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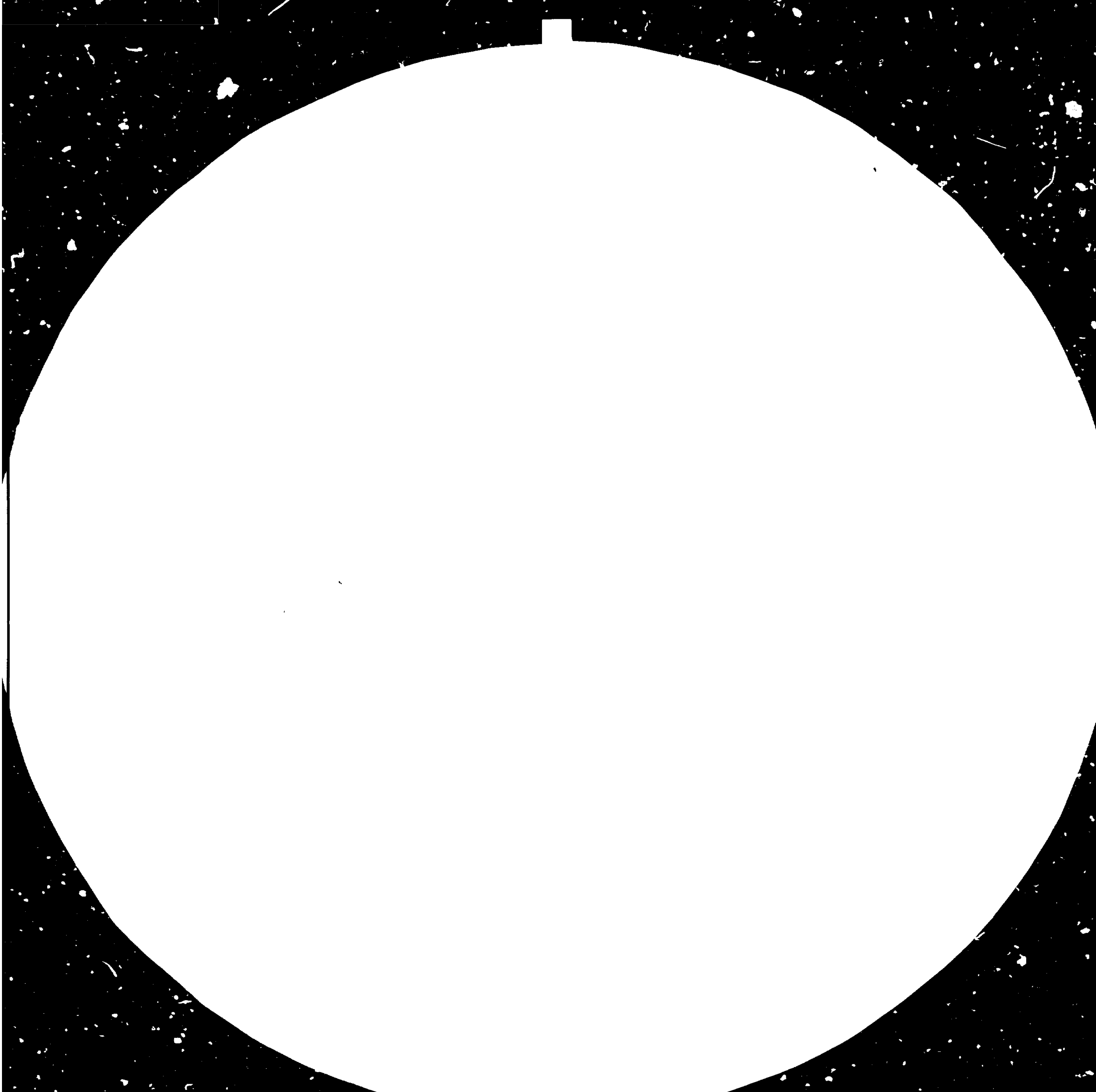

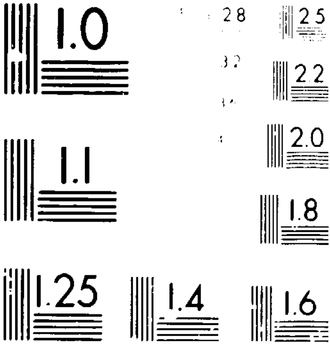

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REPAIRS TO BRONZE PROPELLERS*

prepared by

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V.84-87197

This paper deals with the practical approach to the repair of bronze propellers. Out of the many types of bronze propellers successfully repaired during the past years at the yard, one repair has been chosen in this paper as an example to elaborate on the repair procedure.

I) INTRODUCTION

The screw propeller is perhaps the most important single item of detailed design of any craft. The whole complex arrangement of hull and machinery can be outweighed if incorrect propeller dimensions are chosen. The writers experience is that the design of the propeller calls for a great deal of fineness and even after such fineness, there is a doubt, that after trials whether the proportions chosen are the best for the given conditions. The design of the propeller being such, once satisfactory proportions are arrived at, maintenance of such proportions in operation is vital for the efficiency of the craft. This is where the repairer comes in.

Out of the many design features of the propeller blades, the repairers main concern is to the pitch, which may alter along the radius, the forms of the leading and trailing edges and tips and the fairness of the aerofoil section. After the repair it is of utmost importance to see that the designed strength of the propeller is maintained without any undue stresses induced on the material or changes in the micro-structure etc. This is because in service the propeller blades are subject to a complex pattern of fluctuating stresses due to many varying blade loading components. Namely, hydro dynamic loading, mechanical loading, environmental loading and operational loading. The hydro dynamic components of the propeller blade loading are determined by the characteristics of the wake field in which the *propeller operates and depends upon the ships speed, hull geometry, draft, trim, depth of water below vessel etc. Mechanical loading on a particular section of the blade is a function of the mass of the blade and the relative position of its centre of gravity. As such, a system of forces and moments is produced. Environmental loading broadly speaking falls into 3 major areas of consideration; these being the effects of bad weather, fouling, of ice and submerged objects. The operational loading is a function which varies with the service conditions. These stresses appear as tensile stresses over the pressure face of the blades and as compressive stresses on the back of the blades when moving ahead. These stresses are maximum near the centre of the inner area of each blade and decreases from about 0.5 radius steadily towards the tip and blade edges. Strengthwise therefore the position of any damage determines its level of severity. Due to this, several Classification Societies have divided the surfaces of propeller blades into 3 zones. This is illustrated in Figure I below. (Taken from Det Norske Veritas)*

(FIGURE I)

