m^3 has been used to account for water absorbtion. The cost used in the calculations is the highest recorded locally = ¢ 90,000 per m^3. It is assumed that wastage in planing and cutting is 50% of the net timber volume in the canoe. Other timbers selected by the Consultant Timber Specialist could give a substantial saving both in weight and cost and have a better long term availability than Odum.

The weight and cost for the 14.0 m canoe has been determined by using the midship section and calculating the volume and weight for one metre length of vessel. The total weight and material volume is then calculated by taking this figure and multiplying by 0.93 x Length over all = 0.93 x 14 m = <u>13 m</u> which is a good approximation.

Labour cost has been based on a monthly wage for a skilled carpenter of ¢ 15,000 (US $ 42).

(b) Glassfibre Reinforced Plastic - GRP

The following table gives the bottom thicknesses, outside the keel area, required by the various classification societies:

	Stiffener spacing 400 mm	Stiffener spacing 800 mm
Lloyds	9.8 mm	18.5 mm
ABS	8.4 "	11.3 "
NBS	10.8 "	13.2 "
SFJA	9.8 "	15.9 "

From the above table one will note that in GRP there is much less variation in required bottom thickness between the various classification societies than for wood. For an estimation of cost, a stiffener spacing of 800 mm and a bottom thickness of 15.9 mm according to the SFJA proposal has been selected. The keel has been increased to a thickness of 20.4 mm while the sides have a thickness of 9.9 mm (Appendix 12 F)

(c) Aluminium

The following table gives the required thickness according to NBS and ABS. Scantlings tables for aluminium are not available for Lloyds and SFJA.

	Stiffener spacing 400 mm	Stiffener spacing 800 mm
ABS	4.9 mm	6.0 mm
NBS	4.6 mm	5.6 mm

For cost estimation a bottom thickness of 6.0 mm has been selected with a stiffener spacing of 600 mm. The keel thickness has been increased to 8 mm and the sides reduced to 4 mm. See Appendix 12 G.

9. Evaluation

From Appendix 12, the following summary can be made (See also Fig. 12):

	Weight kg	Cost ¢
Existing 15 m dugout canoe	2,900	900,000
Alternatives :		
A Wooden, planked	2,800	985,000
B Wooden, planked	2,800	990,000
C Wooden strip-planked	2,400	930,000
D Wooden, plywood	2,000	915,000
E Wooden, strip + cold moulded	2,200	1,151,000
F GRP	1,800	2,416,000
G Aluminium	1,300	2,277,000

9.1 Cost

Broadly speaking the five wooden alternatives lie in the same cost group of ¢ 0,9-1,2 million, whilst the GRP and aluminium boats lie in another group ¢ 2,3-2,4 million.

As long as a dugout canoe of 15 m is available at a price of ¢ 0,9 million, it is difficult to see that any fisherman would pay more than the double for a GRP or aluminium canoe, unless he is convinced that it has major advantages in other respects, such as lower weight, not attacked by marine borers and longer durability. It is difficult for an outsider to judge how a Ghanaian fisherman will reason when having a choice of several alternative canoes at different costs. The best way is to demonstrate the different alternatives and let the fisherman himself make the choice.

For the wooden versions the price range is not far from what is at present paid for a dugout canoe.

9.2 Weight

The aluminium canoe is less than half the weight of the dugout canoe. This will improve handling on the beach and increase the service speed. The GRP canoe is also light, followed by the wooden canoe made from marine plywood. The wooden planked canoes are about the same weight as the dugout canoe.

9.3 Construction

The four wooden alternatives A, B, C and D could be built in a village provided sufficient training can be given. However, it would be natural to start with one of the existing wooden boatyards.

The wooden cold moulded alternative E is only suitable for an established boatyard. The GRP canoe alternative F can be built in one of the existing boatyards with sufficient training. The aluminium canoe, alternative G, can at present only be made by Ghana Aluminium Products Ltd.

in Tema.

9.4 Strength and durability

Generally it is easier to achieve strength and durability with GRP and aluminium than wooden construction. Actual strength and durability can, however, only be determined by testing prototypes in beachlanding operation over a long period.

9.5 Acceptance by the fishermen

This can only be determined by demonstration of canoes in actual fishing operation. Only when the fishermen are willing to buy the new canoes with their own money can it be said that the canoe is accepted.

10. Recommendations

Experience from the BOBP project in India and Sri Lanka shows that developing new beachland craft requires a long term effort. The development of an alternative to the Ghana dugout canoe will take about 4 years. Fig. 13 shows the proposed time schedule. The proposal is based on the experience of the BOBP of utilizing, to the maximum extent possible, skilled local persons to provide the continuous supervision required in boatbuilding and repair and in engine repair. The local personnel should be attached to the project for the whole duration and have a direct liaison with a designated FAO officer with the West African Regional Project who should pay periodic visits to the project. Short term input in boat design, boatbuilding and marine engineering will be provided by FAO Consultants.

The work tasks of the project will be split up as follows :

10.1 Technical evaluation of wooden construction methods

Because of local availability of materials and skill, and low cost, wood is the most attractive material for alternative canoe construction. A narrowing down of the many wood construction alternatives is however required. This should be done through collaboration between FAO, a Naval Architect and a selected wood technology organization. The purpose would be to :

- provide a rational approach for determining wood scantlings with different construction methods
- make a theoretical analysis of strength requirement in a Ghana canoe in bending, torsion and shear, and how the various construction methods respond to these stresses
- analyse methods of joining planks with mechanical means that provide transfer of forces, watertightness and easy repair
- provide information on choice of epoxy or phenol resorcinal glue in laminated construction

- execute required tests to clarify aspects not covered by existing theory.

10.2 Design of alternative canoes in wood, GRP and aluminium

The technical evaluation of different wood construction methods should lead to the selection of 3-4 different methods to be tested out in full scale in actual fishing operations. The Naval Architect will prepare detailed working drawings for these alternatives in wood.

The designs will involve the following options :

(a) Petrol or diesel outboard engine mounted outside or inside in a well

(b) Diesel engine with liftable propeller and rudder, possibly in a canoe used for long-range handlining where yearly fuel consumption is high

(c) Decked or open arrangement

In addition a naval architect with experience in GRP and/or aluminium will prepare drawings for one GRP and one aluminium version. Quotations for the GRP and aluminium versions should be obtained from boatyards in Europe and from Ghana Aluminium Products Ltd.

10.3 Order of materials and equipment

Based on specification from the Naval Architect, the required orders will be placed so that delivery can be assured before commencement of construction.

10.4 Construction of prototypes

The decision on building one GRP and one aluminium prototype should be taken after receiving quotations. The construction of four to five wooden prototypes should take place in Ghana at a selected boatyard and under the supervision of an FAO Consultant Boatbuilder. A skilled Ghanaian boatbuilder should be the counterpart to the FAO expert and be attached to the project full time. Engine installation should be carried out by a Consultant Marine Engineer in cooperation with the local counterpart.

10.5 Trials of prototypes

Trials should be carried out in one selected location with fishing operations over a minimum one year period. Trials will also be made with different types of beach hauling devices. A skilled Ghanaian mechanic should provide full time back up, together with the boatbuilder.

10.6 Second stage design and construction of prototypes

The trials should reveal the most suitable construction method and required modifications. Modified drawings will need to be prepared by the Naval Architect and about two more prototypes built for final evaluation. Design and construction of smaller canoes, using the same construction method, will be undertaken.

10.7 Final trials of prototypes

Final trials will be made in a similar way to the first trials, but possibly extended to other areas of the coast.

10.8 Training of boatbuilders in the new type of construction

Training of boatbuilders should only start when the final trials are completed and it is clear which type of canoe and construction method is the most acceptable to the fishermen. The training period should extend over a minimum of two years.

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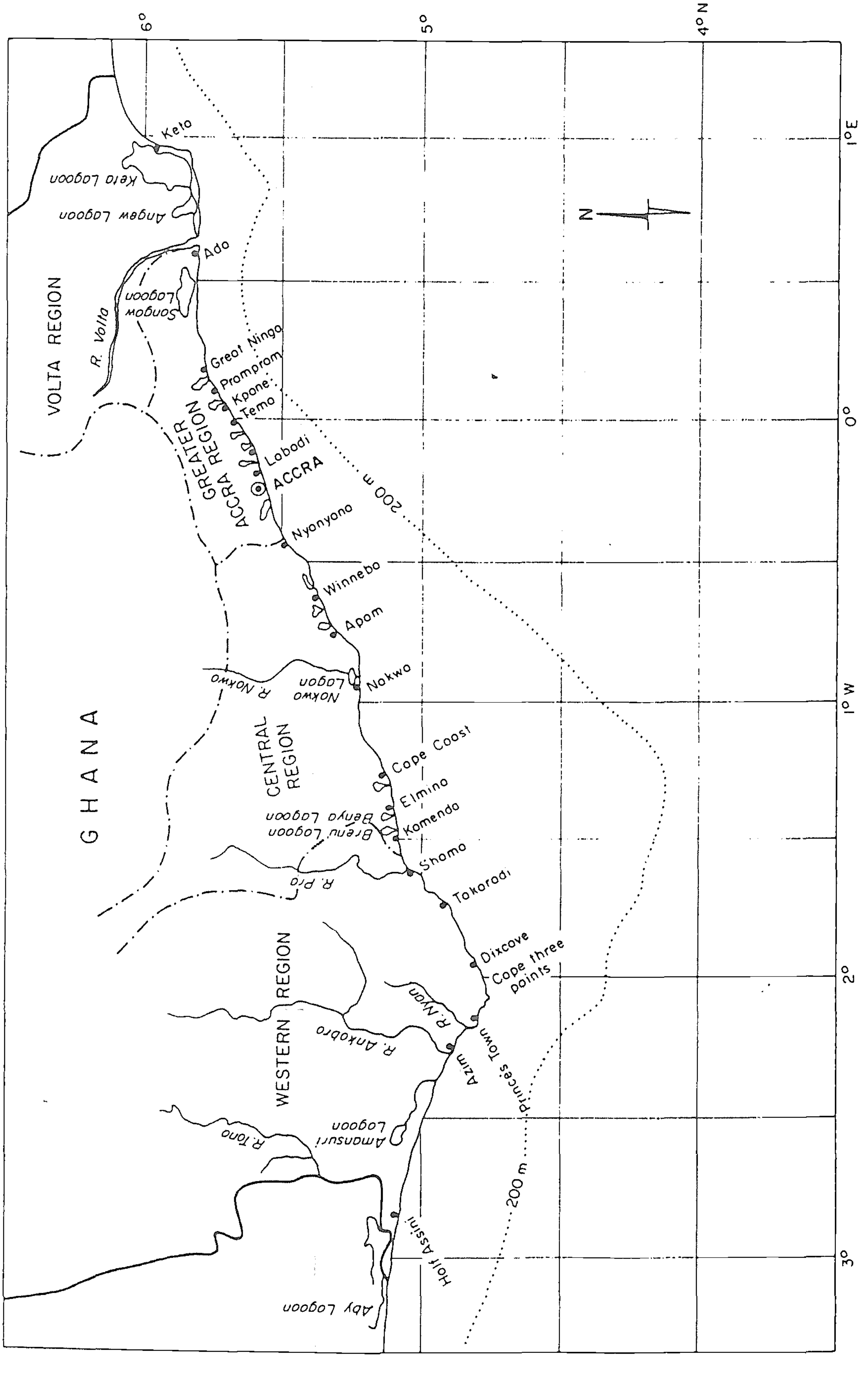
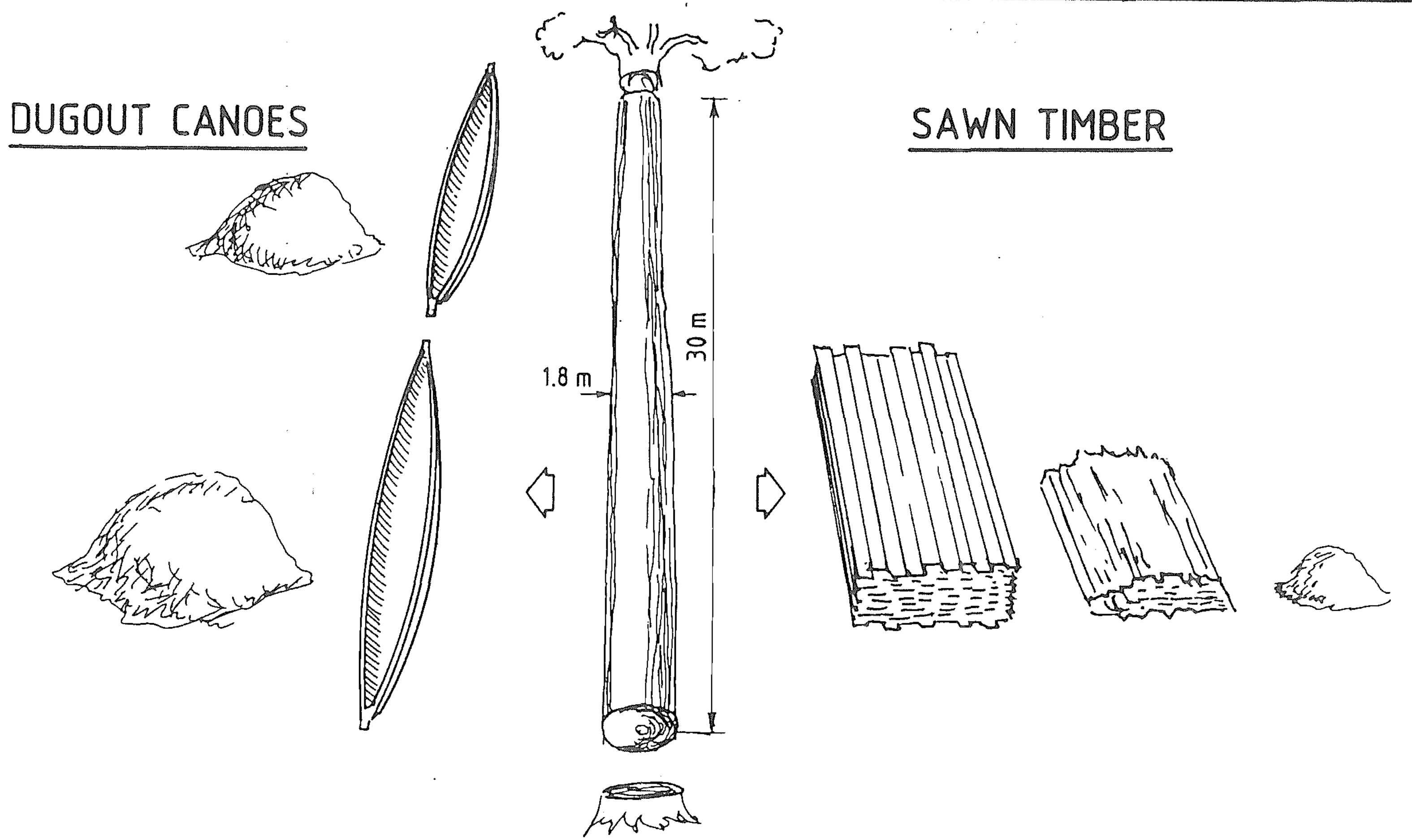


Fig. 1 Coastal map of Ghana, showing the 200 m contour line and the most important lagoons and rivers

Fig. 1



	WOOD CHIPS	1 CANOE 15 M 1 CANOE 9 M	LOG	SAWN TIMBER	SMALL SIZES FIREWOOD	SAWDUST
VOLUME	69 m^3	7 m^3	76 m^3	42 m^3	24 m^3	10 m^3
% OF LOG	91 %	9 %	100 %	55 %	32 %	13 %
VALUE AT COAST	0	¢ 1.0 million		¢ 3.5 million	¢ 0.4 million	0
TOTAL VALUE	¢ 1.0 million			¢ 3.9 million		

