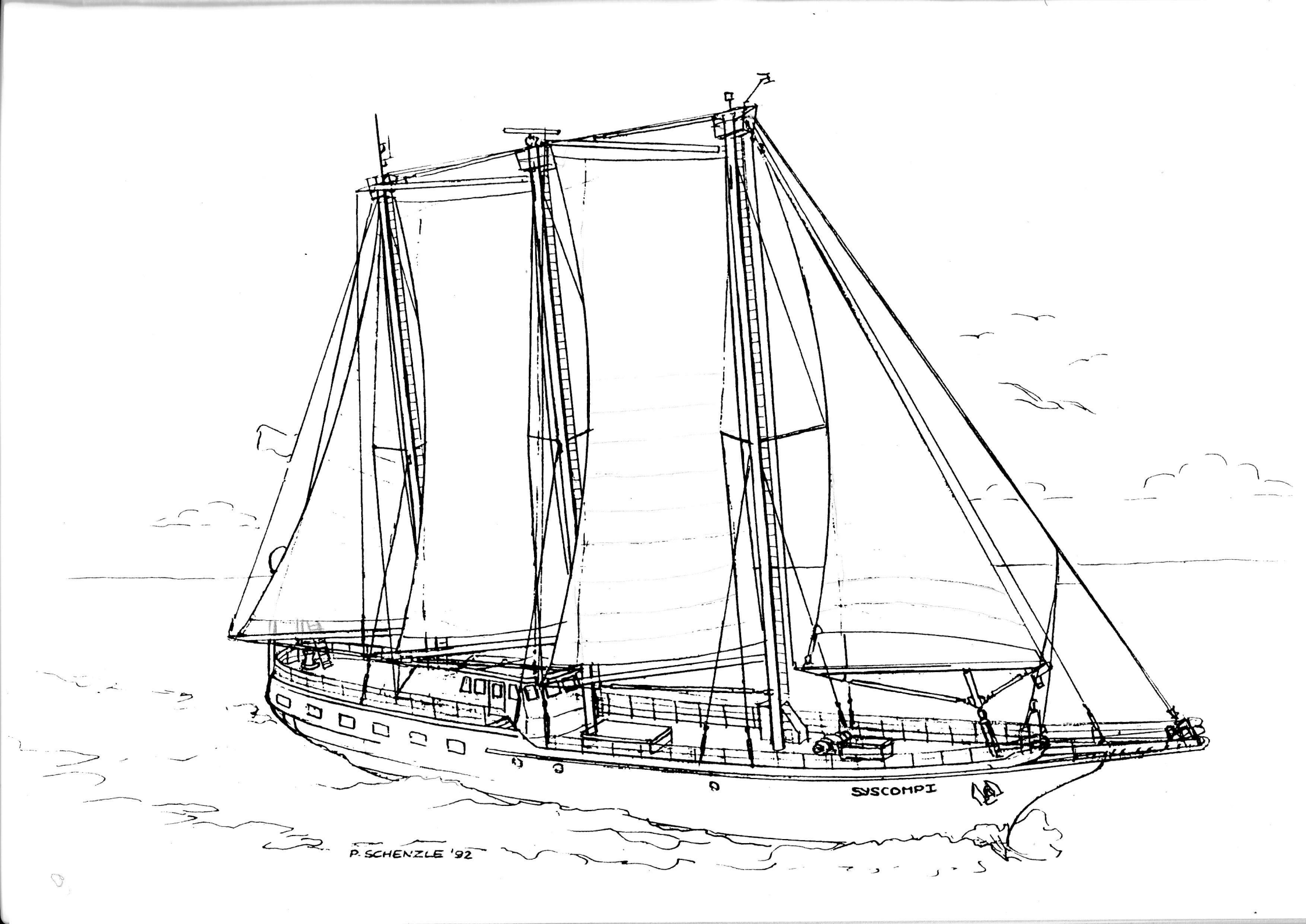
SYSCOMPI
P. SCHENZLE '92

MOTOR SAILING YACHT 'SYSCOMP I'

CONSULTING & TECHNICAL ASSISTANCE FOR THE CONVERSION

Executive Summary

INTRODUCTION

HSVA was ordered by **futura medica edv gmbh** to render Consulting and Technical Assistance for the conversion of the former fishing logger **'ST.KILDA'** into the motor-sailing yacht **'SYSCOMP I'** to **Schiffswerft** Jöhnk GmbH in the following fields:

1. Concept of the sailing rig and ship hull
2. Installation an trials of the sailing rig

CONCEPT OF THE SAILING RIG AND SHIP HULL

The concept of the conversion was based on the following criteria given by the owner:

+ Motor Sailing Schooner for private use
+ Easy handling of the sailing rig by minimum crew
+ Safety in worldwide service
+ Economy in conversion and operation

The selected technical concept for the sailing rig was the **INDOSAIL-Rig**, a utility schooner rig developed for commercial use with improved aerodynamic efficiency, easy control and safe mechanized handling. Special care was taken to introduce all modifications suggested by practical operation experience with the three existing prototypes of the INDOSAIL-Rig.

The lay-out of the rig had to be adjusted to the size, the form and the final floating condition of the ship hull. The hullform could only be modified in the forward part where a clipper bow and bowsprit arrangement was designed by HSVA. The remaining adjustment had to be made by controlling the ship's draft, trim and stability by a steady weight- and centre of gravity survey during the whole conversion period of two years and by numerous inclining tests in all phases of completion. This was the basis for the final tank arrangement and installation of solid ballast and for the satisfactory stability and sailing performance of the resulting ship.

Since the documentation of the old ship andof the conversion was rather incomplete, the actual condition of the ship form and of the general arrangement had to be reconstructed from old fragmentary drawings and from 'in situ survey'.This was the basis of the new drawings of ship's lines and general arrangement and for the new official tonnage measurement.

