AN OVERVIEW OF SEA TRIALS AND CONDITIONS EXPERIENCED IN VOYAGE 4

N.B.J.OFFER B.Sc. M.R.I.N.A.

The Antarctic Division of the Commonwealth of Australia has been seeking the acquisition of a vessel to service its supply and research requirements since time in immemorial. In 1986 the decision was taken in favour of seeking a new vessel of Australian build to be chartered by the Division and that tender was awarded to P&O Polar Australia Ltd in December 1987.

The building programme for the vessel was undertaken by Carrington Shipways of Newcastle, NSW.

COMMISSIONING TRIALS

As the project developed there was a requirement for undertaking various measurements so that the performance of various components on the vessel and the vessel itself were compatible with specified requirements.

Initially STU was involved in such measurements in a minor capacity undertaking measurements of winch capacity. There being thirteen winch/capstan components situated on the after end of the vessel (Figure 1) a simplified procedure of testing was adapted and measurements were undertaken in February 1980.

For such measurements a load cell of tension link format was used. The extension of the link being measured by a strain gauge, the output for which was recorded on paper as a time trace.

For all of the units located at the after end open area, a common cradle was used with strops being run around the substantial pillarring situated therein. The load cell or cells were then positioned between the cradle and the winch under test. After zeroes were checked the test pull was undertaken.

As a finale the pull on each of the two capstans was tested by attaching a strop to one of the major bollards situated just forward of the starboard capstan, placing the load cell adjacent to the bollard and then leading the warp a few turns about the capstan under test, the loose end being kept under tension.

In March 1990 Aurora Australia undertook a series of sea trials.

STU was involved in four principle areas of measurement:-

- Vessel position with respect time
- Engine performance by way of:
    - torque
    - shaft speed
- Noise
- Vibration

i. Vessel Position

For the purposes of defining the vessel's performance capabilities both in speed over measured distance and in undertaking various manoeuvres, a telemetric ranging system was used.

In this instance a Motorola Mini-Ranger measuring system was used consisting of a master station and two slave shore stations. The master station was fitted on board comprising a Mini-Ranger III Position Determining System, Data Processor, Data Terminal and an XY digital Plotter.

On board the vessel, the aerial was fixed to some high position, initially fitted to the mast and latterly on a small mast of its own to the funnel, so that it could continually monitor signals from the two shore stations, the precise location of which were fed into the data terminal.

The data controller had a facility which enabled print-outs to be made of the various data at chosen time intervals. Three methods of recording such data were used:-

(1) The distance from the ship to each shore station.
(2) Co-ordinates of vessel in Easting and Northing.
(3) Distance from an origin set or reset during trials.

In its basic form when the distance between the master and slave position is measured, it is displayed on windows in front of the Mini-Ranger. For such measurements to be accurate it is essential that the distance between slave stations must be accurately known, hence "trig" stations of known position were used for the shore transmitters.

As the master station moves along its track the distances between the slave stations and their master are continually displayed. The time interval between two sets of readings being known it was possible to calculate the speed of the vessel at any given time and from such measurements it was possible to undertake a series of measured distance speed trails at a position offshore with a water depth such that any shallow water effect on ship speed was negligible.

This instrumentation was also used to determine the manoeuvring capability of the vessel under differing initial conditions.

Typical of such manoeuvres were the turning circle trials. In order to gain a perspective of this effect of wind and current on the results it was required that for each turning circle undertaken the vessel was to pass through a minimum of 400 degrees.

Once a complete turn has been recorded (Figure 4) it is possible to undertake post processing procedures to correct for wind and current (Figure 5).

Finally for the purposes of publishing such data for presentation in the Wheelhouse the final corrected plots were reorientated to a common initial course north (Figure 6).

ii. **Engine Performance**

A twin engine - single propeller main propulsion system is used on "Aurora Australis" (Figure 8).

For general performance purposes the powering characteristics of the intermediate shaft line leading to the propeller were required.

A strain gauge transducer was fitted to the shaft, the output of which was transmitted from the shaft using FM telemetry. In addition the FM receiver was capable of inducing a secondary signal of pulse form proportional to the shaft speed.

The final output was presented in digital form for both strain and shaft speed, from which it is possible - given a known Modulus of Rigidity - to derive the torque and power applied through the shaft.

Measurements from this system were recorded throughout the measured distance and endurance trials.

Since the response of the strain gauge is instantaneous to changes in strain and since the frequency of the FM carrier signal is high, it is also possible to use this instrumentation to measure vibrating torque (torsional vibration) in the shaft line.

For this purpose a series of six strain gauges were set up at specific critical positions in the propulsion system (Figure 10).

The output from each gauge was recorded on a magnetic tape recorder so that in post trials analysis the phase between each position for a specific frequency may be determine if such proved necessary.

At the normal service speed of the engine a misfire condition was induced into the system by cutting off fuel to the cylinder which would produce the worst torsional condition as indicated by values calculated by the engine manufacturer (Figure 12).

iii. **Noise and Vibration**

Comprehensive noise and vibration measurements were undertaken throughout the vessel to ensure compliance with the requirements of the appropriate specification.

For noise the requirements of AS 2254 - 1988 were shown to be met.

The vibration levels of the main structure were shown to be satisfactory for habilitity purposes as defined by ISO6954-1984.

In the specification for the vessel there was a requirement for the vessel to undertake specific bollard pull trials to substantiate the power requirements defined for ice breaking duties.

For various reasons the decision was made to forgo the requirements of the bollard pull since the vessel had under single engine modes of operation shown that the power produced by each engine should meet such requirements.

To substantiate that decision the offer was made by the Division to participate in Voyage 4.

VOYAGE 4

Voyage 4 of the 1990-1994 Antarctic Seasons was undertaken by "Aurora Australis" to transport the majority of the expeditioners involved in that seasons summer science programme to Antarctica- Mawson and Davis - with a reduced complement of winter expeditioners returning home.

Since the complete voyage was expected to be a minimum of five weeks duration most of which either would be in transit to or from the ice region or would be spent off or on loading at the bases, the opportunity was taken to record some parameters associated with the seakeeping performance of the vessel during the transit stages of the voyage.

Hence in addition to undertaking a general overview of the icebreaking capability of the vessel the following measurements were made with appropriate instrumentation.

i. For seakeeping - low frequency acceleration measurements were made from three positions - port and starboard amid ships and as far forward as practicable in No 1 Hold.

ii. For icebreaking - the effect of ice impact on the propulsion system was recorded together with the applied torque and power output using torsionmeters set up on the intermediate propeller shafting as had been used during sea trials.

On 25th November 1990 "Aurora Australis" set sail from Hobart for Antarctica.

Whilst the strain gauge transducers had been set up in part prior to departure the first few days were involved in setting up a laboratory full of instrumentation, ensuring its functioning and setting up cables for seakeeping measurements.

Two days out of Hobart, the weather deteriorated and seakeeping observations commenced. Rough weather was encountered for the next five days with the vessel facing head seas.

During the rough weather whilst the vessel did naturally roll, the degree of roll was not as large as could have been expected for the conditions experienced.

With such head seas being encountered the vessel pitched significantly with intermittent slamming occurring.

As a result of the sea conditions a southerly course to Mawson was taken south at the ice pack with its damping effect on the seas would be encountered earlier than direct route.

On 1st December 1990 with the weather improving the first iceberg was sighted at 615107E.

Thereafter numerous icebergs were sighted.

On 3rd December 1990 light pack ice was encountered with negligible effect on reducing the daily average speed of the vessel.

Thereafter during the next day the pack ice varied up to 6/10. Close pack ice - 7/10-10/10 - was met on 5th December 1990.

In such ice the thickness of individual flocs could exceed 2m with a significant snow cover above.

Under all conditions of pack ice encountered the vessel passed comparatively unhindered. Occasionally a larger than normal floc was met as a consequence of which some impact reverberation through the structure occurred.

On 6th December fast ice was reached and the vessel commenced breaking ice through a region known as "Iceberg Alley". This being the charted route through to Mawson.

Whilst ice measurements taken in fast ice immediately off Mawson indicated thicknesses of 1.1-1.3m, the ice encountered in "Iceberg Alley" appeared to be significantly thicker - 1.4m. In addition the bergs along "Iceberg Alley" caused substantial snow drifts to occur on the ice through which the route to Mawson lay.

Since the power required to meet such ice increased the fuel consumption - as compared to normal transit speed - by three to four times, it became obvious for economic considerations that a normal fly off transfer routine would be required.

Unlike the more populous Arctic regions where dedicated ice breakers perform a function of opening or maintaining seaways for commercial traffic, vessels operating off Antarctica are generally station supply vessels making a sole entry to the appropriate research station. Transfers from the edge of the fast ice to the station by air or over ice means in such conditions, are considered the norm.

Whilst moving in the fast ice some measurements of power and the effect of ice impact on the propulsion system were recorded. An overview of the ice breaking capability of the vessel in such conditions was also made from a helicopter.

On 12th December the vessel departed from Mawson through fairly dense pack ice enroute to Davis.

Gale force winds forced a days delay into the anchorage off Davis.

Eventually the anchorage there was reached at midday on 15th December. This required a passage through some fast ice which was undertaken without concern. The fast ice being about 0.7-1.0m thick with minimal snow cover.

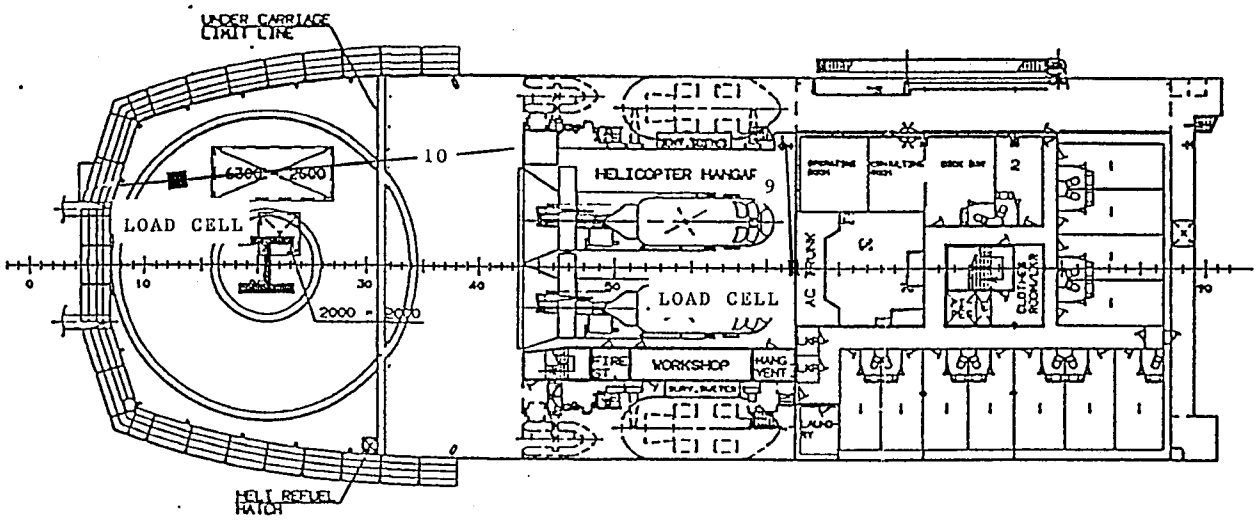
Due to the conditions of the ice a normal fly off procedure was again used for transfer to expeditioners and stores.

Late on 18th December Aurora set sail for Hobart making a passage due north passing through areas of dense pack ice till midday 19th December.

