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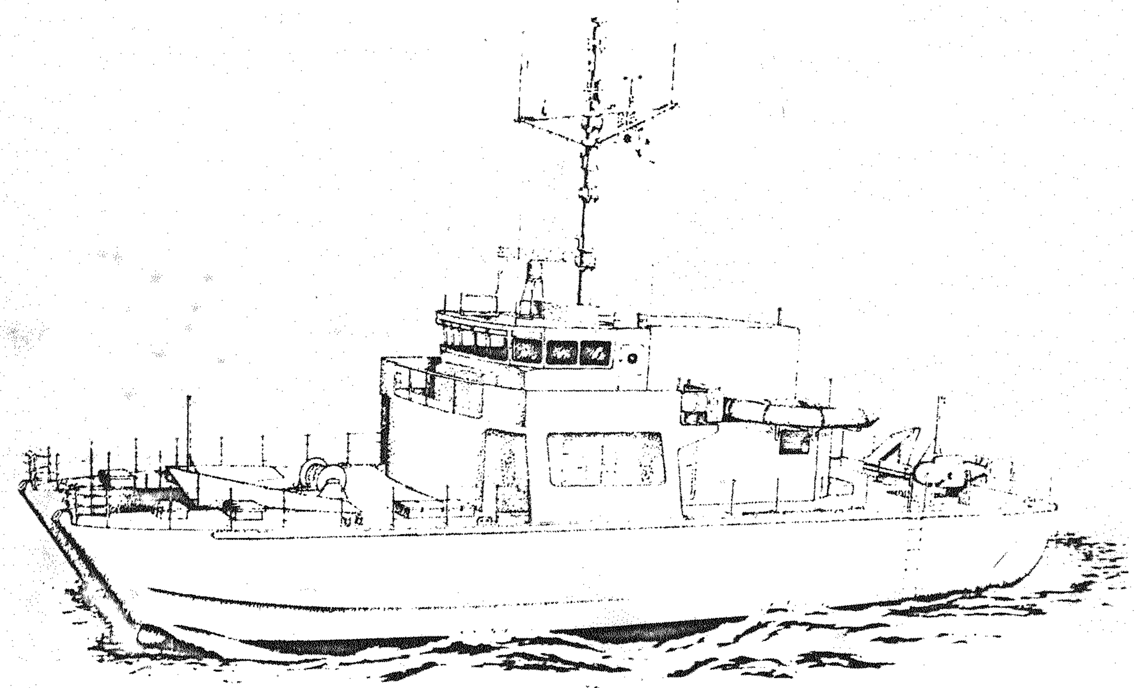
DEVELOPMENT OF THE ROYAL AUSTRALIAN NAVY GRP MINEHUNTER DESIGN



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SUMMARY: The development of the Royal Australian Navy Glass Reinforced Plastic Minehunter Design is discussed. Design rationale, ship model and material test results are presented, proposed production techniques and equipment procurement aspects are also discussed.

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AUSTRALIAN DIVISION
SYDNEY 19 AUGUST 1981

1. INTRODUCTION

During 1975 the Royal Australian Naval Research Laboratories carried out a Mine Warfare Study and validated a need to retain a Mine Warfare Capability well in the 1990s. Due to the rapidly deteriorating condition of the two existing RAN Minehunters which were approaching the end of their economic life and due to be phased out of service during the early 1980s, approval was given to proceed with a Project Definition phase of a Replacement Minehunter Project.

During the early stages of Project Definition and the resulting development of the Naval Staff Requirement for the Minehunter, two procurement options evolved which were significantly different. The first option involved the procurement of up to three Conventional Minehunters of overseas design similar in size to the existing RAN Minehunters (EX RN Ton Class of 468 tonnes displacement). The second option was to acquire a larger number of smaller cheaper craft with reduced capability designed and built in Australia.

The requirement for a small cheap, easily producible Minehunter with a high resistance to underwater shock, low magnetic, acoustic and pressure signature and a limited seakeeping and transit capability led to the Catamaran Design.

The minehunter designed for the Royal Australian Navy is a unique solution to a significant international defence problem. The Navy Minehunter is a small catamaran vessel of 170 tons full load displacement. It is produced in Glass Reinforced Plastic/Foam Sandwich materials with production techniques new to Australian Industry. The Minehunter is being designed by the Design Branch of the Naval Technical Services Division of the Department of Defence with support from other Defence Establishments and Australian Universities.

2. CONCEPT & PRINCIPAL CHARACTERISTICS

The Catamaran Concept was selected because it provided with minimum displacement a very manoeuvrable, stable and spacious working platform. Low displacement for a minehunter can be equated to a low pressure signature. The increased stability inherent with the Catamaran Concept permitted the siting of the propulsion and power generation machinery on No 1 Deck within the superstructure, this had a threefold advantage in that it reduced the magnetic and acoustic signatures of the vessel when measured at a specified distance below the water surface, and it increased the protection of this vital equipment against underwater shock effects. The catamaran concept also provided a very manoevrable vessel when fitted with propulsion steering units in each hull. It is also believed that the degree of hull curvature in a catamaran compared to a monohull will enhance the resistance of the underwater hull structure to underwater shock effects.

Another unique concept of the Minehunter is the modularised/ containerised weapon system. This concept was adopted to simplify weapon integration into the vessel thus reducing the involvement of the shipbuilder with the normal Ship Weapon Integration task and to facilitate maintenance and repair by total module/container replacement.

The approximate principal characteristics of the minehunter are as follows:

Length Overall	31.0m
Beam (Max)	9.0m
Beam Each Hull	3.0m
Depth to No 1 Deck Amidships	5.0m
Draft	2.0m
Displacement (Full Load)	170 Tonnes
Speed	At least 10 Knots
Accommodation	14

3. GENERAL ARRANGEMENT

The General Arrangement of the Minehunter is depicted in Fig 1. Space within the two hulls has generally been allocated for non vital purposes ie. Accommodation, Storerooms and Fuel & Freshwater Tanks. Vital spaces within the Hulls consist of the Sonar Compartment, Propulsion Steering Compartments, Magazines and Pumprooms. All vital equipments in these vital spaces will be designed with an inherent shock stength and will be fitted on shock mounts. Noise making equipments such as pumps and propulsion steering units and their motors in these spaces will be designed to meet a very demanding airbourne noise criteria.

The Main Propulsion and Electrical Power Generation Machinery is located on No 1 Deck inside the superstructure. The Communications Centre, Action Messing Space, Washplaces and WCs are located on No 1 Deck within the forward portion of the superstructure. The Weapon Handling Area is located on the weatherdeck aft. The Operations Room Container and the Bridge are located on No 01 Deck.

4. MAJOR SYSTEMS

4.1 Propulsion System: The Propulsion System consists of two high speed Diesel Engines (approx 220 kw 1800 RPM each) each driving a hydraulic pump from the rear end (180 kw potential) and an electric power generator from the forward end (120kw potential). The hydraulic pump driven by each engine provides hydraulic oil to the driving/steering motors located on a Propulsion Steering Unit (PSU) in each hull which in turn drives the propellers which can vector their thrust through 360 degs. The pump and hydraulic system has been selected and designed respectively with the intention of keeping system structure borne noise to an absolute minimum. A special noise reduced propeller design will be developed for the PSUs. Load sharing between the hydraulic pump and power generator will of course depend on the operating profile of the vessel. While minehunting the propulsive power demand will be low while the electric load for the weapon system will be at its highest level. This situation will reverse when the vessel is in its transit mode. The Diesel Engines and Generators can be removed from the vessel for either maintenance or complete replacement through a large access opening in No 01 Deck. The PSUs are located in trunks in the individual hulls and can be completely removed from the trunks through access openings in No 1 Deck.

4.2 Circulating/Cooling Saltwater System: Two electric motor driven centrifugul pumps each of 680 litres/minute capacity are located in the port and stb pump rooms. The engine coolant pump is located in the starboard pump room and the fire pump is located in the port hull. Both pumps are run in parallel in normal operating conditions. The fire pump provides water to three fire hydrants on No 1 deck and to the magazine spraying system. A hand start diesel driven firemain back-up pump of 680 litres/ minute capacity is located in the starboard hull forward. Ballasting of trim tanks is via a hose from the fire hydrant. Deballasting is via two portable submersible 20 tonnes/hour pumps which can be lowered down into the tanks.

4.3 Airconditioning: A single airconditioning plant of 33kw capacity is installed in the engine room. The system is capable of maintaining a condition of 29.4° dry bulb and 21.7°c wetbulb in operational and accommodation spaces when external atmospheric conditions are 34.4°c dry bulb & 30°c wetbulb.

4.4 Ship Service power generation: The ship service power generation system comprises two 120kw 3 phase 60 Hz Generators driven from the front end of the main propulsion engines. A 2kVA frequency converter for 115v 400 Hz Single Phase is installed in the main machinery compartment.

4.5 Weapons: The weapon system comprises of four sub systems ie. Sonar, Tactical Data, Precision Navigation and the Mine Disposal Weapon. The Sonar Sub System consists of a modularised sonar transducer and directing gear located in the port hull and the tactical data sub system is located in the operations room container. The Mine Disposal Sub System consists of two mine disposal vehicles which can be directly loaded with a bomb from each magazine. The loaded mine disposal vehicle is transferred into the water via a crane located on No 1 Deck Aft. The mine disposal vehicles are wire guided from the Minehunter and controlled via a TV camera in the vehicle and a TV monitor in the operations room container. Precision navigation for the vessel is via a miniranger system. A Dopler Log system is also utilised for shipspeed input into the tactical data sub system.

4.6 Communications: The external communications system will operate in the following frequency bands: MF, HF, VHF, UHF.

5. HULL DEVELOPMENT

5.1 Principal Dimensions: In an attempt to keep the Minehunter as cheap as possible, its overall length was kept to a minimum. The Minehunter's length however, still had to be adequate to provide for an acceptable weapon handling area on the aft weatherdeck and to allow for the siting of the main propulsion machinery on the weatherdeck. The load waterline however had to be long enough to allow the vessel to operate at an efficient speed length ratio.

The beam of the vessel was kept to a minimum in order to reduce the stiff and jerky roll motions inherent in catamaran hulls. The individual hull breadths and spacing between hulls was kept to a minimum while still avoiding wave interference between the hulls.

The height of the underside of the cross structure above the static waterline was determined from ship motion studies with underside slamming being the prime concern. The windage area of the vessel was also treated with some concern in determining the height of the cross structure.

With some hindsight in predicting a possible alternate future role of the minehunter as a shallow water minesweeper the length of the minehunter would have been made some 5 metres longer to provide additional working space aft and to provide for a larger main propulsion machinery space which could accommodate more powerful propulsion engines capable of providing extra power for sweep towing.

5.2 Hull Form: The lines of the hull are depicted in Figs 2 and 3. The hulls are of an assymetrical form although in the early stages of the hull development the lines were of a symetrical form. Subsequent decisions to adopt a foam sandwich construction technique and to fit an anti-pitching fin cancelled out any initial potential cost savings envisaged with the adoption of the symetrical hulls. Geometric characteristics of the assymetrical hulls are as follows:

LWL Design Draft	= 28.09	metres
Beam at LWL (Max)	= 8.94	metres
Beam each Hull at LWL (Max)	= 2.96	metres
Design Draft (Max)	= 1.90	metres
Displacement (Full Load)	= 170	Tonnes
Cb (each Hull)	= 0.525	
Cp (each Hull)	= 0.604	
Cm (each Hull)	= 0.869	
Cwp	= 0.749	
Displacement Length Ratio	= 7670	
LCB Aft Amidships	= 4.78	metres
W.S (Two Hulls)	= 256	sq metres

The Hull Form was based on successful overseas designs with emphasis being placed on highly curved underwater sections to enhance the underwater shock strength of the hull. A knuckle was incorporated on the outside of each hull to reduce wetness on the upper deck and fine entry angles were used on the bow to reduce effects of slamming on the bows. A skeg was essential for docking purposes and subsequently found during ship model tests to be necessary to provide adequate directional stability.

5.3 Cross Structure Configuration: The cross structure configuration is depicted in Fig 4. The underside of the cross structure was configured to reduce underside slamming effects. The distance from the stem to the forward most portion of cross structure was derived from deck space and slamming considerations.

5.4 Hydrostatics: The hydrostatic particulars for the minehunter are depicted in Fig 5. The hydrostatics were developed by the computer using program 'DANDO' purchased from the University of New South Wales. Some particulars were validated manually. Of special note with these particulars is the low moment to change trim one centimeter and the high metecentric height.

6. **PERFORMANCE**

6.1 Powering: Hull resistance model experiments with a 1/20 scale models were conducted in the University of Sydney Ship Model Towing tank to validate preliminary powering calculations which were based on data available from successful overseas catamaran model testing programmes. Model experimentation at the University of Sydney consisted of tests with symetrical and assymetric hulls at various separation, with a bulbous bow in one instance and with an anti-pitching fin at various angles of attack fitted between the hulls. All models were fitted with stud turbulence stimulators. No appendages were attached to the models. All model test results were analysed using the 1957 ITTC line and Cf=0.0004.

Fig 6 depicts the full scale effective power curves at 160 tonnes versus hull centerline separation for the symetrical model without anti-pitching fin. Fig 7 depicts the full scale effective power curves at 160 tonnes versus ship speed in knots for the symetrical model at 6 metre centreline hull separation with bulb and with and without anti-pitching fin. Fig 8 depicts the full scale effective power curve at 160 tonnes for the assymetric hulls, anti-pitching fin and hull separation finally selected for the minehunter. It is of interest to note that the presence of an anti-pitching fin between the symetrical hulls created a very unusual wave pattern at the stern of the model resulting in high resistance. This finally dictated the adoption of the assymetric hulls.

Having selected the hull configuration and determined the naked hull resistance and effective power (with anti-pitching fin) the additional resistance for appendages, surface roughness, fouling, head seas (sea state 3) and head wind of 10 knots was calculated. A wake fraction of 0.17 and a thrust deduction fraction of 0.17 based on data from similar overseas designed hulls was assumed and a relative rotative propeller efficiency and open water propeller efficiency of 100% and 62% was assumed for the purpose of determining delivered power. A PSU efficiency, coupling efficiency and hydraulic system efficiency of 95%, 99% and 72% was assumed to determine the shaft power required at the rear end of the propulsion engine. A further 10% degradation of engine performance in service was assumed.

It should be noted that propulsion experiments and a wake survey will be conducted overseas during 1981 to validate the University of Sydney model test results and to obtain further information for the design of the noise reduced propellers.

6.2 Seakeeping: Ship motion model experiments in head regular waves of various frequencies were conducted in the University of Sydney Ship Model Tank. A symetrical hull model with and without anti-pitching fin and an assymetrical model fitted with an anti-pitching fin was run at equivalent ship speeds of 4.0: 8.0: and 10.0 knots. Heave and pitch response was measured during each model run. Pitch response at 10 knots for the symetric hull model with an anti-pitching fin demonstrated the effectiveness of the fin in reducing pitch motion. Although tests were not conducted on a model of the assymetrical hulls without an anti pitching fin it was considered that its effectiveness could be equated to that of symmetrical hulls. Heave response at 10 knots for the three models was very similar.

Figs 9, 10 and 11 depict response operators for heave pitch and roll at 10 knots with the selected assymetrical hull at 160 tonnes displacement and fitted with an anti-pitching fin.

On completion of the Ship Model Testing Programme at the University of Sydney, a Catamaran Seakeeping

Computer Program was purchased from the USA and set up on CDC 7600 Computer in Canberra. This program was first used to validate the motions in head seas measured with the model in the Ship Model Tank. The program was then used to develop a more extensive picture of the vessel motions in seas representative of the actual condition the vessel is likely to encounter in service.

In seastate 3 using the Pierson & Moskowitz sea spectra significant pitching motions are no worse than that of a mono hull vessel of the same length and displacement. Rolling motion will however be quicker with a smaller roll angle.

6.3 Directional Stability: A simple release test from under the Ship Model Tank Towing Carriage while running at a constant speed was made to determine the directional stability of the assymetrical model used for resistance experiments. This test indicated the marginal directional stability of the model without some form of aft skeg appendage being provided. The skeg shown in Figs 2 and 3 was considered to be necessary to provide adequate directional stability.

6.4 Flow Tests: Some simple flow tests were undertaken with a 1/20th scale model at various yaw angles in the small recirculating water channel at the University of Sydney to examine the effect of cross flow created by the bow of one hull on the external sonar donne on the other hull. It was established that very large yaw angles could be achieved without affecting sonar performance.

6.5 Manoeuvrability: A 1/20th scale radio controlled model with a propulsor on the stern of each hull was tested in Lake Burley Griffin to ascertain the Manoeuvrability and Station Keeping Properties of the minehunter. Although these tests were rather crude it did demonstrate the good manoeuvrability and control of the catamaran concept. Station keeping did appear to be satisfactory but windage was not scaled and therefore the results were suspect. The balance of underwater profile and abovewater profile was however taken into account during the conceptual design stages of the minehunter and therefore confidence in maintaining adequate station keeping is high.

7. **MATERIALS**

7.1 Foam Sandwich: The selection of a foam sandwich method of construction in lieu of the more traditional single skin construction with frames and longitudinals was a decision made by the author in 1977 after returning from a visit to the UK and Sweden to investigate the potential of both methods of construction for adoption in the RAN Minehunter.

The choice of foam sandwich as opposed to single skin construction was made for the following reasons:

a. A lower level of shock resistance was required for the RAN minehunter compared to overseas designed minehunters with single skin construction which were required to minesweep as well as hunt mines.

b. Cost saving with foam sandwich construction when low production numbers are involved.

c. The size of the RAN minehunter was much smaller than overseas designed single skin minehunters and to adopt their scantlings would have meant a very heavy vessel. Table 1 depicts the hull weights of the different types of construction. The alternative of course would have been to scale down the single skin scantlings, but to be confident that the modified single skin scantlings could perform adequately in a shock environment would have meant a long experimental programme which would have introduced additional unnecessary risks into the RAN minehunter programme.

d. The Royal Swedish Navy had already built a small minesweeper in foam sandwich construction which approximated the size of the RAN minehunter. The RSN had also intended to build their M70 class of minehunter in foam sandwich and as part of this programme had successfully tested flat panels and a full scale test section in a shock environment similar to that intended for the RAN minehunter. The RSN was most confident about their choice of foam sandwich construction. The RSN made some test results and details of construction techniques available to the author which gave the author adequate confidence to adopt the RSN foam sandwich materials for the RAN minehunter.

