BASICS FOR THE USEAGE OF WIND PROPULSION ON BOARD SEA-GOING SHIPS (1)

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I. The latest comprehensive demonstration of the various efforts to make use of wind energy for the propulsion of commercial ships was during the symposium on wind propulsion of commercial ships in London in November, 1980 (RINA Symposium), and can be obtained by reading the proceedings of the above mentioned symposium (2).

Since summer, 1980, the "Shin Aitoku Maru", a ship constructed, built and run by Japan has been making worldwide headlines (3).

So far, however, a detailed diagram of efficiency which could serve to justify the investment has not been published (4). Reference has been made to energy savings of 50% (5), but these savings are not solely due to the use of wind energy but also to technical changes and alterations. Size and construction of the area used by the "Shin Aitoku Maru" for wind propulsion (sail) should have produced energy savings of approximately 10% (6), but whether these savings and, subsequently, the feasibility of the system, have been achieved cannot be determined from the publications (7).

As more ships of the "Shin Aitoku Maru" type have been built (8) - the Russians have commissioned a 4770 Tdw tanker with two sails and two additional vertical rotors (9) and the Japanese have recently published plans for a sail-assisted 35,000 Tdw Bulker (10) - some aspects should be outlined which are essential for the success of wind propulsion units on board sea-going ships.

II. The requirements modern wind propulsion units have to fulfill differ substantially from those for the tallships of the turn of the century. Those ships were primarily fair wind sailships, i.e. their prime target was to convert low-range wind forces into propulsion, as engine propulsion was not used or was non-existent. Subsequently, these ships were over-rigged from force 5 BFT upwards, with the result that not only could the existing sails not be used, but the unusable rigging was detrimental to the speed and the stability of the ship. This was the reason why the maximum speed of these ships was far below their possible hullspeed.

For example, between 7 and 8 BFT the windspeed increases by 7 knots; the speed of the "Preussen" could only be increased by 1 knot and above 8 BFT the ship speed decreased (11). These disadvantages also exist to some extent for the Dyna ship which has often been described (12). Furthermore, the necessary technical sophistication would require an investment that would be out of proportion to the envisioned gain. The system would be too vulnerable and would not meet the required safety standard. It is essential that at any time and under any circumstances sails or wind propulsion units can be taken away or neutralised without delay. This is particularly important for systems where the rigging reaches the height of the Dyna ship.

III. Taking the aforementioned into account, it appears that the Japanese with their ship "Shin Aitoku Maru" went in the right direction from the only possible starting point.

The requirements of modern wind propulsion units can be summarised as follows:

1. Only higher windspeeds are economically attractive.
2. The stability of a ship must not be affected by windspeeds in the higher range.
3. The system must be cheap, technically uncomplicated and safely and automatically manageable.
4. The system must satisfy the requirements of modern ship management and economical aspects (trade) as shown in diagram 1.

It goes without saying that the savings over a given period should be substantially higher than the investment and running of the system.

The "Shin Aitoku Maru" fulfills some of the aforementioned requirements, but serious doubts are justified regarding the efficiency of the system and the energy savings.

The following seem to be the major shortfalls:

1. The total sail area is relatively small.
2. If there is a following wind, the forward system does not get full wind power.
3. The system can only be reduced to 20% of the sail area and therefore acts as a brake while steaming only, especially when there are high winds.
4. The rigid construction results in high weight, deterioration of stability and high costs.
5. At the very latest the system has to be shut down when the windforce reaches 8 BFT.

The relationship of these factors can be demonstrated by the following calculation model.

IV. If a tanker of 80,000 TDW were equipped with a sail area of 2000 m² it would have the dimensions shown in illustrations 2 and 3. If aerodynamic factors were taken only slightly into account, the sail area would have the coefficient shown in diagram 4. The propulsion given by the sail area in relation to the windspeed and the trim of the sail is shown in diagram 5.

Diagram 5 shows that with this relatively small sail area winds of up to 4 BFT would have no significant impact on the propulsion. According to this calculation, only winds of more than 4 BFT would provide significant and effective propulsion. Additional calculations reveal that with a given average speed of 12 knots this system would achieve savings of 20-25% on fuel consumption.