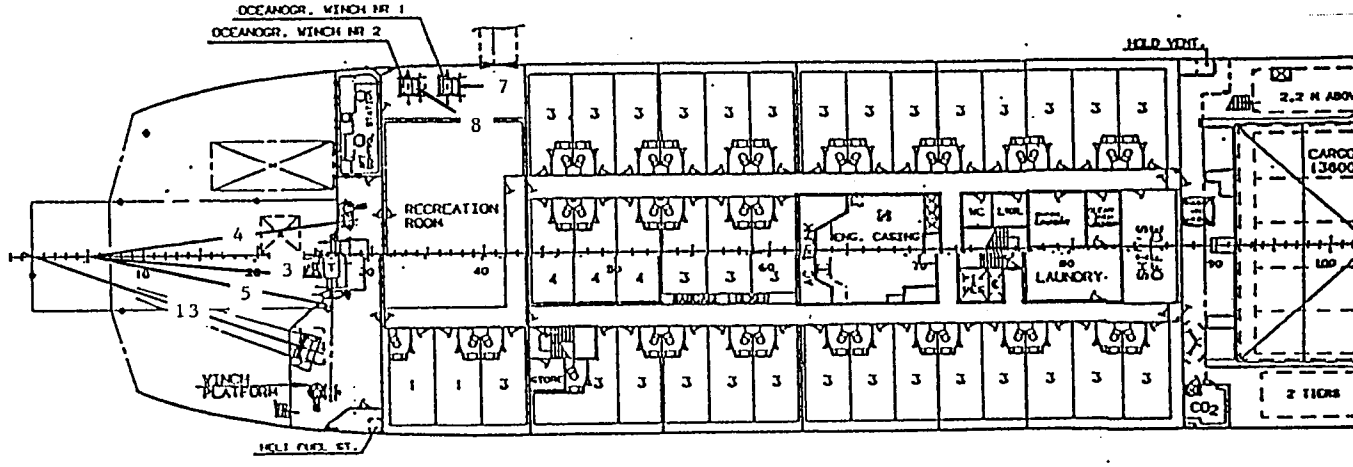
During the voyage home the prevailing wind and weather was on the stern quarter hence a much improved seakeeping condition was experienced, allowing Christmas festivities to pass without untoward discomfort.

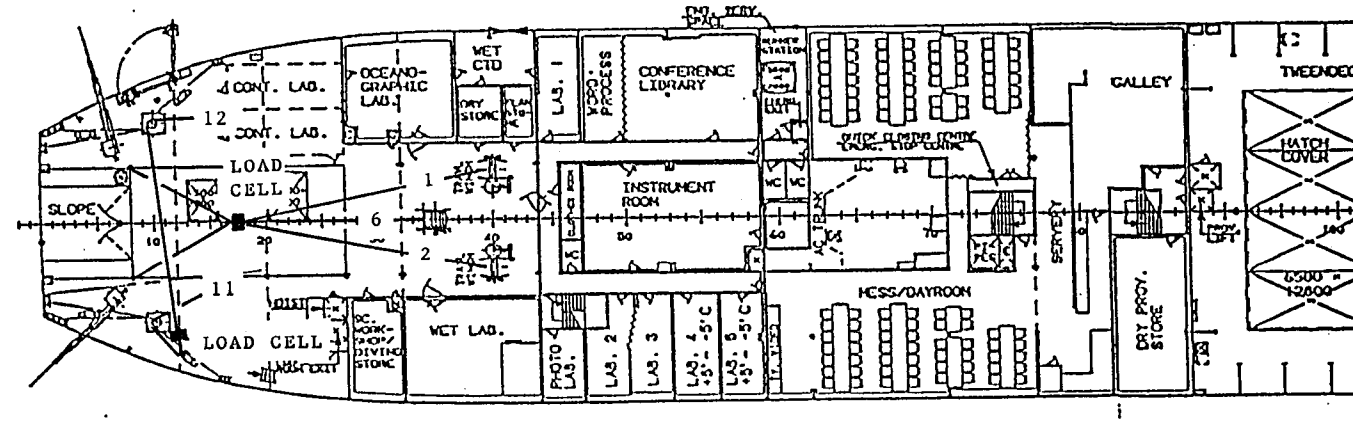
Hobart was reached on 29th December just prior to the arrival of the leading yachts of the Sydney Hobart fleet.

In both trials and voyage undertaken the vessel performed within the specifications placed upon it enabling it to fulfill its functions of supply and research platform for use in the hostile Antarctic environment.



1 ST BRIDGE DECK
(15950)





ANTARCTIC RESEARCH VESSEL "AURORA AUSTRALIS"

WINCH TEST

FIG. 1. POSITION OF VARIOUS WINCHES ON OPEN AFTER DECK 2ND DECK AND WINCH PLATFORM ON UPPER DECK

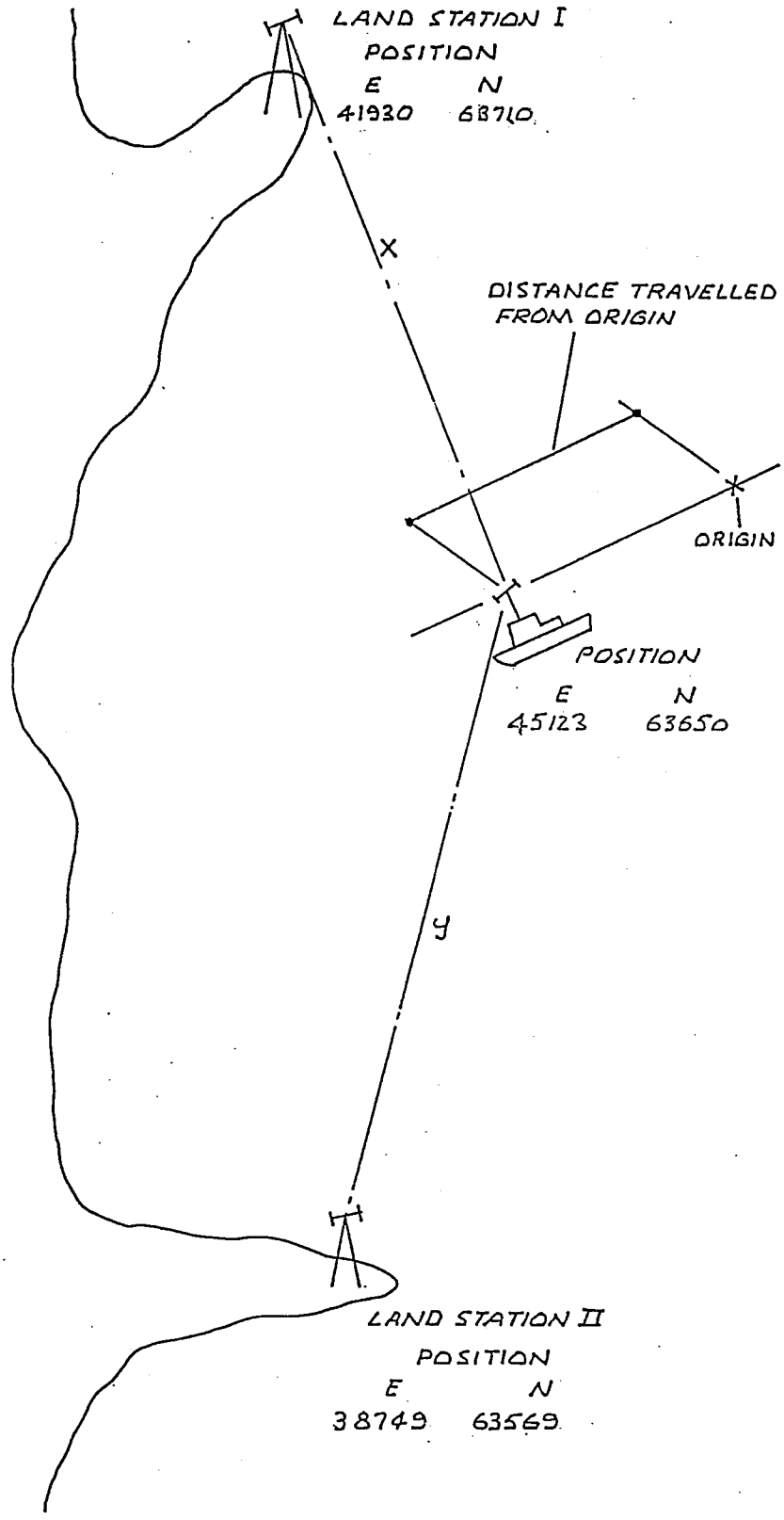


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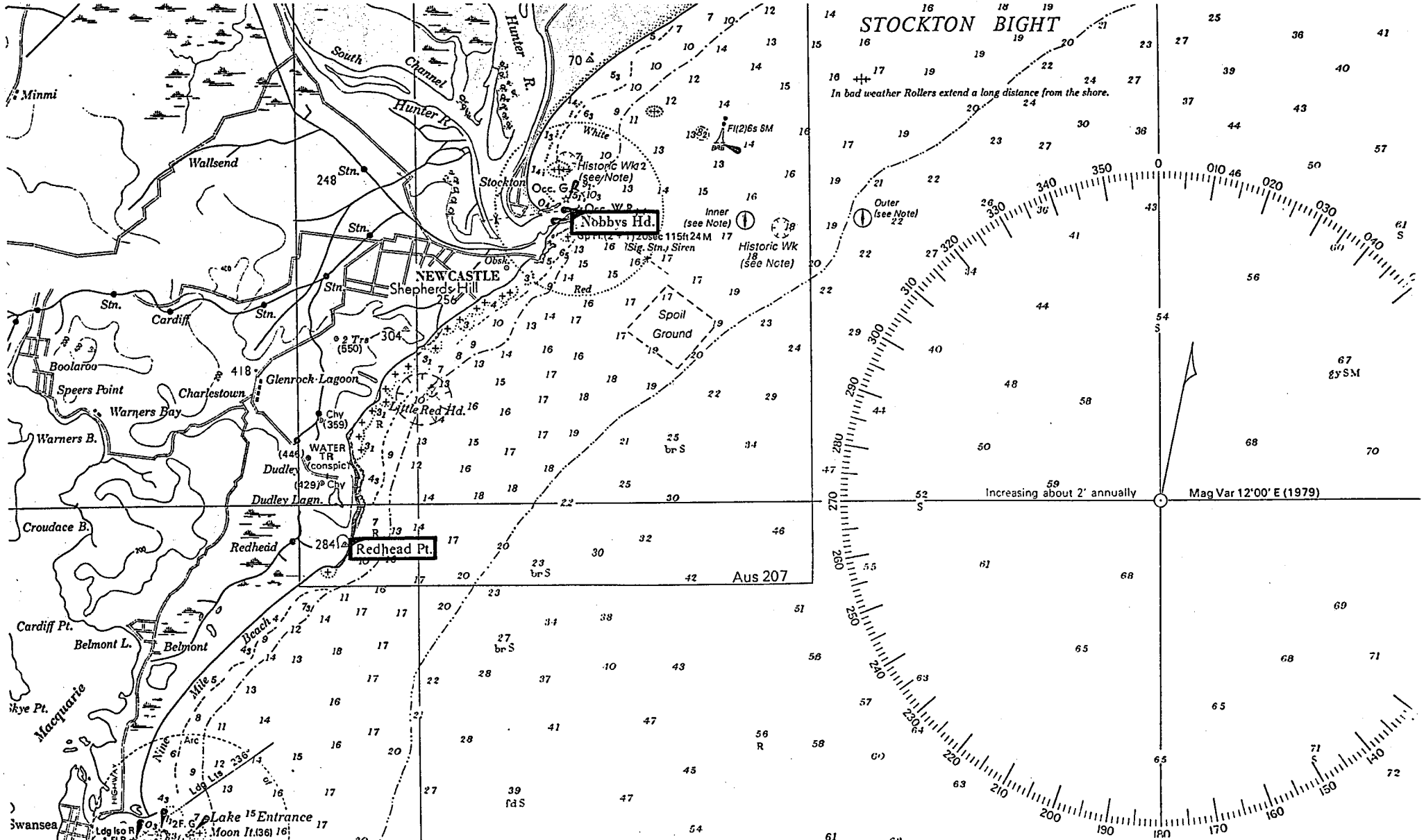
FIG. 2. MINI-RANGER SCHEMATIC