The composite material adopted for the hull of the RAN minehunter consisted of a single layer of 60mm thick high density rigid PVC foam and an inner and outer skin consisting of seven layers of alternating Plys of 600gm/m^2 woven rovings and 300gm/m^2 chopped strand mat. (8mm thick).

7.2 Foam: The basic requirements for a suitable foam for the sandwich core material was high shear strength, low weight, negligible water absorption, stable mechanical properties and to be compatible with the specified resin for the GRP laminated skins. This lead to the selection of two grades of a closed cell, rigid, cross linked PVC foam. One grade was identified as high density foam having a density of 130kg/m^3 while the other grade was identified as standard density foam with a density of 100kg/m^3. Specifications for both foams were developed by the Directorate of Naval Ship Design.

The required properties of both grades of foam are provided in Table 2.

7.3 Chopped Strand Mat: 'E' glass not containing more than 1% by mass of Alkali calculated as Na_2O has been specified for the minehunter because of its relative low cost and its availability. The mat is constructed of 'E' glass strands laid randomly so that when the mat is used as a reinforcement with resins, the properties of the resulting laminate will be similar in all directions in line with the mat. Strands are of a length between 25 and 51 mm and are composed of filaments with a diameter ranging from 8 Um and 15 Um. Desired properties of the mat and corresponding laminate are provided in Table 3. Test procedures and laminate lay up are specified in the appropriate material specification.

7.4 Glass Woven Roving: 'E' glass was also specified for the woven rovings used on the minehunter. The fabric is manufactured from rovings which meet the requirements of W Normal Grade of Weaving as specified in BS3691. Table 4 provides the construction requirements for the woven roving and Table 6 provides the laminate test requirements with the specified resin. Laminate details are specified in the appropriate material specification.

7.5 RESIN: The Resins used for the minehunter are thixotropic unsaturated isophthalic polyester. The Resins are specified in two grades ie Standard (S) and Low Viscosity (LV). The desired properties of the raw resin are provided in Table 5 while desired properties when used in a single woven roving laminate and a composite laminate are provided in Table 6 and 7 respectively. Laminate properties assume that the specified glass has been adopted.

8. MATERIALS TESTING PROGRAMMS

8.1 GENERAL: A comprehensive materials testing programme was initiated by the Naval Design Branch of the Department of Defence to validate the overseas sourced information on Physical and Mechanical Properities of the selected resin, glass and foam and to generally extend our knowledge of the materials for design and production purposes. Material testing was undertaken at the Materials Research Labortaries and the Aeronautical Research Laboratories in Melbourne, The Defence Research Centre at Salisbury South Australia and The Admiralty Marine Technology Establishment in the United Kingdom.

8.2 Foam Static Tests: Tensile, compression and shear tests were conducted on samples of high density and standard density foam samples (H130 and H100) to determine strength and modulus properties. Properties provided in Table 2 represent an average of the test results obtained during the test programme. Tests on H130 foam were carried at elevated temperatures, test results are provided in Table 8.

For H130 foam tensile strength of foam to laminate bond was 3.03 MPa.

Tests were conducted on other foam samples but for production reasons and because of the sensitivity of their mechanical properties to heat, testing was curtailed early in the test programme.

8.3 Composite Panel Static Tests: Four point bending tests were conducted to obtain the failure load of a 2000mm x 300mm beam with a segemented foam core.

The results from this test programme were also required in designing a fatigue test on similar beams. The EI value for the section was also determined. The construction of the beam was as per the hull of the minehunter ie inner and outer skins consisting of 7 layers of alternating plys of 60 gm/m^2 woven roving and

300 gm/m^2 chopped strand mat and a 600mm core of H130 foam. Equal loads were applied at a distance of 400mm from the centre of the beam on both sides, of the centre and the beam was supported on two supports 850mm each side of the beam centre. The average failing load was determined as 76 kn, deflection relative to the end supports at 55kn was 55mm and the EI of the section was 0.735 x 1011 Nmm^2. Failure mode for each test was shear in the foam core at 1.83 to 1.90 MPa with a direct stress in the skins of 103-107 MPa.

Pin ended column tests were conducted on samples constructed as for the four point bending test samples. The overall length was 795mm, width was 300mm and nominal thickness was 80mm (slenderness ratio of 109). Failing load was 510kn, lateral deflection at 500kn was 55mm, end deflection at 280kn was 11mm and the strain at failure was 10.5 micro strain. The duration of the test was one hour.

Creep tests are still progressing but considerable variation in results have been observed. Thick laminate specimens loaded to 70% of ultimate failure gave lives of 53 hours to 4295 hours while thin laminates loaded to 70% of ultimate failure gave lives of 2.5 hours to 70 hours.

8.4 Composite Panel Dynamic Tests: Beam fatigue tests were carried out on beams constructed to the same specification and size as those used for the four point bending tests. Tests were conducted at four point bending and constant amplitude. One speciman completed 332,600 cycles at 37.8 kn followed by 1,773,220 cycles at 30.25 kn. Cracks first appeared in the foam at one end at 1,00300 cycles followed by cracking at the other end at 1,050,000 cycles. It was decided not to cycle this specimen to failure. A fatigue test is continuing on a similar beam with a history to date of 500,000 cycles at 32 kn constant amplitude.

Underwater shock tests were conducted on twelve 1.80Mx0.90M flat panels at the Defence Research Centre Salisbury South Australia. Panel construction consisted of both solid laminates and composite materials with foam and Balsa cores of various thicknesses and construction. The panels were placed in a steel shock box, which in turn was lowered into the water with the panel face exposed to an underwater charge of 0.45kg at various distances from the panel surface to represent pre-determined shock factor values. At the design shock factor some panels proved to be more suitable than others, some proved to be completely unacceptable. The skin construction specified for the RAN minehunter proved to be satisfactory during this small panel test programme.

Following the success of the tests on the small panel constructed to the specifications for the minehunter hull, a large 3.0M x 3.0M flat panel was constructed with a frame attached and tested in the specified shock environment in a much larger shock box at the Admiralty Marine Technology Establishment Dunfermline in the United Kingdom. This testing programme proved to be most successful and gave the designers considerable confidence in the selection of materials, construction methods and fabrication procedures selected for the minehunter.

The culmination of the underwater shock testing programme was the testing of a full scale section of the hull in December 1980. Figures 12 and 13 depict the constructions of the test section and the shock tests respectively. The test section was instrumented to measure strain, acceleration and deflection of the hull structure when exposed to thirteen underwater explosions of increasing intensity. Also during this programme shock mountings selected for the main machinery were checked, and various methods of mechanical fastenings to the structure were tested. Apart from one small failure which occured possibly on the last shot the structure and materials of the section performed exceptionally well. The shockmounts however performed badly. The conduct of the entire test series was a credit to all concerned, some very valuable lessons were learned.

8.5 Other Tests: Many other material tests have been undertaken or are in progress at the Material Research Laboratory and include fire tests, chemical reaction tests, weathering tests, water absorption test and impact tests. A structural test was conducted on a keel section of the vessel with loads representative of a typical docking load, figure 14 depicts the section in the test machine. A load of 372 kn was applied before shear cracks in the foam were observed, ultimate failure occured at 590 kn.

9. STRUCTURAL DESIGN

9.1 Load Criteria: The load criteria selected for the minehunter design was as follows:

a. Hull Girder Seaload: Each hull balanced on a L/9 wave with length equal to the LWL of the hull.

b. Torsion Seaload: Bow of one hull and stern of the other balanced on an L/4.5 wave with length of 11.7 metres.

c. Weather Seaload: No 1 deck 1195 KPa; superstructure front 2390 KPa; No 2 deck 717 KPa; bridge front 1195 KPa and bridge top 478 KPa.

d. Hydrostatic Seaload on Shell: Hydrostatic pressure to No 1 deck plus 1.2 metres = 55 KPa applied in phase with hogging stress.

e. Operational Flooding Load: No 2 deck and watertight bulkheads to withstand flooding to No 1 deck.

f. Operational Docking Load: 5,500 KPa local Vertical shear force on cross structure 15 tonnes, transverse bending moment on cross structure 20 tonnes metre.

g. Operational Slamming Load: Underside cross structure in bow region 6,000 KPa, aft region of cross structure 1,600 KPa.

h. Combat Load: Underwater explosion of a specified mine at a specified distance from the hull and on the seabed at a specified depth.

9.2 Load Factors and Deflection Limits: A minimum load factor of four on failure was utilized although subsequent finite element analysis indicated in many areas of the ship the load factors exceeded 4 by a wide margin. The structure generally is of a 'safe design' nature rather than of a 'fail safe' nature. The cross-structure design however has no redundancy and therefore is critical. The structure is designed to withstand load created by repeated specified underwater explosions but is capable of a fail safe survival at twice the design condition. Panel deflection limit adopted was L/200.

9.3 Structural Analysis: The structual design of the minehunter was a complex task because of the nature of the materials adopted, the dynamic shock environment and the catamaran concept. Both static and dynamic load cases were defined early in the structural design and safety factors and deflections limits were based on overseas experience. The entire structure was developed on the basis of a minimum number of frame to shell connections in the underwater regions of the hulls. The structure was analysed using the 'STARDYNE' Finite Element Program with 900 elements and then more accurately modelled including the superstructure both statically and dynamically using the 'NASTRAN' Finite Element Program with 5000 Elements.

The results obtained from the 'NASTRAN' program indicated that the structure analysed was generally very lightly loaded. It did however highlight some highly stressed areas in the web frames in the cross structure as they merge into the hulls. It also highlighted a high stress area in the hull in the region of the anti-pitching fin connection. Resulting from this structural analysis the scantlings of many of the secondary members including bulkheads have been reduced. Fig 15 generally depicts the element breakdown of the minehunter structure.

10. PRODUCTION

10.1 Producibility Principles: The producibility principles adopted for the GRP structure of the minehunter were intended to produce an effective and a relatively low cost hull. The adoption of the foam sandwich type of construction method was the first step taken to achieve the goal of 'CHEAP BUT EFFECTIVE'. The foam sandwich type of construction meant minimum frames and longitudinals in the hull which are a source of concern in the single skin construction method. The problem being to ensure their effective connection to the skin to withstand the effects of underwater shock loading. For the British 'HUNT CLASS' of minehunter which is constructed with a single skin, titanium bolts have been used to connect the frames to the shell. For the tripartite minehunter, special GRP pins have been used to connect the frames to the skin.

A simple wooden male plug mould is intended for the construction of the hull of the RAN minehunter as opposed to an expensive steel or aluminium female mould used for the Hunt class and the tripartite minehunters.

A flat sandwich panel construction principle is proposed for all decks, bulkheads, web frames, and superstructure sides. Under deck longitudinals and cross structure transverses are simple tophat flat sections. All longitudinals are attached to panels prior to erection at the ship.

Details of structural connections are depicted in Fig 16. Although they may appear to be complex at first sight, considerable effort has been expended on their design to ensure ease of production. The means of connecting structural elements to the hull is most important in providing adequate protection against underwater shock loading. All hull connections have been specified as either requiring a primary or secondary bond to the hull depending on its location and contribution to the overall hull structure strength required to withstand shock lodings. The Scheme of Erection is depicted Fig 17.

The hull itself is built up over a simple wooden mould. First, the 60mm foam is laid up on the mould in either slab of strip form, which is connected to the hull mould by screws from inside the mould. All foam seams and butts are bonded together with either polyester resin or a polyester paste made up of polyester resin and phenolic micro balloons. The outside surface of the foam is faired and smoothed and then the outer skin is laid up over the outside of the foam. When the outside skin is adequately cured and smoothed. The entire mould, with foam and outer skin attached is inverted and placed in a supporting cradle. The inside of the foam is then cleaned and faired before the inner skin is laid up. In areas where primary hull bonds are required, tear-off terylene strips are placed on the surface to inhibit cure for up to seven days before the secondary structural element such as a bulkhead can be dropped into place and reinforcement laid up.

10.2 Environmental Control: To ensure adequate laminate quality during construction all GRP laminating will be carried out in a fully enclosed building facility where temperature can be maintained between 18°C and 24°C with relative humidity held below 65%. An adequate ventilation system is required to ensure styrene given off while laminating is kept to at least one hundred parts in a million for health reasons. Air Flow over the laminate is limited to 1 metre/sec. Materials also need to be stowed in a controlled environment before use.

10.3 Quality Control: Strict quality control will be required while laminating. This will include as well as environmental control, material approval and usage, laminating procedures, 100% laminate inspection, panel weight, and random sample testing. Each ply of a laminate will be inspected for air entrapment, and standards for maximum allowable void size and number have been established. Type and batch approval for glass and resin materials will also be required.

10.4 Test Section and Panels: To validate production techniques a contract was let to two manufacturers to produce between them four 3 metre x 3 metre flat panels, a section of the keel, a deck, shell, web frame section, and a full scale 5 metre long section of one hull and half cross structure which was subsequently shock tested. Producibility of the sections was validated but subsequent inspection and lessons learned during fabrication lead to the preparation of a more detailed and precise specification for the construction of the prototype vessels. Fig 18 depict some of the section manufactured.

11. WEIGHT AND WEIGHT CONTROL

11.1 Weights: The minehunter has developed into a speed critical design and is very sensity to trim changes. All weights and moments have therefore been accurately calculated and arranged into the Navy Weight Breakdown Structure. The single digit breakdown of this structure is as follows:

GROUP NO	DESCRIPTION
100	Hull Structure
200	Propulsion Systems
300	Electrical Systems
400	Command & Surveillance
500	Auxiliary Systems
600	Outfit & Furnishing
700	Armament
	Variable Loads
	Margins

The hull structure group has been brokendown to individual structural members for convenience when comparing calculated weights with as weighed weights when reported by the shipbuilder. At this stage in design the margins remaining for future use are as depicted in Fig 19.

Fig 20 depicts a typical page of the current weight listing, and Fig 21 depicts the summary weight listing for vessel.

11.2 Weight Control: Weight control and monitoring of the minehunter while building is very important and will be rigidly enforced. Not only will weights be important from the viewpoint of vessel performance but it will also be important in the hull structure as a quality control requirement for quantity and mix of materials and chemicals used. At a very early stage after the shipbuilding contract is signed the Designers Allocated Design Weight Estimate Breakdown will be used to develop an Agreed Weight Breakdown which is acceptable to the Department and achievable by the shipbuilder. The Agreed Ship Weight Breakdown will then become the contractual baseline for weight monitoring and weight control purposes during construction. This will be a shipbuilder responsibility. Weight return audits will be undertaken by the designers.

12. EQUIPMENT ACQUISITION

12.1 Acquisition: The acquisition of Australian Government furnished equipment which is supplied to the shipbuilder is proving to be a most difficult task because of the nature of the equipment and the public tendering system.

The equipment is unique in that it must have low magnetic properties, it must not exceed a specified noise level and it must have a high resistance to shock. The procurement of this specialised equipment is being managed through the public tendering system with fixed price contracts. Tenders have been sought from overseas firms known to be competent in the field. Tenders have also been sought from local sources wherever there is a possibility that the item is within the capability of local industry. However the response from local industry for this specialised equipment has in many instances not been as good as hoped.

12.2 Magnetic Characteristics: For the purpose of determining the magnetic characteristics of Government Furnished Equipment as well as Shipbuilder Furnished Equipment, a land based magnetic test range is being built at the Royal Australian Navy Armament Depot at Kingswood NSW. Computer and Ship Model Studies have also been undertaken to build up an appreciation of the magnetic signature of the minehunter as the design and building progresses. The equipment procurement specifications provide guidance to the equipment manufacturer in the selection and use of low magnetic materials.

12.3 Shock Requirements: A complex study was undertaken early in the minehunter design to gain an appreciation of the underwater shock loadings experienced by the minehunter during an underwater explosion. The extent of shock resistance specified for the minehunter equipment was determined by its importance to ship survivability, ship mobility and operational capability in that order of importance and severity. The specified shock resistance of the equipment was also determined by its location in the ship. All equipments will be required to have a minimum inherent shock strength with the specified level being achieved with the equipment on shock mountings or solely by inherent strength. The underwater shock environment can be simulated on shock testing machines already available at the Guided Weapon Electronic Support Facility, St Mary's NSW Prototype equipments will be tested at this facility.

12.4 Noise Criteria: During the early stages of Design, a mathematical study was undertaken to develop an appreciation of what may be required as an equipment noise criteria to ensure the vessel, as built, meets the operational noise levels. Airbourne Noise levels were therefore specified for equipments which depended on their location in the vessel. These levels can be measured in the equipment manufactures workshops and will form part of the acceptance criteria for the equipment.

13. PROJECT STATUS

13.1 Design Development: The Minehunter Design has progressed through the conceptual and Preliminary, Design stages to a stage of approximately 70% complete in the detail design phase. The shipbuilders estimating package which represents a stage of approximately 50% completion of the detail design phase was completed in April 1980 and used for tendering purposes in October 1980. The detail design is programmed for completion in July 1982.

For the development of the Shipbuilders estimating package it was necessary to select likely notional equipment and develop the design of the related ship systems around these equipments. Ship System Design may have to be revised when GFE is finally selected. The preparation of Working or Production Drawings which will have to be developed from the detail design package will be the responsibility of the Shipbuilder and will be dependent on his Production Methods and Facilities.

Strict Configuration Management Principles have been applied during the design of the Minehunter and will continue to be applied after the construction contract has been signed. The first configuration baseline was defined at the completion of the preliminary design and the completion of the Approved Ship Characterisitcs. The complete Shipbuilders Estimating Package consisting of 130 drawings and a comprehensive ship specification was taken as the next configuration baseline and used for tendering purposes. The Third baseline will be the shipbuilders estimating package modified to include queries or corrections raised by the ship construction tenderers, this will form the contract negotiation baseline. The Fourth configuration base line will be the completed detail design package available for negotiation with the shipbuilder in July 1982. This will be some 8-10 months after letting the contract for the production of the two prototype minehunters.