Fig. 2. TIMBER UTILIZATION

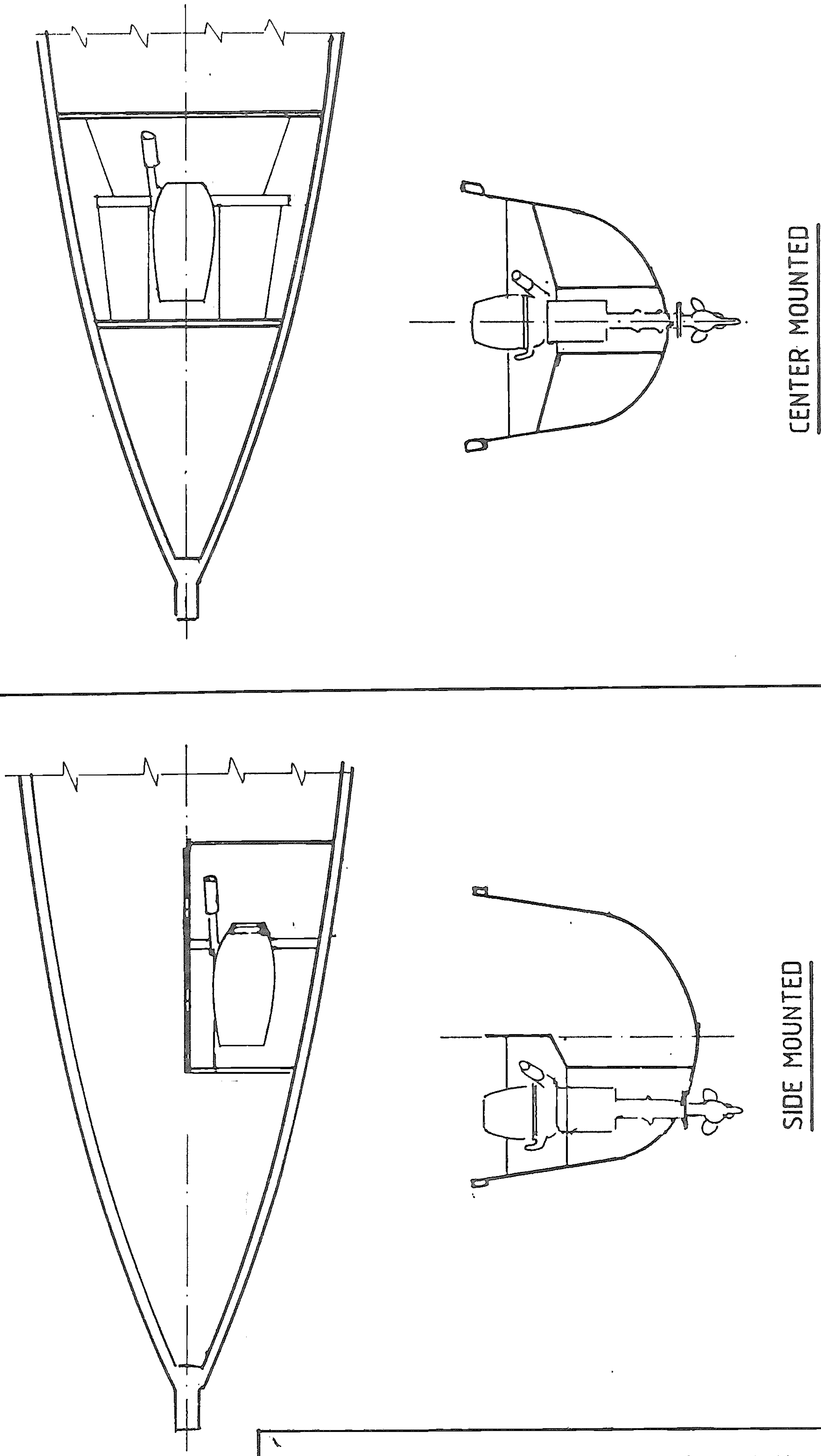


Fig. 3 Alternative Outboardmotor installations

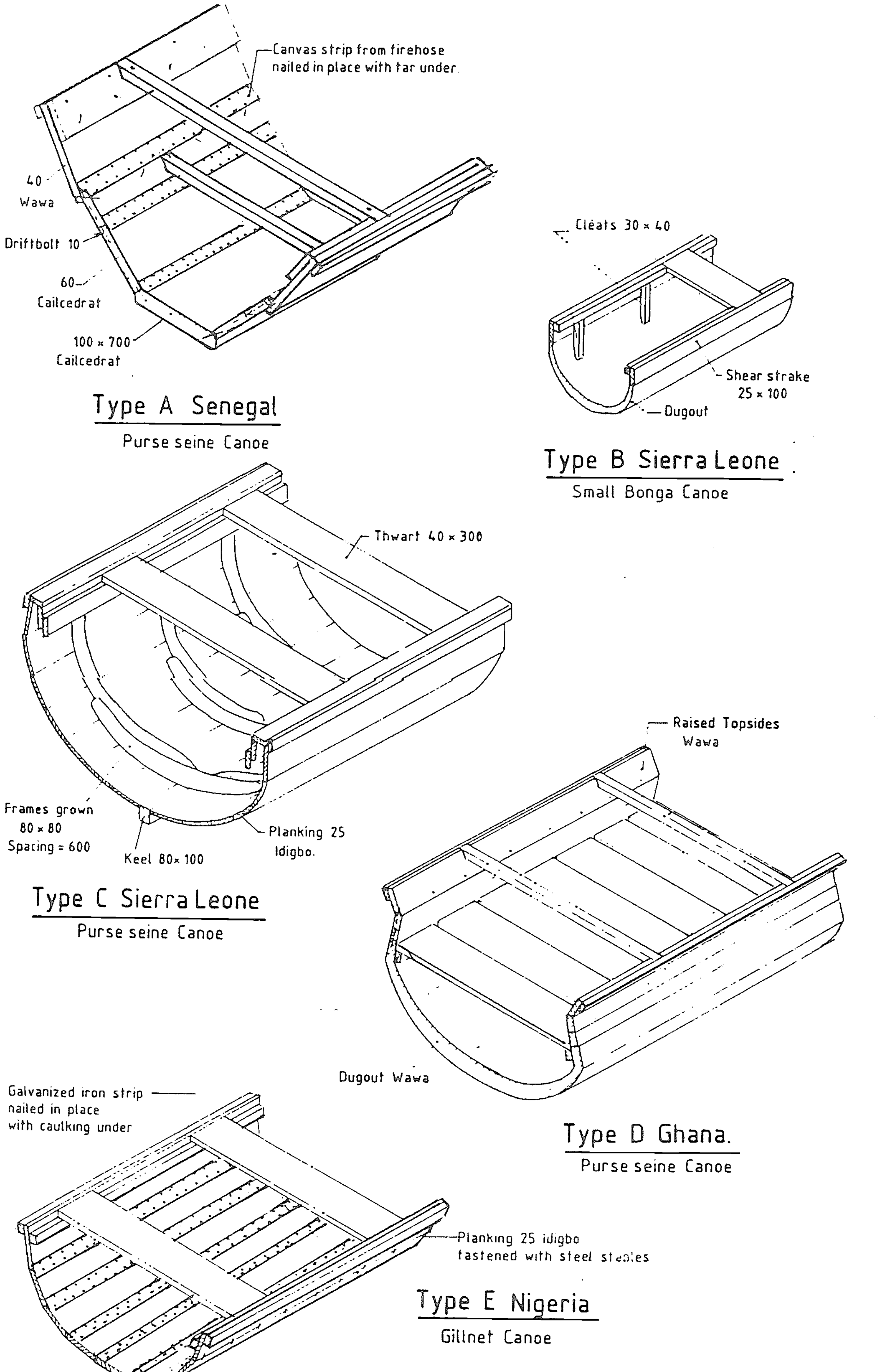


Fig. 4 West African Canoe Types

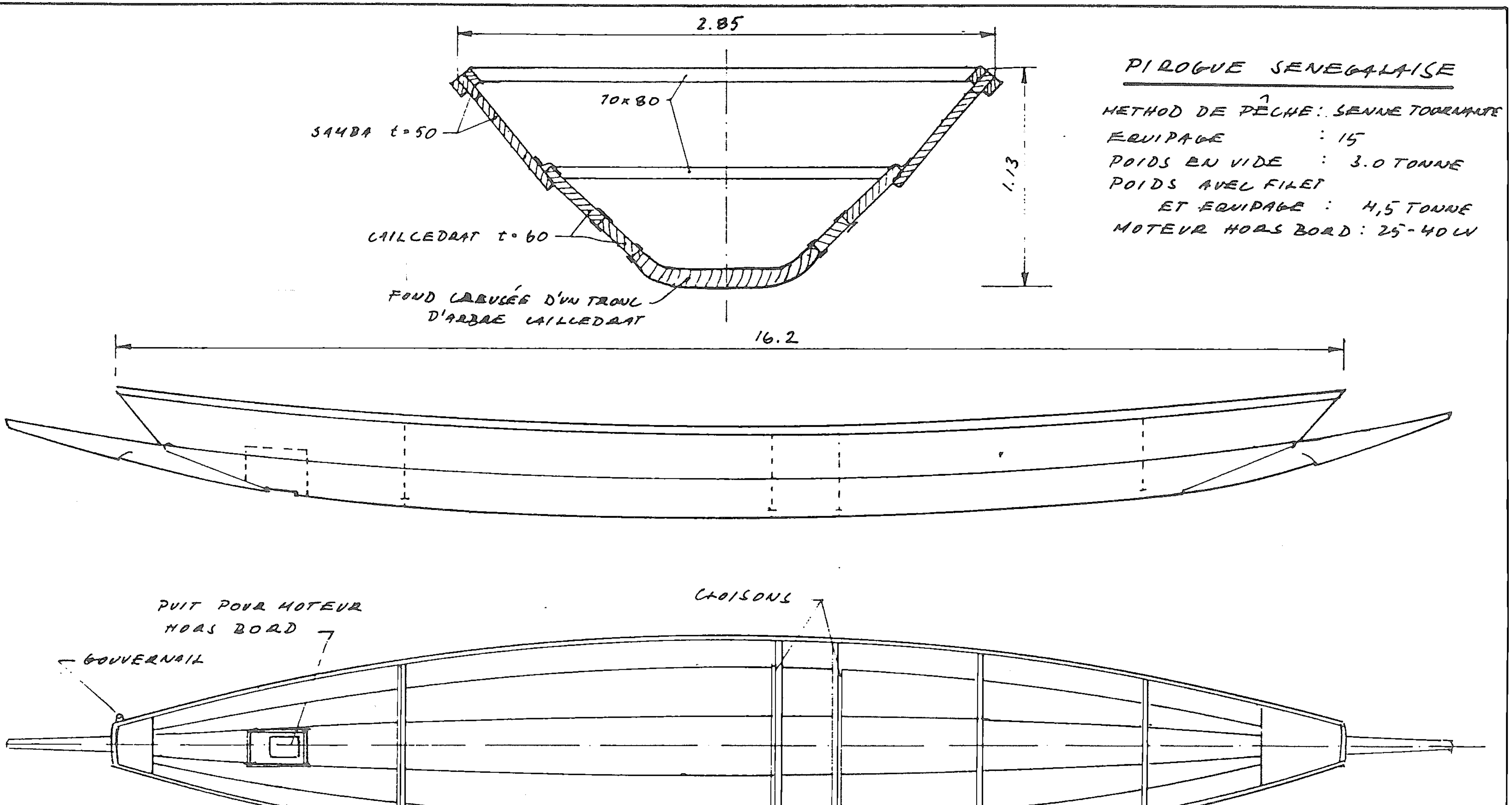

PIROGUE SENEGALAISE
METHOD DE PÊCHE : SENNE TOURNANTE
EQUIPAGE : 15
POIDS EN VIDE : 3.0 TONNE
POIDS AVEC FILET ET EQUIPAGE : 4,5 TONNE
MOTEUR HORS BORD : 25-40 CV
2.85
1.13
70 x 80
SAMBA t=50
CAILCEDRAT t=60
FOND CREUSÉE D'UN TRONC D'ARBRE CAILCEDRAT
16.2
PUIT POUR MOTEUR HORS BORD
GOUVERNAIL
CLOISONS
1.0 0.5 0 1 2 3 4 M

Fig. 5

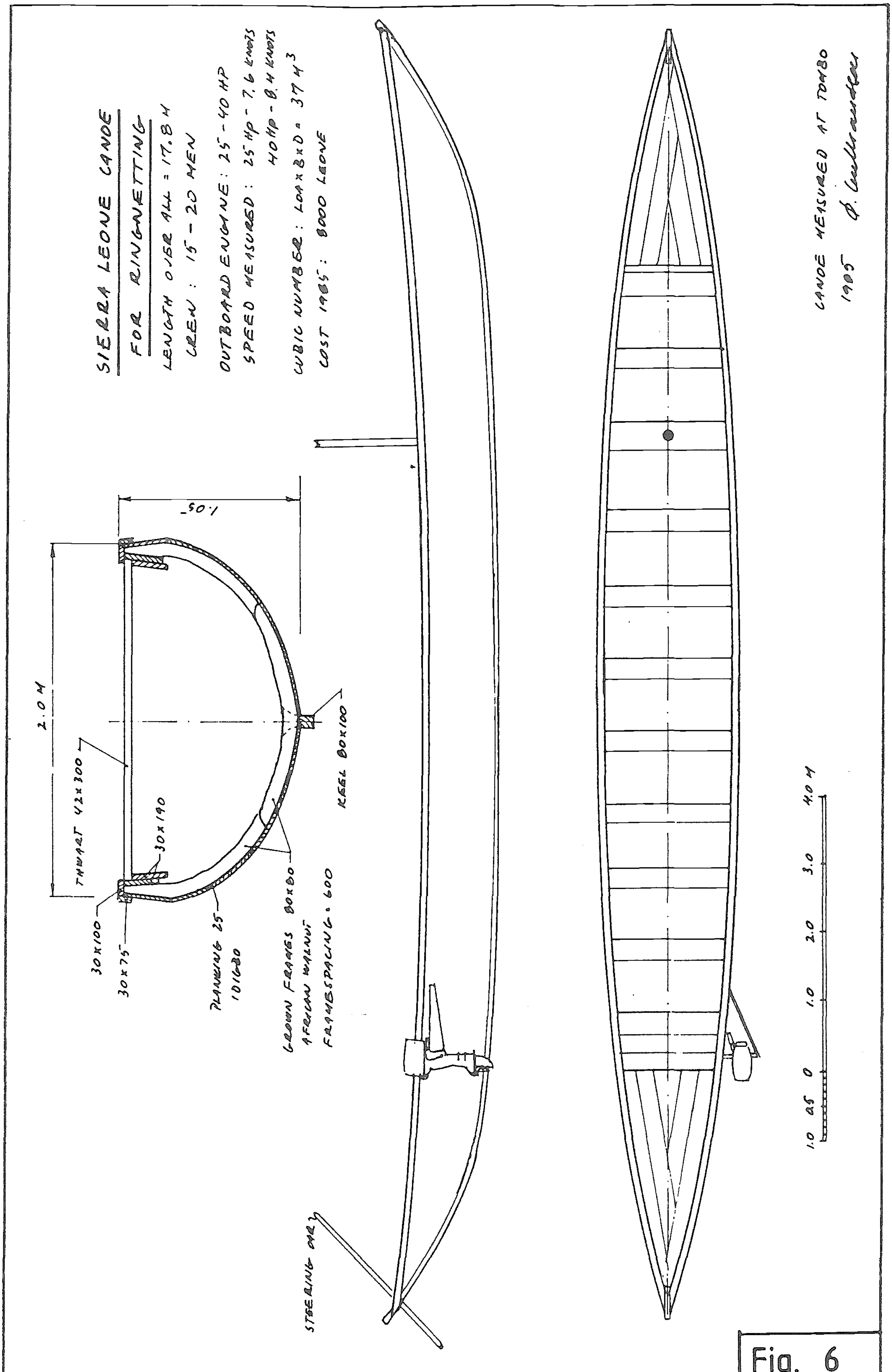

SIERRA LEONE CANOE
FOR RINGNETTING
LENGTH OVER ALL = 17.8 M
CREW : 15 - 20 MEN
OUTBOARD ENGINE : 25 - 40 HP
SPEED MEASURED : 25 HP - 7.6 KNOTS
40 HP - 8.4 KNOTS
CUBIC NUMBER : LOA x B x D = 37 M³
COST 1985 : 8000 LEONE
2.0 M
1.05
THWART 42x300
30x100
30x75
30x190
PLANKING 25
IROKO
GROWN FRAMES 80x80
AFRICAN WALNUT
FRAMESPACING = 600
KEEL 80x100
STEERING OAR
1.0 0.5 0 1.0 2.0 3.0 4.0 M
CANOE MEASURED AT TOMBO
1985

Fig. 6

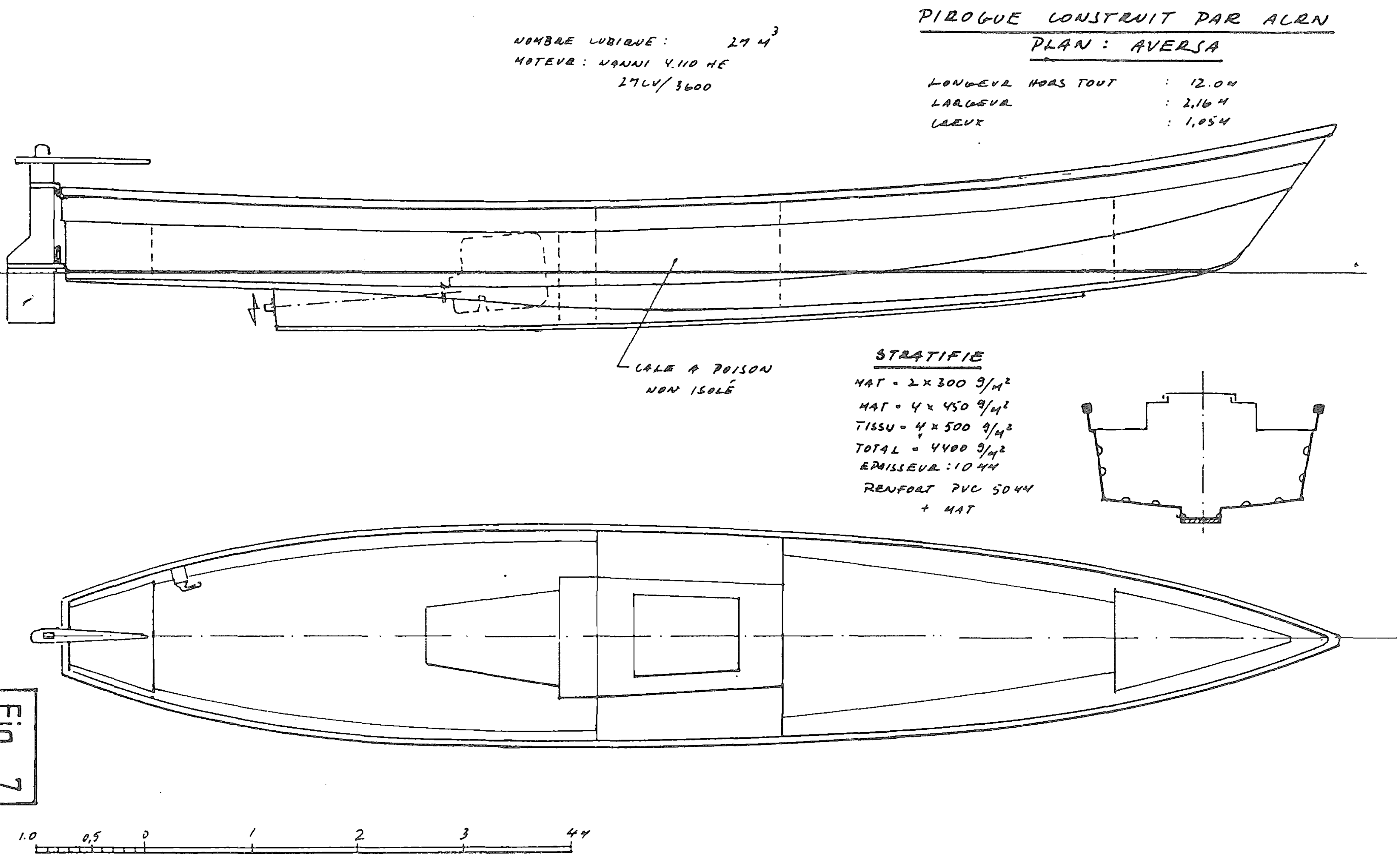

PIROGUE CONSTRUIT PAR ACRN
PLAN : AVERSA
LONGEUR HORS TOUT : 12.0M
LARGEUR : 2,16M
CREUX : 1,05M
NOMBRE CUBIQUE : 27 M3
MOTEUR : NANNI 4.110 HE
27CV/3600
CALE A POISON
NON ISOLÉ
STRATIFIE
MAT = 2×300 g/m²
MAT = 4×450 g/m²
TISSU = 4×500 g/m²
TOTAL = 4400 g/m²
EPAISSEUR : 10 MM
RENFORT PVC 50MM
+ MAT
1.0
0,5
0
1
2
3
4M

Fig. 7

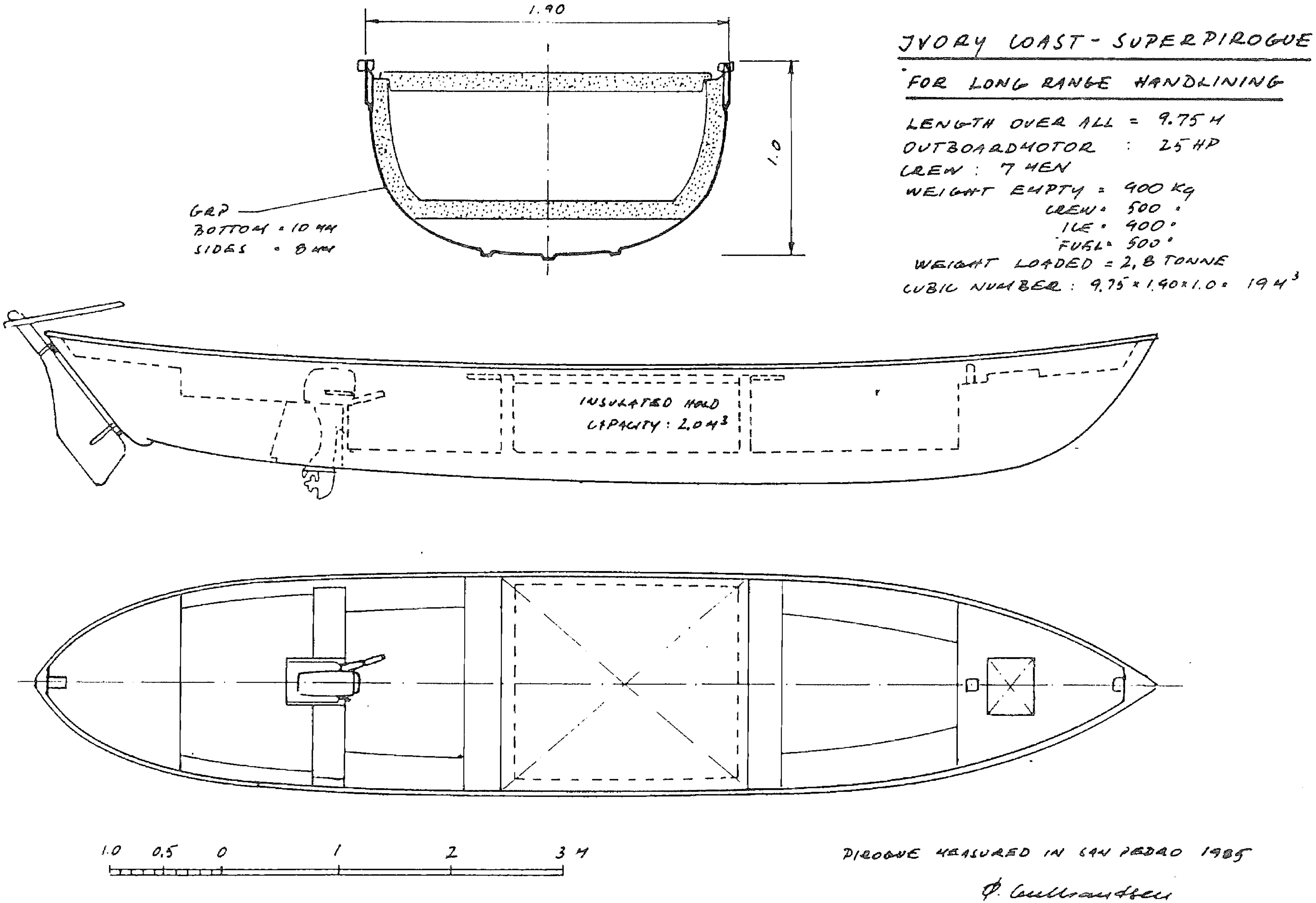
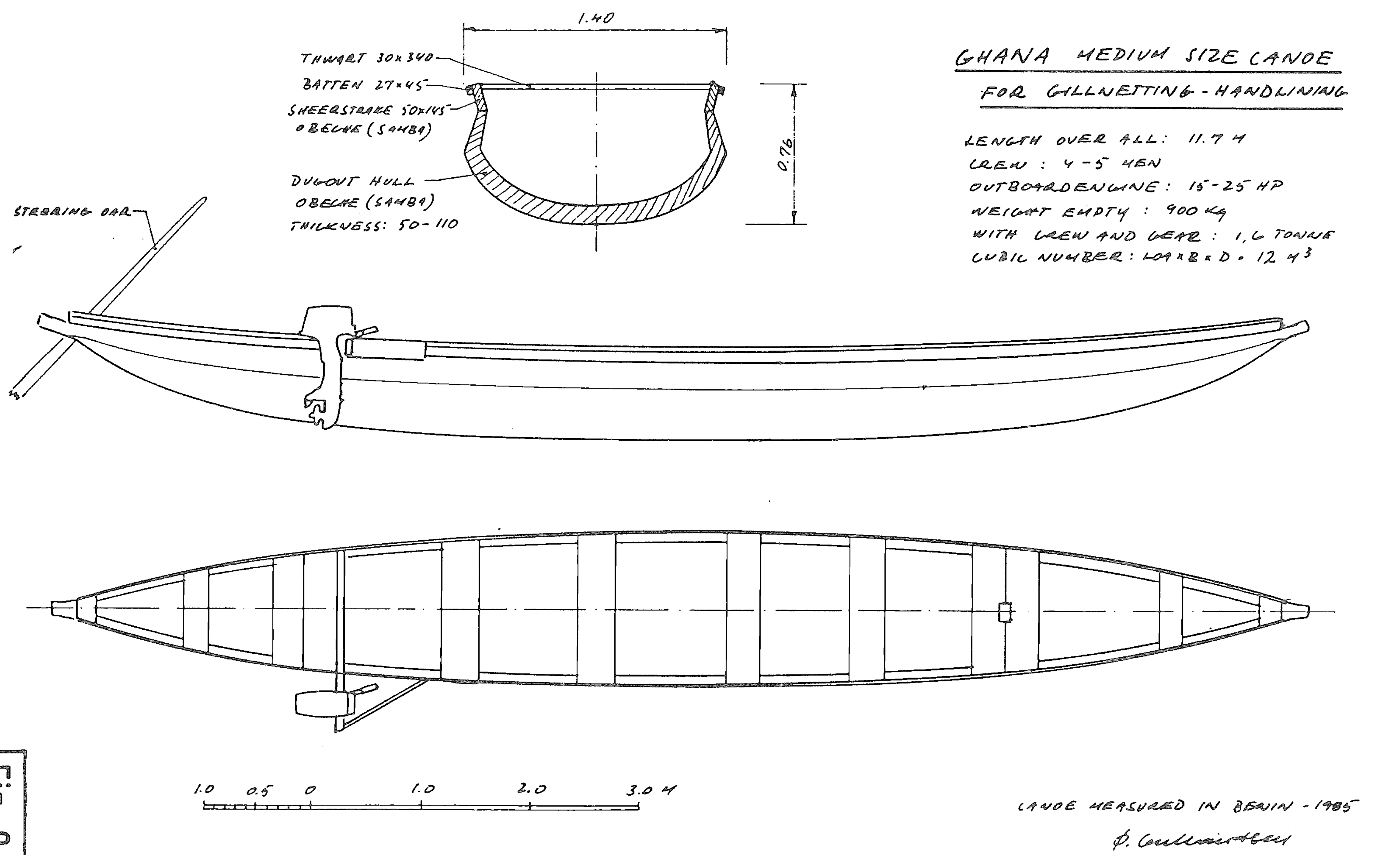

