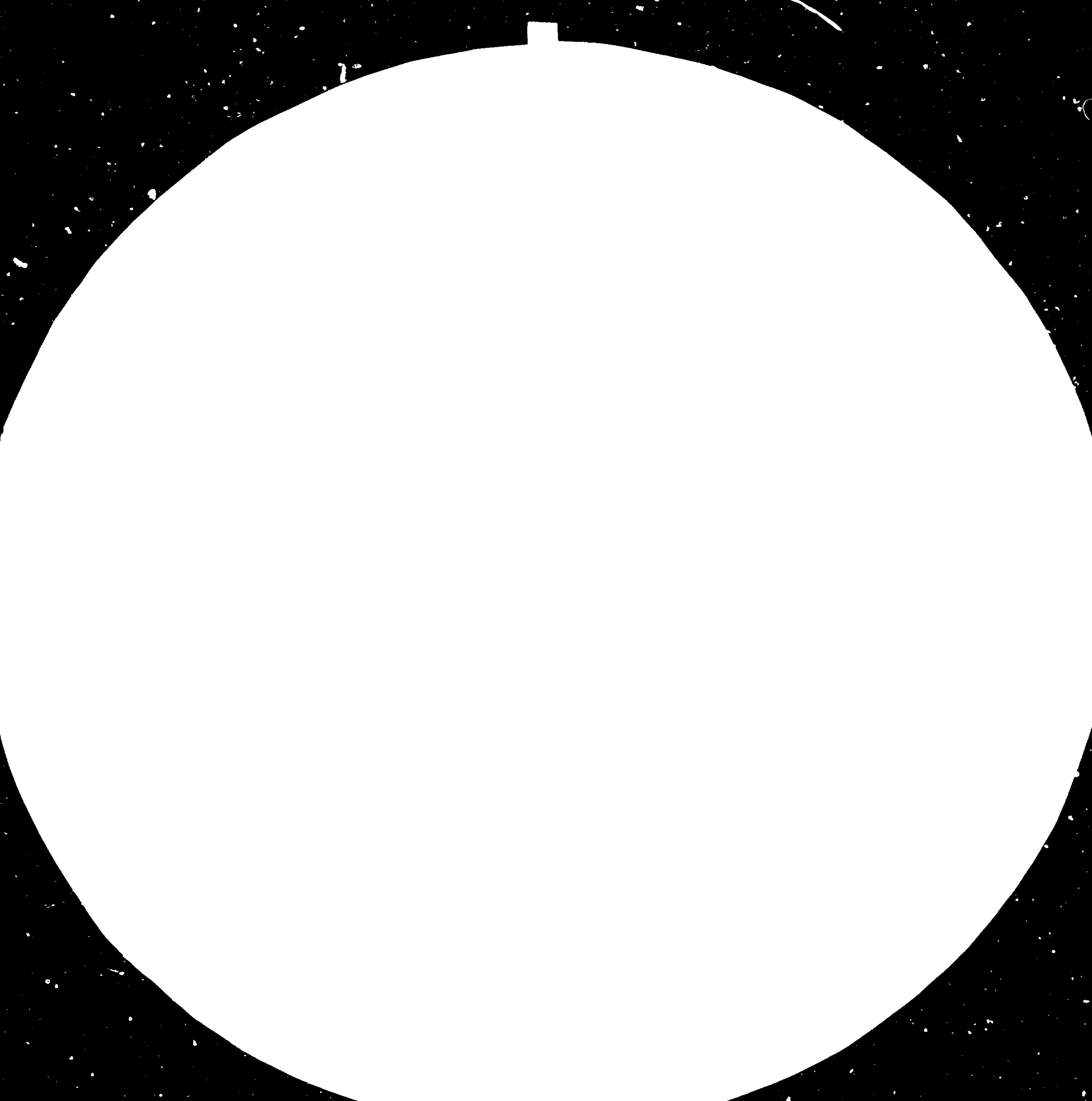
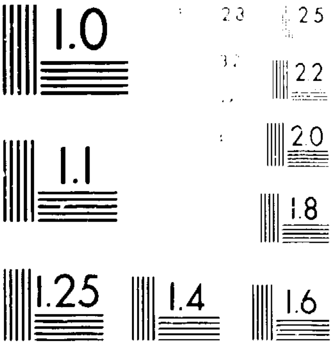
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

13268

Distr.
LIMITED

ID/WG.413/2
25 January 1984

ENGLISH

United Nations Industrial Development Organization

Expert Group Meeting on Shipbuilding and Shiprepair Development for Asian and the Pacific Countries

Jakarta, Indonesia, 26-31 March 1984

WIND-POWER VESSELS
FOR COASTAL AND INTER-ISLAND USE IN THE ESCAP REGION*

prepared by

ESCAP**

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** ESCAP Economic Affairs, Division for Shipping, Ports and Waterways.

