THE ROYAL INSTITUTION OF NAVAL ARCHITECTS

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INTRODUCTION

These notes are intended to bring out some of the special problems with which the designer of small passenger carrying vessels must contend.

Three vessels are considered in some detail. In each case a particular problem seemed to stand out above the general considerations which occur with any design.

The first vessel to be considered was a small game fishing charter boat intended to be used on the Barrier Reef to take paying passengers for a day's fishing. The problem was to design a steel vessel light enough to obtain a minimum speed of 15 knots on service.

The second vessel was a tourist passenger carrier for excursions on the Clarence River - Northern N.S.W. In this case the problem of weight still occurred but in addition the problem of subdivision and flotation, with stability always present to be kept in control.

The third vessel was intended to combine the qualities of a tourist vessel with that of a regular ferry service to ply between Palm Beach (Pittwater) & Bobbin Head or other similar areas on the Hawkesbury Estuary, N.S.W.

In the conclusion some reference is made to the current problem of improving some or all of the Sydney Harbour Ferry Services to entice discussion on this important problem.

DESIGN OF A GAME FISHING VESSEL FOR CHARTER.

The extensive development of game fishing on the North Queensland Coast has created a demand for light high speed craft suitable for work among the Reef Islands off shore from ports such as Cairns, Townsville, Mackay and similar areas.

Vessels which fit into this category and are for charter, or ply daily with tourist fishermen who pay for the facility, must be given a certificate of approval by the Surveyors of the Queensland Department of Harbours and Marine.

Two sets of regulations have been issued regarding the departmental requirements.

The first refers to the training and experience required by the master and crew of such vessels.

However in so doing, it establishes certain other requirements which are briefly summarised below:

1. The vessels shall not operate outside the hours 5am to 9pm.
2. The length of the vessel along the freeboard deck ... shall not exceed 45 ft.
3. The cruising speed in loaded condition shall be at least 15 knots.

The second refers to the construction and equipment and states that not withstanding their small size and numbers of passengers these vessels are to be regarded as passenger vessels and their design must be related to the current regulations for passenger vessels except where special exemption is given.

Requests for exemptions must be supported with detail calculations and explanations justifying the exemption sought.

The immediate problem that arises is how to relate a 34 to 40 ft. vessel to the same set of regulations which have been framed for much larger ships and greater numbers of passengers. In consequence, both the designer and the surveyors must rely on general experience and accepted practice to achieve a reasonably satisfactory design.

Unfortunately this approach does not help, when, owing to special requirements of service speed, the finished all up weight must be kept well below the weights of normal displacement vessels of much lower speed which would fit the code.

In the design of the vessel being considered referred to as DAJARRA, the owner proposed to build the hull in his own works - not at a boat building yard. Steel was the most satisfactory material for him to use.

The dimensions chosen were as follows:

Length overall	34'-6"
Breadth at deck	11'-9"
Depth amidships (mld).	6'-6½"
Draught " "	2'-1½"

The general arrangement is shown in diagram No. 1.

The choice of scantlings and method of construction originally prepared was based largely on the experience gained from earlier designs of pleasure cruisers of about the same size and character, intentionally striving to keep the weight of the hull as light as possible.

These construction plans were submitted to the Dept. of Harbours & Marine, Queensland for consideration and approval. The plans were also sent to Lloyds Register, London through the Sydney office for their approval.

The first examinations by the Queensland Surveyors resulted in the return of plans with heavy modifications marked in red. Some of the increased sizes appeared to be unduly heavy.

It was decided to take out a complete analysis of the structure, in the writer's office by Sean Owen - a long and tedious calculation using the method set out by Heller and Jasper, in their paper to Royal Institution of Naval Architects in 1961. Their calculations referred to larger high speed craft built of aluminium alloy. In consequence some adjustments to the method and modifications due to the use of mild steel were necessary.

The following table compares some of the main scantlings derived during the discussions and those finally approved by the Queensland Department of Harbours and Marine.

COMPARATIVE TABLE OF MILD STEEL SCANTLINGS - DAJARRA

ITEM	ORIGINAL DESIGN	Q'LAND 1st APPROVAL	SEAN OWEN - HELLER & JASPER	LLOYD'S REGISTER	Q'LAND 2nd APPROVAL	HANSEL DESIGN
SHELL SIDE	1/8"	3/16"	.146"	.170"	3/16"	1/8"
" BOTTOM	1/8"	1/4"	.146"	.170"	3/16"	1/8"
FRAME SIDE	2" x 1/4" F.B.	2" x 1/4" F.B.	2" x 1/4" F.B.	2" x 1/4" F.B.	2" x 1/4" F.B.	2" x 1/4" F.B.
" BOTTOM	2" x 1/4" F.B.	2" x 1/4" F.B.	1 3/4" x 1 3/4" x 3/16"	2" x 1/4" F.B.	1 3/4" x 1 3/4" x 3/16"	2" x 1/4" F.B.
DECK	1/8"	1/8"	.146"	3/16"	3/16"	SIDES 3/16" FOR'D 1/8"
BEAMS	2" x 1 1/2" x 3/16" L	2" x 1 1/2" x 3/16" L	2" x 1 1/2" x 3/16" L	2" x 1 1/2" x 3/16"	2" x 1 1/2" x 3/16" L	2" x 1 1/2" x 3/16"
FLOORS	1/8" *	.135" *	3/16" *	.140" *	3/16" *	1/8" *
BULKHEAD.COLLISION	1/8"	1/8"	NO CALCULATION	.140"	1/8"	1/8"
" OTHER	1/8"	1/8"	NO CALCULATION	.140"	1/8"	1/8"
LONGITUDINAL GIRDER	1/8" + 1 1/2" x 3/16"	1/8" + 1 1/2" x 3/16" FL	1/8" + 1 1/2" x 3/16" FL	3/16" + 1 1/2" x 3/16" FL	1/8" x 1 1/2" x 3/16" FL	1/8" + 1 1/2" x 3/16" FL
BOTTOM & SIDE STRINGERS	1 1/2" x 3/16"	1 1/2" x 3/16"	1 1/2" x 3/16"	1 1/2" x 3/16"	1 1/2" x 3/16"	1 1/2" x 3/16"

* ALL WITH 1 1/2" x 3/16" F.B. FLANGE

The scantlings shown for Hansel indicate the design structure of a motor cruiser of the same dimensions but with slightly different underwater form. This motor cruiser was designed in 1962 and it appears from the records of plans sold that some 35 to 40 boats have been built to this design since. Most of these have been built by non professionals.

No evidence has been brought to the writer's notice of failure of any of these boats in service, due to weakness of scantlings.

One is forced to the opinion that there is a tendency to play "over safe" in the choice of steel scantlings of small craft of this type here in Australia.

The form of the hull was of the single or hard chine type, the bottom being of a warped character. The hull lines were developed to produce a surface without compound curves except immediately aft of the stem in the flaired area.

The character of the lines were suited to planing if and when the vessel was light enough. It was realised that the weight in service would be too heavy for true planing although some lift was to be expected.

A $^1/8$ full size framed plywood model was tested in the Hydrodynamics Laboratory at Sydney University under the supervision of Mr. Bob Halliday.

Test runs were carried out at model draughts representing designed light draught equal to 8.022 ton displacement and at draughts 3 inches lighter and 3 inches deeper, representing displacement of 6.180 tons and 9.96 tons respectively, all at level trim. No studs or other turbulence stimulation was used. The hull was without rudder and shaft brackets but carried the skeg keel as designed.

The test results as E.H.P. against speed for the full sized vessel are given for the three displacements, in diagram 2 and a curve of E.H.P. against displacement is shown in diagram 3. Estimates of shaft horse power were made for several values of $\frac{EHP}{SHP}$ and these are compared with estimates made using the Caterpillar scale for both planing and semi displacement hulls.

The values from the model test suggest that the performance of the vessel lies between that of a planing and semi displacement hull.

The power required to meet the stipulated speed would need to be available over a continuous period at least of several hours. Intermittent power and revolutions can appear very attractive on paper but when considered in the light of the time for which such power may be used it is quite unsuited for this application.

Power available on a 10-12 hour continuous rating is the only real guide to what a particular engine can achieve in service.

A difficulty arises in interpreting the published brochure There are a variety of ways in which engine power is stated. In some instances the listed power is the test bed value at the flywheel which will be reduced by about 7 percent through the gear box, and possibly some further slight loss before the propeller receives its quota.

The choice of power and revolutions for the design of a suitable propeller is another problem to be considered. If the propeller is chosen to permit of the full intermittent power being taken for short periods it must be realised that this propeller will lose efficiency when the revolutions are dropped to the nominated R.P.M. for continuous running. The continuous speed in consequence will suffer.

If it is desired to obtain the maximum continuous service speed with the most economy of operation then the propeller should be designed to give the maximum efficiency at the revolutions associated with continuous power.

Choice of Engine

Two engines were considered for comparison of power available.

1. Turbo charged - after cooled Volvo Penta TAMD-70B, a straight six cylinder engine with gear box. Twin Disc MG 506.
   Weight - 0.833 Ton
   Output - Pleasure Boat
   Light Duty - 500 hrs. per annum.
   250 H.P. at 2500 R.P.M.
   Light Duty - 2500 hrs. per annum.
   185 H.P. at 2200 R.P.M.

2. Naturally Aspirated Mercedes Benz
   OM 403 a 10 cylinder VEE configuration, engine with Twin Disc MG 509 Gearbox.
   Weight - 1.180 Tons
   Output - Normal
   10 hours daily
   300 H.P. at 2200 R.P.M.
   Unlimited continuous
   275 H.P. at 2200 R.P.M.

The latter engine is the most suited to the particular requirement of 15 knots speed. The estimated weights are as follows:

ITEM	TONS
Light Ship ex engine.	7.233
Mercedes Benz; OM 403	1.180
Total light ship.	8.413
Fuel 100 gall.	.400
4 Persons & Gear	.350
Fresh Water, etc.	.100
Average displacement.	9.263 Tons

Using this total weight the actual performance can now be looked at using the model E.H.P. corrected to full size.

Referring to the curve of E.H.P. for the naked model for a displacement of 9.263 tons a value of 139 H.P. is obtained. Allowing 10% for appendage and air resistance we obtain 153 H.P. If we consider that the quasi propulsive coefficient could lie between .55 and .60, the equivalent power required would be between 255 S.H.P. and 278 S.H.P. for a speed of 15 knots.