1.90
1.0
GRP
BOTTOM = 10 MM
SIDES = 8 MM
IVORY COAST - SUPERPIROGUE
FOR LONG RANGE HANDLINING
LENGTH OVER ALL = 9.75 M
OUTBOARDMOTOR : 25 HP
CREW : 7 MEN
WEIGHT EMPTY = 900 KG
CREW = 500 "
ICE = 900 "
FUEL = 500 "
WEIGHT LOADED = 2,8 TONNE
CUBIC NUMBER : 9.75 × 1.90 × 1.0 = 19 M³
INSULATED HOLD
CAPACITY : 2.0 M³
1.0 0.5 0 1 2 3 M
PIROGUE MEASURED IN SAN PEDRO 1985

Fig. 8



GHANA MEDIUM SIZE CANOE
FOR GILLNETTING - HANDLINING
LENGTH OVER ALL: 11.7 M
CREW : 4 - 5 MEN
OUTBOARDENGINE: 15 - 25 HP
WEIGHT EMPTY : 900 Kg
WITH CREW AND GEAR : 1,6 TONNE
CUBIC NUMBER: LOA x B x D = 12 M³
1.40
0.76
THWART 30 x 340
BATTEN 27 x 45
SHEERSTRAKE 50 x 145
OBECHE (SAMBA)
DUGOUT HULL
OBECHE (SAMBA)
THICKNESS: 50 - 110
STEERING OAR
1.0
0.5
0
1.0
2.0
3.0 M
CANOE MEASURED IN BENIN - 1985

Fig. 9

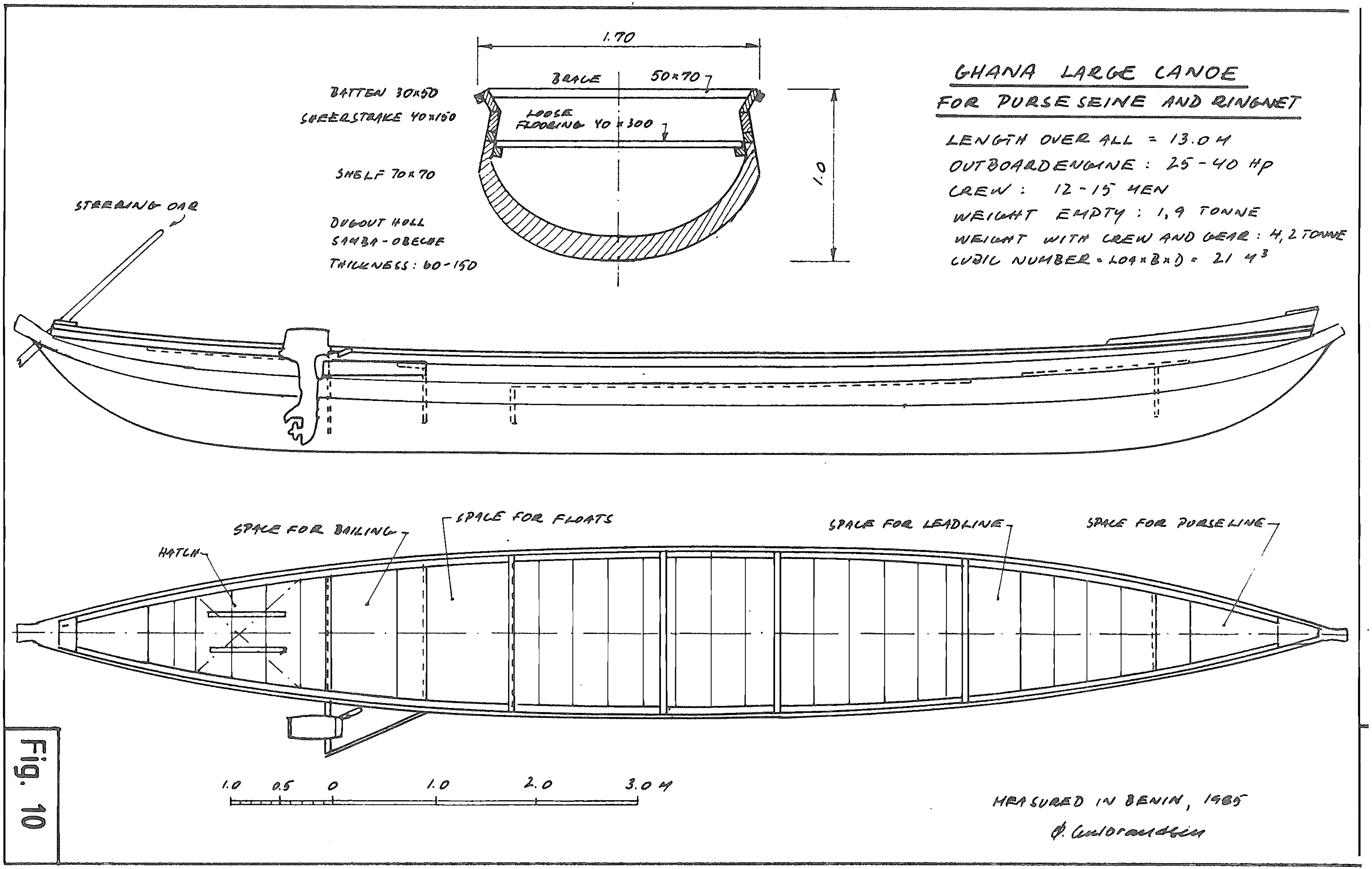

GHANA LARGE CANOE
FOR PURSESEINE AND RINGNET
LENGTH OVER ALL = 13.0 M
OUTBOARDENGINE : 25 - 40 HP
CREW : 12 - 15 MEN
WEIGHT EMPTY : 1,9 TONNE
WEIGHT WITH CREW AND GEAR : 4,2 TONNE
CUBIC NUMBER = LOA × B × D = 21 M3
1.70
BRACE
50×70
BATTEN 30×50
SHEERSTRAKE 40×150
LOOSE FLOORING 40×300
SHELF 70×70
DUGOUT HULL
SAMBA - OBECHE
THICKNESS : 60 - 150
1.0
STEERING OAR
SPACE FOR BAILING
SPACE FOR FLOATS
SPACE FOR LEADLINE
SPACE FOR PURSELINE
HATCH
1.0
0.5
0
1.0
2.0
3.0 M
MEASURED IN BENIN, 1985

Fig. 10

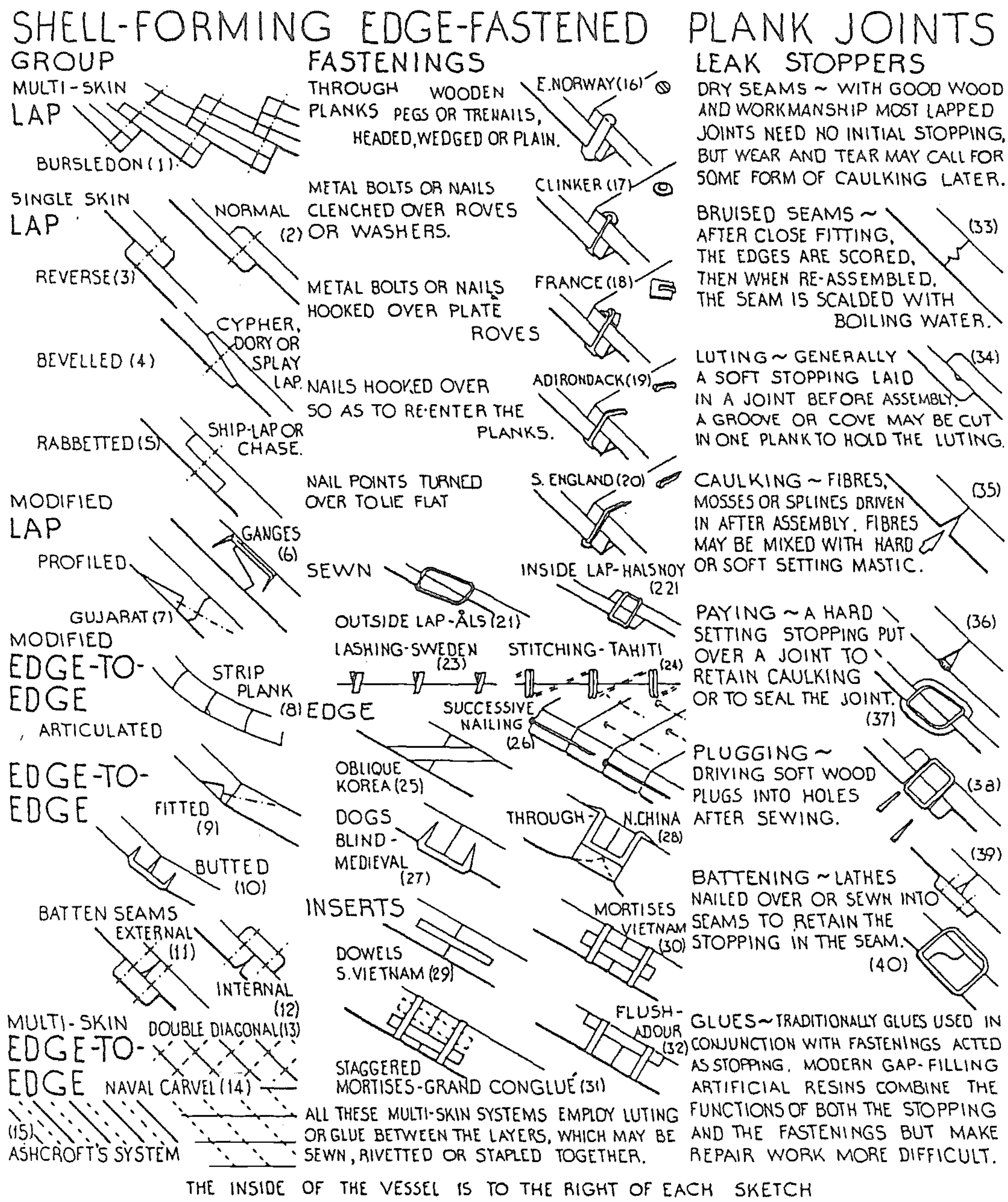


Fig. 11 Different plank joints

from: B. Greenhill: Archeology of the boat, 1976

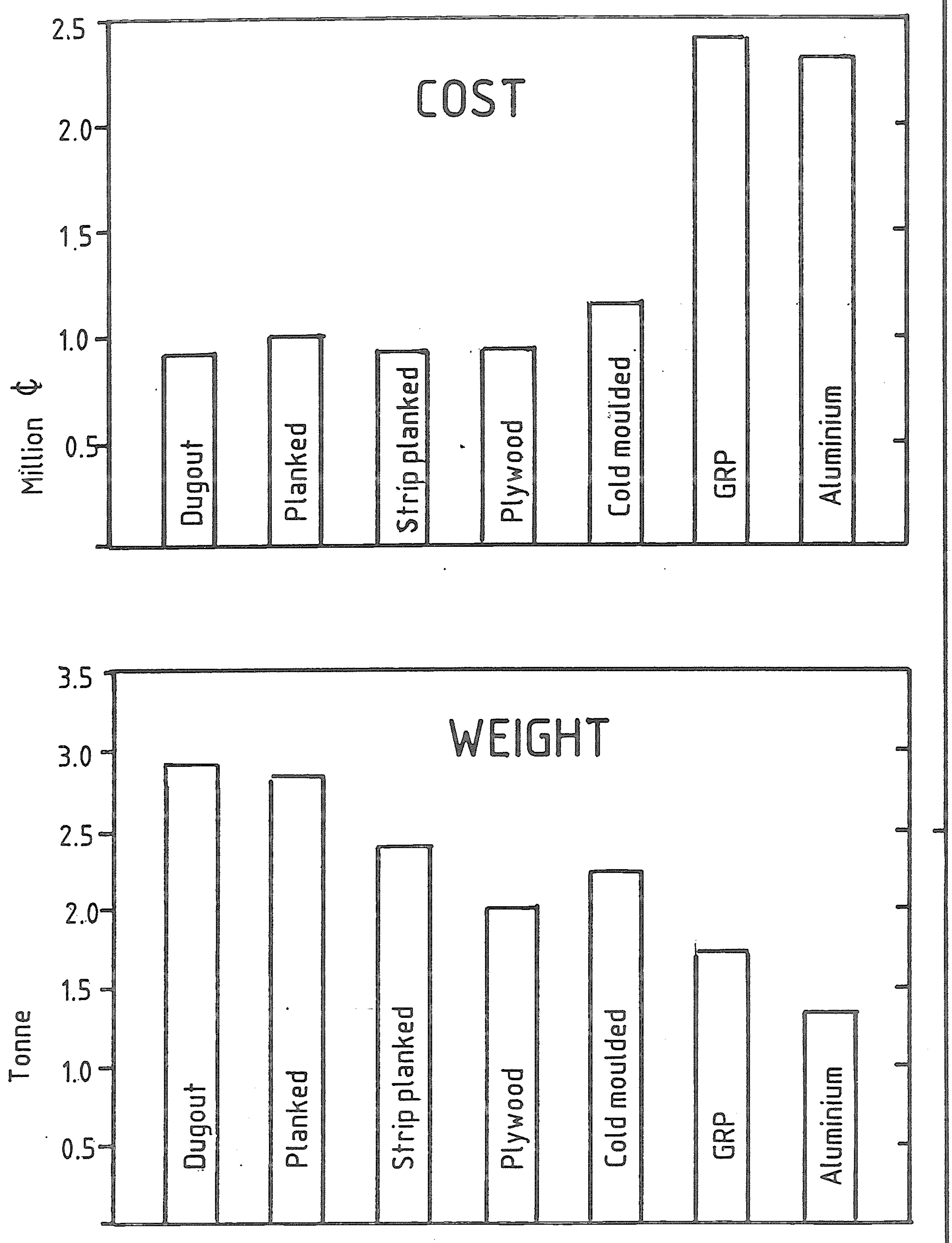
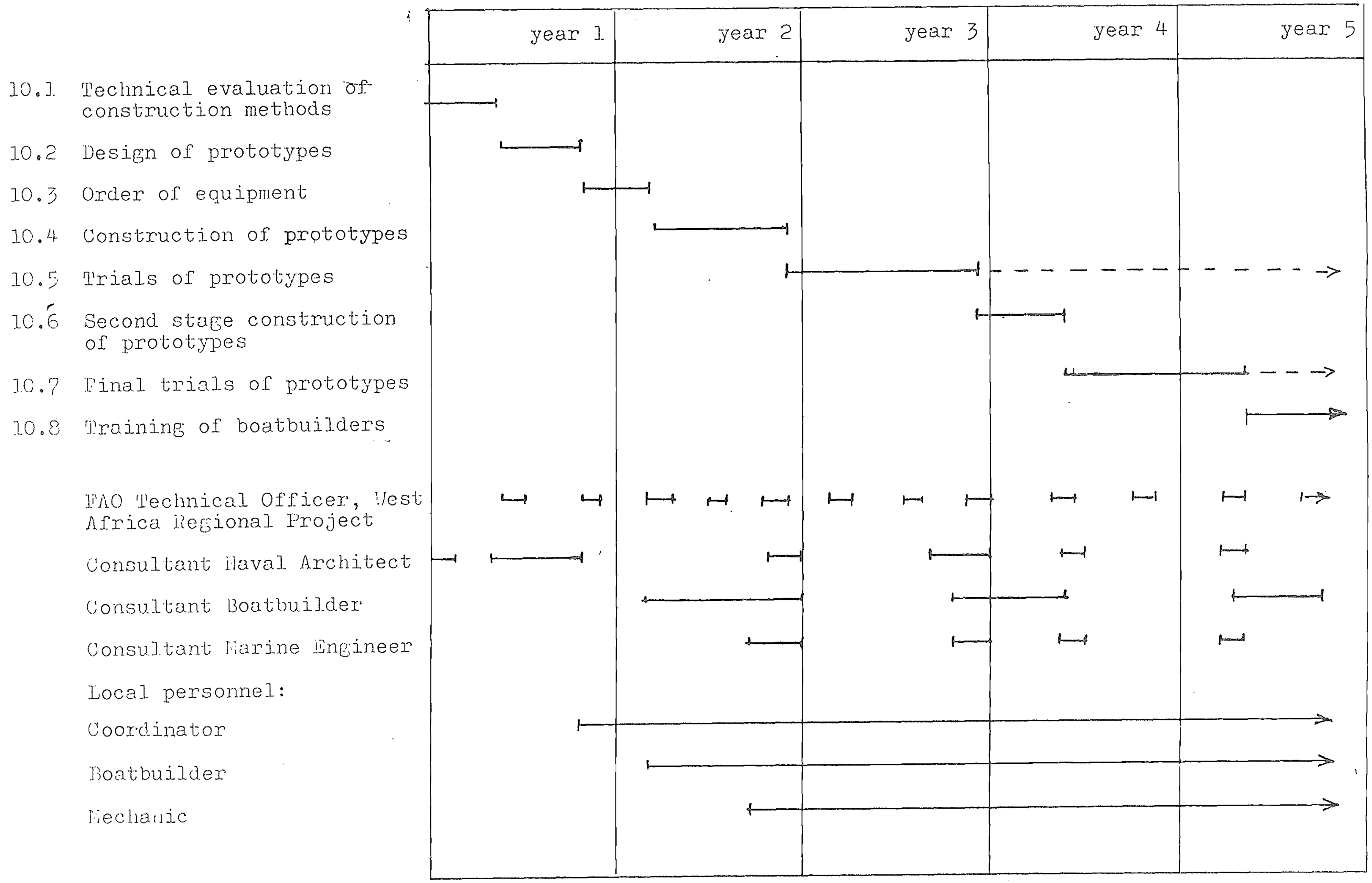

COST
Million ¢
2.5
2.0
1.5
1.0
0.5
Dugout
Planked
Strip planked
Plywood
Cold moulded
GRP
Aluminium
WEIGHT
Tonne
3.5
3.0
2.5
2.0
1.5
1.0
0.5
Dugout
Planked
Strip planked
Plywood
Cold moulded
GRP
Aluminium

Fig. 12

Fig. 13

WORK PLAN



Appendix 1

EXCHANGE RATES MAY 1990

1 £ UK	=	¢ 590
1 US $	=	¢ 360
1 DM	=	¢ 215

Appendix 2

ITINERARY

	Arrival	Departure
Grimstad		6/5
Rome	6/5	11/5
Cotonou	12/5	15/5
Accra	15/5	17/5
Kumasi	17/5	18/5
Accra	18/5	23/5
Takoradi	23/5	24/5
Elmina	24/5	25/5
Accra	25/5	29/5
Dakar	29/5	31/5
Rome	1/6	2/6
Grimstad	2/6	