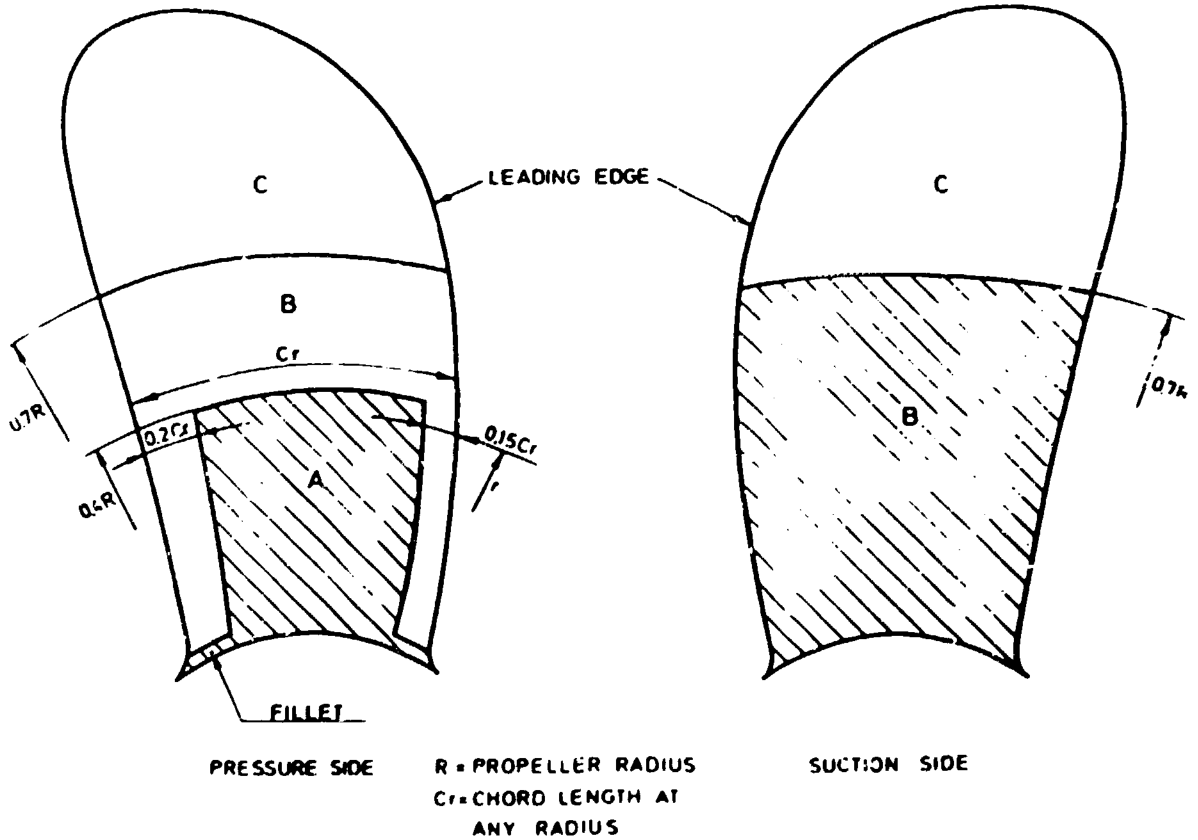


FIG1 SEVERITY ZONES

Zone A is the area on the pressure side of the blade, from and including the fillet to 0.4R and bounded on either sides by lines lying a distance of 0.15 and 0.20 times the chord length from the leading edge and the trailing edge respectively. Zone B is on the pressure side, the remaining area of the base to 0.7R and on the suction side the area from the base to 0.7R. Zone C is the area outside 0.7R on both sides of the propeller blades and the surface of the boss including the bore surface.

II)CHEMICAL COMPOSITION OF PROPELLER BRONZES

Traditionally the principle material for propeller manufacture has been high tensile brasses. With the introduction of increased propulsion power which introduced problems of errosion and corrosion at a much wider scale, materials such as manganese aluminium, nicol aluminium bronzes made their appearance. The typical chemical composition of the four most commonly used copper based materials are given in the Figure II below. (Taken from Det Norske Veritas)

(FIGURE II)

Material	% Cu	%Zn	%Fe	%Al	%Mn	%Ni	%Sn
Mn-bronze*	58	38	1	1	1	0,5	0,5
NiMn-bronze*	56	34	1,5	1,5	3	3,5	0,5
NiAl-bronze	79,5	-	4,5	9	2,5	4,5	-
MnAl-bronze	75	-	3	8	12	2	-

* High tensile brass

III) PREPARATIONS PRIOR TO THE ARRIVAL OF THE SHIP

Following data relative to the damaged propeller obtained from the owners before the ship arrived at the yard.

a) Chemical composition of the propeller material and material test results.

Chemical Composition

Cu	Zn	Mn	Fe	Al	Sn	Ni
58.34	37.55	1.36	0.88	0.67	0.42	0.78

Test Results

Tensile strength:- 51.3 KG/MM2

Elongation on 70mm:- 29.0

Proof stress:- 20.4 KG/MM2

b) Diver's report indicating the extent of damage on the blades

c) Propeller data sheet
(See Annexure 1 and 1a)

With the above in hand, following preliminary work was carried out.

1) Full size developed area of the blade drawn and super imposed the damaged sections.

2) Damaged sections, geometrical forms determined.
Patterns made accordingly and sectins casted according to the given chemical composition.

3) Chemical analysis and physical property test carried out on the casted test piece, the results of which are as given below:-

Cu	Zn	Mn	Fe	Al	Sn	Ni
58	37.92	1.2	1.1	.8	.5	.48

Tensile strength 47.2 Kg/M^2

Elongation on 70mm specimen 29%

Welder approval tests and procedure approval tests were carried out using sample castings.

The data related to the test pieces are as given below and as per Figure III below.

(a) Manual metal arc welding with flux coated electrodes down hand position only, D.C. reverse polarity, (electrode positive)

(b) Electrode type - Sudobronze, MNS special coated electrode with low hydrogen characteristics 3.25mm dia electrode used for the route run. 4.4mm dia electrodes for 1st and 2nd filler run and 5mm electrodes for the 3rd and subsequent filler deposits.

Chemical composition of the electrodes:-

Al :	Ni :	Mn :	Fe :
6%	2.5%	12%	3%

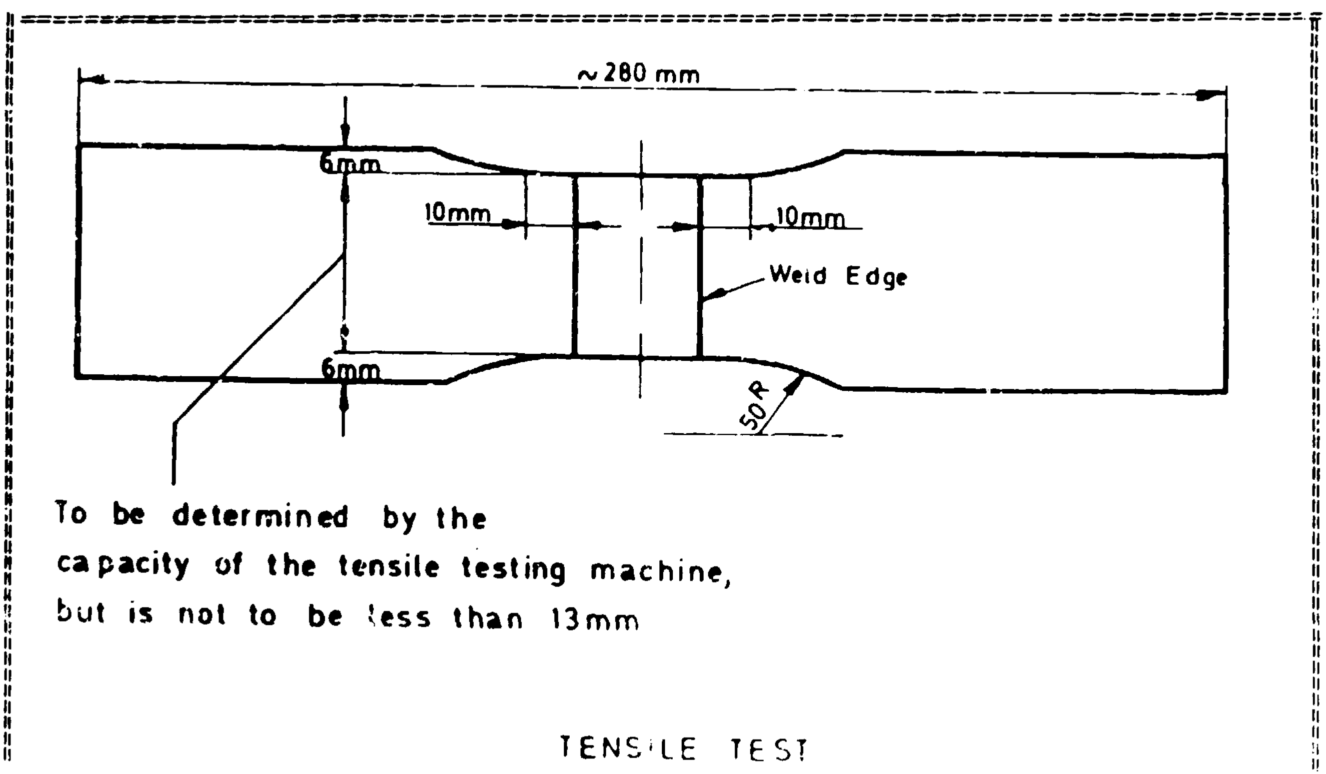
Rest copper.

Pre-heat temperatures of material - 150°C - 200°C for the parent material. 250°C for minimum one hour for electrodes. Work pieces cooled under controlled condition after completion of welding. The test piece finally ground, dye penetrant checks carried out, stress relieved and subjected to tensile test.

All the tests to the satisfaction of the Classification Surveyor.