With the Mercedes Benz engine this power could be available continuously and on a 10 hour per day basis a margin of 20 to 25 S.H.P. would be available to assist should there be a heavier load on board.

The choice of mild steel as a building material was made as a means to simplify the building problem and save cost of basic materials.

The choice of aluminium alloy marine grade would have reduced the all up weight by between two and two and a half tons, giving an approximate load displacement of the order of seven tons. The range of model speeds did not extend to the achievable speed for this condition. However using the Caterpillar scale of speed and power for planing hulls a speed of the order of 22 knots for continuous power and 23 knots for the 10 hour rating of the Mercedes Benz OM402, should be achieved.

TOURIST PASSENGER VESSEL "CLARANDA".

OWNERS REQUIREMENTS.

The basic concept for this vessel was briefly

(1) To provide for the maximum number of passengers in a length on deck of not over 60 ft. in order to meet the minimum manning scale of M.S.B. namely two persons having the required certificates.

(2) To be capable of the return voyage from Grafton to Yamba on the Clarence River. It was considered that a speed of 10½ to 11 knots should be aimed at to give some time ashore at Yamba or vice-a-verse to do shopping at Grafton.

(3) As the purpose was one of providing a tourist attraction there were to be on board facilities for serving light refreshments and in this connection a kiosk was to be provided for the sale of soft drinks and ice cream, etc.

(4) Adequate toilet room facilities to fully meet the regulations must be planned for.

(5) As a tourist attraction the owners planned for a swimming and landing platform at a convenient height above water aft of the transom. This would permit passengers to go on board ski boats or to use it as a diving platform.

(6) Originally the vessel was to be propelled by jet engines at the stern, but in design stages it became impossible to ascertain the actual power and thrust which could be guaranteed by the jet units contemplated. This caused a change in propulsion from jet to propellers driven through vee gears.

Features of the Vessel

The design as finally evolved was of the following dimensions:

LENGTH overall.	60'-5"
LENGTH at Deck.	58'-3"
LENGTH at L.W.L.	57'-0"
BREADTH at Deck.	17'-2"

The hull form was fully developed to avoid compound curvature of plating. A single chine extended from bow to stern. The transom was knuckled transversely providing a vertical transom below water and a forward sloping section from about 1 ft. above water.

The sheer extended from the fore deck to the after deck in a smooth curve. The main passenger area was in the form of a well deck at 2'-0" above the designed water level. See diagram No. 4.

Two main water tight bulkheads extended from the sheer to the keel and produced fully watertight compartments from the collision bulkhead forward and similarly aft. The after main bulkhead became the forward engine room bulkhead.

Between these bulkheads and below the passenger well deck four additional bulkheads provided five water tight dry spaces. The after space was fitted with a circular water tight hatch. Within this space self contained fresh water tanks were arranged. See diagram No. 5.

The hull was of steel construction and decks forward and aft were plated with steel on angle beams toe welded. Well deck was also a water tight steel deck.

The upper deck above the passenger space was of a special design to conserve weight while providing adequate strength to support the load of passengers required on this deck. The deck was of marine waterproof plywood fastened to light pressed steel channels. Detail description of this structure is shown later.

The wheel house was a steel structure with a marine grade plywood deck head over.

An appearance plan is shown in diagram No. 4.

The final allocation of passengers and crew was as follows:

PASSENGERS	Observation Deck	44
	Well Deck	58
	Fore Deck	11
	After Deck	4
	Total Passengers:	117

CREW	Master Wheel House	1
	Kiosk Attendant.Well Deck	1
	Deck hand. Main Deck	1
	Total Crew:	3

Total number of persons - 120

Propulsion

The final decision on propulsion involved the use of a pair of T6.354 Perkins Diesels fitted with Borg Warner Vee drive gear boxes, capable of 140 H.P. at one hour and 120 H.P. at continuous 12 hour rating.

While all ship design involves the solution of problems perculiar to the special function to be served by the vessel, the design of small passenger carrying vessels seems to be especially prone to problems of weight, stability and water tight subdivision.

Consideration of Weight

The problem of weight in the case of "Claranda" was two fold. Firstly in order to obtain the maximum speed within the length chosen, weight of the loaded vessel must be a minimum. Secondly for stability reasons top weight must be kept to a minimum and overall height of the C.G. of all weights as low as possible.

The choice of scantlings finally accepted by the Maritime Services Board are shown in the structural section produced. See diagram No. 5c.

By use of a well deck arrangement both the weight and height of the super structure as well as the passengers on them were kept to a minimum.

Upper Deck Structure

The design of the upper or observation deck called for considerable ingenuity. It was considered that a conventional steel deck in the climate conditions prevailing for 6 to 8 months of the year on the Clarence River would produce an uncomfortable condition both for the observation deck passengers and those below. The addition of insulation under the deck would help to keep down temperature below but this added weight and structure. The use of plywood offered the advantage of some control of temperature without insulation.

The method of fastening the plywood at first appear to involve precision matched drilling of bolt holes in both plywood and mild steel beams. These beams would need to be wide enough to receive the bolts and nuts. The labour involved in the whole exercise appeared very costly.

The answer to this problem was found in the use of a beam composed of two light pressed channels supplied by Lysaghts. These were welded back to back after being cambered. Their attachment to the side of the house required special treatment as shown in the illustration, diagram No. 5b.

The fastening of the plywood became a fairly simple operation by the use of wing teks. These are self drilling and entered through the plywood and steel beam in one operation. They do not require the fitting of any nut as the screw produces a self tapped threaded hole. This design proved to be economical both in weight and labour cost. See diagram No. 5a.

The resultant overall weight of the finished vessel as derived from the draughts at the inclining experiment was 36.33 tons.

Stability

The problem of stability in this case was solved partly by the use of the well deck and consequently the low value of the KG, - height of centre of gravity - approximately 6.90 ft. above the base compared with the corresponding value of the KM - height of metacentre above base - namely 12.25 ft. giving a loaded GM of 5.35 ft.

The curves of stability show that the angle of heel with an upsetting moment of 34.66 tons ft. is approximately 11 degrees. This upsetting moment is equal to the total weight of passengers - 7½ tons at a distance of 4.62 ft. from the centre of the deck that is 0.27 of the maximum beam and exceeds the requirement of the M.S.B. in this case.

The maximum value of GZ is 1.42 ft. at 27 degrees. The opening at the deck at side - that is the lowest window opening - is approximately 5 ft. above the design load water level and in the loaded condition would enter the water at a heel of approximately 40 degrees. At this point the righting moment is 40 ft. tons which exceeds the up-setting moment by 5.5 ft. tons or 13.75% - the dynamical stability at this point has a value of 24.89 tons ft. with a dynamical lever of 0.6842.

Subdivision

It was considered that there should be as much inbuilt buoyancy as possible and that even when any one compartment became open to the sea the water level would not be above the well deck. The spaces under the well deck were kept sealed - with watertight manholes and hatches. A trim line showing the level of the water should one compartment be holed, i.e. the one producing the worst effect, is calculated.

The compartment is number 3 from forward between frames 9 to 16. The resulting water line is 2.039 ft. above the original load water line forward and 0.545 ft. below the original load water line aft. The freeboard to the deck at the bow is this trimmed condition is 3.86 ft. and to the deck at the stern is 4.90 ft. with the least freeboard of 3.81 ft.

The internal profile with the subdivisional bulkheads is shown in diagram No. 5.

DESIGN FOR PROPOSED 280 PASSENGER FERRY.

The operators of small passenger ferries are faced with comparatively high costs for crew as a ratio of the earning capacity of the vessel.

The designer is required to provide passenger accommodation for the maximum possible number of persons within limits of vessel length or engine power in order to use the smallest number of qualified crew.

In a recent design the owners requirement called for the carriage of 280 passengers in a steel, two deck vessel of length, within the limit of length of 60 ft. measured at the main deck level.

Other qualification to the design required the working freeboard to be 3 ft. at half load in order to suit embarking platforms and wharf levels.

The vessel was to be capable of a speed of 9 knots on service.

The voyage proposed was from Pittwater Jetty (Palm Beach) to Bobbin Head in the Hawkesbury River Estuary.

The designer was provided with a preliminary outline general arrangement by the owner.

Apart from the above restrictions and limitations the requirements of the N.S.W. Maritime Services Board for passenger carrying vessels are promulgated in various publications referred to as the "Code". The scantling sizes for the structure of the hull and super structure are as from this Code. Also stated is the area allowance for each passenger on the main deck - 4 sq. ft. per person and on the upper deck - 9 sq. ft. per person. This fixes the number of persons on each deck by dividing the area clear of bulkheads and passage ways or other obstructions by the appropriate number.

Further limitations governing the passenger numbers requires at least 1 ft. 6 inches of seating for each person.

Stability requirements are as the following extract from the "Code of Required Stability Standards and Subdivisions for passenger and fishing vessels".

Sec. 8. MINIMUM STANDARD OF STATICAL STABILITY.

8.1. General Instruction to Surveyors.

8.1.4. Attention is drawn to the possibility of passenger movement taking place to a greater extent or in other ways that those already described. In such cases the Board will require a complete investigation to be made.

8.2. Harbour and River Passenger Vessels carrying more than 12 persons in addition to the Master.

8.2.2. Vessels having Upper Decks.
The owner shall furnish to the Board satisfactory evidence of the initial and statical stability of the vessel under the following conditions:

When a weight equal to 50 percent of the total certificated number of Main Deck passengers (at 16 persons equal one ton) is placed on one side at a distance from the centreline equal to one quarter ($^{1}/4$) the moulded beam at the deck line and a weight equal to the full certified number of upper deck passengers (at 16 persons equal one ton) is placed on one side at a distance from the centre line equal to one quarter ($^{1}/4$) the maximum breadth of the upper deck passenger space, the angle of inclination (or heel) shall not exceed 15 degrees provided that the curve of righting moments has a rising tendency at that angle.

Design Features

The vessel was designed to the following dimensions:

L.O.A.	59'-8"
L.W.L. (Designed)	56'-11"
Beam at Deck	22'-3"
Depth Mld. Ⓧ	9'-0"

To carry 280 passengers with crew of 2.

Both hull and superstructure to be of Mild Steel.

An average freeboard of 3'-0" to the designed water line was provided.

An appearance and upper deck arrangement is shown on diagram No. 6.

