A MODERN PRACTICAL SEAMAN'S VIEWS ON COMMERCIAL SAIL

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ABSTRACT AND INTRODUCTION

Firstly, in Part I it is intended to consider and compare the rigs that may be used on fishing boats and possible means by which fishing boat performance may be increased, and in Part II, rigs for what are defined as fishing ships will be considered. Finally, it is proposed to look briefly at the rigs under serious consideration for larger commercial vessels such as ocean going passenger cruise liners and cargo ships. The effort going into this field may encourage fishermen to consider sail more seriously as an alternative source of motive power for their craft and stimulate some discussion at this meeting.

GENERAL

All forms of commercial sail have been much considered and talked about over the last ten years and various symposiums have been organised, doubtless encouraged by the rapid rise in fossil fuel costs in that period.

It has been said that if it could be harnessed, the hot air generated at these symposiums would drive a fleet of supertankers from Europe to the Persian Gulf and back again. Sadly, however, there has been more talk and more papers read than actual full scale experiments carried out.

We are considering here "Commercial Fishing Vessels", and it is contended that these need to be divided into two classes. Where to divide them is a problem. Straight length or tonnage is bound to be arbitrary and produce anomalies, and so it is proposed to use the definitive point used to explain to landsmen the difference between a ship and a boat in that dim and distant past when the writer was a boy. It was said then: "A ship is a vessel which can carry a boat in davits".

Generally speaking, by this definition it follows that a ship is usually a vessel able to accommodate her crew on board for a voyage lasting several days. In measurement terms, a boat by the above definitions will seldom exceed 35 ft. (10.67 m.) in length, and any sails fitted can be relatively simple and unsophisticated, but on the other hand, the sails found on many small craft in under-developed countries can be much improved at small cost and as a result, greatly increase the practical and financial viability of many fishing communities.

Care has to be taken with regard to the improvements proposed, and it is
contended that they must be inexpensive and hard wearing, virtually unbreakable and easily repairable with local materials. There used to be a saying in Africa amongst the farmers when referring to their unskilled labour force: "Give them the job and they will finish the tools", (with apologies to Winston Churchill). It is worth bearing in mind.

Some twenty years ago in Jamaica there was a grand Government scheme to make loans to fishermen to buy outboard motors for their fishing canoes. It was pointed out that this would enable fishermen to reach their fishing grounds more quickly each day, spend longer fishing and return more quickly before dark. It did not work that way. Once in possession of the motors, the fishermen stayed in bed longer, speeded out to the fishing grounds, fished for the same time as before and sped back. Then they found that petrol had to be paid for, repairs were costly and the loan still had to be repaid from the same income as before. This is obviously the sort of situation which needs to be avoided.

PART I

RIGS FOR FISHING BOATS

In this section as defined above, we are considering craft up to around 35 ft. (10.67 m.).

It goes without saying that all forms of square rig are unsuitable and, except possibly at the top end of the scale, only single masted rigs are worth considering. These are listed below with comments.

BERMUDAN SLOOP

An efficient sailing rig, but requiring a tall mast for optimum efficiency, it is only considered at all suitable for smaller craft where its disadvantages even then will tend to militate against it. Roller furling increases its handiness but also its expense and vulnerability.

GUNTER RIG

The gunter and sliding gunter rigs give almost the same result as the bermudan sail with the advantage of not having to have such a tall mast. It is still a somewhat "yachty" rig and not really recommended for a working boat, except in special circumstances.

DIPPING LUC & LATEEN RIG

These two rigs are extremely close to each other in practice, although their origins are different. Since they can be set on a short simple mast and have a minimum of working gear, they are highly recommended. As a working rig they are efficient to windward and easy to operate. Spars can be made from local material and rigging from readily available stocks. Lateen rig has been very popular for 2,000 years in the Mediterranean.

STANDING LUC

Generally this rig requires a headsail of some sort in addition to it-
self, and also needs a slightly taller mast. It would appear to have no advantage over the dipping lug or lateen.

**SPRITSAIL**

A very early form of fore and aft rig which has found favour in many countries. In a highly developed form it was to be found until very recently in the 100 ton working cargo barges of the River Thames in England and was also found in the Baltic and is frequently seen in fishing canoes in the West Indies.

It particularly lends itself to that type of rectangular sail popular in many under-developed countries where the area is not measured in square feet or square metres but in flour bags, since these are the source material for local sailmaking.

**JUNK RIG**

This rig in two or three mast versions (depending on the size of the craft) is one that is extremely popular with its devotees. Its main disadvantage would appear to be the expertise required in sailmaking. Doubtless this is easily found anywhere between Singapore and Japan, but a considerable education programme would be required to provide the sails (and the crews to handle them) in other parts of the world. It is highly recommended within these limitations and also with the thought that it will not always be easy to install the strong unstayed masts in craft which were not originally conceived to take them.

**LJUNGSTROM RIG**

This is so efficient as a sail plan, both to windward and downwind (when the double sail is gooswung), that it is felt that some effort could be put into mass producing those parts which are relatively difficult to make in unsophisticated communities.

The ease with which sail can be shortened or furled entirely has to be experienced to be believed, and when furled, the sail is entirely clear of any working area. (Fig. 1).

The main requirements for manufacture are the mast heel fitting and the relatively friction-free deck fitting. Well made masts would be a further advantage, but locally made ones should be adequate.

It is thought that a package could be put together containing a mast thwart (with bearing) of adjustable length having a leeboard or a fitting for a leeboard at either end plus the heel fitting with a mast and sail as optional extras.

The combination of an aerodynamically efficient sail which is ridiculously easy to furl or reef, plus the addition of leeboards, could dramatically increase the performance of the dugout canoe and similar craft which are to be found in many under-developed countries.
OTHER RIGS, DEVICES AND MODIFICATIONS

There are, of course, many more modern sophisticated devices - wingsails, rotors, kites and the like and modifications to the main theme such as bipod masts and wishbone spars, but the view has been taken in this paper that such refinements would be either uneconomic or too tiresomely sophisticated for fitting in small fishing boats in general.

(In any case, none have yet been encountered by the author with any overall advantages over the Ljungstrom rig which was invented in the nineteen thirties).

Doubtless that was the view taken by old salts like me when the idea of putting engines of any sort into fishing boats was first suggested, however, one must remember that fishing boats - even sailing craft up to 100 tons and more - were still being built without engines over a hundred years after the first mechanical driven vessels first frightened the horses on the canal banks.

ENCOURAGING THE USE OF SAIL

The small boat fisherman in an under-developed country is not interested in the niceties of sail. To most, its adoption is a retrograde step or a sign of poverty and even stupidity. He wants a simple and reasonably efficient method of propelling his craft and he will frequently need considerable convincing that sail has any value, whatsoever. Some who use primitive sail will see no virtue in improving its performance.

Within the last few years, when many deep sea fishing vessels could not sell their catch for sufficient money to pay for the fuel used during the voyage, the Technical Director of the State owned authority responsible would not even discuss the possibility of using auxiliary sail, but dismissed it as "an absolutely useless idea".

Sixty years ago when sailing fishing boats of all sizes were still common, there used to be an annual race and considerable honour went to the winner. The race encouraged owners and skippers to improve their boat's sailing performance and even to express an interest in speed under sail when building new craft.

The famous Brixham trawlers raced well into the 1930's and the annual race between American and Canadian Grand Banks fishing schooners had a great effect on the design and rig of these vessels in both countries. Even those craft not seriously interested in becoming "Cock of the Fleet" nevertheless followed the successful trends of their faster sisters.

Perhaps some establishment of local competitions for performance under sail could be attempted if only to demonstrate the very considerable difference in time taken over even a relatively short distance between one sailing craft and another. If the prizes were sufficiently substantial, the effort to improve the speed of many fishing craft would be substantial, and if it was possible to encourage international or inter-area competition, then imitation of the winner would result in general improvements to rig and hull designs with consequent overall benefit.
CONCLUSION ON RIGS FOR FISHING BOATS AS DEFINED

It is contended that where it is practical or possible to fit it, the Ljungstrom rig will give the best all round performance coupled with the greatest ease of handling.

Sailing, reefing and furling can be carried out by the helmsman in minimal time without any aid from other crew members in all craft up to 35 ft. (10.67 m.) in length (and even beyond) which covers all craft in the category under discussion.

The rig also offers the minimum of interference to the main activity of the boat - fishing.