(FIGURE III)

(Taken from Det Norske Veritas)



IV) *INSPECTION AND NON-DESTRUCTIVE TEST*

On arrival of the ship at the yard, the ship was dry docked, propeller dismantled and removed to the workshop for inspection and repair. The propeller cleaned and polished with mechanical wire brush. A dye penetrant test was carried out on all 4 blades and on the boss. The defects, even very minute ones were all recorded and listed out with reference to the zones and repairs and method of repair listed out with the following in mind.

a) Repairs of defects in Zone A

In Zone A, the repair by welding is normally not allowed. This is because the massive sections near the blades cause a higher degree of restrain and the consequence of the subsequent failure is greater. Here the defects that are not deeper than $Da = \frac{t}{50}$ mm or 2mm below minimum local thickness according to the rules, should be removed by grinding. Any defects deeper than stated requires individual consideration by Classification Surveyor and owner.

b) Repairs of defects in Zone B

Defects that are not deeper than $Db = \frac{t}{40}$ or 2mm below (whichever is greater) below the minimum local thickness according to the rules, should be removed by grinding. Weld repairs in Zone B should also not be made without consultation between the owners and the Classification Society. Normally those defects that are deeper than allowable for removal by grinding may normally be repaired by welding. The extent of such repairs however should be limited and their depth should not exceed t/3. The possible repair of defects that are deeper than those referred above is to be considered by a surveyor and the owner in each seperate case.

c) *Repairs of defects in Zone C*

In Zone C, weld repairs are generally permitted. The repair of weld should be in accordance with recommendations. Welds in the bore surface need not be stress relieved since this area is not in contact with sea water and therefore not prone to stress corrosion cracking. For weld repairs on the outer surface of the boss and particularly for repairs between the blade fillet areas, care should be exercised to avoid the cracking due to thermal stresses in connection with the welding.

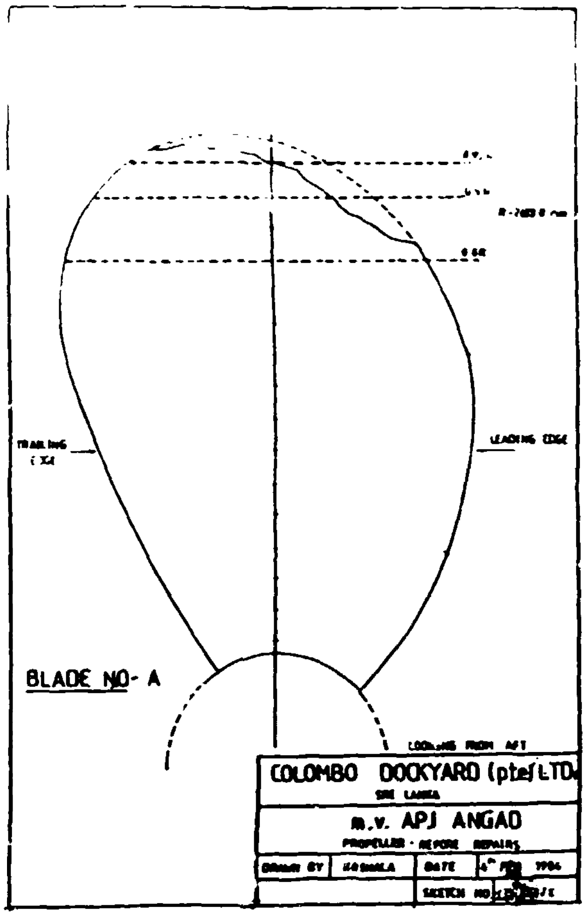
V) THE LEADING EDGE

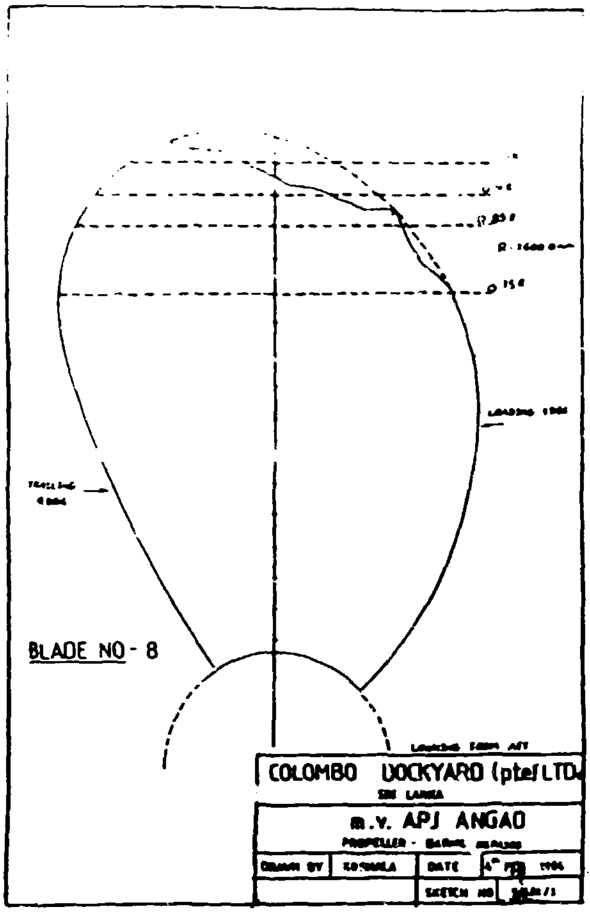
The form of the leading edge of the blade is important because it determines the pattern of the water flow over the blade surface and the degree of any cavitation. Damage even of a minor nature along the leading edge can cause erosion of the blade surface. Fine cracks at the blade edges particularly within the .7R can grow into large ones through fatigue. The damage to the trailing edge is less likely, but because the sections are thinner it is important to restore the correct pitch at all points along the trailing edge.

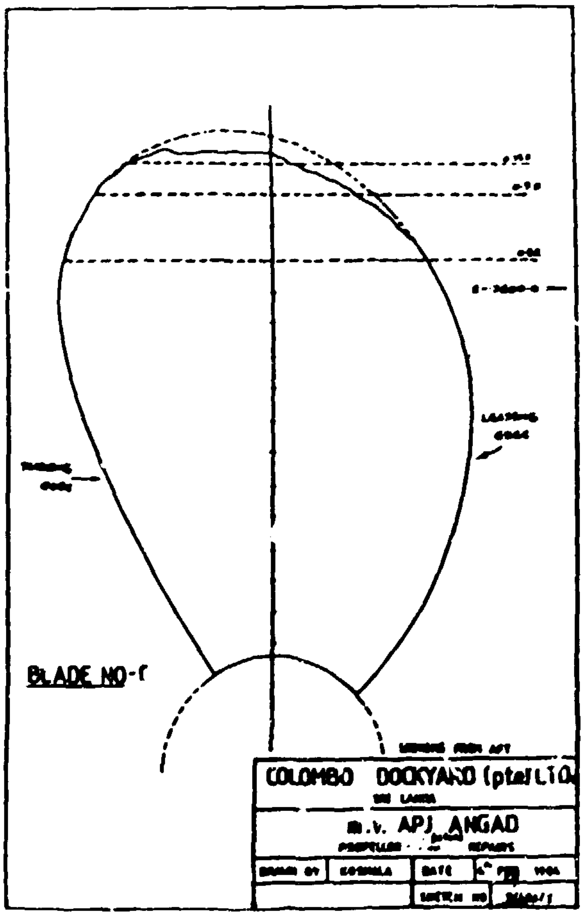
The damage of the propeller under examination has occured due to grounding and the defects were severe raging from hairline cracks to complete tearing off of certain sections.

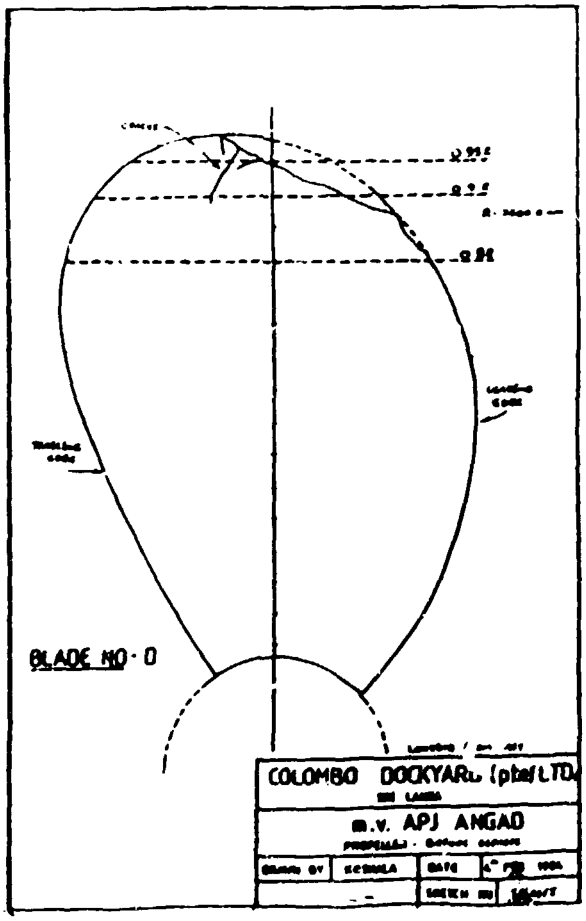
(For details of damage see Figure IV overleaf)