V.84-80839

Contents

		Page
I.	Wind power in shipping	1
	- Introduction	1
	- The sailing ship	3
	- Speed performance	4
	- Sailing performance	5
	- Sail material	6
	- Sail handling	7
II.	An outline specification	10
	- Purpose of the outline specification	10
	- Class	10
	- Principal dimensions and specifications	11
	- Hull	12
	- Hatch covers/deck strength	12
	- Superstructure/accommodation	12
	- Machinery	12
	- Sails	13
III.	Low or medium technology shipyards	14
	- Level of technology required	14
	- How to simplify	15
	- Shipyard layout	16

Figures

1.	Basically square-rigged vessels	8
2.	Fore-and-aft rigged vessels	9
3.	Layout of small shipyard	18

I. WIND POWER IN SHIPPING

Introduction

While shipping was still in the process of adjusting to ever increasing demands for higher wages by maritime employees both afloat and ashore, which resulted in the introduction of various forms of automation on board and in new concepts of cargo handling and conveyance, a new wave of cost increases hit the industry, this time caused by the steep rise of bunker oil prices.

As again the cause of the cost escalation had political implications research which followed to deal with the situation was not aimed directly at finding ways and means of lowering the price of oil, but rather at focussing on reducing the dependency of the industry on oil. The urgency of this research was strengthened by the growing awareness that mineral oil, as a convenient energy source for the transport industry, was at the same time a depletable source and that conservation was required if existing supplies were to last longer.

This has prompted worldwide large-scale investigations into various forms of fuel conservation, including the increased use of wind as a direct or indirect propulsive force for vessels. As regards utilization of wind-power, two basic conceptual approaches can be identified, namely,

- the development of wind-assisted propulsion techniques for mechanically propelled units. These projects deal with modern propeller driven vessels, advanced hull designs, sophisticated equipment and applied computer techniques. Wind propulsion is auxiliary.

- the development of operationally reliable sailing craft for use in low-density trade routes. Here the point of departure mostly is the locally used/constructed sailing vessel which through application of modern materials and new technologies in construction, rigging and operation is developed into a relatively reliable low-cost inter-island vessel. Wind is the primary propulsive power.

In the case of the wind-assisted motor-vessel, it can be argued that achievements made do not make ship-operation any less dependent on mineral oil as the prime energy source. Successful wind-power application is predominantly a step forward in conservation of mineral oils, and equals in character those technical developments in engine design, hull design, propeller design, etc. which also result in decreased use of bunker oil. The economics of such conservation achievements to the shipowners are as yet unclear. While there is little doubt on benefits on macro-level, the relative distribution of costs and benefits over all parties concerned is still puzzling. The greater and the more widespread fuel efficiency in shipping is going to be, the more costly the vessels will become and the greater will be the downward pressure on the bunker oil component (BAF in liner shipping) of sea freight rates. And indeed not much percentage reduction in fuel consumption is needed to turn this component into a negative charge on present rates, biting into the freight earnings of ship operators.

As stated earlier, every achievement in fuel efficiency in shipping has contributed its share to a higher ship price. These extra investments, while not ignored, are invariably followed by a summary calculation on the time needed to earn them back. On the assumption that bunker prices would increase, freight rates/bunker components would not decrease, inflation and wage-scale developments would remain within proportionate limits of bunker prices, etc. The many imponderables are perhaps delaying the breakthrough which is needed, but whether market forces will be allowed to sort things out without government intervention is still an open question.

As regards the advanced sailing vessel, the trend seems to be to give local craft or newly developed craft a dependency on mineral oil, albeit to a small degree (5 to 20 per cent of propulsive power). In fact, the use of mechanical power is predominantly against a background of safety.

The economics of this type of achievements are perhaps less complex from a ship operation point of view but from a service point of view, it would mean subjecting a route service to the fortunes or misfortunes of wind with uncertain and substantially fluctuating sailing schedules sailed at lower speeds. There are few entrepreneurs, if any, interested in offering such a seemingly unattractive proposition, and yet, in the remote archipelagic area'a of developing nations, such operations could be an improvement, costwise and service wise, on the existing conditions as regards sea communications.

Extensive research on wind-power application for ship propulsion has been undertaken in West Germany, Japan, United Kingdom and U.S.A. and a number of prototype vessels have been constructed and are commercially operated, such as 1,600 dwt Shin Aitoku Maru, Japan, coastal tanker; two 3,000 dwt mini-bulkers, Seres Shipping, and some fishing craft. They are all wind-assisted motor vessels.