The Hamburg
Ship Model Basin

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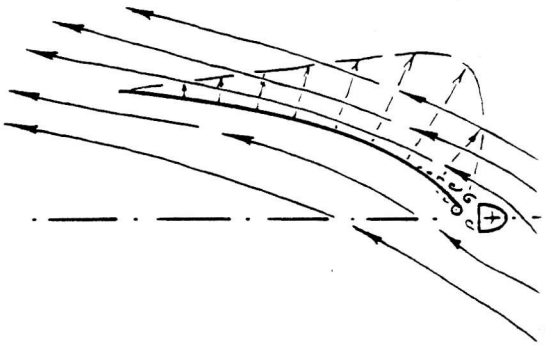
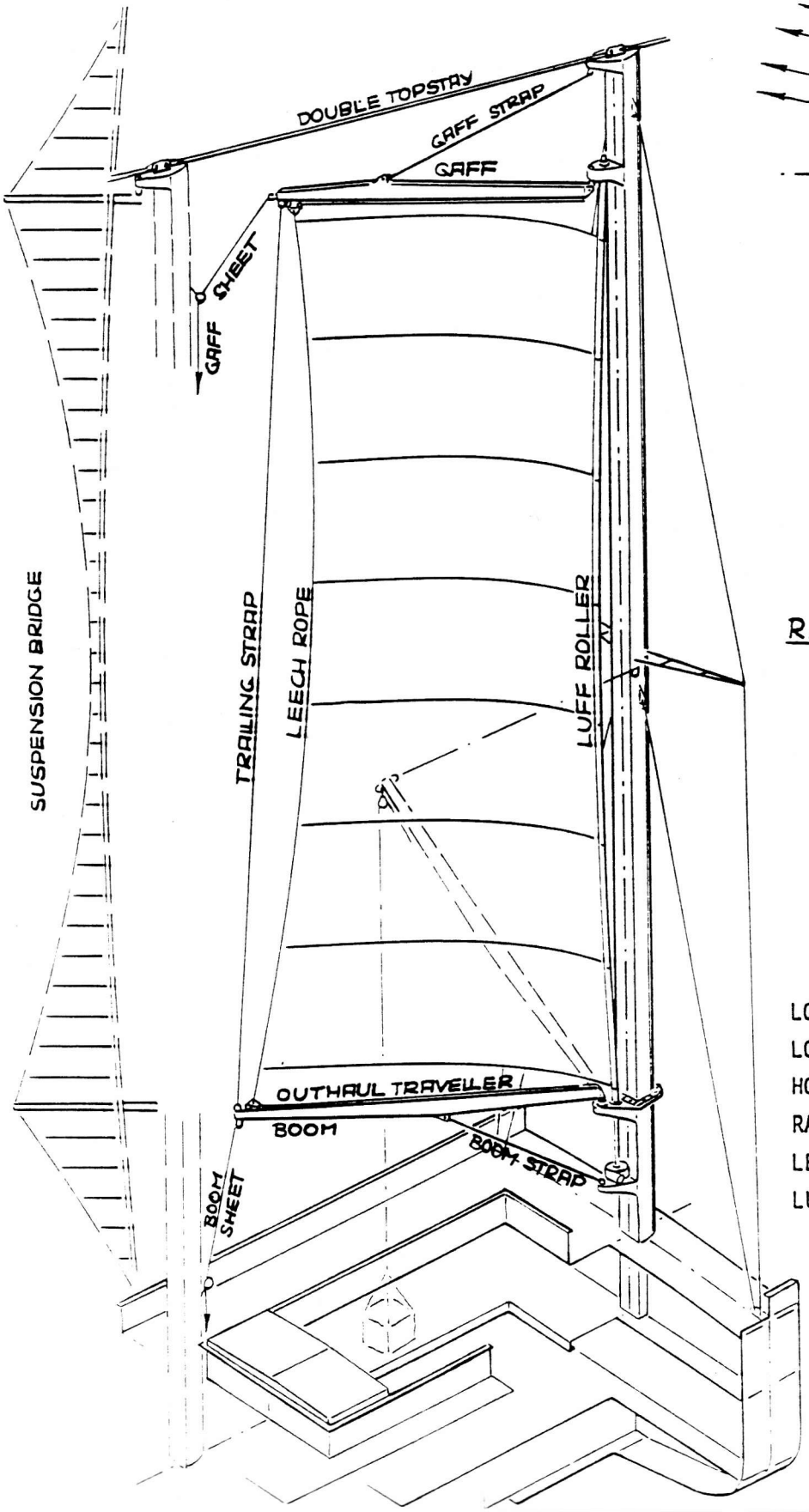
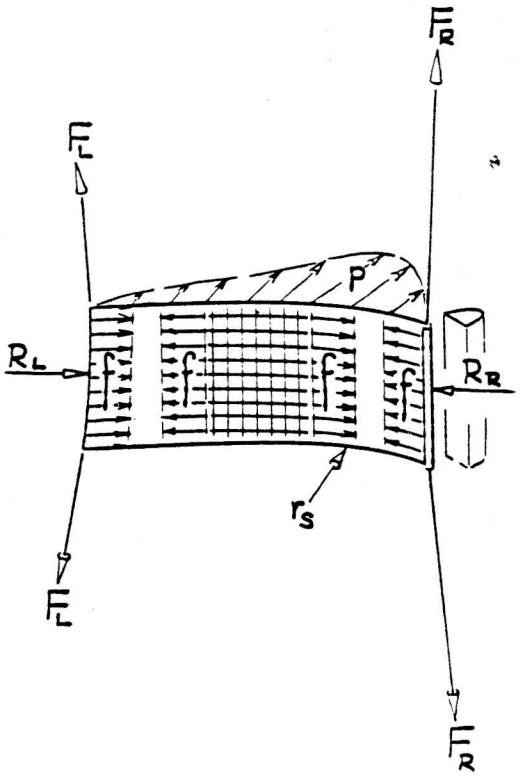
INDOSAIL