(FIGURE IV)


LEADING EDGE
BLADE NO- A
COLOMBO DOCKYARD (pte) LTD.
m.v. APJ ANGAD
DRAWN BY
DATE
SKETCH NO


BLADE NO- B
COLOMBO DOCKYARD (pte) LTD.
m.v. APJ ANGAD
DRAWN BY
DATE
SKETCH NO


BLADE NO- C
COLOMBO DOCKYARD (pte) LTD.
m.v. APJ ANGAD
DRAWN BY
DATE
SKETCH NO


BLADE NO- D
COLOMBO DOCKYARD (pte) LTD.
m.v. APJ ANGAD
DRAWN BY
DATE
SKETCH NO

In general the defects that appear on bronze propeller are as follows:

a) Corrosion

This can range from local roughening along the leading edges and tips to widespread loss of metal, which in some cases affects the whole of the blade surfaces. Although it can produce severe roughening of the blade surface, with subsequent loss of efficiency, the depth is generally slight and it can usually be removed by grinding and polishing the affected area. Propeller wastage and repeated grinding can leave plate edges too thin to resist minor impacts, increase in the susceptibility to tear and cracks. In these cases edges should be cut back and reformed to give adequate strength; the blade outline being faired in gradually with the remainder of the blade.

b) Cavitation Corrosion

This type of attack is usually of the localised nature and is best repaired by welding. For this purpose, the propeller should be removed from the shaft and set upon the dock bottom with the blade surface in the vicinity of the erosion as nearly horizontal as possible.

c) Cracks

Most cracking occurs at blade edges and is usually the result of a mechanical damage. All cracks at or near blade edges, no matter how small, are potentially dangerous. The cracks usually exist in an area containing residual tensile stress and if the crack has been caused by impact the residual stress may be very high. The crack itself is a stress riser and therefore there is every possibility that during service the crack will grow by fatigue and depending on the position in the blade, may lead to the loss of a considerable portion of the blade.

It is important therefore that all cracks be carefully repaired. Very small cracks or tears are best removed by grinding or filing, but large ones should be repaired by welding.

d) *Blade Distortion*

One of the most frequent results of impact damage is that parts of the blade, particularly near the edges and the tip becomes distorted. This distortion is very considerable with the result that the pitch of the blade is incorrect.

e) *Edge Damage*

This usually takes a form of tearing along the blade edge coupled in many cases, with local bendings and sometimes cracking. It is essential that all cracks be attended to as soon as possible and that care be taken to ensure that no cracks are left on the blades when the propeller is returned to service.

f) *Boss Cracks*

Many cases are on record of propeller boss which have cracked as a result of the misapplication of heat to facilitate removal of the propeller from the shaft. These cracks which sometimes spread into the blade routes are caused by a combination of stress and sea water corrosion. The high stress necessary to produce such cracks in the boss are induced by high temperature locally applied flames, oxy-acetylene and oxy-propane being the most dangerous.

The defects of the propeller was repaired in the following manner

Blade Distortion:-

The blade distortions were first attended to. The affected areas were determined by careful measurements. The repair was then carried out by heating up distorted area and the area surrounding it slowly and uniformly, with the help of a propane burner with a large flame. During heating, the top surface of the blade was covered with an asbestos blanket in order to prevent the heat loss and to maintain an uniform temperature of 600°C. The temperature indicating crayons were used for measuring the temperature. Working on the metal was carried out between 600°C and 650°C by the use of weights and levers, in order to correct the distorted areas. The whole straightening was carried out very carefully and slowly. The progress of the straightening operation was checked by the use of a straight edge in addition to a visual examination of the curve along the edge of the blade.

On completion of straightening, the affected area was allowed to cool slowly with the heated zones covered with asbestos and shielded from any draught.

Straightening in general:-

In general, before straightening of bronze propellers, the chemical composition must be determined. This is because the alloy suffers from a drop in ductivity between 300°C and 500°C depending on the composition of the alloy. Small distortions in the sections can be straightened cold, but hot working is preferable at the range of temperature corresponding to the different alloy as given in Figure V below.

(FIGURE V)

RECOMMENDED TEMPERATURE RANGES FOR HOT STRAIGHTENING

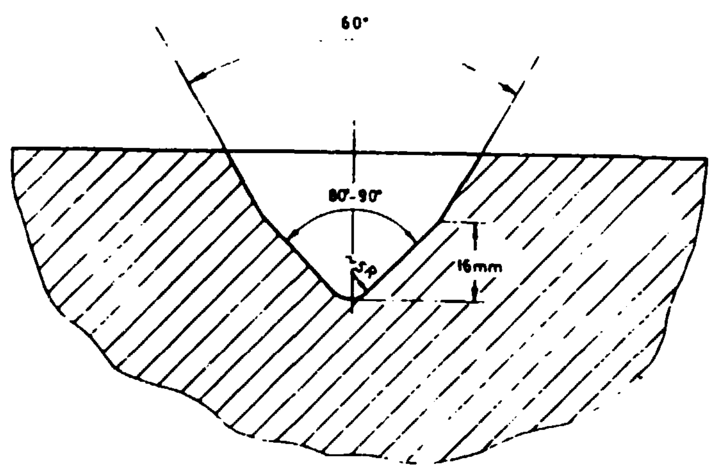
Material	Mn-bronze	NiMn-bronze	NiAl-bronze	MnAl-bronze
Straightening temp. °C	500-800	500-800	700-900	700-850

Straightening of the bent propeller blade should be carried out after heating bent region and approx. 50 cm wide zone on either side to the appropriate temperature range. The heating should be slow and uniform, and concentrated flames such as oxy-acetylene and oxy-propane should not be used. Sufficient time should be allowed for the temperature to become fairly uniform through the full thickness of the blade section. The temperature must be maintained within the recommended range throughout the straightening operations. The thermocouple instrument or temperature indicating crayons could be used to measure the temperature. In order to accomplish a slow rate of cooling after the straightening operation, the heated zones should be wrapped in asbestos blankets or similar. If there are cracks, the growth of the cracks during *straightening can be prevented by drilling large holes at their tips. The working of the metal is recommended either by applying weights, lever or jacks.*

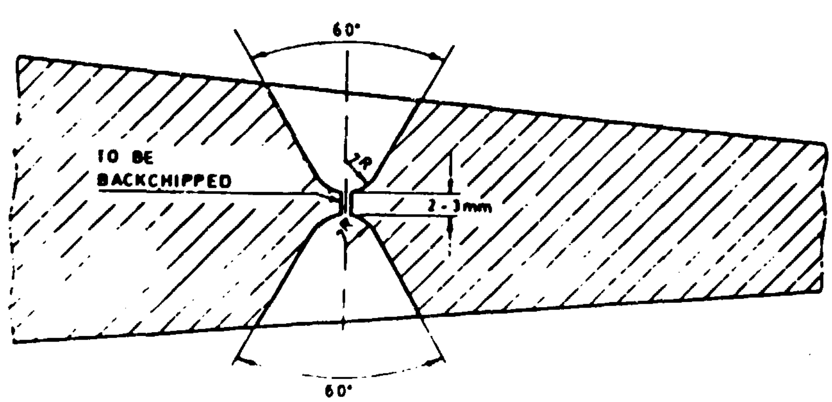
Cracks:-

Attention to cracks were next made. All cracks including hairline cracks were ground to sound material using a high speed grinder with moderate grinding pressure. While grinding, it is important to avoid smearing and masking of possible remaining parts of the defects. The ground surfaces re-examined by dye penetrant method. The grooves and bevels were ground to the shape required for welding. (See fig.vi below)

(FIGURE VI)



REPAIR WELDING
TYPICAL GROOVE PREPARATION



TIP REPAIR
TYPICAL PREPARATION OF JOINT

Edge Damage and missing portions:-

The tearing of blade edges of minor nature was ground and prepared for filling up by welding. The preparation for filling up is 45° bevel Where large portions of the blade is missing, the edges were cut straight and prepared for welding. Casted sections formed & welding preparations prepared by grinding and machining respectively.