The passenger arrangements allowed for 80 persons on the upper deck and 200 persons on the main deck. The upper deck was fitted out in tourist fashion with Kiosk and tables, etc.

Cross curves of stability were prepared on the above design and righting moment curves drawn for the stipulated requirement in the Code quoted above (8.2.2.).

It was found that using 5 tons of ballast in the skeg keel the estimated KG was 10.12 ft. and the corresponding GM was 5.28 ft.

For a displacement of 86.05 tons the righting moment reached a maximum of 112 ft. tons at an angle of heel of approximately 20 degrees.

Under the conditions set out in 8.2.2. of the Code the up-setting moments were as follows:

Main Deck. 50% of 200 persons at $\frac{22.33}{4}$

$$= \frac{6.25 \times 22.33}{4}$$

$$= 34.891 \text{ ft. tons}$$

Upper Deck. All of 80 persons at $\frac{20.25}{4}$

$$= \frac{5 \times 20.25}{4}$$

$$= 25.313 \text{ ft. tons}$$

Total up-setting moment 60.204 ft. tons.

The corresponding approximate angle of heel on the curves is 8 degrees.

Stability curves are shown on diagram No. 7, curve 6.

The calculated effect of a steady wind of 30 knots acting broad side on the vessel assumed to be heeled at 15° would add an additional overturning moment of approximately 20.5 ft. tons which if added to the 60.204 ft. tons would produce an over-turning moment of 80.7 ft. tons and a steady heel of approximately 12 degrees.

A further possible over-turning effect was considered namely the possibility that combined with the above two circumstances the master should be required by some external happening to suddenly put the rudder hard over.

This effect was calculated to produce a heel of approximately 5 degrees under normal speed of 9 knots. If the same effect took place when already heeled to 12 degrees as above a possible angle of heel of 17 degrees would be reached.

Notwithstanding the fact that the published requirements of the Code re passenger movement had been met, following upon consultation with the Naval Architect of the Maritime Services Board it was agreed to further investigate the stability in order to provide increased margins of safety, to meet new special conditions.

These special conditions were as follows:-

(a) Passengers to be placed close together as far as possible toward the vessels side, each person occupying a space 18 inches by 9 inches.

(b) 100 passengers on the main deck to the side as in (a), 180 passengers on the upper deck at $^1/_4$ beam.

Various proposals were considered such as adding ballast, restricting the movement of passengers, reducing top weight and increasing the freeboard, reducing the number of passengers carried.

These propositions were discussed with the owners and it was decided to endeavour to hold to the total number of passengers if possible namely 280.

The ultimate decision was to increase freeboard by 6 inches and to reduce top weight by building the whole superstructure in aluminium alloy, the saving in top weight to be added as ballast as low as possible in the Ship.

The effect of these decisions can be seen in the following summarised calculation.

ITEM	WEIGHT TONS	KG. FT.	VERTICAL MOMENT
Basic Hull (3.0' FBD) & Superstructure.	40.70	10.04	408.55
Raising Deck 6") Added Moment)	(6.46)	Raised 0.5'.	3.23
Increase in Steel	.38	9.45	3.60
Basic Hull (3.5' FBD) & Superstructure.	41.08		415.38
Estimated Weight of Steel Superstructure to be replaced.	−15.54		262.80
Ship Ex Superstructure.	25.54		152.58
Estimated Weight of Aluminium Superstructure.	7.53		133.58
Sundry Weights due to change.	2.00	8.653	17.306
Total Hull & Superstructure with Aluminium Alloy.	35.07	8.653	303.466

In addition to this change in Hull & Superstructure it was decided to alter the propulsion from the original proposed GM 8V71N single engine to a pair of GM 6-71N each delivering a continuous power of 174 S.H.P. at 1800 R.P.M. Each engine would be fitted with a 2.96:1 reversing reduction gear box.

Combining the overall effects of the above changes and increasing the total ballast in keel to 11.05 tons the total estimated loaded displacment became 85.35 tons with a KG of 9.087 ft. and a GM of 6.333 ft.

These changes resulted in the maximum value of the righting moment of approximately 160.2 ft. tons at 24 degrees.

In further discussion with officers of the Naval Architects Department of the M.S.B. it was contended that under certain emergency conditions passengers could occupy such a position that would be equivalent to a crowd of persons each occupying a space equal to 1.5 ft. shoulder to shoulder and 0.75 ft. front to back.

The design staff considered this requirement to be beyond practicability nevertheless the deck plan of the vessel was set out with a diagram showing people in such a situation. The corresponding centre of gravity was obtained and the resulting overturning moment calculated.

The effect of this together with windage is shown in the diagram produced.

Even with this severe condition it was shown that the new design would heel only to 12½ degrees.

The various other conditions investigated are shown on the diagram.

A comparison of the advantage gain is seen in the following table.

ITEM	LOADED WEIGHT	KG FEET	GM FEET	MAXIMUM RIGHTING MOMENT
Ship with Steel Superstructure & single engine.	86.05T	10.12	5.28	112 at 20°
Equivalent Righting Arm GZ = 1.302 Range of Stability 42.3 Degrees				
Ship with Aluminium Alloy Superstructure & twin engines.	85.35T	9.087	6.333	160.2 at 24°
Equivalent Righting Arm GZ = 1.877 Range of Stability 57.3 Degrees				

Speed and Power

The performance of a vessel of this character is not readily predictable from standard available data.

The vessel is beamy 22 ft. 3 inches in a length of 59 ft. 9 inches. More than 1/3 the length. A consequence of this wide beam is the corresponding shallow draught, the B/d value of the amidship section being 3.64, using W.l. beam.

Two models were tested at the Sydney University Hydrodynamics Laboratory. The first displayed a tendency for the flow of water under the stern to depress the bow rather noticeably. The forward lines were modified and the second model tested with satisfactory results.

The curve of EHP for the model without appendages except the skeg is given in diagram No. 8.

After allowing 10% for appendage and air resistance and assuming a quasi propulsive coefficient of approximately 0.62 the estimated service speed could be approximately 10 1/4 knots in normal full load.

GENERAL COMMENTS

In reviewing the three vessels described in this paper, three main considerations stand out as of primary importance - briefly described as

1. Weight minimisation
2. Watertight Subdivision
3. Stability.

Like most problems in ship design all three are closely interwoven. The solution of one will interact with the other two - sometimes favourably, sometimes unfavourably.

With regard to stability it is still with difficulty that a designer can early predict that his design will have inherent high stability qualities.

There are some relationships which can help. One of these is the relationship between the mobile passenger weight and the total of the remaining weight which comprise the vessel.

It is an axiom that over-loading of passengers is dangerous. It is not so easy to determine the point of maximum safe passenger load. The division between safety and unsafety.

Frequently the value of the GZ is used to determine margins of safety. But this in itself is not sufficient. Ultimately when considering the ability of a vessel to resist dangerous heeling it is the comparison between the overturning moment and the righting moment which is important.

The overturning moment depends on two factors, one the freedom of transverse movement and two the weight of passengers moved.

If the passenger load is large in relation to displacement it is apparent that either there must be a relatively large GZ or else the freedom of transverse movement for passengers must be drastically limited.

This fact is quite elementary and is known to every one who has stepped off the wharf into a dinghy without carefully placing his foot toward the centreline of the dinghy.

It appears that in designing a ferry the designer should have some parameter to guide him in selecting a reasonable load of passengers for the vessel and that this parameter should bear some relationship to the total displacement. Using the ratio of passengers load in tons to the loaded displacement in tons we have such a parameter.

Values have been taken out for a few vessels for which data is available.

The following table sets out this data.

VESSEL	LOAD DISPLT. TONS Δ	PASSENGER WEIGHT P	$\frac{P.WT}{\Delta}$	MAX. GZ	RIGHT. MMT.	MAX. UPSETTING MMT.	$\frac{\text{UPSETTING MMT.}}{\text{RIGHT. MMT.}}$
CLARANDA	36.33	7.5	.206	1.43	52.0	34.6	.665
280 PASSENGER FERRY	85.35	17.5	.210	1.877	160.2	60.2	.375
LADY CUTLER	240.72	35.7	.148	1.447	348.3	162.0	.465

A study of these relationships with other vessels would be helpful in determining a suitable guide to the proportion of passenger load to total displacement.

To summarise the available data for the three vessels some further information is given.

Comparison between the principal features of the designs under discussion with those of the "Lady Cutler" are given in the following table.

ITEM	280 PASS. FERRY	LADY CUTLER	CLARANDA
Length LWL	59'-8"	120'-0"	57'-6"
Breadth MLD.	22'-3"	29'-0"	17'-2"
Depth MLD.	9'-6"	10'-0"	7'-7"
Load Displacement	85.35	240.72	36.33
Number of Pass. (P)	280	570	120
Passengers/Ton	3.281	2.368	3.303
Engine Power	348	510	240
Speed Knots (K)	10	11	11
Passengers x Speed	2800	6270	1320
Horse Power/P x K	0.124	0.0814	0.182
Righting Arm Max.	1.877	1.447	1.42
Angle for Max. GZ.	24	22	27
Range of Stability	57.3°	42.2°	40.0° *

* Water commences to flow over window coaming.

It is admitted that the above table is very limited in its choice of vessels. However, it is included as a suggestion for further study when more information on other vessels becomes available.

It is apparent that given a particular set of circumstances the designer can do a great deal to meet them by the application of ingenuity and patience.

For example, nothing has been said of the use of the Catamaran type which the writer explored and considers to offer distinct advantages in the matter of stability where large passenger numbers are involved.

In conclusion it is perhaps appropriate to make some reference to the problems related to the present considerations for the remodelling of the Sydney Harbour Ferry Services and the Manly Service.

In the broad consideration of ferry type for any particular service there are a number of conflicting factors.

These factors may be broadly classified into three categories.

(1) Owner acceptability.
(2) Passenger acceptability.
(3) Public acceptability.

Each of these may be further analysed.

(1) Owner Acceptability.

(a) Passenger numbers adequate to service.
(b) Speed to maintain profitable schedule.
(c) Economy of manning and operation.
(d) Capital cost against annual return.
(e) Minimum maintenance cost.

(2) Passenger Acceptability.

(a) Aesthetic qualities.
(b) Safety, comfort, convenience.
(c) Speed of transport.
(d) Minimum fares.
(e) Integration with other modes of transport.
(f) Frequency and regularity of service.

