AN AUSTRALIAN ANTARCTIC SHIP.

BACKGROUND AND CONSIDERATION

OF TECHNICAL FEATURES

by

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BACKGROUND:

The history associated with efforts to procure a new building vessel to meet the requirements of Australia's involvement in Antarctic operations extends over some 35 years - since, in fact, the end of the second world war.

As a result of its geographical location Australia has, naturally, always had a particular concern with and consequently involvement in Antarctica - initially by way of exploration and most recently in an ever increasing variety of research activities. It is not the function of this paper to detail the growth of Australian involvement in these activities, or the reasons attached; suffice to say that it has been repeatedly stated as official Government policy that Australia has a long-term commitment to be so involved. This has been demonstrated by recent re-endorsement of that policy and the implementation of a substantial re-building programme of Australian bases.

A critical component to Australian operations in Antarctica is the provision of an efficient transport link, to assure the regular supply of personnel and vital stores to Antarctic bases and, associated with this, to provide a base for off-shore research operations. While these aspects have been the subject of much deliberation, on and off, over the past 35 years - and the past 4 - 5 years in particular - it is only now that firm plans appear to be materialising as to the transportation system to meet present and longer term requirements for Australian Antarctic operations.

A variety of factors have led to the procrastination in arriving at this decision - not only the economic aspect, although this undoubtedly has been and may be expected to be a continuing major factor - but constant changes in technology, in particular the increasing impact of air transport, also changing emphasis on requirements in respect of Australian Antarctic operations, such as the present increase in off-shore research operations. In the present hopefully final analysis, it would appear that future transport operations will essentially be met by the following systems:

- Air in respect personnel.
- Ice strengthened cargo ship in respect of replenishment of bases and supply of re-building materials.
- Ice strengthened research ship to meet requirements of the Australian Antarctic Division in respect of off-shore operations.

It is with the sea transport component that this present paper is concerned, and primarily that associated with the procurement of the projected research ship, it being expected that in the short term the Australian Antarctic requirements for the replenishment cargo ship will be met by a continuation of the present chartering arrangements.

An inescapable observation is that all the major countries having an interest in Antarctica - either by way of having a direct involvement by the establishment of bases or tacit recognition of territorial areas - have, to a greater or lesser extent, acquired specialised ships - generally by way of new construction - to ensure their future stake in this strategically vital region. A brief list of these is given in Appendix "A" attached to this paper.

While the function of this present paper is primarily to highlight some of the principal factors relating to operational requirements and consequently affecting ship design - and, in particular, as these relate to Australian involvement in Antarctica - it cannot escape notice that Australia which can rightly claim high recognition internationally by way of its involvement in various areas of research activities, is conspicuous by its absence from the above referred to list, in not owning a modern ship to match its commitment to this area.

Presently its requirements are met by the chartering of the aged 'Nella Dan', supplemented by an equally aged 'Thala Dan' - the latter now no longer available, having recently been sold to other interests - and the 'Nanook S', an ice strengthened cargo vessel whose operations are restricted to a fairly restricted period of the year by virtue of its limited capability to navigate in ice. This restriction was amply demonstrated recently when the 'Nanook S' was caught in the ice for some 10 days during its return from the last voyage of the season in re-supplying the bases. Such a fortuitous result cannot be expected in all circumstances, and demonstrates the ever-present risks that can be met in such a harsh environment, and consequently the need for carefully consider the extent of risks that are involved in either operating a ship inadequate to the conditions, or extending the range of operations beyond reasonable limits in terms of time and/or distance.

A major problem that is peculiar to Australian operations in Antarctica is the need to re-supply a minimum of three major bases, each of which is located at fairly dispersed positions along the coastline of Antarctica. As a further complication, there is a requirement to re-supply a base on Macquarie Island, with the possibility of other bases in Antarctica in the future. Appendix "B" gives some idea of the dispersed location of Australian bases in Antarctica. Apart from the re-supply operations there is the requirement to become increasingly involved in a wide variety of off-shore research activities. Until most recently it was considered that these requirements might best be achieved by a combined re-supply/research ship. This view was primarily based on the fact that it was not considered that air transport of personnel could be implemented in the foreseeable future. This view has recently been reversed, as a result of which a complete re-assessment was done, and the present decisions, as referred to in an earlier paragraph, arrived at.

RECENT DEVELOPMENTS (1977 - 1983).

In 1977 an I.D.C. (Inter-Departmental Committee) set up to investigate the future requirements for the transport of stores, equipment and personnel to Antarctica recommended that:

(i) Australia acquire and operate a specialised ship equipped with long-range helicopters and having passenger and cargo accommodation, an ability to serve as a platform for marine research and as an aid in surveillance activities.

(ii) Design and planning studies of the above vessel commenced in 1977/78 to avoid a discontinuity in Australia's activities in Antarctica.

(iii) A cargo vessel be chartered to support the Australian owned vessel as required, and

(iv) Examination be made of possible RAAF operations between New Zealan and Antarctica, detailed studies of suitable landing facilities in the AAT -including an examination under the Environment Protection (Impact of Proposals) Act - and possible aircraft for inter-continental operations proceed as the basis for the later provisio of a complementary air transport service to Antarctica.

Since then a variety of design and feasibility studies have been undertaken with a view to clarifying the identifying options to meet the requirements and which might finally result in a preferred ship option on which tenders might be called. Without going into details of these, the following summarises the various major studies undertaken over the 1977-1981 period:

- An Initial Design Study by the then Shipbuilding Division of the Department of Industry & Commerce, under the co-ordinated management of a Task Group with representation from the Antarctic Division (Operations), Dept. of Science & Environment (Policy and Finance), Defence and Transport (Fleet Management), as well as the Shipbuilding Division (Design). This identified a multi-purpose vessel of about 105-110 metres length (over-all) as a preferred option - refer Appendix "C".

- Subsequently an open Invitation to Register Interest (ITR) for design was sought. This resulted in world-wide response with, not unnaturally, a fairly wide variation of options being proposed. Suffice to say responses were received from the USA, Canada, Britain, Norway, Finland, Germany and Japan, as well as the local interest expressed. Options proposed ranged in size from abt.108-135 metres in respect of single and twin screw installations, multi diesel and diesel electric propulsion, with a variety of layouts and configurations. Appendix "D" gives some idea of the various options proposed.

- As a result of a further in-depth review of requirements, essentially resulting from an evaluation of responses to the ITR and discussions between the Antarctic Division and comparable overseas organisations, also in light of economic circumstances which were - and still are - prevailing within the Commonwealth Government, the Central Studies Establishment (CSE) of the Defence Science and Technology Organisation was requested to undertake a re-appraisal of proposals for Australian Antarctic Research Support. This resulted in a most thorough and comprehensive review of options in respect of a variety of sizes and types of ships - ranging from a multi-purpose ship some 110 metres in length, through smaller size vessels with back-up support, to small research ships of some 42 metres length, supported by ice strengthened cargo ships, all with or without air support. Appendix "E" gives a brief summary of the range of options reviewed.

A most interesting and informative paper on this investigation was presented to the Canberra Branch of RINA in 1980 by Mr. A. Taylor of C.S.E. entitled 'Predicting Ice Breaking Performance'.

- Concurrently the Ship Design Group of the Department of Industry & Commerce was retained to undertake further design studies. These extended over some 18 - 24 months and were wide-ranging in extent to embrace a variety of operational requirements in respect of cargo capacities, manning and ANARE personnel. The options investigated all related to a multi-purpose vessel - the C.S.E. appraisal tended to confirm this as a preferred option - and ranged in size from 90 - 115 metres. It was considered the 90 metre proposal was too restricted and the optimum size appeared to be about 105/110 metres. Appendix "F" gives a listing of the various sizes of designs considered.

- The Project Design Study was the culmination of the Ship Design Group's studies and, in effect, amounted to a basic design regarded as that which would be best suited to meet the operational requirements of the Antarctic Division and which could form the basis for calling tenders either for the detailed design or for a design and build contract. This was in respect of a multi-purpose vessel, 105 metres length overall, basic particulars of which are given in Appendix "G", and illustrated in Appendix "H".

- Subsequently, further in-house studies were undertaken by the Department of Science & Technology, together with a review of ship options done by the Hamburg design organisation Schiffko - these are understood to have been in respect of some 5 options, comprising the following:

- Single multi-purpose cargo/passenger/research vessel (approx. 110 m).
- Cargo/passenger vessel (approx. 80 - 90 m)
  + research vessel (approx. 65 m).
- Cargo vessel only (approx. 85 m)
  + research vessel (approx. 65 m) + air transport.
- Cargo/research vessel (approx. 80 - 90 m)
  + air transport.
- Passenger/research vessel (approx. 65 - 75 m)
  + cargo vessel (approx. 85 m).

  (Above actually involves 6 alternative vessel types.)

- Most recently the present decision has been arrived at, which is based on essentially the air transport of personnel, the utilisation of a chartered cargo vessel for re-supply of Antarctic bases and the design and building of a research vessel of some 70/80 metres length to meet off-shore research requirements. This latter is also to incorporate additional accommodation to meet contingency requirements in respect of additional supply of personnel to Antarctic bases, VIP's and possibly additional scientists on off-shore research operations. Notwithstanding the most recent changes, brought about by the decision in respect of air transport, it is understood all the various studies undertaken contributed to the evaluation of options.

OPERATIONAL REQUIREMENTS.

During the period of the design studies (1977 - 1981) - which were essentially based on a zero air transport premise - the following represented the basic User Requirements in respect of an Australian Antarctic Ship, whether these be met by a single multi-purpose vessel or by separate research and cargo ships or by other options.

- Logistic supply, including
  abt. 3200 cm general cargo (incl. 220 cm refrigerated)
  abt. 1000 cm bulk cargo oil
  abt. 225 cm aviation fuel

- Accommodation:
  - for about 100 ANARE (Australian National Antarctic Research Expedition) personnel.

- Manning:
  - either by R.A.N., Dept. of Transport or commercial.

- Speed/Power performance:
  - 15 knots service
  - variable slower speed operation in research role from ½ k (up to 24 hours) to 5 - 10 k (indefinitely).

- Ice-breaking/Navigation:
  - to coastline (November-April) and edge of pack-ice (April-October).
  - maintain a forward speed of 3 knots through fast ice at least 0.8 m thickness.

- Cargo facilities (ship-shore operations):
  - amphibious vehicles (LARC V or equivalent)
  - medium lift helicopter.
  - overside craneage (2 x 20 tonne - 40 tonne combined).
  - ship-shore discharge of bulk oil.

- Other features:
  - passive tank stabilisation.
  - active rolling (to facilitate navigation in ice).
  - bow and stern thrusters (manoeuvrability and station keeping).

Over the period of the design studies (1977 - to date), there have been fluctuations in the various requirements, dependent upon prevailing circumstances, such as priorities in relation to the re-supply or research roles, economic factors which might and did result in a refinement of such aspects as the quantities of cargo and/or personnel involved, and operational aspects such as the extent of ice strengthening that might be required to meet varying programmes for re-supply of Antarctic bases.

While each and every one of the above requirements pose problems, to a greater or lesser degree, the main factor affecting the design is obviously the environment in which the ship or ships have to operate, and this permeates virtually all areas of the design. For the sake of convenience in this brief review, the aspects of design are considered under the following categories:

- hull form
- hull construction
- propulsion
- operational aspects, including manning
- layout and outfitting
- research
- cargo handling

Hull form. (refer Appendix "I")

It is perhaps axiomatic to state that a carefully developed hull form, in association with appropriate hull proportions, is an essential pre-requisite to a successful design. This is particularly so for such a specialised vessel, the hull form of which should be developed on the basis of proven technology relating to ice breaking and navigation in ice waters, and taking into consideration the particular conditions that might apply to the service involved. It is essential that the whole process include extensive and comprehensive model tests.

Apart from the general requirement to evolve a hull form to give efficient performance in a normal seaway, particular attention has to be given to the bow and entrance - to provide for ramming and navigation in ice - and also to the stern - to provide for astern operation during the 'ramming in ice' operations.

While advances continue to be made generally with regard to hull forms, these in the main relate to achieving economies by way of reducing fuel consumption - which, while obviously important, is not a primary consideration in ice breakers. The long established outline and shape of ice-breaker bow, associated with a reasonably full entrance to provide 'bulk strength' in ice breaking and clearing of ice, together with a well protected stern - smooth run and fin/guards in way of the propeller(s), continue to predominate.

Such devices as air bubbler systems and even the possibility of an air cushion bow are attracting attention, but must be regarded as adjuncts to a good and well researched hull design in the first instance.

While most of the recognised large model testing authorities are well equipped to advise on hull form generally, certain organisations - such as those located in Canada, Finland and Scandinavia - have very specialised facilities and long experience in testing of hull forms and propulsion systems for ice-breakers and the like. It is, therefore, not unnatural to suggest that any owner contemplating acquisition of such a new building type vessel, be advised to specify that the hull form be developed in association with model testing facilities at an establishment having well-proven experience in this field.

Hull construction. (refer Appendices "J", "K" and "L")

With respect to vessels operating in iced waters, possibly no other aspect has been given more detailed attention in recent years than that of hull construction. The upsurge in the number of countries - and consequently vessels - becoming involved in Arctic and Antarctic operations, whether in research or with a view to the potential of the area in respect of natural resources and their exploitation, has created increasing concern with regard to the dangers of pollution affecting the delicate balance of the environment in these regions.

This was of particular concern to Canada in the late 1960's, occasioned by the increase in marine traffic in the Arctic and, in particular, proposals for large tankers to operate across the top of the continent transporting oil from the rich Alaskan deposits to the eastern seacoast of America. Regulations were developed by the Ministry of Transport to combat this hazard and these are contained in the 'Arctic Shipping Pollution Prevention Regulations', promulgated in the Canada Gazette of 25 October, 1972.