Appendix 3

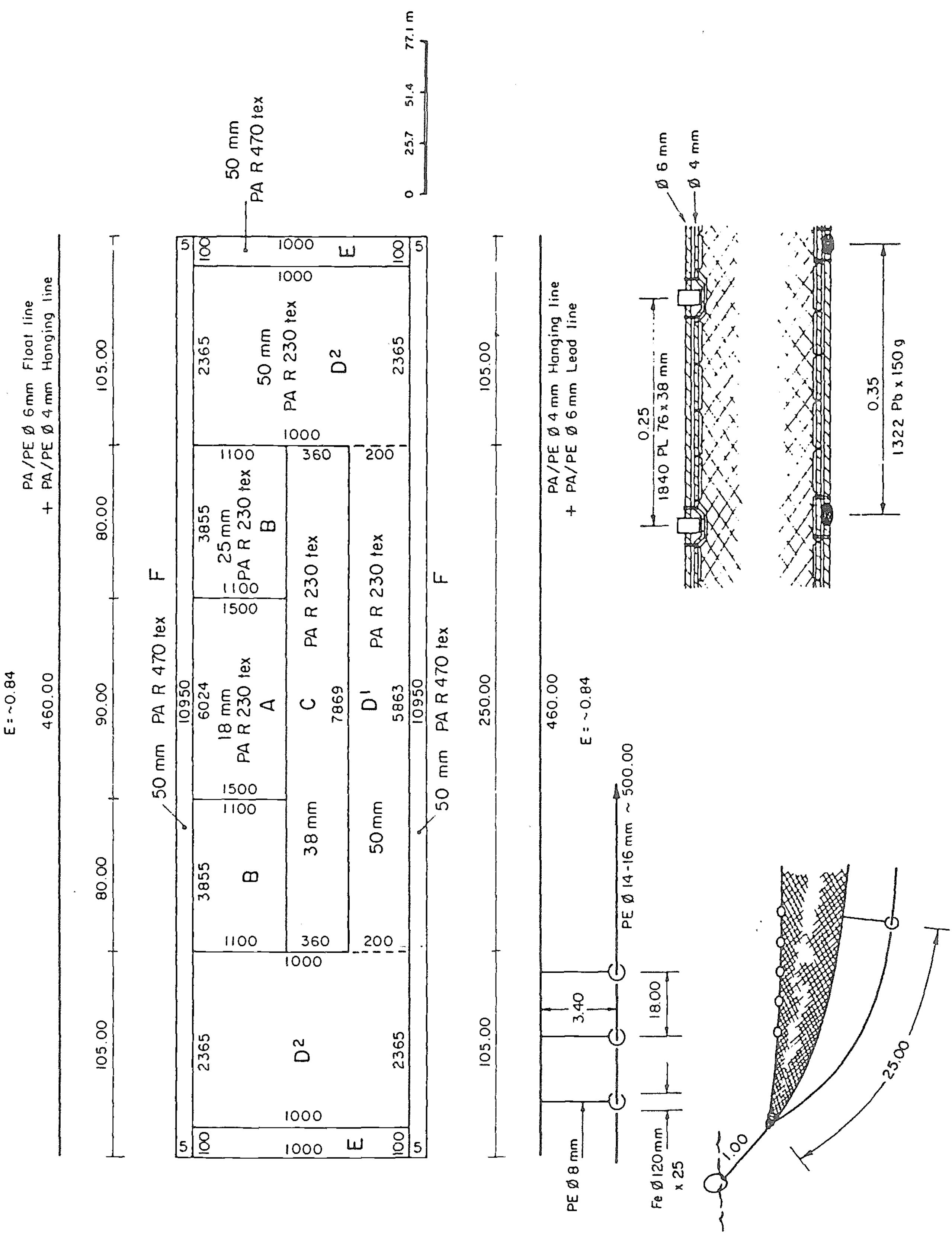
PERSONS MET

F.M.K. Deayoh Acting Director of Fisheries, Accra
Mr. Armah, Deputy Director of Fisheries, Accra
T.Y.B. Opoku, Regional Fishery Officer, Takoradi
Mr. Witty, Regional Fishery Officer, Cape Coast
J.C. MacCarthy, Factory Manager, GIHOC Boatyard, Tema
S.D. Abayah, General Manager, GIHOC Boatyard, Sekondi
K. Yartel, Managing Director, Yartel Boatbuilding Company, Elmina
A. Venables, Managing Director, Woodwork Marine, Takoradi
E. Tonks, Managing Director, Winnoba Shipyard
N.B. Asare, Executive Director, Dupont Wood Treatment Ltd.
M.A. Bentil, Shipping Manager, AT & P Ltd., Takoradi
J.L. Kwong, General Manager, Allied Chemical & Metal Works Ltd., Takoradi
K.K.F. Ghartey, Project Manager, Forest Resource Management Project
T. Nolan, ODA Forest Resource Management Project
D.A. Quaye, Gbese Fishermens Association, Accra
Mr. Hammond, Gbese Fishermens Association, Accra
R.J. Abou-Chedid, Expandable Polystyrene Products Ltd.
A.G. Addal-Mensah, Head, Timber Engineering Section, Forest Products Research Institute
J.N.N. Lcquaye, Ghana Aluminium Products
W. Q-B. West, Senior Regional Fisheries Officer, RAFR
J.J. Meijer, Programme Officer, RAFR
E. Ossinga, Regional Fisheries Officer, RAFR
E. Gianni, Fishing Technologist, IDAF, Cotonou
G.T. Sheves, FAO
J.M.M. Turner, Naval Architect, FAO, Rome
H. Tsubata, Naval Architect, FAO, Rome

Appendix 4

Fig. 27 Watsa purse seine

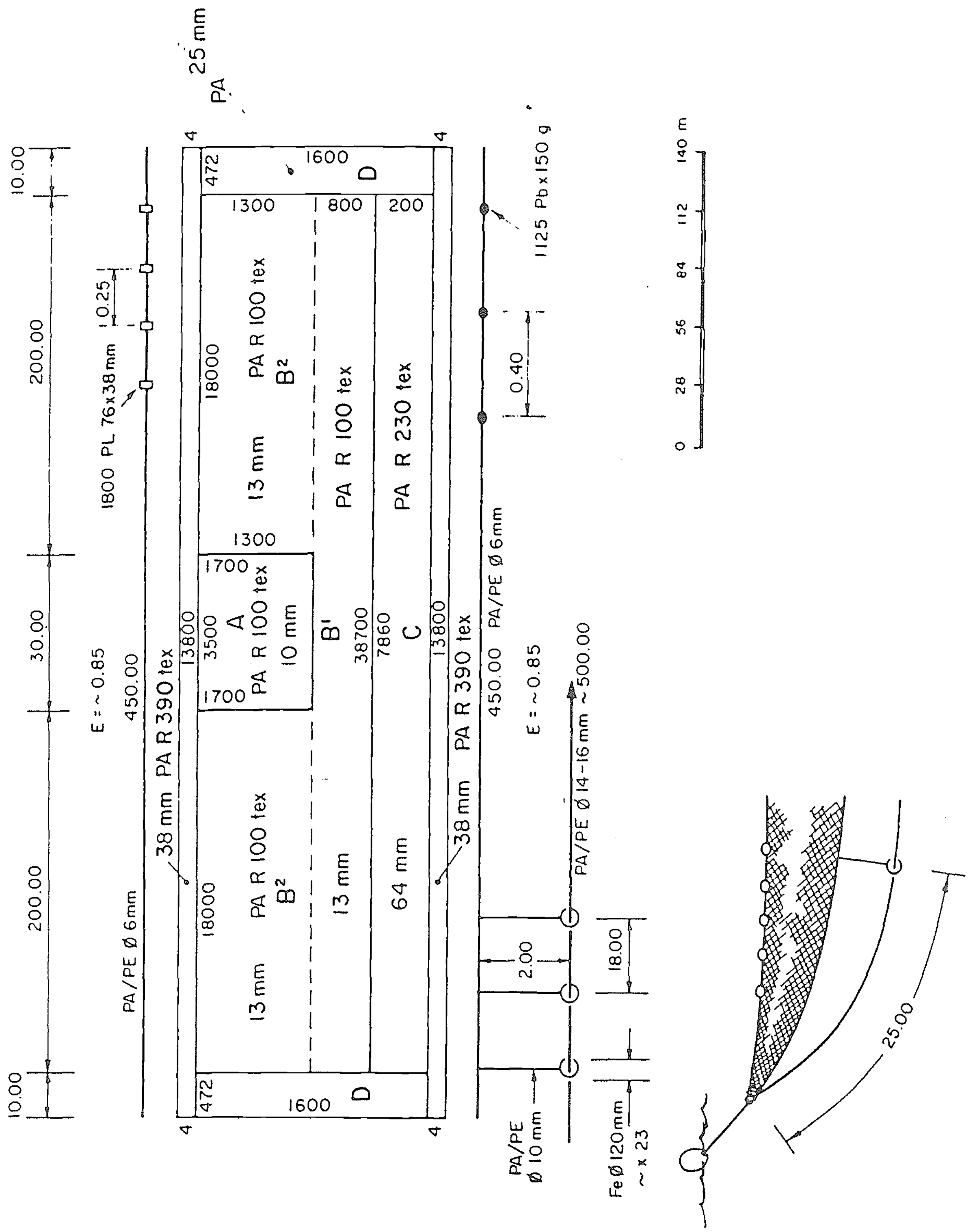
From Ref. 19



Appendix 4

Fig. 28 Poli-sieve purse seine

From Ref. 19



Appendix 5

RESERVE BUOYANCY IN FLOODED CONDITION

The present 15 m dugout canoe has a wood volume of about 6.0 m^3. This gives a submerged buoyancy of about 6,000 kg.

The weights are as follows :

Canoe	2,800 kg
Lead + purse rings	320 kg
Outboard motor + tank	80 kg
Total weight	3,200 kg

The reserve buoyancy is therefore 6,000 kg - 3,200 kg = 2,800 kg.

The present canoe will therefore float fairly high when filled with water.

A canoe built in another method with heavier wood, will also float, but have a reduced reserve buoyancy. Assuming the case of a planked canoe having a net volume of timber of 3.1 m^3, corresponding to a buoyancy of 3,100 kg submerged.

The weights are as follows :

Canoe (700 kg/m^3)	2,400 kg
Equipment (as above)	400 kg
Total weight	2,800 kg

The reserve buoyancy is therefore 3,100 kg - 2,800 kg = 300 kg.

The Nordic Boat Standard (NBS) (Ref. 12) requires that a craft in swamped condition shall be able to support an additional load of:

$$P = 50 + 50\ (LOA - 2.5)$$

For a 15 m canoe this gives an additional weight of 680 kg. To satisfy this criterium, the wooden canoe requires 680 kg - 300 kg = 380 kg additional buoyancy. The buoyancy can be of polystyrene blocks or total 0.4 m^3, available locally at a cost of ⌀ 52,000 per m^3. The cost of the blocks for the wooden canoes is therefore ⌀ 21,000.

The aluminium canoe has the following weight :

Canoe	1,300 kg
Equipment (as above)	400 kg
Total weight	1,700 kg

The swamped buoyancy of the canoe is about 400 kg.

Appendix 5 (continued)

Reserve buoyancy is therefore negative with 1,700 kg - 400 kg = 1,300 kg. With the same additional weight as above = 680 kg, the total requirement of flotation is 1,300 kg + 680 kg = 1,980 kg. The buoyancy required is therefore 2 m^3 of polystyrene blocks at a cost of ₵ 104,000.

The GRP canoe has the following weight :

Canoe	1,700 kg
Equipment (as above)	400 kg
Total weight	2,100 kg

The swamped buoyancy of the GRP canoe is about 1,000 kg. Reserve buoyancy is therefore negative with 2,100 kg - 1,000 kg = 1,100 kg. With additional weight of 680 kg required extra buoyancy is 1,780 kg or about 1.8 m^3 of buoyancy blocks. The cost of these blocks is ₵ 94,000.

The buoyancy blocks should be placed fore and aft so that a level flotation in swamped condition is ensured. The blocks must be enclosed so that they are not damaged or stolen.

Appendix 6

ENGINE COMPARISON

		YAMAHA 40 petrol outboard	YANMAR 27 diesel outboard	SABB 30 diesel inboard
	Engine max. power (Hp)	40	27	30
	Engine max. rpm	5,500	4,500	1,900
	Engine weight, kg	65	87	375
	Engine cost, US $	2,100	3,700	6,100
	(no tax) ¢	750,000	1,330,000	2,200,000
	Service life years	3	4	6
(1)	Depreciation/year ¢	250,000	330,000	370,000
	Service speed, knots	8,0	7,5	8,0
	Service power, Hp	30	22	25
	Fuel consumption, l/h	16.0	5.5	6.2
	Litre/naut. mile	2.0	0.73	0.78
	Fuel cost ¢/l	114	81	81
	Fuel cost ¢/n.mile	228	59	63
	Relative fuel cost %	100	26	28
(2)	Fuel cost/year ¢ 200 trips x 28 n.miles	1,280,000	330,000	350,000
(3)	Repair cost/year ¢	180,000	300,000	200,000
	Total yearly cost (1) + (2) + (3) ¢	1,710,000	960,000	920,000

Appendix 7

RESOURCE LIFE FOR TIMBER SPECIES

From Ref. 15

Table 1 Estimated resource life for some commercial species

Species	Girth limit	Resource > Glimit m^3	Annual growth m^3/yr	Rate of extraction m^3/yr	Resource life yrs
Odum	11 ft	1 408 000	28 650	172 983	10
Edinam		468 000	7 155	33 167	18
Sapele		702 000	13 496	41 135	25
Utile		465 000	8 081	31 891	20
Mahogany		692 000	31 488	66 877	20
Afromosia		0	0	7 190	0
Wawa	7 ft	26 356 000	135 779	366 064	114
Guarea		524 000	4 592	10 972	82
Dahoma		5 254 000	75 569	14 915	***
KyenKyen		3 726 000	33 331	14 801	***
Hyedua		154 000	1 966	10 620	18
Mansonia		695 000	2 753	5 830	226
Danta		1 254 000	10 098	24 787	85
Avodire		2 365 000	13 548	269	***

*** Growth exceeds felling rate. There is a net increase in the resource. These species should be exploited more heavily.

Table 1 shows that the traditional redwoods and Odum are likely to be exhausted within 2-3 decades at present rates of felling. Wawa, the present most heavily felled species (32% of all forest extraction), has a stock life of about 114 years. Given the conservative nature of the yield tables, this approximates to a sustained yield and is acceptable. Species such as Dahoma, KyenKyen and Avodire are underutilised, and should be exploited more heavily.

Appendix 8

TIMBER USED FOR BOATBUILDING IN WEST AFRICA

TRADE NAME	LOCAL NAME	SCIENTIFIC NAME	WEIGHT AT 12% kg/m^3	NATURAL DURABILITY	RESISTANCE TO MARINE BORERS	MOVEMENT IN SERVICE	USE IN BOATBUILDING
African Mahogany	Ivory Coast: Acajou Bassam	Khaya ivorensis	560	Moderate	Low	Medium	Ivory Coast, Senegal: Planking
Afrormosia	Ghana: Kokrodua	Afrormosia elata	700	Very durable	-	Small	Substitute for teak in planking and decking
Afzelia	Ghana: Papao Nigeria: Apa Ivory Coast: Lingue G.Bissau: Pau Conta	Afzelia africana	800	Very durable	Medium	Small	Nigeria: keel, stems, planking under water
Albizia	Ghana: Awiemfo-Samina Ivory Coast: Jatandza	Albizia ferruginea	700	Very durable	-	Small	
Daniellia	G.Bissau: Pau incenso Senegal: Santan	Daniellia oliveri	560	-	-	Medium	Guinea Bissau: Planking
Danta	Ivory Coast: Kotibe	Nesogordonia papaverifera	750	Durable	Medium	Medium	Ghana, Nigeria: steam bent frames
Ekki	Ghana: Kaku Ivory Coast: Azobe	Lophira elata	1,050	Very durable	High	Medium	Ghana: keel shoe
Idigbo	Ghana: Emire Ivory Coast: Framire Sierra Leone: Konko, Bahi Nigeria: Black Afara	Terminalis ivorensis	550	Moderate	Low	Medium	Sierra Leone, Ivory Coast, Nigeria: planking of canoes
Iroko	Ghana: Odum Sierra Leone: Semei G.Bissau: Bicho amarelo	Chlorophora excelsa	660	Very durable	Medium	Medium	Ghana: Frames, planking over water-line, deck Ivory Coast: Keel, frames, deck
Mahogany dry zone	Senegal: Cailcedrat G.Bissau: Bissilon	Khaya senegalensis	810	Durable	-	Medium	Senegal: Canoe bottom and lower planking G.Bissau: frames

Appendix 8 (continued)

TRADE NAME	LOCAL NAME	SCIENTIFIC NAME	WEIGHT AT 12% kg/m^3	NATURAL DURABILITY	RESISTANCE TO MARINE BORERS	MOVEMENT IN SERVICE	USE IN BOATBUILDING
Makore	Ghana: Baku	Tieghemella heckeli	670	Very durable	Medium	Medium	Underwater planking
Niangon	Ghana: Nyankom Sierra Loene: Yawii	Tarrietia utilis	640	Moderate	Low	Medium	Ivory Coast, Sierra Leone: Planking
Obeche	Ghana: Wawa Ivory Coast: Samba	Triplochiton scleroxylon	390	Very low	Very low	Low	Ghana: Dugout canoes
Opepe (Bilinga)	Ghana: Kusia Ivory Coast: Badi Sierra Leone: Bundui Brumston	Nauclea diderrichii	750	Very durable	High	Medium	Ghana, Sierra Leone: Keel and planking under waterline
Sapeli	Ivory Coast: Aboudikro Senegal: Aboudikro	Entandrophragma cylindricum	640	Moderate	Low	Medium	Ivory Coast, Senegal: Planking, decking
Scented Guarea	Ghana: Kwabohoro Ivory Coast: Bosse	Guarea cedrata	650	Durable	-	Medium	
Teak		Tectona grandis	660	Very durable	Medium	Low	Increasingly available from plantations in Nigeria and Benin
Utile	Ivory Coast: Sipo	Entandrophragma utile	600	Moderate	Low	Medium	

Appendix 9

PLYWOOD

Price : June 1990 from African Timber and Plywood (Ghana) Ltd., Takoradi

Water Boil Proof (WBP)

Mixed redwoods	¢ with tax
4 mm	2,035
6 mm	2,387
9 mm	3,476
12 mm	4,180
15 mm	4,785
18 mm	5,555

Special order with only Makore veneers would be ¢ 220,000 per m^3. Minimum order 5 m^3.

Table 4.1.2 Suitable timbers for moulded hull construction

Species	Group	Average density air-dried, kg/m^3
Agba	B	515
Cedar, Central American	B	485
Cedar, Honduras	A	485
Mahogany, African	A	530
Mahogany, Honduras	A	545
Makore	A	625

Table 4.1.3 Guidance on the selection of timbers for use in marine plywood

Common name	Botanical name	Density at 15 per cent moisture content, kg/m^3	Natural durability of heartwood
Durable hardwood timbers in natural state			
Agba	*Gossweilerodendron balsamiferum*	500	Durable
Gedu Nohor	*Entandrophragma angolense*	540	Moderately durable
Guarea	*Guarea spp.*	580	Durable
Idigbo	*Terminalia ivorensis*	540	Durable
African Mahogany	*Khaya spp.*	500	Moderately durable
Makore	*Mimusops heckelii*	620	Very durable
Omu	*Entandrophragma candollei*	620	Moderately durable
Light Red Meranti / Light Red Seraya	*Shorea spp.* (*see* Note 2)	530	Moderately durable
Sapele	*Entandrophragma cylindricum*	620	Moderately durable
Utile	*Entandrophragma utile*	660	Durable
Timbers requiring preservative treatment			
Douglas Fir	*Pseudotsuga taxifolia*	530	Moderately durable
Gaboon/ Okoume	*Aucomea klaineana*	430	Non-durable

NOTES
1. It should be noted that behaviour towards marine borers and insects, including termites, is not equated to this durability scale.
2. Because of reduced durability, the use of *Shorea spp.* below the density quoted is not recommended unless it is treated with a preservative.

Appendix 10

MECHANICAL FASTENINGS

Mechanical fastenings are less dependent on care of the boatbuilder in selecting seasoned timber and in the correct storage and mixing of the glue. From this point of view, mechanical fastenings are more suitable for village construction than glued construction. Nails are the most commonly used fastening in workboat construction. The holding power of a nail is dependent on nail diameter, length and corrosion protection. The following table gives information about fastenings used in Ghana.

FASTENINGS AT PRESENT USED BY BOATYARDS

	Type of Fastening	Dimension diameter x length mm	Corrosion protection	Price ¢
CANOE	Round wire nail, local	5.5 x 125	None	320/kg 1)
	Round wire nail	6.0 x 150	None	320/kg
	Iron rod, local	10	None	
FISHING BOAT	Twisted roofing nail, local	4 x 65	electroplated	1900/kg 2)
	Twisted roofing nail	5.2 x 75	"	1900/kg
	Twisted roofing nail, imported	5.5 x 75	hot dip galvanized	1600/kg
	Twisted roofing nail, imported	7.0 x 120	" " "	1600/kg
	Copper nails, imported			6500/kg
	Bolts, imported	3/8" x 6"	" " "	800/piece

1) Sold in cases of 25 kg from GIHOC Metals Ltd., Accra

2) Sold from Sallman Industries, Accra.

Ungalvanized and electroplated nails should not be used in boat construction. The locally produced roofing nails used by the boatyards have a good holding power because of the twisted shank, but the shiny electroplated finish provides very low corrosion protection in seawater. From the point of view of availability and cost, the best nail would be a specially made round wire nail from GIHOC Metals Ltd. Ordinary wire nails found in the shops are too thin in relation to the length. However, on special order, the factory can produce nails of greater diameter in relation to the length. For example a 75 mm (3") nail which ordinarily is only 4.0 mm (8 SWG) in diameter, can be produced at 5.6 mm (5 SWG), giving a good size boat fastening. For the same weight of fastening, a round wire

Appendix 10 (continued)

nail will have a higher holding power than a square nail and there is therefore little reason to select the traditional square boat nail if round nails of the same weight per nail are available.

The nails should be hot dip galvanized locally. There are local manufacturers of galvanized roofing sheets that could do this, but it is not known at what price. Alternatively FAO should hold a course for the boatyards in the correct procedure of hot dip galvanizing of nails, bolts and other smaller items. The nuts for bolts will need to be tapped out 0.80 mm (1/32") before galvanizing to give room for the zinc coating.

The cost of locally produced wire nails of the correct size, and locally hot dip galvanized, should be less than half of that at present paid for the electroplated roofing nails.

The following table will give a guide when selecting round wire nails :

Plank thickness	Nail			
	length		diameter	
mm	mm	in	mm	SWG
17	50	2	4.5	7
21	63	2 1/2	5.0	6
25	75	3	5.6	5
30	90	3 1/2	6.0	4
33	100	4	6.6	3

Imported square copper nails cannot be considered because of the high cost (Ø 6,500/kg). An alternative could be nails made locally from scrap copperwire. The copper nail is only to be used as a rivet and it is doubtful whether it is worth the extra cost, compared with hot dip galvanized fastenings in the large size of craft considered.