(3) Public Acceptability.

(a) Effect on environment - noise - fumes - wash.
(b) Noninterference with established functions or services.
(c) Safety factor in regard to other harbour users.

The co-ordination of these factors is essentially the work of a Naval Architect - Chartered Engineer.

The name Naval Architect has unfortunately been debased by misuse by untrained persons - I repeat the Naval Architect who is a Chartered Engineer is the person who should be the Chief Co-ordinator of a design to meet all of these requirements.

His training through basic practical experience, higher Tertiary Eductation followed by years of professional experience in his specialised field, enables him to sort out the mutually conflicting factors and to arrive at a viable efficient compromise.

Undoubtedly he will call upon the individual guidance of specialists in the economics of public transport and co-operate with the principals of Government departments concerned.

His function is to arrive at the compromise solution, which in final adoption will give the owner a fair and reasonable profit, the passenger a safe and comfortable journey, at a frequency and with a transit time consistent with the fare he is economically able to pay.

The compromise will be acceptable to the community, non destructive to the environment, and comparable with other functions and services.

In considering such a large issue as the remodelling of a whole system of public transport, it will be necessary to make some changes in the existing functions and services with which the new system must be integrated. A refusal on the part of one or more integrating systems to co-operate in the desirable change could prove to be the "Achilles Heel" leading to the incomplete success of the new system and possibly its failure.

In Sydney Harbour we have a number of well established transport procedures each of which has been independently developed. Some of these may well be conveniently incorporated within a new ferry system. Some however may no longer be entirely adaptable in their present form.

One of these is the conception of the Circular Quay as the ultimate terminal point for the city end of ferry transport from the extremities of the Harbour.

Assuredly the Circular Quay has great merit for many such services but with the further development and possible extension of the ferry system a fresh view must be taken of its place in the co-ordinated scheme.

Passengers arriving at Circular Quay are of two broad types.

(a) Those whose destination is in short walking distance of the Quay.

(b) Those who will take other transport to their destination.

Keeping these facts in mind it appears that better use could be made of the points east and west of the Quay.

Admittedly the completion of the Opera House on Benelong Point appears to preclude the use of this point , although it might even now be possible to devise an attractive wharf on the eastern side of the point so that ferries from Manly and The Spit could disembark their passengers there, to take the bus to the city.

In a similar way ferry services from the west could make use of such a transit wharf at Dawes Point - keeping in mind these possibilities there appear to be some cogent reasons for re-considering the use of Circular Quay as a dead end terminal for all ferries.

The conception of the "straight through" wharf would save length of journey and terminal reversal time.

The acceptance of such a scheme would do much to simplify the problems of the Manly ferry service.

To date the independent operation of this service appears to have prevented any consideration of the integration of this Eastern Service with any comparable Western Service.

However with the present possibility of the whole ferry system being taken over by a common authority it is time to re-consider this possibility.

It was the adoption of such a "straight through" system which changed the early character of the Sydney Central Railway Station and enabled passenger train services from the Southern Suburbs to be co-ordinated with the Northern Suburbs railway system.

In the context of the remodelling of the harbour ferry system the use of double ended ferries with their limitation on speed, could be retained for short runs. Faster single ended vessels and no doubt Catamarans with their wider deck areas could be operated on a straight through basis.

Ferries from the western end of the harbour could unload at Dawes Point, passengers proceeding by bus to the city. The same ferry would continue on to an appropriate destination possibly at The Spit or Manly.

Similarly the ferries from Manly or The Spit would pass on to the western end after their call at Benelong or Dawes Point.

This arrangement would assist in a saving in time and possibly also in the number of units required to provide the service.

In making this suggestion one does not lose sight of the special conditions to be met on the Manly and The Spit run when passing the Heads, and the problem of the wharf at Manly.

The former problem is one for the Naval Architect and can be met by proper design, the other at worst could be met by the acceptance of the present operating style of the Hydrofoil at the Manly end. However a re-design of the Manly Wharf could no doubt provide for a landing pontoon style which would permit the single ended vessel to come along side and move off without the necessity for a complete reversal.

In considering the suitability of a particular ferry type for a given service where the passenger flow in peak hours is high, it is important to know the ability of a type to permit rapid embarkation and disembarkation.

Two parameters might be considered.

(a) The time to arrive at wharf - discharge passengers - receive passengers and reach significant forward motion. In the case of a vessel working to a dead end, this could be called "the terminal reversal time".

(b) The time taken to arrive at a transit wharf (i.e. straight through type) - discharge passengers and receive passengers and reach significant forward motion, this could be called "Passenger exchange time".

The effective performance of any given ferry, i.e. the complete time from commencement to embark at one point, to the completion of disembarkation at its destination, is made up of two segments - the period when the ferry can travel at its full speed and the periods of acceleration and deceleration with the loading and unloading time.

In short distances the time for free running at full speed is consequently limited and the value of so-called high speed ferries is largely lost.

In longer runs speed becomes more valuable in assisting the quick movement of passengers.

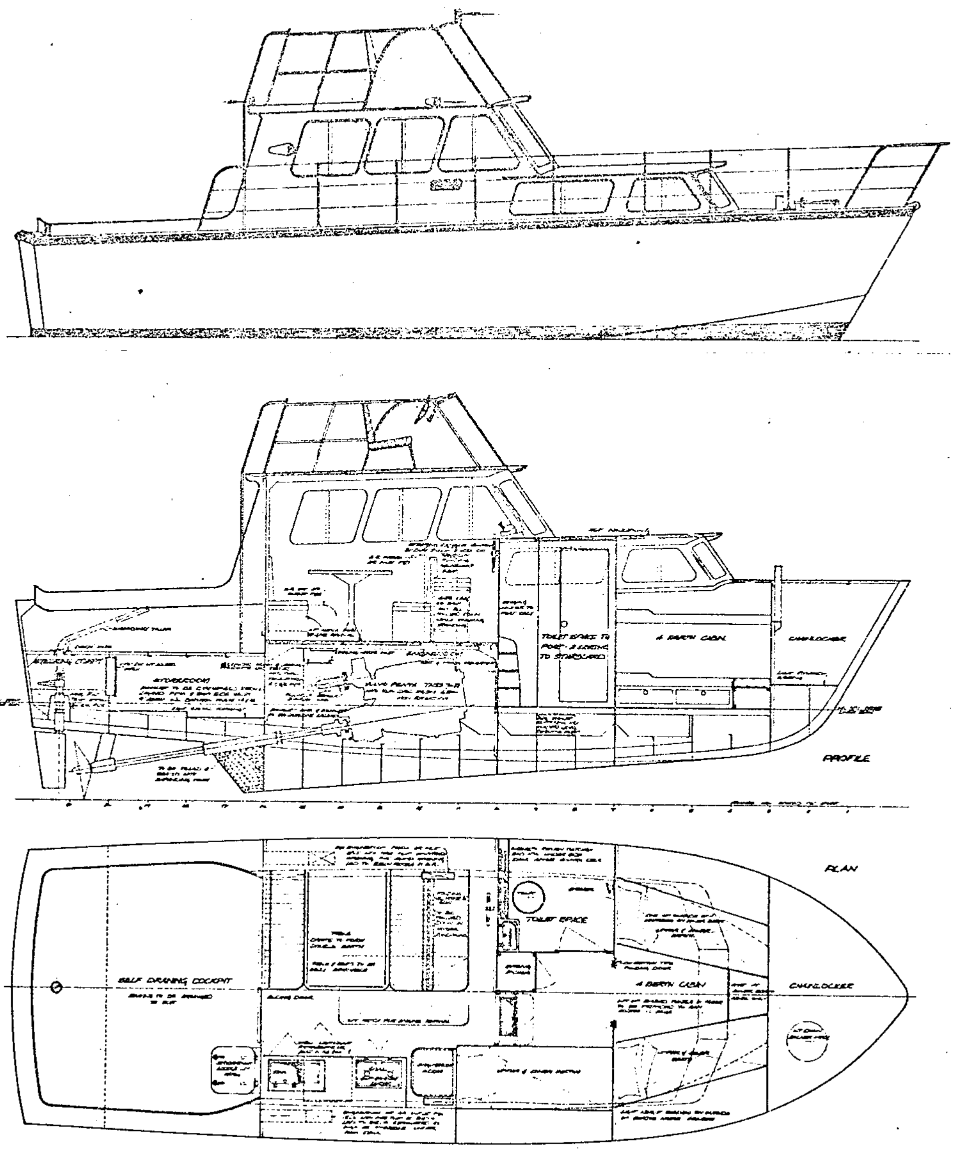
A parameter which indicates the ability of a particular ferry to handle passenger numbers is the product of service speed times maximum number of passengers. This could be called "Passenger miles per hour".

Undoubtedly the high speed ferries require more horsepower to drive them. The cost in "Brake Horsepower per passenger mile per hour" is another parameter which gives a measure of its "power efficiency".

The following table makes some comparisons of these last two parameters.