These Regulations set down standards relating to construction, powering and pollution prevention measures in respect of a range of ship classifications (called 'Arctic Class') and ship categories (defined as 'Type'), and related these to specific areas and periods of operation in Arctic waters (called 'Zones').

Appendix "J1" is an extract from the Canadian Regulations which tabulates the permissable and restricted periods of operation for the various zones in respect of the various Arctic class of vessels or category of ships. Appendix "J2" defines the geographical location of the various zones, and Appendix "J3" is an interpretation of the Arctic Ship Class requirements corresponding to the various zones and time periods, in diagramatic form.

The 'Category' scale of ships - ranging from Type E (standard cargo ship equivalent to Lloyds 100A1) to Type A, are essentially for ships strengthened for navigation in ice, operating in areas of first year ice only and not designed for multi-year ice conditions. The 'Category' scale, in fact, corresponds to the Ice Class notations as set out in the Regulations of the various Classification Societies - refer Appendix "K".

The 'Arctic Class' scale was developed - as the name implies - to specifically define the requirements for ships operating in Arctic waters. The Arctic Shipping Pollution Prevention Regulations set down formulae and tables for determining the scantlings of ship structures, the extent of these, propulsive power determination and other measures to ensure the maximum integrity of ships operating in the various defined zones and over certain specified periods, and consequently minimise the possibilities of pollution. The Arctic Class numbers, ranging from 1 up to 10, correspond to the order of ice thickness in feet which a ship has to be capable of navigating in continuous ahead power. Appendix "L" gives a diagrammatical portrayal of the various areas of strengthening and increased scantlings for a typical ship.

It is of interest to note that, after much consideration and discussions with overseas organisations operating ships in the Antarctic, Arctic Class 3 has been selected for the projected Australian Antarctic research ship as being the class most appropriate to the ice conditions expected to be encountered in the various areas and over the periods of Australian Antarctic operations. In the proposal developed in 1980/81 period by the Ship Design Group of the Department of Industry and Commerce, this involved the following main structural features:

- Continuous double bottom F.P. to A.P.
- Inner skin (side tanks full length from F.P. to A.P.) up to the margin line.
- Closer than normal frame spacing, plus intermediate frames over full length of ship and up to weather deck.
- Full length side stringers plus intermediate stringers in the peaks.
- Solid floors at all frame spaces in peaks.
- Heavy forefoot and stern castings.
- Shell at bottom and bilges 20 mm
at ice belts 28 mm amidships
(light-load w.l.) 36 mm at ends.
- Substantial increases in steering gear and rudder scantlings.
- Horns and ice deflectors at stern.

Appendices "M1", "M2" and "M3" give some indication of the above in respect of a multi-purpose ship some 95 metres in length.

Propulsion.

a) Single or Multiple Screw.
The choice between single or multi propeller installation is influenced by a variety of factors which can essentially be summarised as follows:

- maximum powering requirements
- fixed or controllable pitch propulsion
- safety aspects
- economic aspects.

The first two aspects as listed above can alone by the determining factors, in association with the size of vessel being considered. While the upper limit in respect of single propeller installations increases over the years with the advances being made in technology, restrictions apply at the specific time when each new design is being developed. Additionally, if a controllable pitch propeller is being considered a further restriction may be applicable due to the complexities of such mechanisms. Presently an upper limit in the region of about 30,000 BHP should be considered in relation to a fixed single screw installation with a somewhat lower level in respect of a C.P. installation. These are, to a degree, arbitrary and, as stated above, subject to continual review and up-grading as technology progresses and demands for higher powers with single screw installations develop.

The factor which gives rise to greater argument is that related to safety. On the one hand it can be contended that a multi-screw installation generally twin - gives a higher overall safety factor, in that it provides a back-up reserve in the event of total failure of one screw, which would essentially occur due to ice damage in such a type ship. However, it can be argued that a twin screw installation is more susceptible to damage than a single screw which can be tucked under the protection of the stern. While analysis of data for ships involved in Arctic or Antarctic operations may favour multiple screw propulsion, this choice is generally determined by the first factor listed above - the total power requirements. It is of interest that the responses to the ITR in 1978 generally tended to favour single screw propulsion, although a number of prominent designers with experience of designing ships for operation in ice proposed a twin screw installation.

In respect of the economic factor, a single screw propulsion system is almost invariable a more efficient and consequently more economic option as compared with a twin or multiple screw installation.

In the final analysis, therefore, provided the power requirements are within the range of a single screw installation, while there may be no clear cut decision, present thought tends to the single screw installation; however, the choice may ultimately be determined by the experience of the owner/operator who may opt for twin screws in interests of safety.

b) Diesel or Diesel Electric. (refer Appendices "N" and "O")
While nuclear propulsion and even gas turbines have been considered for some modern and highly powered ice breakers, diesel-electric and geared diesel installations, both of which have enjoyed wide favour, predominate as the choice of machinery fitted to ice breakers or ships operating in ice conditions.

As a propulsion system, the diesel electric has enjoyed wide favour as a selection for puting in ice breakers or ships regularly engaged in navigating in ice. The advantages are obvious in the high flexibility with regard to power output and, in particular, the capability for rapid changes from ahead to astern propulsion, and vice versa. Indeed, the diesel electric propulsion system might almost be said to have been tailor made for such type service but for the substantially higher installation and operating costs as compared with a diesel installation.

With a controllable pitch propeller, there can be no doubt that a geared multi-diesel installation offers an alternative just as flexible and less costly than the diesel electric in respect of ships not necessarily engaged full time in ice breaking duties, but rather operating in essentially non-fast ice conditions. The number of diesel engines can be determined in relation to the operational requirements, to give a range of powers from as low as 10% maximum upwards. This can be achieved with a three or four diesel engine installation, the 10% total power being achieved by operating one engine at between 30% - 50% rating. As previously stated, a multi-geared diesel installation is almost invariably a more economic option as compared with diesel electric, in terms of both initial and operational costs.

Both options - diesel electric or geared multiple diesels - incorporate the facility for take off power for auxiliaries, which is generally utilised for such aspects as generators and bow/stern thrust units.

Basic diagrammatics of power distribution in respect of Geared Diesel and Diesel Electric systems, including power take-offs and electrical distribution are given in Appendices "N" and "O".

Operational aspects.

These can embrace a wide range of features, but in the present context are being restricted to manning and crew accommodation and a general discussion as to their impact on the projected Australian Antarctic ship.

Manning is a major factor affecting operational costs in any ship and particularly so when for a ship which is involved in passenger carrying to a greater or lesser extent. This relates to the space requirements which affect the size and hence the building price of the ship and also, of course, the subsequent operational costs in service. Additionally, for such a ship as a supply and/or research ship intended for operation in the Antarctic, factors relating to the specialised service and expertise required increase the operational costs.

Three options can be considered in relation to the manning of the Australian Antarctic ship, as follows:

- Commercially owned vessel which can be chartered by the Government.

- Government owned vessel, manned by the Dept. of Transport.

- Government owned vessel, Navy manner.

The pros and cons in respect of each option are briefly considered hereunder.

a) Commercially owned.

This, in fact, represents the present situation, whereby the Australian Government charters a ship for its seasonal requirements, and it does undoubtedly have its attractions. Primarily it does not require any initial capital outlay and it avoids direct involvement in the responsibility for ship operation or maintenance. For short term or seasonal usage it can, therefore, represent a most economical option. However, this may not necessarily apply when usage extends over many years, in which event the shipowner will naturally require regular reviews of the contract and inevitably increased charter rates. In this option the charter may, in fact, have acquired a captive market and could seek to exploit the situation. A further factor which is not unimportant is that for this option, in particular, there is the possibility of the crew unions also exploiting the situation to achieve ever increasing rates of remuneration on the basis of the operational and environmental aspects referred to previously, under threat of industrial action. This would be intolerable for a ship restricted to a very tight schedule within the limited season available. While this aspect might still exist for a ship operated by the Dept. of Transport, it is less likely and is non-existent for a vessel Navy manned.

b) Government owned and manned by Dept. of Transport.

While the aspects referred to in respect of a commercially owned and operated vessel do apply to the same extent for a Government owned and operated vessel, that is not to say they do not exist. Obviously operating costs escalate over the years, both in respect of fuel, stores and, of course, wages for the crew, and allowances will likewise be applicable for the special duties involved. However, as owner/operator, the Government has a direct involvement and can exert a direct influence and is less likely to be subject to the pressure exerted in the private commercial area. The prime cost of construction has obviously also to be met directly by the Government and by customary practice this is done by lump sum payments during the construction period with settlement upon completion, whereas a commercial owner can arrange for building by long-term finance, the interest on which can be offset in the charter rates negotiated.

c) Government owned and Navy manned.

The alternative of a Government owned, Navy manned ship offers an interesting and in some ways an attractive option. While it undoubtedly involves a higher manning than by Dept. of Transport or Commercial (both of which should be very similar), to the extent of possibly 70% - 100% greater, the wages are not so high and the possibility of industrial unrest is essentially non-existent. Also, while the manning is higher, the standards of accommodation are significantly less than demanded by commercial manning, and the extent of area required for accommodation is fairly similar. Furthermore, if there may be a possible requirement for a surveillance role, Navy manning would become a virtual necessity. In this option the building cost is likely to be somewhat greater than for (a) or (b), as it can be expected that some specialised Naval requirements would be required.

During the various investigations and studies done over the period 1978 - 1982, indicative comparative costs were assessed for the various options, particularly in respect of manning by the Dept. of Transport and Navy, with differing results, depending upon how the costs were allocated. It appeared that if a proportion of manning and operational costs were absorbed by Navy on the basis of participating to training of personnel etc., then this option could be not unattractive.

Layout and Outfitting. (refer Appendix "P")

a) Layout.

Dependent upon the function or functions of the ship, no other aspect of design is liable to generate more discussion than the layout of spaces as depicted on the General Arrangement plans. Either as a multi-purpose ship, as it originally was, or a primarily research ship, as presently appears likely, the layout can be open to differing interpretations. Location of the machinery space or spaces, number and disposition of cargo and store spaces, how best to provide for specialist features such as the research activities, helicopter operations, ship-shore discharge, and not least the layout of accommodation and all related facilities, are all to a greater or lesser extent open to argument.

In general, however, based on published data for comparable type ships, and a concensus of the options put forward for the multi-purpose Australian Antarctic ship, it would appear that a fairly conventional layout predominates, the machinery being either amidships or semi-aft, cargo spaces forward, research facilities mainly aft, helicopter operations over the research area and accommodation dispersed over the amidships area. A diagramatic sketch of this typical layout is given in Appendix "P".

Aspects of particular concern in the present project - either a multi-purpose or research ship - relate to safety, such as subdivision, fire fighting and life saving - and ship operations, such as cargo and/or stores loading and discharge and research activities. In particular the extent of space required to transport under cover up to three helicopters and provide the necessary landing/lift-off area, is a primary consideration in the development of the layout.

To meet Statutory and Ice Classification requirements, a high degree of subdivision is required, also the provision of an 'inner skin' over the major length of the vessel and extending above the margin line. These requirements not only inhibit the layout, but the 'inner skin' requirement in itself takes up a substantial area of the ship. Likewise fire fighting requirements can be inhibitive, as can the provision of life saving appliances suitable for the hazards and dangers met in Antarctic operations.

b) Outfitting.

Apart from the conventional aspects associated with outfitting, a vessel operating in the Antarctic environment has, naturally, to have special provisions to combat the extremes of temperature. These can and should include a virtual total cocooning of all accommodation and operational areas within a substantial thickness of insulation. Elsewhere, all exposed services, particularly piping, have to be heavily protected and in many instances provided with heaters. Also de-icing provisions have to be fitted to all specialised gear exposed to the elements, such as navigational and research equipment, lifesaving appliances, cargo gear, etc. Even internal systems may require augmented heating, such as oil fuel, lub oil and even water services. All these involve added space and weight and, of course, substantial increases in cost.

Further complexities in such type vessels are the requirements associated with the activities involved, whether cargo or research. In general these include stabilisation, either passive or active and sometimes both, active rolling to facilitate navigation in ice and the provision of bow and/or stern thrusters to assist navigation and station keeping in research activities.

Research operations. (refer Appendices "Q" and "R")

The extent of research activities engaged in by the Antarctic Division of the Dept. of Science & Technology is far ranging, and while until recently has essentially related to land based operations, it is now extending to off-shore activities. The 'Nella Dan' has been fitted up with a limited extent of facilities to enable some off-shore research to be undertaken. It can be expected that while the Antarctic Division will undoubtedly be the prime users, other research organisations - such as CSIRO and the Bureau of Mineral Resources - will be able to use the vessel for their specialised areas of research. It can, therefore, be expected that any new vessel would include for an extended range of off-shore research activities including:

- hydrographic
- oceanographic
- geophysical
- fisheries research
- atmospheric physics
- minerology.

To provide for the above an extensive range of specialised and highly complex gear will be required, also considerable areas given over to laboratories and other requirements related to the various areas of research. Some of these will be incorporated on the ship as fixed structures - naturally generally those in frequent usage - while others can be portable, including such aspects as modular laboratories which can be readily fitted into the ship as required and equally readily removed.

A list of the principal items of equipment relating to research activities is given in Appendix "Q". Likewise a list of specialised gear and equipment relating to navigational and survey activities is given in Appendix "R".

These are not necessarily conclusive, but rather are indicative of the range of gear and equipment likely to be required in the projected new ship.