The purpose of this document is not to focus on that type of vessels, nor to place the economic aspects for discussion.

Rather it is the intention to invite ideas and discussions, proposals and programmes on the technical aspects of design, construction and yard requirements for advanced sailing vessels built with the highest possible local input, and taking into account where possible the features of the many local types and design now in use in Asia.

The sailing ship

Sailing ships were actually in regular commercial service since time immemorial until some 35 years ago, although the large majority of vessels disappeared from the oceans in the beginning of this century. So far, relatively little work has been initiated with regard to developing commercially attractive sailing vessels, although some particular large and innovative designs have in the last decade been presented. It should be fairly obvious that with the technology level achieved regarding hull forms, sail cloths, construction, construction material, etc. and with the understanding of meteorological phenomena and of wind as a driving power, in combination with the refined and highly developed navigating equipment presently available, vessels of various sizes should not only be technically feasible as sail-driven ships, but in addition, they should show a voyage performance superior to that recorded for the large and proud sailing vessels trading the oceans in the beginning of this century. It should be possible, based on well-proven practice of many centuries, to develop modern sail systems which should prove attractive economically. Beyond doubt the use of wind as a regenerating source of energy would benefit the environment and the world energy balance.

Commercial sailing ships constructed in the early decades of this century already took full advantage of technological developments, such as utilizing steel for the hulls and spares and they were even equipped with labour saving devices and auxiliary power for handling sails and gear. One of the best known ships of that period, the German fullrigger "Preussen", was built 1902. She carried 8,000 tons of cargo and had a sail area of some 5,700 m^2 divided among 53 sails on 5 masts. Despite this huge area the sails were safely and adequately handled by a crew of only 41 deckhands, using a hand-powered winch system.

Speed performance

The speed of sailing vessels is very often measured as a function of length, and the "Preussen" had a maximum theorotical full speed of some 22 knots. As she was superbly managed and sailed, the vessel proved over the years to have a maximum sustained sea-speed of 17 knots and an average voyage speed of 7.5 knots.

The lower sustained sea-speed of the vessels was of course in part due to wind and weather, but the major cause was heavy fouling of the underwater hull, as anti-fouling paints were in those days not yet so well developed. The importance of growth on the underwater hull is significantly higher for sailing vessels as total resistance is completely dominated by hull friction roughness of the underwater surface whereas for mechanically propelled vessels the combination with varying degrees of wave resistance is easing the effect of underwater hull fouling. With present technology on paints, where growth of barnacles on hulls practically is non-existent, the average voyage speed of a vessel like "Preussen" would be significantly higher and thus contribute positively to the economy of sailing ships. Still, whatever speed of sailing ships is considered, it is beyond doubt that the average speed will be below that of comparable motor ships.

Sailing performance

There are many ways of converting wind energy through sails into a marine propulsive force and consequently there are many variations on the two basic concepts in rigging, namely a ship is either "square-rigged" (sails abreast) or "fore-and-aft" rigged (in line with ship length).

Each rig has its own peculiarities, its own advantages and disadvantages, whereby a general observation can be made that a "fore-and-aft" rigged vessel is a better craft for close-hauled sailing, and she requires a smaller crew.

Modern aerodynamics have learned that the height-width ratio of a sail has a significant impact on its efficiency, which lead to the application of triangular sails, as on racing craft (Bermuda-rig). Indeed, the mini-bulker "Mini Lace" is equipped with a hydraulically operated boomless Bermuda sail, reporting fuel savings of 20-30 per cent, depending on routes sailed.

The angle to true wind or maximum windward speed is for a boomless fore-and-aft schooner rig down to 40-50 degrees, whereas the full-rigged "Preussen" had an angle as high as 70 degrees, and the Dynaship design, introduced in the latter part of the 1970's, does not have a better angle than 55-60 degrees. When motor-sailing the modern schooner rig is even more attractive, having a true wind-angle of almost 20-40 degrees.

Sailing ships do not have the advantage of being able to proceed in more or less a straight line from one place to the other unless going down wind and the windward ability, as has been previously described, depends very much on the sail arrangement. It is obvious therefore that route structures, prevailing dominant wind patterns, the need of vessel to beat tc windward (and how close), etc. require to be studied before decisions on rigging and auxiliary engine power can be taken. Different operational conditions and circumstances may dictate different rigging of a standard hull.