Some cost will be involved in fitting the gear initially, but it is contended that this would be less than the cost of an outboard engine, and its running cost and repairs would be somewhat less.

Goosewinging the sail before the wind overcomes the natural shortcoming of fore and aft sail when running by doubling the sail area spread.

Second choice would be the dipping lug which has a slight advantage over the true lateen since reefing can be arranged more easily.

Of the other rigs, the spritsail, when modernised a trifle (as has been done by Mr. Gifford), is probably the best, with the remainder only finding favour amongst their own particular devotees.

IMPROVEMENTS OTHER THAN IN RIG

As has been indicated in the "Ljungstrom package" referred to above, improvement in sail performance to windward can also be achieved by the addition of leeboards, centre-boards and dagger plates. Improvements in stability of narrow craft can be achieved with outriggers or the encouragement of catamaran or trimaran hulls, and these latter have the advantage of increasing deck working space for fishing.

For very small canoe type craft, a form of sliding seat to enable the crew to "sit the boat out" and act as moveable ballast will increase the sail carrying power of the craft and thus her speed.

Ultra-violet light has a very deleterious effect on most types of cloth (including dacron), but there is now a sprayed on material which - it is claimed - much reduces this effect. If such material, and the equipment to apply it, can be made available at a nominal cost, the life of sails may be considerably extended. Fishermens cooperatives or Government departments responsible might buy the material in bulk and loan or hire the spraying equipment as required.

ENGINE REQUIREMENT

Where an engine is considered a necessary part of the boat's equipment, it need only be of very small size to enable a moderate speed to be achieved in flat calm and entrance and exit from harbours to be executed with ease. By the same token, fuel capacity need only be enough
for the above requirements

PART II

RIGS FOR FISHING SHIPS

This heading seems rather self-important, but we use the word "ships" as defined above, and thus consider all vessels above 35 ft. (10.67 m.) in length. Apart from fish factory and mother ships, the upper region for vessels under consideration will probably be around 120 ft. (36.58 m.). Those interested in sailing rigs for vessels over 120 ft. (36.58 m.) in length will be interested in Part III of this paper, where current ideas for sailing rigs on commercial passenger and cargo ships up to 400 ft. (121.92) will be discussed.

Let us now view the possibilities:

SQUARE RIG

(a) Ship, Barque and Barquentine

Since we are taking our upper limit as 120 ft. (36.58 m.) on deck, these three rigs are really out of court, although at the top end of this bracket we are nearing the point where they might be considered, and they will be discussed in Part III.

(b) Brig and Brigantine

For general handling under sail, no argument is put forward for either of these rigs for installation in fishing craft. Historically there is little trace of them being used for fishing except in the whaling trade and among the trans-Atlantic Grand Banks vessels where even ship rig was occasionally found. If any fishing operation called for a vessel to heave-to and remain virtually stationary, then square rig would have some merit.

TOPSAIL SCHONER

Although not technically a square rigger since only a square topsail is set, the same lack of argument in favour of this rig applies as for square rig. Traditionally the French Grand Banks Fishermen were two-masted gaff topsail schooners with the deep topsail fitted on a double yard, the lower one of which acted like a roller blind to roll up the square topsail for either reefing or furling.

The existing pair of sail training ships attached to the French Naval Academy at Brest are perfect examples of this rig, but again, no supporting argument is offered for this rig for fishing craft. (The square topsail and a "drabbrler" set below it may well have been useful on passage to and from the Banks.)
TWO AND THREE MASTED SCHOONER

Up to about 100 ft. (30.48 m.) two masts are suitable, but above this three masts become gradually more necessary. The detailed rig on each mast can vary with the choice of bermudan, gaff and staysail rig. Some sails can be fitted these days with "off the shelf" roller furling and reefing gear which makes for easy handling.

Taking all in all and seeking a reasonable compromise between windward and downwind performance, coupled with simple handling, the rig prescribed for the MİCASS (Mini Container Auxiliary Sailing Ship) is recommended. (Fig. 2).

The area is 5,000 sq. ft. (465 sq.m.) which according to formula * will provide 200 BHP in wind force Beaufort 5 (not contrary), and this is the same as the output from the two diesel engines driving the twin screws. Under these conditions and with stronger fair winds, the vessel can rely on sail alone, while at lower wind speeds (or if the wind is contrary), one or both engines may be used as required. To compensate in part for the poor performance of fore and aft sail with the wind right aft, a second roller headail is provided which may then be goosewing (set on the opposite side) to increase the downwind sail area. A simple form of spinnaker boom may be used to improve the spread.

It can be seen that the rig leaves the decks well clear for fishing work and at the smaller end of the size scale, the middle mast could be dispersed with entirely.

Roller furling and reefing gear, both hand-operated and power driven, is readily available depending upon the degree of sophistication required, and by making all the staysails identical in size, the provision of a spare is simplified.

As stated above, the ability in this size of vessel to provide a usable horse power from sail alone equal to that designed to be provided by the engines promises a very considerable fuel saving in general service, depending finally on the weather encountered and the attitude of the skipper. Conservatively it is predicted that fuel costs can be cut by half, but this will depend to some extent on the type of fishing being undertaken.

It is worth noting that the recent Brittany Sailing Tunny Fisherman project produced vessels very similar to the MİCASS in rig and deck layout but appreciably smaller. They were expecting very large fuel savings, but to date the reports after actual service at sea have not been seen.

OTHER FORE AND AFT RIGS

At the smaller end of this range, bermudan ketch and Ljungstrom rig are possible contenders, and claims have been made for the potential use of the latter in large vessels, but no actual examples of this rig in vessels over 40 ft. (12.19 m.) have actually been sighted. Junk rig is to

* 5,000 sq. ft. (465 sq.m.) of sail = 200 horse power in Beaufort 5 not contrary, generally assumed to mean 100 horse power on average.
be found in the Far East in vessels of 100 ft. (30.48 m.) and more, and the only objections would seem to be those expressed in Part I. It would certainly be interesting to see two similar vessels - one junk rigged and one rigged as the M/CASS - so that their initial cost, running cost and overall practical efficiency could be directly compared on an operational basis. It would be surprising if, today, the junk rig would show any substantial overall advantage, although it can be readily seen that before the advent of easily obtainable roller furling gear, the junk rig had some distinct benefits. After all, it has had a couple of thousand years to develop and be refined.

INFLUENCE OF FUEL PRICES ON USE OF WIND POWER

Every time that the price of fossil fuel takes a violent leap upwards, attention is focused on harnessing the wind power which is so frequently referred to as being "FREE". Yes it is free, but sadly it is not constant either in strength or direction, and the means of harnessing it are by no means free and generally require more manpower to produce a quantity of horsepower than an internal combustion engine. In these days of unemployment, this could be a further benefit, but employers do not always take that view.

At the moment we are seeing a slight fall in the price of crude oil (which is likely to be only temporary), but a glance at the spot price of gas oil over the last ten years shows the continuous rise in price overall with two sudden leaps upwards in 1974 and 1979. These prices were actually taken at Southampton, England on the first of June, and the assistance of the Esso Petroleum Company, London is gratefully acknowledged.

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<th>Year</th>
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<td>$39.12 per tonne</td>
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<tr>
<td>&quot; 1972</td>
<td>$40.44 &quot;</td>
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<tr>
<td>&quot; 1973</td>
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<td>&quot; 1978</td>
<td>$136.40 &quot;</td>
</tr>
<tr>
<td>&quot; 1979</td>
<td>$390.00 &quot; (increase of roughly 200% from previous year).</td>
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<tr>
<td>&quot; 1980</td>
<td>$334.00 &quot;</td>
</tr>
<tr>
<td>&quot; 1981</td>
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<td>&quot; 1982</td>
<td>$310.00 &quot;</td>
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<tr>
<td>Feb. 1983</td>
<td>$295.00 &quot;</td>
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All prices are in U.S. Dollars per tonne, free of any tax, duty or delivery charge. Note that between 1971 and 1979 the price increased ten fold.

Sadly for the proponents of the use of wind power, the present pause in the rise of crude oil prices (and in fact the slight fall in prices of crude and refined oil) is used as an excuse for an outbreak of Micawberism amongst ship owners and operators. They appear to work on the politicians' motto - "Don't do anything unless you are forced into it".
On the contrary, it is contended that all fossil fuels are bound to rise in price—in real terms regardless of inflation—as the more easily recoverable deposits are worked out and it becomes necessary to extend operations to sources more difficult and more expensive to service.