An aspect related to the various research activities which has to be very carefully considered is the extent of anti noise and/or vibration provisions which should be incorporated in the structure. This can be one of the most contentious issues and certainly can be highly expensive. The contentious aspect is whether, in fact, this is warranted, and if so the extent that this should be done, bearing in mind that there are practical limits in their implementation. While it is recognised that noise and vibration should be reduced to a minimum, such as by the provision of insulation around areas which emanate heavy noise and likewise the fitting of resilient mounts under machinery likely to generate heavy vibration, it may be debatable whether this should extend to all the main and auxiliary machinery being fitted on a 'floating raft', when in fact the propeller might be generating an equal problem in terms of noise and vibration and which has been reduced to a practical minimum by way of propeller design and clearances.

Cargo handling.

While the preferred option is now apparently for an essentially research/passenger vessel, a major part of the investigations over the period 1978-1982 related to a multi-purpose ship, with a major emphasis on cargo loading and, in particular, cargo discharge. It was envisaged that to make maximum utilisation of the vessel during the relatively short period available annually for reasonable access to Antarctic bases, the ship should initiate the season's activities during late October and carry through to about March/April. During the first and last voyages of the season, and indeed possibly others depending upon conditions, it would not necessarily be practical for the ship to have direct access to the bases due to the presence of fast ice conditions, and some urgent replenishment stores would require to be discharged at the edge of the ice shelf and transmitted to the base by alternative transport. In some circumstances this could be up to 100 or more miles from the base.

Obviously in the above scenario a variety of options had to be investigated, and essentially these involved the following:

a) for major cargo discharge (ship anchored in close proximity to base)

- by crane into barges for transmission to the jetty and discharge ashore.
- by amphibious vehicle operations (LARC), carried on board ship for initial and final voyages.

b) for stores and light cargo (ship located some distance from bases, either due to fast ice conditions, or to enable early despatch of essential stores)

- by heavy lift helicopter.
- by air cushion vehicle operation (hovercraft).

The first, and major type cargo operation, is self-explanatory and needs little further expansion. As most cargo and store requirements associated with Antarctic Division activities are assembled and packaged in the large and modern handling facilities located at their Kingston (Tasmania) establishment and transmitted by road for on-loading to the ship, this can best be achieved by a container type operation. This means that in future the ship cargo off-loading facilities should have a capacity to handle standard ISO 20 foot containers, and likewise the barges and, if practicable, the amphibious vehicles should be of capacity to take these containers. Apart from this, some items of heavy equipment - such as bulldozers and the like - will require transportation and while these can be dismantled into component parts, some can nevertheless be of unwieldy size and require individual planning for discharge at Antarctic bases.

The second type cargo operation - that in respect of advance replenishment of bases with essential stores and possibly gear and equipment associated with the operation of the bases - has to be handled by either a helicopter or hovercraft operation. Presently this is carried out to a limited extent by relatively light load carrying capability helicopters. While with the latest projections some of this type cargo may be expected to be carried by air freight, it is likely that some items could more readily and appropriately be carried by sea and discharged by either heavier lift helicopters and/or air cushion vehicles. Such helicopters would be larger size versions of those presently carried and should have enclosed hangar space to protect them during the arduous voyages to Antarctica.

In this case it would be highly preferable, if not mandatory, that the helicopter blades be collapsible to give minimum extent of hangar space requirements. Presently the maximum load such helicopters can carry is still fairly restricted - ranging from about 1 3/4 tonnes for a Dauphin 2 up to 3½ tonnes for a Puma - however the transport rate is comparatively very high in relation to other modes of transport, being of order 130 - 150 knots.

The other option - the use of air cushion vehicle or, to give it its popular name, hovercraft - is still comparatively evolutionary. Various operations in the Arctic and Antarctic areas have utilised such a transport mode, with apparently quite a high degree of success and a variety of prototype ACV's have been developed and are on offer by various manufacturers, such as Bell Aerospace and Wartsila. These have varying capacities and capabilities, ranging from small units capable of transporting lighter weights to the range 3 - 6 tonnes at speeds up to 20 - 25 knots or even higher. Larger units having a carrying capacity up to and over 20 tonnes, but with a somewhat reduced speed capability have also been developed. Two somewhat contradictory aspects relating to ACV operations are worthy of note as having a direct impact on their future as a method of transportation in ice conditions. One is their limitation to operate in regions involving transit over ridged ice, which can obviously be a severe restriction. The other is their potential to undertake or assist in ice breaking operations. While this ranges from practically zero for the lighter size craft, larger and heavier ACV's have demonstrated a quite remarkable capability in this context.

Finally, a word about the somewhat unique Mitsui A.S.T. (Archimedean Screw Tractor), developed by Mitsui for the transport of equipment and supplies from offshore to a support base on land. This essentially amphibian vehicle incorporates a pair of cylindrical screw rotors which provide buoyancy and propulsion in water (the drive being by an inboard engine), and forward action via the spiral blades digging in on land ice surface conditions.

CONCLUSION.

It is hoped this brief and cursory review of the various investigations relating to marine transport requirements for Australian Antarctic operations, together with a consideration of some technical aspects of design may be of interest and generate discussion which might be of value in the eventual realisation of an essentially Australian designed, built and owned Antarctic ship. It is clearly recognised that the expertise and experience of overseas designers and builders of such ships is required - as indeed the experience of overseas operators in such type service is equally essential - nevertheless in the author's view there is no reason why the larger shipyards in Australia should not be able to construct such a vessel and participate in the design process.

ACKNOWLEDGMENTS.

The author is indebted to the Antarctic Division for provision of background material and likewise to the Central Studies Establishment in Canberra and Mr. A.R. Taylor in particular, for permission to use various diagrams from their investigations as contained in their 'in house' report 'A Rapid Appraisal of Proposals for Australian Antarctic Research Support' of February, 1980.

Elsewhere the author has utilised as background material various papers and articles published in a variety of the marine technical press. For those interested in pursuing an 'in depth' study of some aspects of the design as referred to in this paper, a list of the various bibliography is attached. While some of these may have been written some years ago, their contents are still essentially relevant to the present day problems of marine transport in Polar regions.

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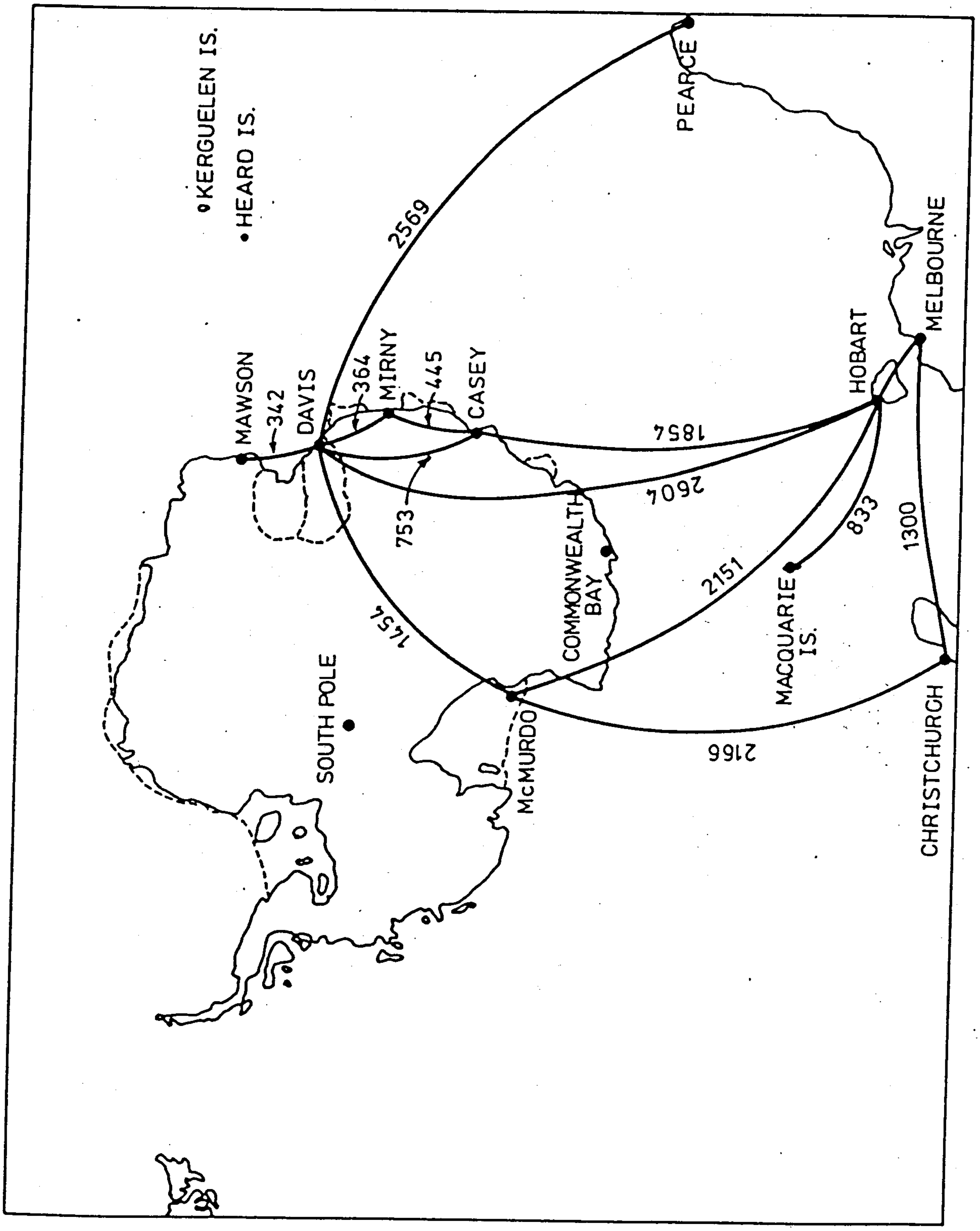
APPENDIX 'A'

VESSELS SPECIFICALLY DESIGNED FOR ANTARCTIC OPERATION

COMPARATIVE TECHNICAL PARTICULARS

VESSEL:		"BRANSFIELD"	"S.A. AGULHAS"	"ALMIRANTE IRIZAR"	"FUJI" REPLACEMENT	"POLAR STAR" "POLAR SEA"	"POLARSTERN"
Owner		U.K.	South Africa	Argentina	Japan	U.S.A.	West Germany
Builder		U.K.	Japan	Finland	Japan	U.S.A.	West Germany
Length	m	90.0 LBP	109.2 LOA	119.0 LOA	134.0 LOA	121.6	117.6 LOA
Beam (moulded)	m	18.3	18.0	25.0	28.0	25.5	25.0
Depth (moulded)	m	9.5	7.5	-	14.5	-	13.6
Draft loaded	m	6.23	6.05	9.5	9.2	10.2	10.[illegible]
Displacement (tonnes)		6900	-	14900	17500	13400	15000
Deadweight (tonnes)		3495	3246		1000		3900
Cargo capacity (m^3):							
General		3452	4007		250		
Refrigerated		194	111				
Cargo oil (inc. aviation)		380	622			186	
Oil fuel (tonnes)		1014	801		700	5400 t	
Fresh water "		364	213				
Complement:							
Officers & crew		36	40	133	174	139	36
Passengers		62	98	100	60	25	70
Engine Power (Bkw)		3730	4500	14340	22400	13400 diesel-elec. 44800 gas turbine	
Service Speed (knots)		13.5	14.5	16.5	15.0	17	
Machinery type		Diesel electric	Geared diesel	Diesel electric	Diesel electric	CODOG	Geared diesel
Propellers		one CP	one CP	two	three CP	three CP	two CP in nozzles
Electric Power (kw)		3 x 425 1 x 150	3 x 770 1 x 140	4 x 600	3 x 750 1 x 400		
Miscellaneous Features		passive stab.	bow jet, stern thruster passive and active stab.	air bubble system fin stab. 2 x 16t cranes 60t towing winch		heeling system 135t @ 50 sec.	bow and stern thrusters 25t, 10t cranes
Classification		Lloyds 100A1 Ice		D.N.V. +1A1			German Lloyd 100A4
Ice Class		Lloyds 1*					Arctic 3
Ice penetration capability (m)		0.67	-	-	1.5	2.0	1.0 @ 5½ knots

APPENDIX 'B'



KERGUELEN IS.
HEARD IS.
PEARCE
2569
MAWSON
342
DAVIS
364
MIRNY
445
CASEY
753
1854
2604
HOBART
MELBOURNE
COMMONWEALTH BAY
833
1300
2151
1454
MACQUARIE IS.
SOUTH POLE
McMURDO
2166
CHRISTCHURCH

APPENDIX 'C'

AUSTRALIAN ANTARCTIC SHIP

PRELIMINARY TECHNICAL PARTICULARS

Length, overall	105.60 m
Length, load water line	101.50 m
Breadth, mld.,	18.50 m
Depth, mld.	11.00 m
Load Draught	About 7.50 m
Load Deadweight	About 4900 tonnes