V. The system used by the "Shin Aitoku Maru" could not produce the results mentioned above as the propulsion below 3-4 BFT is insignificant (approximately 33% of the average winds are below 3 1/2 BFT) and the non-sail areas have a braking effect during steaming time and in winds above 8 BFT.

The theoretically possible time of useage of the "Shin Aitoku

Maru" system would on the average be far less than 50%.

The economical viability of a small system depends on whether high winds can be utilised and on the air resistance of a system when not in use.

VI. The authors are of the opinion that especially the requirement of the smallest possible air resistance in the O position cannot be achieved by using rigid areas. Canvas or similar materials are absolutely essential if a relatively large sail area is to be stowed in a small place. Flexible sail material increases the safety factor by allowing the sail area to be destroyed if difficult situations demand an immediate reduction of the wind pressure on the system.

The sail area could be "hoisted" by the use of two vertical pipes moving between two horizontal beams, rolling or unrolling the canvas or other material as required.

VII. The lack of innovations for sailships around the turn of the century could partly be explained this way: technicians lacked specific knowledge of the practical problems of handling ships and the masters did not have enough knowledge about the technical possibilities and were possibly uninterested in such possibilities. If one considers sailing yachts, it can be seen what developments were possible during the last decades with regard to deep sea yachting; on the other hand, these developments were only made possible by enormous investments. Possibilities for transferring ideas from the construction of deep sea yachts to commercial shipping are limited, and the use of such ideas could even be obstructive if too much consideration is given to yachting problems. This is especially the case when one sees the efforts being made to achieve ideal aerodynamic wind flow.

For a commercial ship, there is no necessity to explore the costly field of making use of light winds. This was of interest for the tallships of around 1900 and is of prime interest for yachting.

/III. Modern shipping has to cope with all hazards, even under difficult conditions. Systems designed to ease the pressure of high operating costs by reducing fuel consumption have to fit in smoothly into the overall transport system ship and must not represent an additional risk factor. The Duke of Edinburgh expressed this very well in his opening speech at the RINA Symposium in 1980:

> "It is easy enough to reduce the whole of the discussion to elegant formulas, beautiful graphs and pages of statistics, but seagoing is not quite as clinical as that. The elements also play a part in the matter, and they are unforgiving."

Many of the ideas published so far would not fulfill the safety standard demanded by the perils of the sea, and others would not justify the high investment costs.

The "Shin Aitoku Maru" takes a step in the right direction by totally dismissing the concept of the tallships at the turn of the century and concentrating on relatively small and compact units. But without new designs, i.e. maintaining the same weight with a larger sail area, smaller area in the zero position, utilisation of higher windspeeds and the elimination of all risk factors by providing that the unit can be put into 0 position under all circumstances or that the wind pressure can be neutralised immediately, this Japanese concept will prove to be a failure.

IX. Nevertheless, the Japanese have made a start and the utilisation of wind energy for the propulsion of ships is so obvious and necessary that the utilisation of wind energy will succeed during the next decade with small wind propulsion units in some areas of the merchant shipping world. Contrary to the land situation, there will be no alternative energy sources available for shipping in the forseeable future. One may regret that research into the utilisation of nuclear energy in merchant ships is not available, but one has to accept the fact that for the time being there is no room for nuclear energy in merchant shipping. Should it be necessary, however, one could utilise the experience of the various navies in this field and put it to good use for the merchant marines (15).

Finally, wind energy is available and cheap, and the fact that the merchant ships consume 2-3% of world oil production shoud provide an incentive to put more effort into the research of utilisation of wind energy for merchant ships. The "Shin Aitoku Maru" is encouragement for this task.

FOOTNOTES

1) Cf. authors' publications: "Rahmenbedingungen für Handelsschiffe mit Windantrieb", Hansa 1982, pp. 974 f. and "Energieeinsparung durch Wind", Hansa 1983, pp. 1012 f.

2) Proceedings of the "Symposium on Wind Propulsion of Commercial Ships", London, Nov. 80, Royal Institution of Naval Architects 1981, RINA Symposium 1980.