To expend money now to research the alternative possibilities seems to be an imaginative and intelligent step on the same basis that some large and successful businesses automatically increase the budget for research following a year where profits drop.

**FORECASTING THE BENEFITS OF SAIL POWER**

About two hundred years ago when steam engines first made their—tosome—unwelcome appearance on this planet, the engine makers had to devise a means of demonstrating to potential customers the benefits of purchasing and installing one of their infernal machines. They chose a method of comparing the work output of their contrivances with the major source of easily measurable power then available and understood. They called it "a horse power" and the term was in due course extended to cover mobile steam engines, and when in turn they were challenged by the internal combustion engine and the electric motor, ways of measuring the comparative output of these newcomers were devised, accepted and understood—more or less—by one and all.

No doubt if we still depended on water or wind power to grind corn and pump water, ways would have been found to describe in horse power the output of windmills and water wheels, but there has never been sufficient demand. (Perhaps it has been done in Holland).

Now some of us are advocating the use of wind power on fishing and commercial vessels—not for romantic reasons, but to lower the operating costs and increase the financial viability of these vessels, even to reduce the installed engine power.

Put yourself in the position of a shipowner considering building a new vessel and the question of her power unit. From previous experience and from qualified technical advice, he can discover the amount of power required for his projected vessel and then it is a simple task to draw up a table showing the various alternatives open to him. Manufacturers' brochures and available reference books will tell him the horse power, weight, size, fuel consumption, revolutions per minute and initial cost of all engines available. Coupled with opinions (his own and others) on the reliability and spares availability factors, he can make his choice.

If, perhaps, he is sufficiently imaginative and intelligent to consider fitting the vessel with equipment to harness the wind power, what similar information can he obtain?

Frankly very little. If his Naval Architect proposes some plan he may be able to get an estimate of cost and weight and, of course, fuel consumption is nil, but it is more difficult to obtain accurate information on the amount of man hours which will have to be applied, and sadly neither his own experience nor the Naval Architect's is likely to be of help. Worst of all, he can get no information on the practical horse power the equipment is even expected to provide, which usually results
in his discarding the idea entirely. After all, who would spend
several thousand dollars on an engine without knowing its horse power,
let alone the other statistics?

There is, however, a simple rule-of-thumb formula to which reference has
been made above, and it reads:-

5,000 sq. ft. (465 sq.m.) of sail in wind force Beaufort 5 (not contrary)
= 200 horse power.

It has to be accepted that the wind will be contrary some of the time,
and that at other times the wind will be less than force 5. To balance
this it may be greater than force 5 at times, but sadly if it becomes
too strong, it will be necessary to reduce the sail area spread on
safety grounds and to prevent excessive heeling, but in this state a
greater horse power than 200 will be generated.

On a moderate further rule-of-thumb basis, it is conservatively estimat-
ed that the 5,000 sq. ft. (465 sq.m.) of sail will produce 100 horse
power on average throughout an operating period of twelve months with
the variation in wind strengths and directions that the seasons and
voyages will provide.

Whether highly accurate or not, this does give a yardstick on which to
work and a reasonable means of forecasting the benefits likely to be ob-
tained.

We have already quoted the MECASS design where the engine power is rated
at 200 BHP and the sail area happens to be 5,000 sq. ft. (465 sq.m.) odd.
On this basis we can reasonably expect to effect a saving of 50% on fuel
costs over a twelve month operation. In fact, the saving should be
greater than this, for although the engines are rated at 100 BHP each,
they will, in fact, be developing less than this at cruising speeds.

The main advantage of this formula is that it provides a ready means of
forecasting the sort of power that a designed sail plan will produce and
enable a reasonable financial judgement to be made on whether to fit it
or not.

There has been a case recently where a tanker company has decided to fit
a sophisticated wing sail which has an area of 2,000 odd sq. ft. (186 m²)
and which - it is claimed - is twice as efficient as conventional sail.
Applying the inventor's claim of double efficiency, this device is still
only going to produce 80 horse power on average through the year, and is
going to cost over five times as much as a conventional sail plan of
4,000 sq. ft. (372 sq.m.) which will produce the same power from the
wind.

Furthermore, by relating the sail produced horse power to the engine
produced horse power, and knowing the engines daily fuel consumption,
coupled with her expected hours at sea in the year, the possible fuel
saving in tonnes - and hence dollars - can be calculated with more chance
of being correct than by previous guesses which were often wildly optim-
istic.
Some small effort with a ruler and pencil on general arrangement plans of various sized vessels will soon bring one to the conclusion that it is relatively easy to fit sufficient sail area of simple form to a vessel up to 100/120 ft. (30.48/36.58 m.) long to provide all the horse power required in force 5 and above.

Try again on a cargo ship of 2,000 tons and you will be able to provide enough horse power from sail to save ten per cent of her fuel.

Then try putting your sails on a 100,000 ton tanker and compare the theoretical sail horse power produced with the ship's engine power, and you will be very disappointed indeed unless you can fit masts of several hundred feet in length (solving all the engineering problems let alone meeting the cost), not to mention allowing for a method of passing under important and well known bridges.

Scaling up is therefore a serious problem and will be referred to again later.

RETRO-FITTING AUXILIARY SAIL TO EXISTING VESSELS

Due to the fact that today motor cruisers are of an entirely different hull design - both underwater and above deck - to sailing yachts, the belief has grown up in certain circles that sail cannot be retro-fitted to a vessel designed to be power driven.

Obviously care must be taken with stability and some results will be more effective than others, but generally speaking, retro-fitting is perfectly practical and again, generally speaking, the larger the craft the more so, (as far as hull design goes) up to say a length of 300 ft. (91 m.) when the scaling up problem referred to above begins to be encountered.

If the hull design of a sailing cargo carrier and a steam cargo ship of the 1920's (when the last sailing cargo carriers were built) are compared, there is indeed very little difference, while in the Mediterranean today, motor fishing and small cargo vessels are still built to designs used for a hundred years and more.

Possibly sailing performance might be improved by designing a hull for the purpose, but when talking of sail assisted commercial vessels rather than pure sailing vessels, retro-fitting of sails to hulls designed for power is generally perfectly practical.

Be encouraged by the fact that two of the most successful sailing cargo carriers in the last century started life as steam ships and ended their careers without engines as highly efficient sailing cargo ships. They were GREAT BRITAIN (now being restored at Bristol, England) and LANCING, long since broken up.

Incidentally, while GREAT BRITAIN still had her boilers and steam engines and a full spread of sail, she averaged 9.3 knots over twenty-seven voyages from England to Australia using steam 10% of the time, steam and sail 30% of the time and the remaining 60% using sail alone. A very creditable performance for a vessel 130 years ago.
Plans to retro-fit auxiliary sail to fishing vessels and coastal cargo ships have not encountered any problems with lack of stability, but the layout of funnel and superstructure has precluded the best type of sail area being proposed. Obviously if a vessel is being built to have auxiliary sail, this factor can be taken into consideration and the most practical solution found.

A further obvious financial and practical problem is the extent to which power driven winches are to be fitted to reduce the man power required for sail handling.

In our fishing boats (up to 35 ft. (10.6 m.), all the requirements can easily be met with inexpensive yacht-type hand winches, but, as the size of the vessel rises more and more, power winches will be required, and these will need to be self-tailing or of the drum-winding type so that they can be operated easily by one man.

While it is well known that the Almighty and his Son are the only Skippers who are able to sail directly into the wind (or even closer than having the wind 30° on either bow), it is not always appreciated that most sail plans are very inefficient with the wind directly aft. This is especially so with the types of fore and aft rig that are most efficient when sailing against the wind, and some thought has to be given to increasing the sail area when the wind is astern. This has been done in the M/CASS with a second roller jib and other methods have been employed in other vessels.

With fishing vessels in the length bracket of say 35 ft. (10.6 m.) to 120 ft. (36.6 m.) we would recommend one of the variations of the fore and aft schooner rig with facilities for spreading additional sail area with the wind aft. Up to the present time, it is contended that this sort of relatively traditional sail plan can be as power productive as any of the more sophisticated devices while being far lower in capital cost and generally far less susceptible to mechanical and electrical breakdown. Doubtless some other interesting and contrary views will be expounded at this symposium.

PART III

A SHORT LOOK AT PLANS FOR THE USE OF SAIL ON OCEAN GOING PASSENGER & CARGO SHIPS.

