SAIL EVOLUTION

A.Y.R.S. PUBLICATION

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Roland Prout's Double Hulled Catamaran.

CONTENTS

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INTRODUCTION

Sail Evolution is a fascinating subject. In this number, an attempt has been made to fix all the known types of sails which exist now or have existed in the past into a relationship with each other. It has been a most interesting study to make and it is hoped that readers will enjoy it.

Logically, this general study is followed by an examination of Captain Illingworth's development of the fore triangle which may be thought of as being typical of the way in which each piece of the general evolution has taken place. This account should be examined with great care by readers as it demonstrates excellently a method which is very much more likely to produce workable improvements in yachts, their sails or gadgets than any other method.

The third article by Major General Parham on his wingsail shows the modern approach to development. Aerodynamic study has shown that the mast eddies account for the loss of 18% in the drive of a Bermudian mainsail and that the twist in a sail is a great loss of power. A sail is therefore invented which has neither of these faults.

It was hoped to include an article on " The Perfect Sail " in this number. This article has had to be held over for lack of space but the sail in question can be briefly described as half an ellipse of an aspect ratio of 6:1 using the formulas $\frac{\text{Span}^2}{\text{Sail Area}} \times \frac{3}{2}$ and fully battened to give a flow of about 1 in 7. This is theoretically the best possible sail. Readers can see if they can find a way to erect such a sail on their boats. I personally favour a squaresail rig with the battens running down a topping lift to the middle of the boom in the Chinese manner.

The last article is by Peter Johnson on Self Steering. This is a practical invention which is simple and works. Its simplicity should be compared with the ideas expressed in the last booklet on HYDRO-FOILS for achieving the same end. There, complex mechanisms are described which can apparently be replaced by a piece of shock cord. The inference is obvious. The simpler idea is always the best.

For those more technically minded, the use of the wind tunnels at the Imperial College at South Kensington has been most kindly

offered for aerodynamic tests on sail models. Details of the sizes of models possible and their necessary construction will be sent on request.

There will be a meeting of the A.Y.R.S. in December to get the Society onto a more formal basis and elect officers. It is hoped to get some people to give papers on their specialities. Ideas for this meeting and the names of people who can be approached to give us their ideas should be sent to the Editor as soon as possible.

Though these A.Y.R.S. publications are still being produced at a financial loss, there has been a great enough increase in subscribers to make it certain that six booklets will be produced in the first year.

Edited and Published by
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Woodacres, Hythe, Kent.

THE EVOLUTION OF SAILS

The very first sail which was ever put on a raft or dugout canoe to help the seaman of many thousands of years ago with his paddling was, naturally, a large leaf probably from a palm tree. It seems likely that this custom first appeared in the Indian Ocean but to get a picture of it, we have to leave that ocean and we find that in a design on a vase of pre-dynastic Egypt dated 5,000 years B.C. there are two such leaves in the bow as shown in Fig. 1. Another piece of evidence that

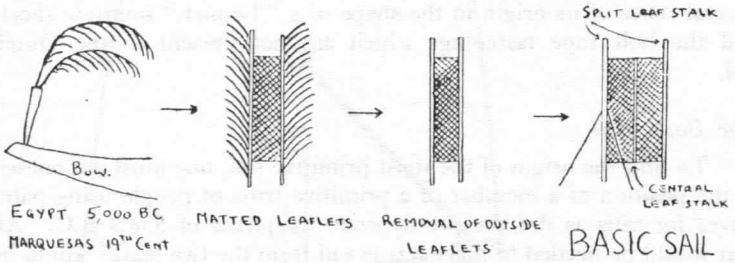

Fig. 1

bears on the subject is the fact that Hodges, of Cook's party, has sketched three wooden structures in the bow of the Marquesan canoes which probably represented these leaves and Stewart in 1831 actually saw three coconut palm leaves in that position.

These palm leaves in the bow illustrate excellently the two ways in which evolution can be studied. Firstly, one can find direct evidence of the existence of a sail from the remote past in the form of a picture or sculpture or, secondly, one can look about in isolated places far removed from the area where the sail originated and find the ancestral form present today. An ancient migration becomes isolated and more or less faithfully copies the original form from generation to generation. The palm leaves in the bow of the pre-dynastic Egyptians represent the same culture as those of the nineteenth century Marquesans. The leaves as shown in the vase of ancient Egypt evolved into better sails (but in the Indian Ocean) while the remote ancestors of the Marquesans carried the primitive idea intact from Indonesia to a far corner of the

Pacific Ocean. The Marquesans in the course of time acquired a sail from a later migration of people but still kept the custom of the leaves in the bow.

One assumption is made in the study which follows. That is, that the alteration from one kind of sail to another takes place by a series of small changes but the accumulation of these small changes alters the sail completely in its nature. In this, I differ from Chatterton who, in his book " Fore and Aft," would have us believe that some Dutchmen put up one of the pre-existing squaresails with the yard as the mast and a separate pole as the sprit to produce the sprit sail all in one piece of ingenious invention. This, in my opinion, is too great a step for any one man to have worked out for himself and it remained a mystery to me till I realised that the spritsail only appeared in Holland (and the Bosphorus) after the time of Marco Polo who must have seen the rig used in China. There still remains the problem of how the Chinese developed it but at least the Chinese spritsail retains several relics of its origin in the shape of a " bonnet," multiple sheets and the bolt rope fastenings which are not present in the Dutch sail.