3) Sunday Times Magazine, Sept. 28, 1980, p. 35; NN, Sail-equipped Motor Ship, The Naval Architect, March 81, pp. E59 f.; NN, Alternative Antriebsenergie Windkraft, Hansa 1981, pp. 584 f; NN, Fuel Savings aboard Japanese Sailing Tanker, Marine Propulsion, Feb. 81, pp. 35 f; and NN, Excellent Sailing Performance Achieved by "Shin Aitoku Maru", Zosen, August, 1981, pp. 30 f.

4) See recent publications: NN, The Indispensable Sail, Fairplay Centenary Issue, 1983, pp. 187 f; NN, Large-sized Sail-rigged Bulk Carrier Developed, Zosen, April, 1983, p. 24; NN, Large Sail-assisted Motorships, Marine Propulsion, April, 1983, p. 30.

5) According to N. Hamada, Jamda Pioneering New Technology, Zosen, June, 1981, p. 20.

6) NN, Sail-equipped Motor Ship, The Naval Architect, March, 1981, pp. E 59 f.

7) Same as Fn. 2 and 4

8) See Lloyd's List of October 1, 1982, p. 5

9) See Lloyd's List of July 27, 1983, p. 3

10) NN, Large-sized Sail-rigged Bulk Carrier Developed, Zosen, April, 1983, pp. 24 f; NN, Large Sail-assisted Motor Ships, Marine Propulsion, April, 1983, pp. 30 f.

11) From H. Hamecher, Königin der See, Fünfmast-Vollschiff "Preußen", Hamburg, 1969, p. 212

12) From P. Schenzel, Standardised Speed Prediction for Wind Propelled Merchant Ships, Proceedings, RINA Symposium, 1980, as above Fn. 2, pp. 173 f with additional literature index

13) As Fn. 6, p. E 61

14) For further details see publications listed in footnote 1

15) There are more than 250 nuclear powered warships in commission; N. Battle/D. J. Morris, Nuclear Propulsion for Merchant Ships. "The Motor Ship": The Motor Ship Conference, London, March, 1979, p. 75