GENERAL

During the last fifteen years a number of schemes have been put forward for the construction and operation of ocean going commercial vessels, and while no major scheme has yet come to fruition, it is highly likely that some will become reality within the next few years. The nearest project to commercial operation has been the conversion of the private yacht SEA CLOUD to act as an 80 passenger luxury cruise ship.

This traditionally rigged four-masted barque built as a wedding present for Marjorie Hutton by Krupps Yard in Kiel, Germany in 1930 has the
following principal statistics:-

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<tbody>
<tr>
<td>Length water line</td>
<td>253 ft. (77.2 m.)</td>
<td>Displacement</td>
<td>3530 tons</td>
</tr>
<tr>
<td>Beam</td>
<td>49 ft. (15.0 m.)</td>
<td>Engines</td>
<td>6000 H.P.</td>
</tr>
<tr>
<td>Draft</td>
<td>16.5 ft. (5.0 m.)</td>
<td>Sail Area</td>
<td>34000 sq ft.</td>
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<td></td>
<td></td>
<td></td>
<td>(3160 m²)</td>
</tr>
<tr>
<td>No. of crew</td>
<td>40</td>
<td>No. of passengers</td>
<td>80</td>
</tr>
</tbody>
</table>

She was originally designed to have two luxury suites (solid gold taps, marble baths and priceless antique furniture) for Edward and Marjorie Hutton and five other double guest cabins. The professional crew then numbered eighty.

Nowadays she accommodates some eighty passengers in this luxury accommodation and other cabins which have been added or converted, while her crew has been reduced to around forty.

She is reported to be operating on full bookings and is even reputed to be booked up ahead for more than a year, which does show that there is some demand for this type of luxury cruise ship, but no real attempt has been made to improve the sail plan or arrange it for a smaller crew.

Some of the other schemes which are merely in the design stage are now described briefly.

**PROELSS DYNASHIP** (See Fig. 3)

This imaginative development of square rig was researched at length by Herr Proelss and others in Hamburg, and designs for both passenger and cargo ships proposed. The basis of the rig is the large diameter unstayed revolving masts with squaresails roller furling horizontally to the centre onto vertical rollers inside the masts.

Wind tunnel tests have shown the rig to be highly efficient, and at first sight it seems highly practical, but it is contended that some problems of maintenance and repair have yet to be solved, and some of the difficulties of dealing with the weights and strains of the large sails need further consideration.

For example, to maintain the high aerodynamic efficiency which is the main claim for this rig, some method of tensioning the sails vertically is required, since even modern man-made cloth does stretch in continuous use. Thus, some means of moving the yards vertically is required for this purpose and not yet available. There are other problems too in dealing with the recovery of blown out sails and their replacement when it is remembered that when rolled up, these sails could weigh around two tons and present a cylinder 30 ft. (9.1 m.) high with a diameter of considerable proportion.

The proof of the pudding must, in the end, be in the eating, and sadly up to now, no sizeable vessel with this rig has yet been put into service, and no rumour of an active building plan has yet reached our ears. It is thus difficult to be sure that this rig's performance will measure up to the theory.
WINDROSE SHIP

This project, masterminded by Captain Mike Willoughby, came within an inch of success recently when plans to build the vessel backed by a long term contract to carry bulk cargo from Europe to Australia and back fell through at the last minute.

Broadly speaking, this was a purely traditional rig with the vessel and rig enlarged to meet present day requirements, and making use of modern materials that were not available to the last generation of cargo carrying square riggers to be built.

The project was meticulously researched, but it failed, sadly, through the inability to finalise the cargo carrying contract which would have backed the building plan. This vessel would have been 450 ft. (137 m.) long of 16,600 tons DWT and powered by 66,700 sq. ft. (6,200 m\(^2\)) of sail and a 3,900 H.P. engine.

WARTSILA WINDCRUISER (Fig.4)

The famous WARTSILA shipyard in Helsinki, Finland (which leads the field in passenger cruise liner construction having built 30% of the cruise liners built worldwide in the 1970's) has taken the idea of sailing cruise ships very seriously, and has published a booklet on their design range which they call the WARTSILA WINDCRUISER.

The main statistics of their design are:-

<table>
<thead>
<tr>
<th>Length overall</th>
<th>295 ft. (90 m.)</th>
<th>Sail area</th>
<th>14,000 sq.ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beam</td>
<td>43 ft. (13 m.)</td>
<td>(1,300 m(^2))</td>
<td></td>
</tr>
<tr>
<td>Draft</td>
<td>13 ft. (4 m.)</td>
<td>Speed under sail</td>
<td>10-15 knots</td>
</tr>
<tr>
<td>No. of passengers</td>
<td>110</td>
<td>Engines</td>
<td>2,000 H.P.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speed under engine</td>
<td>12 knots</td>
</tr>
</tbody>
</table>

The vessel is rigged as a three master setting three equal sized roller furling staysails and - according to the builder's publicity booklet - everything has been worked out on a computer, while another on-board computer will control all the sails and even reduce sail to maintain the angle of heel between 6\(^\circ\) and 8\(^\circ\). Presumably the computer also told them that this was the optimum angle of heel for luxury class passengers paying $1,750 per week to be on board.

While it is grand to see a major shipyard putting out a convincing brochure showing the economic viability of a sailing passenger cruise ship, the practical seaman has some misgivings over the practicability of handling three outsize staysails of around 4,600 sq. ft. (427 m\(^2\)) each.

There will be problems in constructing the clews of the sails to take the sheet loading which will frequently be in the region of 10 tons, and double this in certain circumstances. The thought of dealing with a broken sheet on a dark and stormy night (or a bright and sunny day for that matter) fills the prudent mariner with alarm and despondency.

There will be problems in constructing the furling gear with sufficient
strength to withstand the torque of reefing and the initial diameter of the roller, and the thickness of the sail cloth will make the diameter of the furled sail very considerable. When reefed, the Ljungstrom effect will be considerable and the dangers of unfurling the sail and refurling it in the opposite direction will be very considerable, and could well cause alarm and despondency not only amongst the prudent (and imprudent mariners), but amongst the paying passengers as well.

The ability of the sail area quoted to produce the predicted speeds while maintaining an angle of heel of no more than 8° is also considered doubtful. By formula, the sails will only produce 560 H.P. in wind force Beaufort 5, and in higher winds, an angle of heel will eventually be achieved which will enforce sail reduction. The ship's 2000 H.P. engines are only predicted as producing 12 knots, so it is difficult to believe that the sails are going to produce 10-15 knots even under favourable circumstances.

**FRENCH DESIGN**

A French yacht designer has produced a design for a 250 ft. (76.2 m.) 80 passenger sailing cruise ship which is rigged with three very high aspect ratio bermudan sails with accompanying genoa staysails.

While at first sight this looks an efficient and workmanlike yacht rig, the practical seaman views the handling of these large tall sails with some misgivings. If the jib and staysails are to be roller furling and reefing, the problems encountered by the WARTSILA WINDCRUISER will be increased even further, since the staysails are even greater, reaching 5,800 sq. ft. (540 m²), and the very long luff length will make for even greater difficulties.

To most people used to yachts of up to 70 ft. (21.3 m.), the three bermudan sails look fine, but the problems of stowing them on the boom must be re-assessed when it is realised that the boom is at least 15 ft. (4.6 m.) off the deck. Even if footropes are provided and double sheets are fitted to prevent the boom swinging about, the sheer physical problem of handling 3,300 sq. ft. (306 m²) of sail under these conditions needs to be tried to be appreciated, especially when a sudden Mediterranean increase of wind requires more than one sail to be lowered and stowed quickly.

It would seem that tacking and wearing (gybing) will be manoeuvres requiring three or four men on deck at least, in addition to the helmsman and officer-in-charge, and unless all the staysails and the jib are roller furled as the manoeuvre commences, it would appear to be a rather noisy performance. When tacking, three staysails and a jib would be flogging (and in their sizes, that is pretty terrifying), while in wearing (gybing), one will be experiencing three sharp bangs as the three 3,300 sq.ft. (306 m²) bermudan sails flick over from one side to the other.

Finally there is the matter of angle of heel. It is difficult to believe that this tall sail plan will not produce a significant angle of heel—certainly enough to spill a gin and tonic—in quite moderate amounts of wind, and it is doubtful if a very high performance will be achieved under permanently upright conditions. Racing yachtsmen love skittering along
with a boat sailing on its ear, but regrettably it is felt that $2,000 a week passengers may not appreciate this fun side of sailing - especially at meal times or during the cocktail hour.

