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Mooring design study for DB2 North West of Cape Wrath

A.R. Packwood

January 1986

Internal Document No. 251

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First look mooring study: To examine the feasibility of mooring ODAS 10 GB in 200m or 750m of water to the North West of Cape Wrath.

A general arrangement drawing for the buoy is given in Fig. 1. For other relevant information on mooring design for the DB series of buoys see Packwood (1982) which discusses buoy drag and proposes a mooring for 400m water depth in a different location.

Environmental conditions for the area in question - NW of Cape Wrath

Currents: Tidal 20-30cm/s, very flat tidal ellipse, major axis NE-SW
50 year surge current 20-40cm/s
Measured currents show episodic peaks of 90-100cm/s (Gould (1984))
Predominant current direction NE

Wind: Maximum hourly wind speed @ 10m ~ 40m/s ... with 50 year return

Waves: 50 year storm wave height (for storms longer than 12 hrs) ~ 35m; period ~ 16 sec.
3 year storm wave height ~ 27m

Tidal range: 2m

(Most of the above was obtained from BS 6235, see refs)

Assumptions

... A depth average current of 100cm/s.

... 40m/s wind speed inducing an 80cm/s near surface current acting on the buoy hull.

... The buoy is three point moored, for the purposes of the calculation it will be assumed that all the load is taken on one weather leg of the mooring, the remaining two legs being slack.

... Only the drag of the top half of the two slack legs is transmitted to the buoy.

... The drag coefficient of the braidline is 1.5.

... The drag coefficient of the chain is ~ 2.0 and the chain equivalent diameter is given by $\left(\frac{4W_a}{\pi P_c g}\right)^{\frac{1}{2}}$ where W_a = weight of chain per unit length in air and P_c is the density of the chain material.

... Guess that the super-structure drag is given by ~ $0.6V^2$ (N) where V is the wind speed in m/s.

... Assume the braidline is elastic with E = 3×10^8 N/m². (Very approximate figure).

... Assume a maximum surface elevation change from the design depth of + 30m, due to waves and tide.

... Assume a near surface current + wave partical velocity drag of the form D = Vaw x 513 N based on DB1 hull drag and Saunders (1977) where V = steady current speed in (m/s), a is the wave amplitude in (m) and w is the radian frequency (guess 16 sec. period).

Mooring configurations

ODAS 10 GB is currently moored using 28m of 32mm stud-link chain (230 N/m in air ~ 200 N/m in sea water, proof load 42 tonnes) as dropper chain from the buoy hull, followed by 100m of 81mm dia. nylon braidline (~ 4 N/m in water, breaking load 138 tonnes) and approximately 250m of 32mm stud-link chain to a 1 tonne Bruce anchor. The same arrangement is used for each leg. See fig. 2 for a detail mooring layout of the present arrangement in the S.W. Approaches. Initially it will be assumed that the same components are suitable with differing amounts of braidline and ground chain. A minimum of ~ 30m of ground chain should be suspended above the sea-bed in still water. In the deeper water depths it would be more economic if a smaller diameter braidline could be used. The next size down is 72mm diameter which has a breaking load of 109 tonnes. Moorings were considered for both sites using 81mm and 72mm braidline as possible alternatives.

Mathematical model

The IOS mooring catenary numerical model, described in Packwood (1985), was used to estimate the stretch in the braidline and the amount of ground-chain needed. The model takes the drag forces, described in the assumptions above, imposes the design current and calculates the forces on the buoy, the tensions in the mooring line and the shape of the catenary. The results are summarized for the two design water depths and the two diameters of braidline in the following tables and figures. Figures 3-4 incorporate the 81mm braidline and figures 5-6 show catenaries for the 72mm diameter line.

Water depth (m)	200		750	
Braidline diameter (mm)	81	72	81	72
unstretched length of braidline	140m	140m	700m	700m
max. line tension	5 tonnes	5 tonnes	12 tonnes	12 tonnes
max. vertical load on buoy (inc. weight of slack legs)	7 tonnes	7 tonnes	14 tonnes	13 tonnes
braidline extension	4m	5m	50m	60m
length of chain lifted off sea-bed	130m	130m	340m	330m
max. horizontal pull at the anchor	3 tonnes	3 tonnes	8 tonnes	8 tonnes
horizontal drift of buoy	90m	90m	440m	460m

Results are quoted to the nearest tonne or metre or 10 metres.

Conclusions

It appears that both the 81mm and the 72mm braidline with the 32mm chain have adequate strength to moor ODAS 10 in the stated locations. The minimum lengths of ground chain required are ~ 200m in 200m of water and 400m in 750m of water. In all cases a 1 tonne Bruce embedment anchor would provide adequate holding power provided the ground is good.