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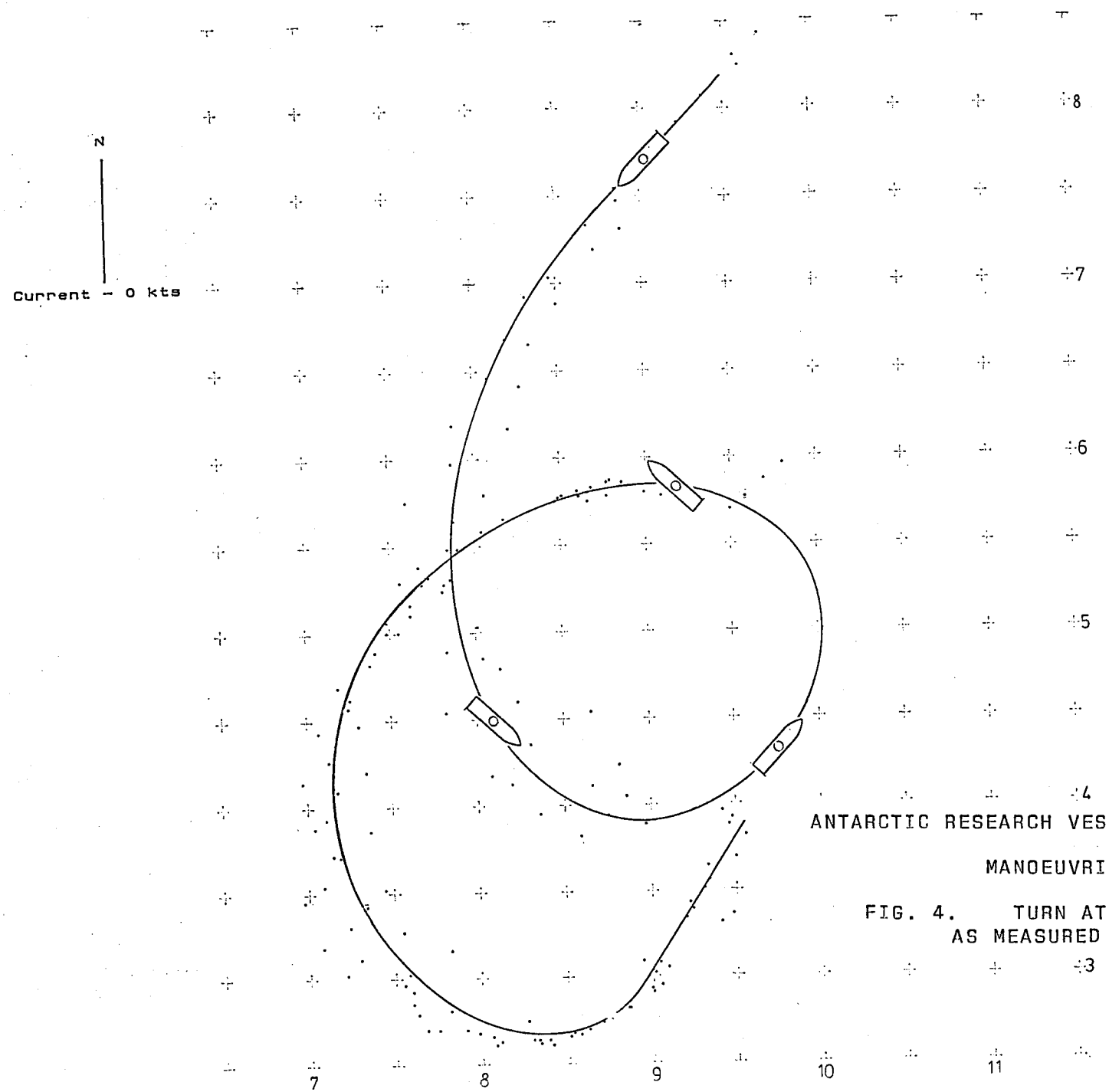
MEASURED DISTANCE SPEED TRIALS
POWER AND DISTANCE MEASUREMENTS

FIG. 3. SECTION OF CHART OFF NEWCASTLE
SHOWING POSITION OF TRANSMITTERS



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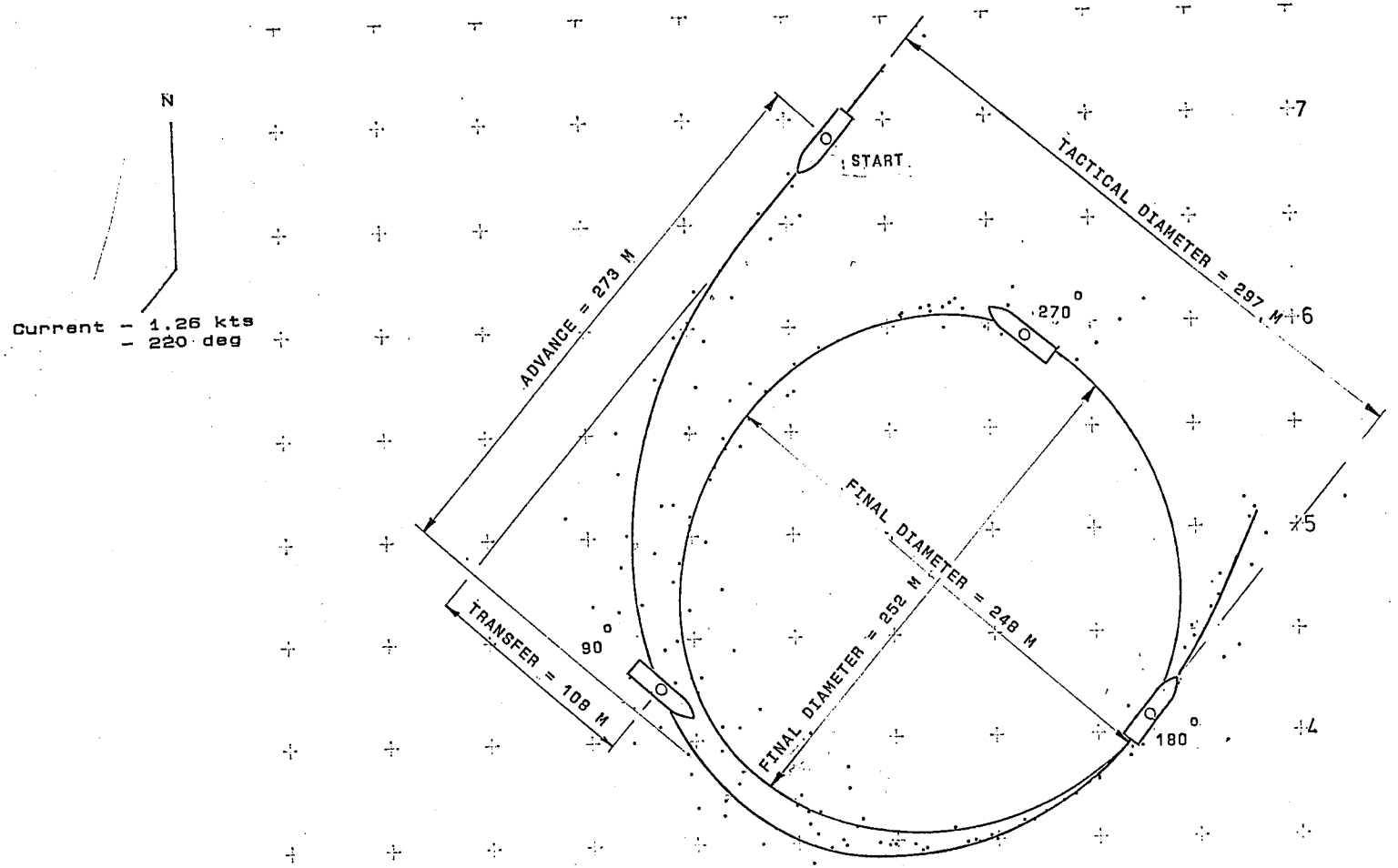
MANOEUVRING TRIALS

FIG. 4. TURN AT 2700 KW – TO PORT
AS MEASURED OVER GROUND



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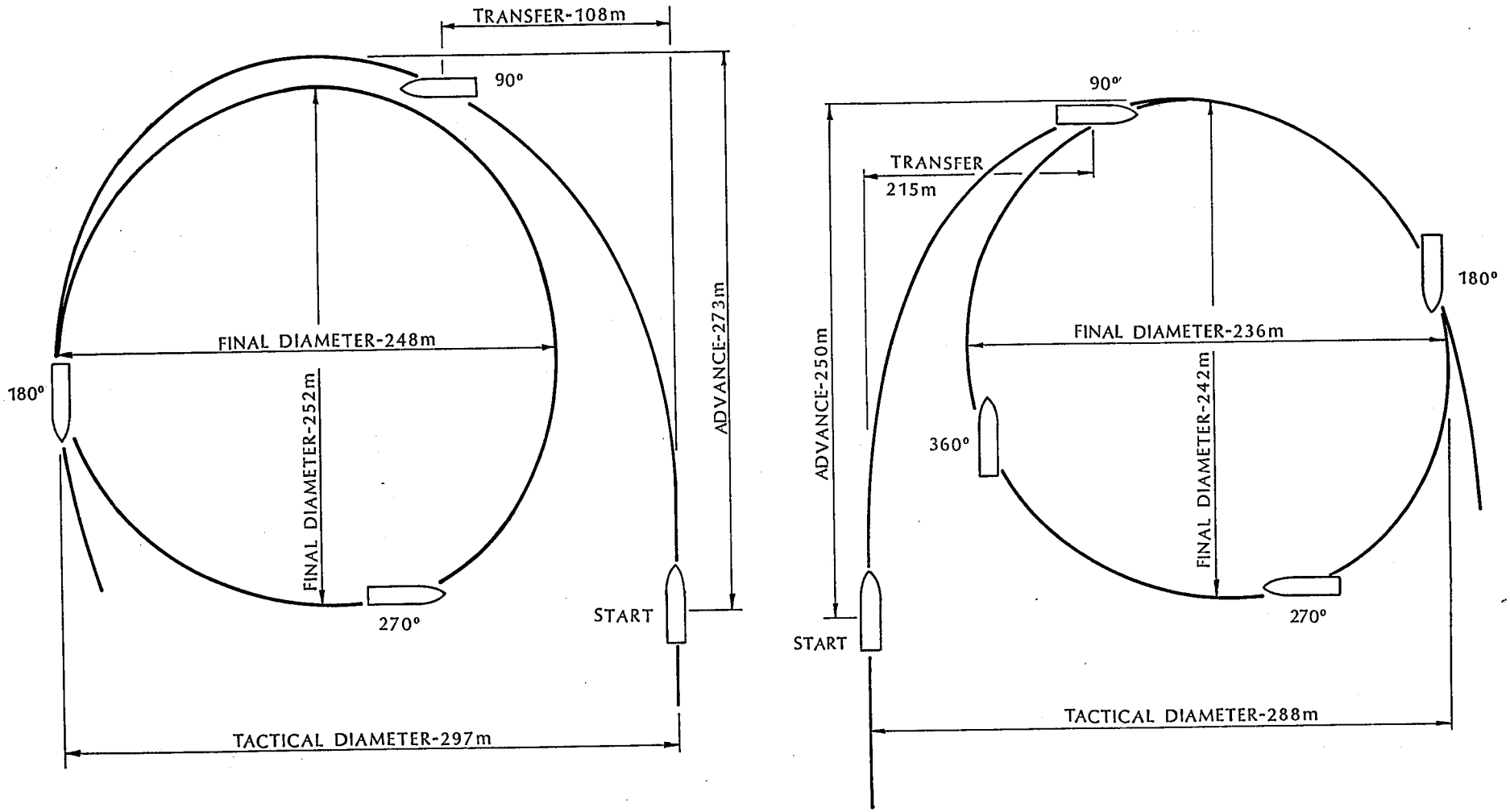
MAOEUVRING TRIALS