The Basic Sail.

To find the origin of the most primitive sail, one must put oneself in the position of a member of a primitive tribe of people using palm leaves for sails as did the pre-dynastic Egyptians of 5,000 B.C. All that would be needed to make a true sail from the two leaves would be the matting together of the intermingling leaflets and the removal of the outside ones. This would produce a rectangular mat sail with the leaf stalks at the edges, and this sail would be set with the " spars " upright as were the single leaves which preceded it.

A sail such as has been described has not, to my knowledge, ever been recorded either for the past in the " central areas " of evolution or in any remote part of the world recently but the natives of certain parts of Papua make a sail in the following way. To avoid the waste of the outside leaflets, the midrib of a coconut leaf is split up its middle and the leaflets are matted with the leaflets of a second whole leaf whose midrib is left in position in the centreline of the sail. The halves of the split midrib form the long borders of the sail which is of about 18 square feet of area. It is my belief that this sail is the basic sail from which all the sails in all parts of the world took their origin. It seems likely that the step of weaving the coconut leaflets took place in Indonesia about 8,000 B.C. During the last Ice Age, a vast continent existed around the Indonesian islands because the waters of the oceans were locked in the Polar ice caps and the sea level was 200 feet

lower than it is now. About 8,000 B.C., the ice caps melted and this continent was flooded, leaving its higher ground as the Indonesia of today. Surely, there could be no greater stimulus to the development of boats and sails.

The basic sail is shown in Fig. 1 developing from the coconut leaves. This type of sail is used at Port Moresby in Papua. The left hand pole acts as a mast with three stays. The pole on the right of the sketch is trimmed to the wind by sheets, its lower end resting on the lee gunwale. The foot of the sail tends to bag a lot.

The Second Stage (*The Nuggar Sail*).

The sail in what I believe to be the primitive form would be unhandy to set and stow. A mast was now added and a useful sail appeared which we will call the " Nuggar Sail " because that is the form in which most of our readers will know it. The Nuggar sail is that found between the second and fourth cataracts of the Nile. Three types of it are shown in Fig. 2 from India, the Nile (and Java in the 9th Century) and Tagula in Papua.

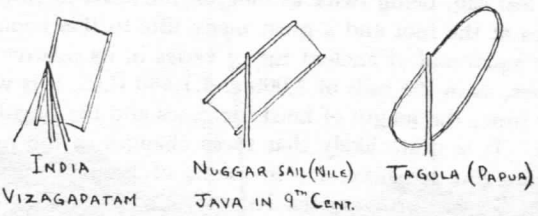

Fig. 2

In the Nuggar sail, the shape still remains the same as for the primitive coconut leaf sail, an oblong rectangle with spars at the long sides. The mast supports the yard or luff spar by about its middle and there is a strong tendency for the oblong to slope backwards. If there are stays, the sail is hoisted outside them. Several sheets are necessary to control the boom and keep it to the side of the stays but a flat set of sail can be achieved which allows a sailing boat to look fairly close to the wind.

This sail possibly developed about 6,000 B.C. and spread to Indonesia, India and Egypt in the west and China and Papua in the east. It is likely to have been the only sail (with a derived squaresail) in the Indian ocean till almost the beginning of our era. It was the sail of Java in the ninth century A.D. being featured in the sculptures at Boro Budur in that island.

The Squaresail Series.

The spars of the Nuggar sail are sometimes nearly vertical but mostly they slope back at the peak. The next step is for the sail to be completely dropped at the peak to form a squaresail as shown in Fig. 3. A picture of a sail of this shape has been found in a vase from Egypt dating back to 4,000 B.C. but the ship of Queen Hatshepsut which she sent on an expedition to Punt about 1,480 B.C. is shown in so

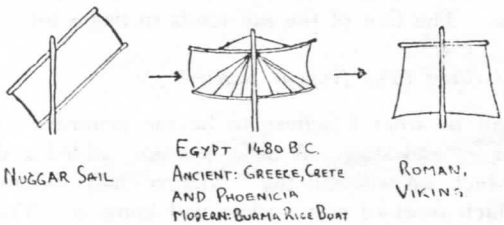

Fig. 3

much detail that its derivation from a Nuggar sail is much more obvious. The sail of Queen Hatshepsut is exactly the same shape as the basic coconut leaf sail, being twice as long on the spars as in hoist. There is a boom at the foot and a great many lifts to this boom.

The squaresail of ancient Egypt varies in its relative proportions. Sometimes, as in the sails of 4,000 and 1,480 B.C., it is wide and low. At other times the length of hoist increases and the breadth of the sail gets less. It is quite likely that these changes in the proportions of the sail are due to successive invasions of Egypt from the Red Sea region, each again bringing the Nuggar sail with it which lowered the sail while, when Egypt was powerful, the sail tended to grow taller.

The sail of Queen Hatshepsut was not unique. It was used by the Phoenicians, the ancient Greeks and Cretans and, up till recently, in the Burma Rice Boat. It is usually stated that this sail later evolved into the Nuggar sail rather than the reverse as is given here. The arguments in favour of the present hypothesis are :—

1. No naturally evolved sail would ever be twice as long on the spars as in the hoist. When rolling, the boom ends would dip in the water.

2. The great number of lifts to the boom are unnecessary and can only be explained as being the relic of the multiple sheets of a Nuggar type sail.