Note that these figures are only approximate, no attempt has been made to model the dynamics of the buoy in large waves. Consequently instantaneous forces due to breaking and slamming could increase these quoted loads considerably. However, the mooring components appear to have a good margin of strength and compliance in hand.

Note should be taken of Gould's comments that appear in the MIAS News Bulletin No. 7 that fishing activity on the slope at depths of ~ 500m was responsible for the majority of instrument losses in the area in question.

References

BS 6235: 1982. Code of practice for fixed offshore structures.

Gould, W.J. (1984) The current regime on the continental shelf North and West of the United Kingdom. SUT one-day conf. "Current measurements offshore". London 17 May 84.

Gould, W.J. (1984) CONSLEX: A progress report on current measurements on the continental slope North-West of the U.K. MIAS News Bulletin No.7: p.12.

Packwood A.R. (1985) Guide to cable catenary calculations. IOS GEC computer file EVERY1.USEB.ARP.OE12.SHAPE.GUIDE, pp.18.

Packwood A.R. (1982) DB2 theoretical mooring study. IOS Internal Document 165 pp.30.

Saunders, P.M. (1977) Average drag in oscillatory flow. Deep Sea Res. 24: 381-384.

FIG. 1

SERVICE ORG. No. 2G1/1670 | SHEET No. OF