CONCEPT OF THE "SUSPENSION SAIL"







LOCAL AERODYN. PRESS. DIFF.	p
LOCAL RAD. OF SAIL PROFILE	r_S
HORIZ. SAIL-CLOTH TENSION	$f = r_S \cdot F$
RADIUS OF LEECH ROPE CURVE	R_L
LEECH ROPE TENSION FORCE	$F_L = R_L \cdot$
LUFF ROLLER TENSION FORCE	$F_R = R_R \cdot$

INSTALLATION AND TRIALS OF THE SAILING RIG

The installation of a large sailing rig of a new type is a critical phase requiring a close cooperation of the designers, the suppliers of the rig and the sails, the rigger and the operator. Apart from the correct assembly of the parts a modern elastic lightweight sailing rig is depending in function and safety on the correct tensioning of the standing rigging: the wire ropes and the roller pipes.

HSVA has developed a simple procedure for checking the rigging tension by measuring the natural frequency of oscillation of the rigging components. This procedure has been successfully applied to adjust the tension of all upper and lower shrouds, of the fore and aft stays and of the roller pipes and trailing straps of the sails.

It was planned to use an extensive yard trial for testing and adjusting the sailing rig thoroughly. Unfortunately this occasion could not be utilized fully because of adverse and too tight scheduling. So only the most urgent adjustments could be made on the yard trial and there was hardly a functional trial of the rig and the sails. To finish at least the essential adjustments HSVA took part on the second trip to Emden but unfortunately there was no occasion for opening the sails, so that it was not surprising that some avoidable trouble came up when the ship had already left the country.

Hamburg, September 1992

P. Schenzle

HSVA

DATE : 31.07.92
NAME : Schenke

INCLINING TEST DATE:

SHIP: S.Y. 'SYSCOMP I' EX. 'ST. KILDA'
CONDITION: ACCOMM. INCOMPLETE, PROVIS. LOADING, GARBAGE ON DECK
~20 PEOPLE ON BOARD, TANKS 90% FULL
PLACE: SCHIFFSWERFT JÖHNK, FRONT OF DRYDOCK
WIND : CALM

L_{PP} = 40.0 m
B = 7.9 m
D = 5.3 m
T = 3.0 m

DRAFT READING: T_A = 3.85 (ft/m) CORRECTED: T_{AP} = 3.60 m
T_F = 2.55 (KEEL.25m) T_{FP} = 2.30 m
T_M = 3.20 T_M = 2.95 m
W_{PERS} = ~~0.~~ t

TEST WEIGHTS W_1 = 2.34 t PS DISTANCE Δy = 5.97 m
W_2 = 2.40 t SB POSITION x = 26.8 m FR 55
$1/2(W_1+W_2) = \bar{W}$ = 2.37 t $\Delta W = 2\bar{W} + W_{PERS} \approx 5$ t z = 6.1 m

DISPLACEMENT ∇ = 525 m^3
(FROM HYDROSTATICS) Δ = 541 t

$\overline{KM}$ = 3.98 m
LCB = 18,63 m REL. TO: AP

HEEL ANGLES

ϕ [° ′]	$\Delta\phi$ [° ′]	PS	SB	WIND
0° +3′				
	+2° 01′	W_2	W_1	
+2° 4′		W_2	W_1	
	−1° 51′	W_1	W_2	
0° +13′		W_2	W_1	
	−2° 03′	W_1	W_2	
−1° 50′				
	+1° 57′	W_2	W_1	
0° 07′				

AVERAGE : $|\Delta\bar{\phi}|$ 1° 58′ = 1,9667° = 0.0343 RAD

METACENTR. HEIGHT: $\overline{GM} = \frac{\bar{W} \cdot \Delta y}{\bar{\phi} \cdot \Delta} = \frac{2,37 \cdot 5,97}{0.0343 \cdot 541} = 0.762$ m

CENT. OF GRAVITY : $\overline{KG} = \overline{KM} - \overline{GM} = 3,98 - 0,76 = 3,22$ m

CORRECTIONS $\Delta_c = \Delta - W = 541 - 5 = 536$ t

$\overline{KG}_c = (\Delta \cdot \overline{KG} - \Delta W \cdot z)/\Delta_c = (541 \cdot 3,22 - 5 \cdot 6,1)/536$
$- I_{B\,TANK}/\nabla$ $- 25/520 = 3,14$ m

$LCB_c = (\Delta \cdot LCB - \Delta W \cdot x)/\Delta_c = (541 \cdot 18,63 - 5 \cdot 268)/536 = 18,55$ m

HSVA

Datum: 01.08.91
Name: Sz

'SYSCOMP I' EX. 'ST. KILDA'

WEIGHT, TRIM & STABILITY ESTIMATION

ITEM	W t	X m	Z m	Mx mt	Mz mt	LCB ΔLC T m ΔT	KM GM
TESTCOND 31.07.92	536	18,55	3,14	9942,80	1683,04	18.55 2,93 1.36	3.98 FR.OR. 0,84 -.05
-20 PERS	- 1.5	15	6	-22.5	-9.0	T_{OH} = 3.86	
-WERFTAUSRÜSTG.	- 1,0	25	6	-25.0	-6.0		
+PROV. + 12P	+ 1,5	20	3	30.0	4.5		
+MÖBEL & TÜREN	+ 1.0	10	5.5	10.0	5.5		
+ RESERVE AUSR	+ 5	15	4	75.0	25.0		
∑SCHIFF ANF. REISE	541	18,50	3,14	10010,3	1698,04	18.5 2.95 1.40	3.99 FR.O. 0.85 → .80
						T_{OH} = 3.90	
VERBRAUCH BRENNST	-50	17.7	1,85	-885,0	-92.5		
PROVIANT	-3	25	2	-75.0	- 6.0		
∑SCHIFF ENDE REISE	488	18.55	3.28	9050.3	1599.4	18.55 2.81 1.37	4,00 FR.O. 0,72 → .67
						T_{OH} = 3.75	

MOTOR-SAILING YACHT 'SYSCOMP I'

SOME HINTS FOR SAIL OPERATION

A GENERAL

STABILITY

By installation of solid concrete ballast, the upright floating stability of the ship was increased to a safe level in all loading conditions. The water ballast tanks are not needed for stability and normally empty. The metacentric height GM is 0.80m with tanks 90% filled and full provisions or almost 0.70m with 20% rest fuel in the tanks, both with free liquid surfaces in the tanks accounted for. (See sheets 'Weight, Trim and Stability' and 'Inclining Test').