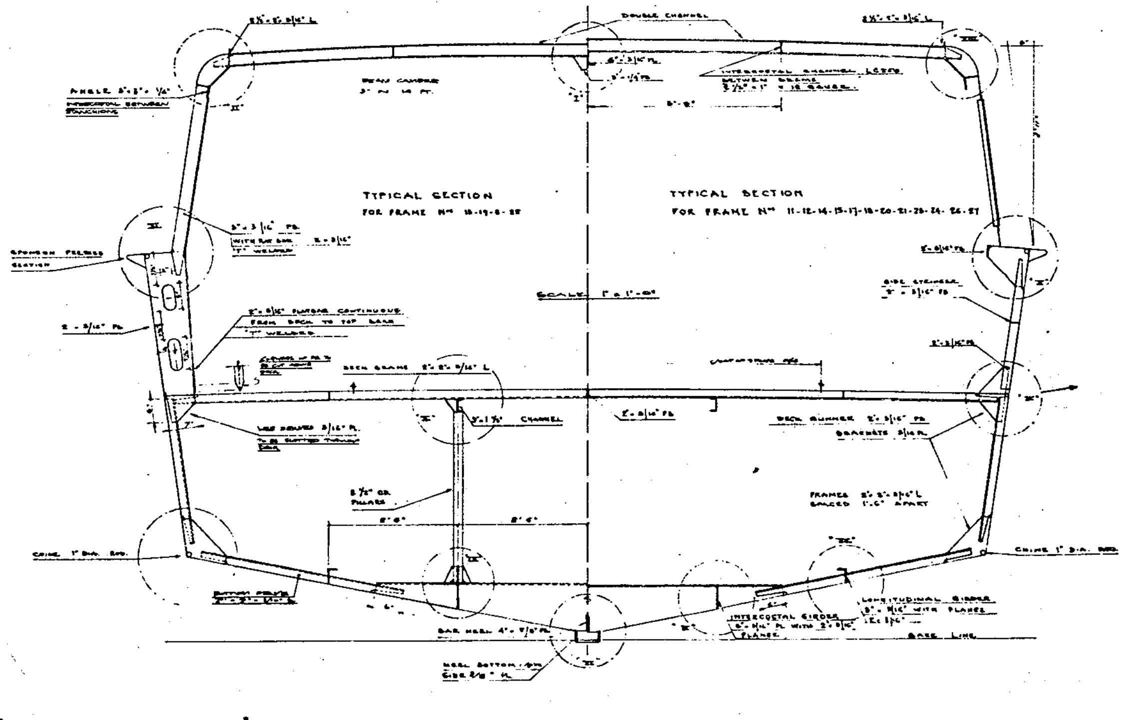
FERRY TYPE	PASSENGERS NUMBER Col (1)	SPEED M.P.H. Co. (2)	PASSENGER x M.P.H. Col (3) = (1) x (2)	TOTAL B.H.P. Col (4)	B.H.P. PER PASS. M.P.H. Col (5) = (4)/(3)
Claranda	120	12.6	1512	240	0.1588
P.B. Ferry	280	11.5	3220	344	0.1068
Lady Cutler	570	12.6	7128	510	0.0718
Rotork (P)	45	24	1080	405	0.375
Rotork (D)	40	11	440	212	0.482
Hovermarine) HM2 Mk8)	65	35	2275	320) 185) 505	0.222
Vosper) Thornycroft) VTI)	270	36	9720	4000) + ?)	0.411 +
Westermaran) Catamaran) 86)	170	31	5270	2200	0.418
Russian Meteor (Hydrofoil)	180	36	6480	2200	0.340

The above comparison indicates very clearly the differences between the conventional ferry vessels and the more sophisticated types being suggested for the remodelled Sydney Harbour Services.



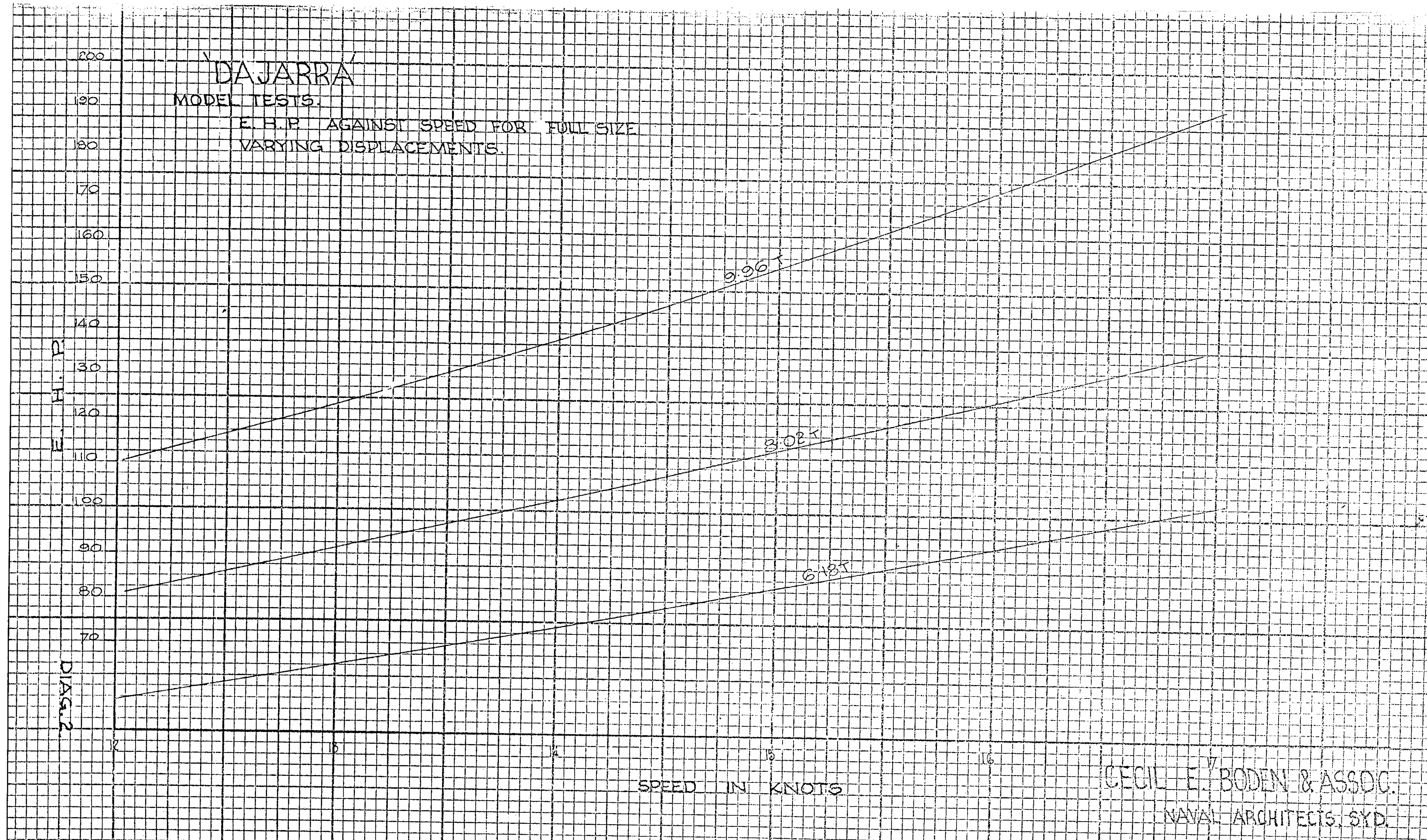
'DAJARRA' GENERAL ARRANGEMENT

DIAG 1



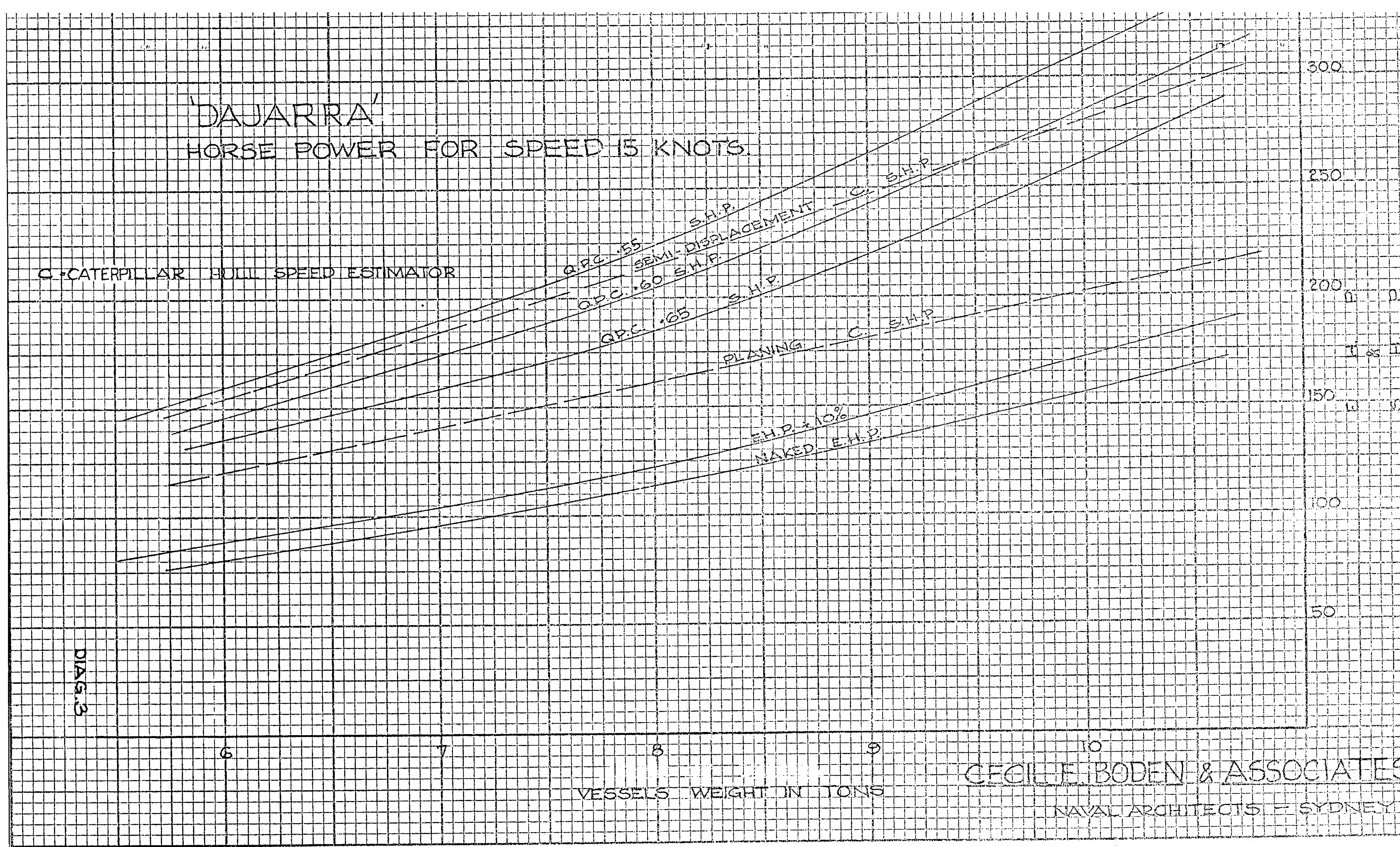
'CLARANDA' TYPICAL CONSTRUCTION SECTIONS