Appendix 11

LAMINATED CONSTRUCTION

The strength of a glue joint is dependent on moisture content of the wood. Optimum strength is achieved at 12-15 per cent moisture content (MC) (Ref. 6). Ref. 7 recommends an even lower MC of 8-12 per cent. Ref. 8 gives maximum 15% and Ref. 9 7-16%. By air drying it should be possible to achieve 18-22 per cent in the coastal areas of Ghana and satisfactory joints can be achieved at this level according to Ref. 6. It is important that the difference in moisture content between the different parts to be laminated is maximum 5 per cent. A moisture content difference of 10 per cent is accepted for plywood and timber because of greater dimensional stability. Ref. 6 also gives a maximum difference of moisture content between gluing and in-service condition of 5 per cent.

Planking under the waterline generally has 20-25% MC and over the waterline 15-20% MC. If wood much drier than these figures is used in a boat, it will result in swelling of the timber that can put great strain on connections if there is no room for the expansion of the timber. One of the main criteria for a good planking timber is low movement in service. African Mahogany will swell tangentically 2% between 15% MC and 25% MC. This means that a plank 200 mm wide will swell to 204 mm and over a width of 1.0 m the swelling would be 20 mm. This movement will lead to very high forces on fastenings, or to the planking buckling away from the frame. If dry timber is used, expansion joints in the form of caulking seams are required. Glued construction consisting of several layers at an angle of 45° to each other will experience high stresses on the glue line. An open fishing boat, such as a Ghana canoe, will, in the bottom parts, be wetted both on the outside and the inside, while the topsides will be drying out. This has to be taken into account when using glued construction. From an optimum strength point of view, timber of 10-15% MC is preferred. From an equilibrium moisture content point of view 20-25% MC on the bottom parts and 15-20% MC on the top sides is preferable.

The time required to air dry timber to 20% MC will mainly depend on air humidity and species of timber. For a 25 mm thick plank stored under cover, it can take 1 1/2 months in dry weather and 6 months in more humid weather. A 50 mm plank will take from 6 months to two years to dry to a 20% MC.

The conclusion on the use of glued construction is the need for control on humidity and if tests indicate that sufficient strength can be obtained with wood of 18-20% MC, this is preferable because :

(a) widespread use of kiln dried timber is not at present feasible in Ghana, and

(b) the MC difference with actual service condition will be minimized.

Appendix 11 (continued)

Proper air drying might be difficult to achieve in a village. The village carpenters do not keep a store of timber for air drying. The timber is bought from the sawmill and used at once. If it is 25 mm thick and has been stored at the sawmill for some time, this could be satisfactory. Thicker planks will definitely not be sufficiently dry to avoid shrinkage in the top sides.

It has been claimed (Ref. 7) that a minimum of two coats of epoxy resin over the wood surface will form an adequate moisture barrier to prevent the dry wood required for high strength laminations from increasing its moisture content. This is probably true for yachts that are not subjected to abrasions, but would be of little value in a Ghana canoe subjected to wear from hauling up the beach on the outside, and from fishing gear and people on the inside.

Epoxy glue is sold at the following price (SP System):

3 x Pack of 198 kg SP 106 Resin + 34.2 kg SP 207 Slow hardener	£ 3479
+ Insurance and freight	£ 282
Total CIF Tema	£ 3761
Total weight	697 kg

Cost CIF per kg = £ 5.40 = ¢ 3,200

The use of Phenol Resorcinol glue (PRF) should be investigated as an alternative to epoxy. This glue has some advantages compared with epoxy : lower cost, longer working life and bond wood of higher MC. It also causes less allergic reaction such as dermatitis in some workers after prolonged exposure. The main disadvantage of PRF glue is the need for high pressure during curing and less gap filling properties than epoxy. Some work has been done to overcome these disadvantages with gap filling (thickened) formulation used in minesweeper construction in the USA. A non-profit volunteer technology transfer organization, "Appropriate Technology Transfer Associates" (ATTA), has done some application work for canoes using this technology. The present state of development in this field should be ascertained. The figure on the next page shows their method for panel making using vacuum begging to obtain sufficient pressure. Further development along this line could be justified.

For cost calculation the following application rates for epoxy resin have been used, (from Ref. 7), including 20% wastage :

Initial coating - 5.9 m^2/kg

Secondary and build up coats - 5.9 m^2/kg

Interlaminate adhesive coat (per glue line) - 2.2 m^2/kg

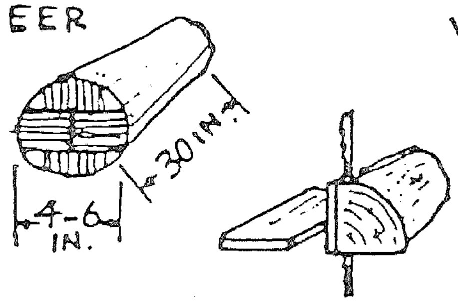
Appendix 11 (continued)

AFPITA

Figure 17.

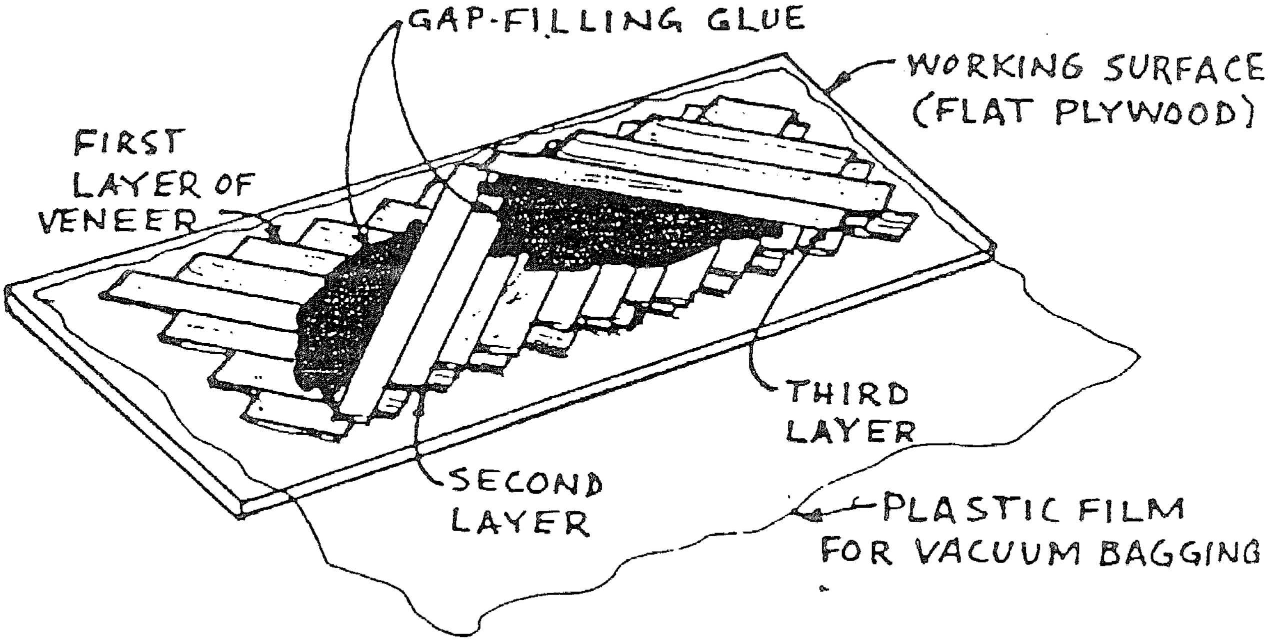
PANEL MAKING METHOD USING GAP-FILLING GLUE

1. CUT VENEER

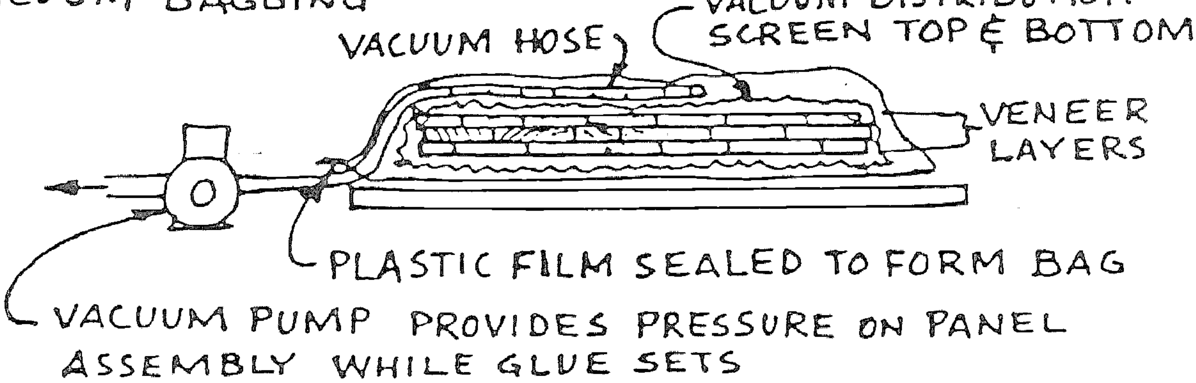


VENEER STRIPS $\frac{1}{8}$" THICK AND $1\frac{1}{2}$ TO 3 IN. WIDE RIPPED FROM SMALL LOGS 4 TO 6 IN. DIAMETER. 30 IN. LONG, FROM VARIOUS SPECIES

2. PANEL LAY-UP



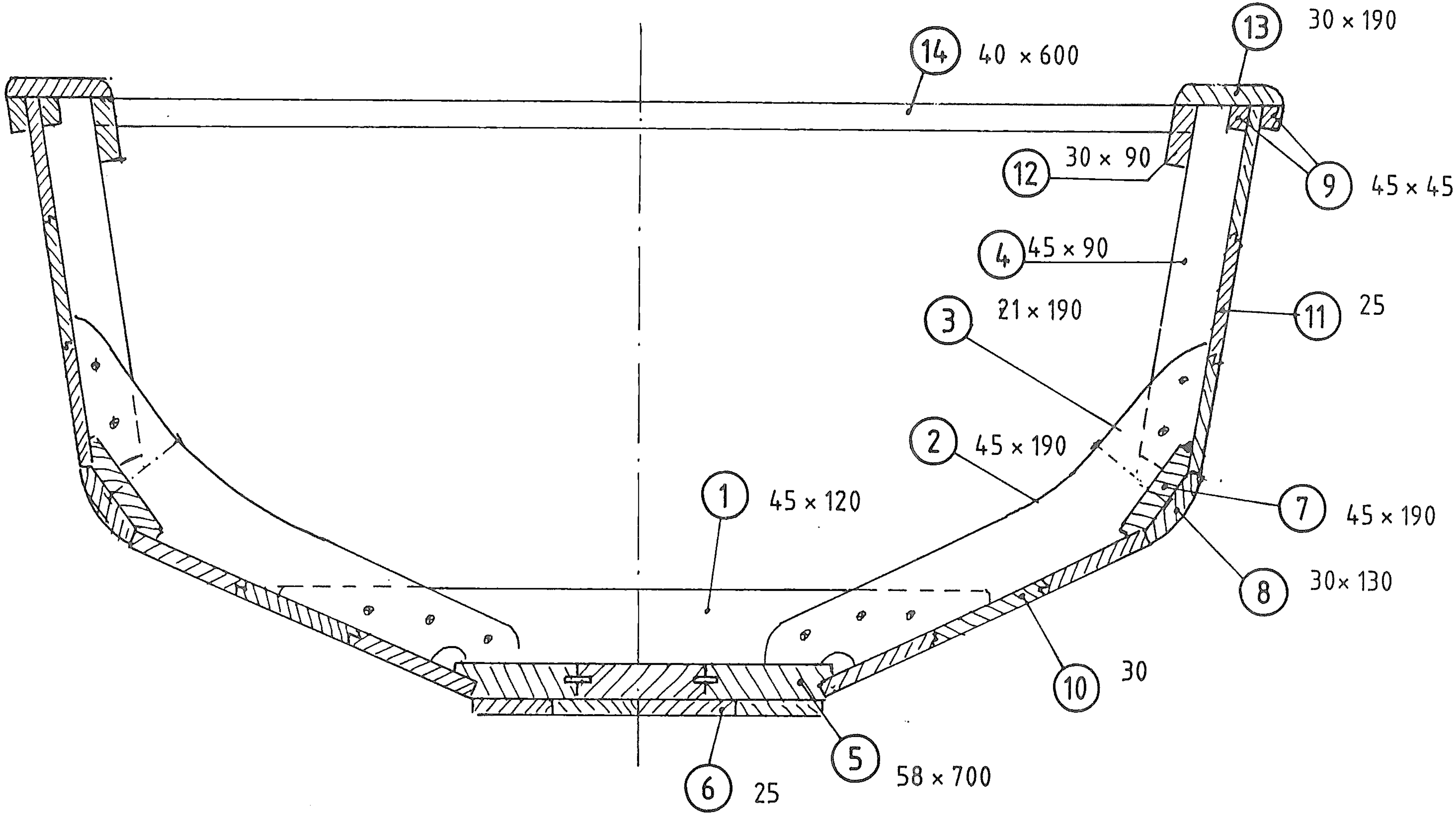
3. VACUUM BAGGING



11-86
PWF

12 A LONGITUDINAL PLANKED

Frame spacing = 400



Appendix 12A

WEIGHT AND COST

WOOD - LONGITUDINAL PLANKED

No.	Item	Dimension (mm)	Quantity	Volume m^3
1	Floor	45 x 120 x 1000	1	0,014
2	Gusset block	45 x 190 x 400	2	0,017
3	Gussets	21 x 190 x 800	4	0,032
4	Side frame	45 x 90 x 600	2	0,012
5	Keel plank	58 x 700	1	0,049
6	Rubbing strake	25 x 600	1	0,015
7	Chine	45 x 190	2	0,017
8	Outer Chine	30 x 130	2	0,008
9	Sheer battens	45 x 45	4	0,008
10	Bottom planking	30 x 630	2	0,038
11	Side planking	25 x 630	2	0,032
12	Coaming	30 x 90	2	0,005
13	Rail cap	30 x 190	2	0,011
14	Thwarts	40 x 600 x 1900	1	0,038
		Total		0,288 m^3

Weight/m = 0,288 x 700 kg/m^3 = 202 kg

Total weight 202 x 13 = 2600 kg

+ fastenings etc. = 150 kg

Total weight 2750 kg

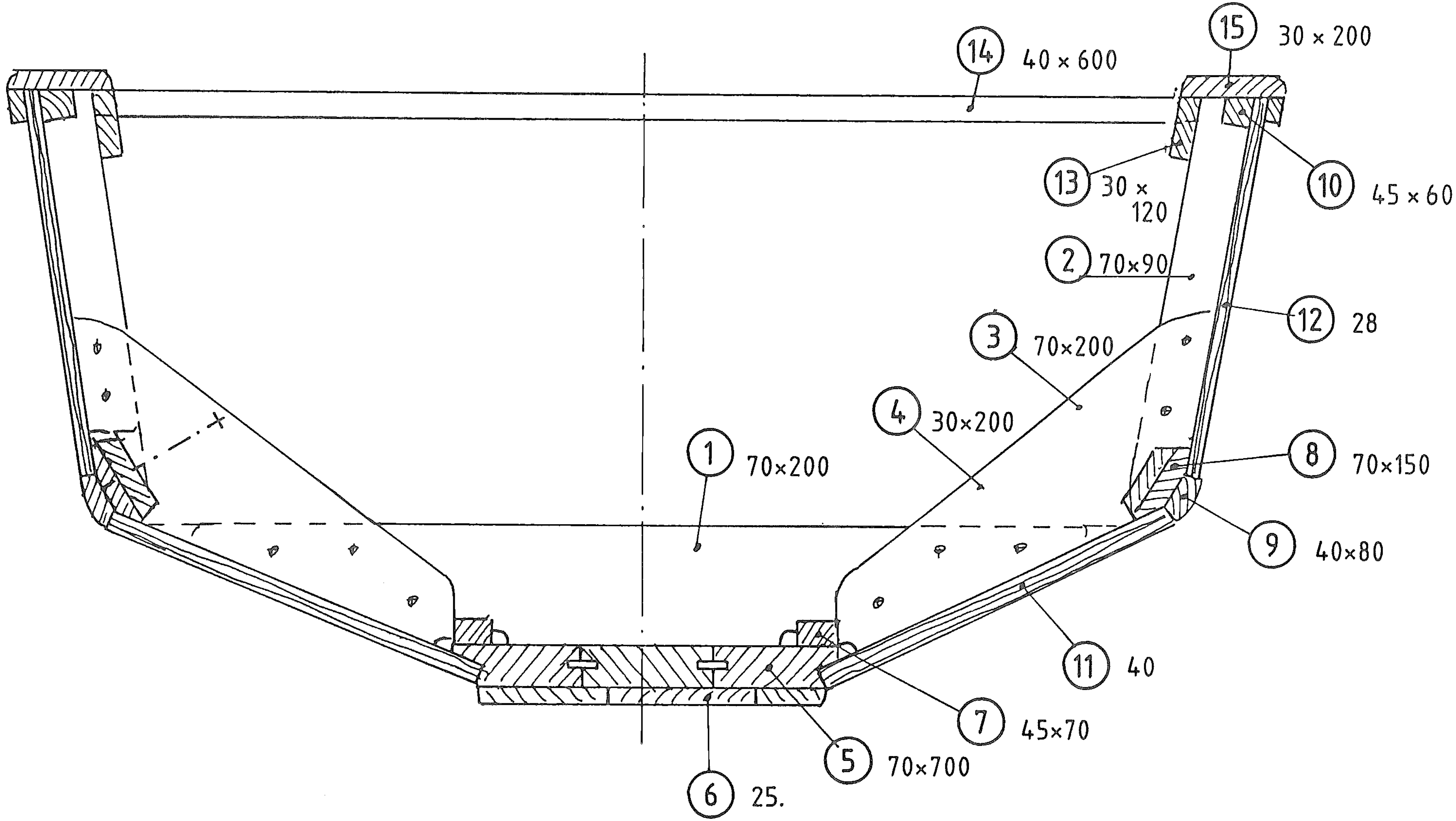
Volume of timber: 0,288 m^3 x 1.5 x 13 = 5.6 m^3.

Cost:

		₵
Timber, 5.6 m^3 x ₵ 90,000	=	504,000
Fastenings	=	80,000
Paint, etc.	=	70,000
Flotation 0.4 m^3	=	21,000
Total materials	=	675,000
Labour cost:		
4 men x 4 months x ₵ 15,000	=	180,000
Overhead + profit	=	130,000
Total	=	985,000

12 B CROSS PLANKED

Frame spacing = 1200



Appendix 12B

WEIGHT AND COST

WOOD - CROSS PLANKED

No.	Item	Dimension (mm)	Quantity	Volume m^3
1	Floor	70 x 200 x 1200	1	0,014
2	Side frame	70 x 90 x 600	2	0,007
3	Chine block	70 x 200 x 350	2	0,003
4	Gussets	30 x 200 x 700	4	0,014
5	Keel	70 x 700	1	0,049
6	Rubbing strake	25 x 600	1	0,015
7	Cheek	45 x 70	2	0,006
8	Chine	70 x 150	2	0,021
9	Outer Chine	40 x 80	2	0,006
10	Sheer batten	45 x 60	2	0,005
11	Bottom planking	40 x 600	2	0,048
12	Side planking	28 x 630	2	0,035
13	Coaming	30 x 120	2	0,007
14	Thwart	40 x 600 x 1900	1	0,038
15	Rail cap	30 x 200	2	0,012
		Total		0,290 m^3

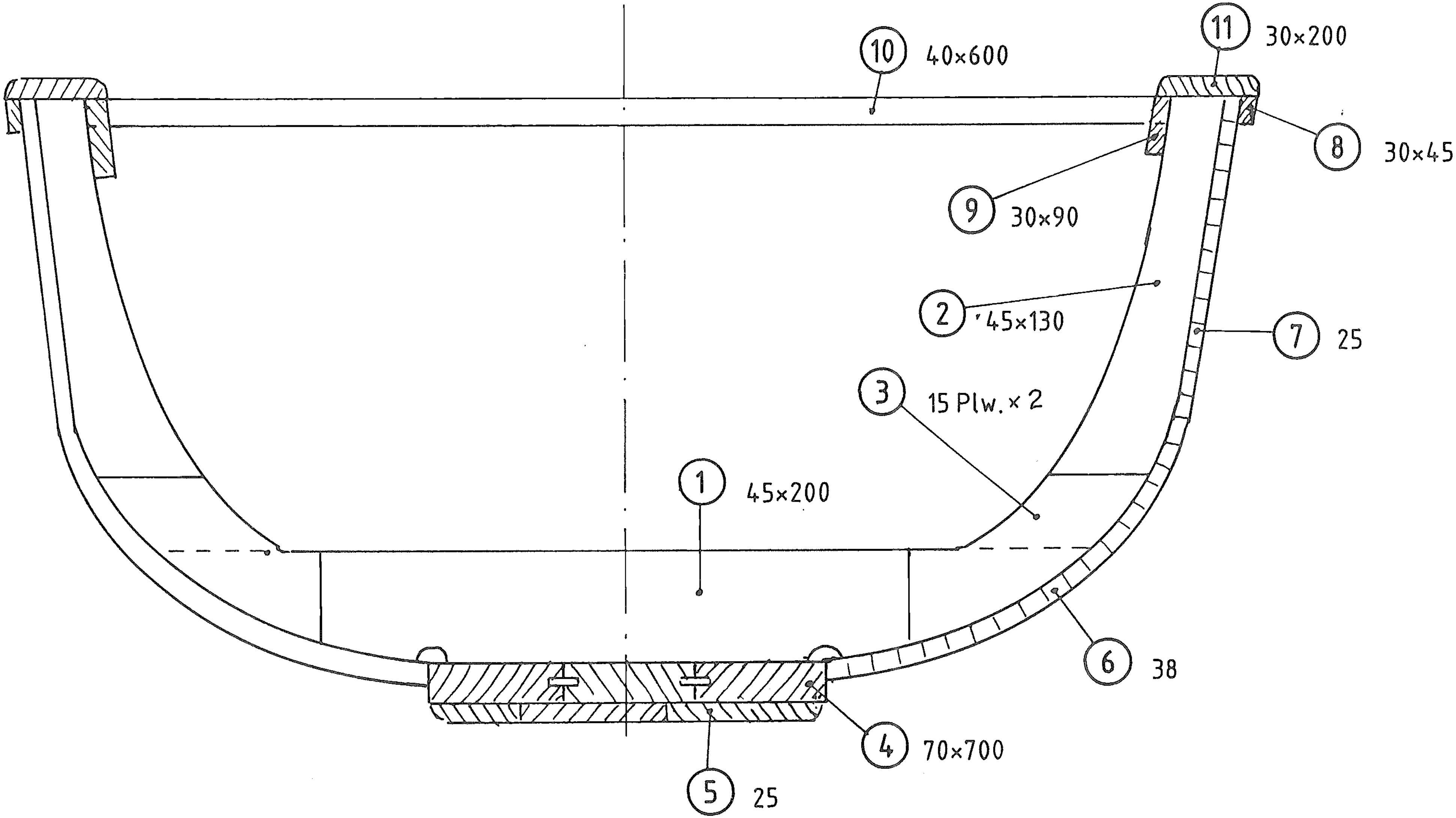
Hull weight/m	= 0,290 m^3 x 700 kg/m^3	= 203 kg
Weight timber hull	= 203 x 13	= 2600 kg
+ fastenings etc.		= 200 kg
Total weight		2800 kg

Gross volume timber = 0,290 m^3 x 13 x 1.5 = 5.7 m^3.