Sailing material

The development of sail cloth has been completely dominated by petro-chemical products. Sails are today made of cloth having a strength almost comparable to steel with a very small stretch and a very smooth surface, thus considerably enhancing sail efficiency. These sails are further virtually mildew-proof and retain their properties for years, minimizing the enormous maintenance and sail replacement programmes which the yester years sailing ships were confronted with. The great advantage of modern sail material coupled with knowledge from modern aerodynamics research and development have brought major advantages to sail and rigs.

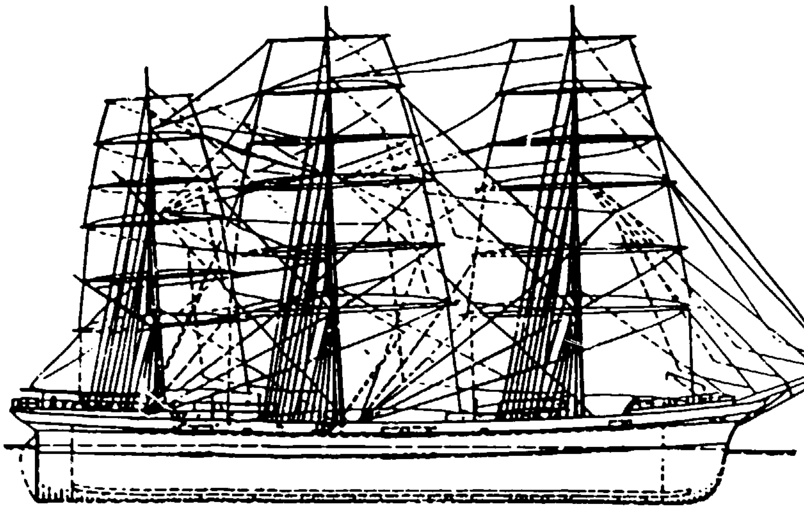
Sail hanlding

Another obvious and indeed very labour-saving device when handling the boomless rigging, is the extreme simplicity with which sails can be handled by the use of a luff roller furling system. The sails will be power furled and unfurled by hydraulic motors and there will be no moving spars such as booms, stay sail clubs, gaffs, yard arms, or spinnaker poles, and all sails will be controlled by their single clews. The importance of this very simple and space-saving system is obvious when planning a coastal transport with frequent port visits where it is of extreme importance to handle sails with a minimum of effort. Furthermore, all sheets would be handled by a constant/adjustable tension system which means that in case of sudden squalls, the rigging of the ship would not be damaged, but the sails would pay out until the sails were partially aluff and by using the boomless sail system there would be no crush against the rigging or other dangerous heavy swinging masses.

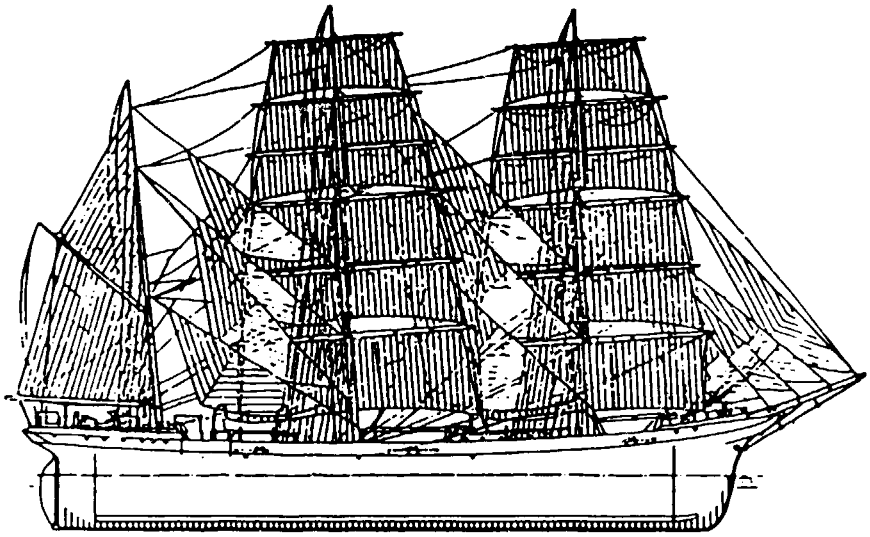
By the above method the sails will be quickly furled without having to manually release sheets. There would basically be no need to go aloft to handle sails, and all sails would be expected to go in and out of grooves by themselves or unattended.

The sails may be considered in two classes: light weather sails, and heavy weather sails capable of withstanding full-gales and hurricanes.

