It is true that the one gun which each boat carries is a very powerful one, but, on the other hand, it is floated in a hull which even boat's guns are sufficient to destroy, so that the mere boats of such vessels as Foo-So and Kon-go would be equal at times to the destruction of these gunboats. The fact that the single gun of these Chinese gunboats is without any power of lateral training would greatly facilitate their destruction by the lightly-armed boats of sea-going ships. No doubt a great deal of offensive power exists in these gunboats, and everything cannot be done in vessels of such small size; still the fact that the guns are without training would under some circumstances, such, for example, as an injury to the exposed propelling machinery, cause these vessels to fall an easy prey to other boats. Moreover, those who know what river service with gunboats in war time is, will not need to be told how often they get aground, even under the most skillful management, especially in tidal rivers and under fire; and when once aground any other boat, though herself aground, would destroy these Chinese boats with the greatest ease by means of their light guns that can fire in any direction. The idea of such boats being qualified for general warfare at sea, or at any distance from a friendly port, is an illusion, and will not bear examination. Their small size only enables them to carry a very limited supply of coal and provisions, and so fixes very narrow limits to the distances they could safely proceed at sea and incur the risk of bad weather arising, in which they could not fight, or of their retreat being cut off by the enemy. Their low speed makes them helpless to fight at sea, except when it best suits the enemy they should do so; their low freeboard of only 3 ft. makes them unable to fight in seas in which the enemy with ships having ports of the necessary height out of water could easily take advantage of their helpless condition and destroy them; while their form and proportion and arrangement of weight is such as to give rise to comparatively quick and uneasy rolling, doubtless causing the firing to be very uncertain and ineffective (even under those favorable conditions of weather which would enable the gun to be fired), as compared with the practice that is made in modern war ships of larger size. These boats can only fight in comparatively smooth water, and within easy reach of shallow water to retreat upon for the purpose of defence; and it is idle to imagine they can ever be effective at sea. They will be valuable for defending rivers and ports and coast lines of a certain character, although even for this they possess, as we have seen, one serious defect, which is that, if running into shallow water, they go too far and get aground, or get left aground by the tide leaving them, they will not be able to train their large guns. These guns cannot be moved about in the boat, and in such cases, therefore, the gunboat would be subjected to the enemy's fire without being able to reply to it except in one direction, which could of course be easily avoided. These small vessels have their uses and advantages and are very valuable in their place, but they are constructed exclusively for certain uses, and are very ill-adapted for any other. The nation that possesses a number of them has a valuable element of defence, but it has not on that account any offensive naval power, or any adequate means of protecting its interests at sea. Aspiring, as they justly do, to real maritime power, both offensive and defensive, the Japanese Government appear to have taken a wise course in building substantial and efficient sea-going ships.—*Engineering.*

HOW TO BUILD CATAMARANS.

By PADDLEFAST.

In the following are full particulars and dimensions how to build a fast, safe, and cheap boat, of the plainest make, or a lighter and more elegant one, as desired, from 25 to 30 feet in length. Technical skill is not necessary, as there is no bending of ribs nor fitting of planks.

A 25 FT. PLAIN CATAMARAN.

The only successful principles in the construction of the catamaran are extremely sharp hulls, and all possible lightness. Hence it is not surprising that a length less than 25 feet is not advisable for these boats, and that the catamaran about to be described will not carry more than two passengers, without detriment to speed and safety. The speed of this boat, under favorable circumstances, is about 14 miles per hour. The approximate cost of materials is \$60. This boat can be used to advantage only in well protected waters.

The two hulls are precisely alike, and much time will be saved by duplicating every stick and board as it enters the hull first built, and laying them systematically away for the construction of the other.

The entire craft is constructed of pine, except the "aprons."