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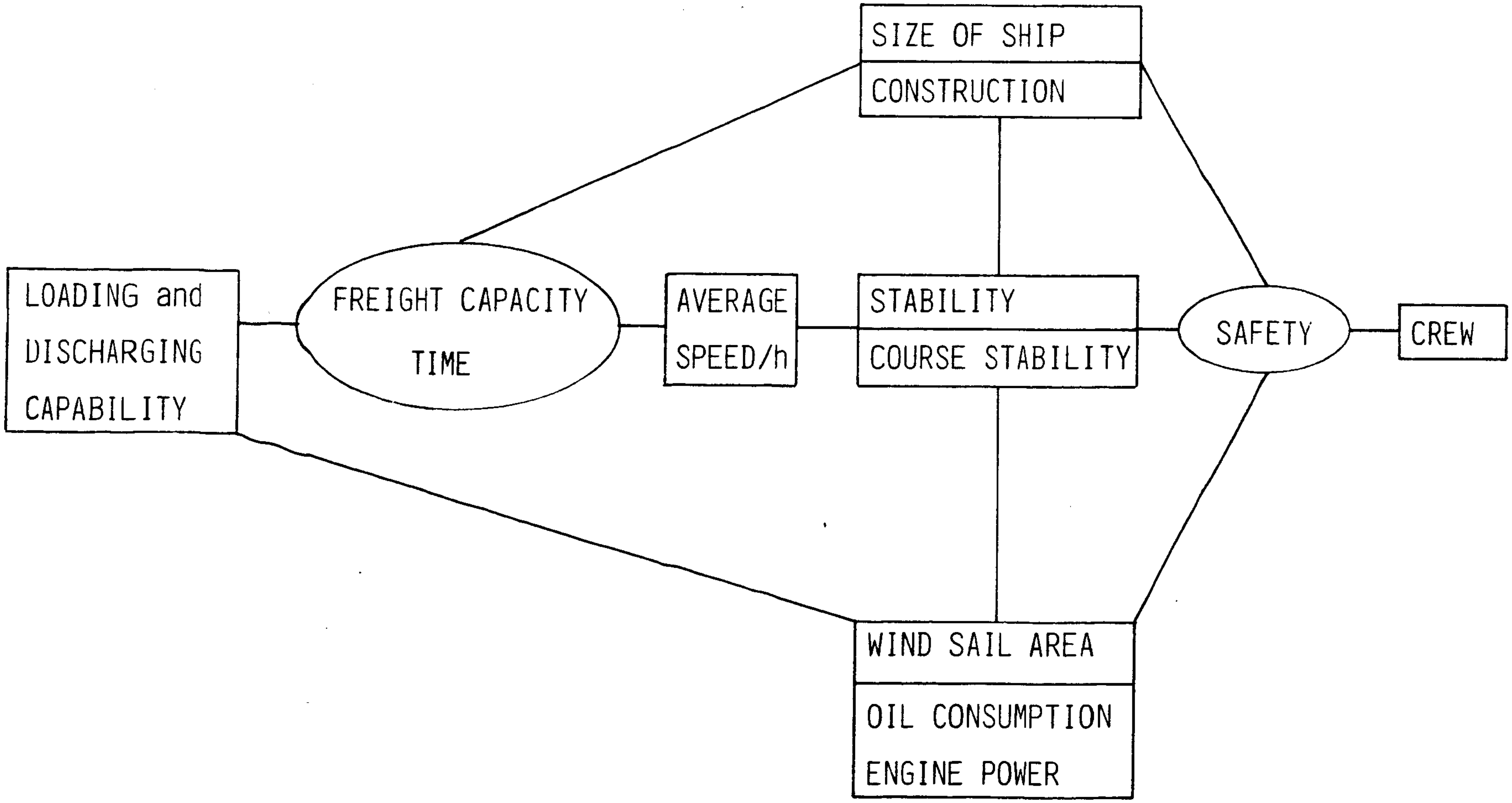