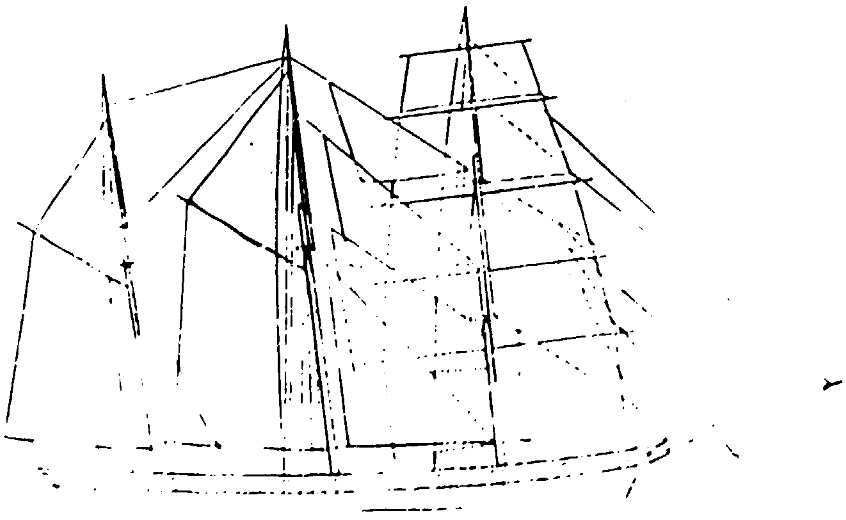
It is of course important that the sails are as quick to set as possible and designs should comply with given efficiency criteria, such as, for example, that the vessel should be under full sail with full crew in about 5-10 minutes, and that the reverse, going from full sail to a 100 per cent furl could be achieved in the same period of time.



full-rigged vessel

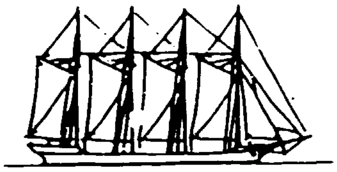


Bark

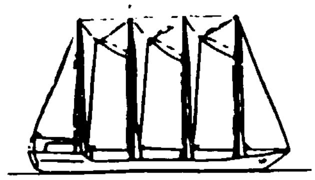


Barkentine

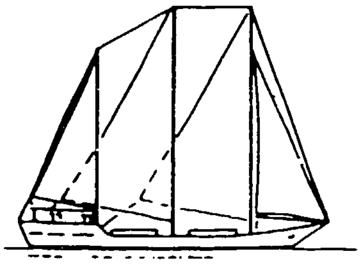
Figure 1   Basically square-rigged vessels