The keel of each hull is of the rocker kind, *i. e.*, curving upward at each end, like the bottom of a surf boat. Placing the keel, about 25 feet long, 2 inches thick, and 5½ in-

ches deep, in proper position, with an upward curvature of 1 foot, we set uprights at both ends, to temporarily represent stem and stern, which are both to be near the vertical. Next, a pair of thin strips, or combination of strips, are tacked to bow and stern and made to describe the curves of the hulls shown in Fig. 4. There are to be 17 frames in the boat, about 16 inches apart. The curve of the strips should be regulated, so that the deadflat, or widest part, is at the seventh frame from the bow. This should also be the lowest point of the keel. The beam between the strips at deadflat is 36 inches. The vertical height from bottom to keel at deadflat to upper edges of strips should be 35 inches. At about a yard from both ends of the boat, the strips may be slightly pressed apart to make a better curve. The sheer given to the strips should not be more than 4 inches.

Fig. 1 gives the deadflat section of the boat. The ribs B are perfectly straight, and are nailed directly to the

keel A, one a little forward of the other, so that one rib is secured against the aft side of the deckbeam C, and the other rib on the forward side.

Now, by placing a stick in the position of B, the lower end against the keel, the upper end against the gunwale strips, and shifting this stick both forward and aft, we can mark out just how much is to be beveled off the lower edges of the keel. By the aid of the strips it will not be difficult to determine the shapes of all the bow and stern pieces, which will be put together as previously described in SUPPLEMENT 30. Fig. 2 shows a section of the boat near bow or stern, wherein the keel fails to afford sufficient nailing room for the ribs B. In this case, however, the bow or stern deadwood, A', is extended to nearly a third of the boat's length to afford a good backing for the ribs.

The temporary framework may now be taken down, the lower edges of the keel properly planed off, and the bow and stern pieces shaped. From this point the builder has no difficulty in replacing the keel in position, setting up bow and stern pieces, which are very much alike, consisting of stem or stern piece, apron (of oak), and deadwood—constructing the deadflat frame, Fig. 1, and the other frames in turn being guided, as before, by the gunwale strips. As the frames are made they are connected by the diagonal braces B, Figs. 1 and 3, the latter being a side-view of boat, the vertical lines representing the frames.

Those deckbeams C, to which the crossbeams D are to be bolted, should be about 1½ x 3 in., the other deckbeams may be 1 x 3, or less. The ribs A should be 1 x 2 in.

After nailing on the deck, composed of ½ inch strips, 2 inches wide, and inserting the bolts intended to secure the hull to the crossbeam D. Fig. 1, the boat is planked up outside with ¾ stuff, caulked and pointed. It must not be forgotten to provide a hatch in each deck, as is shown in Fig. 4, large enough to bale from.

The hulls, when thus far completed, are set perfectly parallel, 11 feet apart from keel to keel. Then to frames 1, 7, 8, 10, and 13, counting from the bows, where the bolts have already been provided, are bolted the five crossbeams D, 2 x 6 in., shown in Fig. 4. On the crossbeams are set edgewise the diagonal pieces E, 1½ x 6 or 2 x 5 in., with end piece E' extending from hull to hull. The space thus enclosed is floored over with ¼ in. matched stuff, after securing the supplementary floor beams F, 2 x 2 in., to the pieces E.

The mast G is stepped midway between the second and third crossbeams, and surrounded by three heavy blocks about 8 inches high, which enclose the end of bowsprit also. The port and starboard blocks are connected by two horizontal bolts, one abaft the mast, passing through the end block there, and one forward of the mast, crossing just over

the bowsprit. The two side blocks are bolted to the crossbeams beneath, also. The bowsprit H is secured to the first crossbeam by the iron strap I'. The bobstays I are attached to the cutwaters at the water line. The mast is supported wholly by the jib-stay and the shrouds I'. The shrouds are carried well back to obtain a firm spread, consequently they are attached to the hulls by blocks and running lines operated from the deck, so that either shroud may be loosened when necessary, to afford sufficient swing to the boom.

The tiller J is about 3½ feet long forward of the pivot, and about twenty inches aft the pivot. The port rudder is several inches higher than the deck, to afford nailing room for the lever L. There is the usual traveler on the stern piece E', with double blocks, as shown.

The best jib is that used on the "John Gilpin" and the "Tarantella," SUPPLEMENT No. 105. The jib-boom projects about 18 inches beyond the end of the bowsprit, to which it is attached by a swivel.