The various configuration baseline can be related by the Delta changes being adequately identified on the relevant documentation.

Subsequent configuration changes past the fourth base line will be independently tracked. Procedures for the introduction of these changes, their approval and their introduction into affected documentation will be rigidly controlled.

13.2 Prototype production: The first ship production contract will be let for the construction of two prototype vessels with an option for a number of Follow-on-Craft to be built after the satisfactory completion of an extensive prototype evaluation programme. Current programming allows for the placement of the contract for the prototype vessels towards the end of 1981 with completion of the first prototype in late 1984. A programme for Follow-on-Craft at this stage has still to be finalised but it would appear that a production gap of some twelve months will exist between the completion of the last prototype vessel and the first production vessel.

13.3 Government furnished equipment: Some minor items of GFE have been ordered. It is hoped that by late 1981 main items of GFE will be ordered.

13.4 Reseach and Developement: Apart from R&D that may have to be carried out by the GFE manufacturers very little R&D associated with the design is still outstanding. Hydrodynamic testing required for the propeller design and the 1/20 scale magnetic modelling are two major outstanding items.

14. PROTOTYPE EVALUATION

Before embarking upon a production run of minehunters, it is intended to build and evaluate two prototype vessels. These two prototype vessels will be evaluated for a period of eight months during which time the design expectations of the vessel will be validated, margins established and the operational suitability of the vessel proven.

The Test and Evaluation Programme will consist of three separate but integrated phases, consisting of production acceptance, developmental and operational test and evaluation. During the developmental test and evaluation phase the following principal tests and trials will be undertaken:

1. Speed and endurance trials.

2. Ship motion trials.

3. Shock trials.

4. Structural responses.

5. Vibration trials.

6. Magnetic ranging.

7. Noise ranging.

8. Manoeuvrability trials.

The success or otherwise of this Evaluation Programme will be the prime determining factor for determining the way ahead with the project.

15. CONCLUSIONS

The Minehunter is entirely Australian by concept and design and will be built in Australia. The design is innovative and has potential for overseas sales, which is a credit to all associated with the project. Many problems have of course been encountered and solutions determined which at this stage of development leaves the project in a healthy state.

The project still has a long way to go before vessels can be made available to the Fleet ie prototype vessel completion programmed for end of 1984, however we are optimistic in the expectation that the Minehunter will adequately fulfil the mine-hunting needs into the twenty first century.

16. ACKNOWLEDGEMENT

The author wishes to make it clear that the Minehunter design has been a team effort & over the years of development many participants have been involved in this team. The author had the good fortune of managing the design team for three & one half years & without the full support & enthusiasm of each participant the Minehunter design would not have developed to its current status. The author therefore wishes to thank all participants for their support to the design manager and their unyeilding dedication and professionalism applied to their assigned tasks.

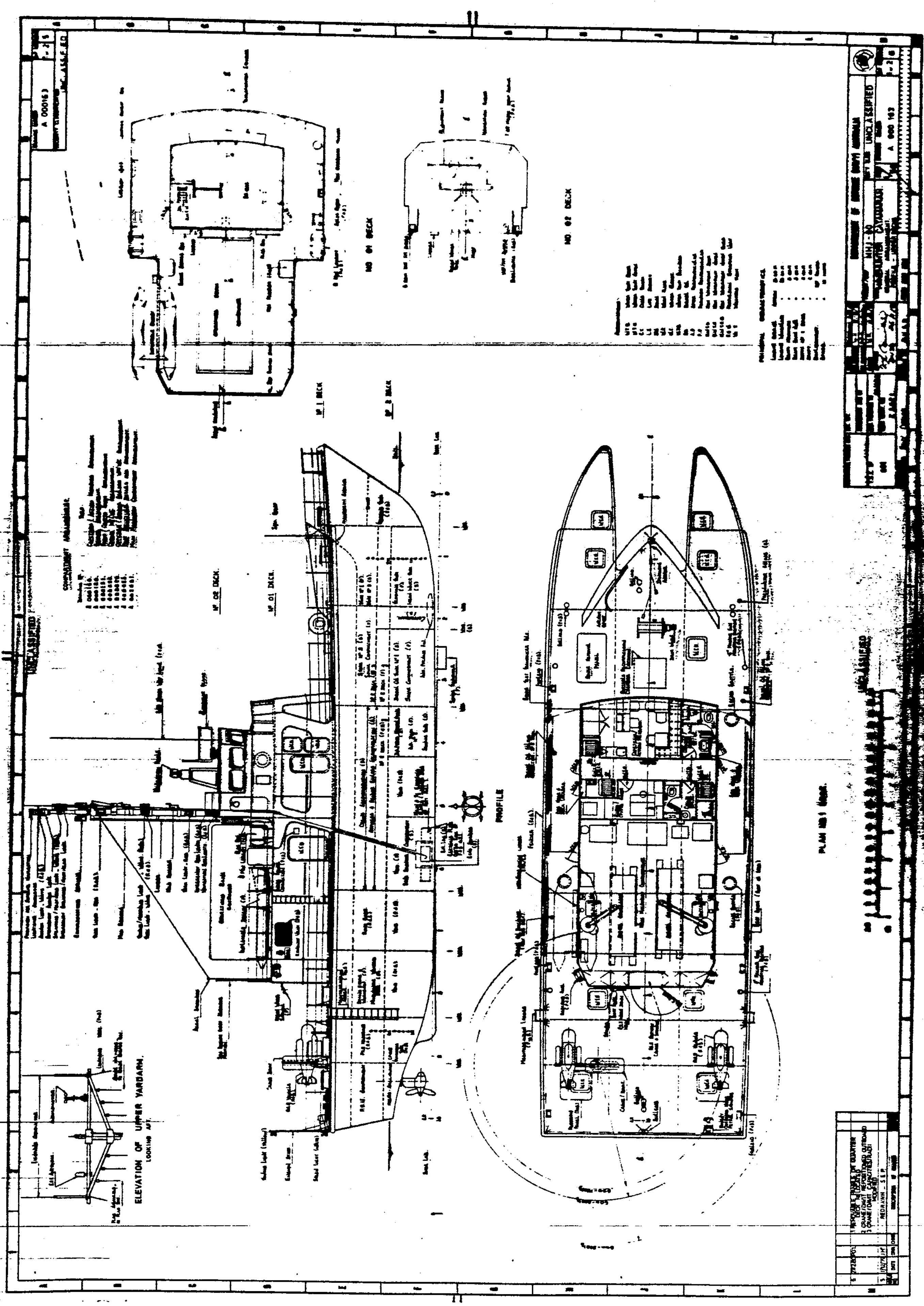
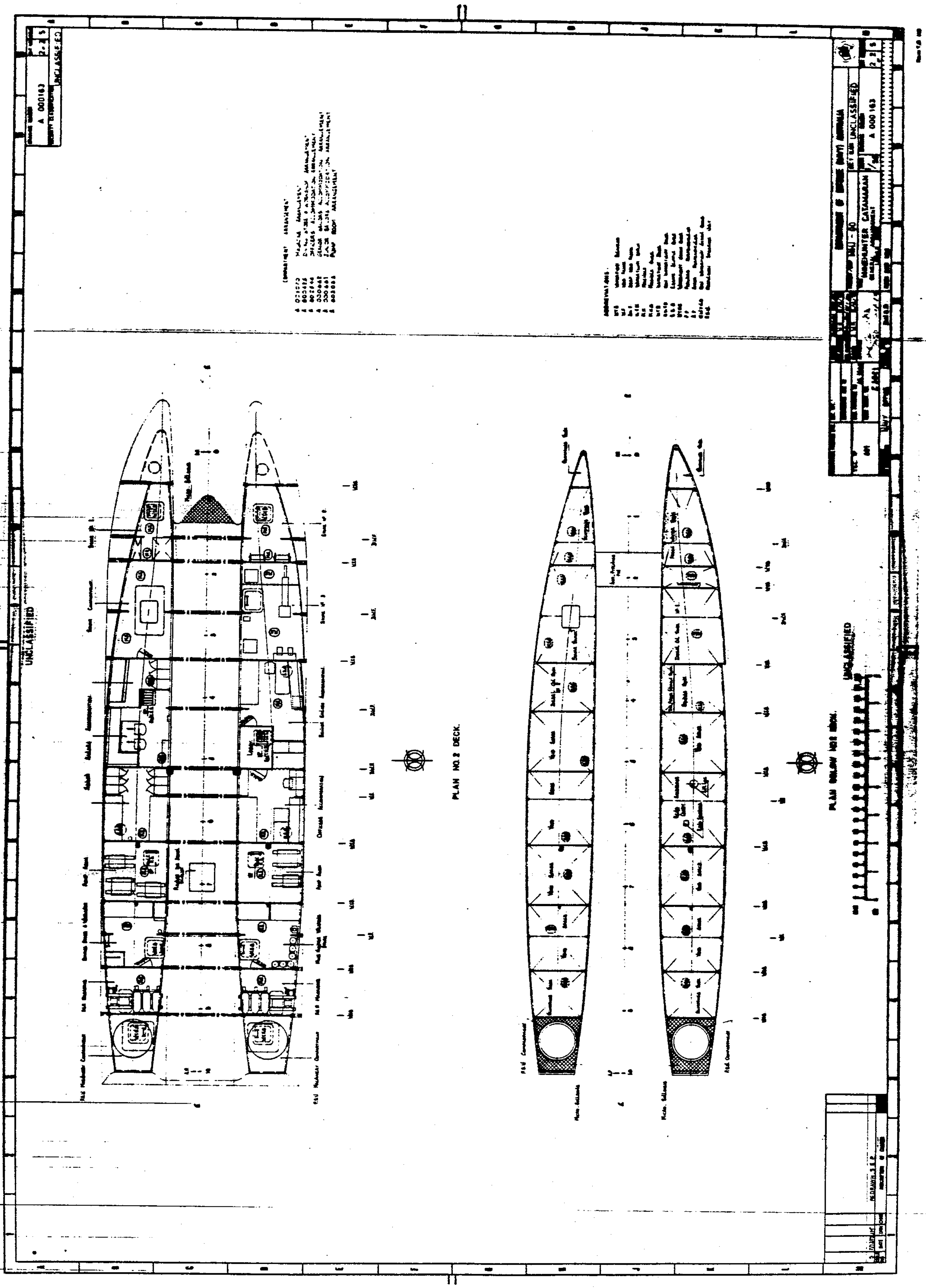


FIG. 1A



UNCLASSIFIED
A 000163
PLAN NO.2 DECK
PLAN BELOW NO2 DECK
MINEHUNTER CATAMARAN

FIG. 1B

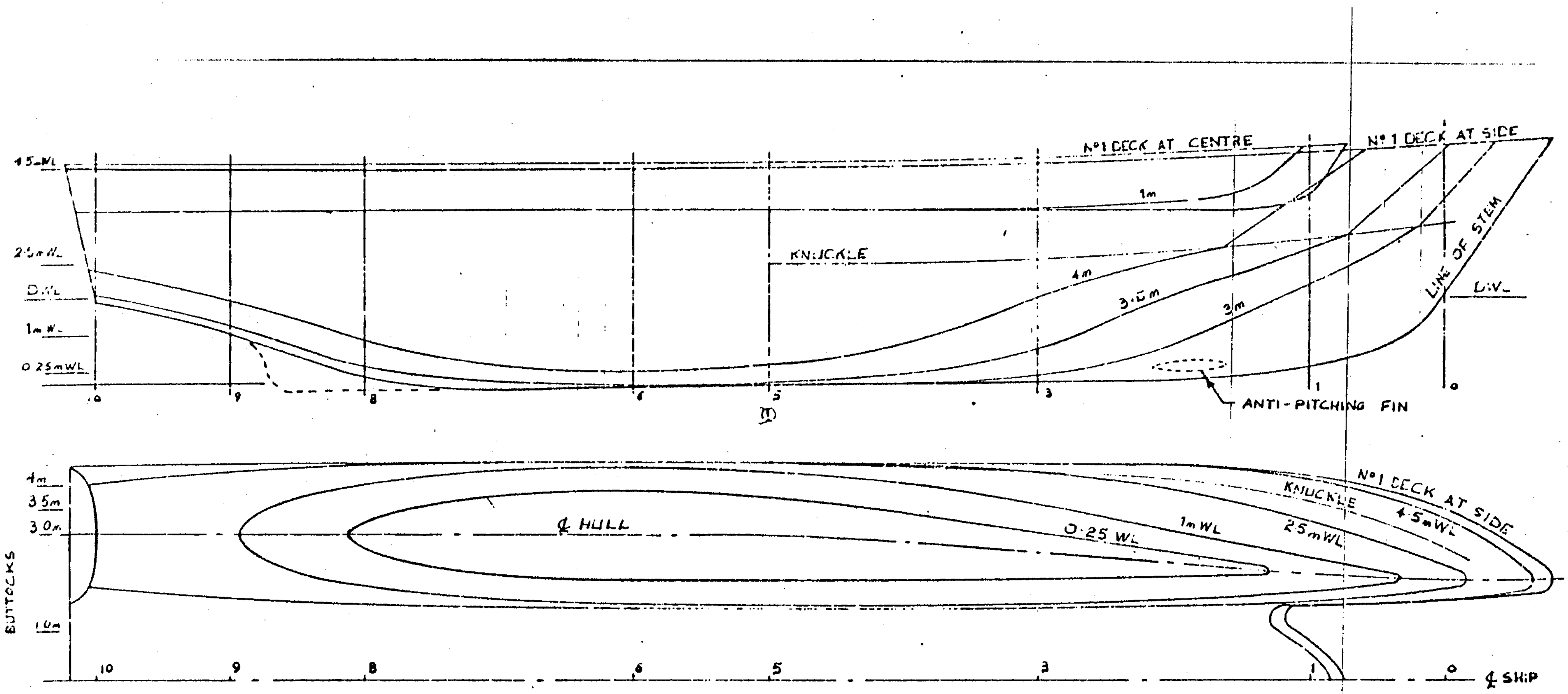


Figure 2 Lines - Profile and Waterline

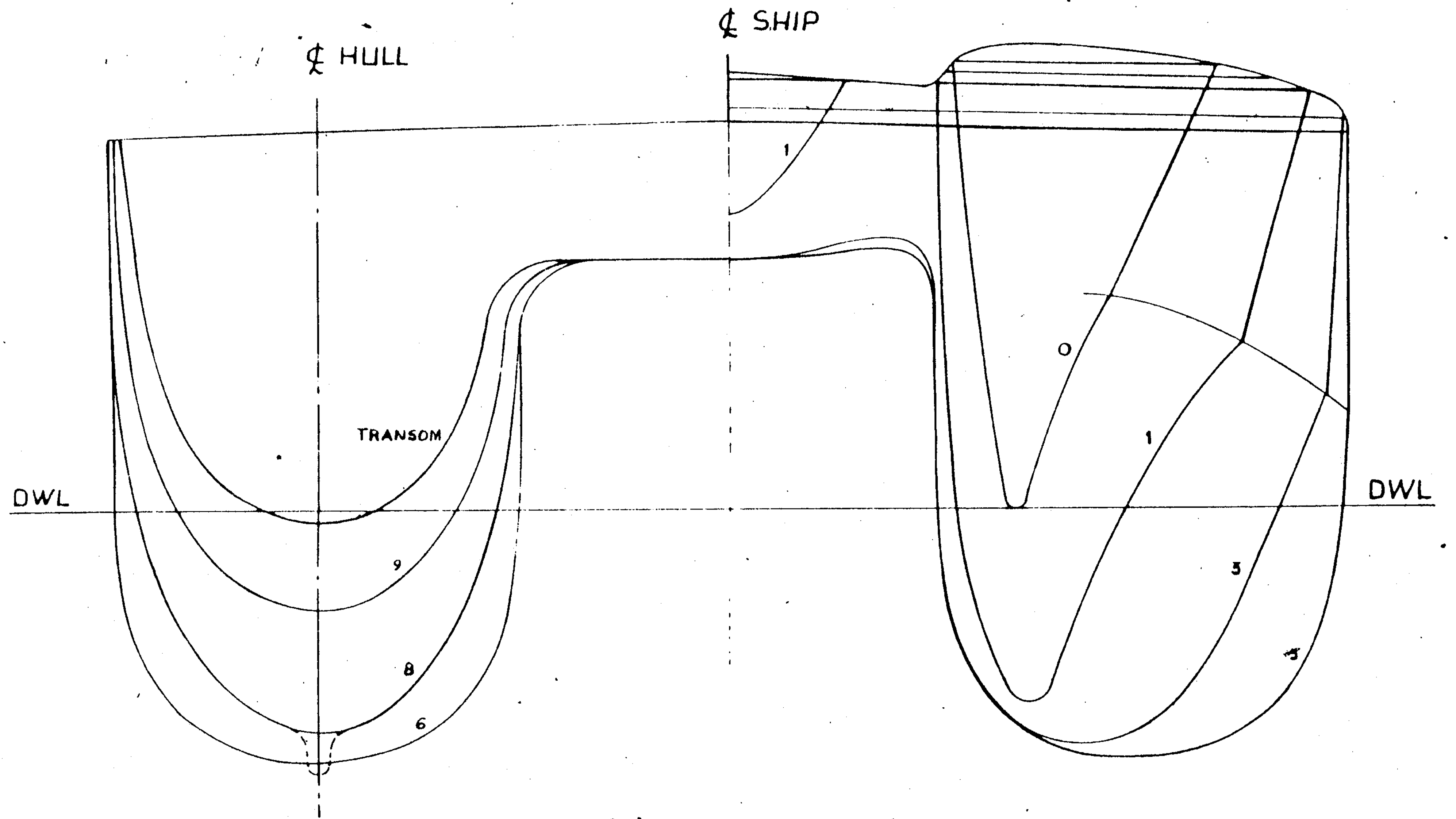
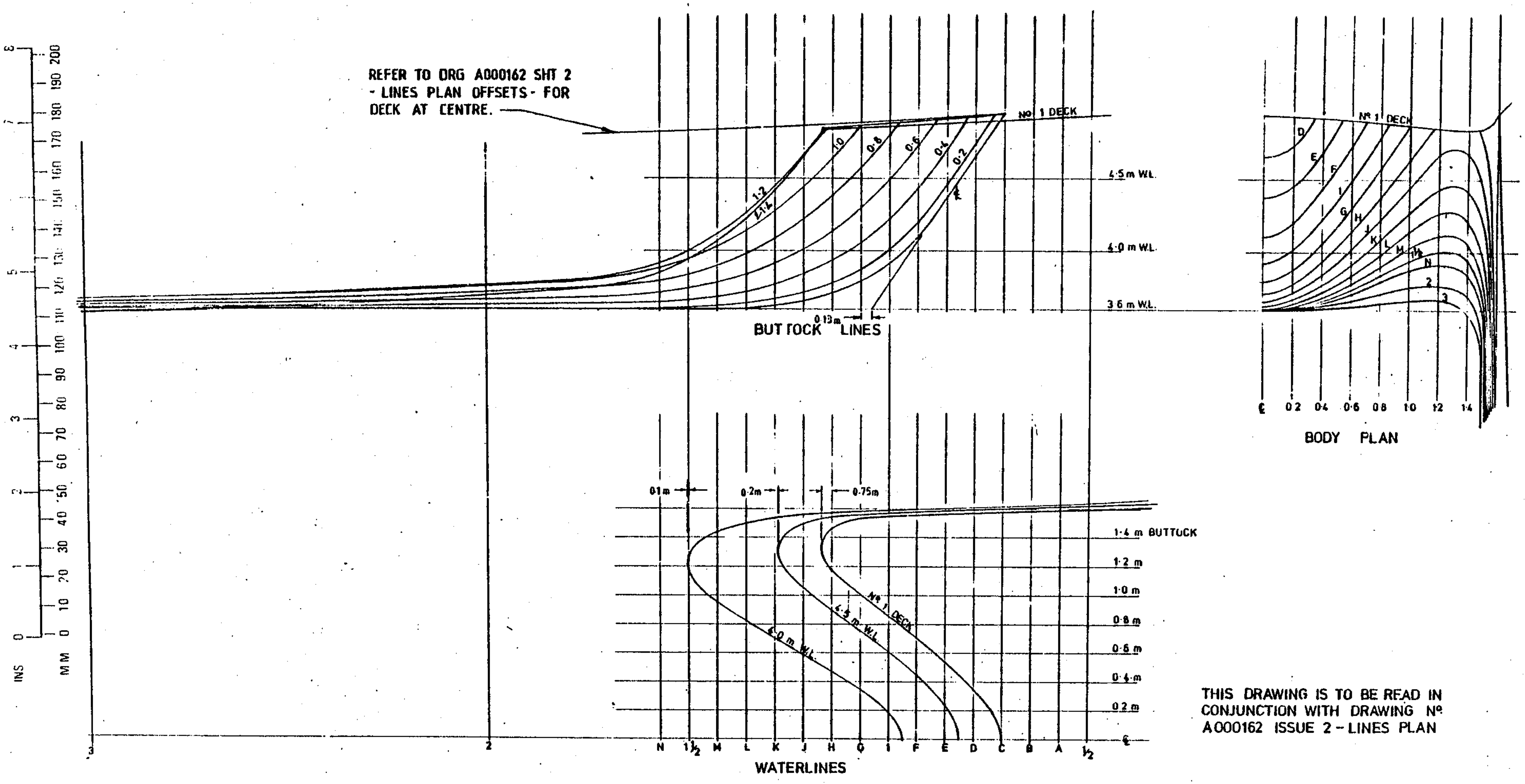