FIG. 5. TURN AT 2700 KW - TO PORT
CORRECTED FOR CURRENT AS INDICATED

R.V. AURORA AUSTRALIS

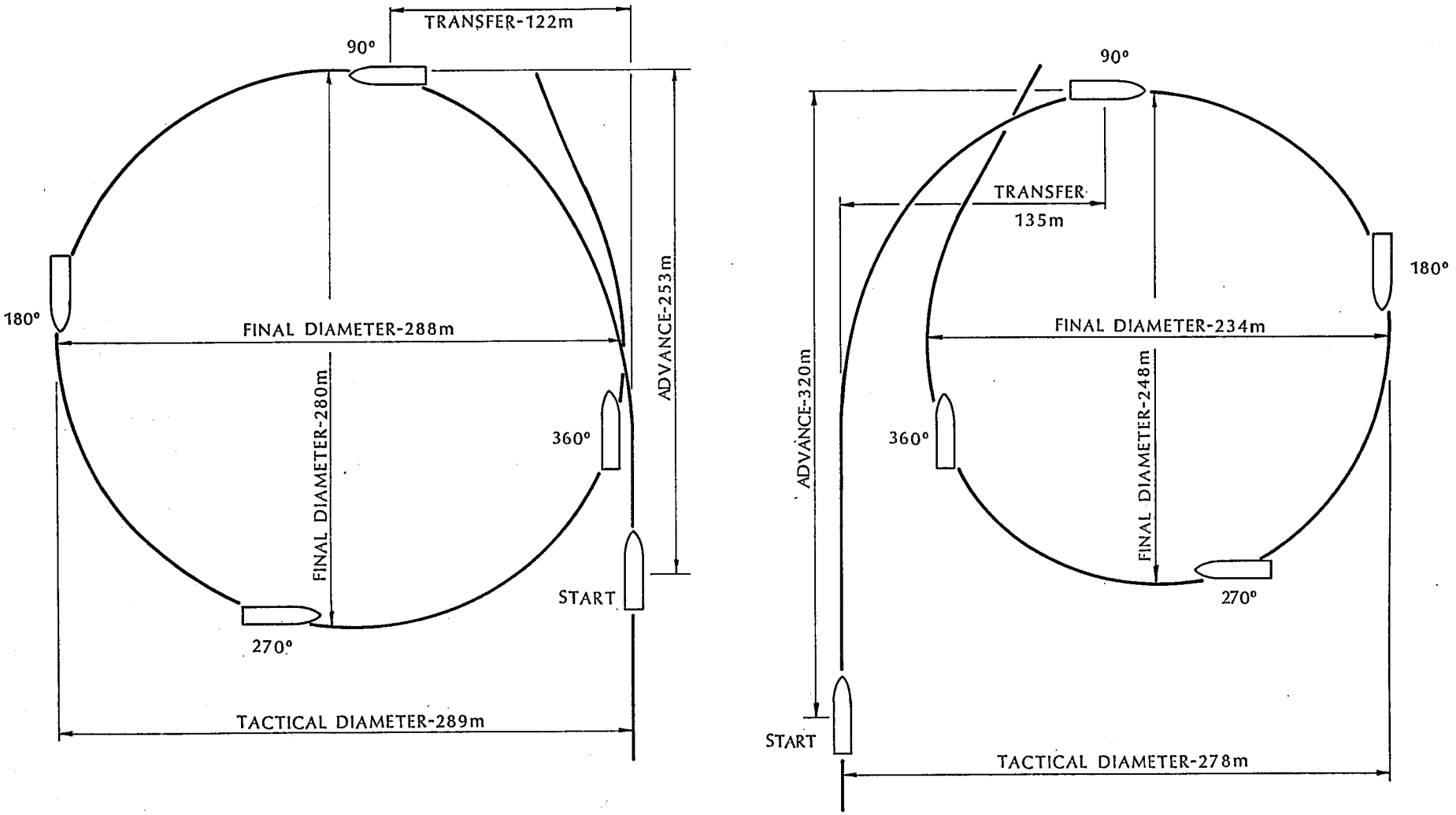


PORT TURN ANTARCTIC RESEARCH VESSEL "AURORA AUSTRALIS" STARBOARD TURN

2700 K.W. MANOEUVRING 2700 K.W.

FIG. 6. FINAL DIAGRAM - 2700 KW

R.V. AURORA AUSTRALIS



PORT TURN ANTARCTIC RESEARCH VESSEL "AURORA AUSTRALIS" STARBOARD TURN

7900 K.W. MANOEUVRING 7900 K.W.

FIG. 7. FINAL DIAGRAM - 7900 KW

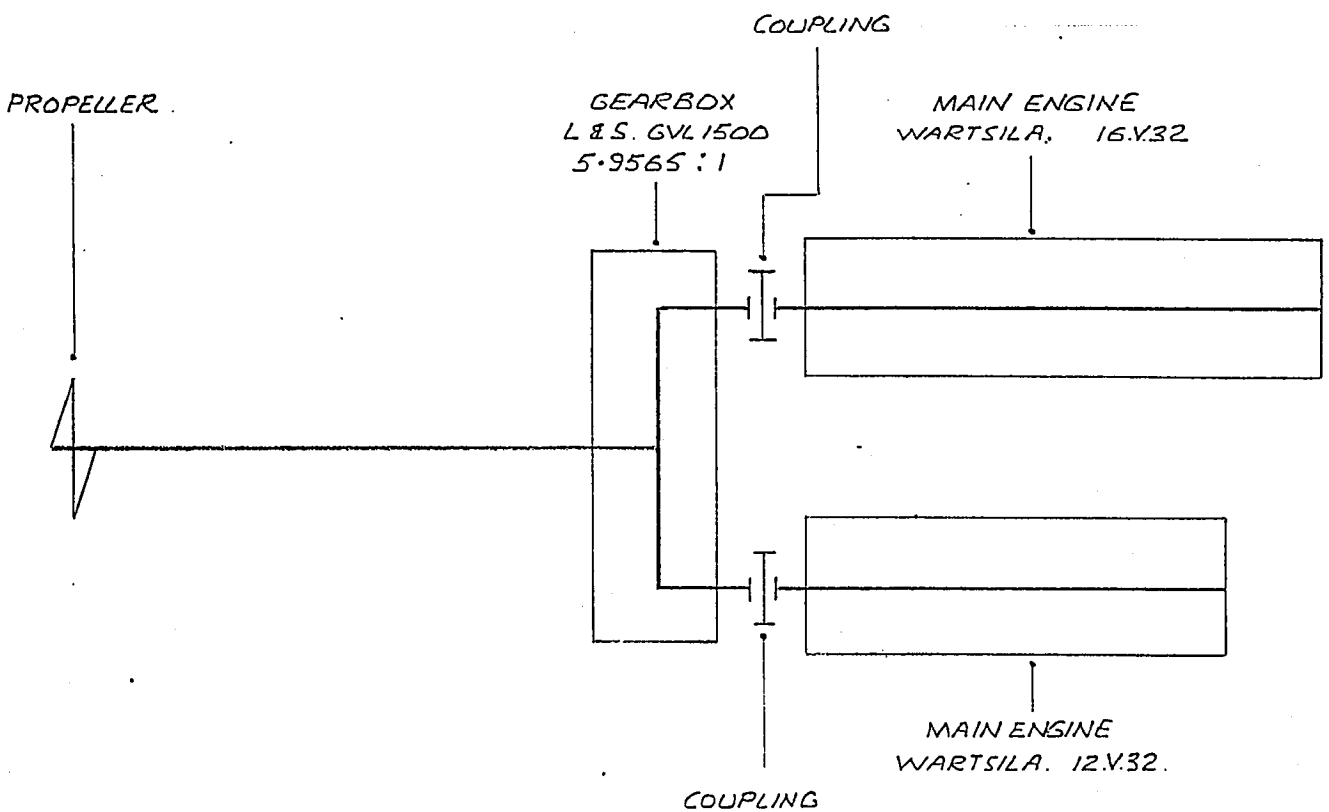


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FIG. 8. PROPULSION SYSTEM SCHEMATIC