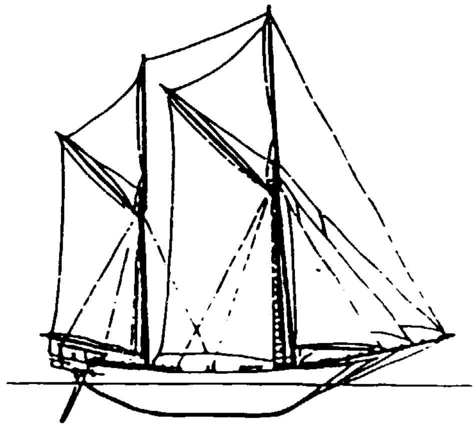
conventional schooner



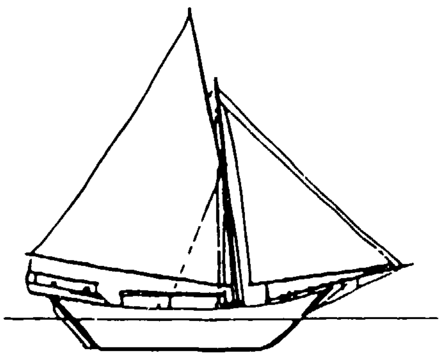
modern schooner



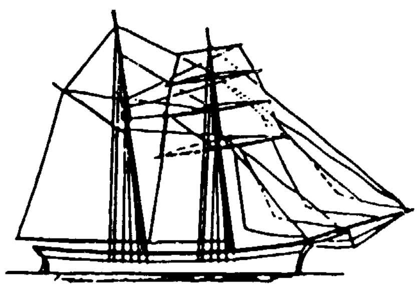
Bermuda rigged schooner



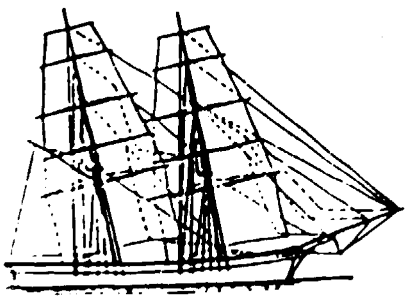
Makassar gaff-topsail schooner



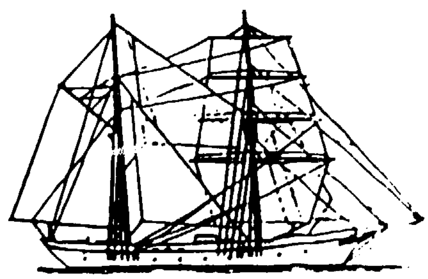
Buginese prao



topsail schooner



brig



schooner brig

Figure 2 Fore-and-aft rigged vessels

II. AN OUTLINE SPECIFICATION

Purpose of the outline specification

Under a number of the usual headings of an outline specification of a vessel, the various characteristics, standards, construction requirements, operational features, etc. are dealt with in a brief and summarized way. It is not the intention that this document describes a certain design, a preconceived vessel or a prototype project ship. Rather, discussion is invited on the various design points while this outline specification may serve to critically review local designs of Asian built sailing craft to identify where improvements are desired and possible and what suggestions can be submitted in this respect.

The ESCAP secretariat is preparing for an expert group meeting on the application of wind-power as a propulsive force in shipping and professional and experts views on the development of advanced sailing craft based on local designs and construction potentials are invited.

It is hoped that this present expert group meeting on shiprepair/maintenance and shipbuilding may serve as a catalyst for further activities and research at national levels, and subsequent submissions of results, findings or proposals to the Division for Shipping, Ports and Inland Waterways of the ESCAP secretariat at Bangkok, Thailand.

As stated earlier, the following headings are not related to a particular design or to a given size of vessel. This provides the opportunity to mention certain construction features, or operational capabilities which fit in a certain line of development approach, but could be totally out of place in other conceptual ideas.

Class

Safety of human life, of cargo and of the ship itself dictates that construction of sailing vessels, whether they be built of wood or of steel, should comply with class requirements of a recognized body. Such body could be one of the internationally accepted classification societies, but it could as well be a national private or public body, especially when only domestic operation of the craft is foreseen.

It is anticipated that many new rules will have to be developed by the classification organization regarding rigging and sails, and it is expected that for this part of the construction a sort of experimental certificate of limited time value prior to a final certificate may have to be issued. The vessel will have to abide by current international legislations with respect to safety at sea, SOLAS 1974, as well as pollution standards set forth and she has to abide by international safety regulations regarding crew, working of vessel in harbours, etc.

Principal dimensions and specifications

Length overall	..... m
Length between perp.	..... m
Breadth mld	..... m
Depth mld	..... m
Draught fully loaded	..... m
Corresponding dw	..... tonnes of 1,000 kgs
Cubic capacity (bale)	..... m^3
Number of hatches	.....
Machinery: single engine/propeller double engine/single propeller	..... BHP
Speed, under power only	..... knots
Bunker storage capacity	..... m^3
Fresh water storage capacity	..... m^3
Rig configuration	.....
Sail area	..... m^2
Theoretical sailing speed	..... knots

The rig will have to be particularly calculated as no fixed rules are supposed to be existing for each type or design. The materials and the construction to be developed jointly with the classification society. Material used to be either aluminium or steel.

Hull

The hull lines, whether the vessel is to be built of wood or steel, to be designed according to latest technological advancements, adjusted to suit less sophisticated local production capabilities.

Hull particulars may be influenced by number of continuous decks, provision of double bottom arrangements, whether the craft is to be beachable or not, flat or V-shaped bottom, provided with bowdoors/side doors, etc.

Hatch covers/deck strength

Dimensions of hatches to be determined bearing in mind efficiency in cargo handling and cargo transport mode to be served. Related to this is also the point-load strength requirement of loading decks and tank top.

To minimize crew strength and use of stevedoring labour easy to handle hatch covers (e.g. single pull type) are recommended.

Superstructure/accommodation

The bigger the vessel, the greater the need may be for superstructure to comprise navigating room, crew/passenger quarters, stores and control rooms, galley, etc.

Application of maintenance saving materials and constructions.

Machinery

Machinery for auxiliary propulsion could be so chosen and installed/fitted as to serve simultaneously, or predominantly, for electricity generation. Thus the application of cluthch and gear arrangement may be required.

Matters such as bridge control of engines, automation, power supply, pump, etc. to be decided.

Deck machinery such as cargo handling gear, windlass, sail servicing machinery to be determined. The use of low-pressure hydraulic equipment may be considered for these purposes.

Sails

Sail material to be developed closely with a well reputed sail manufacturer. The latest techniques developed for the fabrication of sail cloth is to be investigated as well as the possibilities of producing such cloth locally or regionally should substantial demand be foreseen.