The range of positive righting moment is up to 90 degrees heeling angle. This would be valid only, if all hull openings could be closed tightly. Since this is not possible, especially with many ventilators on deck, occasional immersion of the side of the main deck in heavy gusts, or about 30 degrees of heeling, must be considered as the practical safety limit. However during normal close hauled sailing average heeling angles of more than 10 to 12 degrees are neither efficient to increase ship speed, nor safe and comfortable for living and working conditions on board.

STRUCTURAL STRENGTH OF THE RIG

The structural system of the sailing rig is a lightweight, pre-tensioned, elastic system. It is designed to withstand the maximum righting moments at 45 degrees heeling, the corresponding wind pressure and tension forces in the standing rigging and the pitch acceleration forces on the masts in heavy seas.

TENSIONING THE STANDING RIGGING

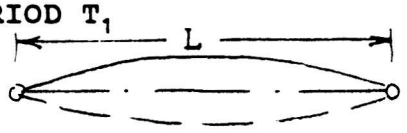
The required pre-tension in the stays, the shrouds the trailing straps between booms and gaffs and the luff roller pipes of the sails can be checked by the natural period of oscillation between two fix points. (See sheets 'Checking standing rigging tension').

Since new wire ropes are stretching the check must be repeated after the first hard sails and heavy seas and the tension must be corrected if necessary. After the tension has stabilized the rigging screws can be secured and the check can be at longer intervals.

ELECTRIC SAILWINCH LAYOUT

The electric sailwinches, including those for the double genoa, are limited to a certain maximum working load with a reasonable safety allowance. In practical operation, a sense for these limits of working load must be developed by observations, to replace the lost physical feeling from manual handling.

CHECKING STANDING RIGGING ROPE TENSION FORCE F
BY TAKING RESONANT OSCILLATION PERIOD T_1



LENGTH BETW.FIX POINTS	L	
FIRST OSCILLATION MODE	T_1	
TENSION FORCE	F	
ROPE MASS/ UNIT LENGTH	m/L	$T_1 = 2L/c$
WIRE MASS DENSITY	r	$c = \sqrt{F/(m/L)} = \sqrt{\sigma/r}$
WIRE TENSION STRESS	σ	$T_1 = 2L\sqrt{(m/L)/F}$
OSCILLATION SPEED	c	$= 2L\sqrt{r/\sigma}$

CHECKING PROCEDURE:

1. Rock the wire of length L between two fix points (e.g.upper shroud between deck and spreader) in a natural, harmonic way.

2. Make sure you got the first natural oscillation mode (just one belly, no knot, between fix points; no S-shape).

3. Take the time for 10 (or 20) full oscillations (in & out, come & go).
Start stopwatch when counting 0 (zero) - Stop when counting 10 (or 20).

4. Divide the result by 10 (or 20) and compare with the recommended period T_1 [s] (if no recomm. available, use approxim. $T_1 \approx L/(60\ m/s)...L/(70\ m/s)$) (*For wire rope only!*)

5. A longer period T_1 means a lower tension F.
(10% longer T_1 means 20% lower F; $F \rightarrow 1/T_1^2$).

6. The recommended range of period T_1 means that the actual tension F should be between 70 and 100% of the wanted tension.

The Hamburg
Ship Model Basin

HSVA

CHECK OF STANDING RIGGING TENSION BY NATURAL PERIOD T_1

SHIP: 'SYSCOMP I' EX. 'ST. KILDA' DATE: 01.06.92 NAME: SZ

ROPE-	NAME	LENGTH	DIAM.	MASS	RECOMM. TENSION	SPEED	PERIOD	PERIOD	
		L [m]	d [mm]	$\frac{m}{L}\left[\frac{kg}{m}\right]$	F [kN]	$C=\sqrt{\frac{F}{m/L}}\left[\frac{m}{s}\right]$	$T_1=\frac{2L}{C}$ [s]	measure	
STAYS:		STAGE	: 6×19 SE		min (80%)			PS.	STB.
FOREST.	VORSTAG.	26.7	28	3.1₅	50 (40)	126 (113)	0.42 (.47)		
TOPST.	FORE VOR	9.9	16	1.0	15 (12)	121 (110)	0.16 (.18)		
TOPST.	AFT ACHT	10,2	16	1.0	15 (12)	121 (110)	0.17 (.19)		
AFTST.	ACHTERST.	26.7	26	2.7	40 (30)	122 (105)	0.44 (.51)		
SHROUDS:		WANTEN:	6×19 SE						
FORE	LOW. UNT.	11.7	26	2.7	40 (30)	122 (105)	0.19 (.22)		
VOR-	UPP. OB	12,8	28	3.1₅	50 (40)	126 (113)	0.21 (.23)		
MAIN	LOW. UNT.	12.0	26	2.7	40 (30)	122 (105)	0.20 (.23)		
GROSZ-	UPP. OB.	13.4	26	2.7	40 (30)	122 (105)	0.22 (.26)		
MIZZEN	LOW. UNT.	11.2	26	2.7	40 (30)	122 (105)	0.18 (.21)		
BESAN-	UPP. OB.	12.5	26	2.7	40 (30)	122 (105)	0.20 (.24)		
TRAILG.	STRAPS:	DIRKEN:	1×19						
FOCK-	JIB	21.8	12	.68	15 (12)	149 (133)	0.29 (.32)		
VOR-	FORE	20.2	12	.68	15 (12)	149 (133)	0.27 (.30)		
GROSZ-	MAIN	20.2	12	.68	15 (12)	149 (133)	0.27 (.30)		
BESAN-	MIZZEN	22.5	12	.68	15 (12)	149 (133)	0.30 (.34)		
ROLLER	PIPES:	ROHR+SEGEL	$\frac{m}{[kg]}$						
KLÜVER		29	300	10.3	60 (50)	76 (69)	0.76 (.83)		
FOCK-	JIB	24	210	8.7₅	60 (50)	83 (76)	0.58 (.64)		
VOR-	FORE	21	260	12.4	60 (50)	70 (64)	0.60 (.66)		
GROSZ-	MAIN	21	260	12.4	60 (50)	70 (64)	0.60 (.66)		
BESAN	MIZZEN	22	195	8.9	60 (50)	82 (75)	0.54 (.59)		