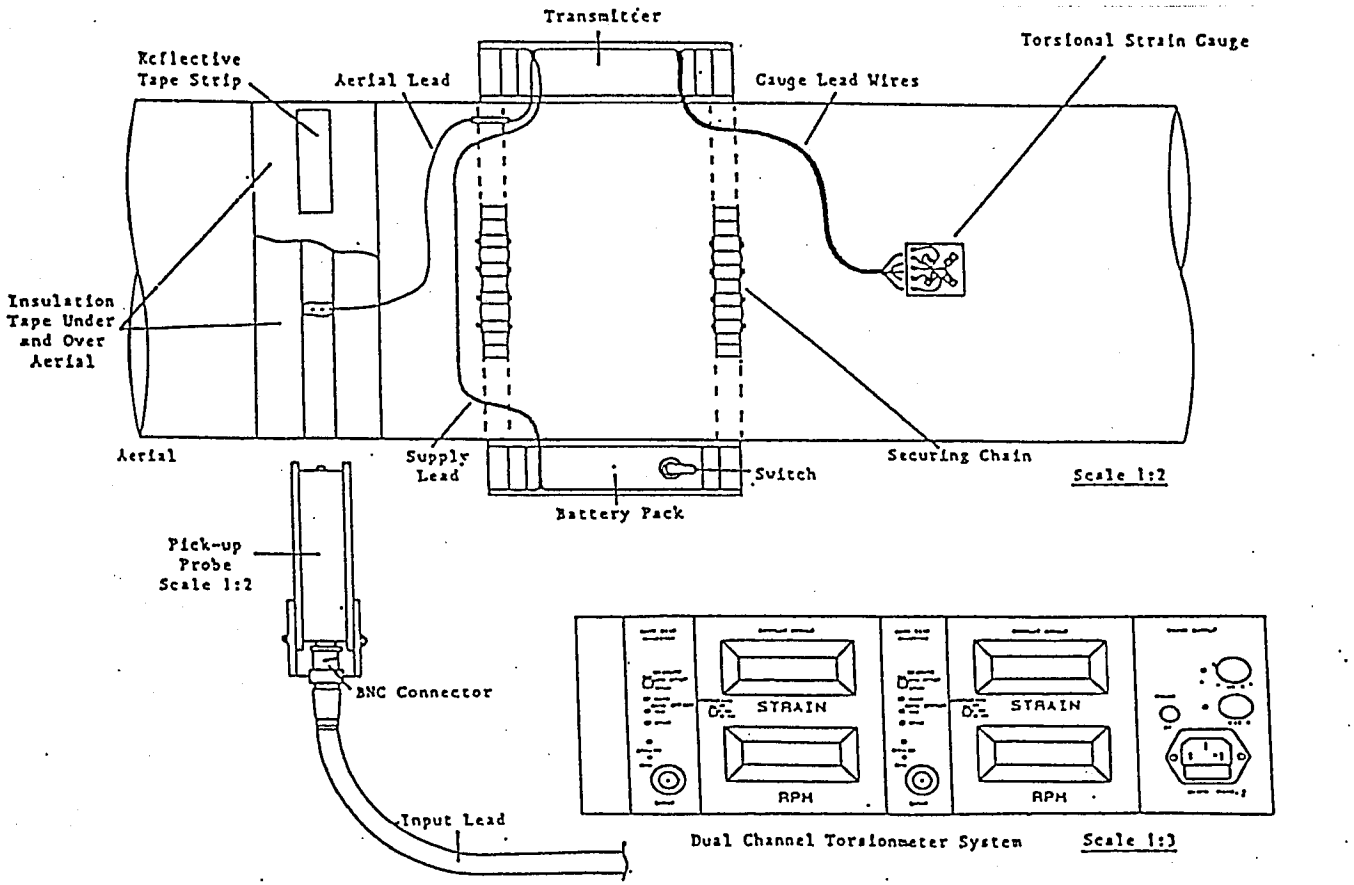

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FIG. 9. SCHEMATIC OF TORSIONMETER WITH F.M. TELEMETRIC TRANSMISSION

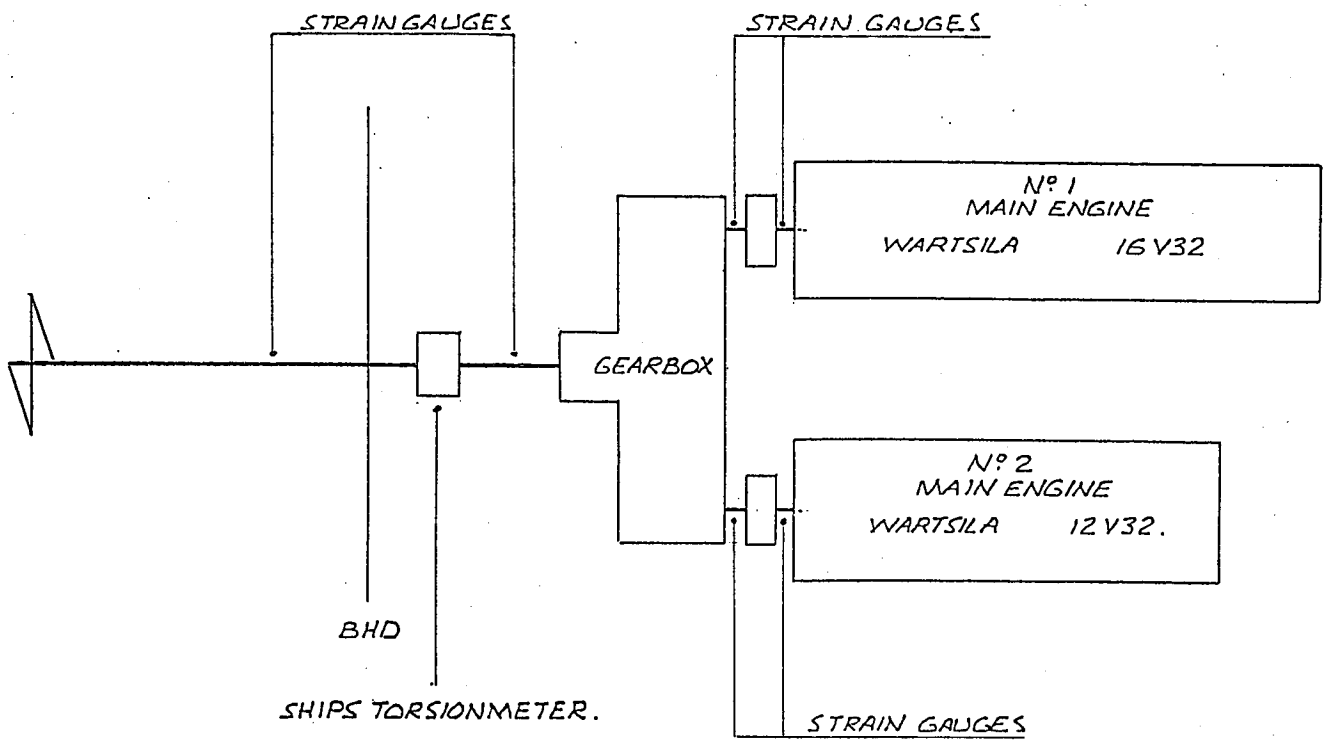

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FIG. 10. LOCATION OF STRAIN GAUGES

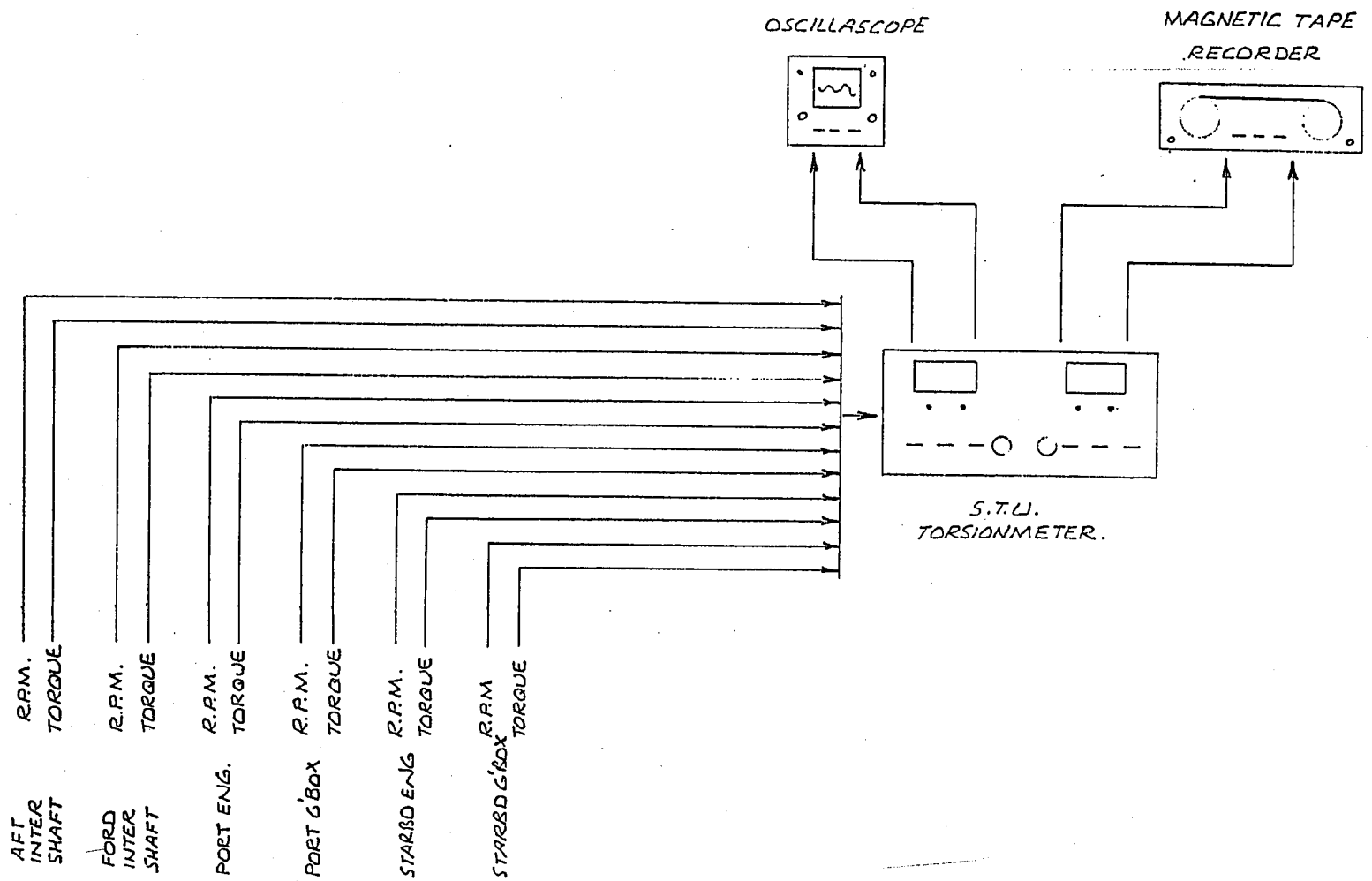

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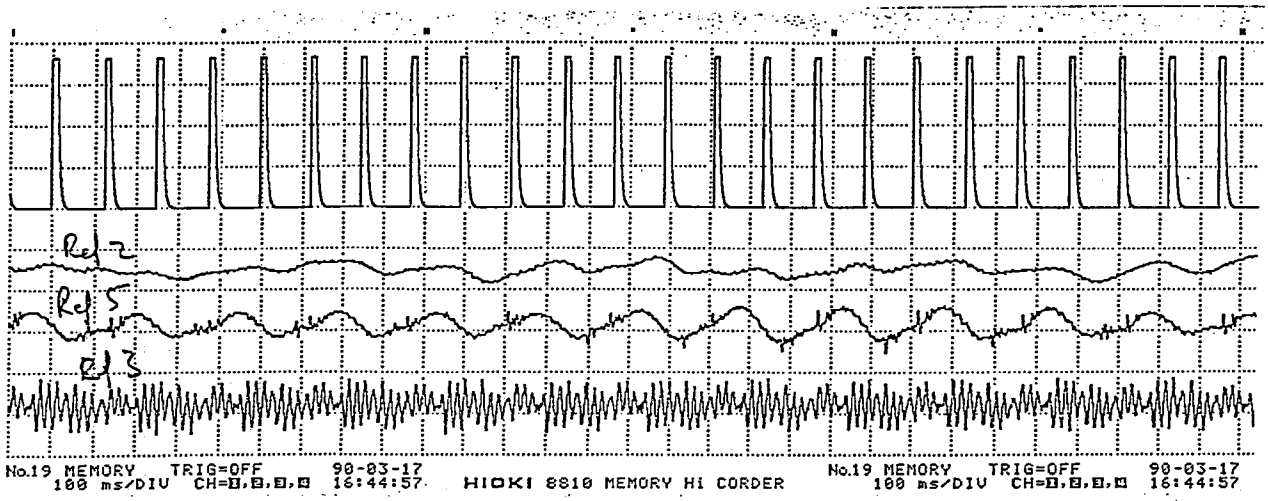
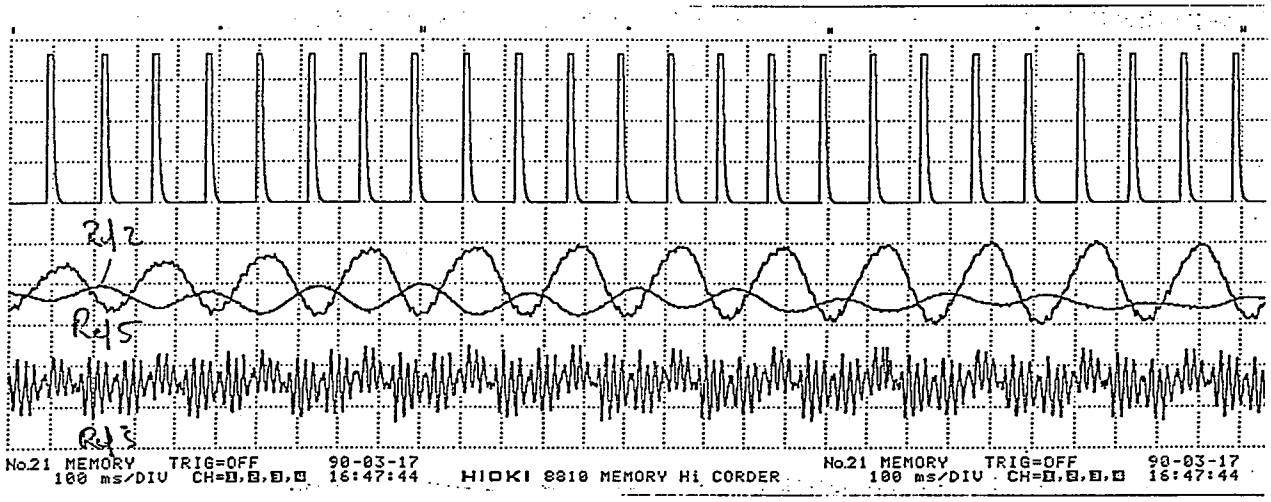
FIG. 11. SCHEMATIC DIAGRAM OF INSTRUMENTATION