			¢
Cost:	Timber, 5.7 m^3 x ¢ 90,000	=	510,000
	Fastenings	=	80,000
	Paint etc.	=	70,000
	Flotation 0.4 m^3	=	20,000
	Total materials	=	680,000
	Labour cost:		
	4 men x 3 months x ¢ 15,000	=	180,000
	Overhead and profit	=	130,000
	Total	=	990,000

12 C STRIP PLANKING

Frame spacing = 800



Appendix 12C

WEIGHT AND COST

WOOD - STRIP PLANKING

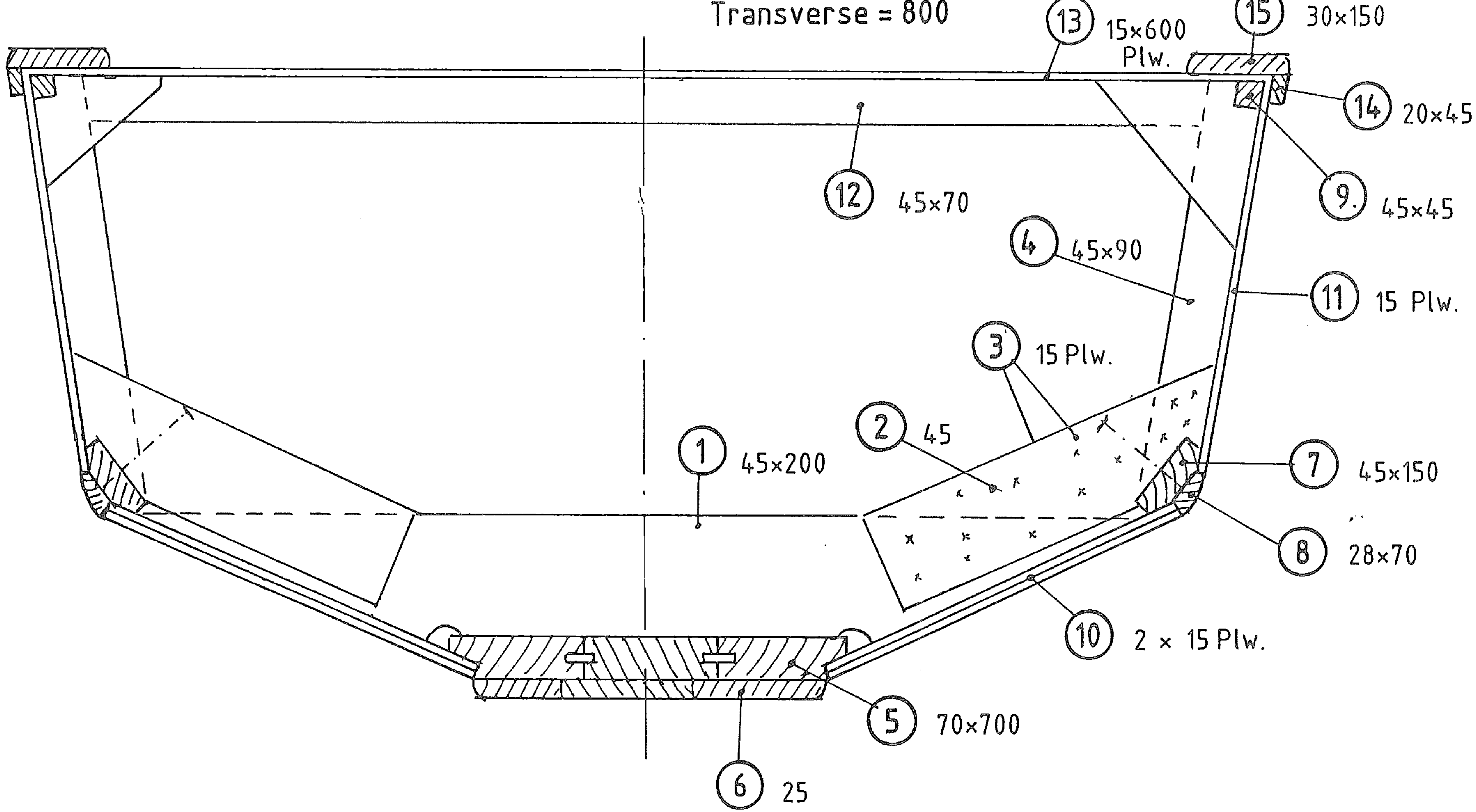
No.	Item	Dimension (mm)	Quantity	Volume m^3
1	Floor	45 x 200 x 1200	1	0,014
2	Side frame	45 x 130 x 850	2	0,012
3	Gussets	15 plw	4	
4	Keel	70 x 700	1	0,049
5	Rubbing strake	25 x 700	1	0,0175
6	Bottom planking	38 x 750	2	0,057
7	Side planking	25 x 650	2	0,033
8	Rubbing strip	30 x 45	2	0,003
9	Coaming	30 x 90	2	0,005
10	Thwart	40 x 600 x 1900		0,038
11	Rail cap	30 x 200	2	0,012
		Total		0,240 m^3

Weight timber per m = 0,240 m^3 x 700 kg/m^3	=	168 kg
Weight hull = 168 kg x 13 m	=	2180 kg
+ fastenings etc.	=	200 kg
Total weight	=	2380 kg
Quantity: Sawn timber = 0,240 x 13 x 1.5	=	4.68 m^3
Cost:		¢
Timber, 4.68 m^3 x ¢ 90,000	=	421,000
Fastenings	=	100,000
Epoxy glue 15 kg x ¢ 3,200	=	48,000
Paint etc.	=	40,000
Flotation 0,4 m^3	=	21,000
Total materials	=	630,000
Labour cost: 4 men x 2 1/2 months x ¢ 15,000	=	150,000
Overhead and profit	=	150,000
Total	=	930,000

12 D MARINE PLYWOOD

Frame spacing Longitudinal = 600

Transverse = 800



Appendix 12D

WEIGHT AND COST

WOOD - MARINE PLYWOOD

No.	Item	Dimension (mm)	Quantity	Volume m^3
1	Floor	45 x 200 x 1200	1	0,014
2	Chine block	45 x 200 x 600	2	0,014
3	Gussets	15 plw		
4	Side frame	45 x 90 x 600	2	0,005
5	Keel	70 x 700	1	0,049
6	Rubbing strake	25 x 600	1	0,015
7	Chine	45 x 150	2	0,014
8	Outer chine	28 x 70	2	0,004
9	Sheer batten	45 x 45	2	0,004
10	Bottom planking	2 x 15 plw		
11	Side planking	15 plw		
12	Thwart support	45 x 70	2	0,006
13	Thwarts	15 x 600 plw	1	
14	Outer batten	20 x 45	2	0,002
15	Rail cap	30 x 150	2	0,009
		Total		0,136 m^3

Weight timber per m = 0,136 x 700 = 95 kg
Weight plywood per m = 0,066 x 750 = 50 kg

145 kg

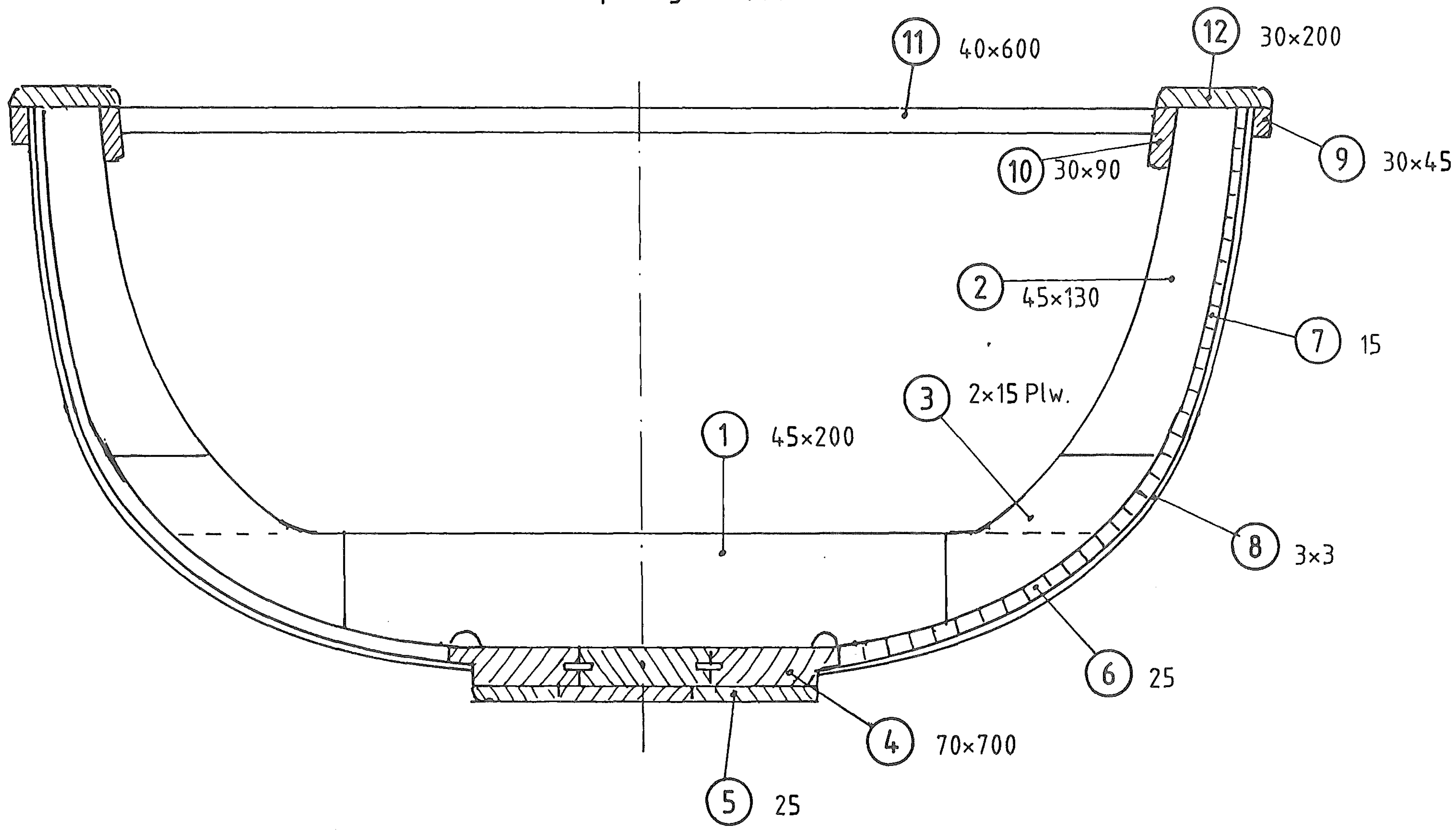
Weight hull = 145 x 13 = 1885 kg + fastenings = 2000 kg
Gross volume timber = 0,136 x 13 x 1.5 = 2.65 m^3
Gross volume plywood = 0,066 x 13 x 1.2 = 1.03 m^3

Cost:

		Ø
Timber, 2.65 m^3 x Ø 90,000	=	239,000
Plywood, 1,03 m^3 x Ø 220,000	=	227,000
Fastenings	=	70,000
Epoxy glue 15 kg x Ø 3,200	=	48,000
Paint, etc.	=	40,000
Flotation 0,4 m^3	=	21,000
Total materials	=	645,000
Labour cost: 4 men x 2 months x Ø 15,000	=	120,000
Overhead + profit	=	150,000
Total	=	915,000

12 E STRIP PLANKING + COLD MOULDED

Frame spacing = 800



Appendix 12E

WEIGHT AND COST

WOOD - STRIP + COLD MOULDED

No.	Item	Dimension (mm)	Quantity	Volume m^3
1	Floor	45 x 200 x 1200	1	0,014
2	Side frame	45 x 130 x 850	2	0,012
3	Gusset	15 plw		
4	Keel	70 x 700	1	0,049
5	Rubbing strake	25 x 700	1	0,018
6	Strip plank, bottom	25 x 700	2	0,035
7	Strip plank, side	15 x 700	2	0,021
8	Veneers	3 x 2600	3	-
9	Rubbing strip	30 x 45	2	0,003
10	Coaming	30 x 90	2	0,005
11	Thwart	40 x 600 x 1900	1	0,038
12	Rail cap	30 x 200	2	0,012
		Total		0,207 m^3

Weight timber per m = 0,207 m^3 x 700 kg/m^3 = 145 kg
Weight veneer = 0,023 x 700 kg/m^3 = 16 kg

Total weight per m 161 kg

Weight of hull = 161 x 13 = 2090 kg
+ fastenings etc. = 150 kg

= 2240 kg

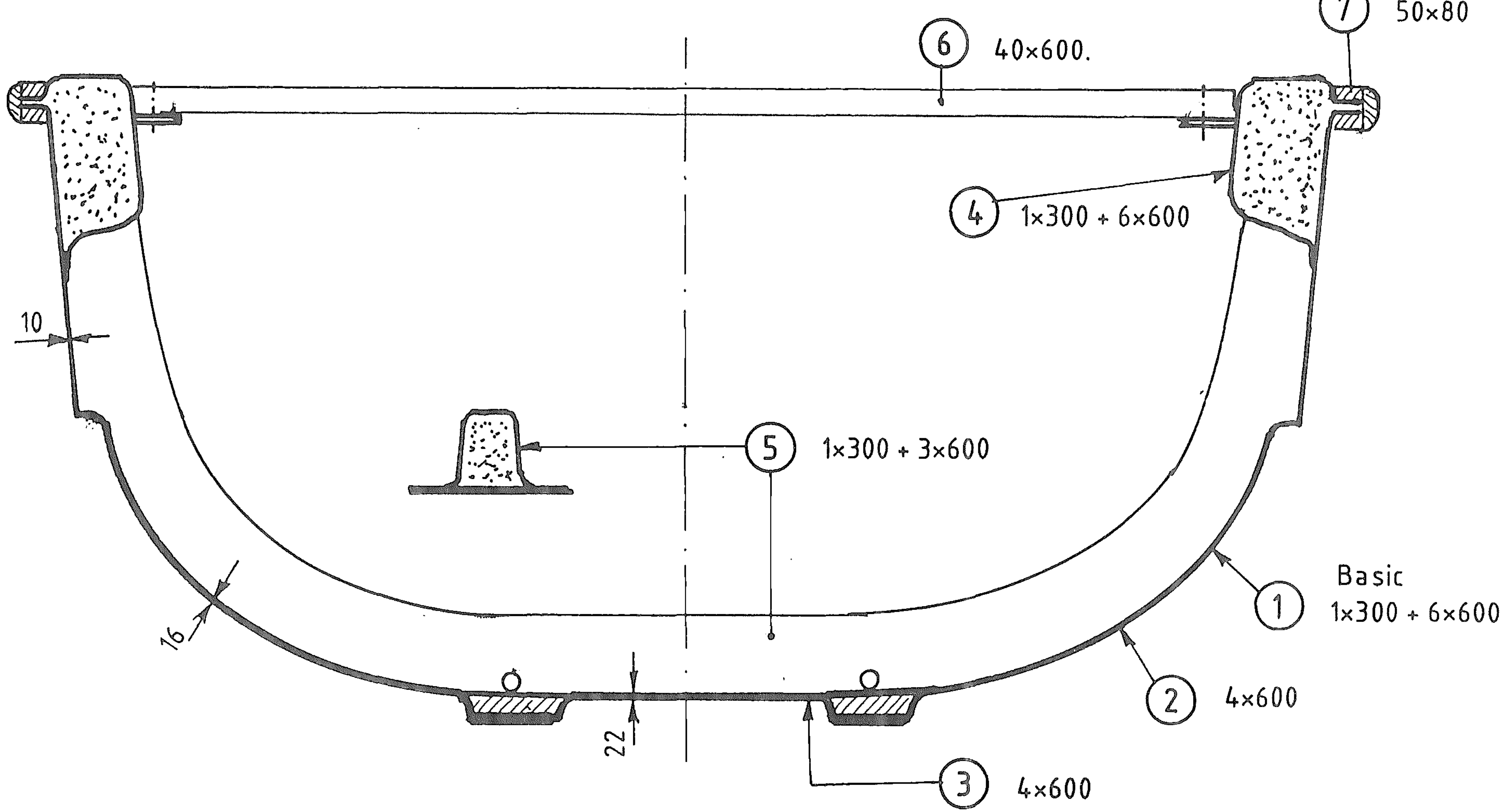
Quantity of sawn timber : 0,207 x 13 x 1,5 = 4,04 m^3
Quantity of veneers : 0,023 x 13 x 1,5 = 0,45 m^3

Cost:

			Ø
Timber, 4,04 m^3 x Ø 90,000		=	364,000
Veneers, 0,45 m^3 x Ø 200,000		=	90,000
Fastenings		=	30,000
Epoxy glue	80 kg x Ø 3,200	=	256,000
Paint, etc.		=	30,000
Flotation	0,4 m^3	=	21,000
Total materials		=	791,000
Labour cost: 4 men x 3 months x Ø 15,000		=	180,000
Overhead + profit		=	180,000
	Total	=	1,151,000

12 F - GRP

Frame distance = 800



Appendix 12F

WEIGHT AND COST

GRP

		CSM g/m^2	Total g/m^2	Area m^2	CSM kg
1	Basic lay up	1 x 300 + 6 x 600	3900	4,3	16,8
2	Bottom reinforcement	4 x 600	2400	2,8	6,7
3	Keel reinforcement	4 x 600	2400	1,2	2,9
4	Sheer reinforcement	1 x 300 + 6 x 600	3900	0,5	2,0
5	Frame	1 x 300 + 3 x 600	2100	1,4	2,9
		Total			31,3

6	Wooden thwarts	40 x 600 x 1900	=	0,038 m^3
7	Rubbing strake	50 x 80 x 2	=	0,008 m^3
		Total wood		0,046 m^3

Per m length : kg

Weight CSM	=	31,3
Weight resin = 31,3 x 2,5	=	78,3
Weight of gelcoat	=	2,3
Total GRP materials	=	111,9
+ Wood	=	32,0
Weight per m length	=	143,9
Weight of hull = 143,9 x 13	=	1870 kg

Materials:

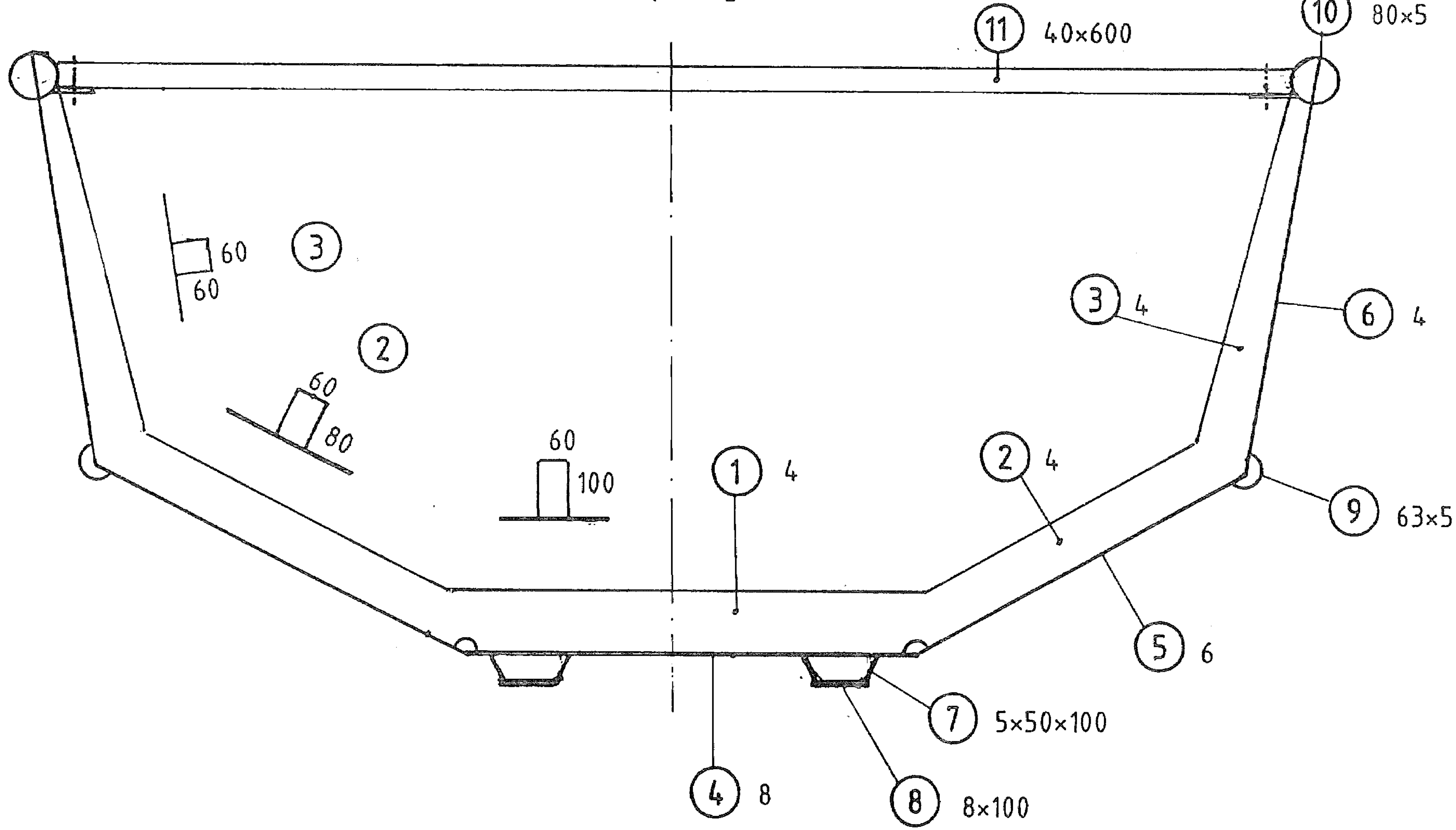
Chopped strand mat, CSM	407 kg
+ 12% wastage	49 kg
Total CSM	456 kg
Polyester resin	1018 kg
+ 12% wastage	122 kg
Total polyester resin	1140 kg
Wood : 0,046 m^3 + 1,5	0,069 m^3
Flotation material	

Cost:

		¢
Chopped strand mat 456 kg x ¢ 1,400	=	638,000
Polyester resin 1140 kg x ¢ 1,200	=	1,368,000
Gelcoat 35 kg x ¢ 2,000	=	70,000
Timber 0,069 m^3 x ¢ 90,000	=	6,000
Flotation 1,8 m^3	=	94,000
Total materials	=	2,176,000
Labour: 4 men x 0,5 month x ¢ 20,000	=	40,000
Overhead + profit	=	200,000
Total	=	2,416,000

12 G ALUMINIUM

Frame spacing = 800



Appendix 12G

WEIGHT AND COST

ALUMINIUM

Frame spacing : Transverse = 0.80 m Longitudinal = 0.60 m

No.	Item	Dimension (mm)	No.	Weight kg
1	Floor	4 x 260 x 800	1	2,3
2	Bottom frame	4 x 220 x 600	2	2,9
3	Side frame	4 x 200 x 600	2	2,6
4	Keel plate	8 x 750	1	16,2
5	Bottom plate	6 x 600	2	21,1
6	Side plate	4 x 650	2	14,0
7	Keel	5 x 50 x 100	2	5,4
8	Keel reinforcement	8 x 100	2	4,3
9	Chine reinforcement	63 x 5	1	2,5
10	Sheer tube	80 x 5	2	6,4
		Total		77,7
11	Wooden thwarts	40 x 600 x 1900	=	0,038 m^3

Weight aluminium/m	=	77,7 kg
Weight wooden thwarts/m	=	22,0 kg
Weight of hull/m	=	99,7 kg
Weight of hull = 99,7 x 13	=	1296 kg
Net weight aluminium plates	=	825 kg
+ wastage 15%	=	124 kg
Total plates	=	949 kg
Net weight aluminium extrusions	=	186 kg
+ wastage 15%	=	28 kg
Total extrusions	=	214 kg
Net volume timber	=	0,038 m^3
+ wastage 50% Total	=	0,057 m^3

Cost:

		¢
Aluminium plates, 949 kg x ¢ 1,500	=	1,424,000
Aluminium extrusions, 214 kg x ¢ 1,700	=	364,000
Timber, 0,057 m^3 x ¢ 90,000	=	5,000
Flotation 2,0 m^3	=	104,000
Total materials	=	1,897,000
Labour cost:		
4 men x 1 month x ¢ 20,000	=	80,000
Overhead + profit	=	300,000
Total	=	2,277,000

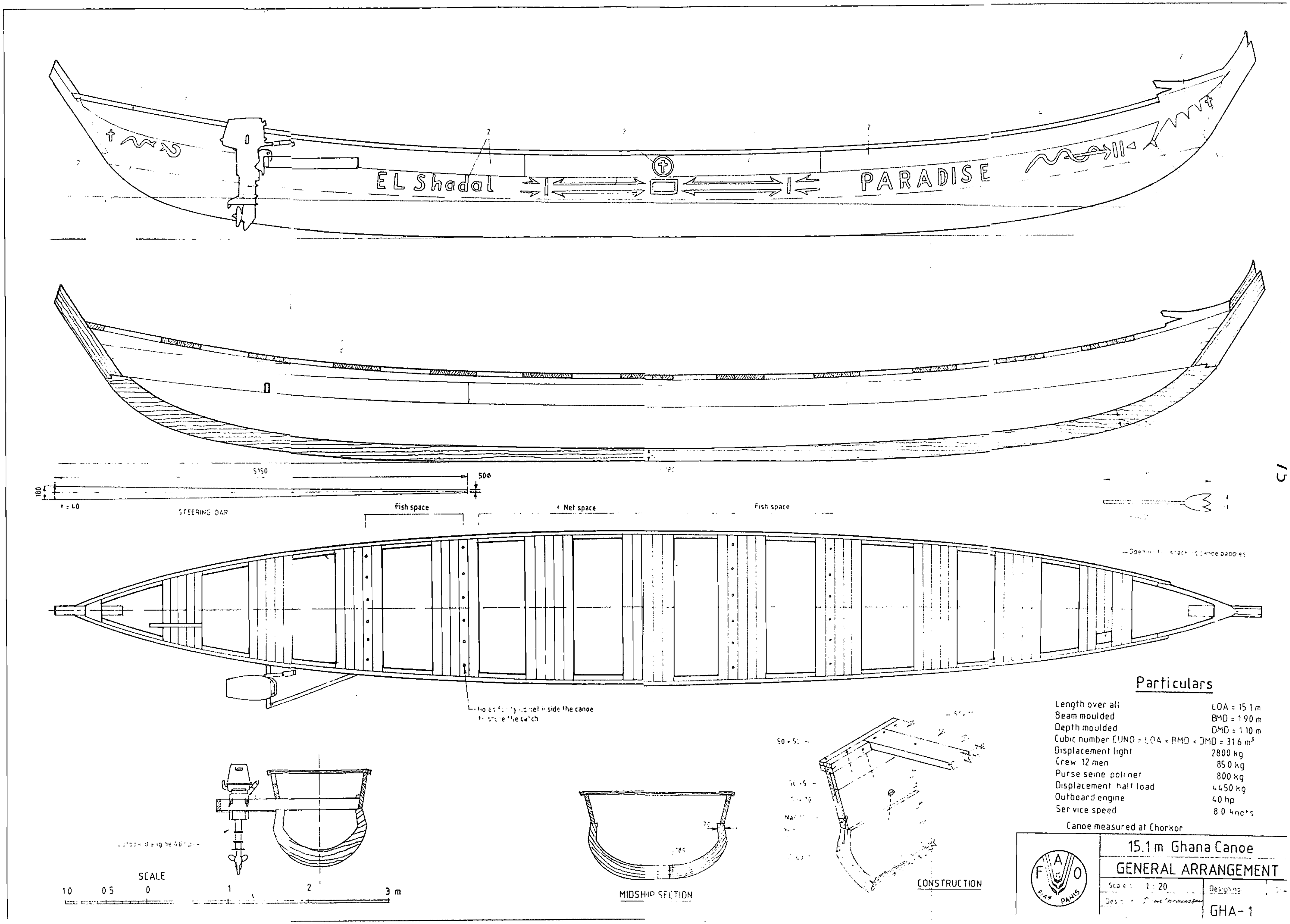
DRAWINGS

15,1 m Ghana Canoe - Poli net

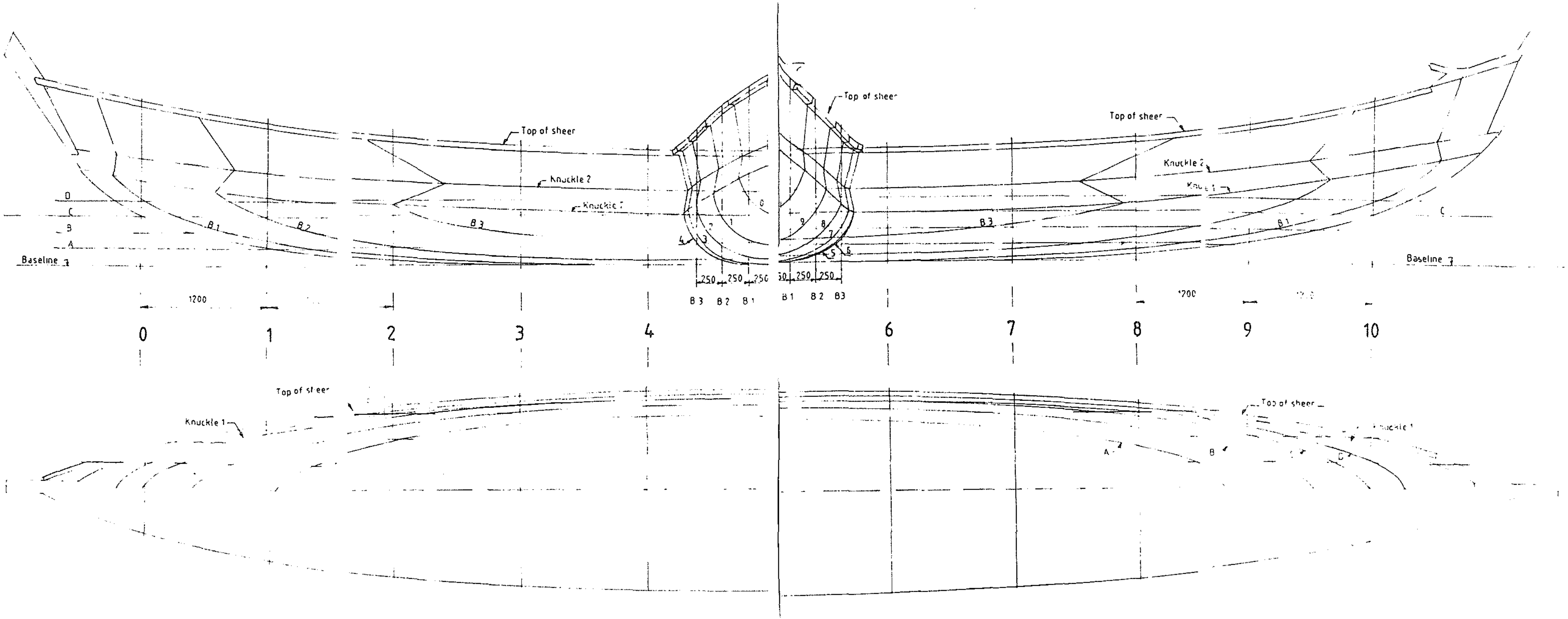
GHA-1	No. 1	General Arrangement
GHA-1	No. 2	Lines
GHA-1	No. 3	Stability
GHA-1	No. 4	Poli purseseining
GHA-1	No. 5	Manufacture

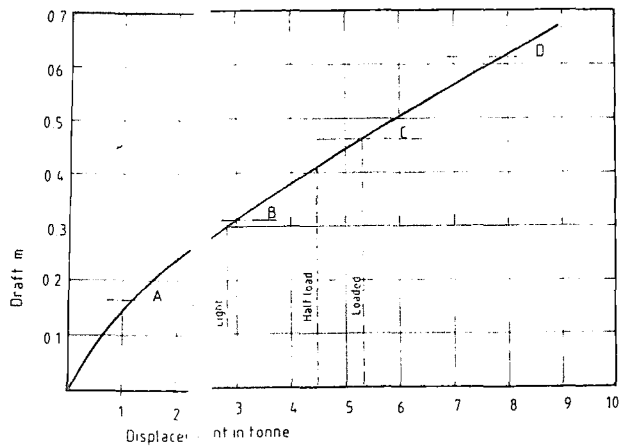
14.0 m Ghana Canoe - Watsa net

GHA-2	No. 1	General Arrangement
GHA-3	No. 1	Handling on the beach
GHA-3	No. 2	Methods of planking



EL Shadal
PARADISE
STEERING OAR
5150
50ø
180
t = 40
Fish space
Net space
Fish space
Particulars
Length over all LOA = 15.1 m
Beam moulded BMD = 1.90 m
Depth moulded DMD = 1.10 m
Cubic number CUNO = LOA × BMD × DMD = 31.6 m³
Displacement light 2800 kg
Crew 12 men 850 kg
Purse seine poli net 800 kg
Displacement half load 4450 kg
Outboard engine 40 hp
Service speed 8.0 knots
Canoe measured at Chorkor
SCALE
1.0 0.5 0 1 2 3 m
MIDSHIP SECTION
CONSTRUCTION
15.1 m Ghana Canoe
GENERAL ARRANGEMENT
Scale 1 : 20
GHA-1





Particulars

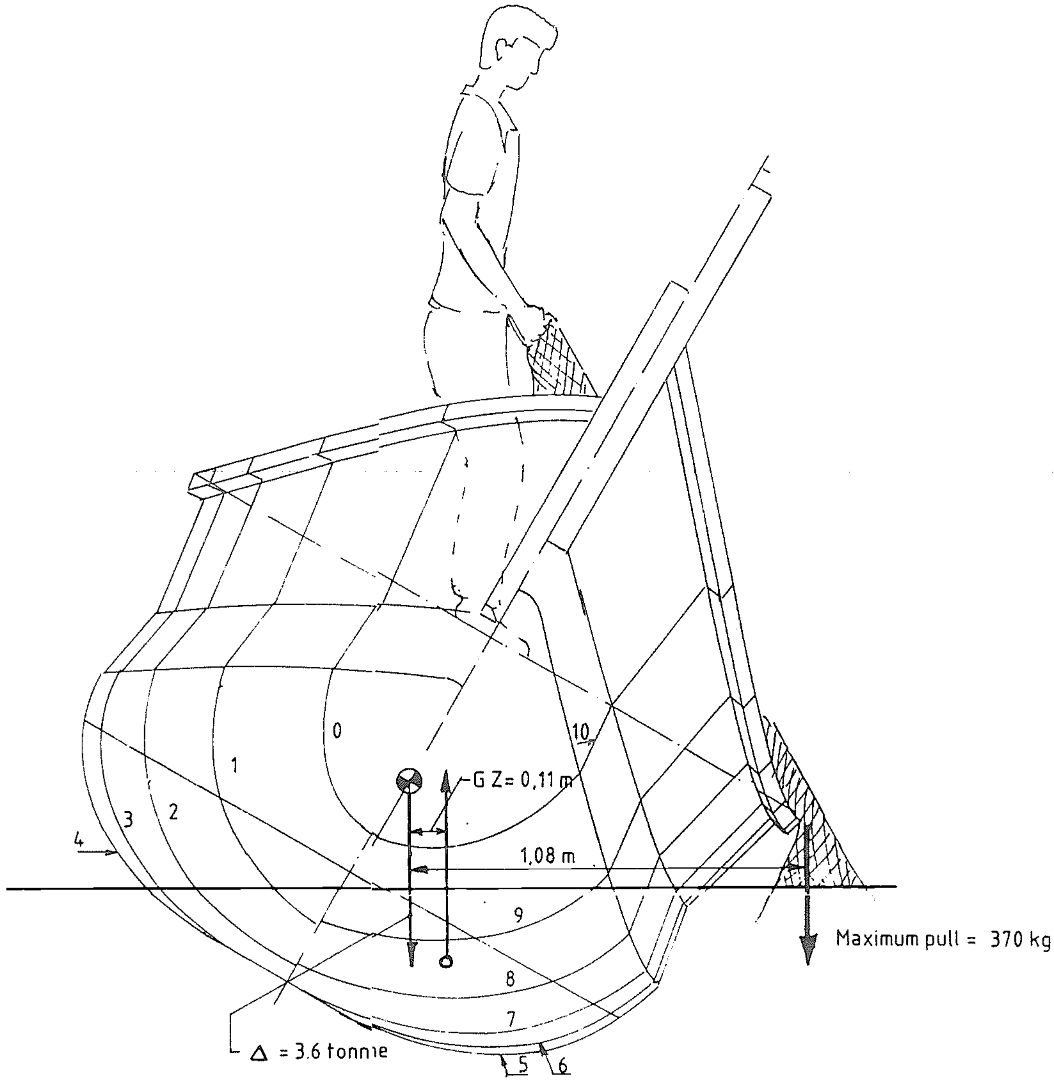
Length over all	LOA = 15.10 m
Beam moulded	BMD = 1.90 m
Depth moulded	DMD = 1.10 m
Cubic number CUNO = LOA × BMD × DMD	= 31.6 m^3
HALF LOAD with crew 12 men and polinet	
Length waterline	L = 11.70 m
Beam waterline	B = 1.72 m
Draft	T = 0.40 m
Freeboard, minimum	F = 0.65 m
Displacement	Δ = 4.5 tonne

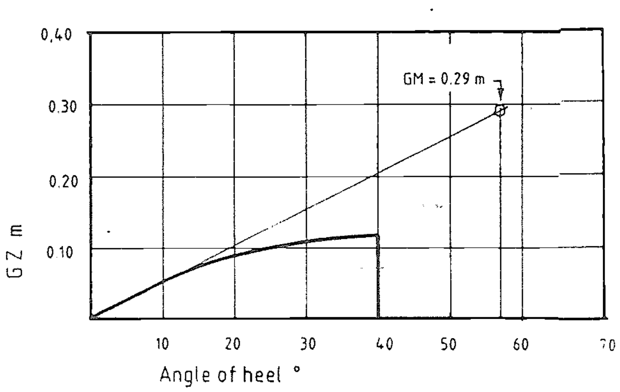
RATIOS WL-C

$L/B = 6.8$ $\quad \nabla/(0.1L)^3 = 2.8$

Outboardengine 40 hp, Service speed at $V/\sqrt{L} = 1.3$, V = 8.0 kno

FAO FIAT PANIS	15.1 m Ghana Canoe
	LINES
Scale 1 : 20	Designs
Design Ø. Gulbrandsen	GHA - 1 2

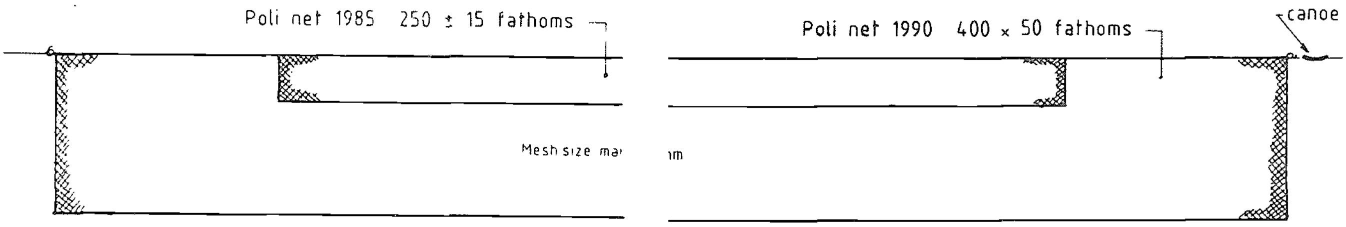




WORST STABILITY CONDITION :

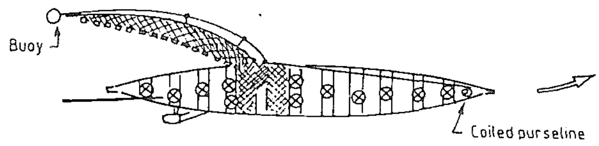
Crew of 12 men standing on the thwarts and pulling the net over the side.
At 30° angle of heel, the righting moment RM = $\Delta \times$ G Z
RM = 3600 kg × 0,11 m = 400 kgm. The maximum pull from the net can be 370 kg before the canoe capsizes.
The crew compensates by shifting position.
At 40° angle of heel water starts to come over the side and stability is lost.