3. The boom is not necessary in a squaresail.

4. If the squaresail had been the first sail, it would have been used in the Norse (Humber Keel) way for beating to windward and the spars would not have been sloped, Nuggar fashion.

5. Though it is not impossible to believe that the low aspect ratio squaresail could be transformed into the Nuggar sail, it is quite impossible to believe that the Nuggar sail would ever be replaced by either of the sails which are used in Papua or India which I believe to have preceded it. No practical sailor would ever do such a thing.

6. If the Nuggar sail had been an improvement on the squaresail, it would have spread to the Mediterranean generally and not have been confined to the middle waters of the Nile.

This low aspect ratio squaresail of ancient Egypt spread to Greece, Crete and the Eastern basin of the Mediterranean. The Phoenicians took it to Rome and Scandinavia where its aspect ratio was increased and the boom at the foot of the sail disappeared. Both the Romans and the Vikings were able to beat to windward and they did so by bracing the yard around on the mast and not by tilting it.

The Chinese Squaresail.

On the upper reaches of the Ch'ient'ang river in the Chekiang province of China, above Haining, a squaresail is found which is about the same length along the spars as in vertical height. There is a boom at the foot of the sail. It is used as a squaresail with a following wind but, when tacking is required, the sail is not twisted about a vertical axis in the European way. By contrast, one of the tacks is brought to the mast, the yard is tilted up and the sail is used as a fore and aft sail. Thus, it is both a squaresail and a lugsail. No stays are present with this or any other Chinese mast, except at Hong Kong where they are due to foreign influence.

This Chinese squaresail, being boomed, must have taken its origin from the Nuggar type sail of the first wide diffusion by a simple

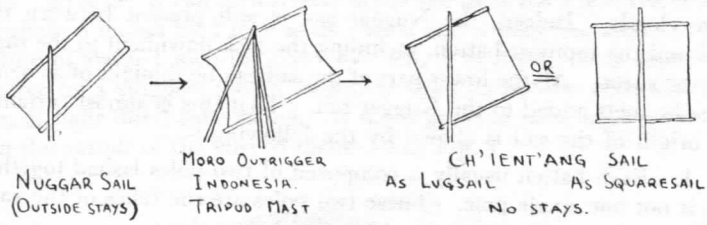

Fig. 4

process of increase in aspect ratio. It is my opinion that it was at first only used in the lugsail form because sails of that type are found in Papua and the Moro islands of the Sulu sea in Indonesia where they are set outside a tripod mast. However, the Ch'ient'ang, being a

river, wanders about and this produces gybes which must have strained the mat sails which were used in these junks till recently. So the sail was altered to the squaresail for running.

The Chinese Lugsail Series.

This series, whose peculiar characteristic is multiple battens, appears in Malaya and is present along the whole Chinese coast and in the large and small rivers. The more primitive type is shown from Penang in Malaya but the same type is present in the upper reaches of the Yangtze river. This sail is obviously a direct descendent of the coconut leaf sail shown in Fig. 5 from Massim, near Papua, the battens replacing the midribs of the coconut leaves and the sail from

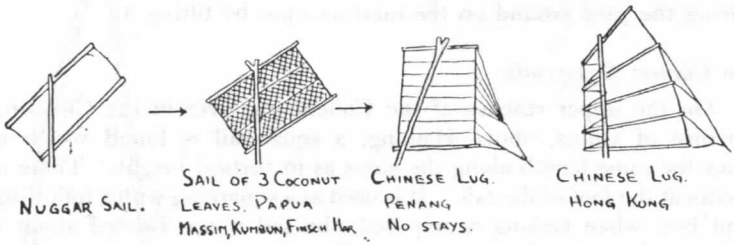

Fig. 5

Massim surely takes its origin from a Nuggar like sail. In the Penang sail, the mast is given a rake aft to bring the luff of the sail vertical. There are no stays but there is a multiple sheet with parts to each batten.

The more advanced Chinese lug, shown in Fig. 5 in a simple version from Hong Kong betrays its origin from the Nuggar sail much more clearly. Indeed, the Nuggar sail is still present between the yard and the topmost batten, including the tack downhaul to the mast and the sheet. All the lower part of the sail can be thought of as being three bonnets added to the Nuggar sail. That this is almost certainly the origin of the sail is shown by the following :-

1. Each batten usually is composed of two poles lashed together and is not one single pole. These two poles are the relics of the yard and boom of the Nuggar sails above and below them.

2. When the batten *is* composed of one pole as is the case with some types of this sail, there is an unnecessarily long parallel batten holding the main batten to the mast. This also could be the remnant of the yard of the bonnet below.

3. Each bonnet has its separate sheet and tack downhaul.

4. The multiple sheets come from the batten ends in groups, indicating the recent addition of bonnets.

5. The more primitive sails have fewer battens than the more advanced.

The Lateen Series.

The next great series of sails may be called the " Lateen Series " because most of them are of that type of lugsail.

This series takes its origin from the basic coconut leaf sail and this time we have no doubt in placing the place of its development in Indonesia because the people who used even the most elementary stages of it were known to have lived there about 2,000 years ago. These were, of course, the Polynesians. There is an exactly parallel series among the Melanesians associated with characteristic curved spars. Both series are shown in Fig. 6.