Make-up of Load Deadweight, tonnes

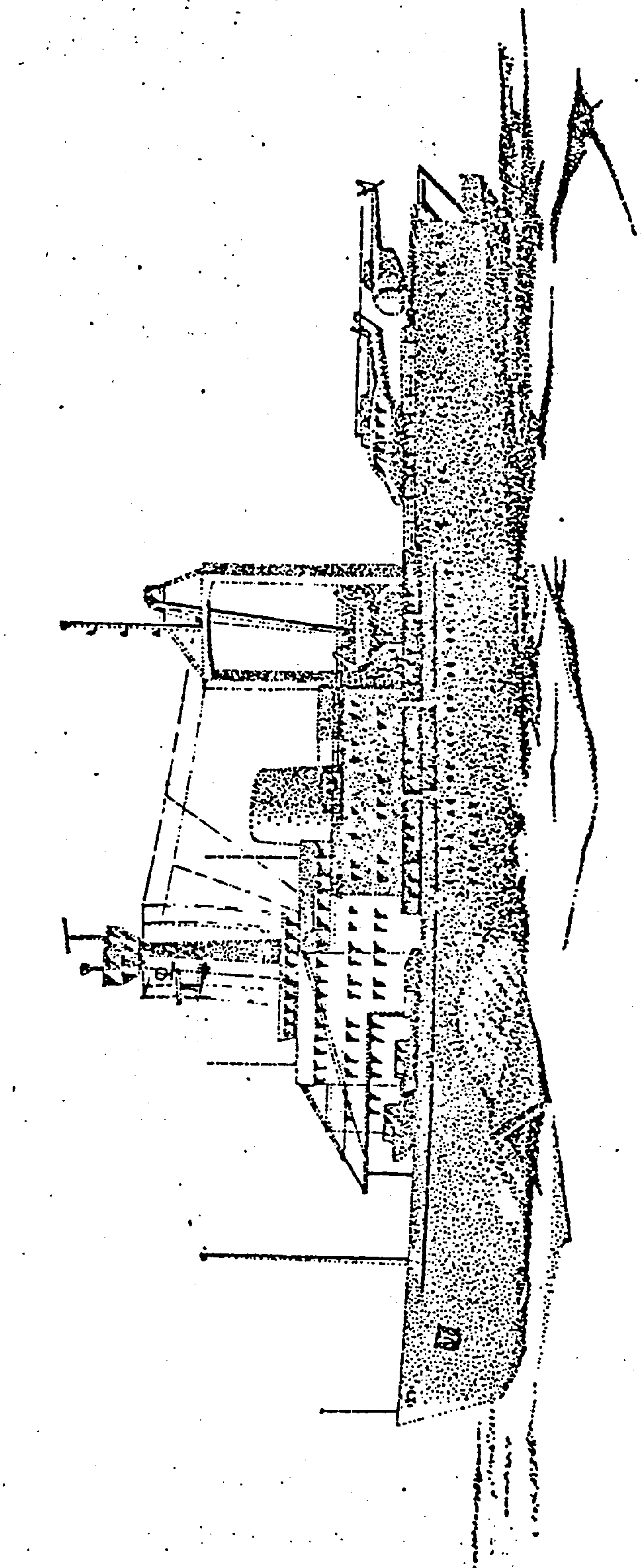
Dry Cargo	1,750
Refrigerated Cargo	300
Cargo Oil	800
Aviation Fuel	220
Oil Fuel	1,200
Fresh Water (+ distillation)	240
Passengers and Baggage	15
Crew and Effects	15
Consumable Stores	170
Stabiliser Tank Water	120
Accom. Modules/Aircraft/ LARC'S	70
Load Deadweight	4,900

Manning

	Navy manning	Transport manning
Passengers berthed	42	32
modular units	48	56
Officers and Crew	67	44
Total Complement	157	132

Machinery	Single screw diesel propulsion (C.P. Propeller)
Service speed	15 knots
Endurance	12,000 nautical miles

APPENDIX 'C'



APPENDIX "

SUMMARY OF PRINCIPAL TECHNICAL CHARACTERISTICS

PROPOSED BY RESPONDENTS TO I.T.R.

DESIGN	A	B	C	D	E	F	G	H	I	J	K
Length O.A. (m)	135	132	135	131.6	119.5	130	121.5	131	125	121	108.5
Breadth (m)	24	20	23	20	20	20	23	18.6	20	24	12
Depth (m)	-	10	15	14.2	11.5	11.3	10.5	10.4	11	10	7.8
Load Draft (m)	7.5	6.5	7.0	6.6	7.5	7.0	7.5	6.2	6.5	7	-
Load Displ.	14000	-	-	-	-	-	-	-	-	12000	-
Load Dwt.	6150	-	3500	5280	4800	5380	-	-	5100	5400	5200
Machinery	T.S. Diesel Electric	S.S.(CP) Diesel	T.S. -	S.S.(CP) Diesel Electric	S.S.(CP) Diesel	S.S./T.S.	S.S.(CP) Diesel	S.S.(CP) Diesel	S.S. Diesel Electric	S.S. Diesel Elec.	T.S. Diesel Elec.
Power (BHP)	12000	6750	12000	6400	6750	7000	-	8500	7000	12000	10000/ 12000

SUPPORT OPTIONS BASED ON THE PROPOSED AAS (GROUP 1)

OPTION TYPE	OPTION NO.	PROPOSED AAS: ICE CLASS CANADIAN ARCTIC 4	3	2	LLOYDS 1*	HELICOPTERS: MLH	UH	CARGO SHIP LLOYDS 1*: HIRED	BOUGHT	FIXED WING AIRCRAFT: C130H	LC130R	AIRFIELDS AND FACILITIES: DAVIS AIRBASE	CASEY SKIWAY BASE	VOYAGES TO AAT BY AAS: INTO ICE	TO BASE	VOYAGES TO AAT BY CARGO SHIP: TO BASE	CHARTER DAYS	NOMINAL CAPACITY TO AAT (per annum) PERSONNEL: IN AAT	SHIP RESEARCH	CARGO TONNES/M^3
	1	1				2								1	3			170	20	9000/15 000
	2	1					2							1	3			170	20	9000/15 000
AAS	3		1			2								1	3			170	20	9000/15 000
VARIANTS	4		1				2							1	3			170	20	9000/15 000
ALONE	5			1		2								1	3			170	20	9000/15 000
	6			1			2							1	3			170	20	9000/15 000
	7				1	2								1	2			170	20	6000/10 000
	8				1		2							1	2			170	20	6000/10 000
	9	1				2		1						1	2	1	133	170	20	9000/15 000
AAS	10	1					2	1						1	2	1	133	170	20	9000/15 000
VARIANTS	11		1			2		1						1	2	1	133	170	20	9000/15 000
WITH	12		1				2	1						1	2	1	133	170	20	9000/15 000
CARGO	13			1		2		1						1	2	1	133	170	20	9000/15 000
SHIP	14			1			2	1						1	2	1	133	170	20	9000/15 000
SUPPORT	15				1	2		1						1	2	1	133	170	20	9000/15 000
	16				1		2	1						1	2	1	133	170	20	9000/15 000
	17	1				2					2		1	1	3			230+	20	9000/15 000
AAS	18	1				2				2		1		1	3			230+	20	9000/15 000
VARIANTS	19		1			2					2		1	1	3			230+	20	9000/15 000
WITH	20		1			2				2		1		1	3			230+	20	9000/15 000
AIR	21			1		2					2		1	1	3			230+	20	9000/15 000
TRANSPORT	22			1		2				2		1		1	3			230+	20	9000/15 000
SUPPORT	23				1	2					2		1	1	2			230+	20	9000/15 000
	24				1	2				2		1		1	2			230+	20	9000/15 000

SUPPORT OPTIONS BASED ON THE SMALL AAS (GROUP 2)

OPTION TYPE	OPTION NO.	SMALL AAS			HELI-COPTERS		CARGO SHIP LLOYDS 1*		FIXED WING AIRCRAFT		AIRFIELDS AND FACILITIES		VOYAGES TO AAT				NOMINAL CAPACITY TO AAT (PER ANNUM)		
		ICE CLASS											BY SAAS		BY CARGO SHIP		PERSONNEL		
		CANADIAN ARCTIC 3	CANADIAN ARCTIC 2	LLOYDS 1*	MLH	UH	HIRED	BOUGHT	C130H	LC130R	DAVIS AIRBASE	CASEY SKIWAY BASE	INTO ICE	TO BASE	TO BASE	CHARTER DAYS	IN AAT	SHIP RESEARCH	CARGO TONNES/M³
	1	1			2								1	3			100	20	3800/6300
	2	1				2							1	3			105	20	3800/6300
SMALL AAS	3		1		2								1	3			100	20	3800/6300
VARIANTS	4		1			2							1	3			105	20	3800/6300
ALONE	5			1	2								1	2			100	20	2500/4200
	6			1		2							1	2			105	20	2500/4200
	7	1			2		1						1	2	1	133	100	20	5500/9200
SMALL AAS	8	1				2	1						1	2	1	133	105	20	5500/9200
VARIANTS WITH	9		1		2		1						1	2	1	133	100	20	5500/9200
CARGO	10		1			2	1						1	2	1	133	105	20	5500/9200
SHIP SUPPORT	11			1	2		1						1	2	1	133	100	20	5500/9200
	12			1		2	1						1	2	1	133	105	20	5500/9200
SMALL AAS	13	1			2		1			2		1	1	2	1	133	220	20	5500/9200
VARIANTS WITH	14	1			2		1		2		1		1	2	1	133	225	20	5500/9200
CARGO SHIP	15		1		2		1			2		1	1	2	1	133	220	20	5500/9200
AND	16		1		2		1		2		1		1	2	1	133	225	20	5500/9200
AIR TRANSPORT	17			1	2		1			2		1	1	2	1	133	220	20	5500/9200
SUPPORT	18			1	2		1		2		1		1	2	1	133	225	20	5500/9200

SUPPORT OPTIONS BASED ON AN AUSTRALIAN ANTARCTIC RESEARCH VESSEL (GROUP 3)

OPTION TYPE	OPTION NO.	AARS		CARGO SHIP LLOYDS 1*		HELI-COPTER	FIXED WING AIRCRAFT		AIRFIELDS AND FACILITIES		VOYAGES TO AAT			NOMINAL CAPACITY TO AAT (PER ANNUM)		
		AARS	HELI-COPTERS UH/LOH	HIRED	BOUGHT	MLH	C130H	LC130R	DAVIS AIRBASE	CASEY SKIWAY BASE	BY AARS	BY CARGO SHIP TO BASE	BY CARGO SHIP CHARTER DAYS	PERSONNEL IN AAT	PERSONNEL SHIP RESEARCH	CARGO TONNES/M^3
AARS WITH CARGO SHIP AND AIR TRANSPORT SUPPORT	1	1	1		1	2		2		1	1+	3[1]		180	20	6000/10 000
	2	1	1		1	2	2		1		1+	3[1]		180	20	6000/10 000
	3	1	1	1		2		2		1	1+	3[1]	200	180	20	6000/10 000
	4	1	1	1		2	2		1		1+	3[1]	200	180	20	6000/10 000
	5	1	1	1		2		2		1	1+	2[1]	151	180	20	3000/5000
	6	1	1	1		2	2		1		1+	2[1]	151	180	20	3000/5000
NO SHIPBASED RESEARCH	7	-	-		1	2		2		1	-	3[1]		180	-	6000/10 000
	8	-	-		1	2	2		1		-	3[1]		180	-	6000/10 000
	9	-	-	1		2		2		1	-	3[1]	200	180	-	6000/10 000
	10	-	-	1		2	2		1		-	3[1]	200	180	-	6000/10 000

ALTERNATIVE OPTIONS INVESTIGATED (WITH RESPECT TO SIZE AND LAYOUT OF VESSEL)

GENERAL ARRGT. NO.	BASIC DESCRIPTION	DIMENSIONS (m) LOA x B x D (main deck)	CARGO CAPACITY (m^3)		ACCOMMODATION	
			Dry	Insul.	Pass.	Crew
	INITIAL DESIGN (AS CONTAINED IN SDG SUBMISSION OF JUNE 1978)					
38-1H/1	Supply Role, Navy Manning	110 x 18.5 x 11.0	4600	300	42 Perm. 48 Mod.	67
38-1H/1A	Plan of Aft End - Research Role/ Navy Manning					
38-1H/1B	Supply Role, Transport Manning	110 x 18.5 x 11.0	4600	300	32 Perm. 56 Mod.	44
38-1H/1C	Plan of Aft End - Research Role/ Transport Manning					
	DESIGN DEVELOPMENT					
38-1H/2	Follow-up to Initial Design, developed to meet all operational requirements. Uncompleted pending decision for CSE investigation and anticipated reappraisal of requirements with view to reducing cost.	115 x 20.0 x 13.00	4600	300	70 Perm. 24 Mod.	88
38-1H/2A	Proposed arrangement of Research Facilities for above.					
38-1H/3	Vessel of similar length but revised configuration to plan no. 38-1H/2. All cargo space forward with "through drive" hangar space to provide flexibility in cargo loading/discharge. All requirements for specified cargo capacity, research facilities and accommodation met.	115.0 x 22.0 x 13.0	5170	220	66 Perm. 32 Mod.	102
38-1H/4	Design developed for a smaller size Navy manned vessel of reduced capability. "Through Drive" cargo and hangar space provided with gantry crane access.	90.0 x 20.0 x 11.5	3590	260	74	58
38-1H/4A	Outline plan developed from arrangement 38-1H/4 with modified (reduced) cargo and passenger capacity, but increased crew complement.	90.0 x 20.0 x 11.5	3180	220	54	82
38-1H/5	Alternative version of smaller size ship with reduced cargo capacity and research facilities. Passenger and crew complement increased above that provided on G.A. plans 38-1H/4 and 4A.	90.6 x 20.0 x 11.5	3180	180	100	84
38-1H/5A	Modified version of plan no. 38-1H/5. Accommodation, machinery spaces and tanks re-arranged.	90.6 x 20.0 x 11.5	3180	180	100	84