Welding:-

The propeller was placed in a horizontal position and blades well supported. Preheating applied with propane burner to ensure dryness of the area being welded and to improve weld penetration. The temperature kept between 100°C - 150°C checked with crayons. The heated sections were covered with asbestos cloth to minimise heat losses during welding and preheating.

When building up the edges, the graphite block was used as a backing plate. All welding carried out down hand. The pressure face was first welded and completed, the propeller was then turned over the weld back, chipped and ground to sound root material, and welding completed. Before laying each subsequent weld layer, care taken to remove slag from undercuts and other defects by chipping and grinding. The insert pieces were offset 5 - 10' depending on the size and section and held by clamps before welding. This is because the stress from the welding causes the insert pieces to lift After allowing the propeller to cool down with asbestos cloth wrapped round it, the welds and insert pieces were ground down to conform with the propeller blade surface and carefully examined by means of dye penetrant for any defects such as cracks, lack of penetration etc. All defects attended to before heat treatment.

Heat Treatment:-

After making sure that all defects are rectified and that no other defect exists, the propeller was prepared for stress relieving. The propeller laid horizontal, with the complete weight taken on the boss. All blades were then well supported. For local stress relieving all welded areas and around were laid with electric resistance heating pad(cooper heat pads) and the complete propeller blanketted with asbestos cloth. Heat was then applied under controlled conditions. The temperature was recorded by thermocouple instrument placed at several places. The rate of heating, soakage temperature and time and cooling rate applied is given seperately in Annexure II.

In general except for non-critical areas of nicol aluminium bronze propellers, welding of all bronze alloy propeller should be followed by stress relief to avoid the risk of subsequent cracking through corrosion fatigue and stress corrosion. The heat treatment also improves the micro structure and corrosion resistance. Heat treatment can also be done by heating the entire propeller in a furnace, or by local heating applied using soft gas torch. When local heat is applied to minimise stress strained during thermal changes, the boundary of the heated zone should be as straight as possible and never enclosed by colder parts of the blade. Cooling from the stress relieving temperature should be slow in order to give time for the correct micro structure to form and to avoid build up of residual stress.
The recommended temperature ranges for stress relief of various bronze alloys are given in Figure VII below and Figure VIII overleaf.

(FIGURE VII)

SOAKING TIMES FOR STRESS RELIEF HEAT TREATMENT OF BRONZE PROPELLERS

Stress Relief Temperatures		Soaking Times (hours)			
		High Tensile Brass		Aluminium Bronzes	
°C	°F	Hours per 25mm(1 in) of thickness	Maximum recommended total time	Hours per 25 mm(1 in) of thickness	Maximum recommended total time
350	660	5	15	-	-
400	750	1	5	-	-
450	840	1/2	2	5	15
500	930	1/4	1	1	5
550	1020	1/4	1/2	1/2	2
600	1110	-	-	1/4	1
650	1200	-	-	1/4	1/2

(FIGURE VIII)

WELDING PROCESSES, FILLER METALS AND HEAT TREATMENTS

Alloy	Welding process	Filler Metal	Preheat temp. °C	Stress relief temp. °C
Manganese bronze (high-tensile brass)	Shielded metal-arc Inert gas metal-arc (MIG) Inert gas tungsten-arc (TIG) Inert gas tungsten-arc (TIG) Gas welding	Al-bronze* Mn-bronze Mn-bronze	150-250	350-550
Nickel Manganese Bronze (high-tensile brass)	Shielded metal-arc Inert gas metal-arc (MIG) Inert gas tungsten-arc (TIG) Inert gas tungsten-arc (TIG) Gas welding	Al-bronze NiMn-bronze NiMn-bronze	150-250	350-550
Nickel Aluminium bronze	Shielded metal-arc Inert gas metal-arc (MIG) Inert gas tungsten-arc (TIG)	Al-bronze NiAl-bronze MnAl-bronze	50-150	None
Manganese Aluminium bronze	Shielded metal-arc Inert gas metal-arc (MIG) Inert gas tungsten-arc (TIG	MnAl-bronze	100-250	450-600

* NiAl-bronze and MnAl-bronze are acceptable.

Annexure III - Shows the propeller blades after repairs

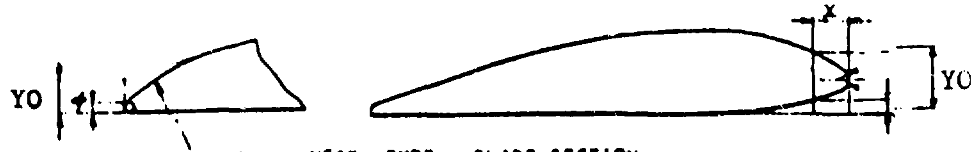
Annexure IV - Shows photographs of various defects and repair in progress at the yard.

22nd March 1984
Sri Lanka.

(ANNEXURE I)

Propeller Data Sheet

**** DIMENSION OF BLADE SECTION ****



X : DISTANCE FROM LEADING EDGE (MM)

YO : HEIGHT OF BACK FACE (MM)

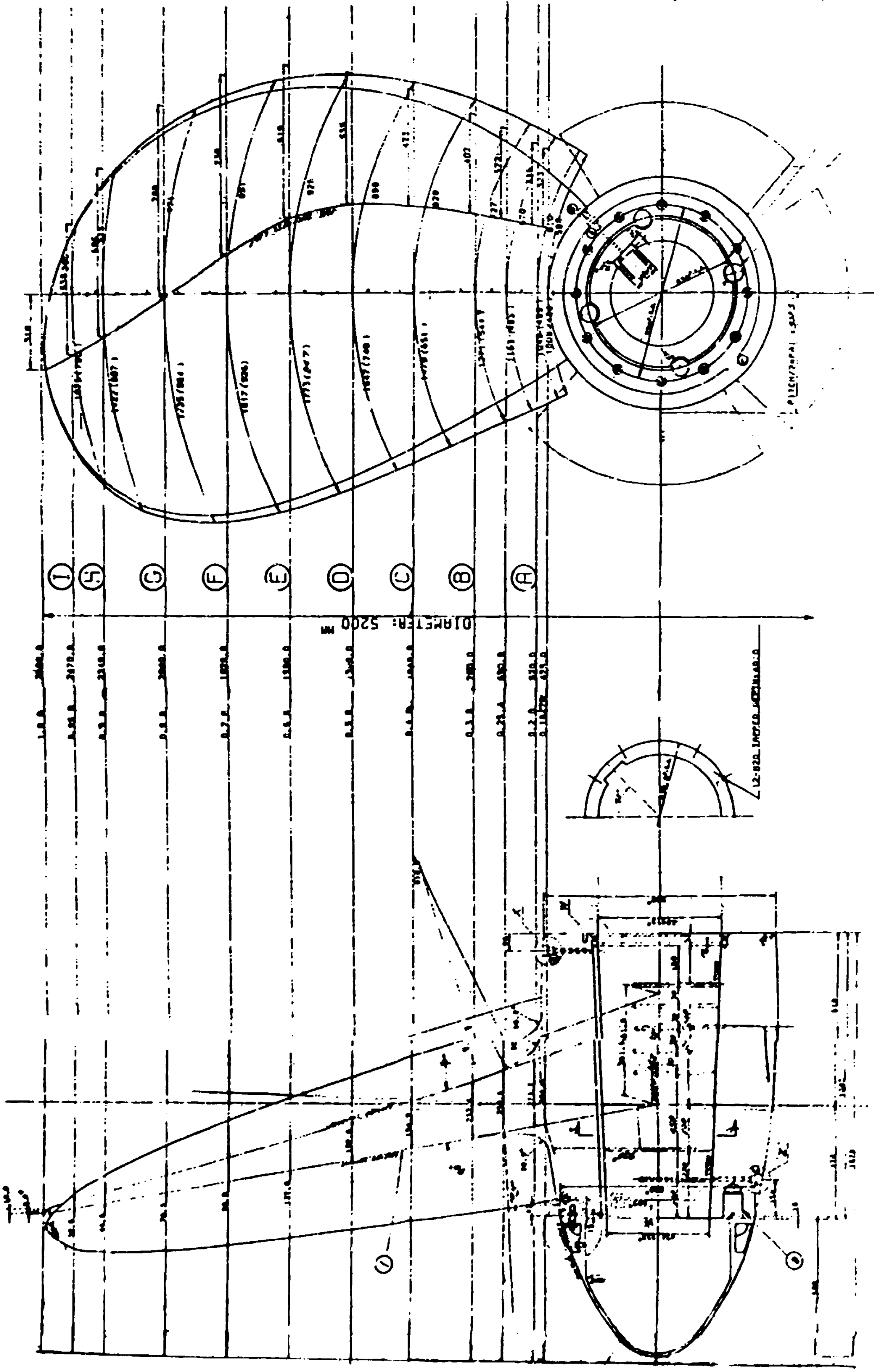
YU : HEIGHT OF PITCH FACE (MM)