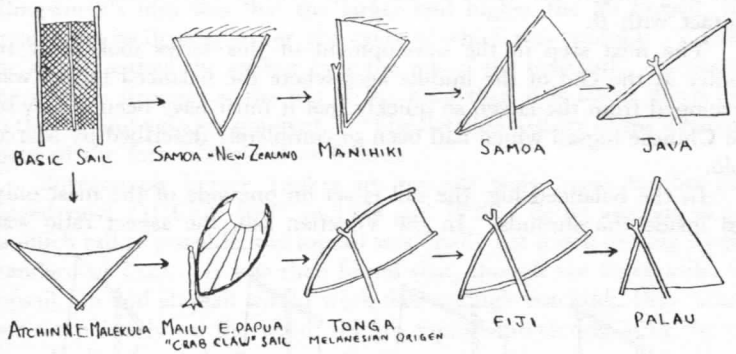

Fig. 6

The first step of all gives the character to the whole series and this step is the bringing together of the lower ends of the spars of the basic sail, thus converting it into a triangle with the apex downwards. This sail, though a powerful driver, has a lot of heeling moment and could only have been originated for use with an outrigged canoe which had plenty of stability. It was actually seen in Samoa and New Zealand when the early European Navigators arrived there. (Melanesia : Malekula).

The next step in this series is for the triangular sail to be hoisted to a mast as shown in Fig. 6 as recorded at Manihiki. (Melanesia : Mailu, Papua). This is a good fore and aft rig but the heeling force still stays great so the bottom angle is allowed to go forward of the mast, thus lowering the centre of effort. The ultimate end of this process is for the after edge of the sail to be lowered till it becomes

horizontal, still maintaining the fully triangular shape of sail. This occurred in Java with a low aspect ratio and in the Palau islands in Micronesia, where there is a good deal of Melanesian culture, with a high aspect ratio.

This type of sail is called " The Oceanic Lateen " sail. About the time of Mahomet, it was in frequent use in Indonesia, having replaced the Nuggar sail in many places. The Persians were the great Navigators of those days and were making voyages to Indonesia in ships either with sails of the Nuggar type or squaresails, probably the former. In Indonesia, they met the Oceanic Lateen and adopted it.

The Arabs were an inland people before Mahomet but quickly learned seamanship and navigation from the Persians when that people had been converted to the Faith. Indeed, most nautical terms of the Arabs are Persian in origin to this day. The Arabs took the lateen rig with them in their conquests in the Mediterranean as far west as Portugal and most of the peoples of this great sea came into contact with it.

The next step in the development of this series took place in Venice at the end of the middle ages where the balanced lugsail was developed from the lateen so quickly that it must have been a copy of the Chinese lugsail which had been so completely described by Marco Polo.

In the balanced lug, the sail is set on one side of the mast only and inside the shrouds. In the Venetian sail, the aspect ratio was

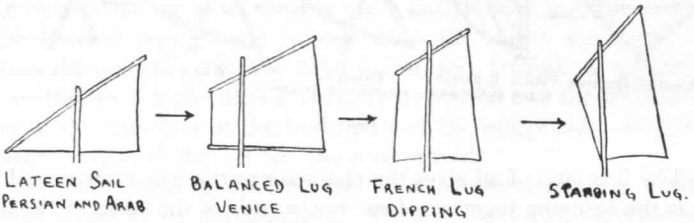

Fig. 7

increased somewhat from the very low sail of the Arabs but the angle of the yard was kept the same, as shown in Fig. 7. This gave a handy and useful sail for the very first time in Europe, capable of short tacking to windward with great efficiency.

The French now increased the aspect ratio still further and by doing this, increased windward performance but they still kept the low angle of the yard. On putting about, the yard was now " dipped " and put on the lee side of the mast on each tack. The dipping lugsail is very efficient and might, even now, be able to sail with the Bermudian rig on almost equal terms if anyone were prepared to use it.

Finally the yard was given an acute angle and the tack of the sail was brought into the mast to increase the tension in the luff forming the " Standing lug " which is not dipped on putting about.

The Hawaiian Sail.

This small stream, while starting off to a triangular sail similar to that of Samoa, uses the fore pole as a true mast in the Marquesas and where this sail was isolated in Hawaii for many centuries, it

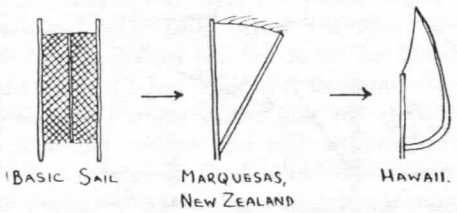

Fig. 8

slowly developed into the unique shape shown. The gradual increase in sail area low down is the main line of this stream. Its end result would have been interesting if it had not been arrested by the arrival of the European. Perhaps a jib-headed sail was in the course of development.

The Bermudian Series.

From a Nuggar type sail with a mast stretching half way up the leading edge spar as in the top left hand drawing of Fig. 9, a series of sails can be traced right up to the Bermudian mainsail of today.

We have to start by making an excursion into the areas of the outrigger canoe to show that the principle of holding up the trailing edge spar of a rectangular sail by a sprit is very ancient.

In the Torres Strait to the north of Australia, the basic sail is used on a double outrigger canoe supported by sprits through grommets half way up both spars. In use, one edge of the sail would be the luff on a given tack and the leach would be trimmed by moving its supporting sprit. Now we know that the double outrigger canoe is associated with Indonesia as is the sail shown as belonging to Ceylon and Madagascar which must have been derived from a sail of the kind noted at the Torres Strait so we can say that this sail came from Indonesia a long time ago possibly about the time of the birth of Christ.