Figure 3 Lines - Body Plan

DRAWING NUMBER	SHT NO/ISSUE
A 000203	3

FIG 4



THIS DRAWING IS TO BE READ IN CONJUNCTION WITH DRAWING No A000162 ISSUE 2 - LINES PLAN

ISSUE NO	DATE	DRN	CHKD	DESCRIPTION OF CHANGE	VER ZONE	HOR REF
3	3.10.80	D.R.	D.R.	℄ SHOWN ON 'BUTTOCK LINES' VIEW.	5	B.
2	13.12.77	GH		REDRAWN FOR ASYMMETRIC HULL FORM		

TOLERANCES, FINISHES ETC.
EST WT.
DIMENSIONS ARE IN
DRG PRACTICE TO
CFEC IDENT No Z3821
CONTRACTOR OR ORIGINATOR: NAVY OFFICE

DRAWN	GH	13/12/77
DRG CHECKED		/ /
DES CHECKED	BLR.	17/2/78
PASSED		/ /
APPROVED	[signature]	17/4/78
CONTR ORIGR DRAWING REF	D.F.D.	

DEPARTMENT OF DEFENCE (NAVY) AUSTRALIA

PROJECT/SHIP: MHJ 000

SEC CLASS: UNCLASSIFIED.

TITLE: MINEHUNTER CATAMARAN
LINES PLAN OF FORWARD CENTRE HULL
ASYMMETRIC HULL FORM

SCALE: 1:20

DRAWING NUMBER: A 000203

SHT NO: 1 OF 2 ISSUE: 3

PUNCH CARD TITLE

Fig. 4

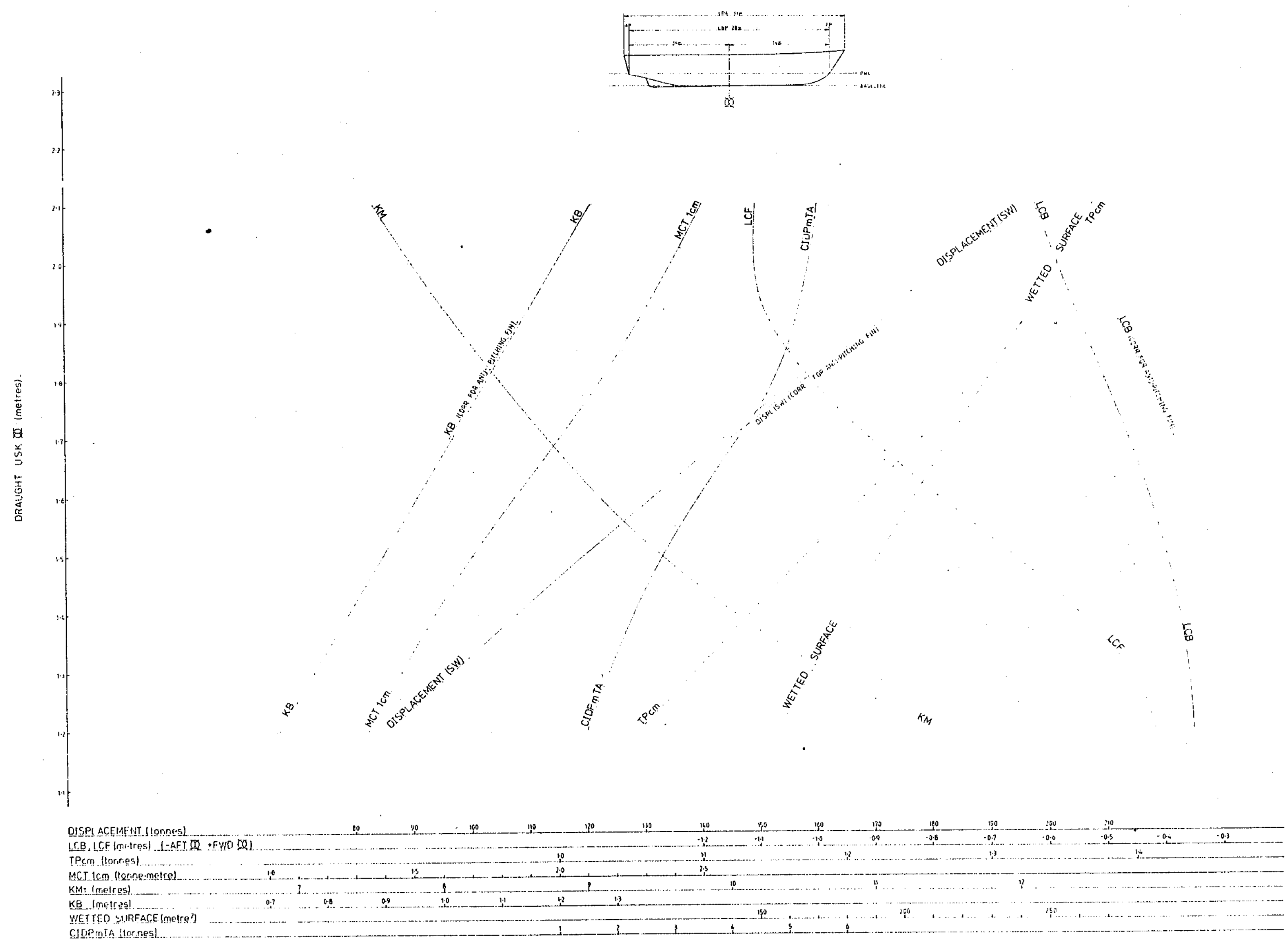


FIG 5

079

DEPARTMENT OF DEFENCE (NAVY) AUSTRALIA

PROJECT/SHIP MHJ-00

TITLE HYDROSTATIC CURVES

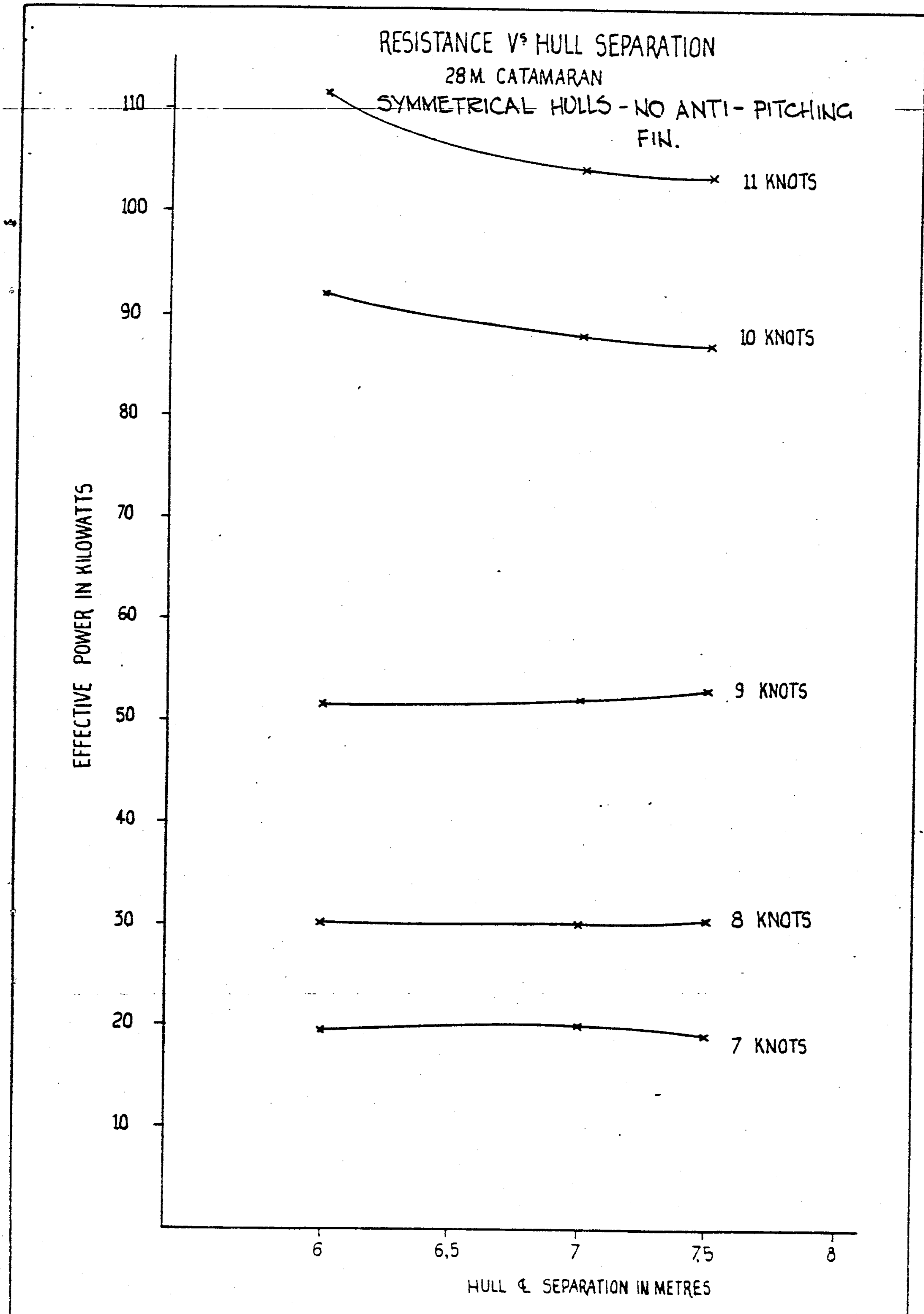
DRAWING NUMBER A003338

SECY CLASS UNCLASSIFIED

NAVY OFFICE DNSD

Z3821

FIG 6



RAN MINEHUNTER

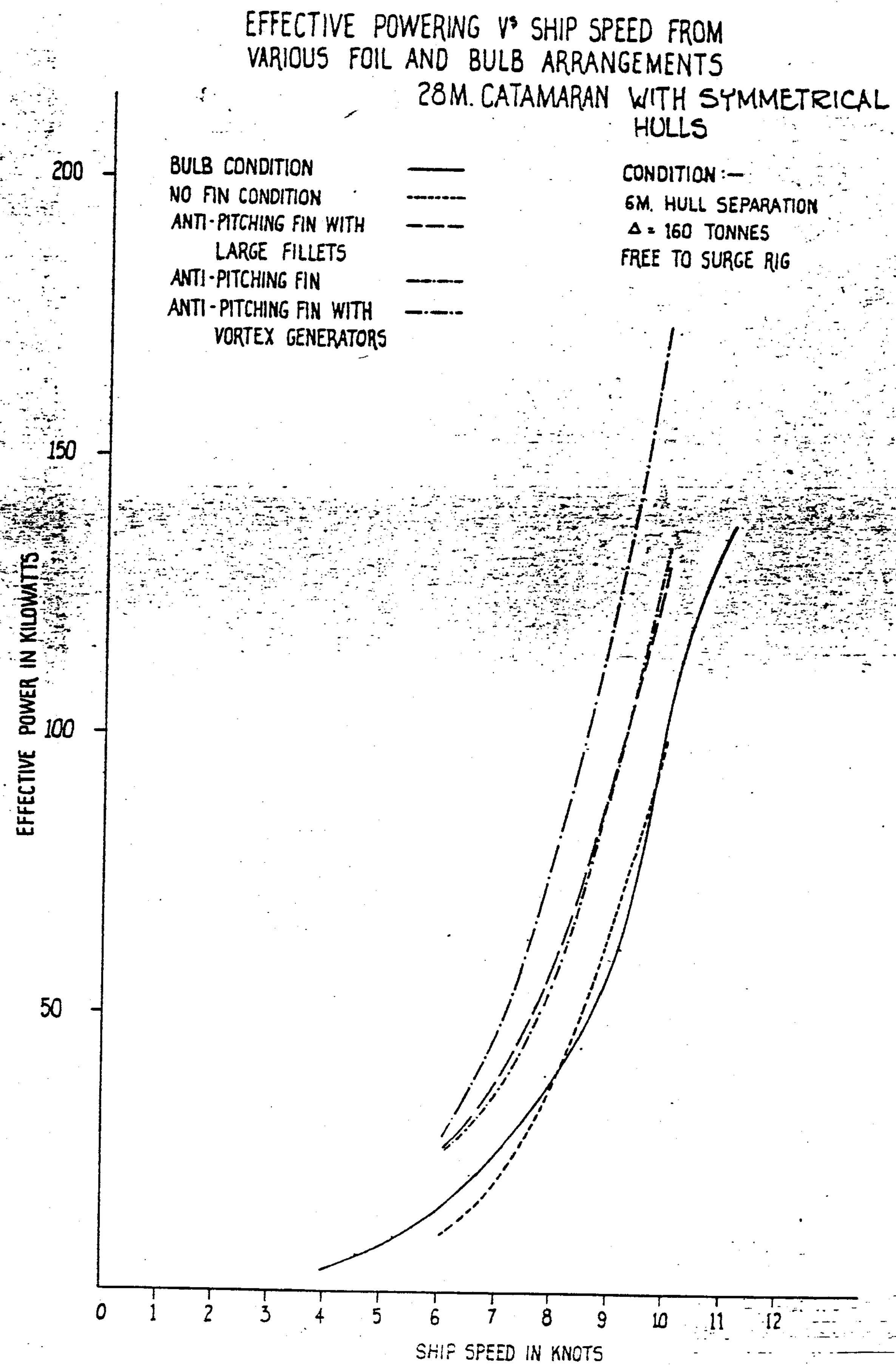
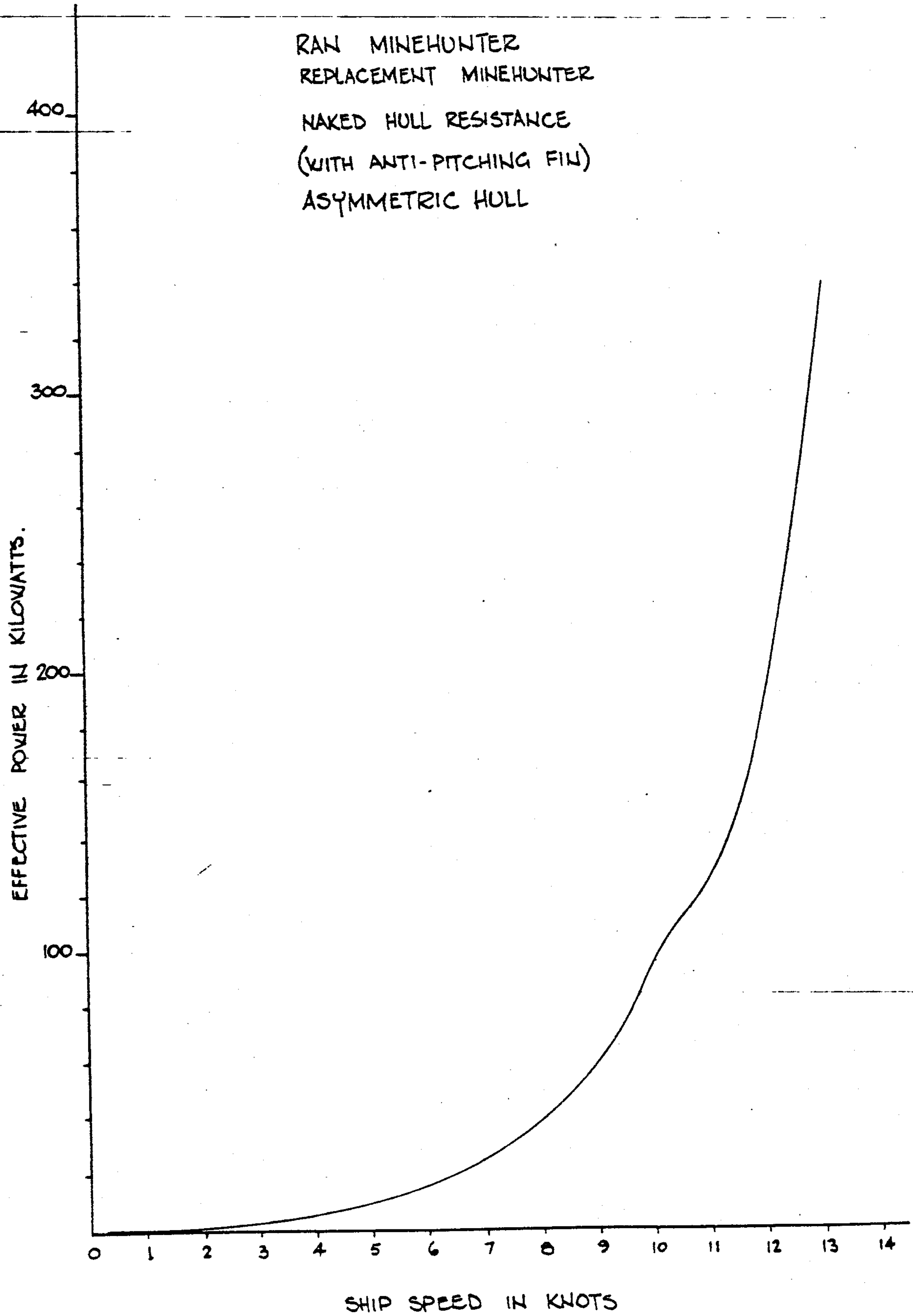