III. LOW OR MEDIUM TECHNOLOGY SHIPYARDS

Level of technology required

It is obvious that a low-skilled technology shipyard for building sailing vessels can be established/developed without heavy reliance on technology and manpower recruited from the traditional shipbuilding enterprises abroad. But it may be necessary that designs and special machinery and equipment are imported and expert advice obtained.

Advanced sailing vessels resulting from studies and research may be basically the same craft which have been built and used locally for centuries, but with applied improvements to make them more reliable, more efficient, safer in use. In such cases chances are that local building yards need to be developed and trained to incorporate the improvements in the new constructions, because research basically kept the vessel within the routine and potentials of local boat builders.

The situation changes when study and design research result in a basically different craft which may need other construction materials and techniques, or dictate substantially larger craft and vessels as the solution to low-cost sea communications. In such cases, the low-skilled technology yard may not prove capable to properly construct a vessel of advanced type or size and medium level technology has to be introduced, perhaps necessitating the establishment of a new small yard.

While therefore the level of technology required in actual construction of the vessel may be low or medium, research on the type of vessel, on operational performance and on design specifications and drawings, including the adjustments to acceptably lower levels available in the construction stage, should be carried out with all sophistication and advanced technology at present available.

High technology therefore is used in the study and design stage and to determine how the result is to be implemented in a medium or low-skilled technology industry.

Even so, with the shipbuilding industry basically being an assembling industry, there is ample scope to have component parts manufactured elsewhere for subsequent assembling of the yard.

How to simplify

Recognizing that there is no comprehensive answer to this question, and that imagination and innovation usually determine the successful entrepreneur, some ideas are nevertheless submitted for consideration.

The fine hull lines of a sailing vessel, when to be constructed on a low-technology yard should be transformed into a single bent plate (two-chine) construction. It is said that this will not impair too much on the flowlines and handling characteristics of the vessel. When section building is utilized whilst working with less experienced welders, good working conditions are to be ensured allowing proper supervision.

Careful planning of section building allows that additional equipment such as pipes, fittings, etc. may be put into each structure prior to its assembly on the berth.

With only auxiliary machinery to be installed and therefore dealing with a relatively easy engine room layout and fitting, a sailing vessel would seem to lend itself fairly well for low-technology hull construction. Engine room components will be few and probably can be arranged into package units to be installed. Package units may moreover be self-sustaining to a great extent, eliminating the need for separate fitting of pumps, pipings, controls, etc. thereby easing installation procedures.

Superstructures are expected to be fairly simplified structures. The original design may be developed as the local environmental conditions and the trading area allows.

Navigating equipment, deck machinery, etc. will have to be installed as units purchased.

Sails and rigging, masts, stays, etc. will have to be purchased from specialized manufacturers. These items have to be well and precisely engineered products as the whole efficiency of the sailing vessels relies on high quality production and fitting, and at this stage expert advice may be needed for some time.

Low-cost shipyard development will mean building a ship on a traditional berth, launching her in a traditional manner and completing the building of the vessel along the fitting-out berth.

Shipyard layout

The following shipyard layout is intended as an example for a yard where the basic philosophy is utilization of low-technology, but a modern system of steel handling machinery and a modern machine shop, as well as a sail loft are also foreseen. As shown on figure 3, the area considered is relatively small, but considered enough for the purpose of building ships up to 100 metres length with the required auxiliary services. The steel production system is based on direct development line principle by means of overhead cranes taking the steel from the plate profile stockyard directly into the covered building shed where marking of plates, cutting by oxygen acetylene burners will take place prior to welding of plates and profiles into sections. For this purpose, two overhead cranes are foreseen, one of 10 tons capacity and the other for the final assembly section of the building shed of 15 tons capacity. The building shed is supposed to be roofed and built up of a steel basic structure with low maintenance walls and roof and with sides open towards the berth and partly open towards the fitting-out quay.

Adjacent and perpendicular to the building shed is the out-fitting shop (machinery shop, pipe shop, electrical shop as well as sail-loft). The equipment required in the machine shop and pipe shop is small in number and is basically related to pipe work, welding of flanges, installing of valves, etc. as well as small machinery for doing various machine shop work. The electrical jobs required are intended to be few but have to be undertaken by the shipyard and likewise all installation of instruments and electrical fittings, whether being a radar set or illumination of accommodation and decks.

The sail-loft will have a minor function if the sails are ordered ready-made but in course of times it must be anticipated that the sail-making technology will be transformed to the shipyard.

The out-fitting shop will also include the rigging shop. The amount of rigging required when compared to an oil-burning vessel is immense but in relation to the sailing vessels known by the turn of the century it has been drastically reduced, due to new principles of supporting the masts. It is necessary that the equipment installed for undertaking these jobs must be first class and it is anticipated that well-qualified supervisors are utilized extensively for these jobs.