The origin of the Chinese spritsail can now be quite easily understood because, if a sail like that seen at the Torres Strait were to be taken to near the mouth of the Yangtze river, the luff pole were to be

used as a mast and the leach pole sprit brought to its foot, a sail would result such as is shown marked " Hypothetical " in Fig. 9. Three sheets would be needed for such a sail, one for the sprit and two others for the top and bottom of the leach pole. This sail would be an

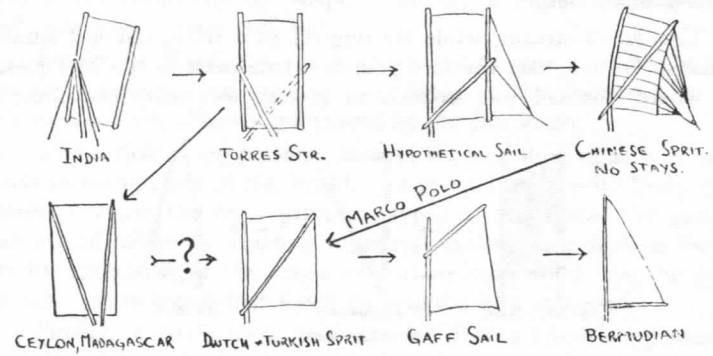

Fig. 9

immediate advance on its forerunner because it is a fore and aft sail capable of easy working and able to beat to windward. If this were, in fact, the method of origin of the Chinese spritsail, this hypothetical sail in more or less this form should still be present in some out of the way place along the coast or in a lake in China or have been noted there last century.

It is an easy stage from my hypothetical sail to the fully developed spritsail of China. All that would be needed is for the sprit to be carried up to the peak of the sail and it would appear that there is a natural tendency for this to occur from a consideration of the sails of Ceylon and Madagascar.

This hypothesis would give a reason for the use of the multiple Chinese sheet with this sail. The hypothetical spritsail would need three sheets, but, when the leach pole began to be made lighter, it would start to bend between the supporting sheets and further sheets would be added to keep it straight.

The Chinese spritsail is of comparatively recent origin because it is only found on a limited extent of coast south of the mouth of the Yangtze and a short way up that river to Chinkiang. It preceded the European spritsail by some centuries, however.

Marco Polo, who lived from 1254 to 1324, spent 24 years of his life at the court of Kublai Khan who was the ruler of China at that time. He must have seen a great deal of the junks which were and are such a part of Chinese trade and travel. In the books of his travels, the Chinese lugsail is described in great detail probably resulting in

the development of the Venetian balanced lugsail as already stated but, in addition, Marco Polo is credited with introducing into Europe macaroni, coal mining, banknotes, moveable printing types and water clocks. Surely then, it is no accident that the spritsail appeared in Europe after his return along with the leeboard and the flat bottomed and flat nosed shape of craft which was the Thames barge 150 years ago, very similar to the Chinese junk in its essentials. We know that he crossed the Yangtze at Chinkiang where the spritsail is to be found.

The Venetians found the lugsail a much better sail than the lateen which they had been using before and adopted it leaving the development of the spritsail in the hands of the Dutch and Turks.

Some recent evidence has appeared to show that there was a spritsail in what is now Turkey in the first and third centuries A.D. On careful examination, however, the sails in question are seen to be the sails which are now seen in Ceylon and Madagascar. It is quite possible that the Turks made an independent development of the spritsail from them, however.

The gaff sail is an easy step from the spritsail which was carried out entirely by the Dutch. A parallel line which developed the jib headed mainsail in Holland in the early seventeenth century seems to have disappeared, though it might have influenced the gaff sail in so far as the Dutch gaff became very much shorter than the earlier long gaff which was adopted in England.

In England, the gaff sail eventually became transformed into a high peaked gunter lug in the smaller boats. In larger yachts, the mainsail and topsail together slowly became one large triangle. Both these became Bermudian sails by the natural evolutionary process of the replacement of duplicated spars by a single one and the abolition of the redundant gaff.

The Bismark Archipelago Gaff Sail.

This stream, shown in Fig. 10, illustrates the evolutionary method extremely well. The basic sail, having been firstly hoisted to a mast,

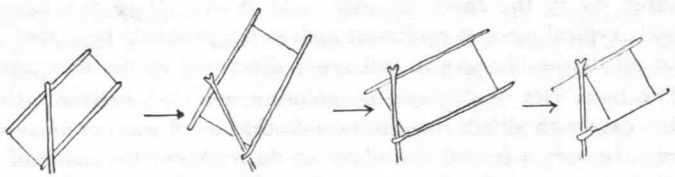

Fig. 10

is tilted to more or less the Nuggar angle at the Ninigo islands. However, instead of being placed outside the stays in the Nuggar way, it is put inside them and the after yard is put to the mast with jaws.

At the Hermit islands, the mast is brought to the vertical, the jaws of the boom and the shape of the sail being retained, giving a very low aspect ratio gaff sail.

Finally, at Siassi, the sail is shortened to give what might have become a boomed gaff sail. It is unlikely, in my opinion, that this development was directly influenced by the European.

This article is my personal view of the evolution of sails of many kinds in many parts of the world. In general, it is quite likely to be correct because the most primitive types of sails show the greatest number of offshoots which is a general evolutionary feature, but in my interpretation of the origin of certain sails, there may be faults for which it is hoped that I will be forgiven and corrected.