ASTACE/COLIN MUDIE DESIGNS (Fig. 5)

Another contender in the coming "Sailing Passenger Cruise Ship" stakes is the interesting modernised three masted barque design produced by Colin Mudie, F.R.I.N.A. for the Spanish shipyard Astilleros y Talleros Celaya S.A. of Bilbao, which is normally shortened to ASTACE.

This yard has built four large square rigged sail training ships in the last twelve years, these being:

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLORIA</td>
<td>1100 ton 3 masted barque</td>
<td>Colombia</td>
</tr>
<tr>
<td>GUAYAS</td>
<td>&quot; &quot; &quot; &quot; Equador.</td>
<td>&quot; &quot; &quot; &quot; Equador.</td>
</tr>
<tr>
<td>SIMON BOLIVAR</td>
<td>1400 &quot; &quot; &quot; &quot; Venezuela.</td>
<td>&quot; &quot; &quot; &quot; Venezuela.</td>
</tr>
<tr>
<td>CUARTEMOC</td>
<td>1700 &quot; &quot; &quot; &quot; Mexico.</td>
<td>&quot; &quot; &quot; &quot; Mexico.</td>
</tr>
</tbody>
</table>

Now, desirous of capitalising on the experience gained in this field, ASTACE commissioned the British Naval Architect Colin Mudie to design an 80 passenger luxury cruise ship some 250 ft. (76.2 m.) on deck, utilising square rig brought up to date with all the best of the technology of the end of the clipper ship era, onto which has been grafted the practical use of modern materials like aluminium, stainless steel, terylene (dacron) sails and ropes, hydraulic winches and other modern equipment.

Sail training ships have very large crews and their gear is designed to utilise the crew to the fullest, and Colin Mudie has experience in this field, having been the designer of the highly successful small British training brig T.S. ROYALIST and her Indian sister ship VARUNA. He has also been commissioned to design a 165 ft. (50.0 m.) barque as a training ship for the Indian Navy.

Now he has taken on the design of an even larger sailing vessel which has to be operated with a very small crew for financial viability, but which needs to set a considerable sail area in something near a traditional clipper ship configuration to achieve passenger appeal and to provide effective fuel economy. An interesting concept.

As can be seen, a three masted barque rig has been chosen, and your attention is drawn to the following special features:-

a. Tripod masts are shown to reduce windage and rigging maintenance.

b. Near triangular courses (lower square sails) are shown to do away with the labour required to handle the four sheets and four tacks that would be used on a traditional arrangement.

c. All jibs and staysails are roller furling and reefing, but these are all of moderate size, the biggest being 2,300 sq. ft. (213 m²) and this could (and may) be replaced by two smaller sails. This in a total sail area of almost 28,000 sq. ft. (2,600 m²).
d. The mizzen has been given three gaffs to split up the sail area. The three lower sails can be brailed into the mast by ropes leading to the deck, while the topsail can be lowered to the deck down a conventional mast track set to one side of the mast to avoid the gaffs.

e. The squaresails may be roller furled inside the yards or, if handled traditionally, they can be bunted and clewed up (like brailing) from the deck which furls them temporarily so that they can be stowed in slow time.

f. All the braces from the two masts would be led to two hydraulic Jarvis winches. These are multiple drum winches so designed to haul in the braces on one side and pay out the appropriate amount on the other side when swinging the yards.

g. Despite the apparent complexity, only four men would be required on deck - at maximum - for tacking, wearing or other manoeuvres, as well as the helmsman and officer-in-charge. With skilled and experienced crew, this could be reduced to two.

h. With the wind dead astern, the vessel may alter course up to forty degrees either side of her course without touching a brace or sheet. No noise or other effect occurs when passing the wind across the stern.

i. Upper sails may be furled easily to reduce the angle of heel as required.

j. With all squaresails furled, the vessel may make good speed to windward under up to 13,000 sq. ft. (1,207 m²) assisted by the lee engine or both engines.

Altogether this seems an intelligent and practical approach to a carefully considered viable use of commercial sail.

THE GERMAN DESIGN

A scheme is afoot in Germany under Captain Hartmut Schwarz to build a four masted barque rigged passenger vessel 410 ft. (125 m.) on deck. She too will have tripod masts and other labour saving devices, but further details are not available for publication at the present time. Captain Schwarz is also planning to follow his passenger ship with a number of cargo-carrying sailing vessels.

THE AUSTRALIAN DESIGN

In its early stages as yet, there is an idea emanating from Australia to build a 250 ft. (76.2 m.) staysail schooner with the finance coming from the sale of time shares. At least it demonstrates that the thinking about this type of vessel is widespread around the world.

GENERAL OVERALL CONCLUSIONS

For the past one hundred years, and more especially in the last fifty
years, the world has more and more come to depend on the relative speed and reliability of motor power, casting off the use of wind power like a worn out overcoat. The financial influence has been strong, with cost of labour rising continuously and the availability of relatively cheap fossil fuel becoming more and more convenient. In smaller craft at first, and later in larger vessels, petrol and diesel engines have provided economical power from smaller and smaller sized units.

In the last ten years a rapid tenfold rise in the price of crude oil and its derivatives - mainly in two violent upward leaps - has encouraged the consideration of alternative sources of power. In ships and fishing craft this has mainly brought to mind a return to sail which had not been abandoned that long previously.

It is contended that initially the best way of re-adopting sail power is to utilise known and tried methods and rigs improved intelligently by the application of modern materials and technology.

With such schemes as a yardstick, it is then appropriate, where theoretical and experimental evidence warrants it, to try out various radical ideas, comparing them as accurately as possible in similar operating conditions to the relatively traditional systems. After a reasonable period - preferably twelve months to cover all seasons - a practical comparison can be made, not only in efficiency, but in capital cost, running expenses, labour attitudes and any other relevant factors.

With respect to the protagonists for wingsails, windmills, kites, dynasails and others of that ilk, it is pointed out that there really is no virtue in constructing and fitting to a ship an expensive, computerised device which produces overall a lesser driving force than a simple seamanlike sail, well designed and built, and suited to the trade for which it is intended.

Progress is fine and should be supported and encouraged, but let us not be humbugged into adopting an untried device merely because it teems with microchips, is constructed of carbon fibre, looks like a refugee from "Star Wars" and thus is "NEW".

In short, the KISS principle is advocated.

**BIOGRAPHY OF AUTHOR**

The author, born in 1922, entered the Royal Navy at the age of 13½ and attended the Royal Naval College, Dartmouth, where both engineering and sailing formed a large part of the curriculum. An 800 ton non-magnetic brigantine was building in the port at the time, and he was accepted as a crew member and did some sea-time in a cargo-carrying square rigger as training. From 1939-1946 he served at sea in the Royal Navy as an officer in corvettes, frigates and destroyers. He was active in sailing circles in the post-war period and returned actively to square rig in the 1960's, becoming involved in Sail Training for youth. Since 1972 he has been Managing Director of Square
Rigged Services Ltd., Consultants in all aspects of the operation of large sailing vessels, advising on the re-rigging and designing of sailing vessels for sail training and commercial purposes, as well as contributing papers to several International Symposia on commercial sail and commanding square riggers in Tall Ships Races and other voyages at the present time.

Fig. 1
RIGS FOR SMALL FISHING BOATS.

BERMUDAN SLOOP

GUNTER LUG

DIPPING LUG

LATEEN

STANDING LUG

SPRITSAIL

JUNK

LJUNGSTROM
Fig. 3 PROELSS DYNASHIP

Fig. 4 WARTSILA WIND CRUISER
Fig. 5 ASTACE/COLIN MUDIE PASSENGER LINER

Fig. 6 STAYSAIL SCHONER
CHARACTERISTICS OF MULTI-HULLED
SAIL-ASSISTED WORKING WATERCRAFT:
HULL AND PROPULSION SYSTEMS

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Considering the range of the subject, we shall voluntarily restrict ourselves to two points, which we believe are fundamental. We have over the past ten years attempted to form an opinion upon them.

These points are, respectively, pitching of the catamaran and sail propulsion of present working watercraft.

DAMPING OF THE PITCHING OF WORKING CATAMARAN

The various problems due to pitching of catamarans are well known to the users. Let us try to understand the various aspects of this phenomenon.