The shipyard shown is of a very simple layout, having a fitting-out quay perpendicular to the building berth. For obvious reasons a very tall light-weight crane movable along the fitting-out quay must be used for the erection of the rig. The components to be fitted in the fitting-out process will be of minor weight and the structure of the movable crane can consequently be fairly light.

The number of engineers and draftsmen will be small if it is the intention to purchase complete sets of the calculations and drawings required for the construction of a sailing vessel. There will, however, always be a fair number of adjustments to be made during the construction period, which will require the availability of design engineering and drawing expertise.

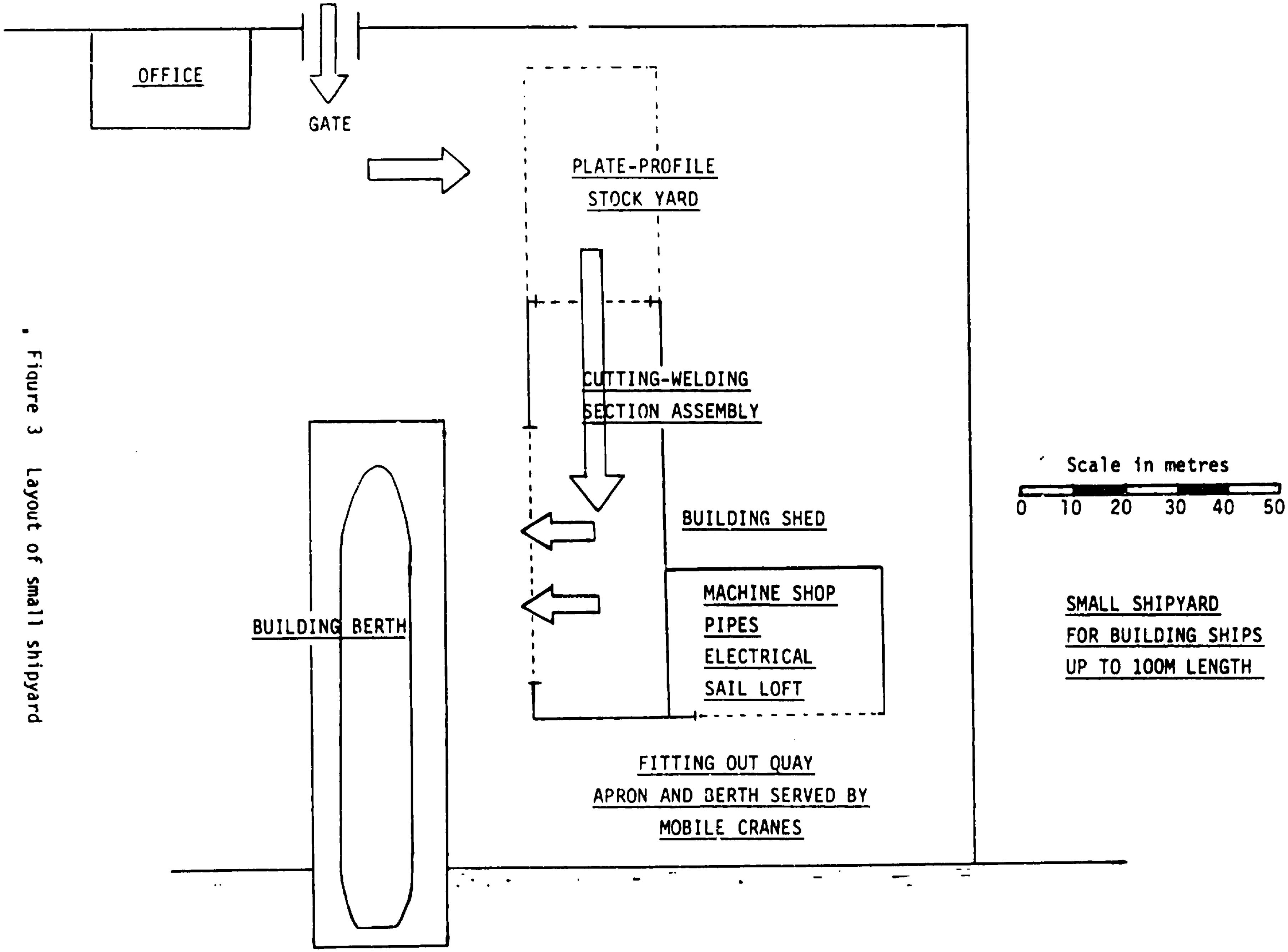


Figure 3 Layout of small shipyard