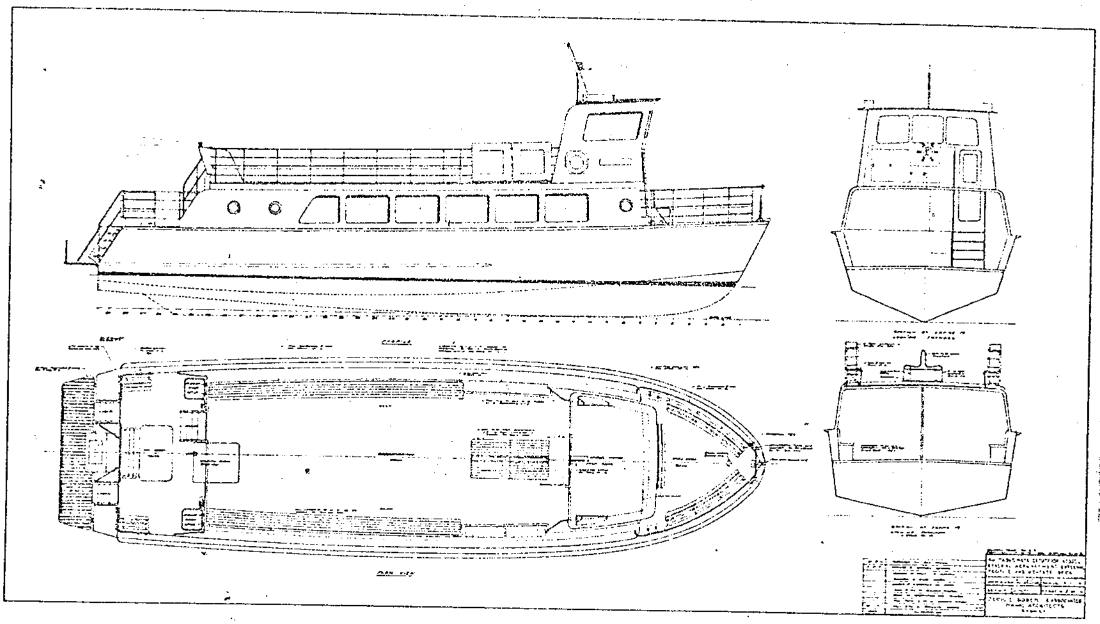
DIAG. 5C



DIAG. 2

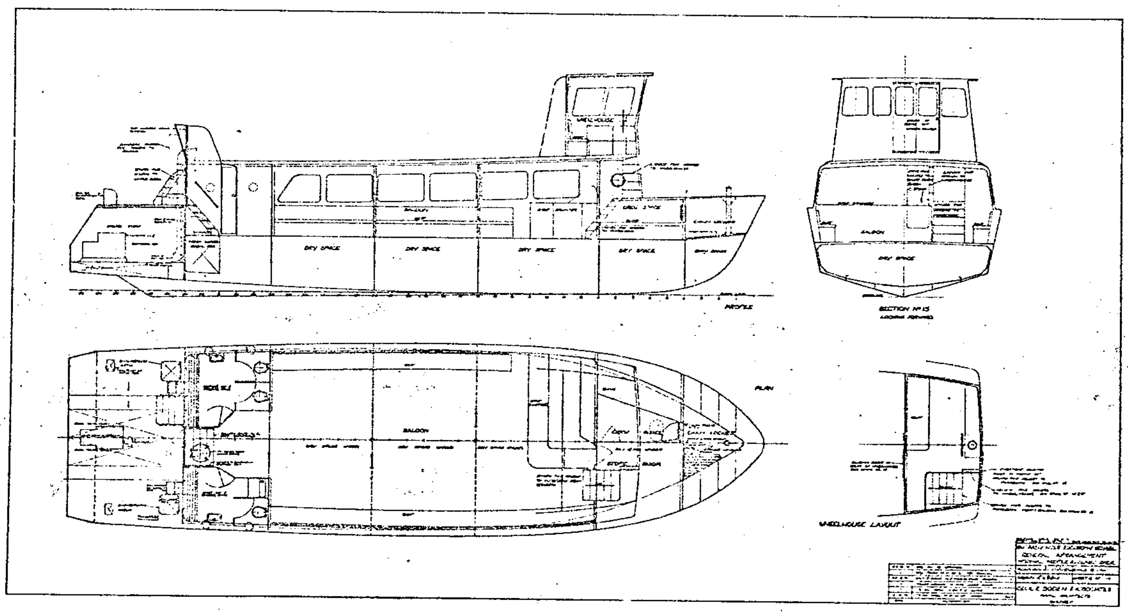
CECIL E. BODEN & ASSOC.
NAVAL ARCHITECTS, SYD.


'DAJARRA'
HORSE POWER FOR SPEED 15 KNOTS.
C - CATERPILLAR HULL SPEED ESTIMATOR
Q.P.C. ·55 S.H.P.
SEMI - DISPLACEMENT C. S.H.P.
Q.P.C. ·60 S.H.P.
Q.P.C. ·65 S.H.P.
PLANING C. S.H.P.
E.H.P. + 10%
NAKED E.H.P.
300
250
200
150
100
50
6
7
8
9
10
VESSELS WEIGHT IN TONS
DIAG. 3
CECIL E. BODEN & ASSOCIATES
NAVAL ARCHITECTS - SYDNEY



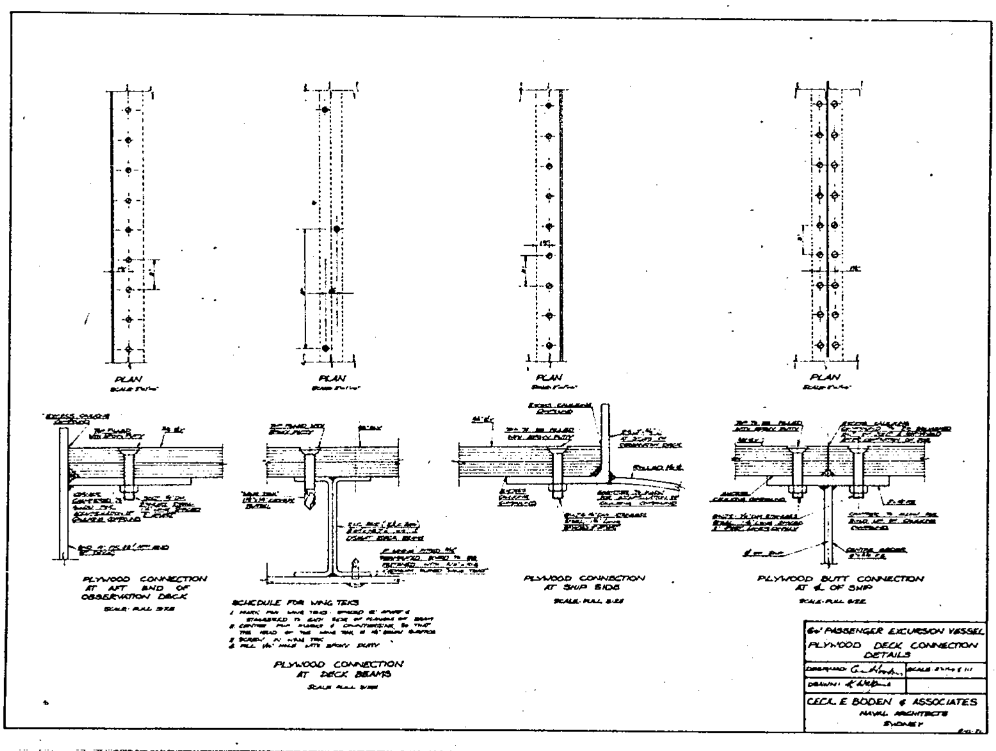
CLARANDA - APPEARANCE & OBSERVATION DECK.

DIAG. 4



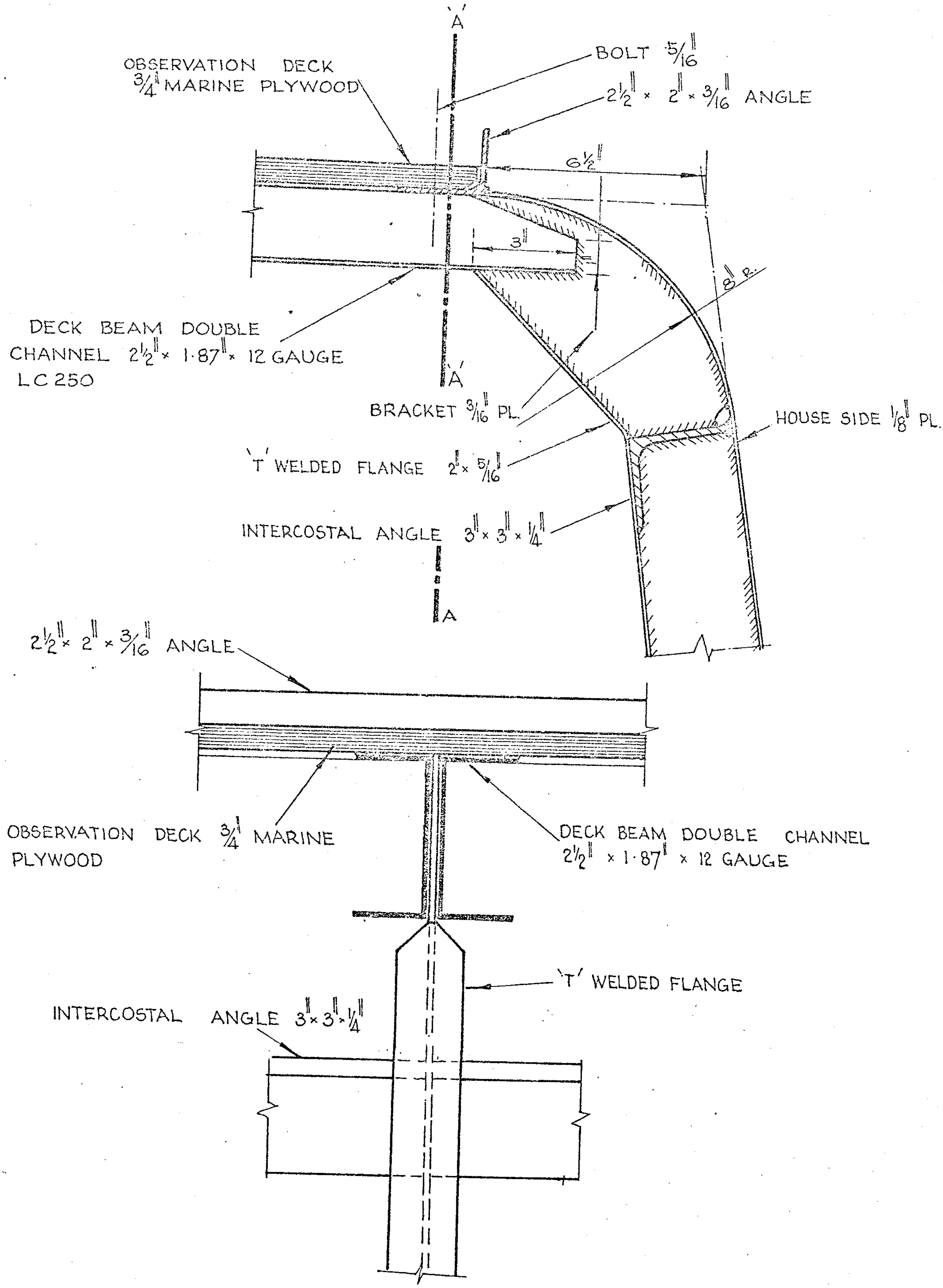
CLARANDA - INTERNAL ARRANGEMENT.