I. Effects

A catamaran sailing in a formed sea, will experience high amplitude pitching motion. When the frequency of encounter with the waves comes into resonance with the natural pitching frequency of the ship, the fore-part of the hulls may become submerged, or the fore-platform may slap violently, in the case where there is a forward platform. The force of the action obviously depends on the actual speed of the ship, on the pitching period, on the distance between the crests of the waves and on the height of the waves.

This phenomenon has the following effects:

a) considerable slowing down of the ship, each wave producing a violent breaking action.
b) destructive effect on the fore platforms or on the cross beams, which can lead to total failure and loss of the ship. This effect is all the more important since the joining central platform is extended into the front of the hulls.

For example: during a crossing of the Gulf of Gascogne which I made aboard a cruise catamaran four years ago, the platform longitudinals were completely dislocated and the platform began to separate from the hull after five days at sea.

This catamaran was 22m (72 ft.) long and was constructed in plywood with a platform which extended almost to the fore. Moreover, this platform was at about 0,80m (2'7 1/2") above the water. That is very low for a boat of this size.

c) fatigue for the crew.
d) loss of one of the major qualities of a catamaran, i.e. platform stability and the possibility to have a large deck for working space.

II. Causes
Multiple causes are responsible for the pitching action which is more severe than that experienced by other types of ships. We shall try to distinguish the major causes.

a) Fundamental lack of damping; in most instances, the sea is never exactly perpendicular to the direction of the advancing vessel. The same wave will meet the two bows with a lag in time.

Due to this lag time, one hull will be more immersed than the other, with the passage of each wave.

This being said, let us consider that the damping of vertical motion is essentially due to the resistance of the forward part of the hull to this motion.

This resistance is of the type: encounter resistance + frictional resistance.

On a catamaran, the damping of the pitching action, that is the dissipation of the energy of the pendulum equivalent to the entire ship, thereby meaning the two hulls plus a platform, is accomplished by the surface and volume of a single hull. This is precisely where lies the difficulty in principle for the catamaran to damp its own pitching motion.

To this main cause may be added other causes which at times may be very important.

b) The platform being, for obvious reasons of construction, placed low enough in relation to the water line, will hit the wave either from the fore or the aft and set back the ship.

Since the surface provided by the platform is one of the fundamental advantages of the catamarans, the builder often has a tendency to extend the platform towards the ship's extremities, which serves to aggravate the problem.

c) The longitudinal weight distribution, given this platform, is unfavorable, since it is more important at the extremities, than in the case of a single hull. The pitching period $S$ of the ship pendulum is of the form $S = KI$, $I$ being the moment of inertia of the ship pendulum. The farther away the ship's weights will be from the axis of rotation and therefore transferred towards the ends, the larger $I$ will be.

This will have the effect of lengthening this period and increasing its amplitude, thereby increasing the total amount of energy which will be dissipated.

d) Lastly, given the asymmetry of the attack of the wave, pitching will occur along a more or less diagonal axis.

These diagonal motions will generate extra torsion which, in the case of relatively flexible linking structures, may also enter into resonance with the period of pitching or the frequency of the waves.
III. Possible Solutions

a) Increase the damping.

This may be achieved by increasing the volume above the average flotation, thus causing an important deflection to the planking above the waterline. Even more than this deflection, which increases the volume, it is important to slow down the vertical flow.

One effective solution consists in placing a hard chine near the waterline, or better still, a step. Why near the waterline? Because this slowing down must take place from the beginning of the separation from the position of equilibrium of the ship pendulum.

Such a device must be carefully put in place because, in the vertical breaking force, there is nearly always a component of breaking towards the rear, and the damping of the pitching should not result in the end to an increased drag.

b) Reduce the moment of inertia of the hip pendulum.

This reduction implies lightening of the structure both fore and aft, since we cannot diminish the load-carrying capacity either for working craft (fishing boat), or for the payload (freighter) transport vessel.

That implies therefore the necessity to accommodate for the bending and torsion loads acting on the cross beams by placing elements as close as possible to the axis of rotation in pitching (central beam).

Such a design remains perfectly feasible for working vessels, following the example of certain racing boats, and is less expensive to build.

This axis of rotation in pitch is, for all catamarans we have studied up until now, approximately an axis containing the center of gravity of the waterline surface (these are catamarans 8 to 25m in length (26 to 82 ft.).

c) Minimize "returning" effects by decreasing the lift of aft lines.

Such an option must be carefully handled since at a certain speed the drag is considerably increased for fine stern lines. Moreover, too large a fineness limits aft damping.

Finally, and to conclude this paragraph on the pitching of multi-hulls, we are now working on a peculiar device which is a sort of automatic foil which damps the pitching by artificially varying the pitching period of the ship and avoids dangerous resonances between ship pendulum's own period and the frequency of encounter with the waves.

Finally, and as a result of our experience with sail trimarans for offshore racing, we believe that all we have just indicated
for catamarans is also partially true for trimarans but to a lesser degree (the relation between catamaran and trimaran necessitates a discussion which cannot be developed in this paper).

THE MEANS OF SAIL-ASSISTED PROPULSION APPROPRIATE TO A CATAMARAN AND ITS MANEUVERING

In the case of sail propulsion, sailing along the wind always remains a problem which is difficult to solve for the following reasons:

a- The problems of pitching are more severe when sailing along the wind, as each pitch of the sea empties the sails.

b- The fact that in the case of a momentarily strong wind, the catamaran, which does not heel, cannot absorb by some heeling the energy of this strong wind, for the boat cannot accelerate instantaneously. This requires a reinforcement of the masts and rigs, as well as of the scantling of the sails, thus increasing the weight in upper regions (topheaviness) thus the moment of inertia, thus the pitching.

The actual course of a sailing catamaran does not exceed 45° from the real wind in the best of cases, that is to say a racing sail boat with a revolving mast and an elaborate sail with batten, an efficient center board surface, aspect ration on the order of 3, and a leeway angle of 2° (testing done aboard the 20m (65 ft. 7 1/2 in.) catamaran "Elf Aquitaine").

In the case of a working vessel with a more classical sail, a furling jib, a normal mast, a sail with a few battens, a center board aspect ratio on the order of 1/3, which is already quite rare for a working catamaran, the course does not go beyond 70 to 75° of the real wind with a leeway of 5° to 7° (tests done aboard the fishing catamaran "Dar Mad") in good sea conditions. (In this case an interesting thing was noted: the fact of setting one of the two motors at approximately quarter speed almost completely eliminates the leeway).

It would appear therefore quite unrealistic to envisage a catamaran working vessel that is entirely or almost so sail powered. To eliminate 150° direction appears to be very penalizing as much for fishing (lobster potting, maneuvering round rocks, retrieving a floating net, etc.) as for the transportation of cargo, due to the suppression of certain possible routes.

What's more, maneuverability in port becomes a real problem, whereas at engine power in the case of a twin engine, a catamaran achieves a 360° turning circle.

Only trimarans may for certain usages (tuna fishing or coastal trawling in the case of small vessels), get along with a low powered motor since their capability along the wind is much better.

On the other hand, on a catamaran the disposable surface and the lateral stability of the platform allow for almost all possible rigging systems.
Our current philosophy on this subject is now decided, following 15 years of experience with the sailing systems on two types of boats which appear in fact quite similar, as paradoxical as that may appear: --racing single handed sailboats,
--sail assisted working sailboats,
for, in both cases, it appears absolutely indispensable to facilitate the maneuver of the sails to the maximum.

This present philosophy may be stated as follows:
-- one or more masts classically rigged,
-- one or more jibs on rollers,
-- one or more main sails on rollers,
-- reduction of the number of masts in relation to the size of the ship because of the interactions between the two, even with beam wind.

The wing masts coupled with a fully battened mainsail represent real aerodynamic progress and, what's more, the maneuverability of sails is very simple in principle, but for the time being, their reliability is insufficient for if we wish to have a simplified shroud (only one stay and two back stays), there must be one revolving mast with very large inertia due to the enormous stiffness under sail of working catamarans.

Such a mast is technically feasible, but the current cost is prohibitive (approximately 6 to 8 times more expensive than that of a normally rigged mast).

The masts without shroud, simply implanted "wishbone" style, are equally inconvenient from the point of view of cost, but to a lesser degree than for the revolving masts. Also, their aerodynamic efficiency remains very mediocre.