The jib-stay runs to the end of the boom, but is quite independent of the jib. The jib, instead of sliding up the stay with hoops, is simply hoisted by the halyard with double blocks, and hauled taut.

The end of the peak halyard is attached to the gaff well up toward the peak; the halyard is then run through a double block at the mast head, then through a single block on the gaff, again through the double masthead block, thence to the deck.

The stays and shrouds should be wire rope ½ in. diameter. The anchor should weigh 30 lbs.

The mast should be tapered considerably from the middle downward.

The foot needs but very little more diameter than the head.

We will again run over the principal

Dimensions.

Length of hulls over all.....	25 ft.
Beam " " on deck.....	3 "
Draft " "	17 in.
Height " " out of water, at X.....	18 "
Distance " " apart, center to center.....	11 ft.
Length of boom.....	23 "
" " bowsprit.....	16 ft. 9 in.
" " jib-boom.....	18 ft.
Hoist of mainsail.....	16 "
Diameter of mast and main boom.....	5½ in.
" " bowsprit.....	5 "

A 30 FT. CATAMARAN.

The deck of the previous boat is but 18 inches above the surface of the water, and besides a great bulk of hulls is exposed to the action of the sea; consequently it would hardly do for bay sailing. The boat that we have now to do with is intended to be safe, fast, and serviceable in almost any waters, and the combination of simplicity and lightness in construction is unequalled.

This boat, like the previous, is not expected to carry a much greater weight than two persons. The maximum speed will, doubtless, be 18 miles per hour, as that rate has been reached by the "Amaryllis," a catamaran 5 feet shorter, but of lighter construction.

The cost of materials, including sail cloth and rigging, will be about \$80.

The hulls are made just as before, save that the length over all is to be 30 feet, and the height out of water, 12 inches, instead of 18 inches, or, in other words, the vertical depth at the deadflat frame, from the upper edge of the deck-beam to the lower edge of the keel, is 29 inches. The beam on deck is thus reduced to 30 inches. The frames are still 16 inches apart.

As our isometrical scale drawing, Fig. 4, shows, the boat consists of two low hulls connected by crossbeams at intervals, and a passenger deck or car swung midway between the hulls at a higher level than the decks of the latter. This car consists mainly of the sides E, 1½ in. x 6 in., to which the ¾ in. flooring is nailed. The flooring is strengthened by the middle piece F, beneath, 1½ x 6 in. The car is supported at the stern end by the vertical pieces E', which rest upon the rearmost crossbeam. Fig. 9 shows a good method of bolting E' to the crossbeam. The car at the bow end hangs from the junction of the pieces L, which serve somewhat the purpose of shears. As Fig. 7 represents, the shear-pieces L are attached to the rear end of the bowsprit H, by a joint that allows free vertical play. The bowsprit is squared for about 4 inches at the end, and bound by two iron straps carrying rings to which the pieces L are hinged. The forward of these two straps also binds the pendant piece R securely to the bowsprit. This latter is firmly nailed to the end piece of the car on the outside, and a narrow portion of R continues down and is secured to the middle piece F, as Fig. 6 shows.

THE CATAMARAN OR DOUBLE HULLED SAIL BOAT.

To prevent oscillation, the car is secured to one of the shear pieces L by a bent bolt, also represented in Fig. 6; and the space that occurs between the upper edge of the side of the car and the under side of L is firmly blocked up. The shears L are attached to the deck beams of the hulls, by the strap and bolt shown in Fig. 8.

As the backstays I' are occasionally required to be loosed to give the boom sufficient latitude, they are attached to the hulls by blocks and running lines operated from the car.

A portion of the boom is shown at T, and the sheet N is run through a block on the rear end of the middle F, which

and from 18 to 20 inches abaft. The rudders are carried to 8 or 9 inches below the keel and are about 2 feet long.

The diagonal stays F' are attached to the middle piece F and to the last two crossbeams. These, and the other stays $\frac{3}{8}$ and shrouds I, I', F, K, should be $\frac{3}{8}$ inch wire rope.

THE CATAMARAN OR DOUBLE-HULLED SAIL BOAT.—BY PADDLEFAST.