B OPERATION OF THE RIG

OPENING THE SAILS

Opening the sails is done by the movable control boxes at the respective mast from a position with visual contact to all moving parts - the roller, the travellers on gaff and boom and the winch drum. All control ropes - outhauls and sheets - and the sails should be kept under moderate tension during the procedure. Flutter of sails must be avoided. This is achieved by carefully observing the motions of the sails, the ropes and the winches; and by occasionally stopping the faster drive - outhaul or roller - or by adjusting the sheets for moderate sail load.

REEFING AND FURLING THE SAILS

Reefing and furling the sails requires basicly the same procedure and the same precautions as opening the sails.

Reefing should be started early enough. In increasing wind speeds reefing may require to carefully ease the sheets first to a moderate tension. Slack of sheets and flutter of sails must be avoided again. Hauling the sheets under excessive wind pressure may result in just opening the breaks and paying the sheet out against the power of the winch. This is a signal to stop the attempt immediately and that reefing was required first. Too hard attempts may even result in dropping of the overload circuit breaker in the distribution box in the cargo hold. Earlier signals that it is time for reefing are heeling angles exceeding the limit of 10 to 12 degrees while beating upwind, or slackening of correctly tensioned trailing straps above the boom ends on all courses to the wind.

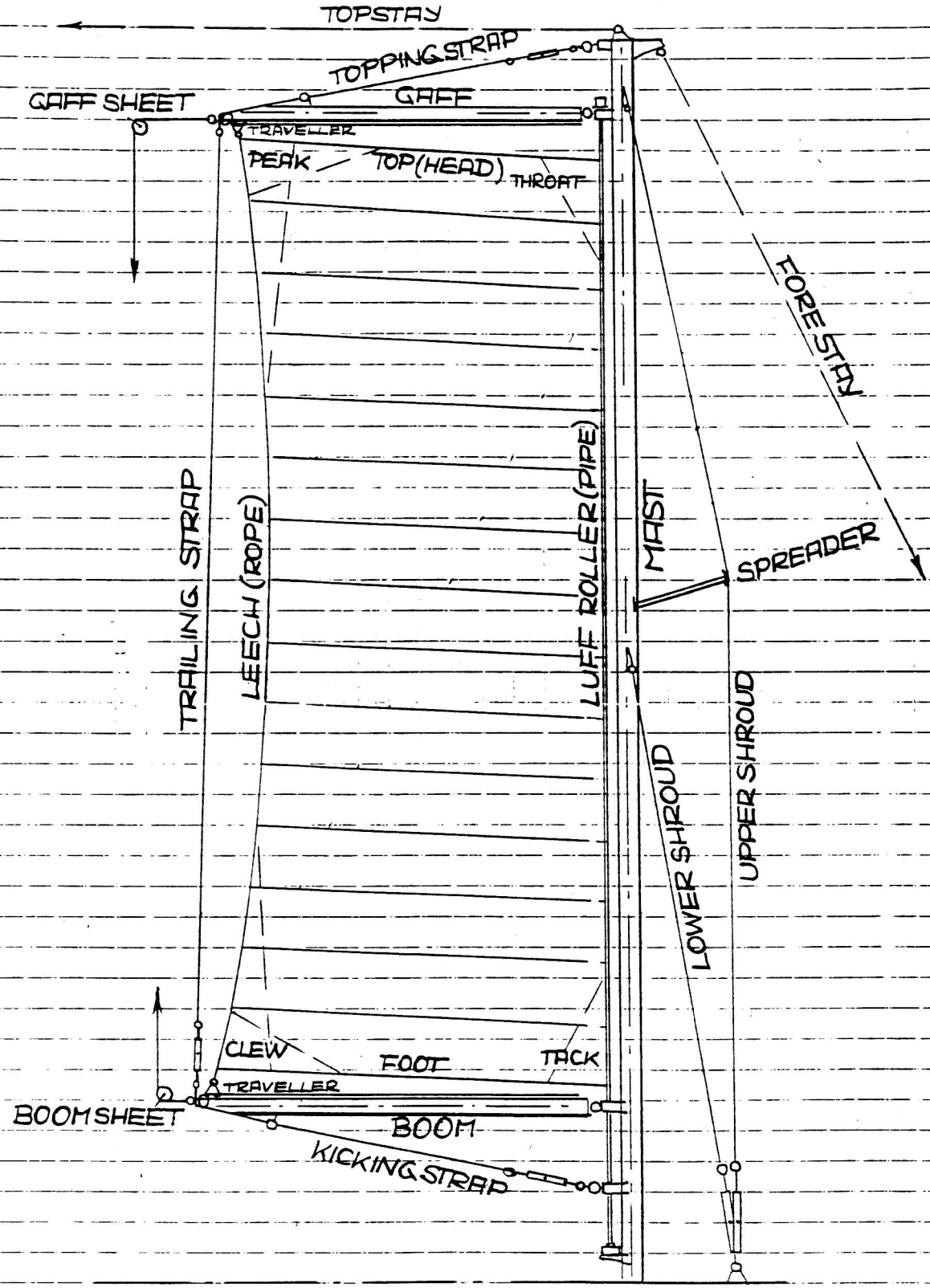
Total furling of sails should never be done with the sheets widely open, but under progressive hauling until the sail is furled. Furled sails should be reasonably tightened, but the gaff traveller carriage should not be pulled too hard against the forward stopper. The tension can be judged from the direction of the connecting strap between the sail clew and the traveller carriage. This should be almost in line with the leech curve and not too much angling back and pulling the foot or the top of the sail.