EFFECTIVE POWERING V^s SHIP SPEED FROM
VARIOUS FOIL AND BULB ARRANGEMENTS
28M. CATAMARAN WITH SYMMETRICAL HULLS
BULB CONDITION
NO FIN CONDITION
ANTI-PITCHING FIN WITH LARGE FILLETS
ANTI-PITCHING FIN
ANTI-PITCHING FIN WITH VORTEX GENERATORS
CONDITION :—
6M. HULL SEPARATION
Δ = 160 TONNES
FREE TO SURGE RIG
EFFECTIVE POWER IN KILOWATTS
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
SHIP SPEED IN KNOTS

Fig. 7

FIG 8



RAN MINEHUNTER
REPLACEMENT MINEHUNTER
NAKED HULL RESISTANCE
(WITH ANTI-PITCHING FIN)
ASYMMETRIC HULL
EFFECTIVE POWER IN KILOWATTS.
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
SHIP SPEED IN KNOTS

Fig 9

RAN MINEHUNTER
HEAVE RESPONSE
ASYMMETRIC HULL
WITH ANTI-PITCHING FIN
(10 KNOTS HEAD SEAS)

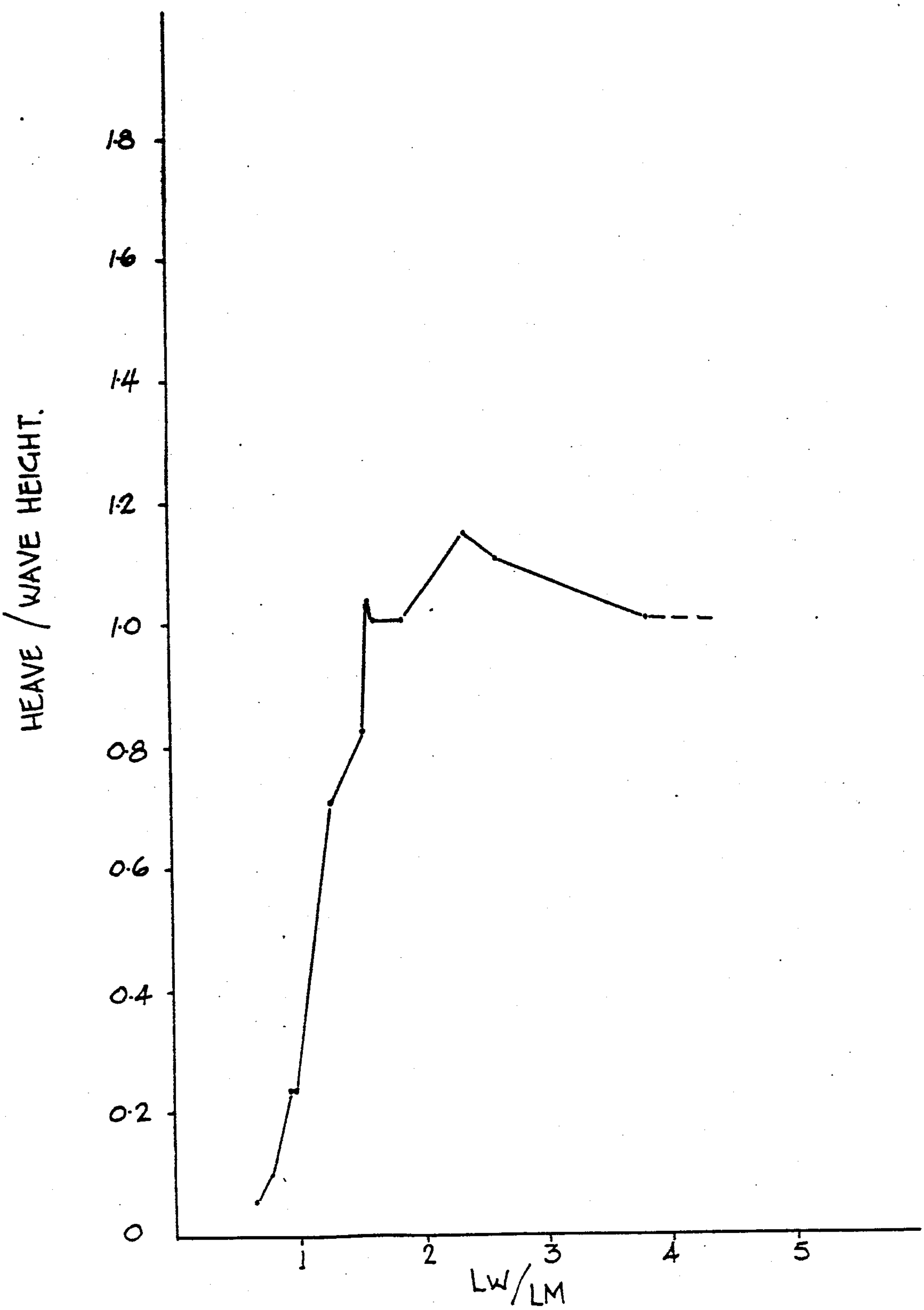
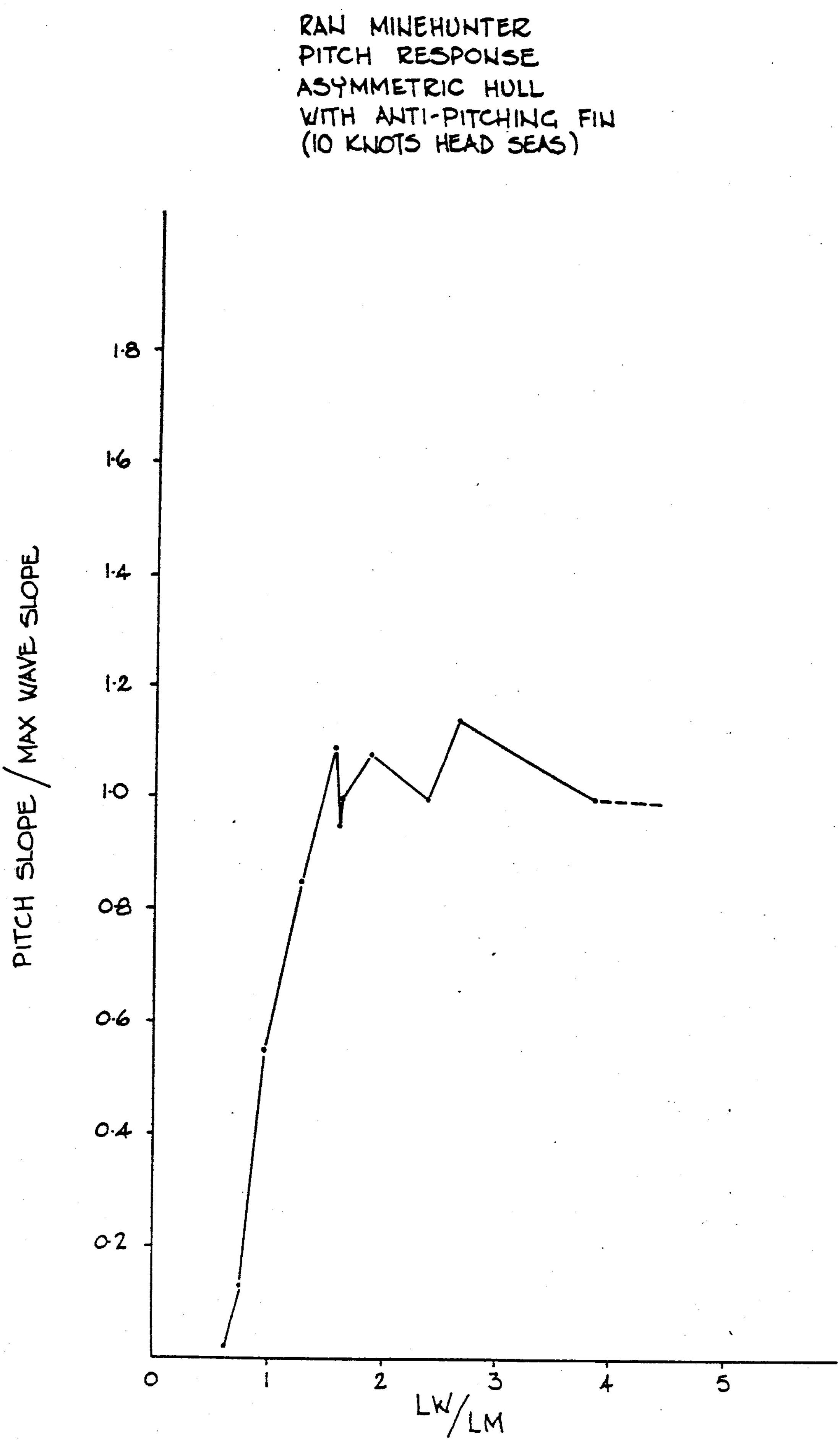


Fig. 10


RAN MINEHUNTER
PITCH RESPONSE
ASYMMETRIC HULL
WITH ANTI-PITCHING FIN
(10 KNOTS HEAD SEAS)
PITCH SLOPE / MAX WAVE SLOPE
1·8
1·6
1·4
1·2
1·0
0·8
0·6
0·4
0·2
0
1
2
3
4
5
LW/LM

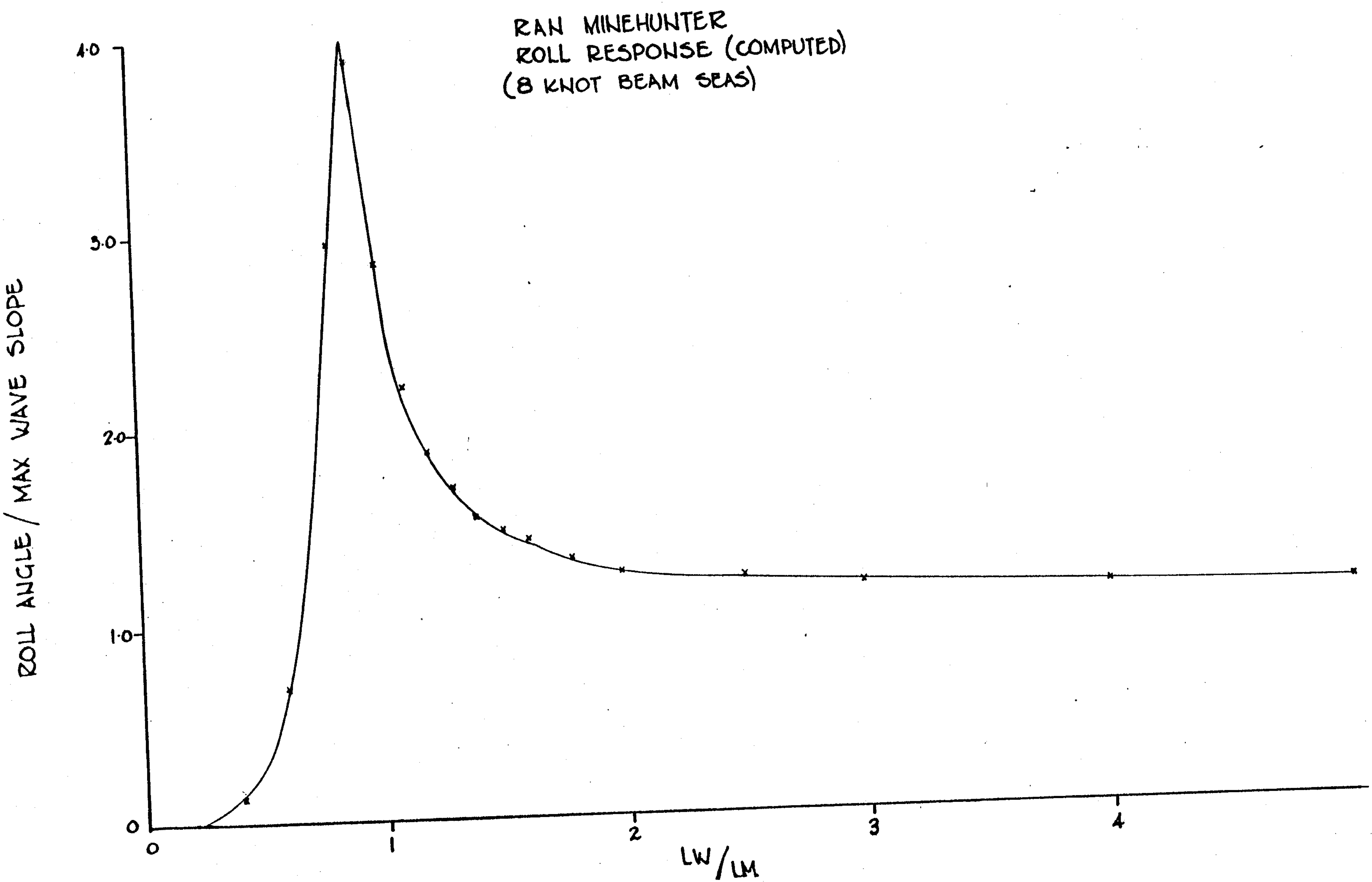

RAN MINEHUNTER
ROLL RESPONSE (COMPUTED)
(8 KNOT BEAM SEAS)
ROLL ANGLE / MAX WAVE SLOPE
4.0
3.0
2.0
1.0
0
0
1
2
3
4
LW/LM

FIG. 11

TABLE 1

	Foam Sandwich	Single skin as for "Wilton"	Modified Single Skin
Lay up details	Inner & Outer skins 8mm thick 7 LES with 60mm PVC foam	43 layers 24oz/ yd^2 woven rovings	20 layers 830gm/ M^2 Woven rovings
Skin Thickness	76mm	41mm	20mm
Hull Weight	70.75 tonnes	120.0 tonnes	78.0 tonnes

TABLE 2

Required test results - foam core material

TEST	FOAM TYPE	UNITS OF RESULTS	NO OF TESTS FOR TYPE APPROVAL	INDIV TEST RESULTS	MEAN OF TESTS	NO OF TESTS FOR BATCH SAMPLING
Thickness	HDF 130	mm	40	60 ± 2	60 ± 1	each slab to be measured 8
	SDF 100	mm	40	30 ± 1	30 ± 1	
Density	HDF 130	kg/m^3	40	130 ± 15	130 ± 3	each slab to be measured
	SDF 100	kg/m^3	40	100 ± 10	100 ± 3	
Tensile Strength 20°C	HDF 130	MPa	10	3.2 (min)	3.4 (min)	0
	SDF 100	MPa	10	2.2 (min)	2.3 (min)	0
Tensile Modulus 20°C	HDF 130	MPa	10	42 (min)	50 (min)	0
	SDF 100	MPa	10	(Report)		0
Compressive Strength 20°C	HDF 130	MPa	10	1.8 (min)	1.9 (min)	0
	SDF 100	MPa	10	1.2 (min)	1.3 (min)	0
Compressive Modulus 20°C	HDF 130	MPa	10	40 (min)	42 (min)	0
	SDF 100	MPa	100	(Report)		0
Shear Strength 20°C	HDF 130	MPa	10	1.7	1.8	2
	SDF 100	MPa	10	1.1	1.2	2
Shear Modulus 20°C	HDF 130	MPa	10	60	65	2
	SDF 100	MPa	10	(Report)		2

TABLE 3 REQUIRED TEST RESULTS
CHOPPED STRAND MAT

Property	Nominal Value	Limits
Width (cm)	100 or 200 or as agreed between the supplier and the purchaser	+3 at any point -0 (see Note 1)
Moisture content (mass %)	-	0.5% max
Loss on ignition (mass %)	Percentage as agreed between the supplier and the purchaser	± 2% (see Note 2)
Average mass per unit area (g/m^2)	300	± 8%
Percentage variation in mass per unit area	-	Individual specimens not more than 19% from the nominal mass per unit area and the range not to exceed. No of Specimens / Range 8 / 25%) of the nominal mass 10 / 26%) per unit area The mean of mass/unit area of the sample shall be $300 g/m^2$ $\pm 15 g/m^2$
Cross-breaking strength of laminate (MPa*)	-	Mean of dry samples = 186 MPa range to be reported Mean of wet samples to be reported range of wet sample to be reported

P10655

Conductivity of water extract (mS/m) (See Note 3)	-	12.5 max

* 1 MPa = 1 MN/m^2

NOTE 1. These tolerances apply only to mat trimmed on both edges.