GENERAL ARRGT. NO.	BASIC DESCRIPTION	DIMENSIONS (m) LOA x B x D (main deck)	CARGO CAPACITY (m^3)		ACCOMMODATION	
			Dry	Insul.	Pass.	Crew
38-1H/6	Increased length version of 38-1H/5A with increased research facilities and reduced "top hamper". Accommodation arranged mainly in 6 berth cabins. Revised machinery space arrangement.	95.0 x 20.0 x 11.5	3180	200	104	84
38-1H/6A	Arrangement 38-1H/6 with increased passenger accommodation to include civilian helicopter pilots and maintenance crews. Research facilities updated and hospital and tank arrangements modified.	95.0 x 20.0 x 11.5	3180	200	120	73
38-1H/7	Smallest vessel considered necessary to incorporate all the minimum requirements demanded for this type of ship. Accommodation generally in 4 berth cabins to suit nature of work. All research laboratories and work areas grouped aft on main deck. Hatches and holds suitable for the handling and storage of up to twenty - 20 foot ISO containers.	105.0 x 22.0 x 11.5	3250	230	102	82
38-1H/8	Navy manned 24 passenger version of vessel, with air lifting of personnel as necessary.	105.0 x 22.0 x 11.5	3250	230	24	86
38-1H/9	Similar to above with civilian manning.	105.0 x 22.0 x 11.5	3250	230	24	42

AUSTRALIAN ANTARCTIC SHIP

BASIC TECHNICAL PARTICULARS*

Length, overall		105.0 m
Length, B.P.		97.0 m
Breadth, mld.		22.0 m
Depth, mld., to Main Deck (including 1 m deep box keel)		12.5 m
Load Draught (to underside of box keel)	abt	8.5 m
Load Displacement, tonnes	"	10200
Load Deadweight, tonnes	"	4200

made up of

. Cargo (incl. refrig.)	1200	tonnes
. Cargo Oil (incl. aviation fuel)	1050	"
. Oil Fuel	1200	"
. Fresh Water	250	"
. Stores, etc.	200	"
. Passengers, Crew	30	"
. Stabiliser Water	200	"
. Aircraft, LARC's, etc.	70	"
	4200	"

Main Propulsion — Geared Diesel Machinery (4 engines) driving a single C.P. propeller

Power, M.C.R.	abt	12000 B.Kw.
Service Speed (up to Beaufort 5 sea conditions)		15 knots
Endurance (at 15 knots)		12000 miles
Accommodation	- Passengers, up to	102
	- Officers and Crew	73
Ice Class		Canadian Class 2 (minimum)

*in respect of minimum size of vessel which it is assessed will meet all the basic operational requirements

AUSTRALIAN ANTARCTIC SHIP

BASIC REQUIREMENTS

The following represent the operational requirements as advised by Antarctic Division and which are the basis for the Project Design:

Logistic supply

- 3200 c.m. of general cargo
- 1000 c.m. bulk cargo oil
- 225 c.m. bulk aviation fuel

Research capabilities

- oceanography
- hydrographic
- marine biology
- marine geosciences and bathymetry
- environmental studies
- meteorology

Accommodation

- for 102 ANARE personnel (incl. air crew)
  (4 berth cabins all with separate toilet facilities, plus 2 single berth cabins)

Manning

- by RAN and to RAN standards
- complement 73 officers and crew (incl. LARC)

Speed/Power Performance

- 15 knots service speed (in sea conditions up to Beaufort No. 5, main engines 85% M.C.R.)
- 12,000 miles endurance at 15 knots
- extended slow speed operation (for research — 1-2 knot for 24 hours/5-10 knots indefinitely)
- single controllable pitch propeller driven through gearing by 3 medium speed diesel engines

.../2

Systems

- 415 volt, 3 phase, A.C. main electric supply (3 main generators)
- bow and stern thrust units (to provide high degree of manoeuvrability and facilitate station keeping)
- passive tank stabilisation
- active rolling (to assist navigation in ice)

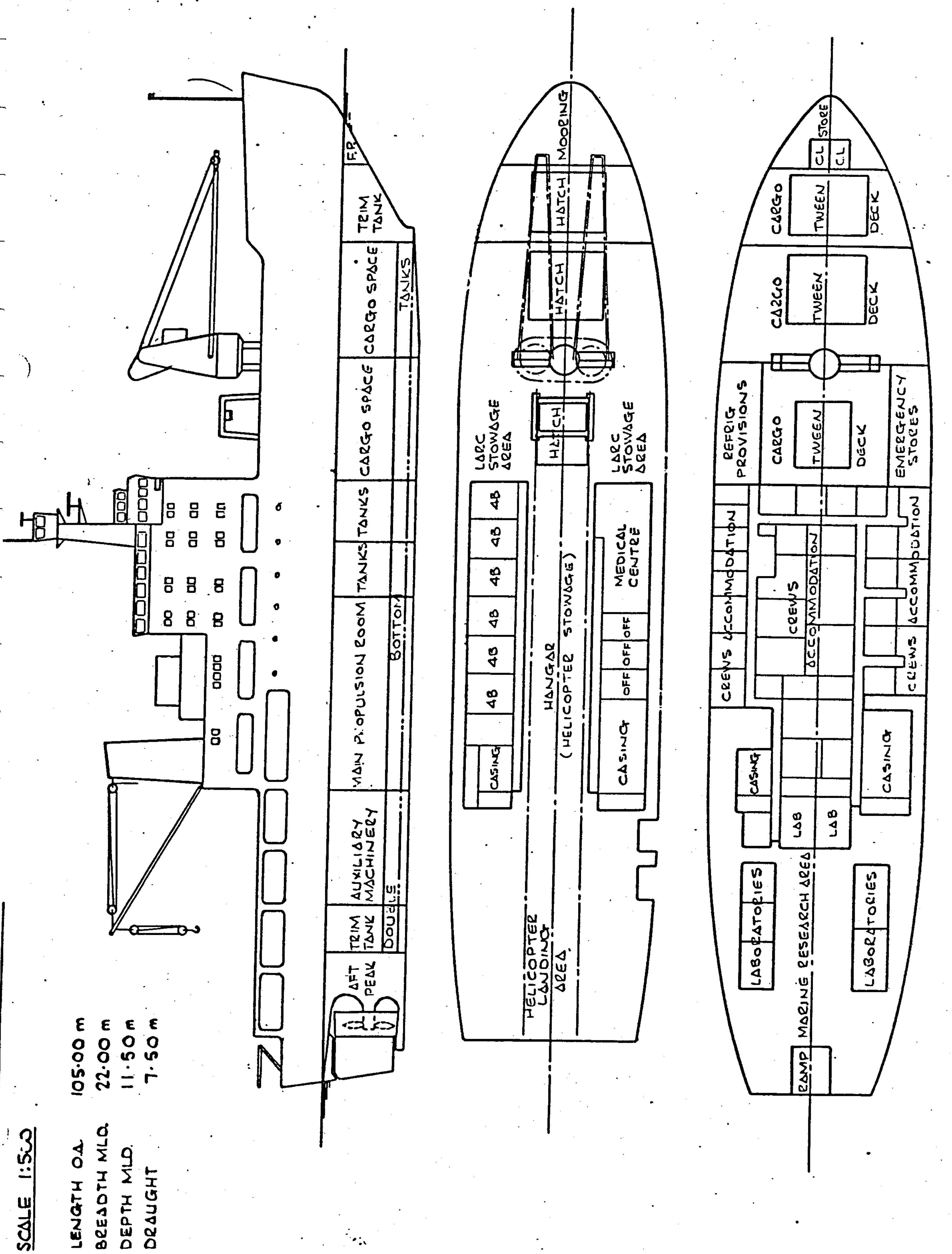
Ice-Breaking Capability

- coastline (November-April) and edge of pack ice (April-October)
- maintain forward speed of 3 knots through fast ice of at least 0.8m thickness
- ice strengthening and breaking capability to a minimum of Arctic Class 2 (Canadian Arctic Shipping Pollution Prevention Regulations)

Cargo Loading/Discharge facilities

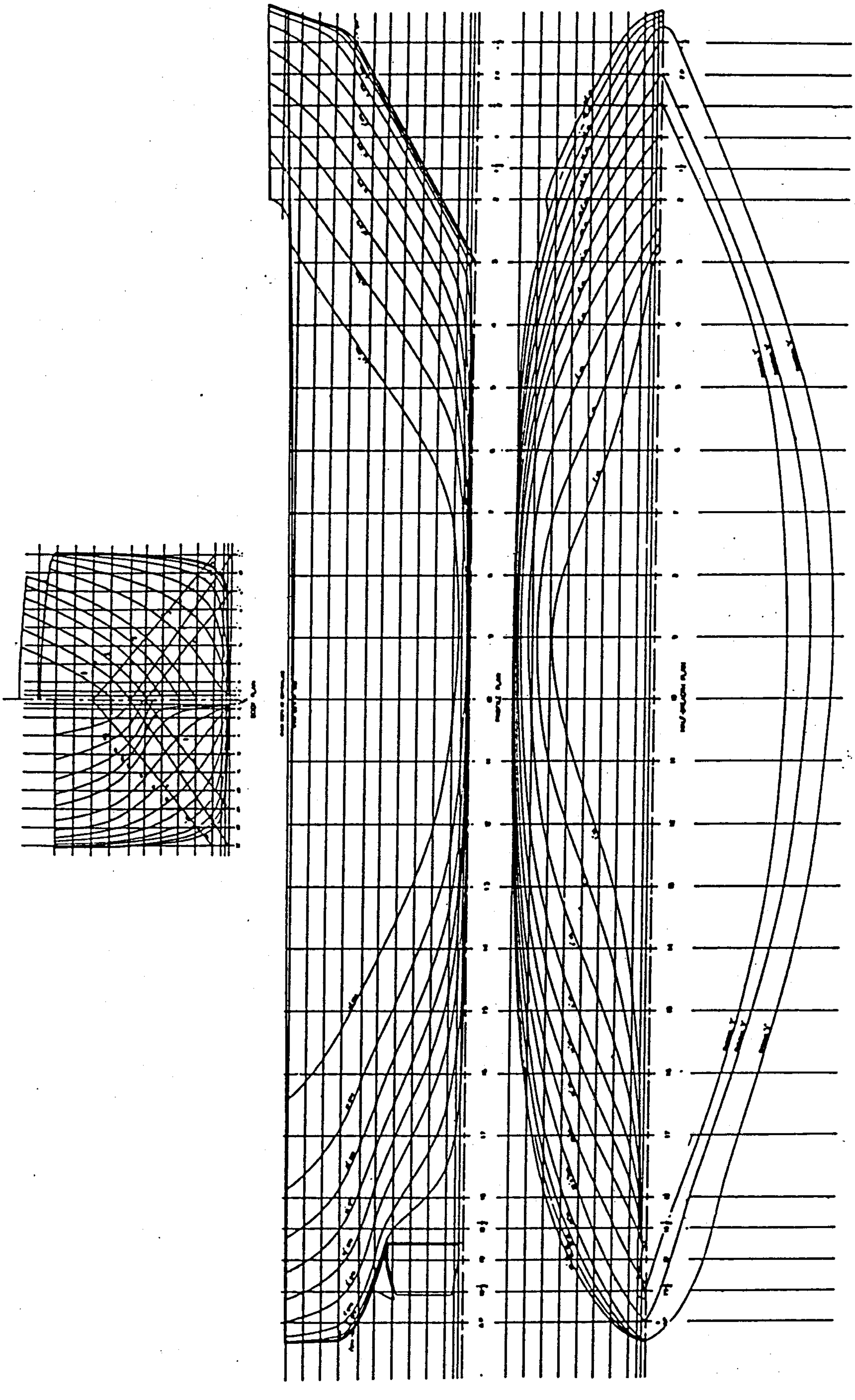
- 2 LARC V amphibious vehicles
- 2 medium lift helicopters (also 1 reconnaissance helicopter)
- 2-20 tonne cranes (40 tonne combined lift)
- 1-5 tonne crane aft
- ship/shore discharge of bulk fuel

APPENDIX 'H'



SCALE 1:500
LENGTH O.A. 105.00 m
BREADTH MLD. 22.00 m
DEPTH MLD. 11.50 m
DRAUGHT 7.50 m
F.P.
TRIM TANK
CARGO SPACE
TANKS
CARGO SPACE
TANKS
TANKS
MAIN PROPULSION ROOM
BOTTOM
AUXILIARY MACHINERY
DOUBLE
TRIM TANK
AFT PEAK
MOORING
HATCH
HATCH
HATCH
LARC STOWAGE AREA
LARC STOWAGE AREA
4B
MEDICAL CENTRE
OFF
HANGAR (HELICOPTER STOWAGE)
CASING
CASING
HELICOPTER LANDING AREA
STORE
C.L
C.L
CARGO
TWEEN
DECK
CARGO
TWEEN
DECK
REFRIG PROVISIONS
CARGO
TWEEN
DECK
EMERGENCY STORES
CREWS ACCOMMODATION
CREWS ACCOMMODATION
CREWS ACCOMMODATION
CASING
CASING
LAB
LAB
LABORATORIES
LABORATORIES
MARINE RESEARCH AREA
RAMP