In strong winds and with sails furled, the roller pipes may be excited to strong oscillations by eddy-shedding behind the mast. This can be stopped by changing the course and thus the direction of inflow. Correct tension of the roller pipe and of the outhauls can reduce the phenomenon.

SHEETING THE SAILS

Sheeting the sails is possible from the local control boxes at the respective mast or from the central control panel on the flying bridge. Proper sheeting requires sufficient view on the sails and booms. Remote sheeting without viewing the winch drum should only be done with reasonably tensioned sheets. Rolling up slack sheets should be controlled by a second person at the winch drum.

INDOSAIL RIG ELEMENTS



SAILING RIG TERMINOLOGY

C EFFICIENCY

SAIL TRIM

All sails are made of soft UV-resistant cloth. They are of flat cut with a hollow curved leech seam. The sails under wind load are suspended by a strong, curved leech rope similar to a 'Suspension Bridge' (See sheet 'Suspension Sail').

Therefore the control forces for sail shape and profile are introduced not directly into the cloth but via the curved leech rope. Proper trim of the sails can be checked by the sail profile and by the angle of the connecting straps between sail clew and traveller carriage. A reasonable average sail profile draft in abt. 10% cord length - more flat when beating - more rounded when reaching. In decreasing wind speeds the profile can be pulled flat by the elastic outhauler ropes, and readjustment may become necessary.

On upwind beating courses, careful sail trimming is worthwhile to optimize the speed-made-good. In a multi mast sailing rig - as with an aircraft wing in the start or landing configuration - the optimum adjustment of the sail- or wing elements to the local flow conditions is resulting in a fairly open sheeting of the jib and a progressively closer sheeting of the following sails with the mizzen sheeted closest. The purpose is to force the wind flow step by step to turn its direction closer to the midship line for optimum propulsion thrust and even distribution of the contributions of the sail elements. The practical optimum should be sought by considering also the reasonable limits of the heeling and rudder angles.

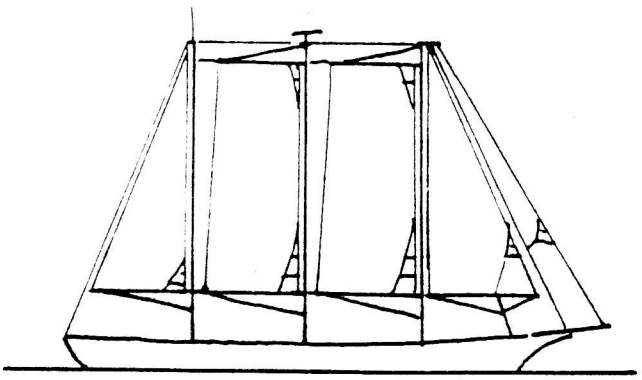
SAIL CONFIGURATION

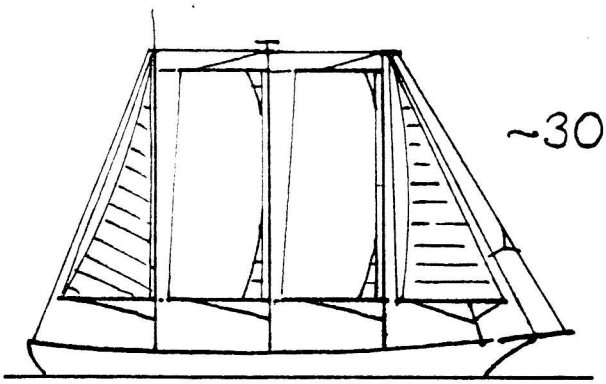
Appropriate sail configurations should be selected according to both efficiency and safety criteria.

A fore-and-aft mainsail attached to the mast or a luff roller close to the mast is suffering from disturbed flow on its most critical leading edge. The gap between mast and roller is marginally improving the flow but a considerable improvement is found from the slipstream of a jib sail in front. Thus the propulsive effect of the combination is much more than the sum of the effects of the individual sails.

Consequently, to open the gaff sails only is not an efficient configuration. It is suggested instead, to open the jib and mizzen sails first and to open the gaff fore and mainsails then to a degree compatible with the course and wind conditions.

With increasing wind speeds the gaff sails should be reefed progressively with the jib and mizzen sails still full. With the gaff sails fully furled the jib and mizzen are an efficient strong wind configuration with abt. 1/3 of the working sail area and a lower center of effort, suitable up to abt. 20 m/s apparent wind.