In conclusion, let us say a word about this stiffness under sail of working catamarans:

-- The maximum lateral stability of a working catamaran is in fact very large when compared to a monohull of the same displacement in loaded condition.
-- What's more and this is one of the extremely interesting peculiarities of this type of ship, the lateral stability increases with the deck load because this stability is of the following form (see appendix).

This feature is extremely interesting for all types of boats which load from the deck (for example, coastal fishing crafts, passenger vessels, etc. ...).

For example, two boats of equal displacement and similar length (this example refers to two working boats which we have effectively studied and for which we have verified the stabilities): a 12 meter (39 ft.), a 12 meter (39 ft.) fishing catamaran.

One of the consequences of this lateral stiffness is the necessity to overdesign all the parts of the sail propulsion system, which is to say:
-- the mast
-- the standing rigging
-- the weight of the sails
-- the running rigging.

The exact calculation of the loads remains difficult because, although the righting moment may fairly well be determined, the sail remains approximately perpendicular to the direction of the force aerodynamic. What is the reduction of these loads due to the instantaneous stretching of the sail material and what is the influence of the air to the top of the sail due to the heeling?

We have been able to determine experimentally that: comparing identical sail surfaces on a catamaran and on a monohull, the supplementary load carried by this rigging leads to an increase of 25 to 30% of the moments of inertia of the mast, of 25 to 30% for the strength of the standing and running rigging, the strength of the sail material increasing a proportion of 15 to 20%.

It is of course obvious that these results obtained from analysis performed on several boats, are not valid unless we consider other boats destined for similar usage, the speed achieved by a catamaran being always larger for a given surface than that achieved by a monohull.

Conclusion

These considerations concerning working multihulls do not pretend to represent a complete study; however, I wish to add that, in spite of the need for the careful elaboration of the means of reducing pitching moment and of the location of the cross beams, the future of service multihulls, whether sail-assisted or motor driven only seems to be assured. Their advantages are real (improved platform stability, greater speed, reduced fuel consumption, improved maneuverability, etc. ...).

However, this type of ship is revolutionary, and requires an extremely rigorous and careful design in order to convince the maritime world (fishing, service and transportation).

Annex 1

HIGH EFFICIENCY SAIL

The necessity to have best efficiency of the sail, with the same speed of wind and with the same surface of sail is very important in first, on the racing boats (vector Fa bigger with the same wind).

The wing sail and the wing mast have been known for a long time, but these were not developed for a long time for two reasons:

1. - The technological difficulties:
   a) the possibility of building wing sail light and with reduced surface area,
   b) building battens strong and light
   c) building a wing mast light and strong enough with a large section.

2. - The problem of racing rules because the progress starts with
the racing machines and during sixty years all the racing rules (RORC - CCA - IOR and so on ...) have forbidden all the full batten sails or wing mast or furling mast. Progress has been made only on the rigging materials (Kevlar - rod rigging - and so on ...), the weight of the canvas and alloy masts.

The new success of multihulls races without rules have utilized all the principles of sail and mast, with the only rule: efficiency.

We have particularly studied and installed on racing multihulls two systems of sail:

1.- A wing sail soft and thick (Chapouteau System) with a classic mast (annex 2).
2.- A wing mast with a fully batten sail.

These two systems are very interesting for the direction of apparent wind (25° to 70°):

a) the efficiency is better. The vector FP is 6 to 10% more than with a good classic sail. The efficiency is better for the Chapouteau Sail in more than 15 knots wind and better for the wing mast and the fully batten sail under 15 knots wind;

b) these two systems are also very interesting when the sail is in "flag position" (lifting), specially for the Chapouteau Sail. This quality is interesting for working boats because it needs to reduce the sail area less often;

c) when the boat is running or has the wind on the quarter, the efficiency of the Chapouteau Sail is not pleasant because we cannot modify the belly of the main sail; a fully batten sail is better (but not better than a classic mainsail) and we are obliged to stress the leech to bend the batten.

Conclusions

1.- The efficiency of these systems are a reality, but the efficiency is better when the boat is faster, because the boat is almost always on the wind (the new fast multihull racer beat when the wind is free). The sail-assisted working boats are not fast on the wind except with sail and engine.

2.- Now, all these systems are expensive and not so strong because of many parts (sail, mast, batten, bearing) but it is certainly possible to progress and we study now a wing mast with a non expensive building cost.

3.- The possibility of lifting without slatting (put in a flagging position) is very interesting for all fishing boats, because it is not necessary to reduce the area of sail so often (to reef is not easy for a short time).

For us, it is very important to study the wing mast more. The thick sail (soft and rigid) although the actual price and the actual strength is not adequate for a working boat actually.
Section of the "Chapouteau Sail"
ANNEX 3

Description of the "Chapoutreau Sail"

1. Central cloth in the neutral fiber of the wing
2. Rib in Polyurethan expedeed
3. Skin of the intrados and extrados surfaces
ANNEX 4

NOTE: Annexes 4 and 5 were translated by the conference organizer, and the author is not responsible for errors in such. JWS

ANALYSIS OF THE CALCULATION OF AVERAGE PRESSURE

The specific mass of air is related to the specific weight and the acceleration of gravity: g.

The mass volume at sea level at a temperature of 15° C.

\[ \text{volumetric mass} = 1.225 \text{ Kg/m}^3 \quad \gamma = \text{m/g} \]

\[ g = 9.81 \text{ m/sec}^2 \]

\[ \gamma = 0.125 \text{ Kg-sec}^2/\text{m}^2 \]

\[ P = 0.5 \gamma \times V^2 \times C3 \]

27 n. - 13.8 m/sec

\[ P = 0.5 \times 0.125 \times 13.8^2 \times Cz \]

\[ Cz = 1 \quad P = 11.9 \text{ Kg} \]

22 n. - 10.8 m/sec

\[ P = 0.5 \times 0.125 \times 10.8^2 \times Cz \]

\[ Cz = 1 \quad P = 7.29 \text{ Kg} \]

The value of one for Cz has been used in our calculations.

Average Pressure: \[ P = (11.9 + 7.29)/2 = 9.6 \text{ Kg} \]

Letting Cz have the value of 1.17 corresponds to placing a flat plate perpendicular to the wind.

For 27 n., \[ P = 13.92 \text{ Kg} \]

For 22 n., \[ P = 8.53 \text{ Kg} \]

\[ P \text{ average} = (13.92 + 8.53)/2 = 11.22 \text{ Kg}. \]
ANNEX 5

FISHING CATAMARAN OF 11.5 METERS (37.7 ft.)

STUDY OF THE CAPSIZING MOMENT FROM THE SAILS

The capsize moment of the sails is produced by the lateral component of the force resulting from wind pressure on the sail. (See sketch of the sail plan with maximum righting moment).

Let us call $F_l$ this lateral component

$F_p$ is the total lift force

$F_A$ is the forward component

Thus, $L$ is the lever arm of the $F_l$ component.

The sail force capsize moment equation is of the form:

$$C_v = F_l \times L$$

(This is valid if the craft is horizontal, and less so when heeling, for the force exercised is at maximum when the sails are on the wind; however, let us consider therefore this maximum value.)

CALCULATION OF PRESSURE ON THE SAILS

This pressure, $F_p$ is of the form:

$$F_p = S \times P \text{ (unit force)}$$

Pressure per square meter depends on the wind speed.

Let us calculate $F_p$ for a wind of Force 6, assuming (which is already an overestimate) that sails are not reefed before force 6.

At force 6, (27 knots) unit pressure $= P = 9.5 \text{ Kg/m}^2$

Thus, $F_p = 53 \times 9.5 = 503.5 \text{ Kg}$

If one considers that $F_l = F_p \times 0.9$ and $L = 6.45 \text{ m}$

$$C_v = 503.5 \times 0.9 \times 6.45 = 2922 \text{ m/Kg}$$

Let us examine the righting moment at 12530 m/Kg:

$$C_m/C_v = 12530/2922 = 4.28$$

The maximum righting moment is thus four times the capsize moment from the sails.
Annex 6

Catamaran de Pêche

Schéma des efforts dus aux Voles
Now, let us determine the wind speed necessary for equilibrium for the maximum righting moment.

Thus, \( C_{\text{max}} = C_v = 53 \times P_u \times 6.45 \times 0.9 = 18596 \ \text{m/Kg} \)

\[ P_u = \frac{18596}{(53 \times 6.45 \times 0.9)} = 60.44 \ \text{Kg/m}^2 \]

A pressure of 60.44 Kg/m corresponds to a wind speed of 60 knots, force 10 to 11 on the Beaufort scale. (If sails have not been reduced they will be torn to pieces by this wind force.)