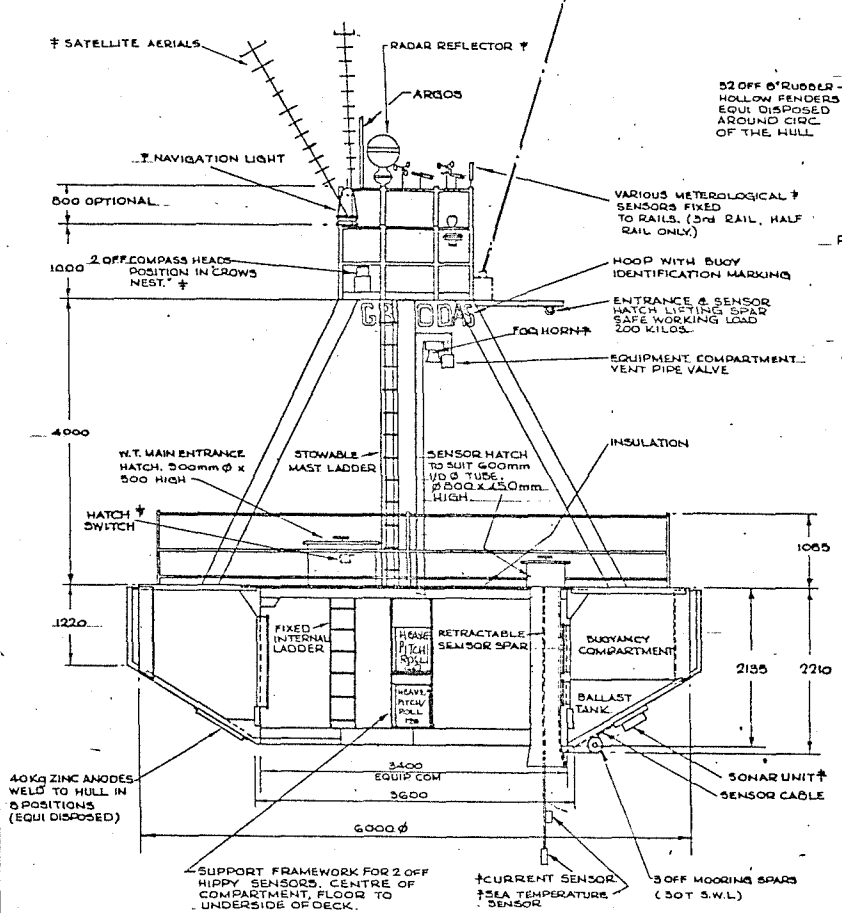
~~3rd ANGLE PROJECTION~~

DRG TO BE READ IN CONJUNCTION WITH BS 308
REMOVE BURRS SHARP EDGES OR FLASH

SECURITY CLASSIFICATION UNCLASSIFIED

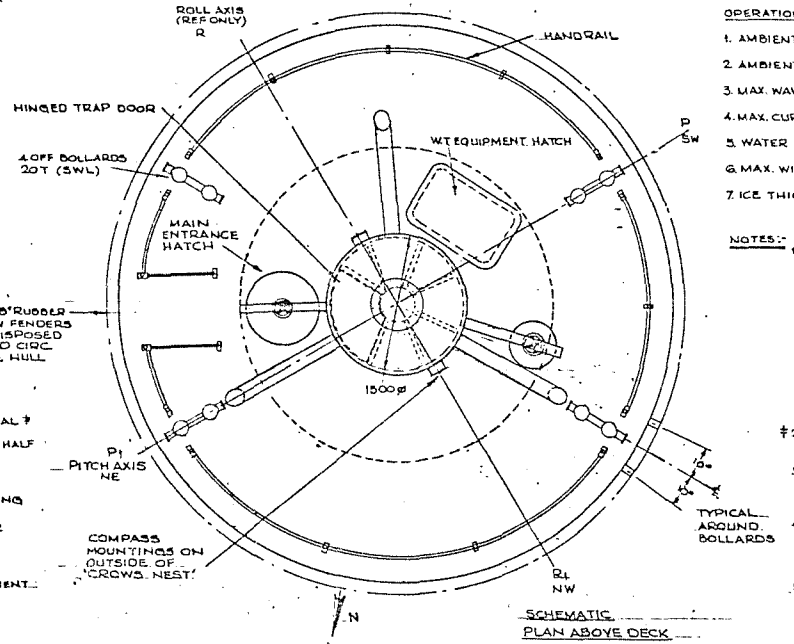
USED ON

METEOSAT AERIALS	BEARING	ELEVATION
DB2 (ODAS 10GB)	154°	32°
DB3 (ODAS 11GB)	165°	21°

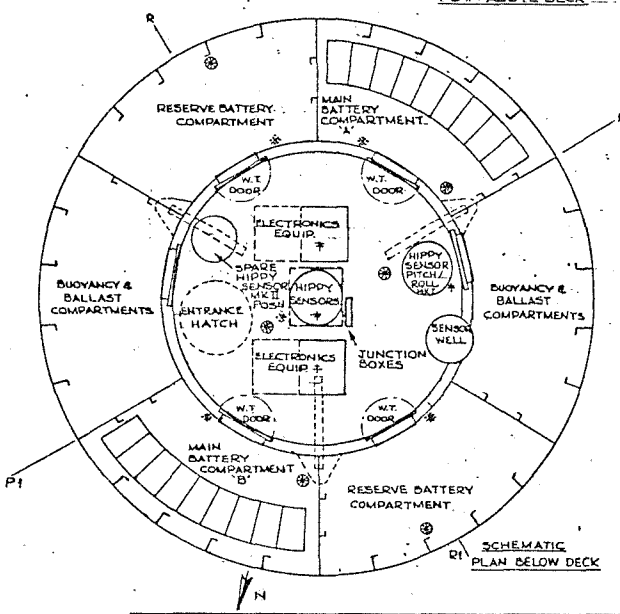


SCHEMATIC PART SECTION THROUGH R-R1

WT. 22 TONNES.



SCHEMATIC PLAN ABOVE DECK



SCHEMATIC PLAN BELOW DECK

OPERATIONAL PARAMETERS

1. AMBIENT OUTSIDE AIR TEMP RANGE FROM -20°C TO 40°C.
2. AMBIENT WATER TEMP RANGE FROM -2°C TO 30°C.
3. MAX. WAVE HEIGHT OF 35 METRES. WITH SPILLING WAVES.
4. MAX. CURRENT SPEED OF 5 KNOTS.
5. WATER DEPTH UP TO 400 METRES.
6. MAX. WIND SPEED OF 100 KNOTS
7. ICE THICKNESS OF 100mm RADIALLY ON MAIN MAST TRIPOD 125mm ON PLATFORM & DECK

NOTES:-

1. MATERIALS
BOTTOM, CONICAL & VERTICAL SIDE AND DECK - LLOYDS GRADE 'D' (FIRST CHOICE) OR BS 4360 GRADE 430 (BOTTOM 12mm THK, SIDES & DECK 10mm THK)
INTERNAL PLATEWORK - LLOYDS GRADE 'A' OR BS 4SA (6mm THK)
SECTIONS BS 4360 GRADE 43A OR EQUIVALENT.
PIPES BS 3601 OR EQUIVALENT.
MANHOLES & W.T. DOORS, LLOYDS GRADE 'A' 6mm THK & COAMINGS. LLOYDS 'A' 10mm THK (900mm ø MANHOLES ARE FOR ACCESS ONLY)
UNDERSIDE OF DECK WILL HAVE 38mm THK INSULATION.