- Normal -



- Misfire -

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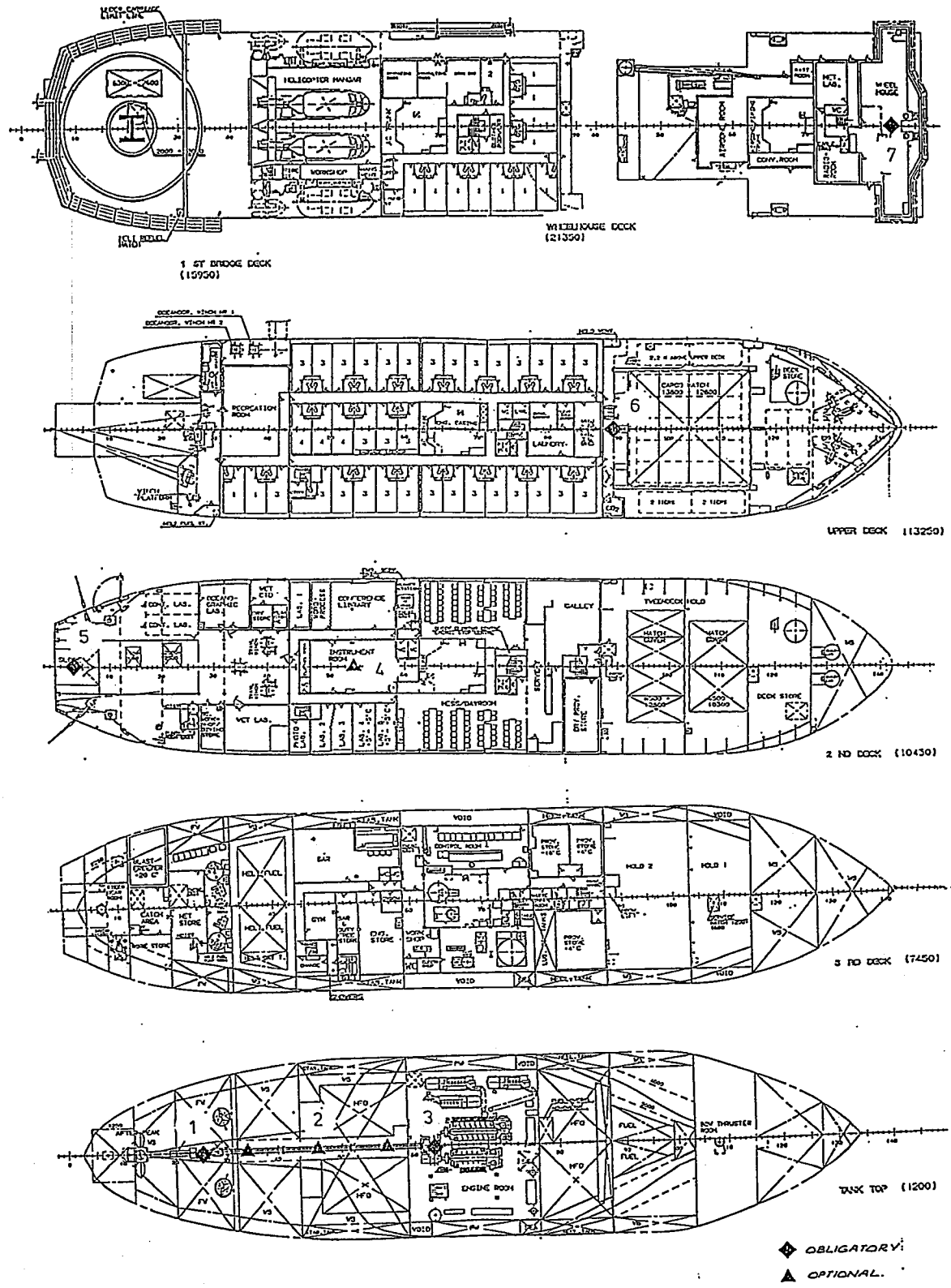
VIBRATORY TORQUE AND POWER MEASUREMENTS

FIG. 12. TYPICAL SAMPLES OF TIME TRACES
- TEST I - No. 1 ENGINE ONLY
- AT 760 rev/min Engine Speed - Normal & Misfire -



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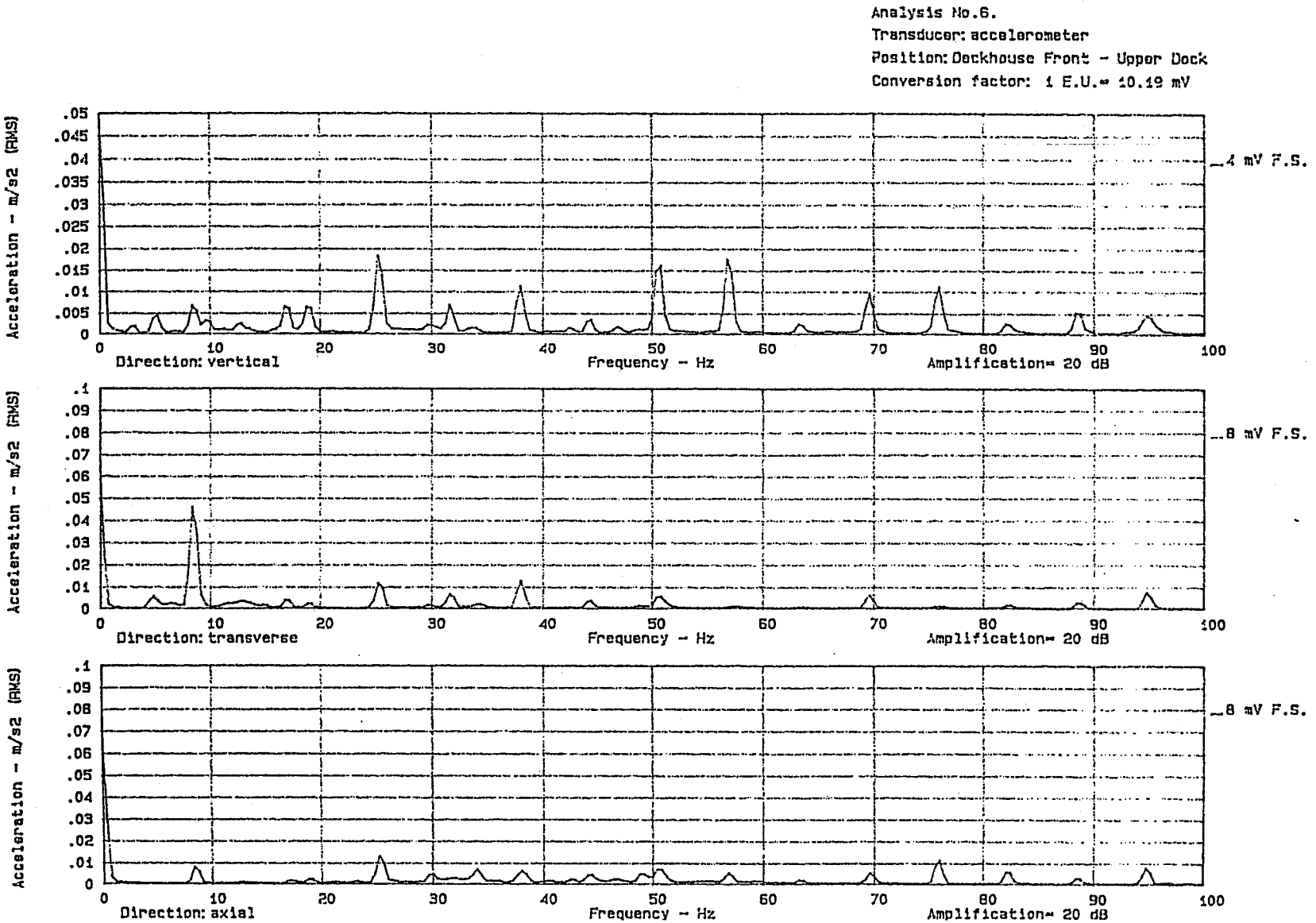
LINEAR VIBRATION

FIG.13. POSITION OF LINEAR VIBRATION MEASUREMENTS



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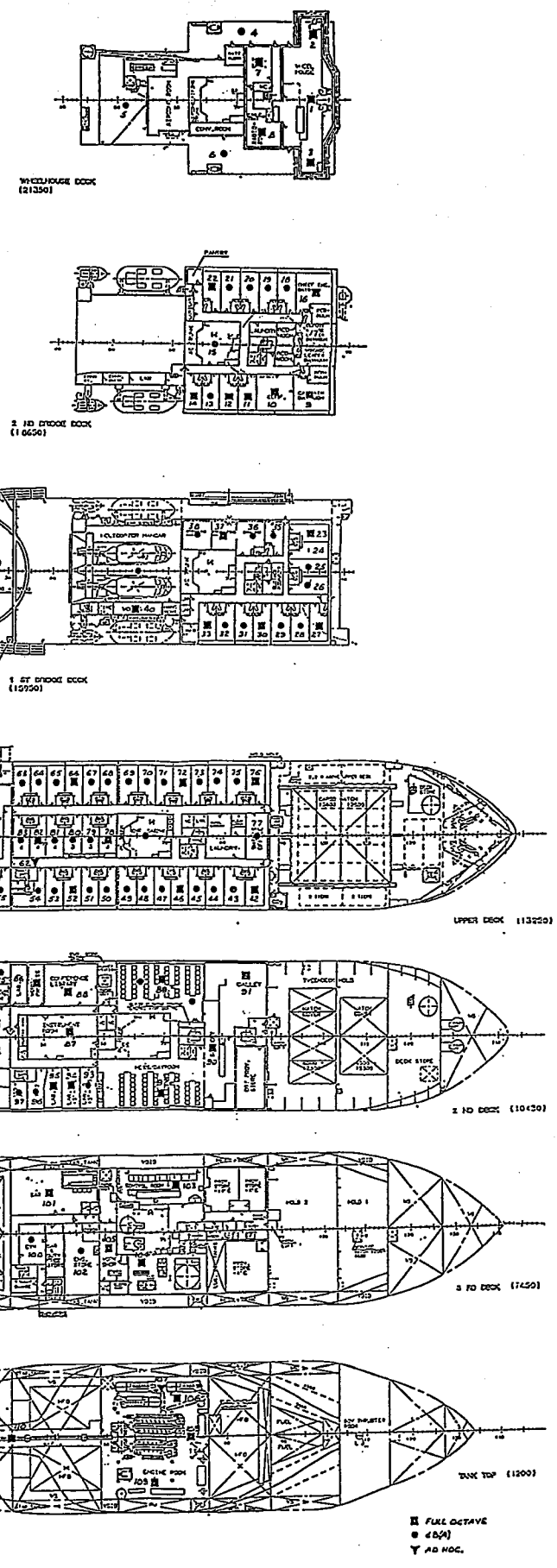
LINEAR VIBRATION