Moreover, and in every case shown in the figure, above force 5, even taking into account leeway prevention, the boat will slip to leeward, thus diminishing markedly the heeling moment.
PRELIMINARY FISHING TRIALS IN NEW ENGLAND WATERS OF THE
OCEAN PICKUP, A SAIL POWERED TRIMARAN

by

Richard C. Newick, Sherrill B. Smith, and John H. Todd, Ph.D.

Background

Ocean Arks International is a research and communication organization working on ecological development issues. Over the past ten years we have had experience with fishing communities in the Indian Ocean, South Pacific, Caribbean, and the Atlantic coast of northeastern South America. Fisheries development in many countries is at a crisis point. Many tropical nations are losing their access to hard international currencies and are facing bankruptcy. With the decline in economic stability is a concurrent deterioration of the fishery infrastructure which is dependent upon supply and technical inputs from the industrial nations. Spare parts, fuel, processing and ice-making equipment, as well as new boats, are in many instances unavailable. International aid programs cannot fill the gap or sustain the infrastructures.

The problem is compounded by the inability of many fishermen to revert to traditional vessels and methods. One reason is that many coastal communities no longer have access to rot-resistant and long-lived boat building woods. Even where the woods still exist they are often targeted for export to gain foreign exchange.
Project

Ocean Arks International has embarked upon a long-term project to develop advanced design fishing craft powered by sail. They are designed to be constructed from rapid growing and low value "weed" trees which can be grown to a useful size in a few years. Part of our research involves collaborating with N.A.I.S.A. in Costa Rica in the planting of a wide variety of trees and evaluating their usefulness as wood/epoxy composite construction materials.

Another design objective was to develop a vessel in which fully three-quarters of its costs would be based upon local economic activity and less than twenty-five percent require imported materials.

Three relatively new technologies were selected and combined for the development of fishing vessels. They included:

i. The wood/epoxy saturation technique, or WEST SYSTEM®, developed by the Gougeon Brothers (1). The wood/epoxy composite building materials can produce boats with high strength-to-weight ratios. Modern racing yachts, airplanes, and windmill blades are being built with WEST SYSTEM® methods. The WEST SYSTEM® has the additional advantage of enabling low value and rapid growing trees to be utilized.

ii. Naval architect James Brown, in collaboration with Richard Newick, developed a master mold concept called Constant Camber® which permits the lamination of compound curved plywood. Hulls of different sizes and shapes can be built from the same mold (2). Constant Camber®
simplifies cold molding methods and is adaptable to construction in rural or remote settings.

iii. Vacuum bagging allows pressure to be applied over large surfaces during cold molding. Originally an industrial process, it has been detuned to a "backyard" or remote setting scale by John Marples in association with Brown and Newick (3).

The wood/epoxy saturation technique, WEST SYSTEM®, with Constant Camber® cold molding, and vacuum bagging combine well to permit the construction of high performance vessels suitable for commercial fishing.

Design and Construction of the Prototype Ocean Pickup

The design requirements were to develop a multihull specifically adapted to the needs of fishermen who had become accustomed to fast vessels powered by outboards. The vessel was to provide a stable working platform with a large area for fishing gear. It was to have a motoring speed with a 15 hp outboard of 10+ knots, and a sailing speed of 12+ knots. It was to be seaworthy, beachable, and safe. Ocean Arks International turned to Richard Newick for the design. See Photograph 1 and Drawing 1.
Specifications

32' Trimaran Sloop

Length -- 32'
Beam -- 20'-9"
Draft -- 15' hull; 26' rudder; 5' daggerboard
Sail Area -- 335 sq.ft.
Weight -- 2,000 lbs.
Payload -- 3,000 lbs.
(Optional) Outboard Motor -- 5 to 15 hp

Construction materials: Chosen for availability away from industrial centers, ability to be used with simple tools.

2,200 sq.ft. Douglas Fir (or any similar wood) veneer 0.1" thick
11 sheets 3/8" x 4'x8' marine grade fir (or similar) plywood
300 board feet Douglas Fir (or similar) good grade wood
40 gals. epoxy resin for adhesive/coating plus additives
125 yds. 4' wide fiberglass 10 oz. cloth
50 sq.yds. 7 oz. Dacron sailcloth, thread for sewing, grommets
500 ft. 3/8" dia. Dacron and Nylon cordage
Paint, 8 blocks, 26 galvanized steel bolts, non-ferrous staples
4 mil. or 6 mil. polyethylene plastic for vacuum bags

Construction method: Constant Camber\textsuperscript{\textregistered} mold (curved in two directions) of 1" lumber, coated and glued with epoxy. Patterns for hull sides are made of fiberglass (mold and batten materials not listed above).

Assemble three plies of pre-fit and epoxy-coated veneers on mold, hold in place with a few staples until vacuum bag is put on top, sealed at edges and air is exhausted. Epoxy cure takes several hours, work should be done in moderate temperature and humidity.

Coat exterior of panel (after sanding) with fiberglass cloth set in epoxy; epoxy coat interior of panel; trim panel edges to pattern;

Assemble two hull sides, glass taped along keel/stern line inside and outside;

Install transom, bulkheads, sheer stringers, daggerboard trunk, deck beams, deck and sheer rub rail;
Paint, add hardware;
Glue up hollow box spars for connecting structure and mast;
Make rudder and daggerboard.

CONSTRUCTION TIME ABOUT 1,500 MAN-HOURS

Construction method noted above can be further simplified for remote area assembly where electric power is not available or where it is more important to put people to work than to build most efficiently -- substitute nail pressure for vacuum pressure when gluing veneers together on mold.

This method of building can produce long-lived boats. The designer has had commercial sailing craft of similar configuration and materials, with good maintenance, give a useful life of over twenty years in the Caribbean.

Performance and Fishing Gear

The prototype was launched on Martha's Vineyard in November, 1982, and has been sailed off Cape Cod all winter in a variety of wind and sea conditions. It has proven to be fast, maneuverable and seaworthy. It was originally rigged as a sprit sail sloop with a roller reefing jib. The sprit has been replaced by a gaff for greater ease of handling and reefing.

The Ocean Pickup has been rigged for bottom trawling, trolling, trap and hook and line fishing, long lining, and gill netting. All of the gear is handled by hand. Our objective is to have a sail powered research vessel capable of studying a variety of fisheries.
Bottom Trawling:

To date our most interesting experiment has been setting and towing a trawl net. In the past trawling was possible for deep keel sail boats only by towing with a long beam to spread the mouth of the net. With 20' between the amas, or outer hulls, of the trimaran, we were able to run the towing warps through blocks hung outboard of the amas and this stern width was sufficient to keep the net spread without a beam or traditional otter boards. The net has a 22' sweep chain and the wing ends were supported with a pair of rectangular danleno frames with skids on the bottom. The danleno design we used was by Harry Buckingham, an English fisherman (Drawing 2). The trawls were made in 5 to 10 fathoms of water, and the boat was able to maintain trawling speeds and adequate maneuverability in 12 - 15 knot winds. Deep water trawling is probably not feasible, unless Ocean Pickups trawl in pairs.

We also experimented with the same trawl net and 12" and 24" doors. They worked well; however, higher wind speeds of 15+ knots were required to maintain trawling speeds.

Gill Netting:

Light PVC "H" frames, or "goal posts" have been installed on the aft part of the between-hull working platforms. These are used for setting and hauling gill nets. We have found the large deck space to be a major plus for the design as it permits the carrying of a large quantity of nets and traps.
As of this writing -- mid-March -- the Ocean Pickup has not been used for trolling, hook and line, long lining, or pot fishing. However, it appears that the vessel is well suited as a general purpose fishing vessel.

**Future**

By the time of The International Conference on Sail Assisted Commercial Fishing Vessels, the Ocean Pickup will be undertaking fishing trials in the waters off Guyana in South America. The Ocean Arks International project, sponsored by Guyana Fisheries Limited with the support of the Canadian International Development Agency, will investigate sail power in the shrimp, snapper/grouper, and inshore net fisheries. We will also carry out trials in the by-catch fishery as a buy-back boat returning the incidental fish catch from offshore shrimp trawlers. A preliminary economic evaluation of a larger three-ton payload version of the Ocean Pickup indicates that it would be cost effective as a buy-back vessel in the Guyana shrimp fishery.
References Cited


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