‡2. FIRE EXTINGUISHERS (HALON GAS SPRINKLERS) TO BE POSITIONED IN EACH COMPARTMENT SHOW THUS ⊛

3. ALL BULKHEAD CABLE GLANDS, ELECTRICAL FITTINGS, CABLE TRAYS & CABLE DUCTING TO BE OF 6000 MARINE STANDARD.

4. BATTERY RACKS TO BE FITTED INTO MAIN & RESERVE BATTERY COMPARTMENTS. BATTERY RACKS (3 ROWS x 4 UNITS HIGH) = 36 CASES / COMPARTMENT.

5. DECK TO HAVE ANTI-SKID SURFACES AROUND ALL HATCHES AND MAST LADDER.

6. FACILITY TO BE MADE FOR SENSOR CABLES (‡) TO BE ROUTED FROM TOP OF SENSOR HATCH INTO MAIN EQUIPMENT COMPARTMENT.

‡7. BILGE SENSORS TO BE POSITIONED IN EACH COMPARTMENT SHOWN THUS ⊛

8. ALL WELDING TO BE LLOYDS CLASSIFICATION & TO BE TAKEN AROUND ENDS OF SECTIONS, BRACKETS ETC.

9. HINGED TRAP DOOR TO BE IN GRATING OF "CROWS NEST" ABOVE STOWABLE MAST LADDER FITMENTS.

10. ALL MAST CABLING TO BE TAKEN DOWN INSIDE OF TRIPOD LEGS, THROUGH W.T. CABLE GLANDS AT MAST PLATFORM.

11. EQUIPMENT COMPARTMENT TO HAVE REMOVABLE FLOOR GRATINGS

12. PAINT
HULL & MAST
ABRASIVE BLAST ALL UNTREATED SURFACES. PRIME COAT THEN PAINT DECK, MAST & SIDES OF HULL WITH EPOXY MARINE PAINT, COLOUR YELLOW. (SEE PAINT SPEC. No. 2G4/1671)

HULL BOTTOM & SIDES
ABRASIVE BLAST. PRIME & PAINT. FINAL COATS TO BE ANTI-FOULING SCHEME ⊛
(INTERNATIONAL PAINTS LTD.)
(SEE PAINT SPEC. No. 2G4/1671)

13. ALL SENSORS & EQUIPMENT SHOWN THUS ‡ WILL BE FREE ISSUED TO SUB-CONTRACTOR BEFORE 'FITTING OUT'.

14. DIMENSIONS, WEIGHT & FIXING REQUIREMENTS WHERE RELEVANT, OF FREE ISSUED EQUIPMENT ITEMS TO BE DECIDED DURING DESIGN OF EQUIPMENTS & NOTIFIED TO SUB-CONTRACTOR WHEN INFORMATION IS AVAILABLE.

DB2 ODAS 10GB SOUTH WEST APPROACHES

DB3 ODAS 11GB WEST OF SHETLANDS

TRACED B.A.O	4	5.11.82																	
CERTIFIED	3	13.9.82																	
CHECKED	2	24.8.82																	
	1	1.7.82		5.3.84															
DRAWN J.C.J.	ISSUE	DATE	CHANGE No.	ISSUE	DATE	CHANGE No.	ISSUE	DATE	CHANGE No.	ISSUE	DATE	CHANGE No.	ISSUE	DATE	CHANGE No.	ISSUE	DATE	CHANGE No.	