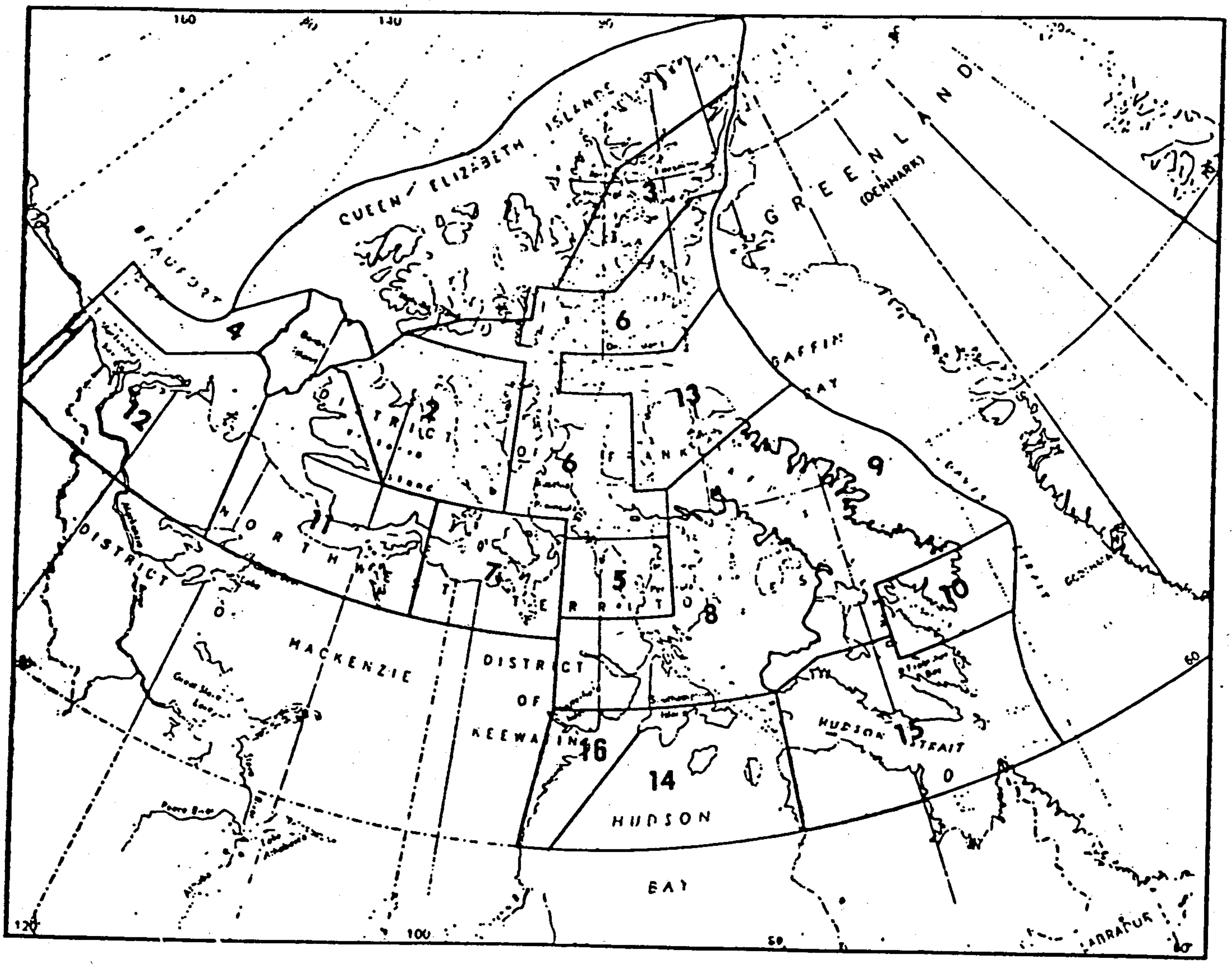
APPENDIX "I"



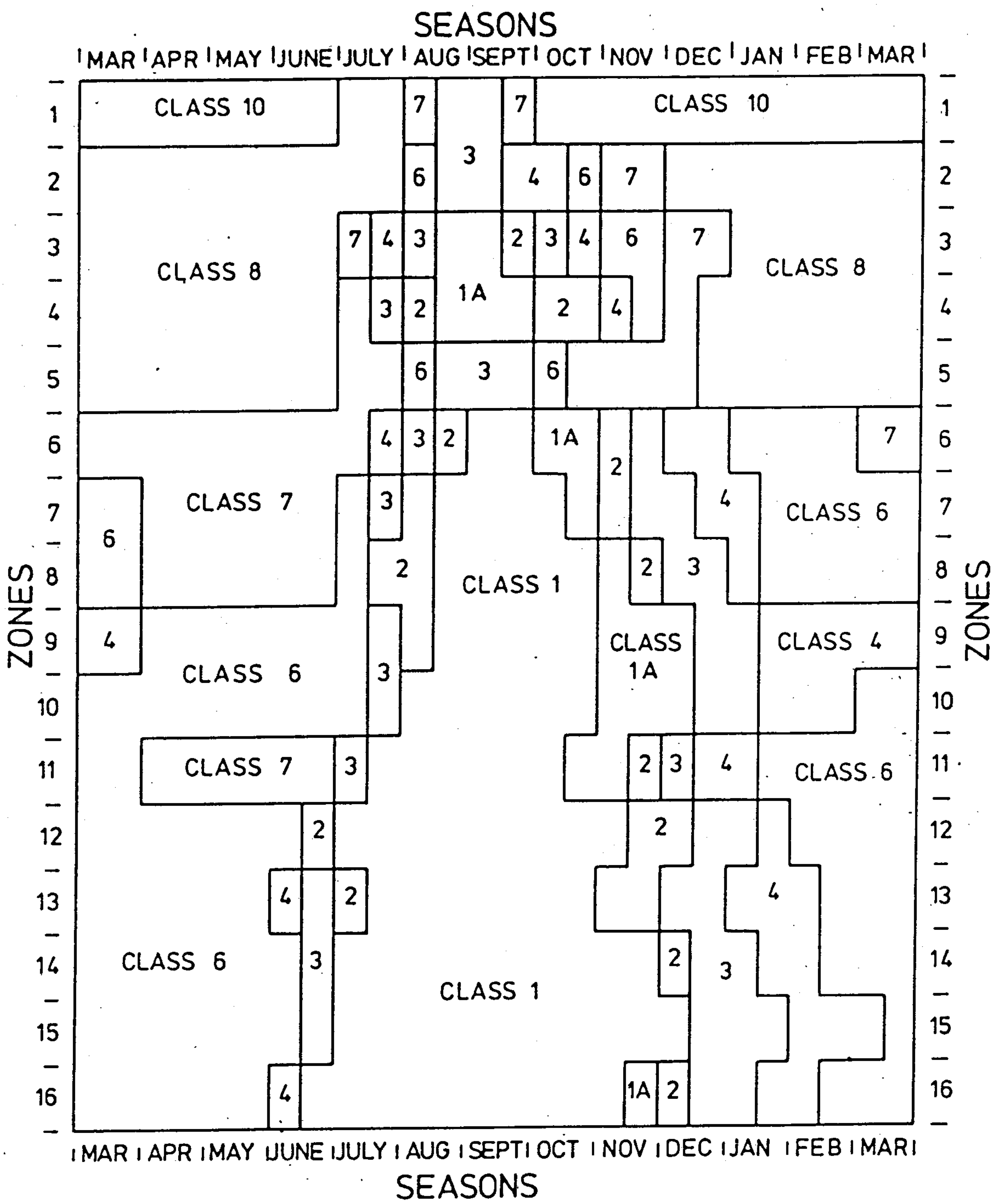
ALTERNATIVE OPTIONS INVESTIGATED (WITH RESPECT TO SIZE AND LAYOUT OF VESSEL)

GENERAL ARRGT. NO.	BASIC DESCRIPTION	DIMENSIONS (m) LOA x B x D (main deck)	CARGO CAPACITY (m^3)		ACCOMMODATION	
			Dry	Insul.	Pass.	Crew
	INITIAL DESIGN (AS CONTAINED IN SDG SUBMISSION OF JUNE 1978)					
38-1H/1	Supply Role, Navy Manning	110 x 18.5 x 11.0	4600	300	42 Perm. 48 Mod.	67
38-1H/1A	Plan of Aft End - Research Role/ Navy Manning					
38-1H/1B	Supply Role, Transport Manning	110 x 18.5 x 11.0	4600	300	32 Perm. 56 Mod.	44
38-1H/1C	Plan of Aft End - Research Role/ Transport Manning					
	DESIGN DEVELOPMENT					
38-1H/2	Follow-up to Initial Design, developed to meet all operational requirements. Uncompleted pending decision for CSE investigation and anticipated reappraisal of requirements with view to reducing cost.	115 x 20.0 x 13.00	4600	300	70 Perm. 24 Mod.	88
38-1H/2A	Proposed arrangement of Research Facilities for above.					
38-1H/3	Vessel of similar length but revised configuration to plan no. 38-1H/2. All cargo space forward with "through drive" hangar space to provide flexibility in cargo loading/discharge. All requirements for specified cargo capacity, research facilities and accommodation met.	115.0 x 22.0 x 13.0	5170	220	66 Perm. 32 Mod.	102
38-1H/4	Design developed for a smaller size Navy manned vessel of reduced capability. "Through Drive" cargo and hangar space provided with gantry crane access.	90.0 x 20.0 x 11.5	3590	260	74	58
38-1H/4A	Outline plan developed from arrangement 38-1H/4 with modified (reduced) cargo and passenger capacity, but increased crew complement.	90.0 x 20.0 x 11.5	3180	220	54	82
38-1H/5	Alternative version of smaller size ship with reduced cargo capacity and research facilities. Passenger and crew complement increased above that provided on G.A. plans 38-1H/4 and 4A.	90.6 x 20.0 x 11.5	3180	180	100	84
38-1H/5A	Modified version of plan no. 38-1H/5. Accommodation, machinery spaces and tanks re-arranged.	90.6 x 20.0 x 11.5	3180	180	100	84

APPENDIX "J2"



CANADIAN ARCTIC CONTROL ZONES



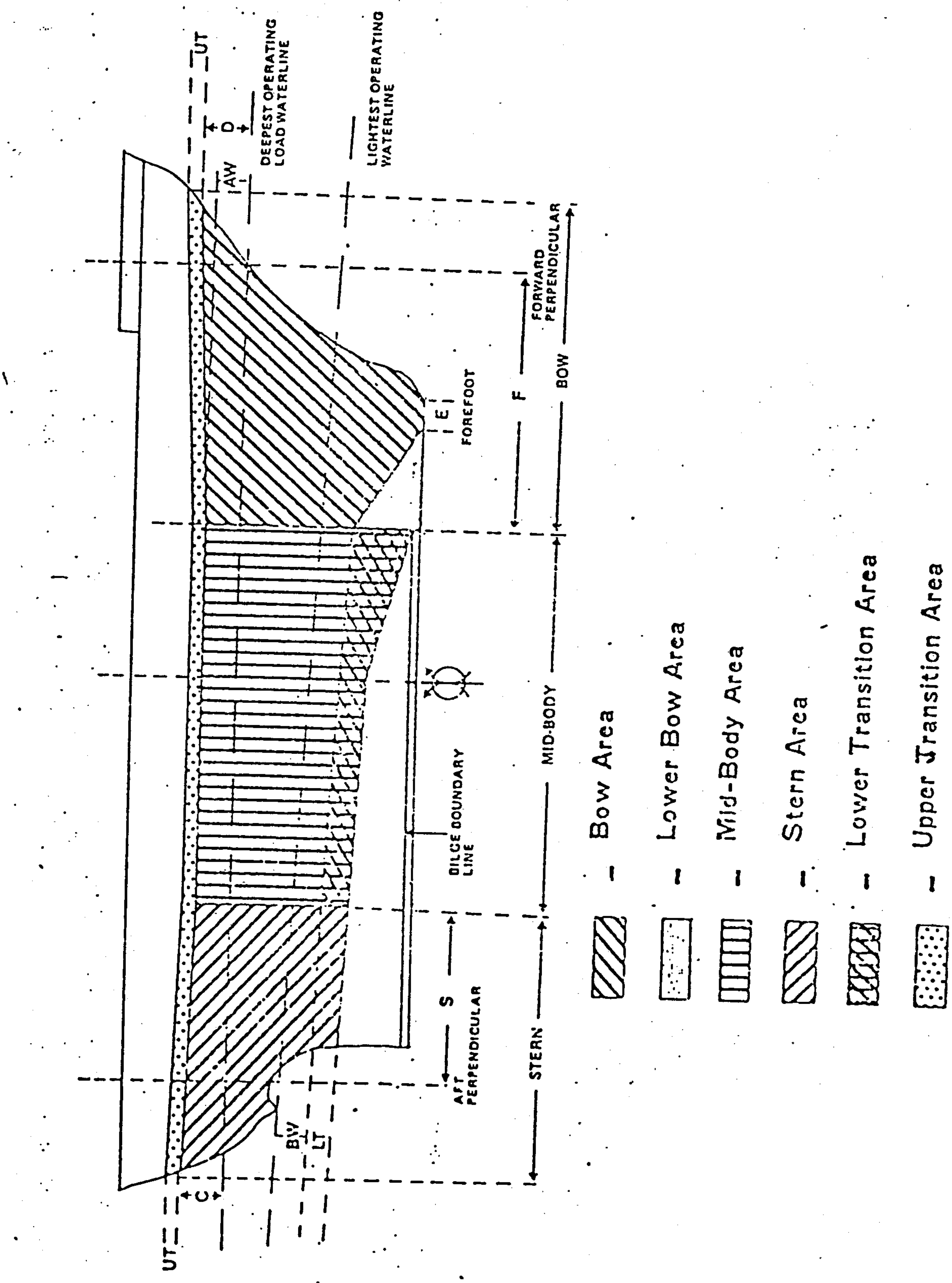
MINIMUM ARCTIC SHIP CLASSES FOR THE VARIOUS ZONES AND SEASONS

APPENDIX "K"