NOTE 2. For example, if the nominal loss on ignition is 6%, the actual loss on ignition may be between 4% and 8%.

NOTE 3. 1 mS/m = 10 micromhos per centimetre.

TABLE 4 CONSTRUCTION REQUIREMENTS FOR WOVEN ROVINGS

Property	Units	Value	Tolerance
Mass per unit area	g/m^2	600	± 5%
Warp - Ends	per 100mm	19.7	± 5%
Wef - Picks	per 100mm	15.8	± 5%
Nominal linear			
density of roving Tex			
warp	g/km	1500	
weft	g/km	1800	
Width, to outermost			
warp ends	mm	1000	± 2%
Selvedge tassels	mm	20	± 10%
Approximate thickness	mm	0.55	

TABLE 5 REQUIRED PROPERTIES FOR RESINS

PROPERTY	MAX OR MIN	UNITS	VALUE
Specific gravity	-	-	1.10 to 1.15
Acid value	Max	mg KOH/gm	20.0
Volatile content	Max	%	46.0
Gel time at 25°	-	minutes	120 to 150
Temperature of deflection under load of cast resin	Min	°C	60
Water absorption (24 hours)	Max	mg	30
Water absorption (100 days)	Max	mg	150
Flammability	-	-	To be reported

			GRADE 'S'	GRADE 'LV'
Resin Viscosity at 25°C				
True shear rate:				
at 100/sec	Max	Poise	9.0	-
at 0.2/sec	Min	Poise	55.0	-
Mean shear rate:				
at 50 rpm	Range	Poise	11 to 16	6 to 12
at 5 rpm	Min	Poise	30	-
	Max	Poise		15

P10655

TABLE 6 REQUIRED WOVEN ROVING LAMINATE
PROPERTIES WITH SPECIFIED RESIN
FOR TYPE APPROVAL

Property	Max or Min	Unit	Value 'S' Grade and 'LV' Grade Resins
Cross breaking strength of Laminate	min	MPa	275
Cross breaking strength of Laminate at nominal deflection temperature after 168 hours at this temperature	min	MPa	138
Cross breaking strength of Laminate after 100 days immersion in water at 7 MPa	min	MPa	To be reported
Compression strength	min	MPa	170
Compression modulus	min	MPa	15,900
Compression modulus after 100 days immersion in water at 7 MPa	min	MPa	13,800
Compression strength			To be reported
Tensile strength	min	MPa	228
Delayed lay-up - cross breaking strength	-	MPa	To be reported
Delayed lay-up - inter laminar shear strength	-	MPa	To be reported
Resin content individual specimens	range	% weight	46 to 54
Resin content - average of 14 specimens (para 7.2.5)	range	% weight	48 to 52

Degree of resin cure		Barcol Hardness	Minimum at 48hrs and 72 hrs to be quoted

NOTE: The properties of laminate produced using LV grade resin are to be as for 'S' grade resin.

TABLE 7 REQUIRED COMPOSITE LAMINATE PROPERTIES FOR RESIN TYPE APPROVAL

Property	Max or Min	Units	Value 'S' Grade & 'LV' Grade Resins
Cross breaking strength of laminate	min	MPa	214
Cross breaking strength of laminate at nominal deflection temperature after 168 hours at this temperature	min	MPa	To be reported
Cross breaking strength of laminate after 100 days immersion in water at 7 MPa.	min	MPa	75% of initial cross breaking strength
Compression strength	min	MPa	149
Compression modulus	min	MPa	10,896
Compression strength after 100 days immersion in water at 7 MPa	min	MPa	112
Compression modulus after 100 days immersion in water at 7 MPa.	min	MPa	To be reported
Tensile strength	min	MPa	122
Delayed lay-up - cross breaking strength	-	MPa	To be reported

Delayed lay-up - inter laminar shear strength	-	MPa	To be reported
Resin content - individual specimens	range	% weight	56 to 64
Resin content - average of 14 specimens	range	% weight	58 to 62
Degree of resin cure		Barcol Hardness	Minimum at 48 hrs and 72 hrs to be quoted

NOTE: The properties of laminate produced using LV grade resin are to be as for S grade resin.

TABLE 8 - TEST RESULTS ON H130 FOAM
AT ELEVATED TEMPERATURES

Temp C°	Compressive Strength MPa	Compressive Modulus MPa
20	2.01	45.00
30	1.92	36.80
40	1.77	42.90
50	1.56	37.60
65	1.02	28.00

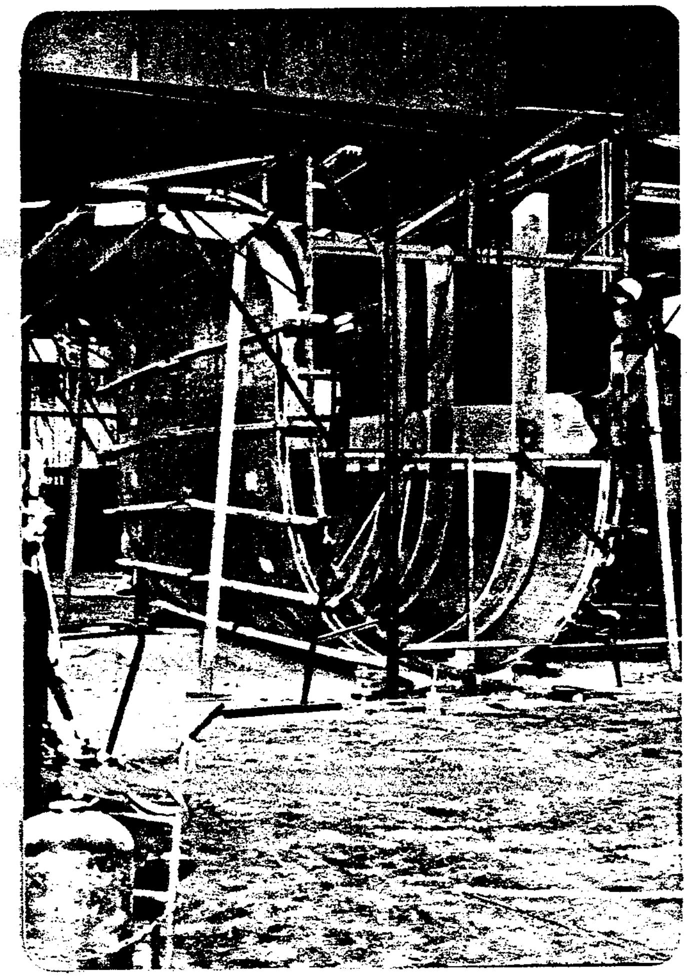
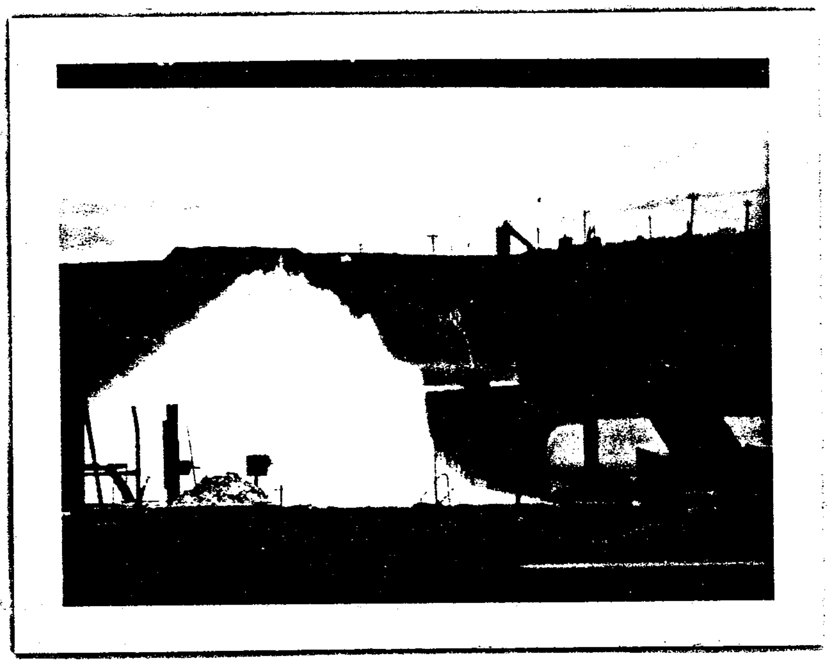


FIG. 12



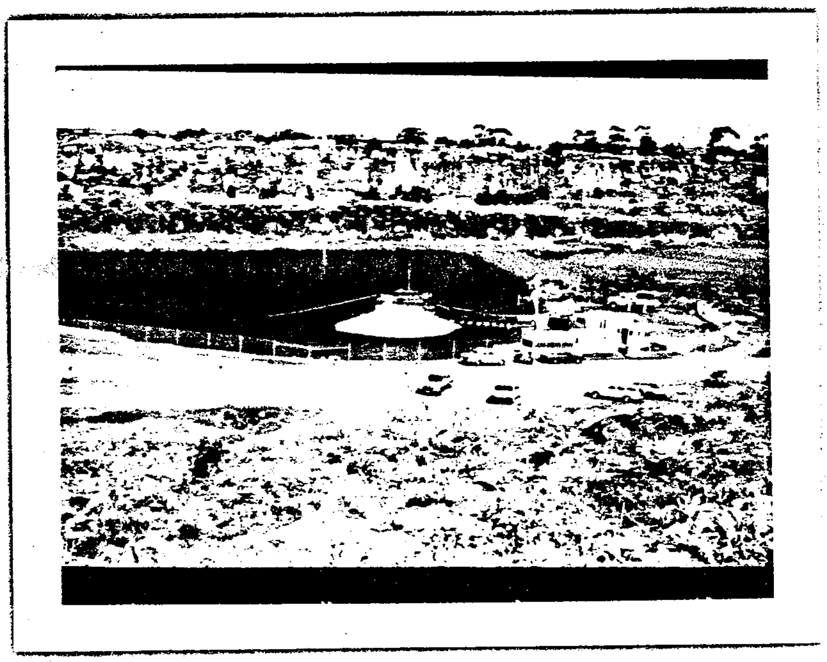
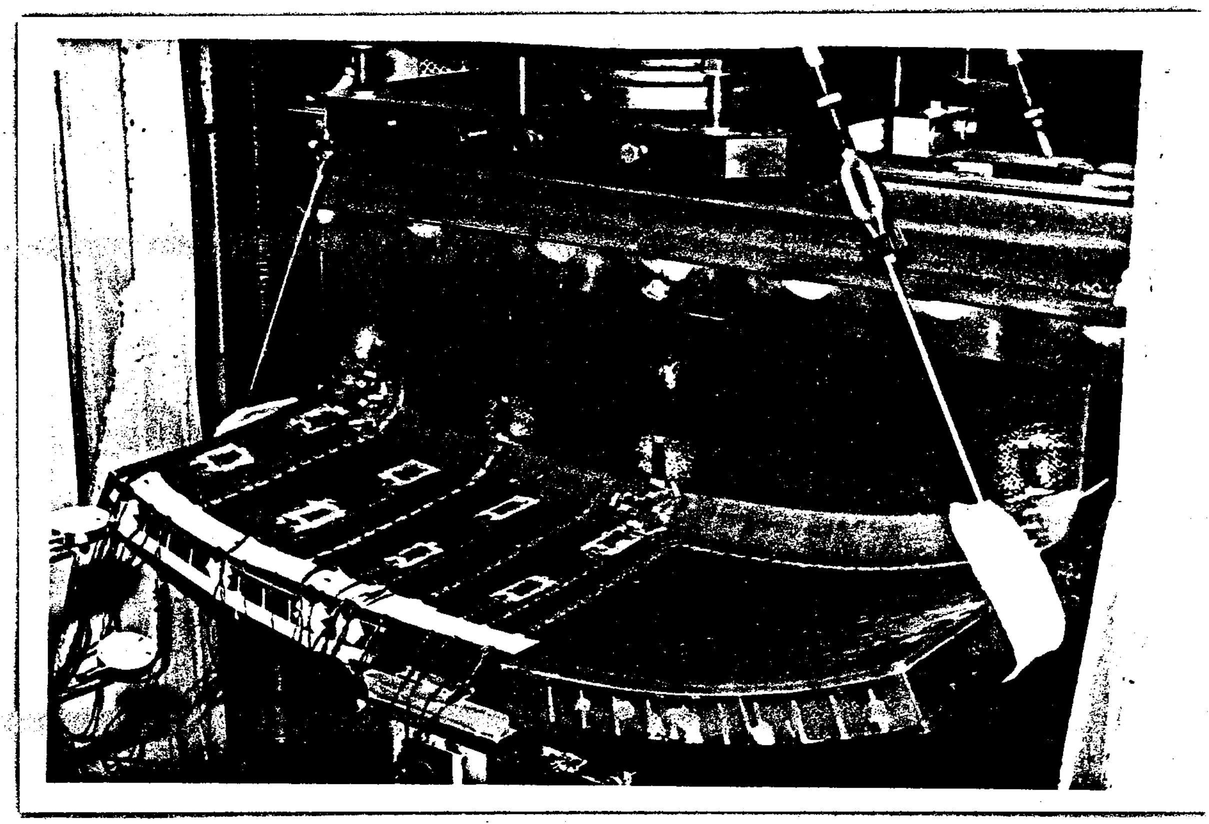