FIG. 14. TYPICAL FREQUENCY SPECTRA OF LINEAR VIBRATION



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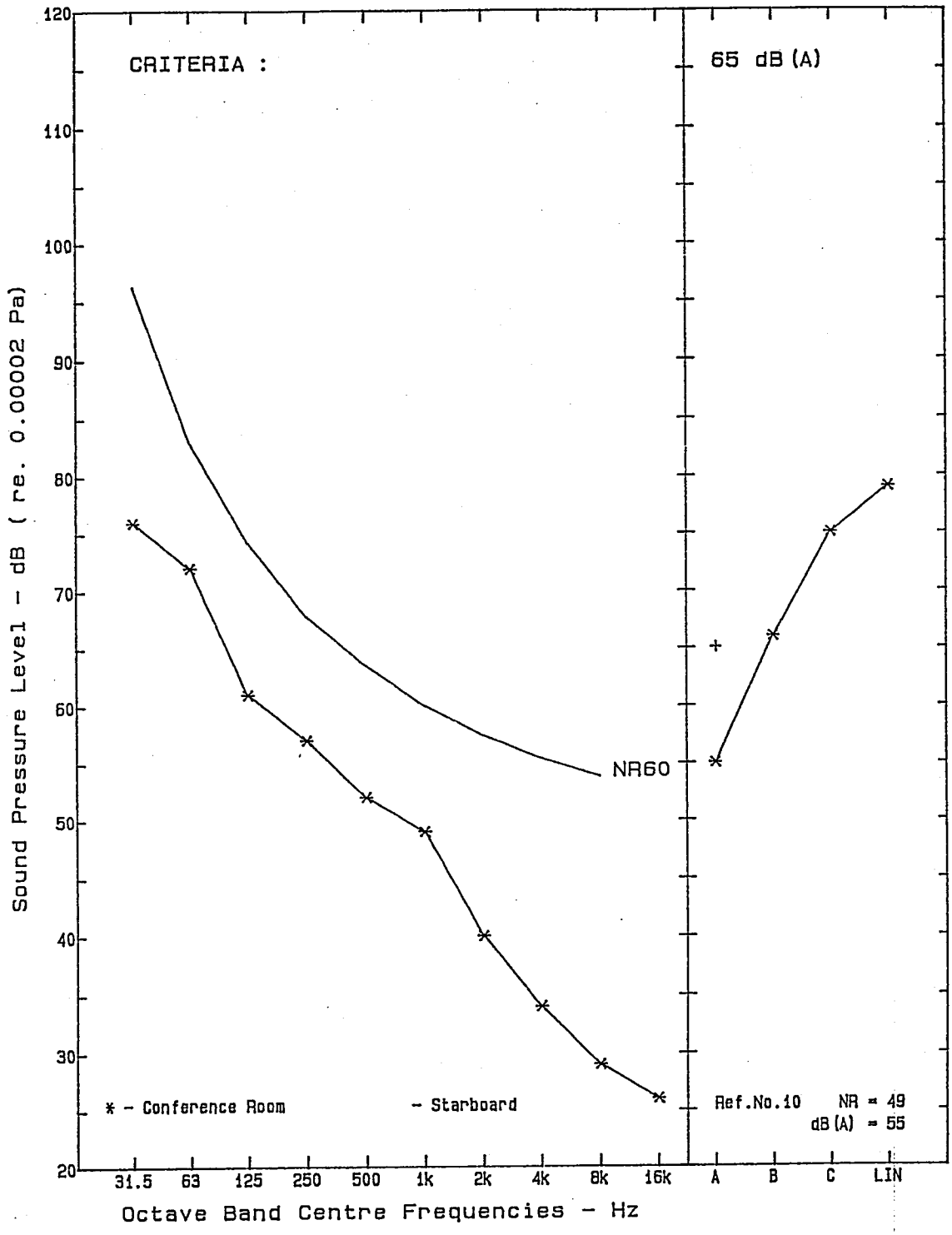
NOISE SURVEY

FIG. 15. POSITIONS OF NOISE MEASUREMENTS



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NOISE SURVEY REPORT

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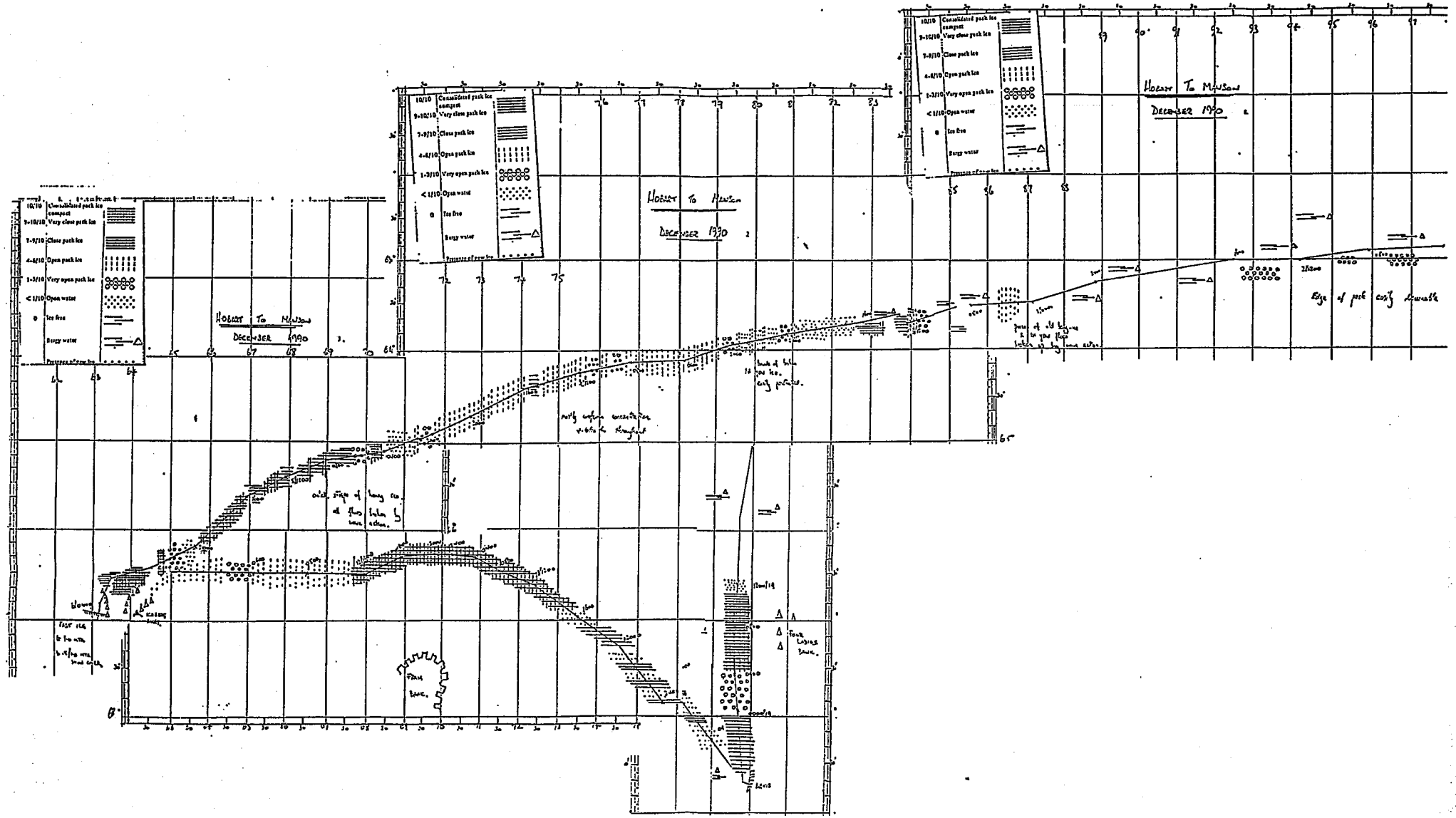
NOISE SURVEY

FIG. 16. TYPICAL NOISE SPECTRA UNDER TWIN ENGINE SERVICE CONDITIONS



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VOYAGE 4.

FIG. 17. ROUTE OF VESSEL SHOWING ICE ENCOUNTERED

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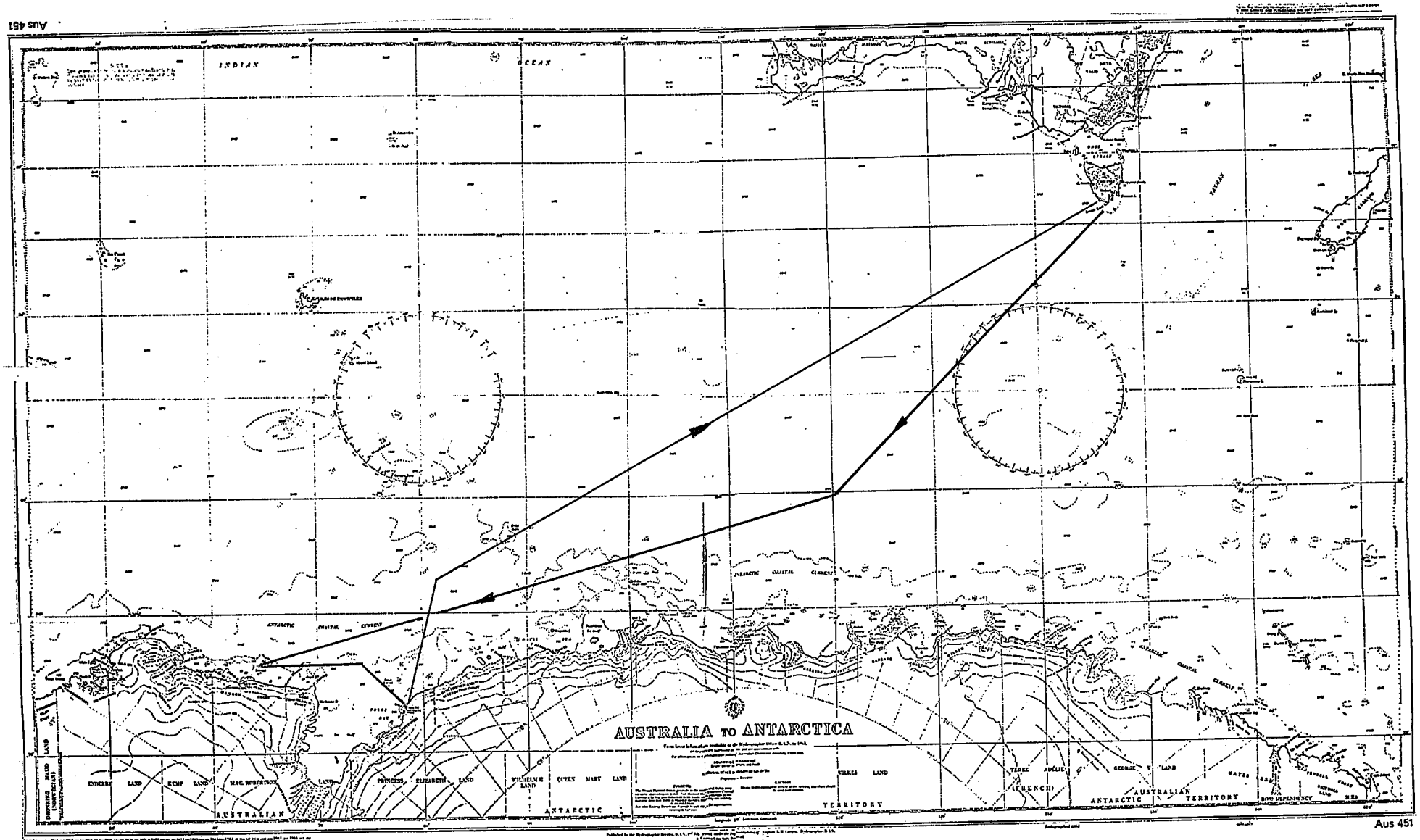
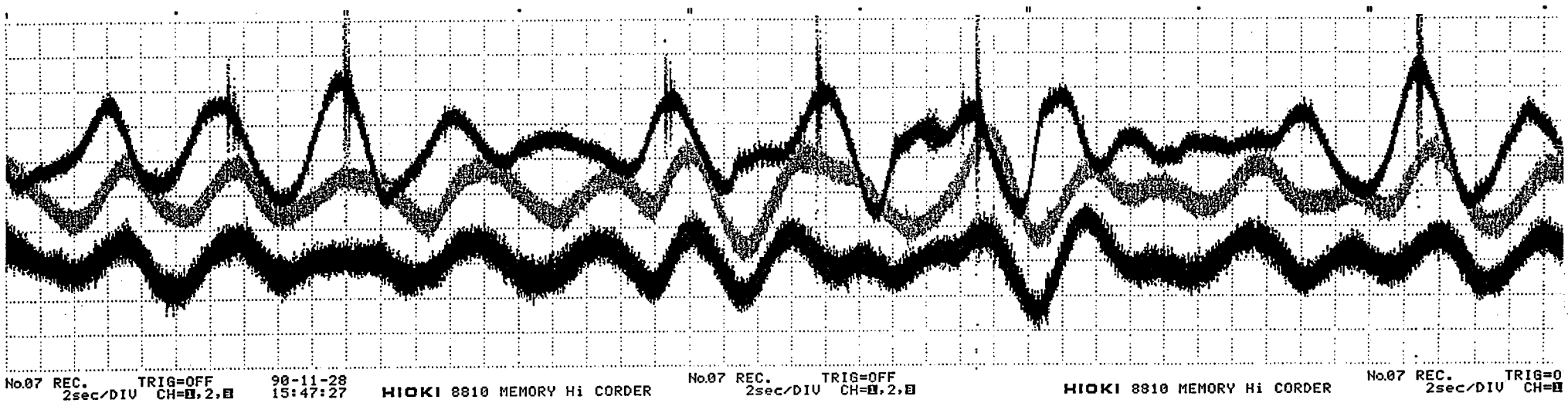
VOYAGE 4.