Finally, it surely must make the A.Y.R.S. a humble organisation to realise that in the few pages in which I have attempted to describe how sails developed, many many millions of experiments must have been made to bring the various types of sails to their final state. Among us, we may perhaps try forty new ideas a year.

All the sails of this account are either well known to yachtsmen or may be found in Haddon and Hornell's book "The Canoes of Oceana."

I wish to thank G. R. G. Worcester for his advice in the presentation of this material.

CAPTAIN JOHN ILLINGWORTH'S DEVELOPMENT OF THE FORE TRIANGLE

We have just been examining how sails change from one type to another in a general way in the first article in this booklet. In this article, we can now see how one stage of evolution has occurred within the cutter rig in the space of only eight years. Here, we have an absolutely typical piece of evolution such as has probably been responsible for all of the changes in sail types described in the first article.

The basic fact of this recent evolution, which I believe to have been the case with all advances in sails, is that there was one man with an idea. In only a few of the advances do we know the name of the man who was responsible but we are lucky here and we not only know who made the advance but we have his own account of his idea and how he achieved it though, as Captain Illingworth points out, no doubt parallel development was going on elsewhere.

Captain Illingworth pioneered the " masthead rig " which he defines as a rig in which the *working* jib is set to the masthead. Prior to his influence on our sails, there had been three headsails to the cutter rig.

1. A stay sail which was set on the stay from the stemhead to near the main masthead (on the after side of which was a gaff sail).

2. A jib either set flying or on the stay from the end of the bowsprit to the main masthead (generally set flying).

3. A small jib topsail again either set flying or on a stay from the end of the bowsprit to the topmast head and used in light weather only.

The next stage was the " Yankee " jib topsail named after the American yacht, which was again a light weather sail but of greater size, cut high in the foot and set near to the topmast head. Captain Illingworth's idea was that the larger and higher the jib topsail, the greater was its driving power, the cause of which was twofold. Firstly, the sail smoothed the airflow over the top of the mainsail. Secondly, the wind is stronger at the top of the mast than it is lower down due to the " Wind velocity gradient." The detailed history of his development of the fore triangle is as follows :-

Successively bigger Yankee jib topsails were made for his gaff rigged yawl, QUEEN BEE, in 1928 and 1929. Being anxious to get as much sail as possible, the topsail was finally cut much too big by the standard of 1928. It was then found that, though the three sails, jib topsail, jib and staysail would work well enough reaching, they would not set properly on the wind, the jib topsail interfering with the jib since both were tacked near to the bowsprit end.

For a while, this big sail was reserved for reaching only. Then it was realised that it could be kept set when going to windward if the normal jib were taken in. By this time, Captain Illingworth had also enlarged his staysail so that there was some overlap on the mast and he thus had arrived at more or less the modern rig with two parallel luffed sails, the upper one set to the topmast head with its clew about on the main shrouds and an overlapping staysail below. Fortunately, the " topmast " of the pole mast was fairly manly, though not as much so as it would have been if it had been designed for the purpose to which it was being put. But it showed that, with a stronger mast, the jib topsail could be made to sit well as a working sail. This rig was used at first only in light and moderate winds and the normal jib was reset in fresh breezes to windward. But soon the jib topsail was set in fresher and fresher weather till eventually it blew out altogether, just before the boat was sold.

Captain Illingworth's next boat, LO III, was unsuitable for this rig so it was not until 1934/35 that it was used again on the Bermudian rigged THALASSA and later on BLUEBIRD in 1936. THALASSA's mast was, however, too short and BLUEBIRD's too slender for the best results.

Finally, in the autumn of 1936, when Jack Giles was designing MAID OF MALHAM for him, a real man-sized hollow mast was asked for which could really carry the working jib to the masthead. Despite discouraging advice from the experts, Captain Illingworth was determined to give the pure masthead rig a real tryout with a proper mast and did so, even persuading Colonel King to try almost the same system in the new ORTAC, though she did set a lower jib in the 1937 season. The success of these two boats that year firmly established the masthead rig, which supplanted the three headsail combination thenceforward. Later, further detail development was chiefly concerned with altering the exact headsail proportions so that they would work to best advantage in a narrow triangle.

In this development let us now examine what has been accomplished. Firstly, three headsail sheets have been replaced by two, resulting in a simplification of handling. Secondly, the greatest amount of effective sail area has been put on a mast of a given height. The reason why it is so effective is that the jib makes full use of all its sail area whereas the top of a Bermudian mainsail is of much reduced value because of the mast eddies. Thirdly, one of the greatest defects of the Bermudian rig as we usually use it is that both the mainsail and the jib become very greatly twisted when the sheets are eased. In Captain Illingworth's rig, the twist in the fore triangle is minimised because the jib is high cut and virtually untwisted and the staysail can be set to the windflow at the lower part of the sailspread. Fourthly, the aspect ratio of the jib has been improved.

The Bermudian rig has, by this piece of evolution, now reached the final stages of its development. We now have two versions of it which are perfect in their own ways and can only be improved by very minor alterations in the relative lengths of the sides of the sails. The first of these rigs is, of course, the sloop rig which gives the greatest amount of drive for a fixed amount of sail area. It also gives the greatest amount of drive for a fixed amount of heeling moment when its aspect ratio if 6:1 using the formula $Span^2/Area \times 3/2$ (because of the reflective effect of the sea surface). Captain Illingworth's rig, on the other hand, gives the greatest amount of drive for a given mast height and is therefore a better rig for cruising yachts especially as the sail area can so easily be reduced.