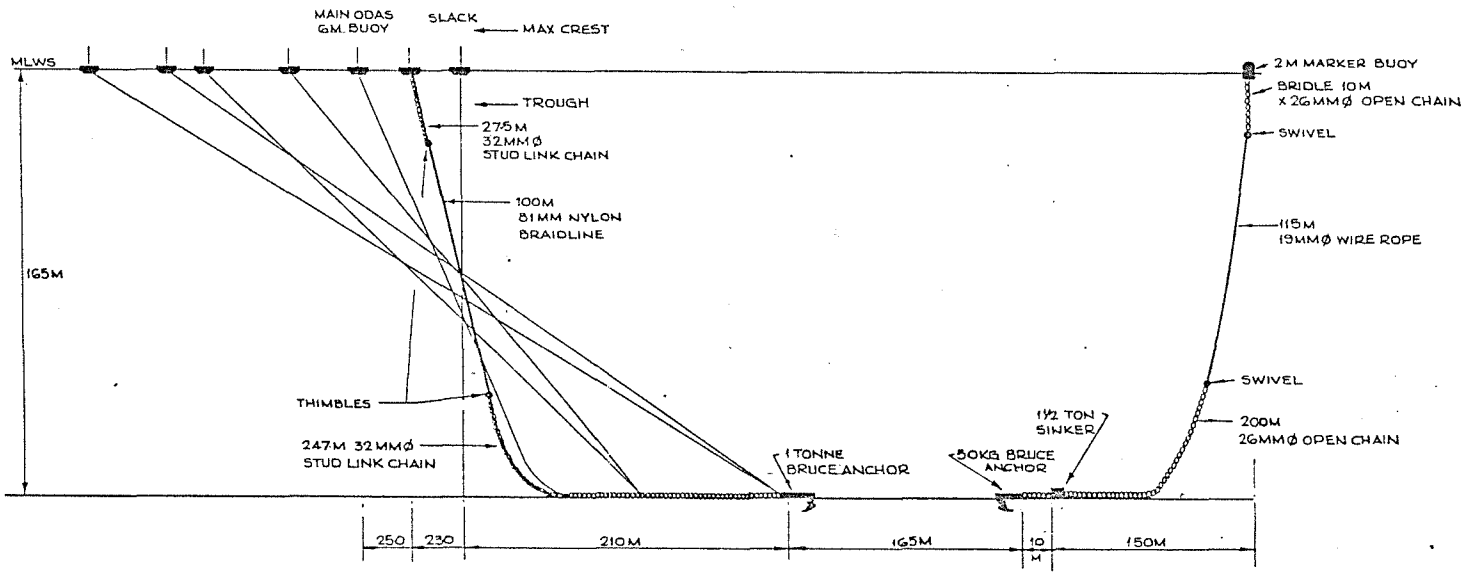
DESIGN GRADING — GRADE — SPEC — ORIGINAL SCALE N.T.S DO NOT SCALE PRINT — DIMENSIONS IN mm	MATERIAL MILD STEEL SEE NOTES — CONTRACTOR'S CODE — ESTIMATED MASS	FINISH SEE NOTE 12 — CONTRACTORS CODE — PLATING THICKNESS 10	TITLE GENERAL ARRANGEMENT OF DATABUOY DB2/3 — N.S.N. — THORN EMI ELECTRONICS LTD. — ©1982 — MOD ESTABLISHMENT

RESPONSIBLE AUTHORITY
SECURITY CLASSIFICATION UNCLASSIFIED
CONTRACTORS DRG No.
SERVICE DRG No. 2G1/1670
SHEET No. 1

FIG. 2

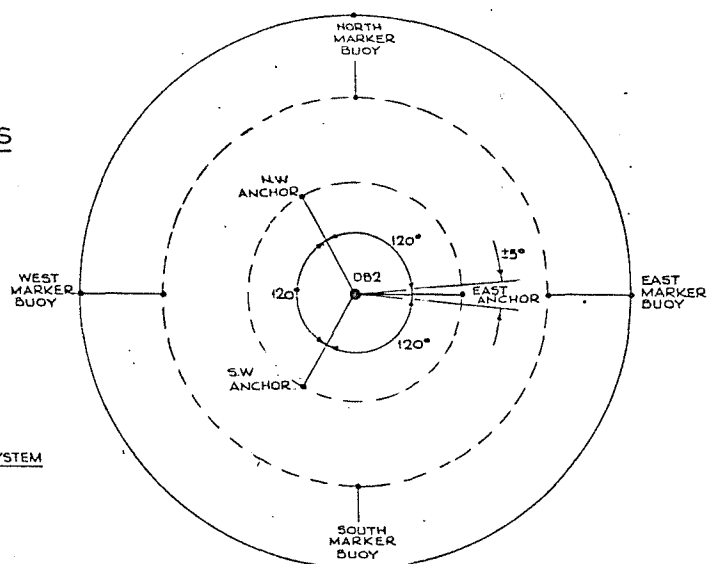
SERVICE DRG. No. 2G0/1670/1 | SHEET 1 No 1 OF 1 | 3rd ANGLE PROJECTION
DRG TO BE READ IN CONJUNCTION WITH BS 308
REMOVE BURRS SHARP EDGES OR FLASH

SECURITY CLASSIFICATION UNCLASSIFIED
USED ON



NOT TO SCALE

DB2 (ODAS 10 GB) S.W. APPROACHES
48° 44·2′ NORTH 8° 57·8′ WEST.
DB3 (ODAS 11 GB) WEST OF SHETLANDS
60° 31′ NORTH 2° 52′ WEST.



I.A.L.A CARDINAL BUOYAGE SYSTEM

SCALE 1:50

NAVIGATIONAL LIGHT CHARACTERISTICS
MAIN BUOY ODAS 10 & ODAS 11
YELLOW LIGHT (RANGE 5·1 NM) AT 0·74 TRANSMISSIVITY FACTOR
5 FLASHES X 0·5 SEC
4 ECLIPSE X 3 SEC
1 ECLIPSE X 5·5 SEC
TOTAL 20 SEC

MARKER BUOYS
WHITE LIGHT (RANGE 5·1 NM) AT 0·74 TRANSMISSIVITY FACTOR
NORTH - QUICK FLASH
SOUTH - QUICK FLASH (6) + LONG FLASH EVERY 15 SECS
EAST - QUICK FLASH (3) EVERY 10 SECS.
WEST - QUICK FLASH (9) EVERY 15 SECS.