FIG. 18. ROUTE TO MAWSON AND DAVIS FROM HOBART





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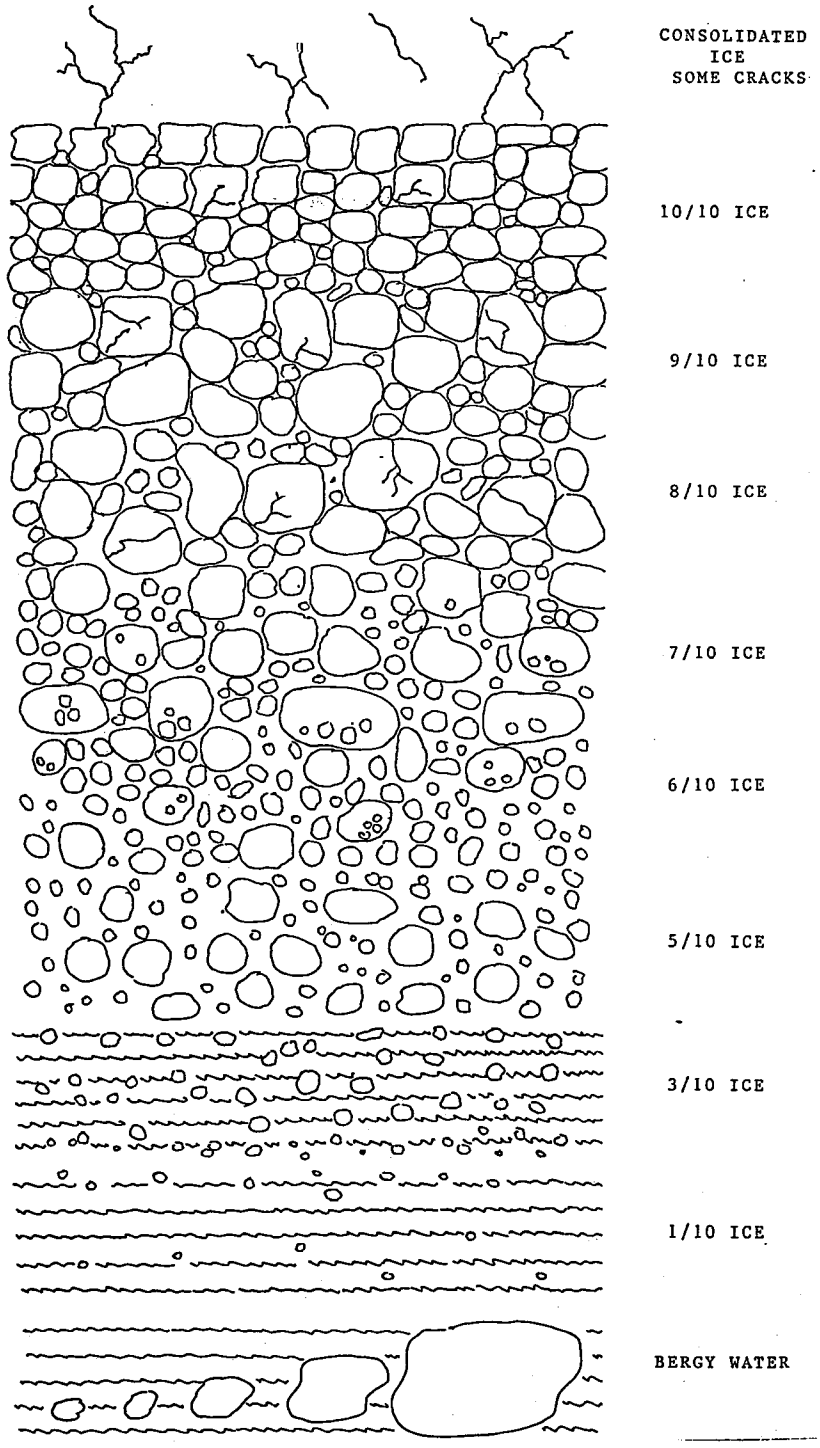
VOYAGE. 4.

FIG. 19. TYPICAL SAMPLE OUTPUT OF
ACCELERATION DUE TO PITCH AND ROLL



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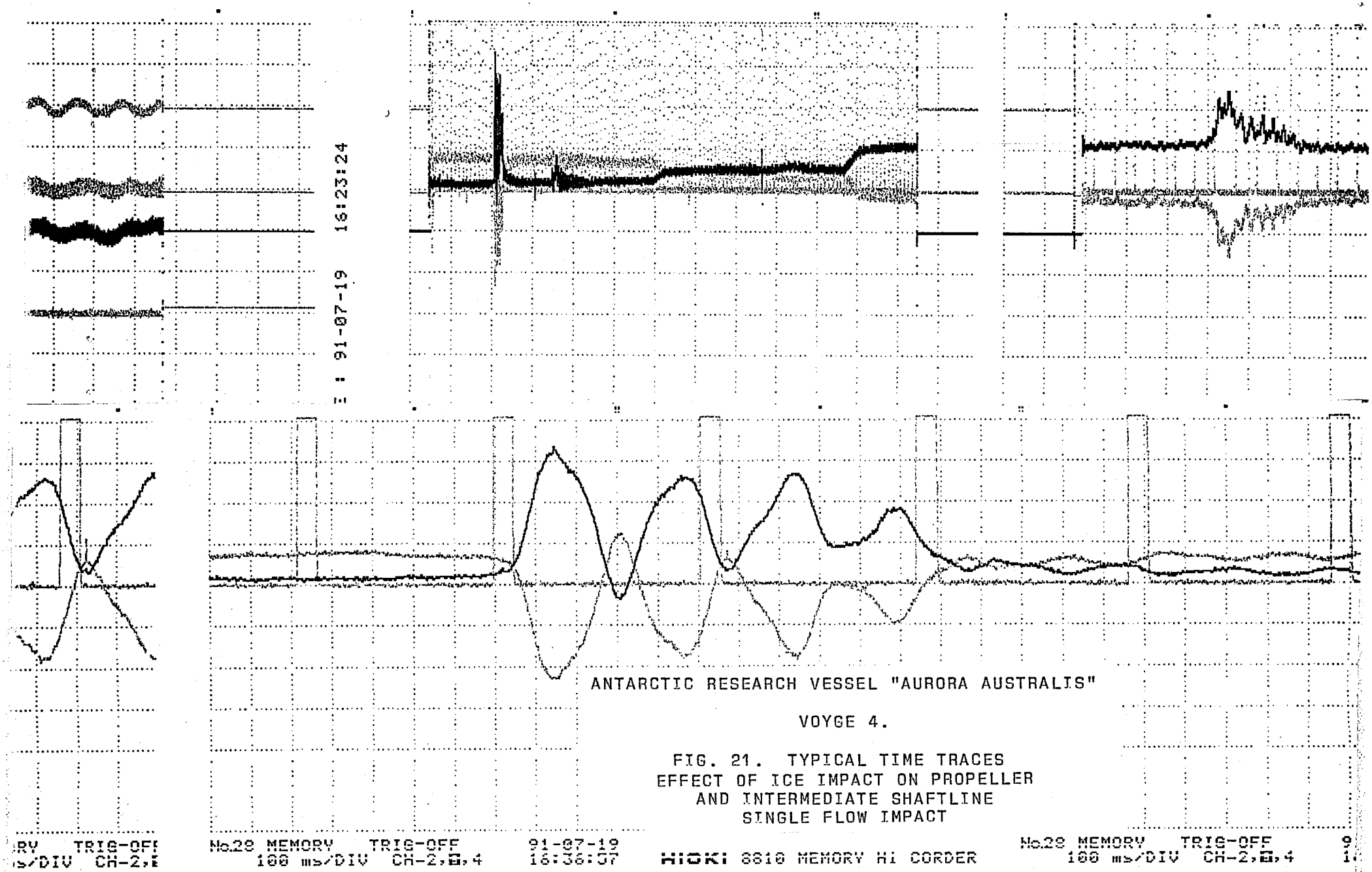
VOYAGE 4.

FIG. 20. DEFINITION OF PACK ICE



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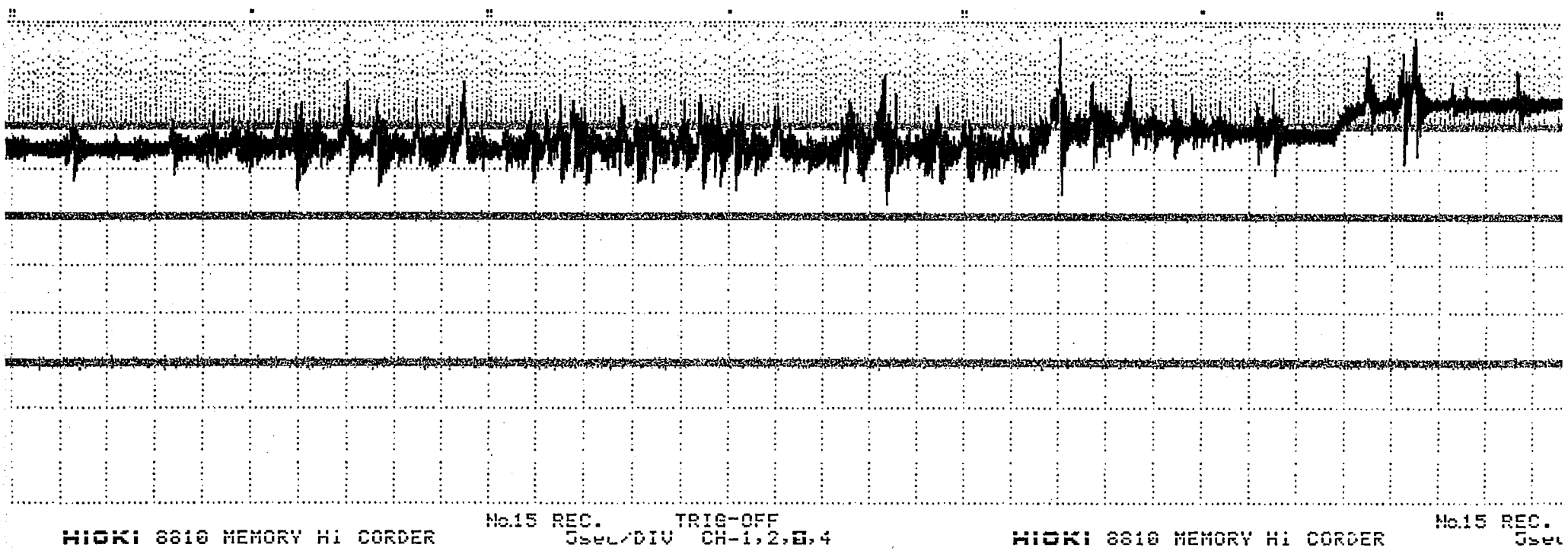
VOYGE 4.

FIG. 21. TYPICAL TIME TRACES
EFFECT OF ICE IMPACT ON PROPELLER
AND INTERMEDIATE SHAFTLINE
SINGLE FLOW IMPACT



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VOYAGE 4.

FIG. 22. TYPICAL TIME TRACE
EFFECT OF FAST ICE IMPACT ON PROPELLER - MAWSON