FAO FIAT PANIS	15,1m Ghana Canoe		
	STABILITY		
	SCALE 1 : 10	DESIGN NO	DRWG NO
	DESIGN Ø Gulbrandsen	GHA - 1	3

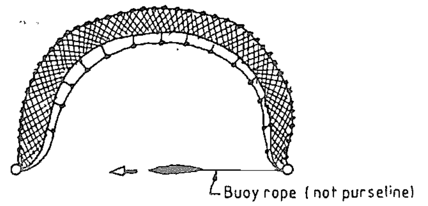


DEVELOPMENT OF PURSESEINE

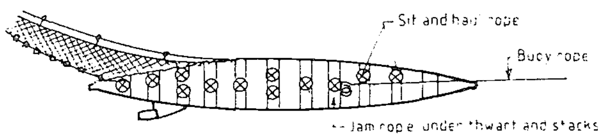
Source . A Do 5
G Sh 1990



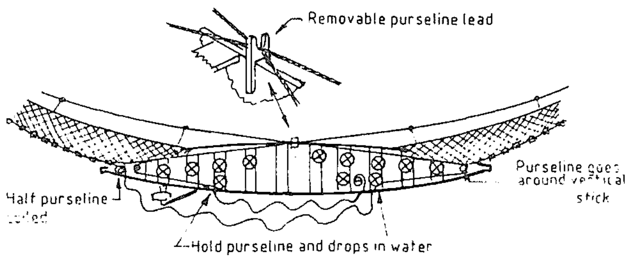
1 Setting the purseseine



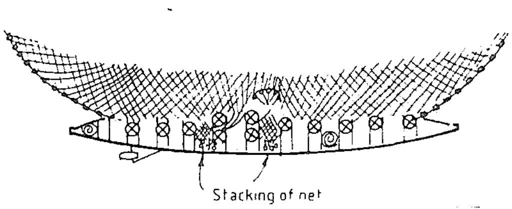
2. Dropping the end buoy and going back to the first buoy.



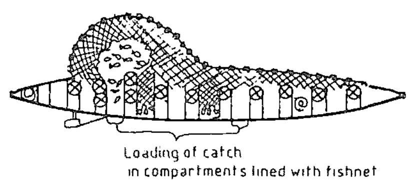
3 Closing the net slowly and hauling the buoy rope.



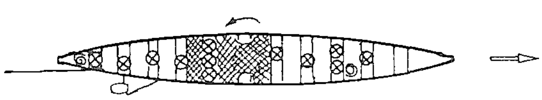
4. Hauling the purseline



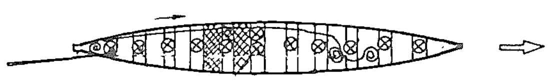
5. Hauling the net



6. Brailing.



7 Restacking half of the purseline



8 Recoiling half of the purseline

The purseline is carried from the canoe to the store after returning to the beach

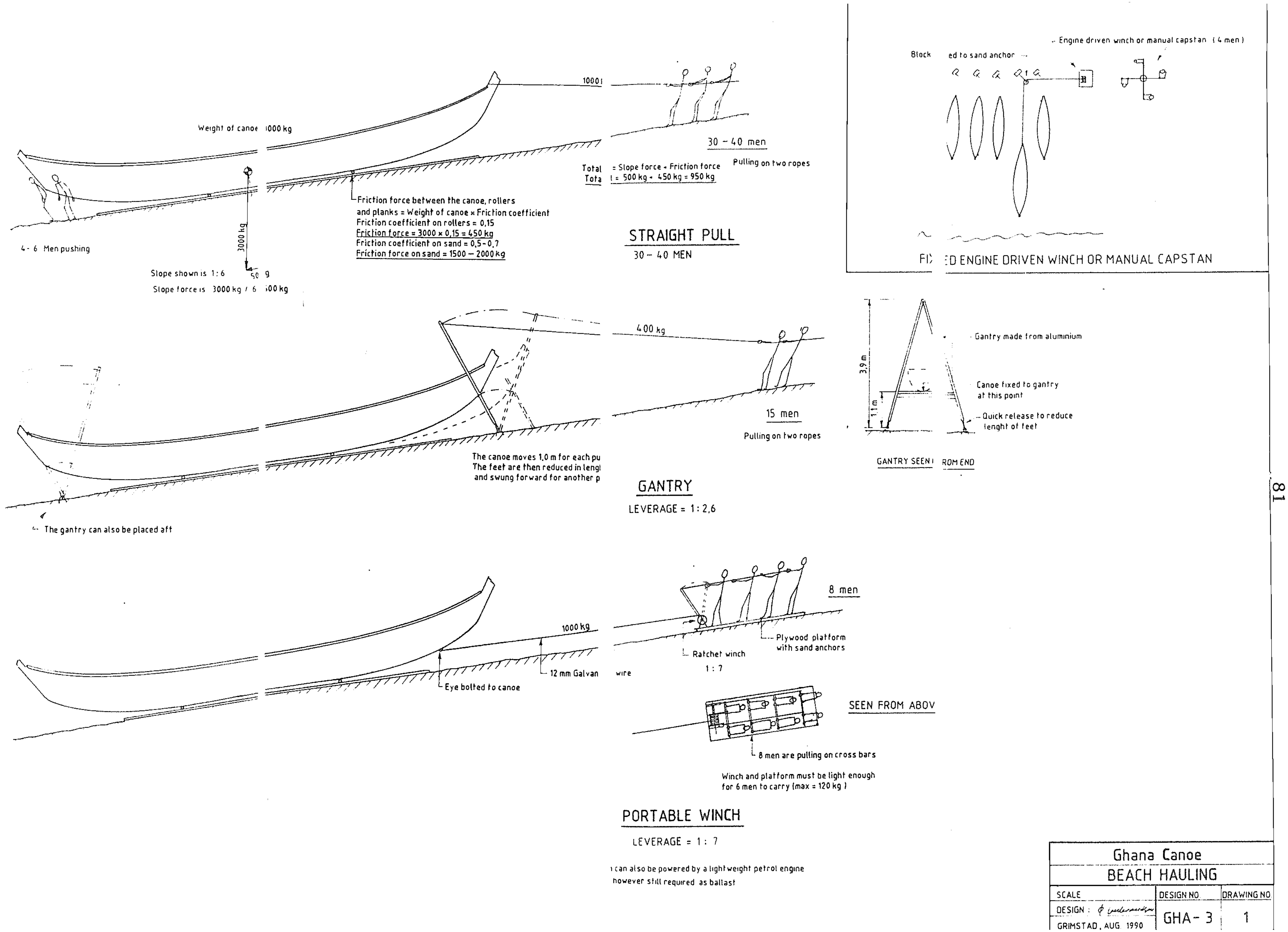
Method shown is as observed on a fishing trip from Accra beach
Departure at 0100, Return at 0800

FAO FIAT PANIS

15.1 m Ghana canoe

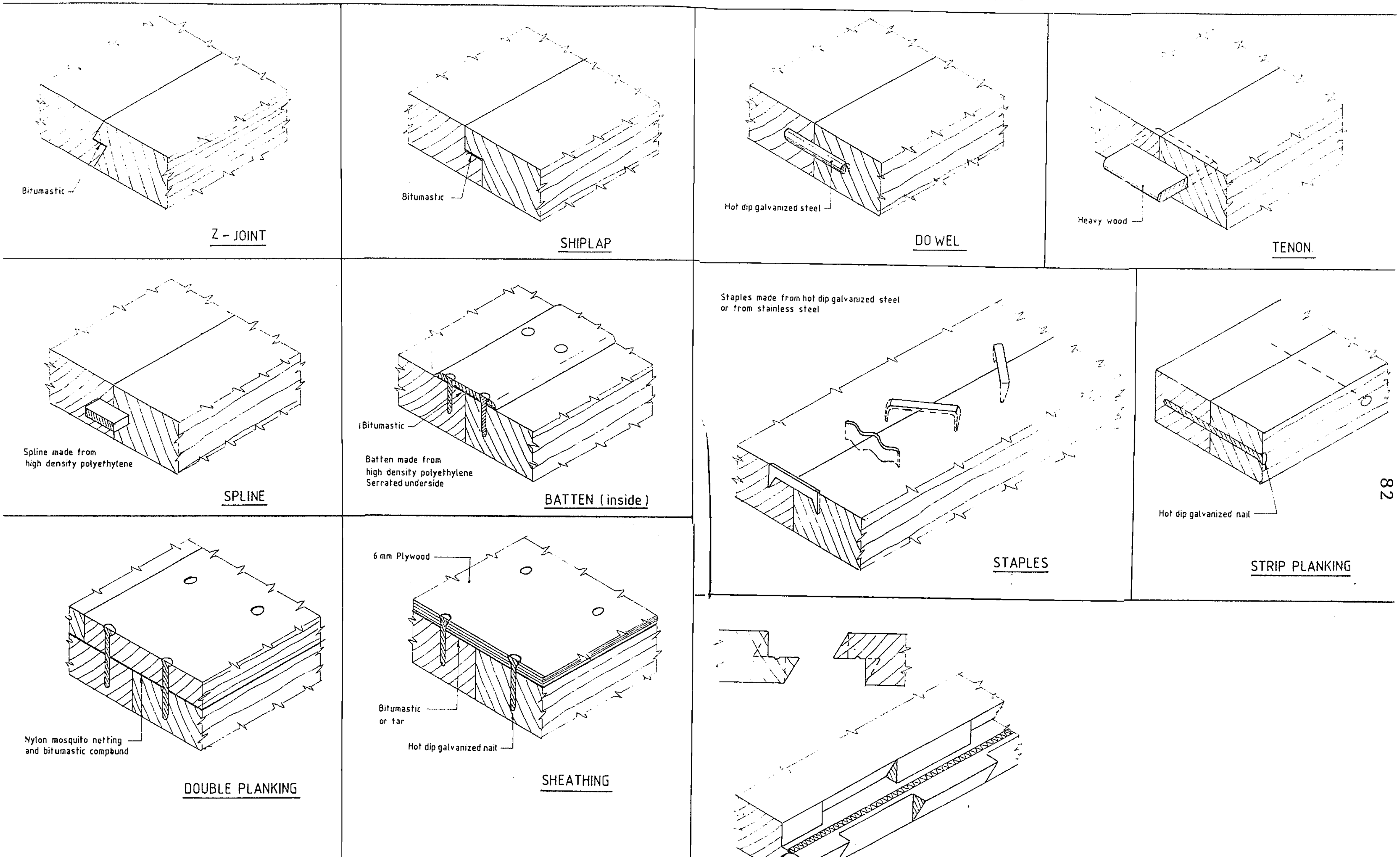
POLI PURSESEINING

SCALE	DESIGN NO	DRAWING NO
DESIGN : Ø. Gulbrandsen Grimstad, July 1990	GHA 1	4

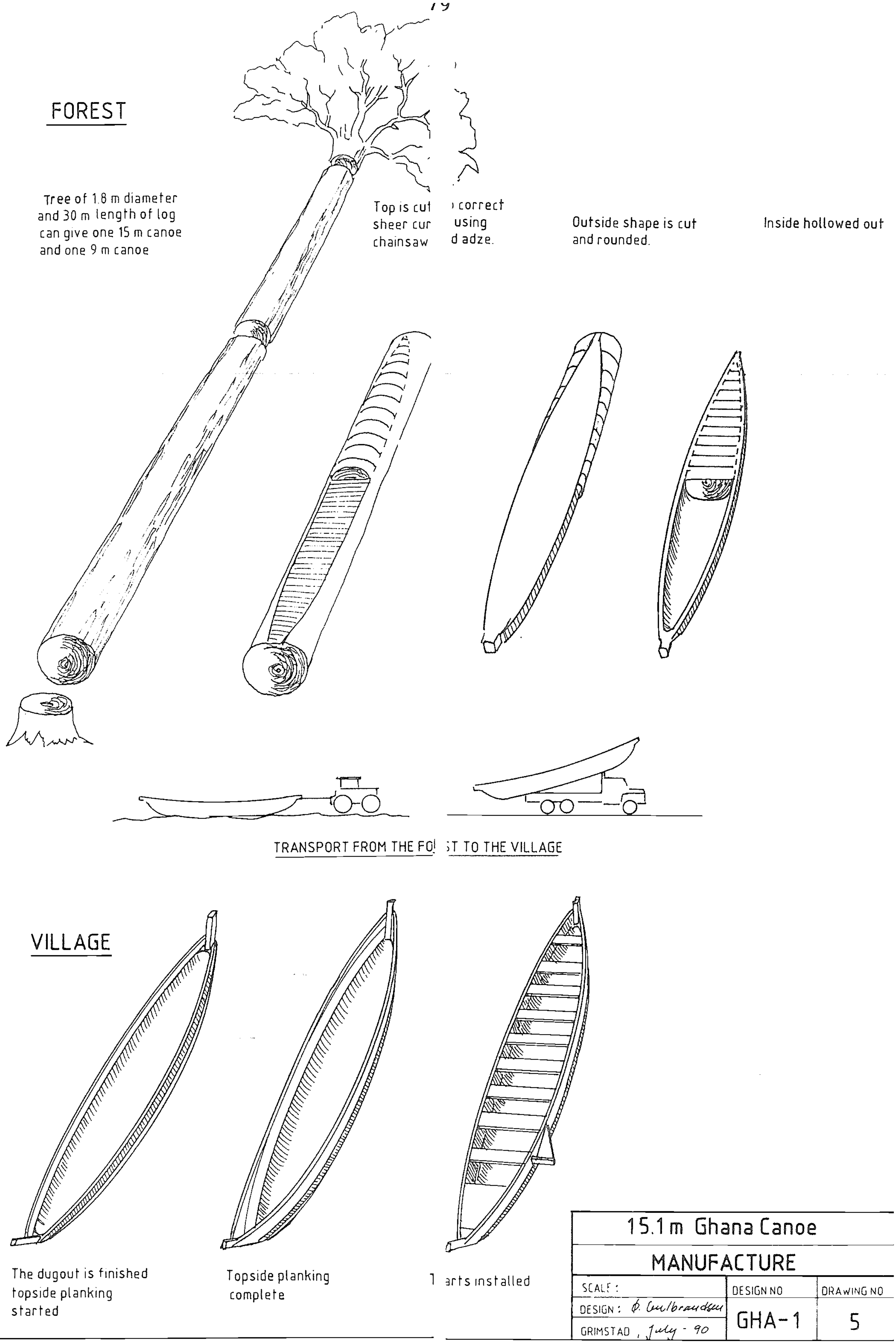


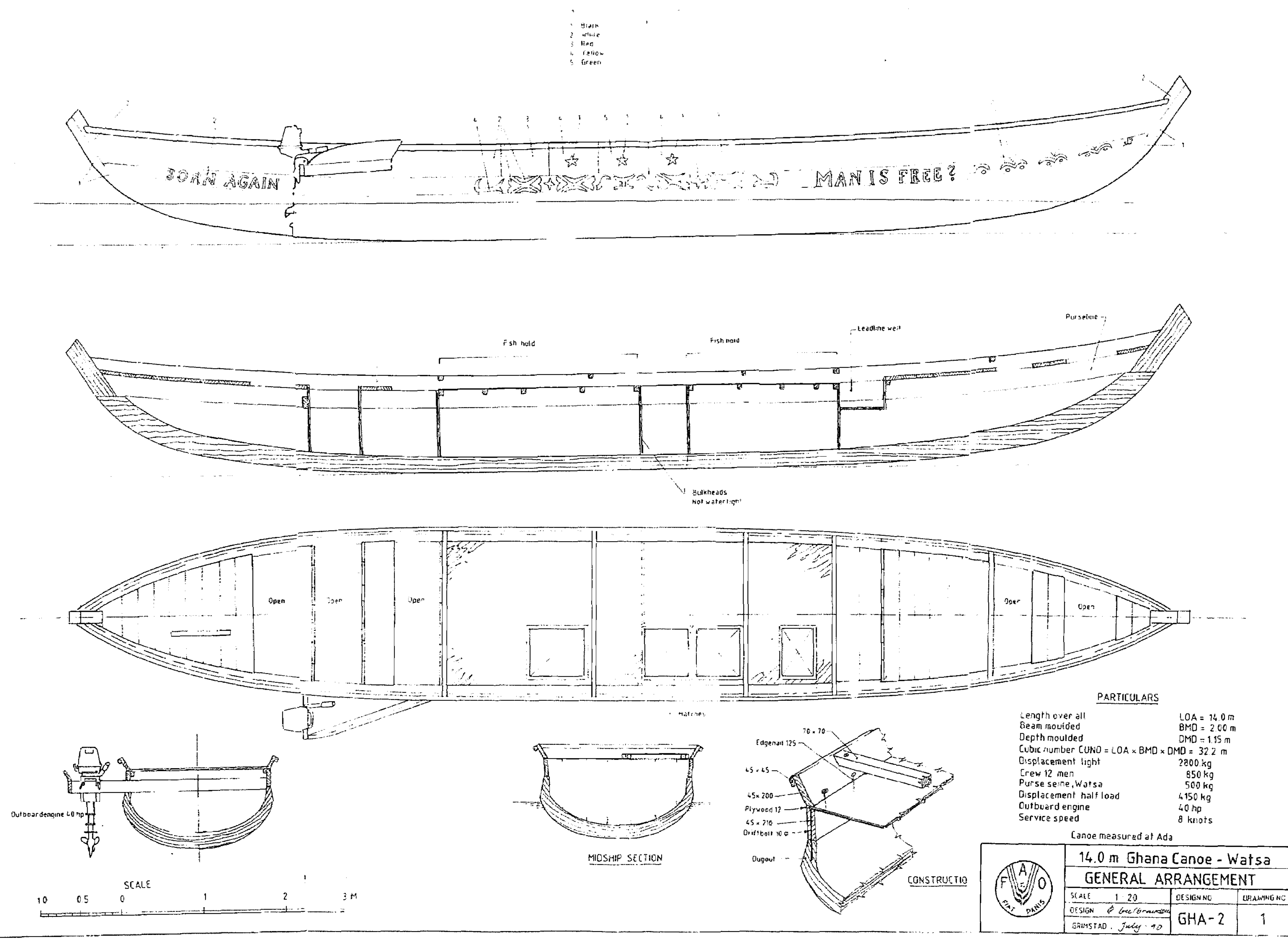
Weight of canoe 3000 kg
4 - 6 Men pushing
3000 kg
Slope shown is 1:6
Slope force is 3000 kg / 6 500 kg
Friction force between the canoe, rollers and planks = Weight of canoe × Friction coefficient
Friction coefficient on rollers = 0,15
Friction force = 3000 × 0,15 = 450 kg
Friction coefficient on sand = 0,5 - 0,7
Friction force on sand = 1500 — 2000 kg
Total = Slope force + Friction force
Total = 500 kg + 450 kg = 950 kg
30 - 40 men
Pulling on two ropes
STRAIGHT PULL
30 - 40 MEN
Block ed to sand anchor
Engine driven winch or manual capstan (4 men)
FI ED ENGINE DRIVEN WINCH OR MANUAL CAPSTAN
400 kg
15 men
Pulling on two ropes
The canoe moves 1,0 m for each pu
The feet are then reduced in lengt
and swung forward for another p
The gantry can also be placed aft
GANTRY
LEVERAGE = 1 : 2,6
3,9 m
1,1 m
Gantry made from aluminium
Canoe fixed to gantry at this point
Quick release to reduce lenght of feet
GANTRY SEEN FROM END
1000 kg
12 mm Galvan wire
Eye bolted to canoe
8 men
Ratchet winch
1 : 7
Plywood platform with sand anchors
SEEN FROM ABOV
8 men are pulling on cross bars
Winch and platform must be light enough for 6 men to carry (max = 120 kg)
PORTABLE WINCH
LEVERAGE = 1 : 7
can also be powered by a light weight petrol engine however still required as ballast
Ghana Canoe
BEACH HAULING
SCALE
DESIGN NO
DRAWING NO
DESIGN :
GRIMSTAD, AUG 1990
GHA - 3
1

SOME METHODS OF ACHIEVING WATERTIGHTNESS AND TRANSFER OF FORCES BETWEEN PLANKS



Ghana Canoe		
PLANKING		
SCALE = 1:1	DESIGN NO.	DRAWING
DESIGN: Ø. Gulbrandsen GRIMSTAD AUG 1990	GHA-3	2


FOREST
Tree of 1.8 m diameter and 30 m length of log can give one 15 m canoe and one 9 m canoe
Top is cut) correct sheer cur using chainsaw d adze.
Outside shape is cut and rounded.
Inside hollowed out
TRANSPORT FROM THE FO ST TO THE VILLAGE
VILLAGE
The dugout is finished topside planking started
Topside planking complete
T arts installed
15.1 m Ghana Canoe
MANUFACTURE
SCALE :
DESIGN NO
DRAWING NO
DESIGN : Ø. Gulbrandsen
GRIMSTAD , July - 90
GHA-1
5


1 Black
2 White
3 Red
4 Yellow
5 Green
BORN AGAIN
MAN IS FREE?
Fish hold
Fish hold
Leadline well
Purseine
Bulkheads
Not watertight
Open
Open
Open
Open
Open
Hatches
Outboardengine 40 hp
MIDSHIP SECTION
70 × 70
Edgenail 125
45 × 45
45 × 200
Plywood 12
45 × 210
Driftbolt 10 ⌀
Dugout
CONSTRUCTIO
SCALE
1.0 0.5 0 1 2 3 M
PARTICULARS
Length over all LOA = 14.0 m
Beam moulded BMD = 2.00 m
Depth moulded DMD = 1.15 m
Cubic number CUNO = LOA × BMD × DMD = 32.2 m
Displacement light 2800 kg
Crew 12 men 850 kg
Purse seine, Watsa 500 kg
Displacement half load 4150 kg
Outboard engine 40 hp
Service speed 8 knots
Canoe measured at Ada
FAO
FIAT PANIS
14.0 m Ghana Canoe - Watsa
GENERAL ARRANGEMENT
SCALE 1 : 20
DESIGN NO GHA-2
DRAWING NO 1
GRIMSTAD . July . 90

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