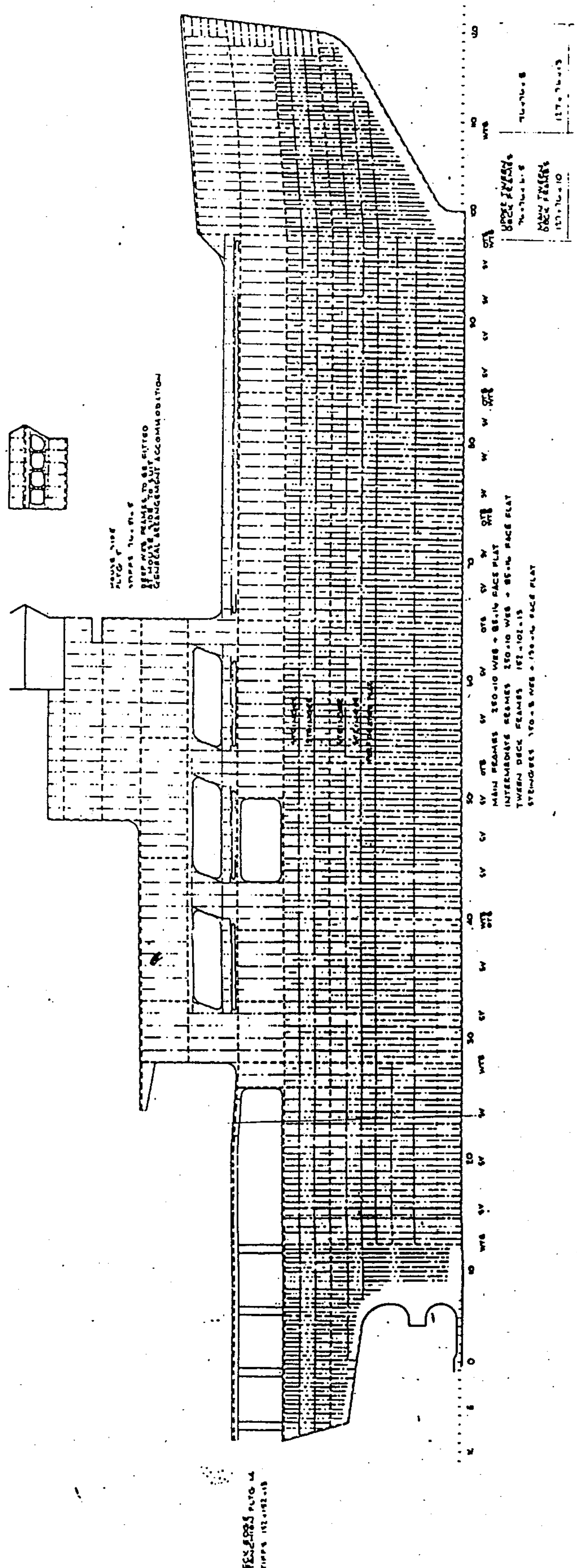
EQUIVALENCE OF ICE STRENGTHENING CLASSIFICATIONS BY DIFFERENT SOCIETIES

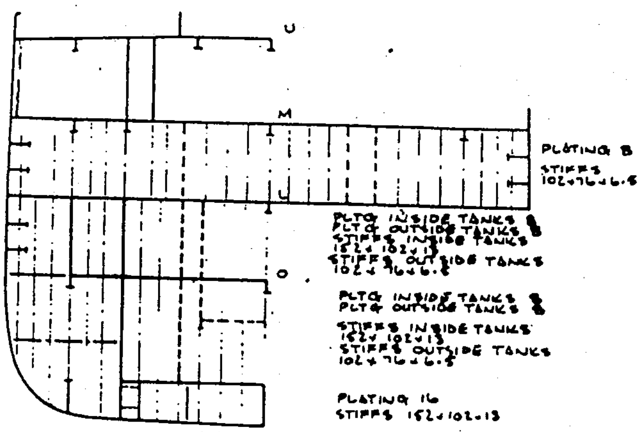
COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V	COLUMN VI	COLUMN VII
ITEM	LLOYDS' REGISTER OF SHIPPING	AMERICAN BUREAU OF SHIPPING	BUREAU VERITAS	DET NORSKE VERITAS	GERMAN-ISCHER LLOYD	REGISTRO ITALIANO NAVALE
Type A 1.	100A1 Ice Class 1*	A1 Ice Class 1AA	I 3/3E Ice I Super	Class 1A1 Ice A*	100A4E4	100A1.1 RG1
Type B 2.	100A1 Ice Class 1	A1 Ice Class 1A	I 3/3E Ice I	Class 1A1 Ice A	100A4E3	100A1.1 RG2
Type C 3.	100A1 Ice Class 2	A1 Ice Class 1B	I 3/3E Ice II	Class 1A1 Ice B	100A4E2	100A1.1 RG3
Type D 4.	100A1 Ice Class 3	A1 Ice Class 1C	I 3/3E Ice III	Class 1A1 Ice C	100A4E1 or 100A4E	100A1.1 RG4
Type E 5.	100A1	A1	I 3/3E	Class 1A1	100A4	100A1.1

APPENDIX "L"

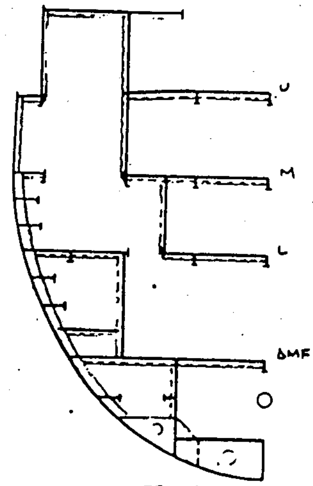

UT
D
AW
DEEPEST OPERATING LOAD WATERLINE
LIGHTEST OPERATING WATERLINE
FORWARD PERPENDICULAR
F
BOW
E
FOREFOOT
MID-BODY
BILGE BOUNDARY LINE
S
AFT PERPENDICULAR
STERN
BW
LT
C
UT
Bow Area
Lower Bow Area
Mid-Body Area
Stern Area
Lower Transition Area
Upper Transition Area

APPENDIX M1.

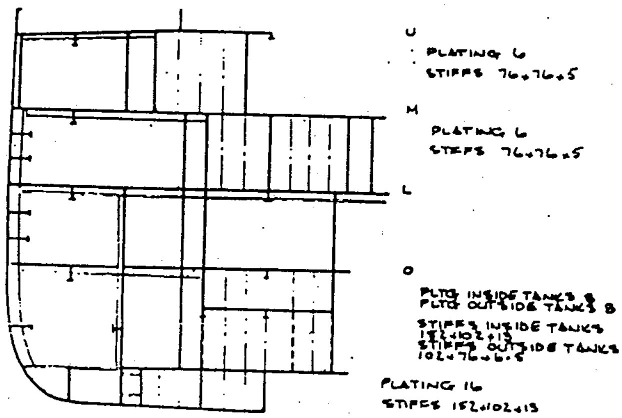




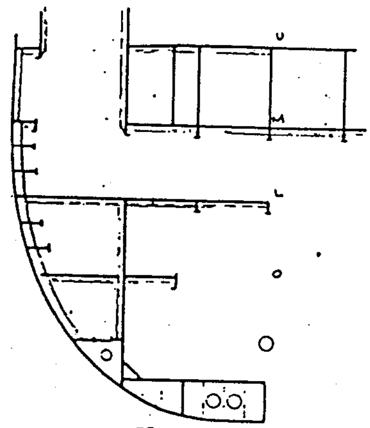
OT BHD FR 53



FRAME 27



WT BHD FR 59



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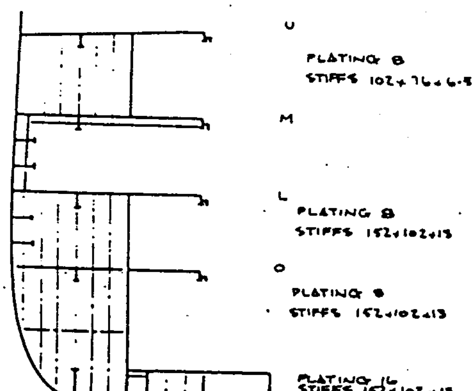
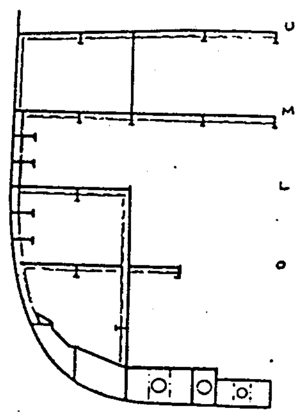
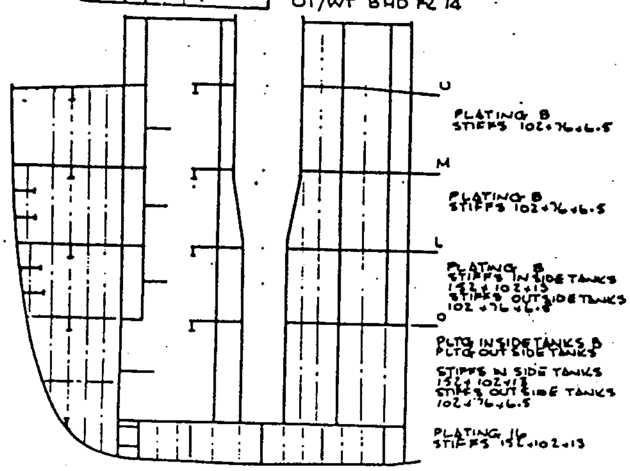


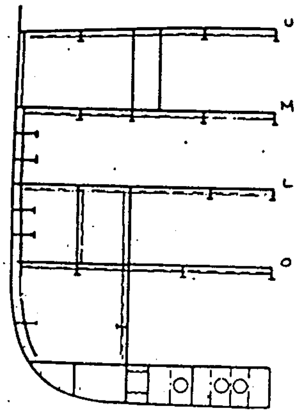
OT/WT BHD FR 74



FRAME 41

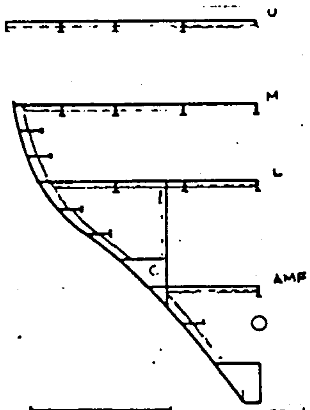


OT/WT BHD FR 84

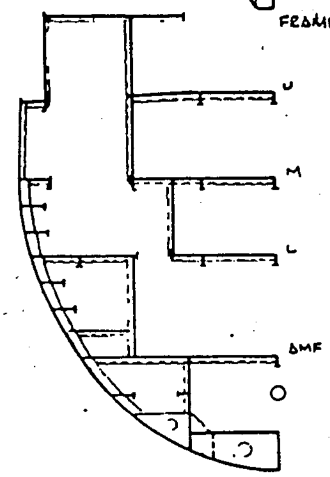


FRAME 52

APPENDIX M3



FRAME 17



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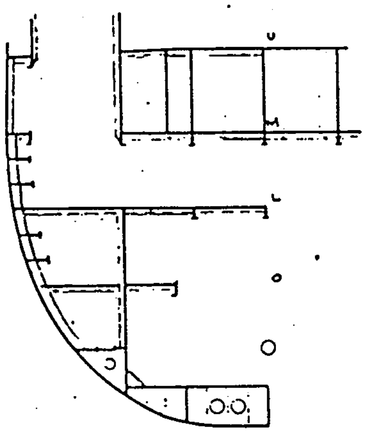

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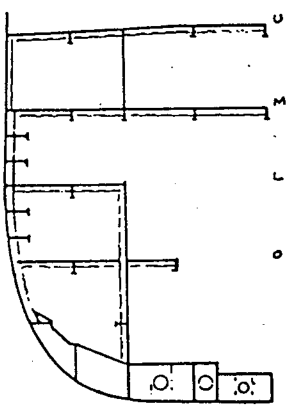

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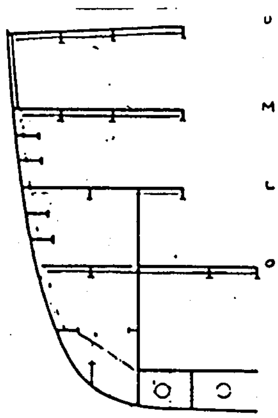
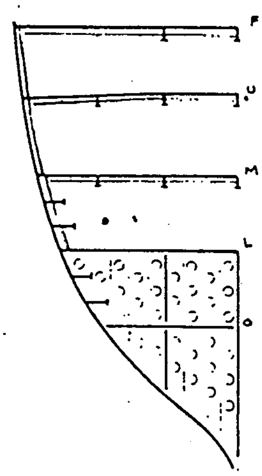
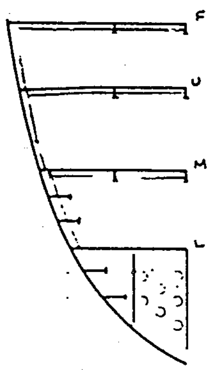