A WING SAIL DESIGN

by Maj. General H. J. Parham.

By " wing sail " I understand any sail which endeavours to present to the airflow a reasonable wing section set at a reasonably uniform angle of attack.

The first considerations therefore are elimination of twist and reduction of mast interference. Whether the sail is " all soft," " all hard " or a mixture of both is a matter of practical convenience. I have tried the " all soft " and the mixed hard and soft (i.e. a built up wooden front portion with a canvas trailing portion) and, though the latter is far better once it is erected, I have come to use the former for general convenience.

The rig now to be described has been used by me for five or six years and is quite good. It more or less eliminates twist by using a mast bent to about the same curve as that normally taken up by the leach and it greatly reduces mast interference by using a plank mast which meets the air always edge on and fairs smoothly into the curve of the canvas. Against all this, one must admit that the rig is heavy (nearly 3/4 lb. per sq. ft. of area in my roughly made affairs) and needs a very strong " housing " in the hull to take the stresses set up by pitching. I have also no experience of areas larger than about 80 sq. ft.

The rig consists of :-

1. A stub mast which is a stout steel tube some $1\frac{3}{4}$ inches in outside diameter, stepped in two bearings in the hull one on the keel and one some 3 feet above it. This stub mast carries, above the top bearing, a box into which the boom is pushed.

2. A boom which is a cantilever and acts as its own kicking strap.

3. A curved mast which drops into the top of the stub mast and " floats " on it i.e., it can turn freely, as the sail pulls it. This mast is a plank about 5 inches by 1 inch at its widest and is bent like a bow to a curvature of about 1 inch for every foot length of mast. It is kept in this curve by a kingpost (about 30 inches from its bottom end) and a system of light dural tube struts. It has a grooved mast track which lies on the *outside* of the curved plank. See Fig. 1.

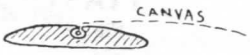

Fig. 1

The sail is a normal Bermudian mainsail with two variations. Firstly, its luff is cut with a slight curve forward. Secondly, it has no headboard. It must be cut fairly flat and be loose footed. The main

halliard has to be cleated onto the mast, not the boat, otherwise the free movement of the mast on the stub mast will be impeded.

The action of the mast is as follows :- On the port tack, the mast takes up a position as shown in A in Fig. 2. When going about, the mast is flicked round by hand through some 220° and when halfway round the state is shown in B in Fig. 2. On the starboard tack it is as shown at C.

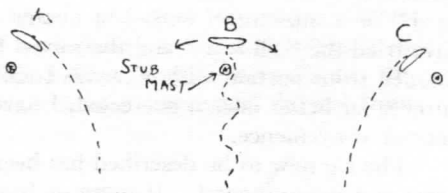

Fig. 2

Fig. 3

It is vital that the correct point (along the kingpost) is found from which to hinge the fitting which enters the top of the stub mast as upon this depends the set of the sail. The fitting A must be bolted to the king post B in Fig. 3 so that the axis of the stub mast, when " produced " upwards cuts the mast at X, about $\frac{1}{4}$ to $\frac{1}{3}$ of the length

measured down from its top. Only trial and error will decide the correct position for A, but once found it is fixed for good. The fitting C is a metal jaw bolted to the bottom of the plank, which embraces the stub mast and is retained to it by a push-in pin. (See small sketch). For small sails of around 50 sq. ft., one Dural tube, D, is adequate. For larger areas, two tubes are needed here, converging upwards from a fairly wide based kingpost.

It will be discovered that, when flicking the mast round to go about,

An early example with two King posts and a single bracing strut

the head of the sail is pulled forward by the top of the mast and the leach gets so tight that one *cannot* twist the mast past " dead centre." To defeat this, the clew of the sail is not made fast to the boom but to a single block pulley. The main sheet is attached to the end of the boom, passes through this block, back to another pulley inserted *in* the boom and thence (in small sails) direct to the helmsman's hand or, in larger sails to a block on the horse, back to another block on the boom and so to the hand. These leads are shown in Fig. 4.

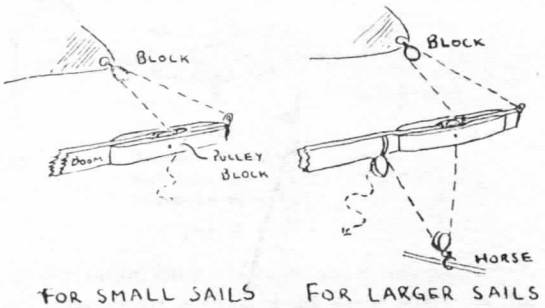

Fig. 4

SELF STEERING FOR EVERY YACHT

by Peter C. Johnson.

Cost : Five Shillings. *Time :* Five Minutes

It is not only to the singlehanded ocean voyager that self steering is useful. Every yacht owner has times when he is shorthanded, and it is very satisfying to be able to go forward while the vessel surges onward on a steady course. There are enough essential tasks in fitting out without bothering about elaborate automatic steering devices, and the key asset in the method which is described here is that it can be rigged from scratch in five minutes, and the gear used costs less than five shillings.

The principle upon which it is based is that when a yacht luffs the mainsail is not so hard pressed and the sheet slackens, and when she bears away the sheet hardens. This applies with the wind between four points (close hauled) and thirteen points off the bow.