DIAG.5



CLARANDA - FASTENING OF PLYWOOD DECK.

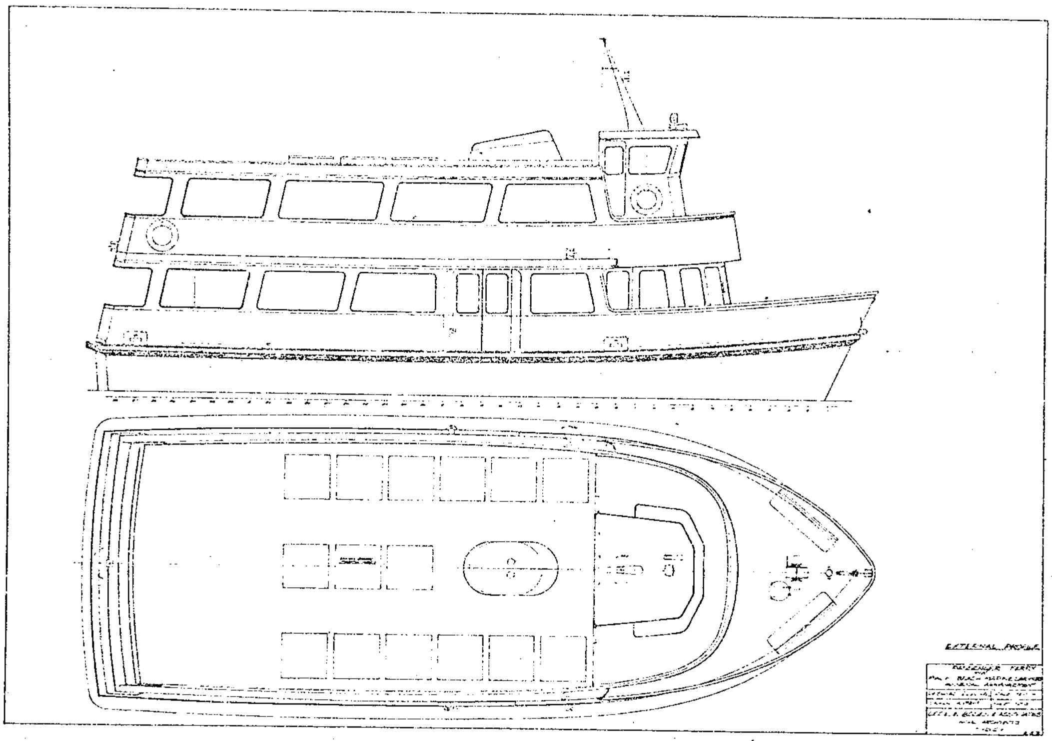
DIAG.5A



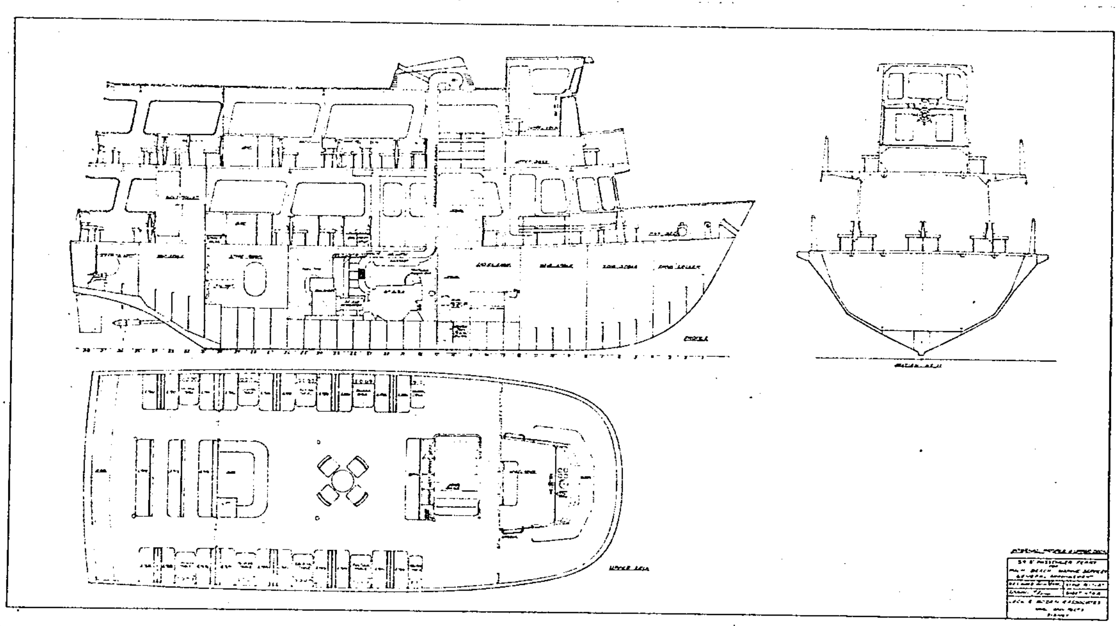
COMPOSITE BEAM ATTACHMENT TO HOUSE SIDE

T.S.M.V. CLARANDA

DIAG. 5B

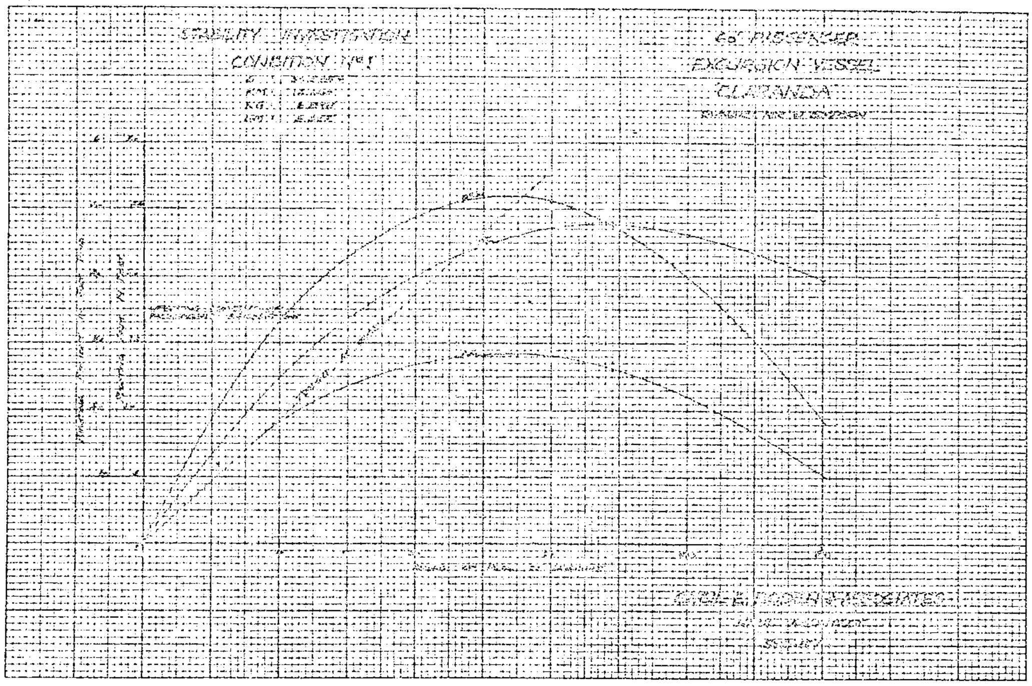


280 PASSENGER FERRY - APPEARANCE

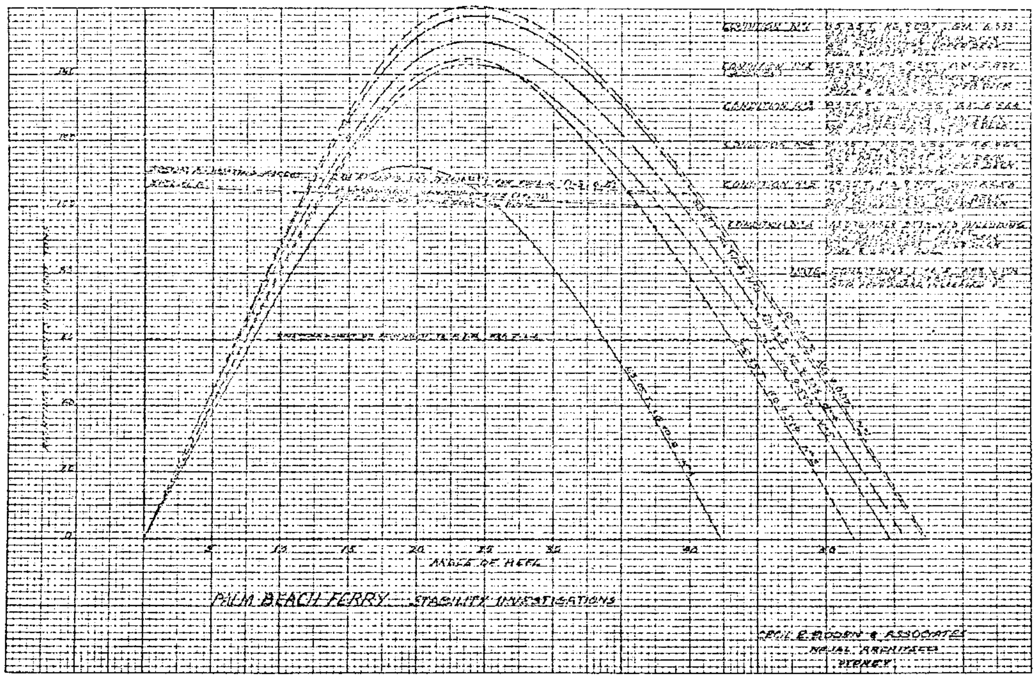


280 PASSENGER FERRY - INTERNAL PROFILE AND UPPER DECK

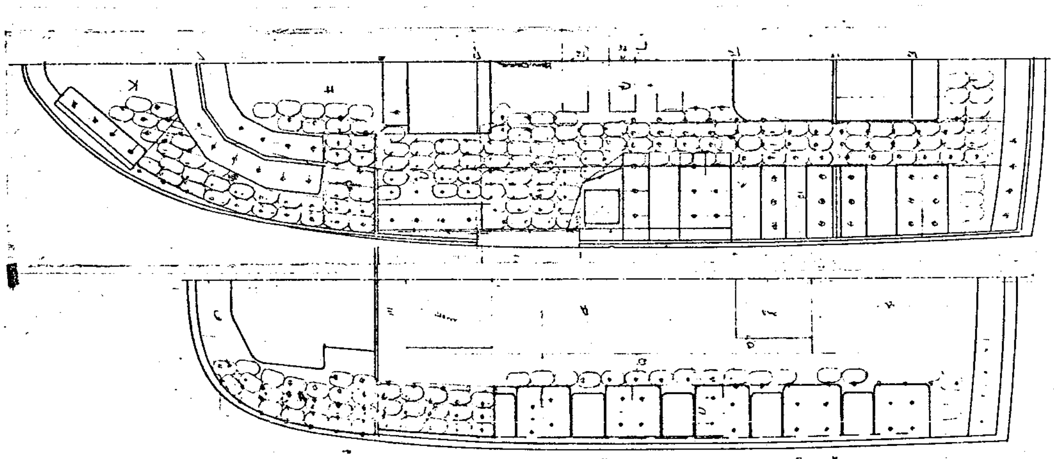
DIAG 6