FIG 13



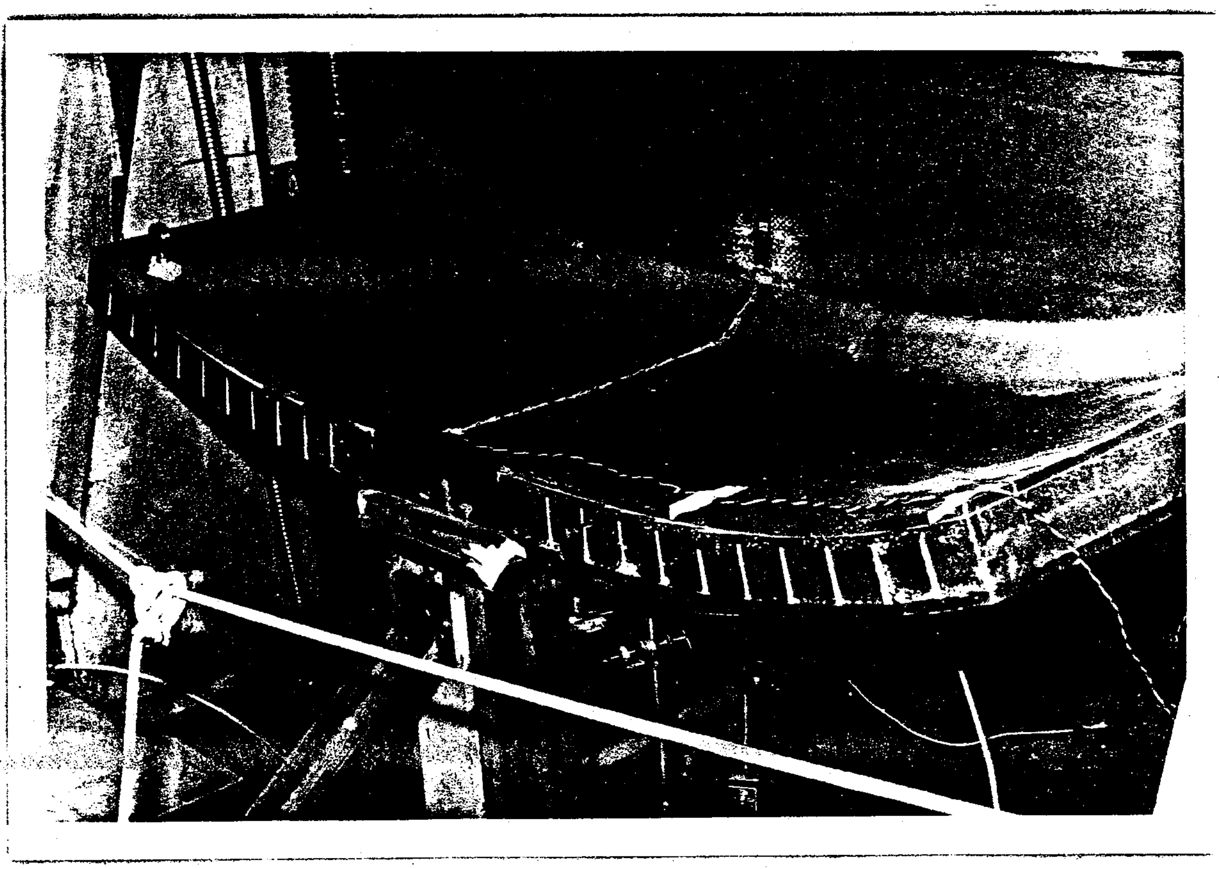


FIG 14

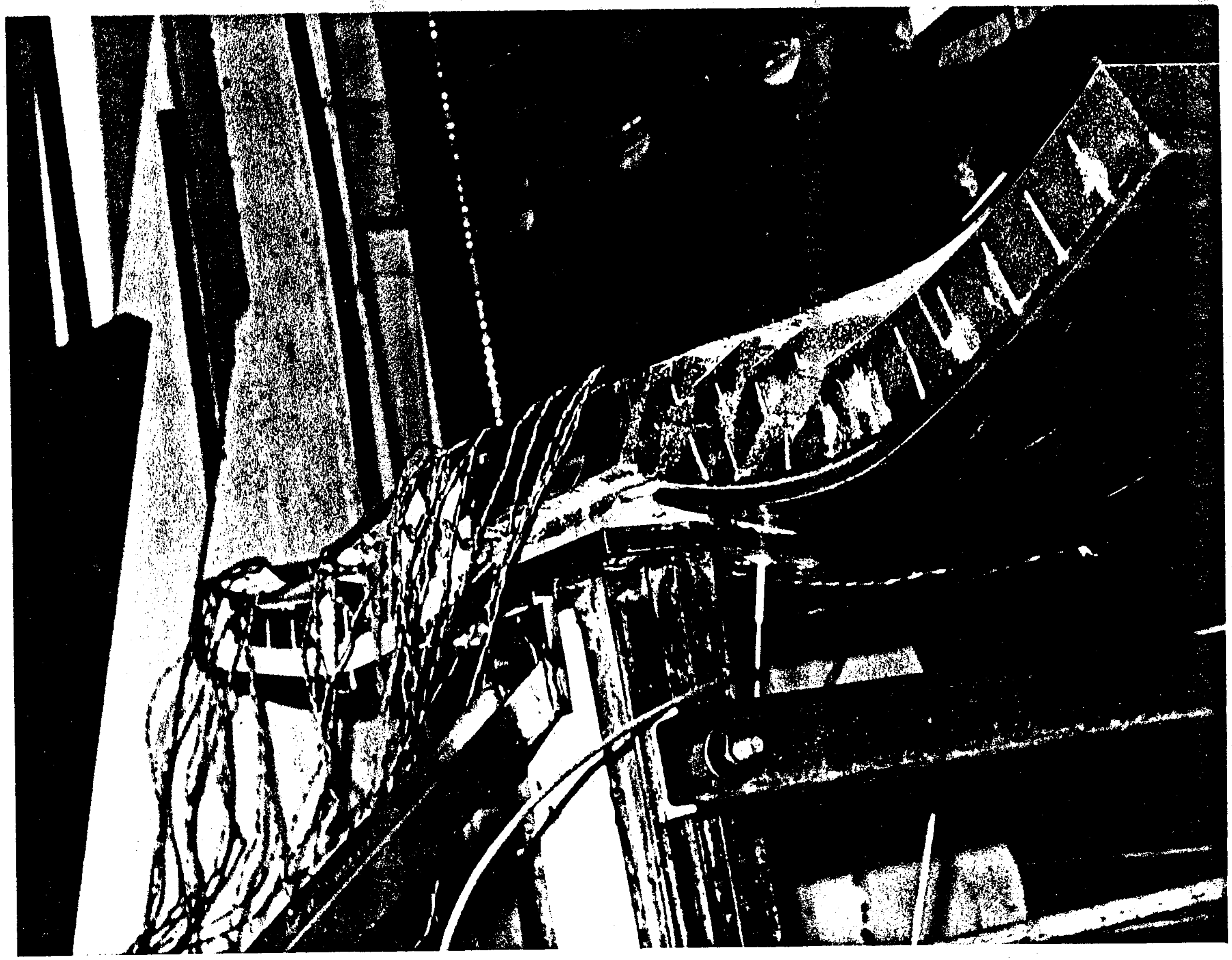
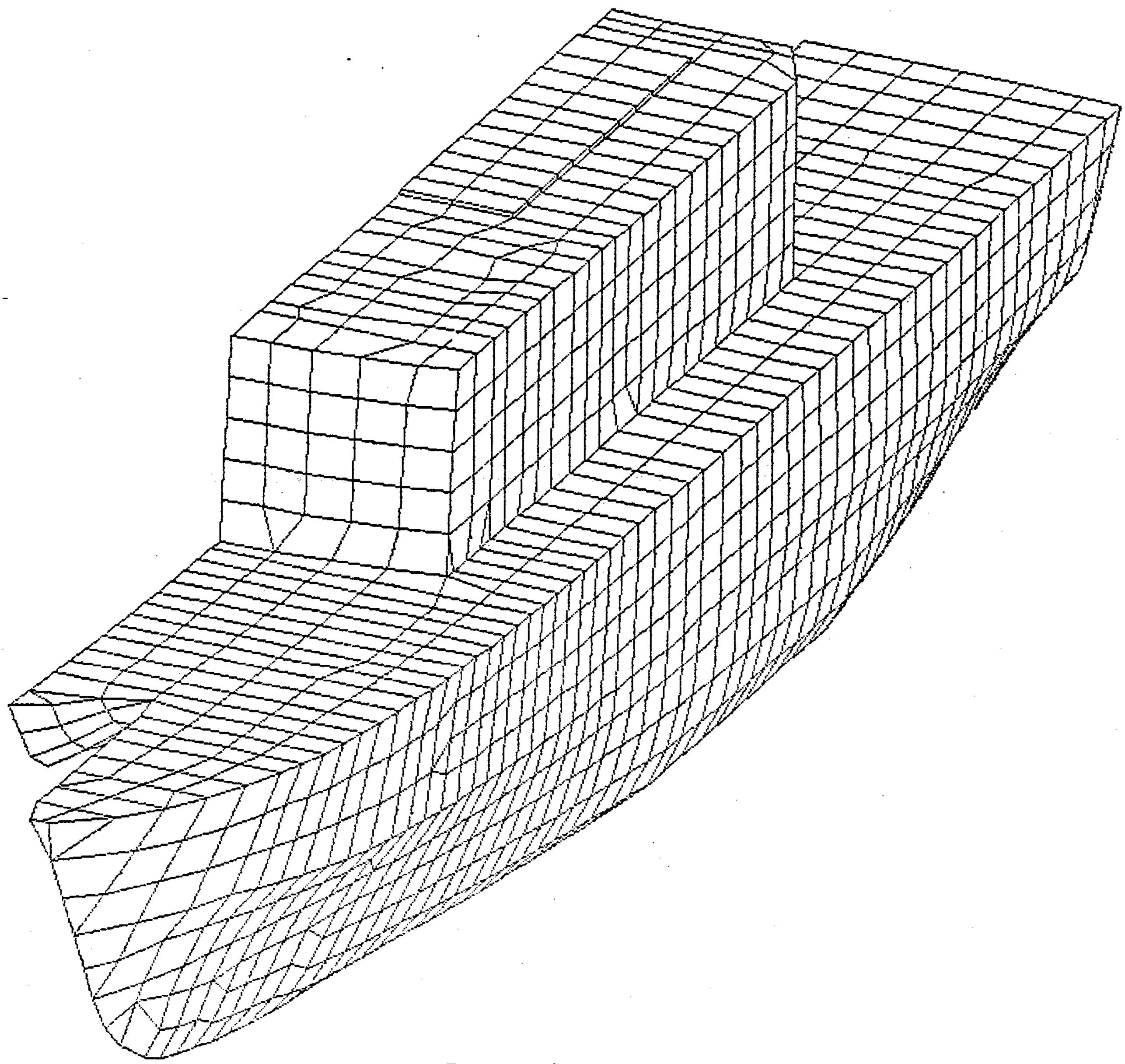


Fig. 14A

PROJECT MHJ-00, GENERAL VIEW

EXTERIOR VIEW - HIDDEN LINES REMOVED



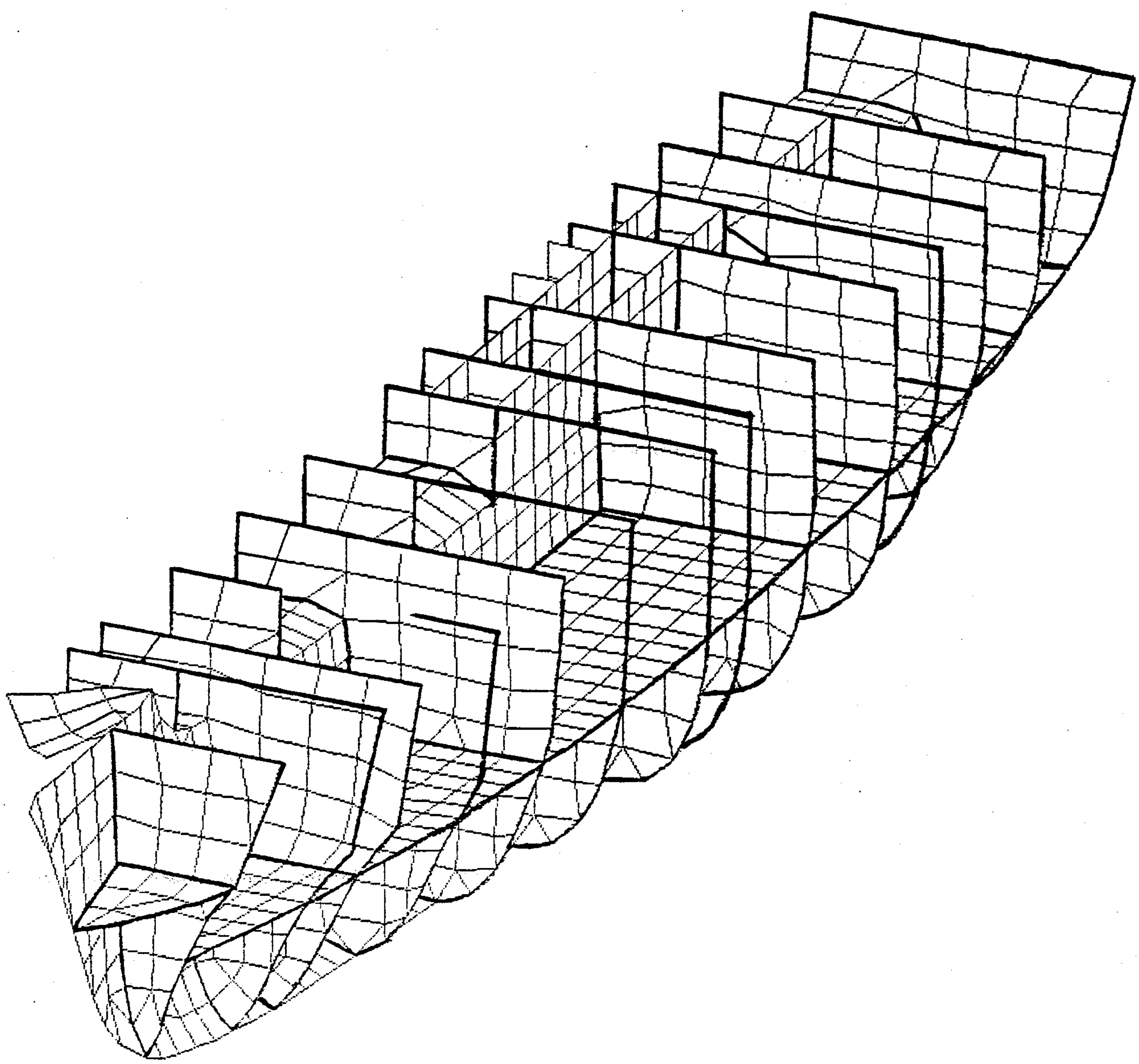
81/06/03.

FIG. 15A

PROGRAM SKHIDE

PROJECT MHJ-00, GENERAL VIEW

CUTAWAY VIEW BELOW 1 DECK - HIDDEN LINES REMOVED.



81/06/03.

FIG. 15B

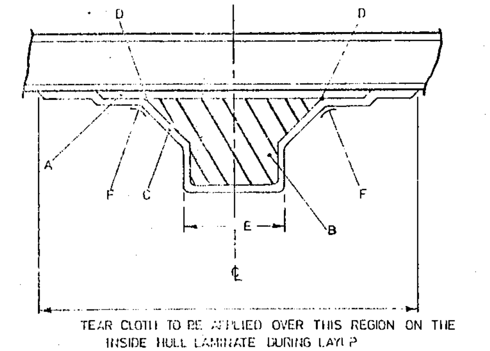
PROGRAM SKHIDE

UNCLASSIFIED

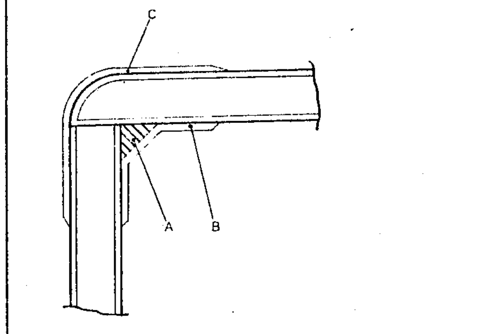
DRAWING NUMBER	SHT. NO	ISSUE
A002546	1 OF 6	1

SEC'Y CLASS UNCLASSIFIED

101



DETAIL N° 1



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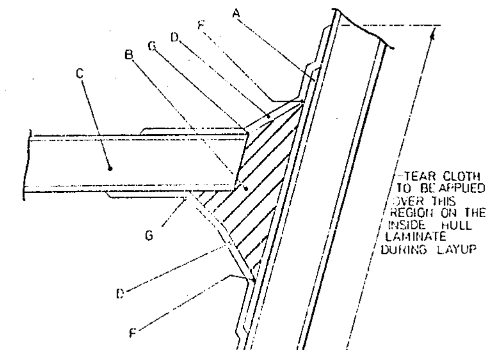
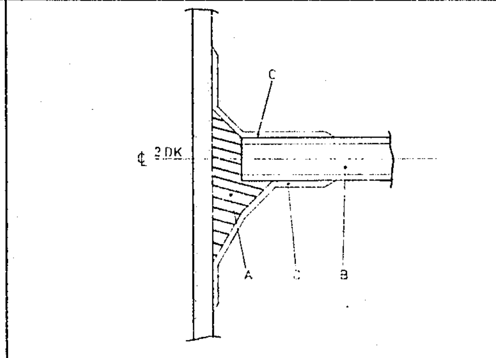
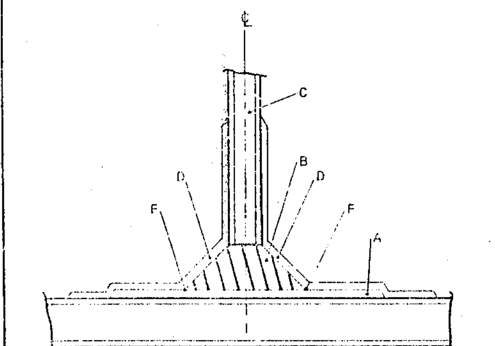


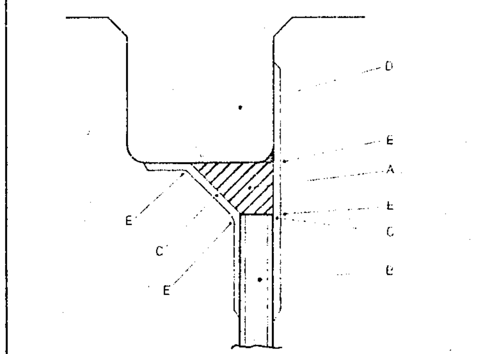
DETAIL N° 3



DETAIL N° 5



DETAIL N° 7



DETAIL N° 8

Detail No 1
Tear cloth to be removed as necessary.

Item A: GRP, 1 ply CSM laid onto laminates as PB extends 150mm each side of girder centreline.

Item B: HDF, glued onto item A as PB using PR.

Item C: GRP, 7 layers, SOT 100mm from Points D TR 10:1, PB.

Item E: GRP 1 extra layer to be included before the last layer of item C on face of stiffener only. PB.

Item F: GRP 1 extra layer to be included before the the last layer of item C, PB. The CSM of Item F to extend 25mm each side of re-entrant corner, D. The WR of item F to extend 50mm each side of re-entrant corner D.

Detail No 3

Item A: SDF, glued in with PRP, SB.

Item B: GRP, 7 layers, SOT 100mm from Item A, TR 15:1, PB or SB to deck and hull laminates.

Item C: GRP, 7 layers, SOT 300mm from gunwale curve. PB or SB to deck and hull laminates, TR 20:1.

Detail No 5

Item A: HDF, glued to sonar trunk girth using PR.

Item B: 2 Dk, glued to Item A using PRP.

Item C: GRP, 7 layers, SOT 100mm from re-entrant corners, TR 10:1, SB. (tear cloth may be used on 2 DK).

Detail No 7

Item A: GRP, 1 ply CSM laid onto deck laminates to extend 120mm either side of centreline of Item C.

Item B: HDF, glued onto item A using PR.

Item C: Superstructure side, glued to item B using PR.

Item D: GRP, 10 layers, 1st ply 70mm wide, placed with 50mm of its width on deck from Points F, SOT at each side of 1st ply, TR 10:1, laminate laid on as SB or PB using tear cloth on SS side and as PB using tear cloths on 1 DK.

Detail No 6
Tear cloth removed as necessary.

Item A: GRP, 1 ply CSM laid onto hull laminates approx. 300mm wide so as to extend approx [illegible] up and down from Points F.

Item B: [illegible], glued onto Item A with PR.

Item C: Deck, glued to item B using PRP.

Item D: GRP, 10 layers, SOT 100mm from re-entrant [illegible]; TR 10:1, PB to hull and 2 Dk [illegible] use of tear cloths). SB [illegible] used on 2 Dk.

Detail No 8

Item A: HDF, glued to item D using PR

Item B: minor bulkhead glued to item A using PR.

Item C: GRP, 3 layers, SOT 20mm from Points E, TR 10:1 SB or PB using tear cloths.

REFERENCE DRAWINGS:- HULL STRUCTURE SECTIONS---------A000656 SHEETS 1-4, HULL STRUCTURAL PROFILE--A000659 SH 1-2, STRUCTURE IN WAY OF SONAR----A003066.