Two blocks are secured, one each side of the tiller. Probably they can be lashed to the rails. Their exact position depends upon the lead of the mainsheet, but if this comes down somewhere in the region of the rudder head, then the end of it is led through the leeward block. A bight of the sheet is now taken, and secured to the tiller by means of a round turn and two half hitches.

Also required is about two foot of shock cord. One end of this is seized back on itself to form a loop which will fit over the tiller. A thin piece of line is clove hitched somewhere in the middle of the cord. Most yachts have small cleats or hooks either side of the tiller for lashing it, and to the windward one of these (or some other object to windward) the line is secured. The apparatus for self steering is now complete. See Fig. 1.

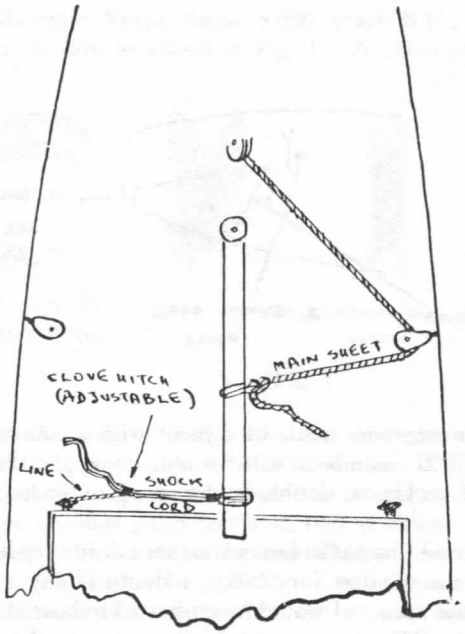

Fig. 1

Now for its operation. You are close reaching across the Channel in your 5 tonner when your shipmate calls " Grub up : Come and get it before it's cold." He himself is busy making some coffee. There is no reason why he should have to act as steward as well as cook. You take the shock cord, loop it over the tiller, and then make sure you are properly on course, and that the sheets are trimmed efficiently. Its line is made fast to the windward cleat. Now for some yachts

this is enough, and nothing else need be done. The helm is lashed. But for others the extra adjustment is required. The mainsheet is cast off its normal cleat, and a bight taken from the end which already leads through the special leeward block. It is made fast about half way up the tiller. Once it is on, a fine adjustment can be made by sliding it along to regulate its pull.

The yacht is now steering herself. If there is a tendency to luff then immediately there is a slackening in the sheet. The shock cord pulls — she bears away. But she will not sheer about : she finds an equilibrium position and forges ahead on it. (Fig. 2).

Come a gust of wind. The sheet hardens and she works up to windward—dare I say it—better than with many a human helmsman.

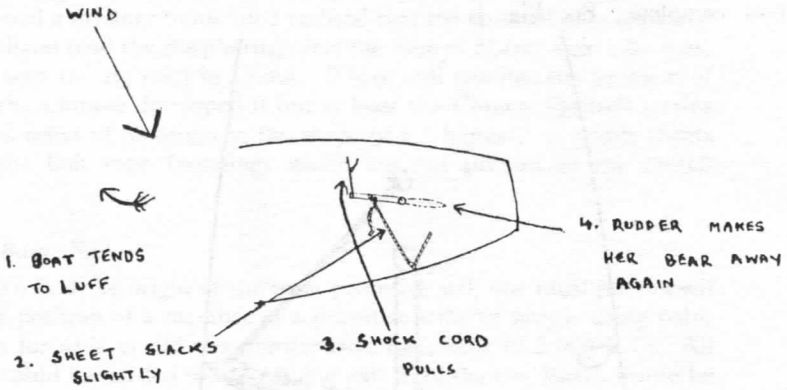

Fig. 2

My experiments were made in a yacht with a counter stern, but I am sure A.Y.R.S. members will be able to apply the idea, with almost identical tackle to double enders and outboard rudders on transoms.

I have not tried this out in heavy weather nor in very light weather. In the latter if the wind is very fluky, I doubt if any system would work, certainly not mine. I would be interested to hear of experiments in strong blows. The crux would be *control* — is the yacht really under your thumb ?

The other problem is running, and I have not dealt with this. Using twin running sails is a completely different subject, and is a well established method of automatic steering. As far as I know Joshua Slocum's SPRAY was the only yacht to run with her fore and aft sails hoisted and the helm lashed.

Meanwhile let us try in the A.Y.R.S. to perfect simple methods of self steering for every point of sailing. PETER C. JOHNSON.

CONGRATULATIONS TO Roland Prout for his initiative in designing and building the resin bonded plywood hulls which were used by Ken Pearse in his double hulled Catamaran " Endeavour " which won the speed trials at Cowes at 14.6 knots. The cover picture shows Roland's first craft using plywood hulls in 1954.

Roland's present Catamaran has been timed at 21 knots and he believes he reached 25 knots on one occasion. Ken Pearse was unofficially timed at 21 knots by the Navy at Cowes in a strong wind and calm water.

The A.Y.R.S. Catamaran consists of one of Roland's hulls fitted with Indonesian type floats, though trials of different types are being made. It seems to be as fast as the double hulled type in light winds.

A.Y.R.S. PUBLICATIONS

List of Publications available at 2/6 each

1. Catamarans
2. Hydrofoils
3. Sail Evolution
4. Outriggers
5. Sailing Hull Design
6. Outrigged Craft
7. Catamaran Construction
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