MAU. - MESK TYPE BLADE SECTION

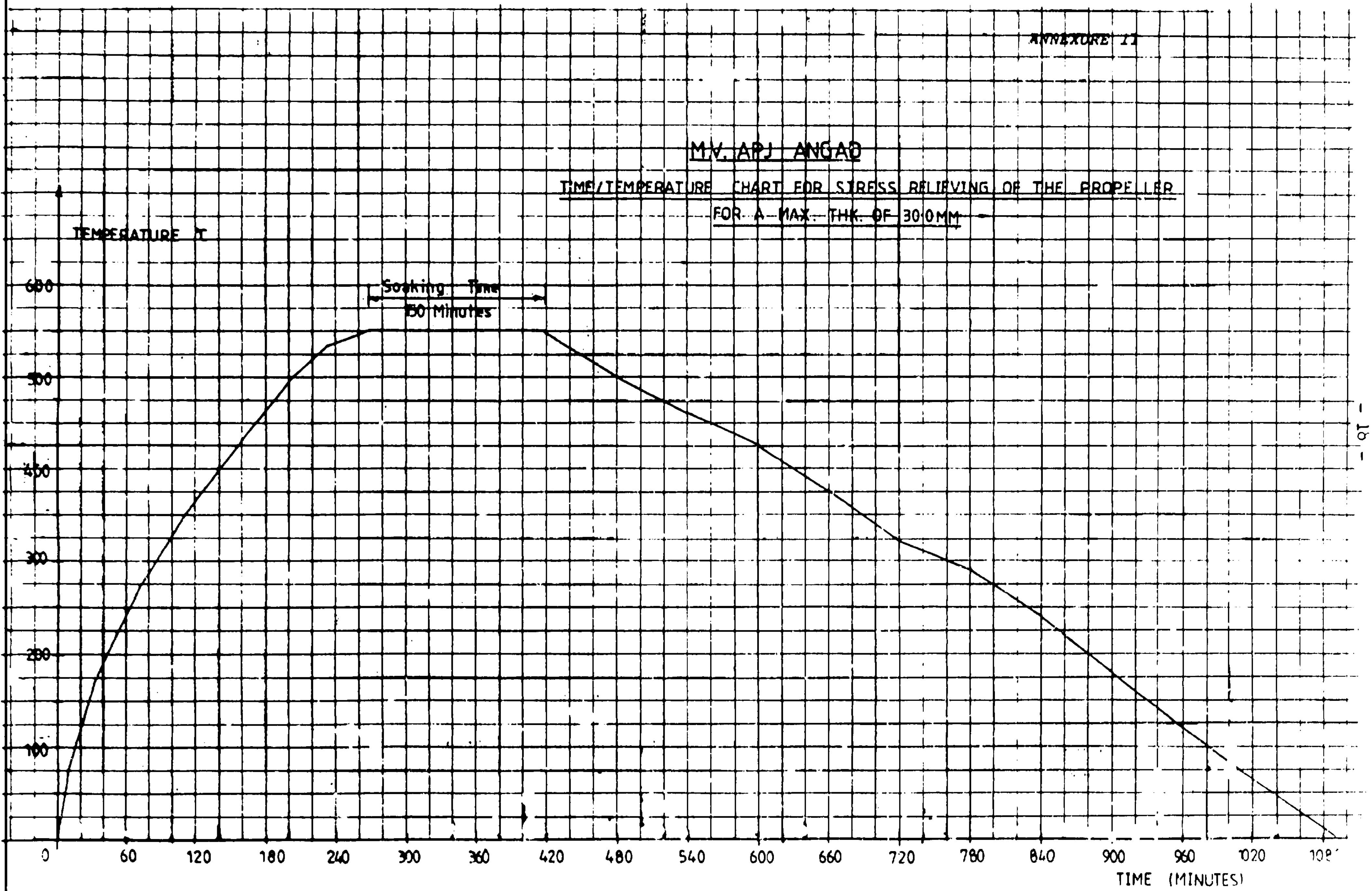
X/R																		
0.20	X	0.0	21.0	42.0	62.9	105.0	157.0	210.0	315.0	336.0	420.0	525.0	629.0	734.0	839.0	944.0	997.0	1049.0
	YO	95.8	141.9	163.5	181.1	208.1	233.3	252.4	273.2	273.7	267.5	246.2	213.9	172.8	123.8	69.2	41.1	12.3
	YU		66.4	52.1	41.1	27.4	14.8	6.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.30	X	0.0	25.4	50.8	76.3	127.0	191.0	254.0	381.0	407.0	508.0	636.0	763.0	890.0	1017.0	1144.0	1207.0	1271.0
	YO	81.3	120.5	138.9	153.7	176.7	190.1	214.3	231.9	232.4	227.2	209.0	181.6	146.8	105.2	58.8	34.9	10.5
	YU		56.4	44.3	34.9	23.2	12.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.40	X	0.0	29.6	59.2	88.7	148.0	222.0	296.0	444.0	473.0	592.0	740.0	887.0	1035.0	1183.0	1331.0	1405.0	1479.0
	YO	68.2	101.1	116.5	128.9	148.2	166.2	179.7	194.5	194.9	190.9	175.3	152.3	123.1	88.2	49.3	29.2	8.8
	YU		47.3	37.1	29.2	19.5	10.5	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.50	X	0.0	33.4	66.9	100.0	167.0	251.0	335.0	502.0	535.0	666.0	830.0	993.0	1157.0	1320.0	1483.0	1565.0	1647.0
	YO	55.9	82.9	95.5	105.7	121.[illegible]	136.2	147.3	159.5	159.8	156.9	143.8	125.0	101.2	72.3	40.8	24.4	7.8
	YU		38.8	30.4	24.0	16.0	8.6	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.60	X	0.0	38.7	77.3	116.0	193.0	290.0	387.0	580.0	619.0	755.0	924.0	1094.0	1264.0	1433.0	1603.0	1688.0	1773.0
	YO	43.5	63.4	74.1	87.8	96.1	108.4	117.3	127.5	127.8	125.0	115.1	100.3	81.4	58.9	33.7	20.7	7.7
	YU		30.2	23.1	18.2	12.1	6.4	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.70	X	0.0	45.6	91.4	137.0	228.0	342.0	456.0	685.0	730.0	858.0	1018.0	1178.0	1338.0	1497.0	1657.0	1737.0	1817.0
	YO	29.9	44.1	52.8	60.1	71.2	81.3	89.1	97.8	98.0	95.8	88.4	77.2	63.0	46.0			
	YU		20.1	15.1	11.7	7.5	4.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.80	X	0.0	49.3	98.5	148.0	246.0	369.0	492.0	738.0	788.0	899.0	1038.0	1178.0	1317.0	1456.0	1596.0	1665.0	1735.0
	YO	14.8	27.0	32.9	38.3	47.6	56.5	63.2	70.2	70.3	68.8	63.7	55.9	45.9	34.1			
	YU		9.8	7.3	5.7	3.6	1.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.90	X	0.0	43.5	86.9	130.0	217.0	326.0	435.0	652.0	695.0	781.0	888.0	995.0	1101.0	1208.0	1315.0	1369.0	1422.0
	YO	6.1	14.0	18.0	21.7	28.1	34.8	39.7	44.5	44.6	44.8	41.7	37.8	32.2				
	YU		1.8	1.2	0.9	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.95	X	0.0	33.6	67.2	101.0	168.0	252.0	336.0	504.0	538.0	601.	680.0	759.0	838.0	917.0	996.0	1035.0	1075.0
	YO	3.7	10.3	13.2	15.8	20.6	25.4	29.0	32.5	32.6	32.	30.8	28.3	24.7				
	YU		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

LEADING EDGE R1/R2

X/R	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95
R1	57.5	38.1	26.1	17.3	9.9	4.7	4.1	3.7	3.7
R2	25.8	17.9	12.9	8.8	5.8	4.0	3.8	3.7	3.7