FOG SIGNAL ON MAIN BUOY
1SEC BLAST EVERY 30 SECS. (RANGE ½ NM)

TRACED	D	29.8.84																		
CHECKED	C	2-7-84																		
CHECKED	B	11.3.83.																		
DRAWN B.A.O	A	10.11.82	ISSUE	DATE	CHANGE No	ISSUE	DATE	CHANGE No	ISSUE	DATE	CHANGE No	ISSUE	DATE	CHANGE No	ISSUE	DATE	CHANGE No	ISSUE	DATE	CHANGE No

DESIGN GRADING / SPEC / ORIGINAL SCALE DO NOT SCALE PRINT / DIMENSIONS IN	MATERIAL / CONTRACTORS CODE / ESTIMATED MASS	FINISH / CONTRACTORS CODE / PLATING THICKNESS TO	TITLE: DATA BUOY DB2/3 MOORING DETAILS NSN THORN-EMI ELECTRONICS LTD ©1982 MOD ESTABLISHMENT

RESPONSIBLE AUTHORITY
SECURITY CLASSIFICATION UNCLASSIFIED
CONTRACTORS DRG No
SERVICE DRG No 2G1/1670/1
SHEET 1 No 1

FIG. 3

CABLE CATENARY SHAPE

DB2 OFF CAPE WRATH IN 200m. WATER DEPTH 27m WAVE + 40 m/s WIND