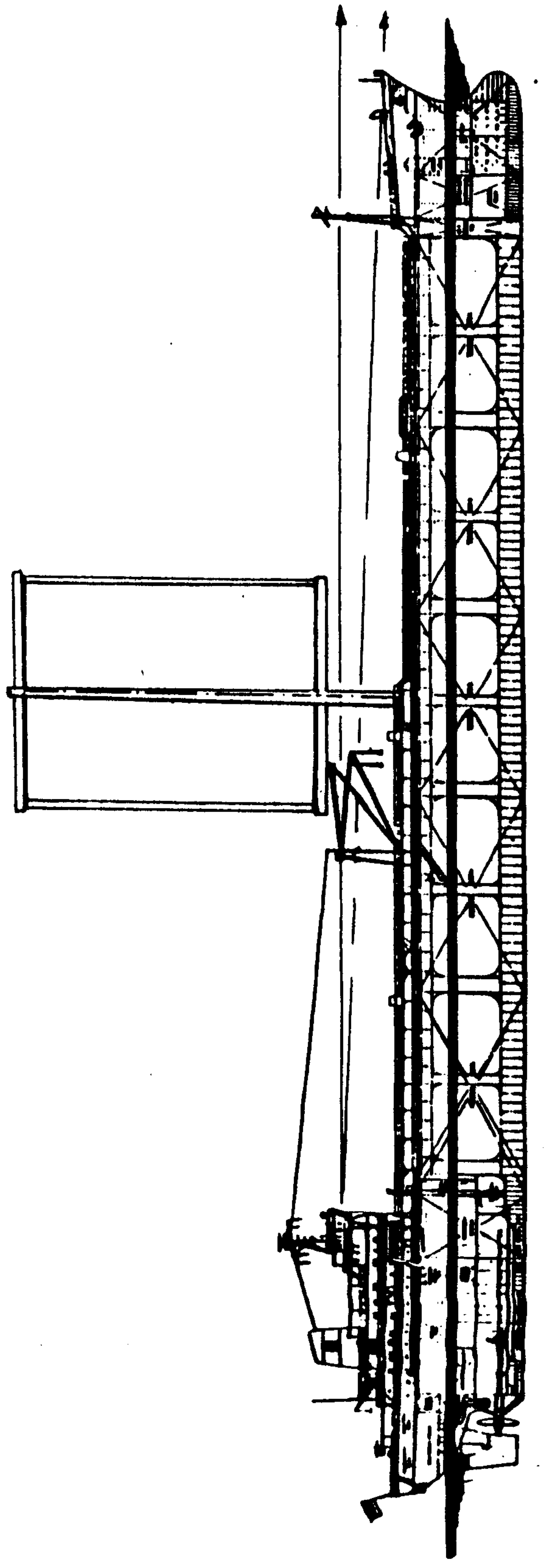
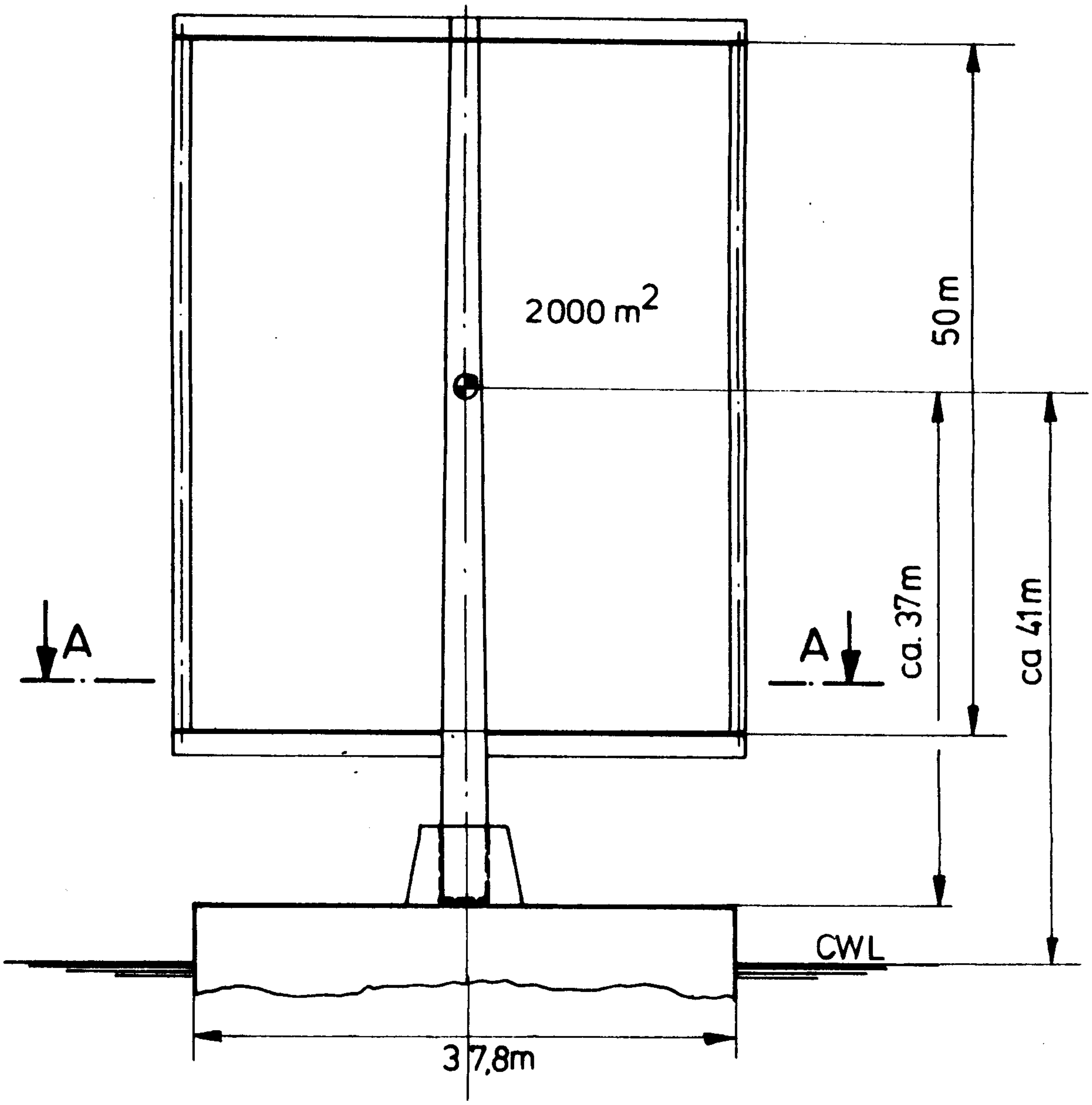