CLARANDA – STABILITY FULL LOAD CONDITION DIAG 7A



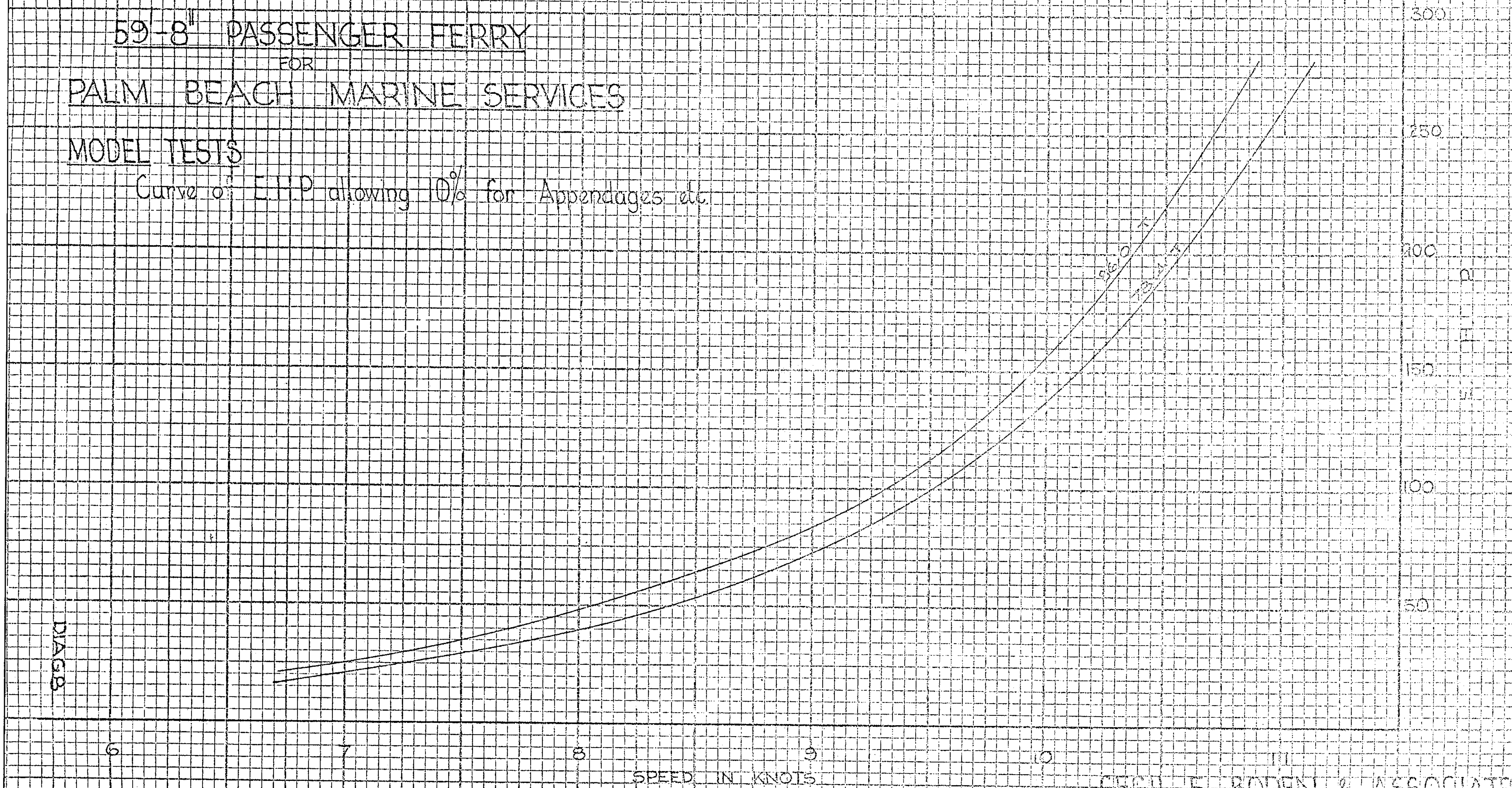
280 PASSENGER FERRY STABILITY DIAG 7B



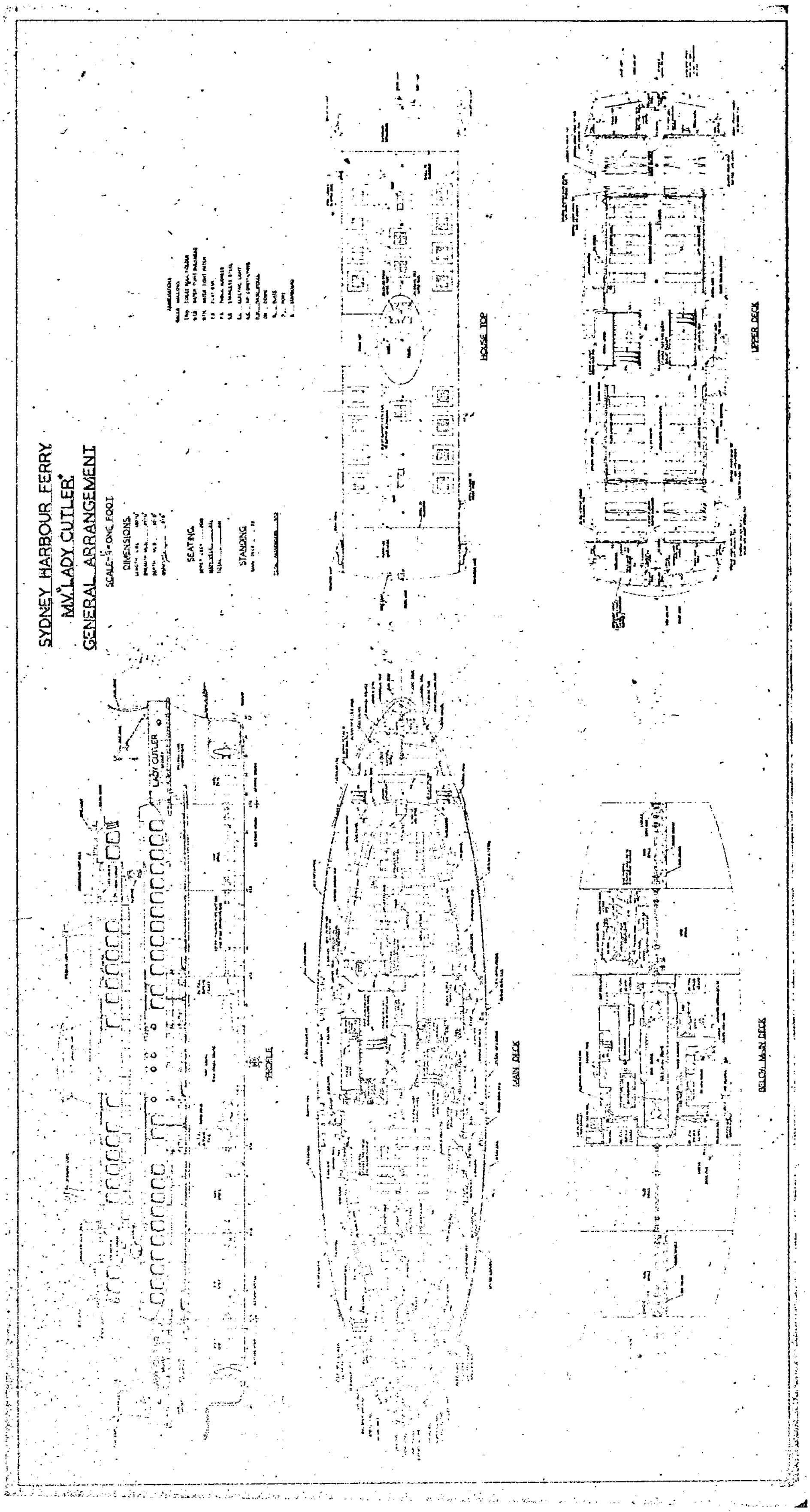
280 PASSENGER FERRY - OVERTURNING CONDITION DIAG.7C

59'-8" PASSENGER FERRY
FOR
PALM BEACH MARINE SERVICES

MODEL TESTS
Curve of E.H.P. allowing 10% for Appendages etc.



CECIL E. BODEN & ASSOCIATES
NAVAL ARCHITECTS
SYDNEY



LADY CUTLER-GENERAL ARRANGEMENT

DIAG. 9