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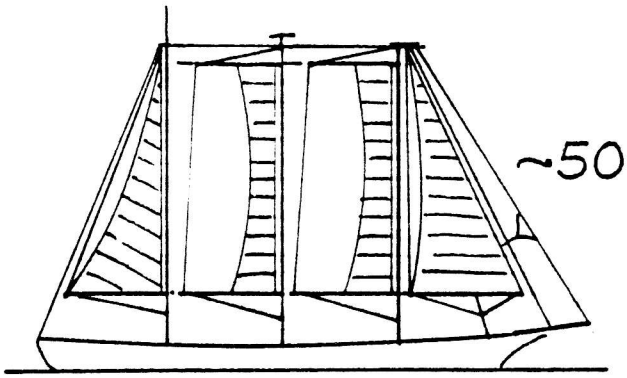

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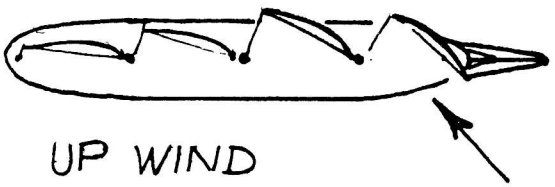
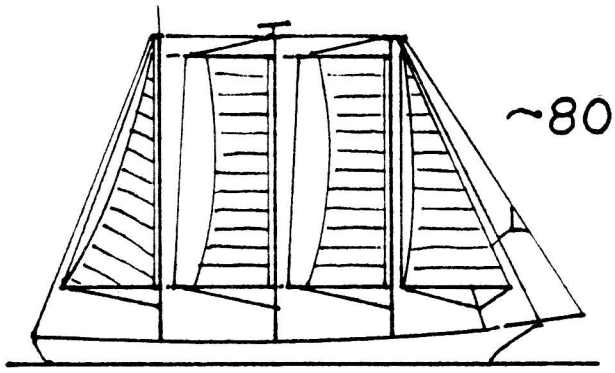


UP WIND



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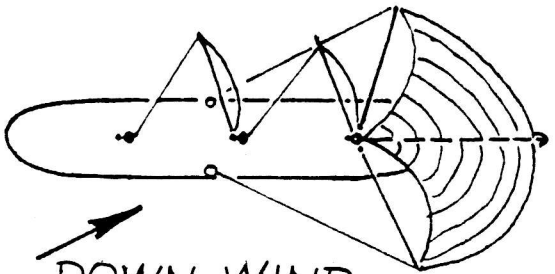
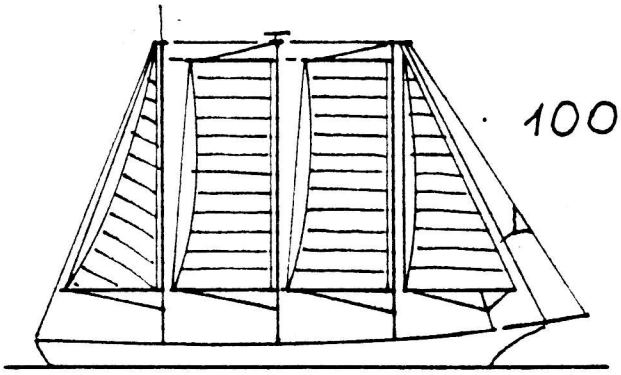


DOWN WIND



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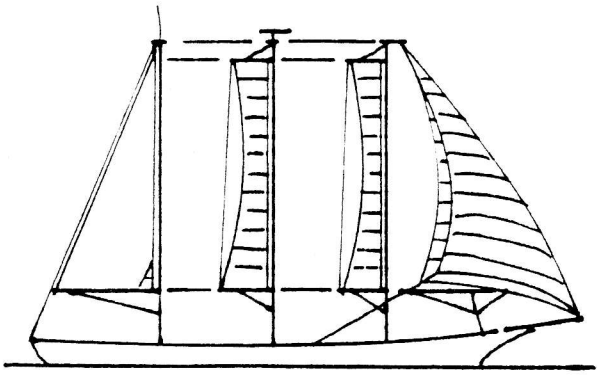

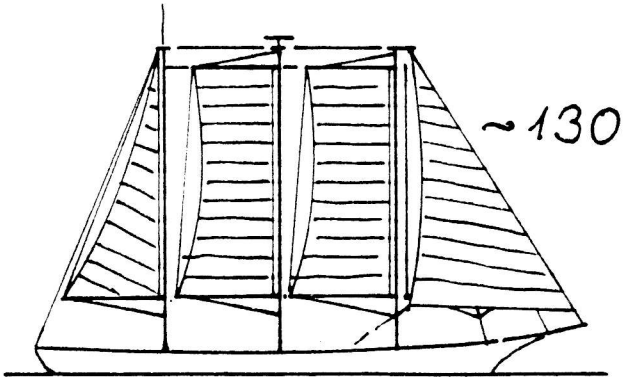

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REASONABLE SAIL CONFIGURATIONS