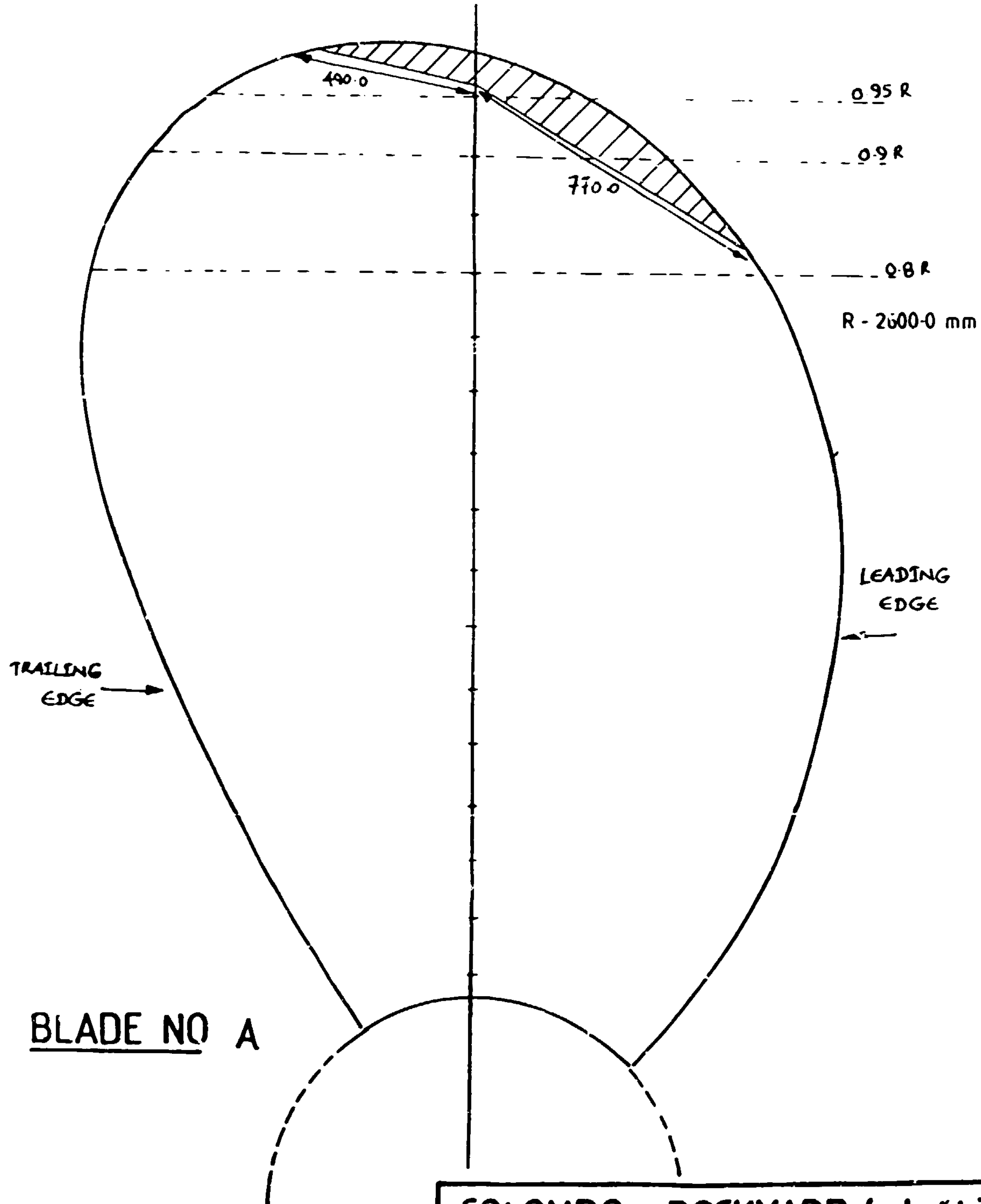


ANNEXURE II



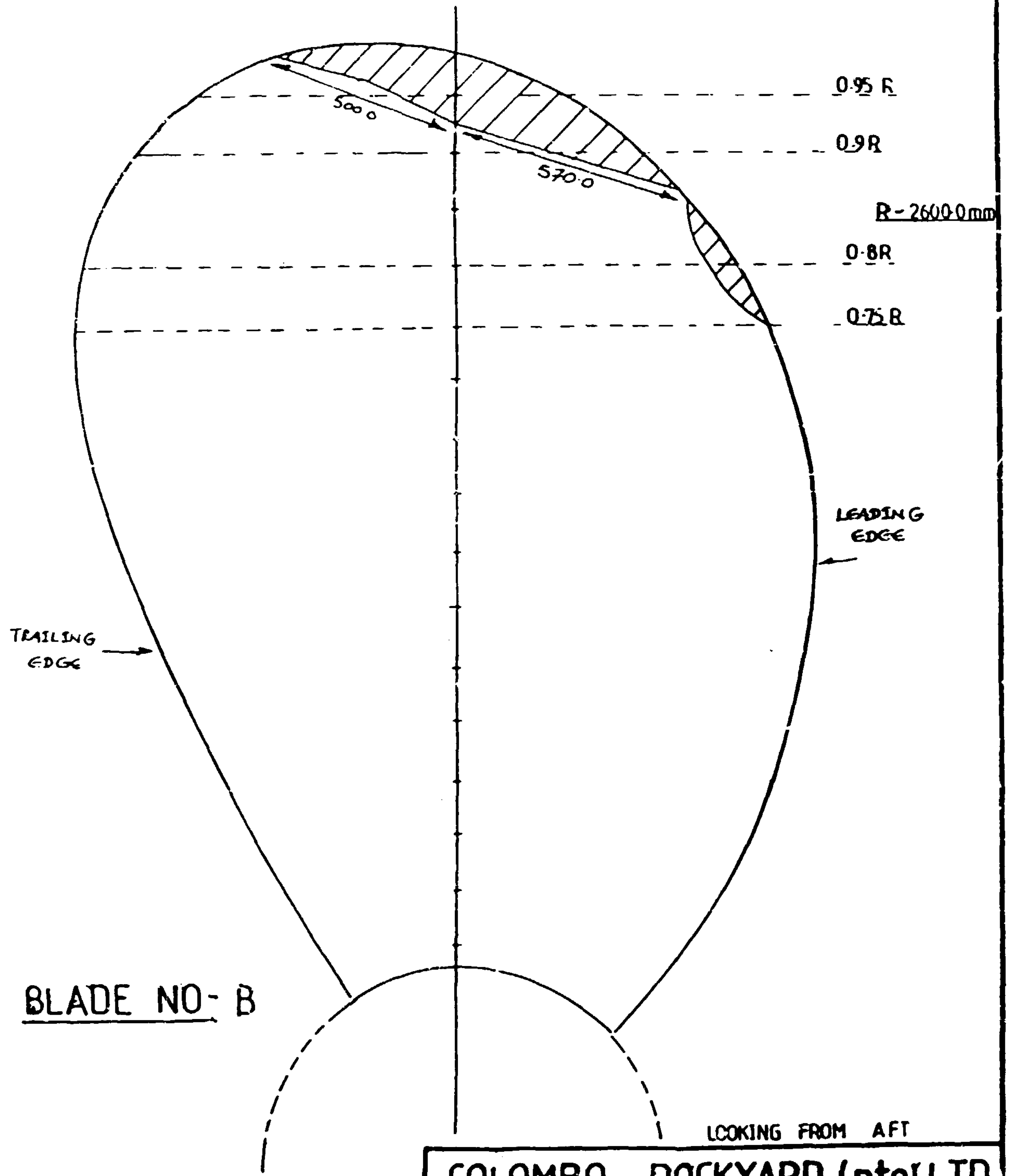
M.V. APJ ANGAD
TIME/TEMPERATURE CHART FOR STRESS RELIEVING OF THE PROPELLER
FOR A MAX. THK. OF 300MM
TEMPERATURE °C
Soaking Time
150 Minutes
600
500
400
300
200
100
0
60
120
180
240
300
360
420
480
540
600
660
720
780
840
900
960
1020
TIME (MINUTES)

ANNEXURE IIIa



COLOMBO DOCKYARD (pte) LTD SRI LANKA			
m.v. APJ ANGAD PROPELLER -			
DRAWN BY	KOSHALA	DATE	4 FEB 1984
		SKETCH NO	S/454/A