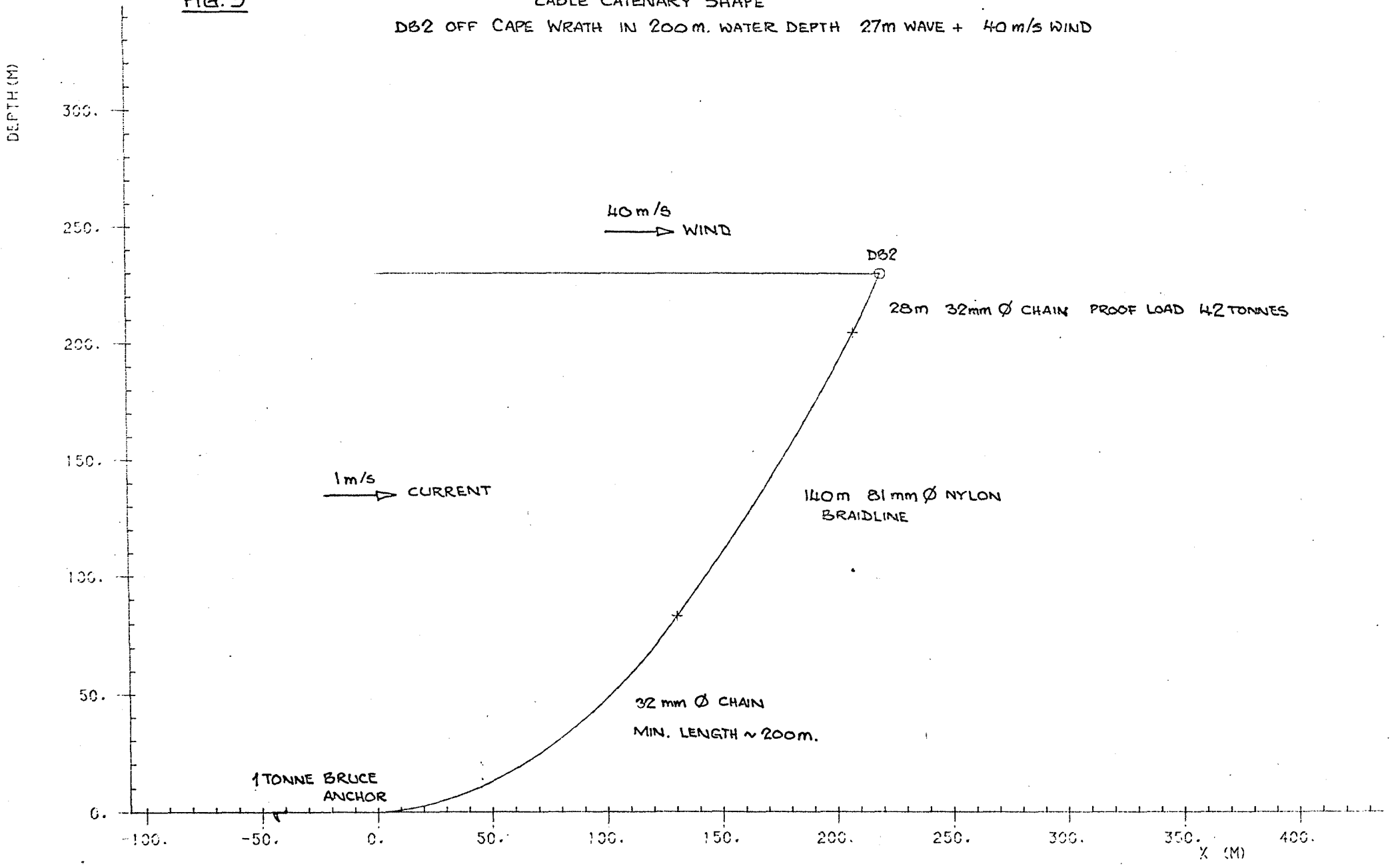


FIG. 4

CABLE CATENARY SHAPE
DB2 OFF CAPE WRATH IN 750M WATER DEPTH 27M WAVE + 40M/S WIND

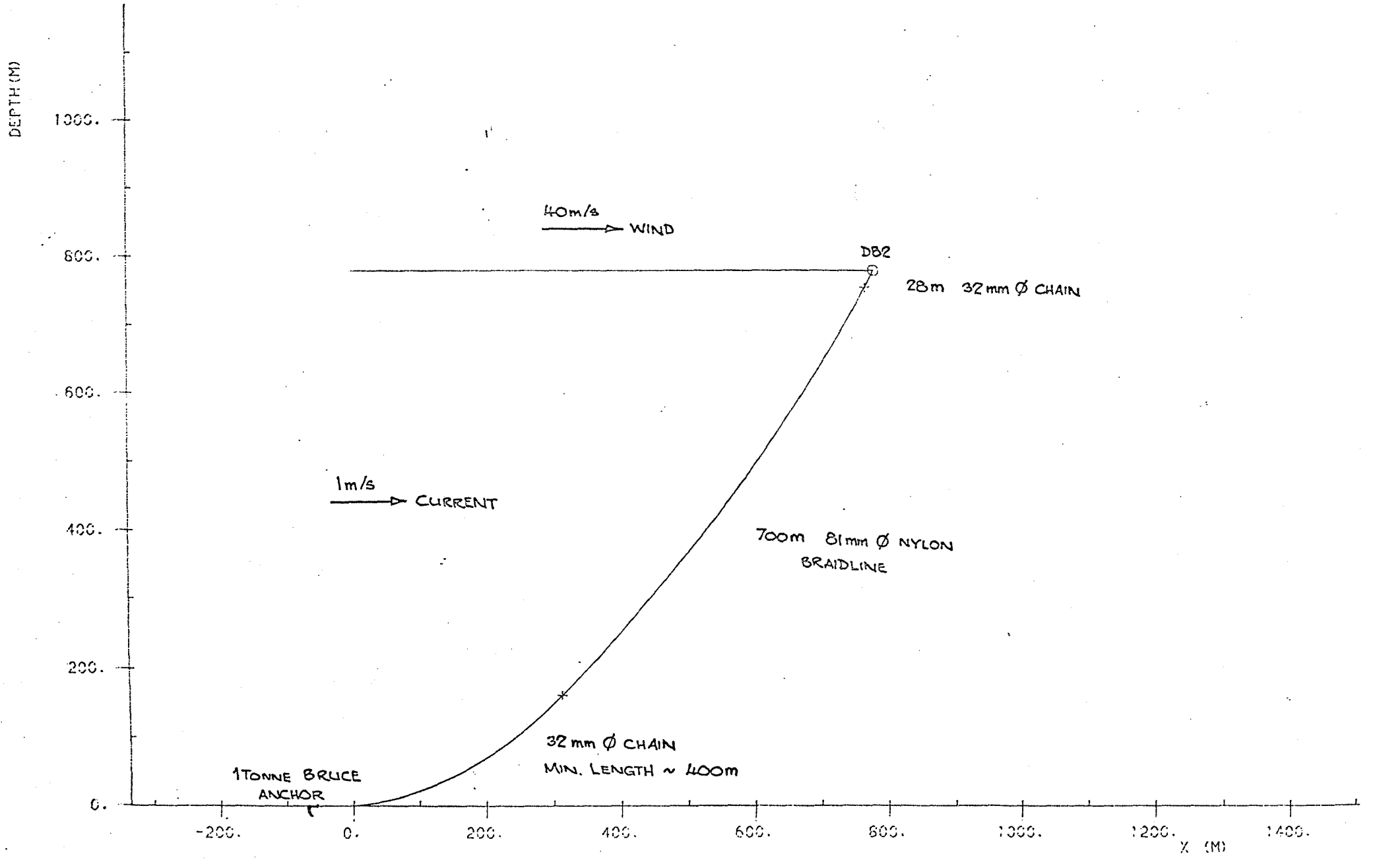


FIG. 5

CABLE CATENARY SHAPE
DB2 OFF CAPE WRATH IN 200M WATER DEPTH 27M WAVE + 40M/S WIND

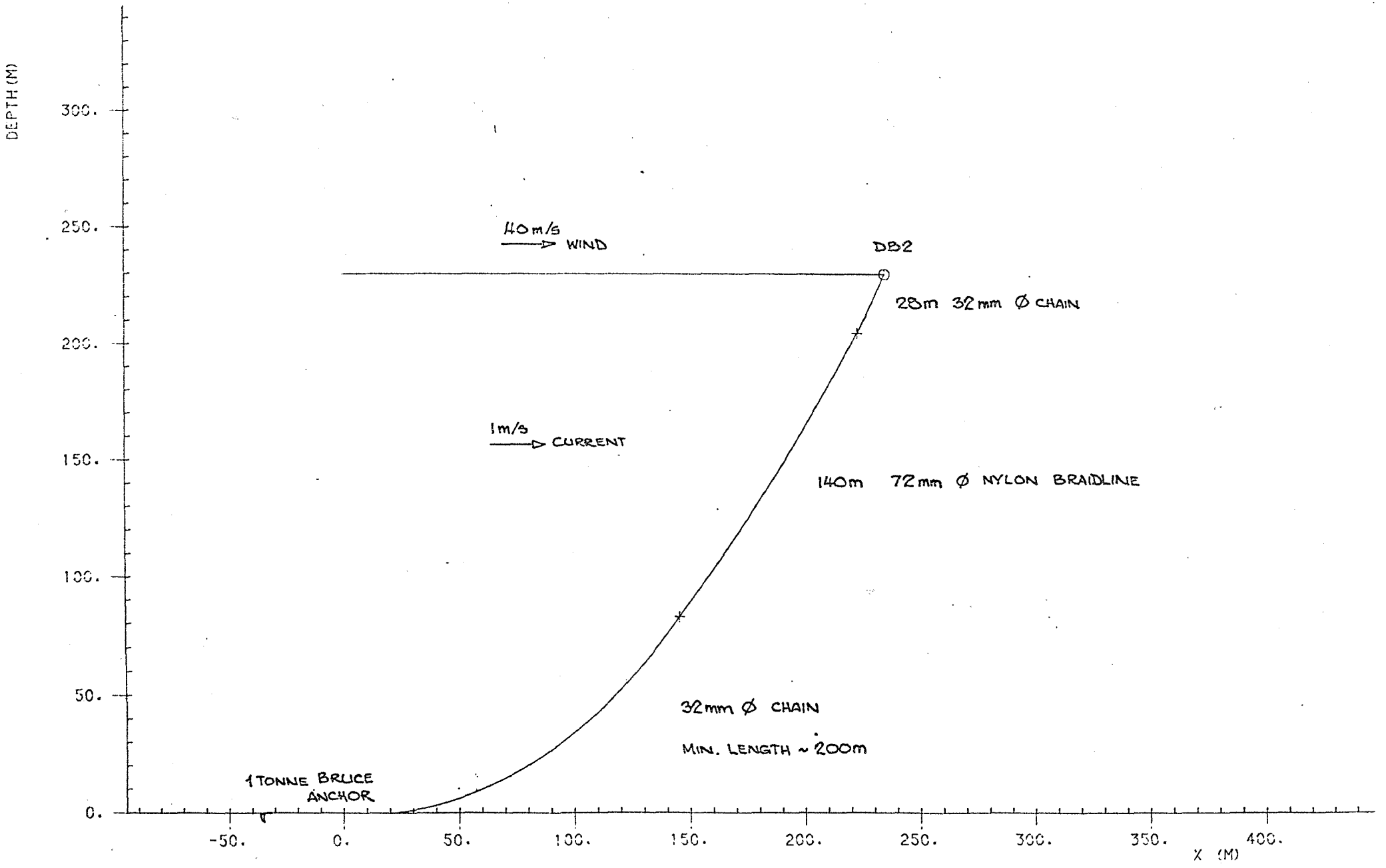


FIG. 6

CABLE CATENARY SHAPE
DB2 OFF CAPE WRATH IN 750M WATER DEPTH 27M WAVE + 40M/S WIND