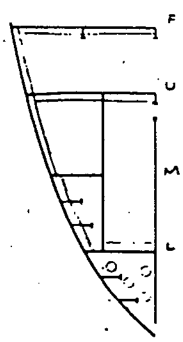
FRAME 88



FRAME 58

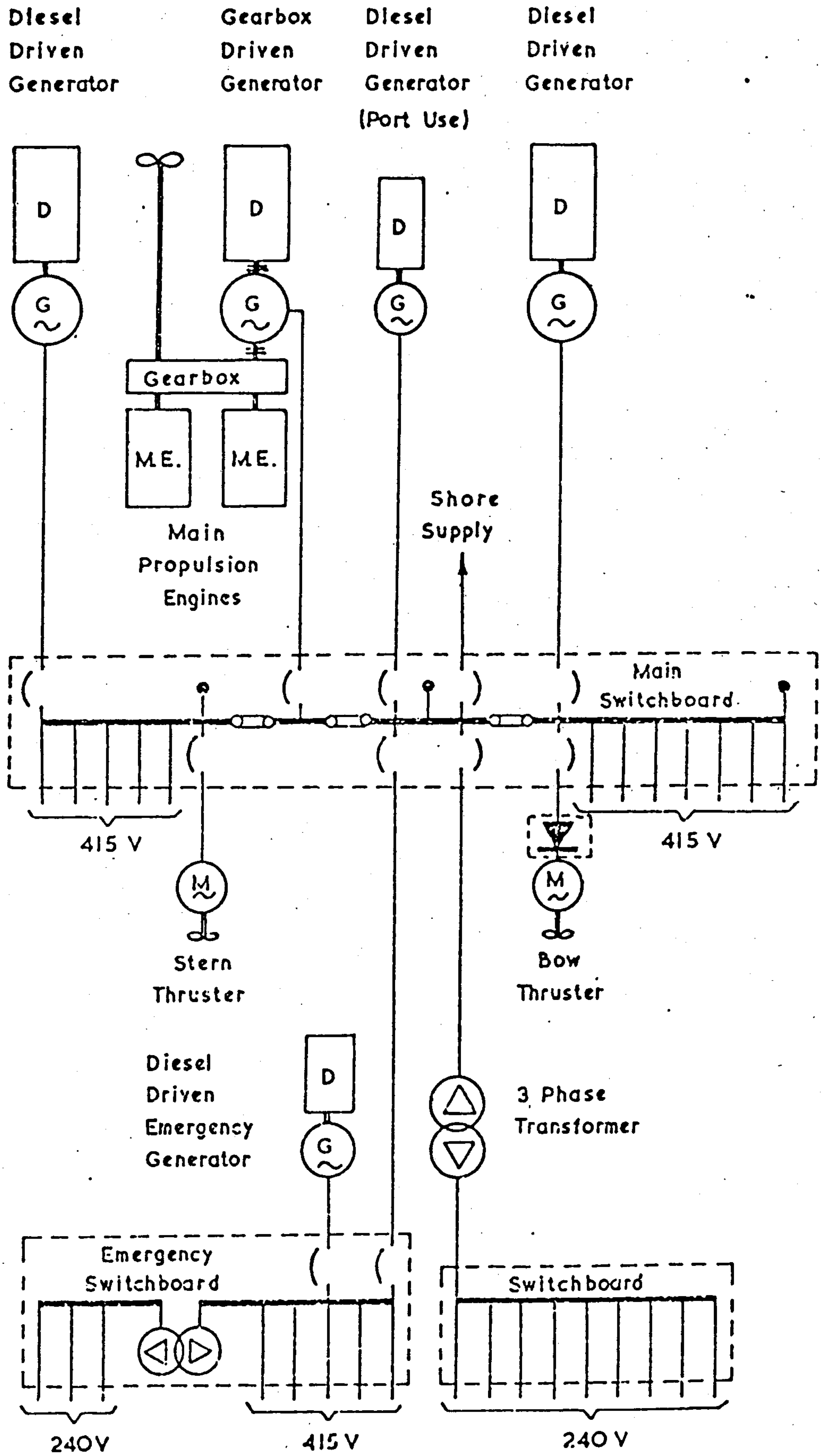


FRAME 108

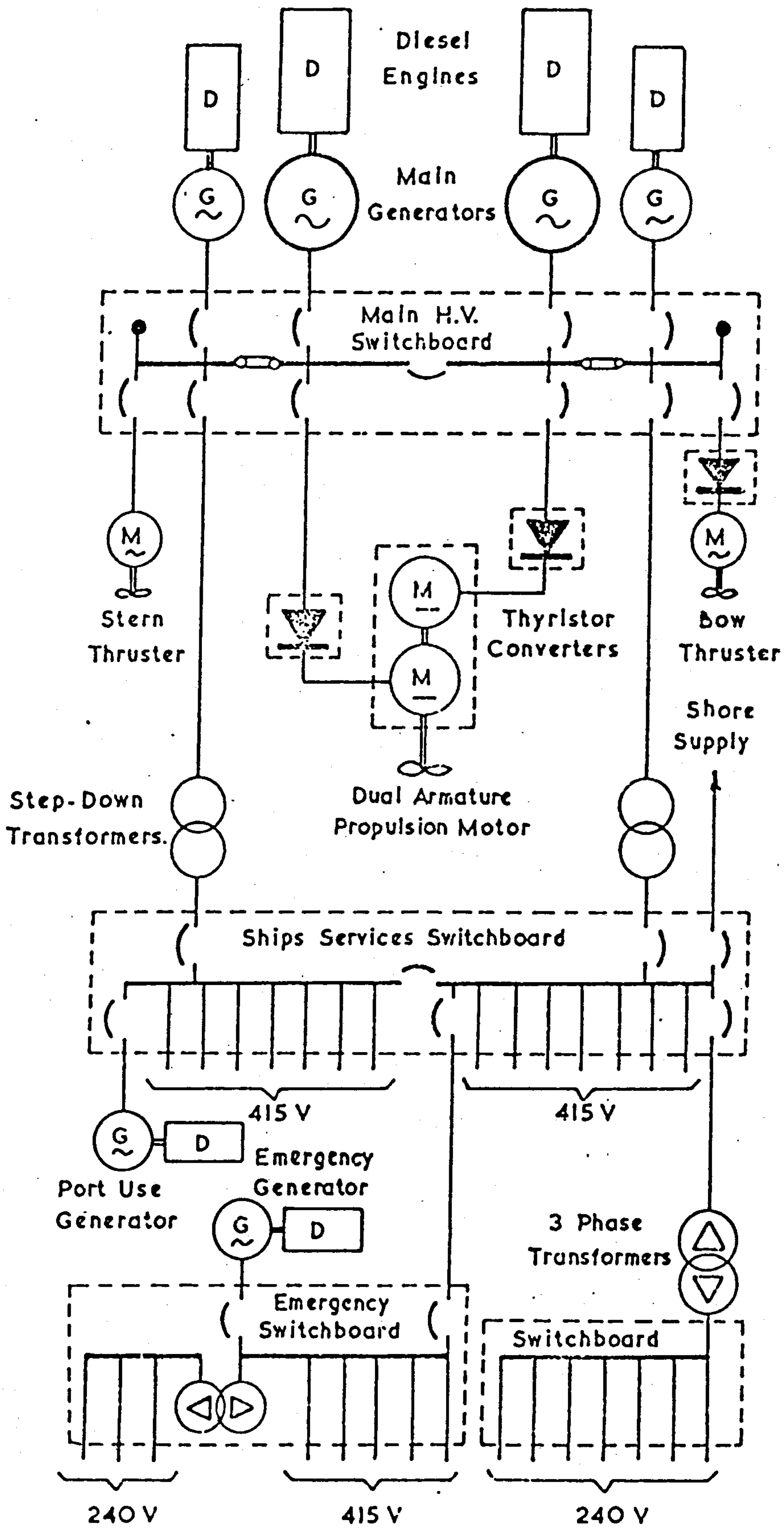


APPENDIX "N"

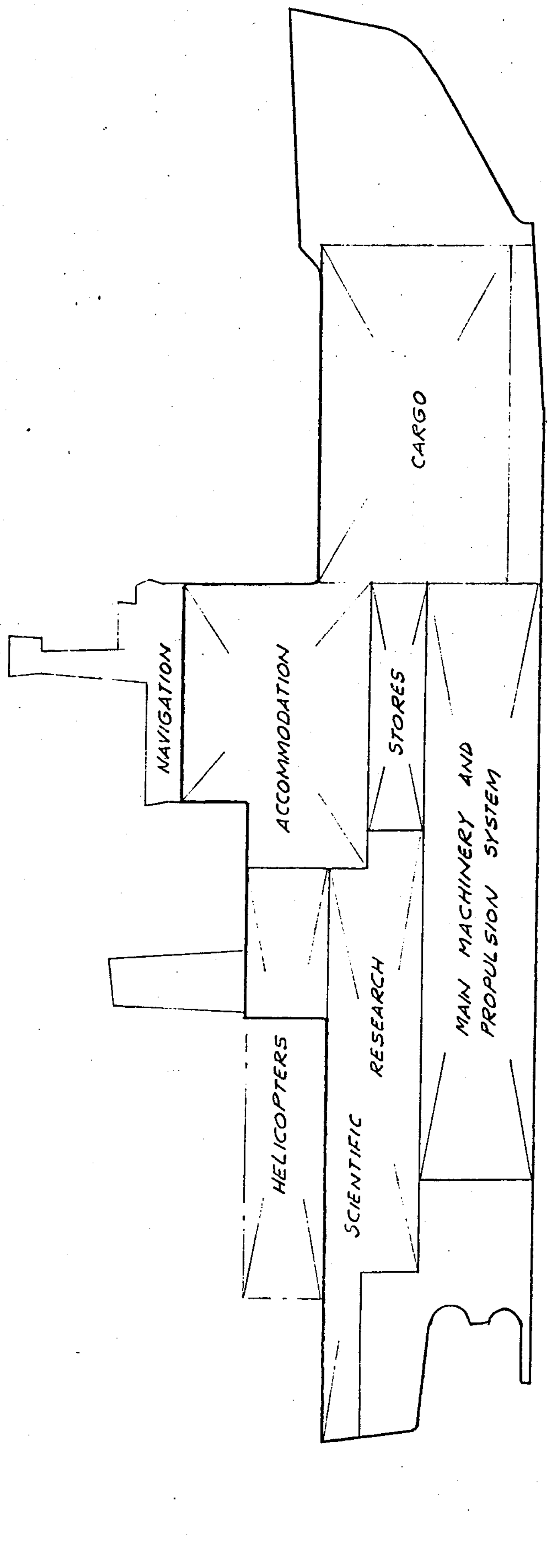
GEARED DIESEL DRIVE



DIESEL ELECTRIC DRIVE



APPENDIX "P"


CARGO
NAVIGATION
ACCOMMODATION
STORES
MAIN MACHINERY AND PROPULSION SYSTEM
SCIENTIFIC RESEARCH
HELICOPTERS

Research Operations

APPENDIX "Q"

The following permanent machinery and equipment for research operations is to be provided:

- Biological winch for sampling scale trawling and sampling operations. Capacity for 5000 metres of 12 mm diameter wire on each of two declutchable drums. Accurate speed control is to be possible from 0-150 metres per minute using both wires.
- Hydrographic winch for measurements including deep stations using instrument packages and sampling bottles and underway measurements of various kinds. Capacity for 8000 metres of 6 mm diameter wire, conducting and non-conducting, on each of two declutchable drums. Recovery speeds up to 120 metres per minute.

  This winch is to be operated in conjunction with a swinging type 'A' frame with a vertical lift of 3.25 metres (both located aft on the starboard side of the main deck).
- Dual "hero" platforms for ease of deploying and recovering hydrographic equipment are to be provided at the main deck level, starboard side, underneath the 'A' frame.
- Single channel seismic winch and reel for streaming and recovery of transducers and associated air gun.
- Magnetometer winch and davit for operation of proton magnetometer.
- Two tonne low profile davit for handling meteorological drifting buoys and stores, storage below deck for 15 buoys.
- A centreline gantry located over the ramp at the aft end of the main deck and capable of operation at least 2 metres aft from the ship's stern to 1 metre forward of the forward end of the stern ramp.
- Retractable boom from the ship side extending at least 10 metres for specialised air-sea interaction studies including surface temperature and down to several metres depth.
- Facility for operation of expendable bathythermograph equipment.
- Two 200 c.f.m. and two 20 c.f.m. 2,000 p.s.i. air compressors for single and multi channel seismic air guns.
- Deep coring winch, core cradle and davits for recovery of 20 metre length cores. Drum capacity 10,000 metres wire with 10 tonne maximum line pull. Recovery speed up to 60 metres per minute with 3 tonne line pull. To be located aft on the port side of the main deck.
- Multi channel seismic winch and reel for streaming and recovery of transducers and air gun array.
- A crane for deployment of acoustic sounding equipment located aft on the starboard side of the main deck.

APPENDIX "R"

Navigational and Survey Equipment

The following navigational and survey equipment suitable for operation in the Antarctic region is to be provided and installed in approved positions in the vessel:

- Satellite navigation system incorporating "dead reckoning" facilities and outputs for data acquisition and other equipment as required.
- Automatic Omega receiver incorporating outputs for data acquisition and other equipment as required.
- A true motion 3 cm (high definition) and 10 cm (general purpose) interswitched dual radar system having a slave unit fitted in the crow's nest and other slave units fitted as required. A system of collision avoidance is also to be incorporated.
- A Doppler speed and distance run log incorporating outputs for data acquisition, satellite navigation and radar systems. Remote display units are to be provided where required.
- Navigational echo sounder incorporating chart recorder, digital display and remote displays as required.
- A precision deep water depth recorder including digital slave units as required.
- Automatic/manual, trainable, forward and side scanning sonar incorporating P.P.I. display and retractable stabilised transducer.
- Automatic weather satellite receiver/recorder.
- Automatic photography facsimile receiver/recorder via geostationary satellite for navigation in ice.
- Composite meteorological display unit incorporating instruments indicating wind speed, wind direction, temperature, humidity % and barometric pressure.
- A master gyro compass suitable for operation in the Antarctic latitudes is to be provided complete with course recorder, repeaters as required, and outputs for direction finder, automatic pilot, satellite navigation, radar and data acquisition systems.
- A stand-by gyro compass having outputs as for the master compass.
- Automatic pilot automatic steering control system.
- All other minor navigational aids required for a vessel of this type.