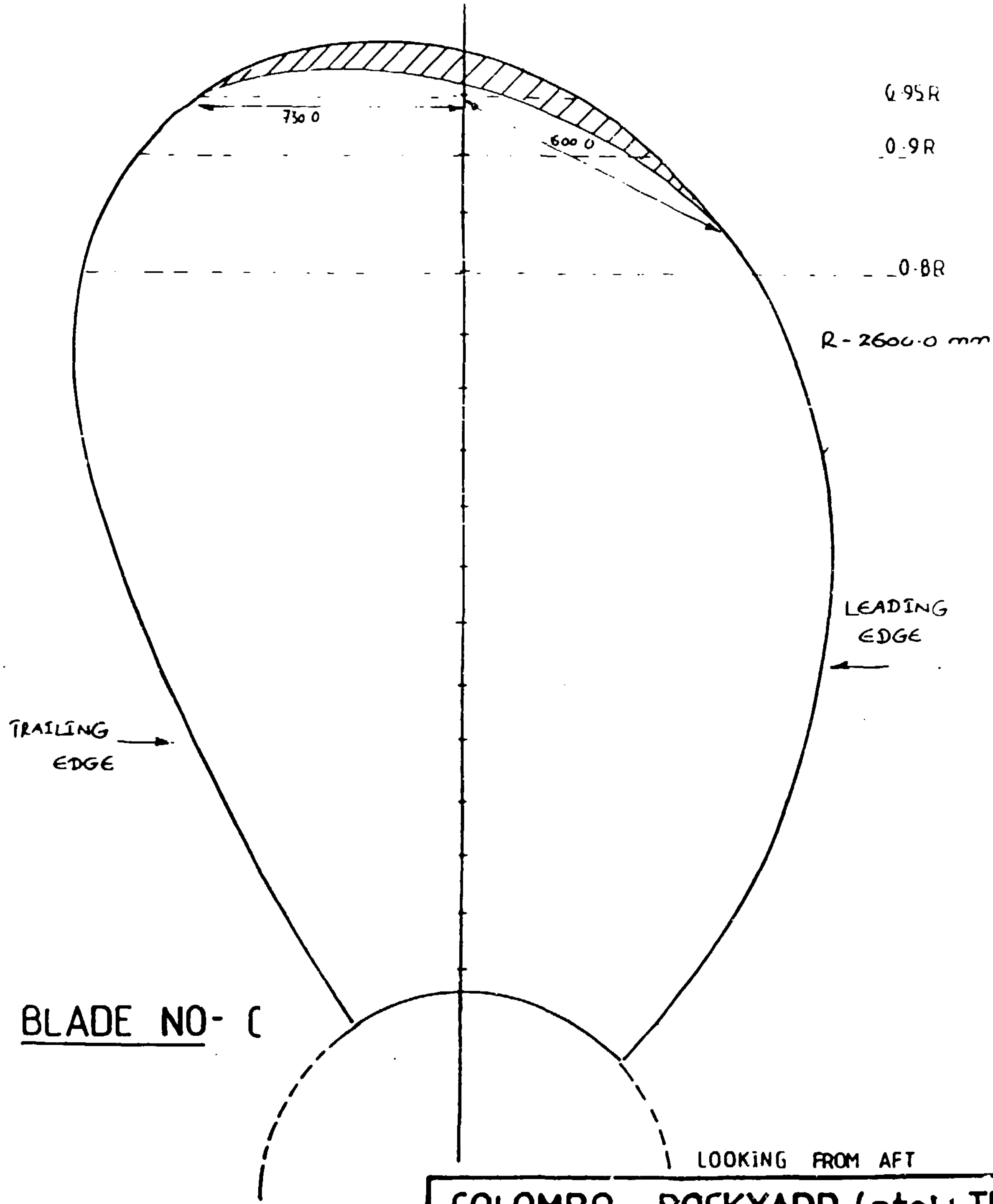
ANNEXURE III (b)



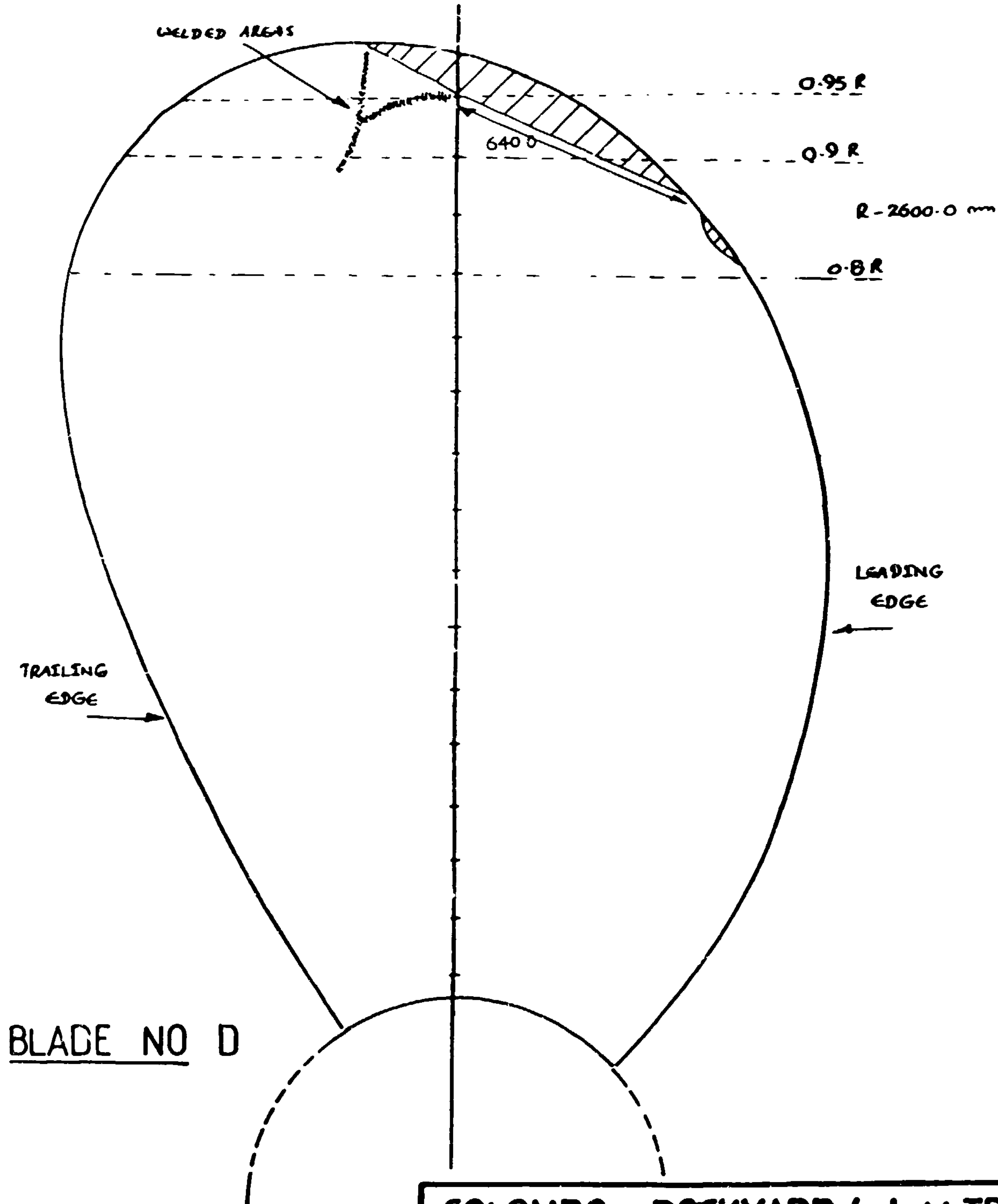
BLADE NO- B

LOOKING FROM AFT

COLOMBO DOCKYARD (pte) LTD SRI LANKA			
m.v. APJ ANGAD PROPELLER - AFTER REPAIRS			
DRAWN BY	KOSHALA	DATE	4 FEB 1984
		SKETCH NO	S/451 / A



COLOMBO DOCKYARD (pte) LTD SRI LANKA			
m.v. APJ ANGAD PROPELLER - AFTER REPAIRS			
DRAWN BY	KOSHALA	DATE	4 FEB 1984
		SKETCH NO	S/456/R



COLOMBO DOCKYARD (pte) LTD. SRI LANKA			
m.v. APJ ANGAD PROPELLER -			
DRAWN BY	KOSHALA	DATE	4 FEB 1984
		SKETCH NO	S/450/R