LOADING and
DISCHARGING
CAPABILITY
FREIGHT CAPACITY
TIME
AVERAGE
SPEED/h
SIZE OF SHIP
CONSTRUCTION
STABILITY
COURSE STABILITY
WIND SAIL AREA
OIL CONSUMPTION
ENGINE POWER
SAFETY
CREW

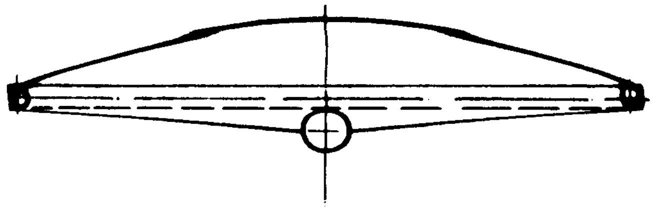
Rys. 2



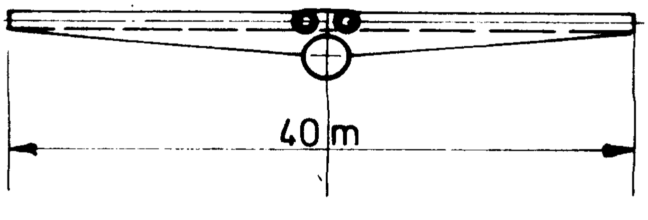
LOOKING FOREWARD



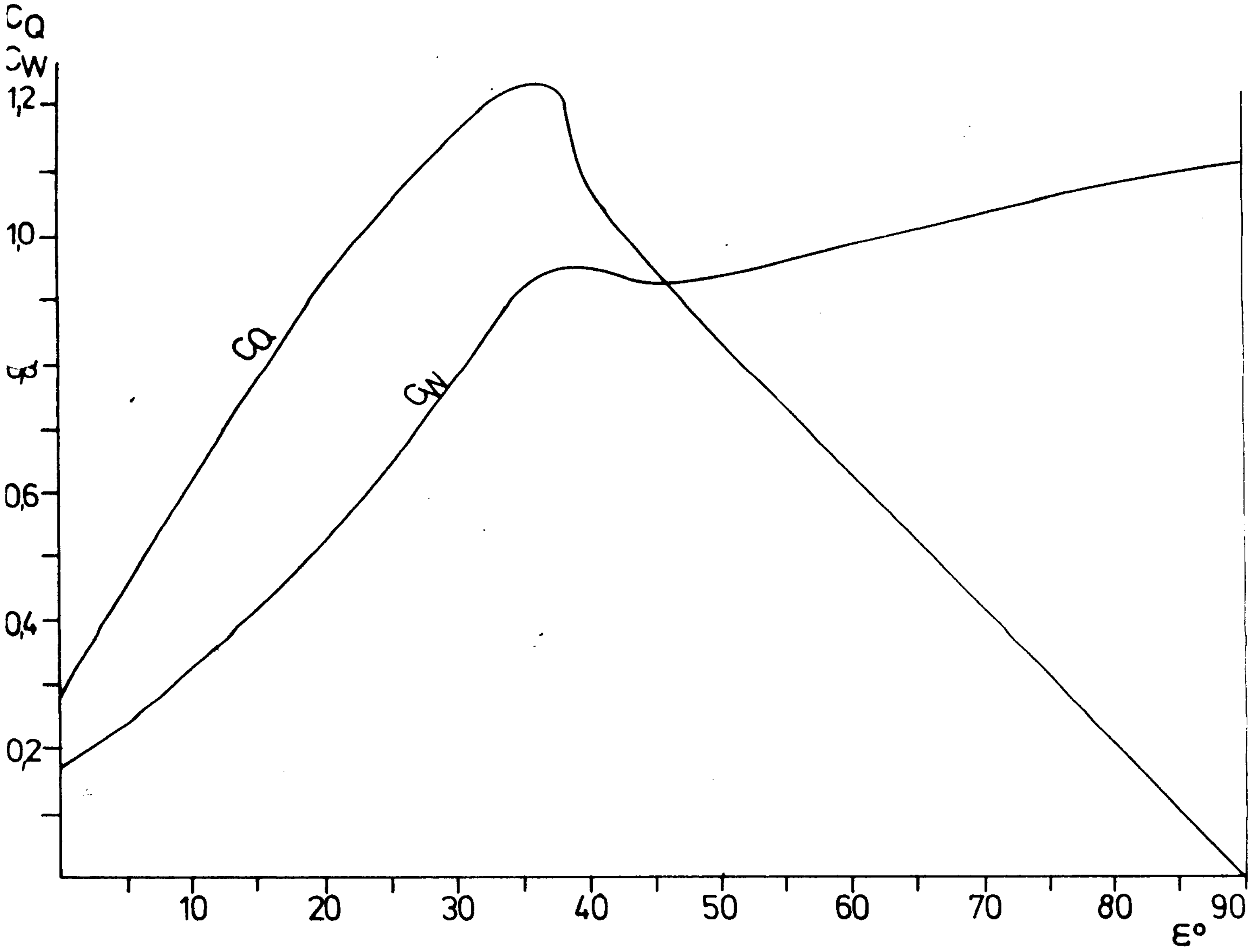
SECTION A - A

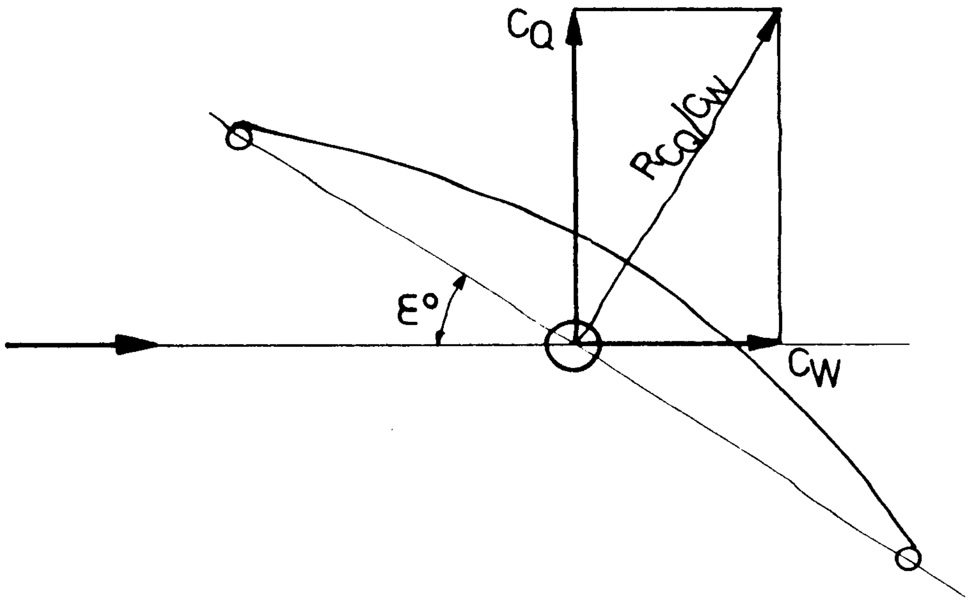


SECTION A - A SAIL IN ZERO POSITION



TRANSVERSAL FORCE COEFFICIENT C_Q AND RESISTANCE COEFFICIENT C_W IN RELATION TO ANGLE OF WIND ε





PROPULSION FROM AUXILIARY SAILS FOR VARIOUS SHIP- SPEEDS V_S AND VARIOUS WINDFORCES IN RELATION TO THE ANGLE OF WIND ε

EXAMPLE: SHIP v_S 12 kn → NECESS. ENG.PROP

WIND Bft. 8

Pos.	ε°	NECESS. ENG.PROP	S[kN] Wind
1	0-~50	1040	—
2	70	390	650
3	111-133	—	1040
4	170	230	810