D MAINTENANCE

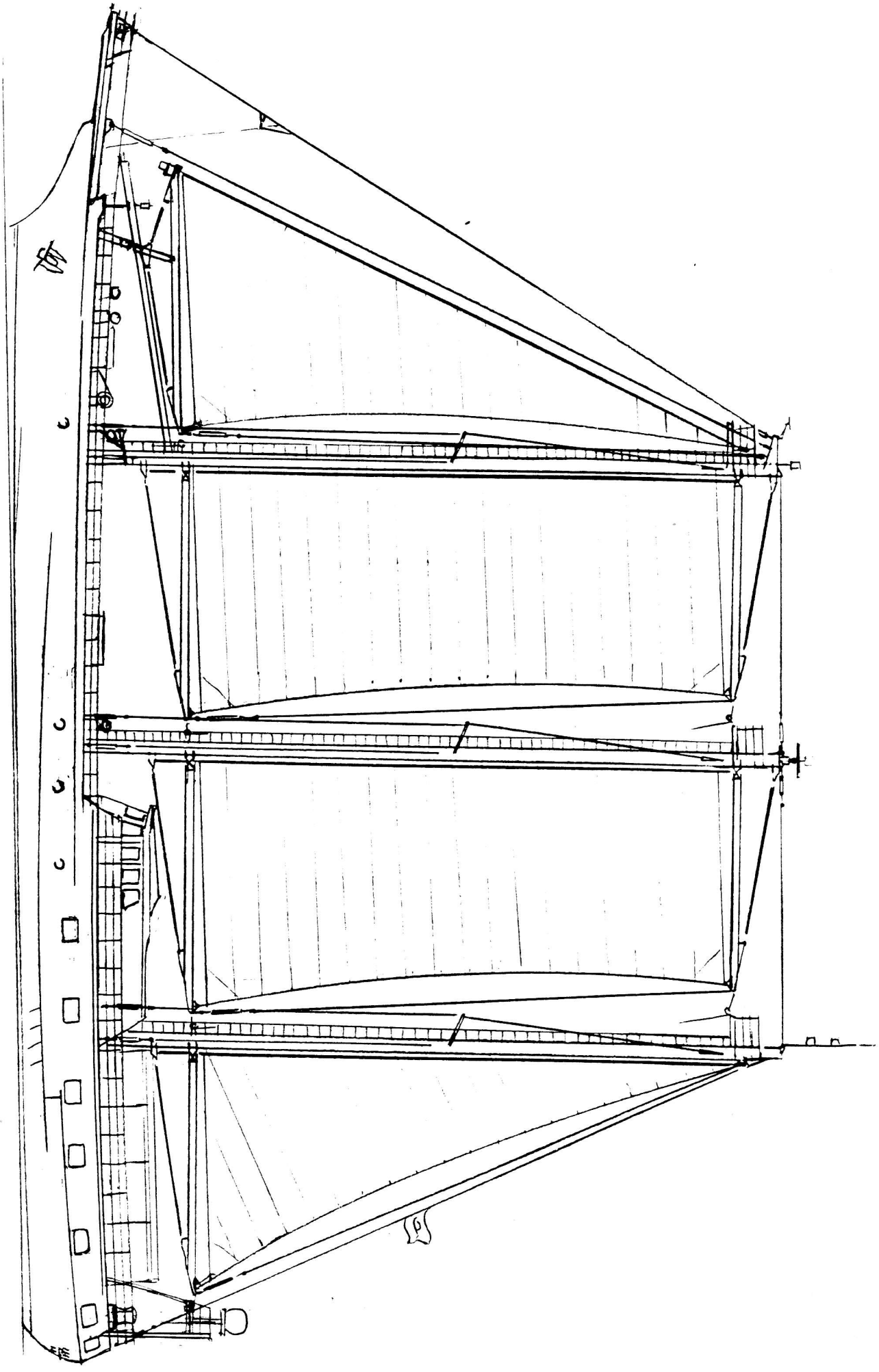
The basis for rig maintenance is the regular inspection of the critical components. Special attention must be paid to the parts close to the mast tops which are too far aloft for close observation from the deck level.

All steel parts, the masts, the kicking and topping straps and the standing rigging wire ropes with all fittings must be regularly inspected for and protected against corrosion. This applies especially to all retrofitted eye plates and fittings and to the wire ropes that could be coated with a permanently elastic paint.

All shackles and turnbuckles and other screws must be greased and secured. All bearings and winches are to be properly maintained. All rope sheaves and traveller wheels are made of virtually maintenance-free, oil-filled, heavy-duty polyamide material.

Critical points of chafe for sails and running textile ropes must be identified and protected by soft covers or smooth fairleads. Fairleads should also be fitted to ropes running all the way up the masts to prevent excessive shaking and hooking.

The electric control boxes and panels on deck must be checked for dryness, especially after bad weather, dried and properly sealed again.



E EMERGENCY

SHEETS OFF

The most important provision for emergency is the possibility to ease all sheets in a sudden strong squall. This is achieved by electrically lifting the sheet winch breaks by pressing the red button in the wheel house or on the flying bridge, which is operational as long as DC-power is available, if only from the emergency batteries.

HAND REEFING & FURLING

In case of an electrical black-out the sails can be reefed or furled manually using the big LEWMAR hand winches. For this purpose a wire rope is rolled on a drum at the foot of each roller pipe.

A suitable fibre rope must be prepared via special wide sheave block from the hand winch to the drum and connected to the wire. The wire rope tied to the drum should be opened only after tensioning the rope.

Then the roller must be detached from the break, either by pulling the four bolts off the flange below the drum or by lifting the break of the motor by DC voltage from the batteries.

Before the sail can be furled by hand, the outhauler winch must be detached from the break, either by preparing the outhauler winch for manual operation or by lifting the break by battery voltage.

Then the sail can be reefed or furled by hauling the wire rope from the drum with the big LEWMAR hand winch.

OVERLOAD

Dropping of overload circuit breakers is only the last signal of mechanical and electrical overload during sail handling.

In ordinary sail handling the earlier visual signals, like excessive heeling or slack trailing straps should have caused reefing the sails in time, to prevent overloading attempts.

In cases, where the limits are already exceeded, the proper sequence of action is:

1. easing the sheets, to reduce the load (open break),
2. reefing the sail area,
3. trimming the sails and adjusting the sheets.

PREPARING THE HATLAPA WINCHES FOR MANUAL OPERATION

In case of electrical or engine breakdown, it may be necessary to furl or open the sails by manual winch operation. The following procedure for preparing the electrical HATLAPA-winches for manual operation must be followed carefully, to avoid complications or damage:

1. Shift the small cog wheel on the handle shaft into the teeth of the large drum wheel by pulling the transverse handle up. Assist the grip of the teeth by 'playing' with the shaft. Close the lock screw in the new position. This action also disconnects the winch from electric power.

2. Open the coupling on the left hand side of the winch drum by inserting the steel rod into the radial holes and turning left. Plastic caps must be removed during manual operation. If necessary use one of the rods lengthened by pipe.

3. Now the winch is ready for manual operation by the handle on the right.

4. When the winch shall be rearranged for electrical operation, the coupling on the left must be closed again firmly by turning right with the radial rod.

5. Only after making sure that the coupling is properly closed, the tension can be released from the handle shaft by striking on the ratchet on the right.

6. Then the small cog wheel can be detached from the large one by lowering the transverse handle and fixing the lock screw in the old position. By this action the winch is again connected to the electric power and ready for operation.