UNCLASSIFIED

ISSU. NO.	DATE	DRN	CHKD	DESCRIPTION OF CHANGE	VER ZONE	HOR REF
1				ISSUED FOR S.E.R DOCUMENT PRELIMINARY [illegible]		

TOLERANCES, FINISHES ETC.	
EST. WT.	
DIMENSIONS ARE IN	
DRG. PRACTICE TO	AS 1100
CODE IDENT. NO.	Z3821
CONTRACTOR OR ORIGINATOR	NAVY OFFICE

DRAWN	B R	20/11/79
DRG CHECKED	W H	27/11/79
DES CHECKED	[illegible]	[illegible]
PASSED	W H	27/11/79
APPROVED	[signature]	11/2/80
CONTR. ORIGR DRAWING REF.	DNSD	

DEPARTMENT OF DEFENCE (NAVY) AUSTRALIA

PROJECT/SHIP	M H J-00
SEC'Y. CLASS.	UNCLASSIFIED
TITLE	HULL STRUCTURE — LAY UP DETAILS OF CONNECTNS
SCALE	NTS
DRAWING NUMBER	A002546
SHT NO	1 OF 6
ISSUE	1
PUNCH CARD TITLE	

A2

FORM NO. TD 103

Fig. 16

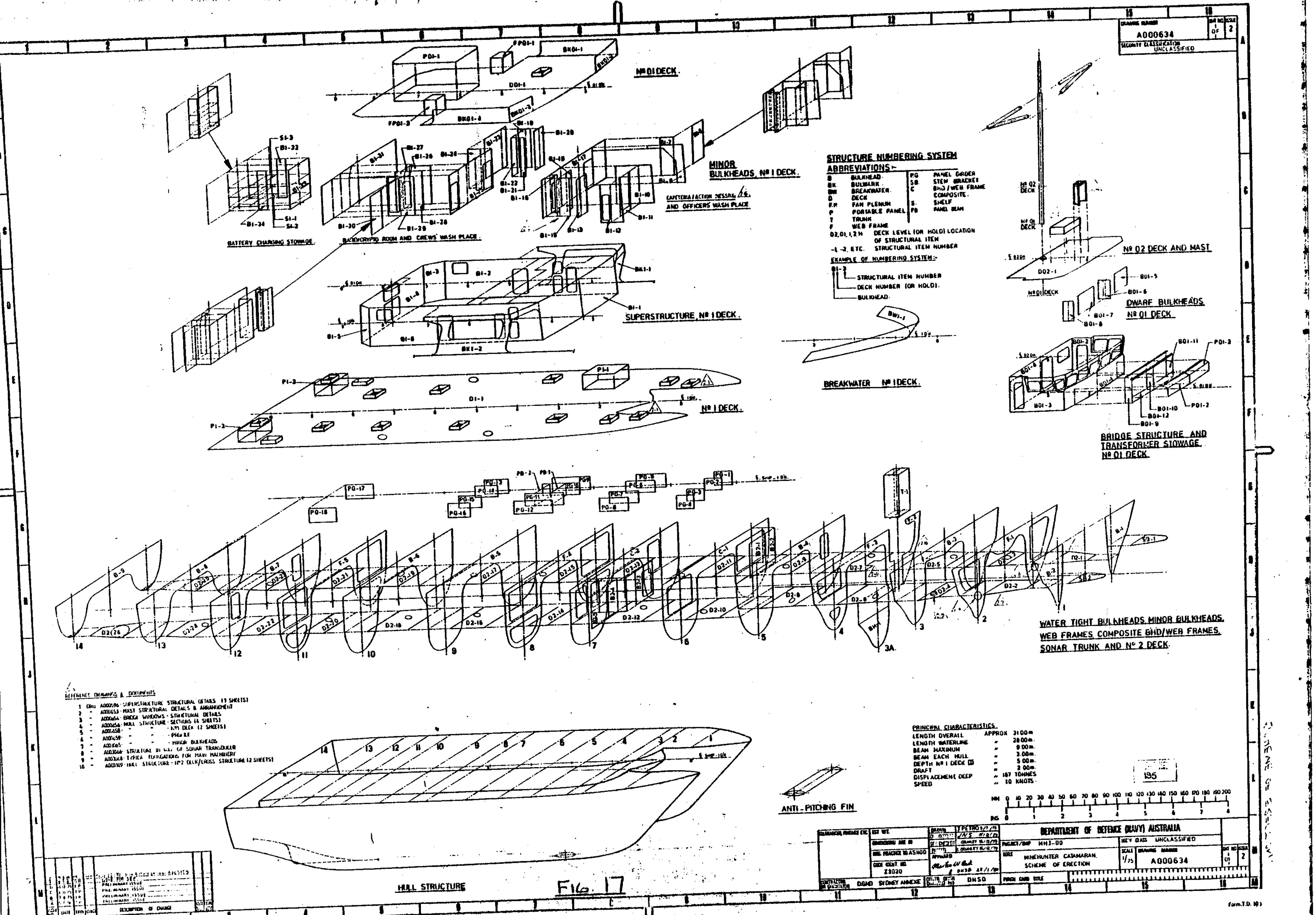

A000634
UNCLASSIFIED
Nº 01 DECK.
MINOR BULKHEADS, Nº 1 DECK.
CAFETERIA/ACTION MESSING & AND OFFICERS WASH PLACE
BATTERY CHARGING STOWAGE.
RADIO/CRYPTO ROOM AND CREWS' WASH PLACE.
SUPERSTRUCTURE, Nº 1 DECK.
Nº 1 DECK.
BREAKWATER Nº 1 DECK.
STRUCTURE NUMBERING SYSTEM
ABBREVIATIONS:-
B BULKHEAD
BK BULWARK
BW BREAKWATER
D DECK
F.P. FAN PLENUM
P PORTABLE PANEL
T TRUNK
F WEB FRAME
PG PANEL GIRDER
SB STEM BRACKET
C BHD/WEB FRAME COMPOSITE
S SHELF
PB PANEL BEAM
O2, O1, 1, 2, H DECK LEVEL (OR HOLD) LOCATION OF STRUCTURAL ITEM
-1, -2, ETC. STRUCTURAL ITEM NUMBER
EXAMPLE OF NUMBERING SYSTEM:-
B1-2 STRUCTURAL ITEM NUMBER
DECK NUMBER (OR HOLD)
BULKHEAD
Nº 02 DECK AND MAST
DWARF BULKHEADS Nº 01 DECK
BRIDGE STRUCTURE AND TRANSFORMER STOWAGE Nº 01 DECK
WATER TIGHT BULKHEADS, MINOR BULKHEADS, WEB FRAMES, COMPOSITE BHD/WEB FRAMES, SONAR TRUNK AND Nº 2 DECK.
REFERENCE DRAWINGS & DOCUMENTS
PRINCIPAL CHARACTERISTICS.
LENGTH OVERALL APPROX 31.00m
LENGTH WATERLINE 28.00m
BEAM MAXIMUM 9.00m
BEAM EACH HULL 3.00m
DEPTH Nº 1 DECK 5.00m
DRAFT 2.00m
DISPLACEMENT DEEP 187 TONNES
SPEED 10 KNOTS
ANTI-PITCHING FIN
HULL STRUCTURE
195
DEPARTMENT OF DEFENCE (NAVY) AUSTRALIA
UNCLASSIFIED
MH3-00
MINEHUNTER CATAMARAN, SCHEME OF ERECTION
1/75
A000634
DNSO
SYDNEY ANNEXE
Z3020
Form T.D. 10

FIG. 17

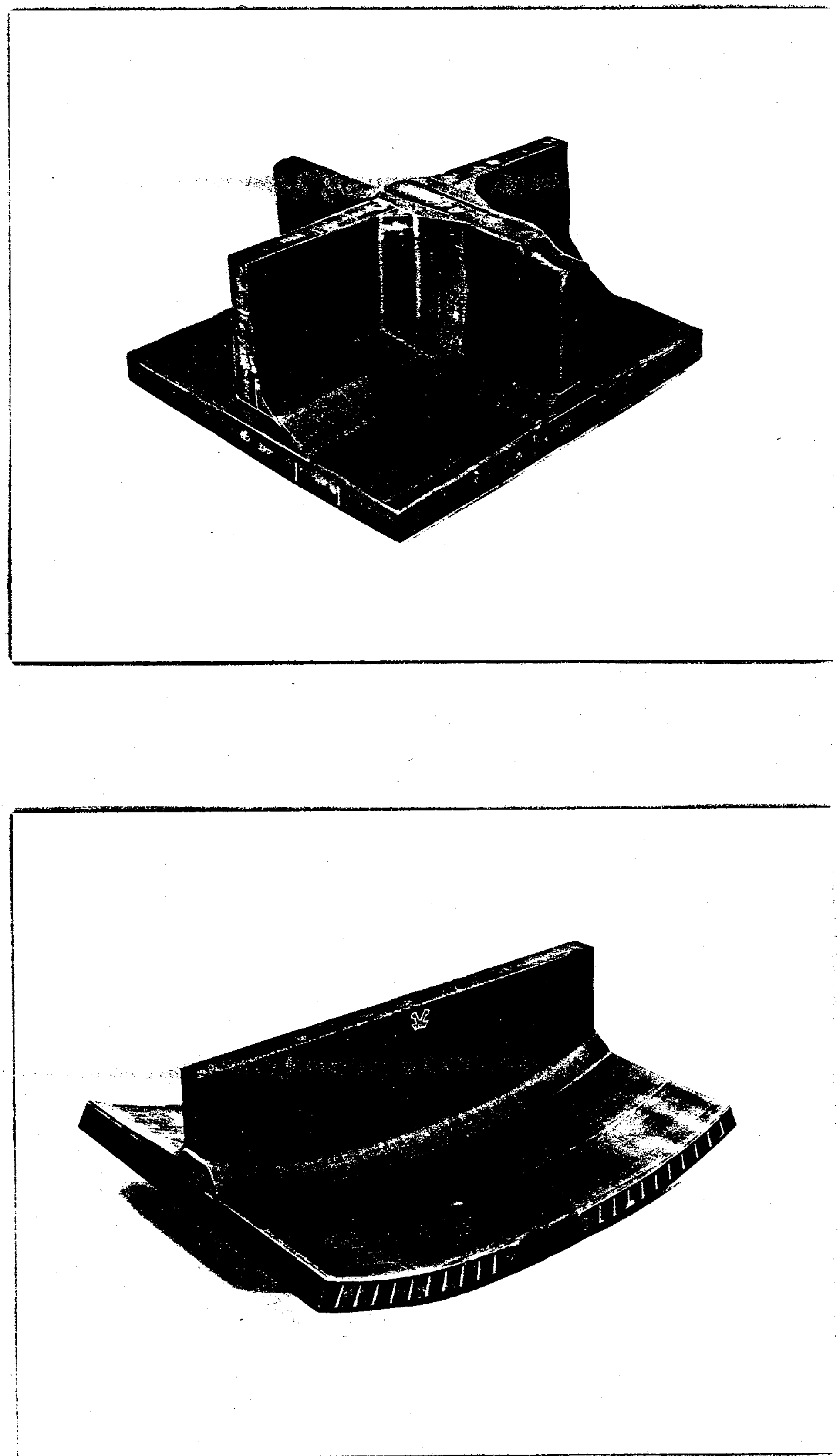


FIG 18

*** PROGRAM EWTLIST *** DATE 13/02/81

MCMV MINE HUNTER CATAMARAN WEIGHT ESTIMATE

++900 MARGINS

+910 MARGINS ON LIGHTSHIP

ITEM NO.	DESCRIPTION	WEIGHT	V.C.G.	MV	L.C.G.	ML	T.C.G.	MT	SPAN	REMARKS
0	DESIGN	9.680	3.41	33.01	-5.00	-48.40	0.00	0.00	28.0	
0	G.F.E.	3.194	3.41	10.89	-5.00	-15.97	0.00	0.00	28.0	
0	BUILDERS	5.000	3.41	17.05	-.46	-2.30	0.00	0.00	28.0	
0	CHANGE IN PRODUCTION	2.000	3.41	6.82	-.46	-.92	0.00	0.00	28.0	
0	NATURAL GROWTH	2.000	3.41	6.82	-.46	-.92	0.00	0.00	28.0	
	TOTAL FOR SUB-GROUP 0	21.874	3.41	74.59	-3.13	-68.51	0.00	0.00		
	TOTAL FOR GROUP 0	21.874	3.41	74.59	-3.13	-68.51	0.00	0.00		

FIG. 19

0	1200 AFT ST.3	PORT	(I)	.264	2.08	.55	-2.55	-.67	-1.60	-.42	13.9	*
0			(I)	.264	2.08	.55	-2.55	-.67	-4.40	-1.16	13.9	*
0		STBD	(I)	.264	2.08	.55	-2.55	-.67	1.60	.42	13.9	*
0	TO		(O)	.264	2.08	.55	-2.55	-.67	4.40	1.16	13.9	*
0	1100 AFT ST.8	PORT	(IE	.038	2.08	.08	-10.50	-.40	-1.90	-.07	2.0	*
0			(O)	.038	2.08	.08	-10.50	-.40	-4.15	-.16	2.0	*
0		STBD	(I)	.038	2.08	.08	-10.50	-.40	1.90	.07	2.0	*
0	TO		(O)	.038	2.08	.08	-10.50	-.40	4.15	.16	2.0	*
0	300 AFT ST.9	PORT	(I)	.023	2.08	.05	-12.90	-.30	-2.10	-.05	2.4	*
0			(O)	.023	2.08	.05	-12.90	-.30	-3.90	-.09	2.4	*
0		STBD	(I)	.023	2.08	.05	-12.90	-.30	2.10	.05	2.4	*
0	TO TRANSOM		(O)	.023	2.08	.05	-12.90	-.30	3.90	.09	2.4	*
	TOTAL FOR SUB-SUB-GROUP		0	2.003	2.22	4.44	.43	.86	.05	.10		
	TOTAL FOR SUB-GROUP		0	4.496	2.20	9.88	-.11	-.50	.08	.36		

+150 SUPERSTRUCTURE AND DECKHOUSES - 01 DECK

150-1 01 DECK PLATING INCLUDING MACHINERY HATCH (W.B.1 PAGE 95)

ITEM NO.	DESCRIPTION		WEIGHT	V.C.G.	MV	L.C.G.	ML	T.C.G.	MT	SPAN	REMARKS
0	UNDER BRIDGE	PORT	.452	7.20	3.25	1.30	.59	-2.10	-.95	6.5	
0		STBD	.452	7.20	3.25	1.30	.59	2.10	.95	6.5	
0	OVER MACHINERY	PORT	.252	7.20	1.81	-4.40	-1.11	-1.50	-.38	5.1	
0		STBD	.252	7.20	1.81	-4.40	-1.11	1.50	.38	5.1	
0	AFT END	PORT	.041	7.20	.30	-7.50	-.31	-1.30	-.05	1.0	
0		STBD	.041	7.20	.30	-7.50	-.31	1.30	.05	1.0	
0	CORNERS AFT	PORT	.004	7.20	.03	-7.50	-.03	-2.80	-.01	1.0	
0		STBD	.004	7.20	.03	-7.50	-.03	2.80	.01	1.0	
0	DECK DELETED FOR MACH'Y HAT.		-.245	7.20	-1.76	-3.90	.96	0.00	0.00	5.5	
0	MACHINERY HATCH		.316	7.20	2.28	-3.90	-1.23	0.00	0.00	5.5	
0	HATCH COAMING & INSERTS		.123	7.20	.89	-3.90	-.48	0.00	0.00	5.5	
	TOTAL FOR SUB-SUB-GROUP	0	1.692	7.20	12.18	-1.46	-2.47	0.00	0.00		

150-2 BEAMS AND GIRDERS UNDER 01 DECK (W.B.1 PAGE 99)

ITEM NO.	DESCRIPTION		WEIGHT	V.C.G.	MV	L.C.G.	ML	T.C.G.	MT	SPAN	REMARKS
0	FWD BEAM 305X250		.145	7.00	1.02	-.90	-.13	0.00	0.00	.3	
0	FWD END OF SIDE GIRDER	PORT	.039	7.00	.27	-.60	-.02	-1.50	-.06	.7	
0		STBD	.039	7.00	.27	-.60	-.02	1.50	.06	.7	
0	TAPERED SECTION OF S.G.	PORT	.008	7.00	.06	-1.30	-.01	-1.50	-.01	.2	
0		STBD	.008	7.00	.06	-1.30	-.01	1.50	.01	.2	
0	SIDE GIRDERS	PORT	.067	7.00	.47	-3.60	-.24	-1.60	-.11	5.3	
0		STBD	.067	7.00	.47	-3.60	-.24	1.60	.11	5.3	
0	SIDE BEAMS	PORT	.042	7.00	.29	-4.00	-.17	-2.30	-.10	.3	
0		STBD	.042	7.00	.29	-4.00	-.17	2.30	.10	.3	
0	AFT BEAM	C.L.	.201	7.00	1.41	-6.90	-1.39	0.00	0.00	.3	
0	TAPERS ON AFT BEAM	PORT	.065	7.00	.46	-6.80	-.44	-2.30	-.15	.3	
0		STBD	.065	7.00	.46	-6.80	-.44	2.30	.15	.3	
	TOTAL FOR SUB-SUB-GROUP	0	.788	7.00	5.52	-4.17	-3.29	0.00	0.00		

150-3 BRACKETS UNDER 01 DECK (W.B.1 PAGE 99)

FIG. 20

*** PROGRAM EWTLIST *** DATE 13/02/81

MCMV MINE HUNTER CATAMARAN WEIGHT ESTIMATE

GROUP SUMMARY

DESCRIPTION	WEIGHT	VCG	VERT MOMENT	LCG	LONGL MOMENT	TCG	TRANS MOMENT
++100 HULL STRUCTURE GENERAL	70.759	3.60	254.95	-.19	-13.16	.01	.54
++200 PROPULSION SYSTEMS GENERAL	12.374	4.44	54.93	-5.97	-73.89	.26	3.17
++300 ELECTRICAL SYSTEMS GENERAL	4.207	4.77	20.07	-.72	-3.03	-.05	-.22
++400 COMMAND AND SURVEILLANCE	12.408	5.66	70.22	-.81	-10.03	-.93	-11.55
++500 AUXILIARY SYSTEMS GENERAL	13.404	4.79	64.19	-4.42	-59.24	-.26	-3.48
++600 OUTFIT AND FURNISHINGS GENERAL	4.475	4.27	19.10	-.38	-1.70	.03	.15
++ LOAD 800 LOAD VARIABLES	30.738	1.95	60.03	3.98	122.37	.47	14.59
++900 MARGINS	21.874	3.41	74.59	-3.13	-68.51	0.00	0.00
TOTAL	170.239	3.63	618.08	-.63	-107.19	.02	3.20

MASS MOMENT OF INERTIA ABOUT KEEL = 3431. TONNES M**2.
MASS MOMENT OF INERTIA ABOUT LONGITUDINAL AXIS THROUGH CENTRE OF GRAVITY = 1187. TONNES M**2.

FIG. 21