The butt of the mast G should be grooved, so that, passing through the floor of the car, it sets over the middle piece F. The shrouds I are permanently secured in any convenient manner to strong rings or staples in the decks.

should extend about 28 inches beyond the car, and also through a block on the traveler upon the rear of the car. The suggestions previously given on tapering mast, the jib, and the rigging of the peak halyard, apply here as well. The helm J should be about 4 feet long forward of its pivot,

There must be a pump in each hull. The cheapest construction is a square wooden tube about 2½ inches square inside; a loose-fitting plunger of oak, with a ¼ inch hole in the center, covered by a leather flap attached by a brass or copper screw; a wooden rod attached to the plunger by an iron fork.

The first crossbeam D is bolted to the second frame from the bow. The shears L come over the eighth frame from the bow; the second crossbeam D over the ninth frame; the deadlat and the mast also are at the ninth frame. The third crossbeam comes over the eleventh frame; the backstay I' is attached to the thirteenth frame, and the fourth crossbeam is at the nineteenth frame. The car overhangs the fourth crossbeam by about 2 feet 6 inches.

When cruising, the sail may be furled at night, the boom supported at convenient height by the throat halyard and a crutch, and a piece of canvas thrown over the boom and attached to the sides of the car, making a snug tent.

Dimensions.

Length of hulls over all.....	30 ft.
Beam " " on deck.....	30 in.
Depth " " at deadflat.....	29 "
Draft " ".....	17 "
Sheer or rise of keel.....	12 "
Frames apart.....	16 "
Beam from center to center of hulls.....	13 ft.
Shear pieces L.....	3 x 3 in.
Crossbeams D.....	2 x 6 "
Middle piece F.....	11 1/2 x 6 "
Side pieces E of car.....	11 1/2 x 6 "
Diameter of bowsprit.....	5 1/4 "
" " mast and beam.....	5 3/4 "
Length of bowsprit.....	21 ft 6 in.
" " boom.....	30 " 4 "
Hoist of mainsail.....	19 " 3 "
Weight of anchor.....	34 lbs.

A BETTER FORM OF CATAMARAN

may be built by attaching the deckbeams, car, etc., of the preceding boat to full-modeled hulls, *i. e.*, hulls of curved cross-section, thereby obtaining a handsomer and faster boat. This involves an increase in cost of materials of about \$15. The principal dimensions would be the same.

The best form of section of hulls for speed has been determined by numerous experiments, and persons desirous of building a full-modeled catamaran may obtain a "body plan" from the writer at reasonable price.

TOW AND JUTE CARDING ENGINE.

CARDING engines are always described in English feet; thus, we designate ours 5 x 6—that is to say, the drum is five feet in diameter and six feet long. The width of the tables corresponds with the length of the drum, there being three of these, each two feet wide.

On this and succeeding pages will be found views which indicate very clearly the arrangement of the machine, the

action of which we are considering. Fig. 1 is an elevation on one side showing the driving pulleys, the diameters of which in inches are shown by the figures on each. Fig. 3 is an elevation on the other side, representing the toothed gearing for actuating the various parts, the number of teeth in each wheel being indicated by the figures contiguous to

TOW AND JUTE CARDING ENGINE.—FIG. 2.

each, and Fig. 2 is a section up the center, showing particularly the feeding apron, and the relative positions of the rollers, cylinders, etc.

The third doffer is fitted below with a sheet-iron cover, or shield, to prevent contact with the tow arriving by the endless apron. The second doffer is separated from the third by a tin plate. The doffer is placed too high to require any protection.

Another iron cover keeps the carder constantly separated from the roller of the endless apron, which it would otherwise indubitably touch when loaded to a certain extent.

The supports of the rollers, fixed and movable, play a certain part in the action of the engine (see Fig. 1).

Fig. 5 shows the detail of the supports of the axes of the strippers E¹, E², E³; they are fitted with bronze bearings, mounted on screwed rods which pass through the nuts a¹, fixed by means of spiral springs, which are supported by the cast-iron crown which forms the frame (see Fig. 1). By this arrangement the exact height of the strippers and their parallelism with the drum is secured by turning the supports to the right or left, and securing them in position by the nuts already mentioned.

The supports f of the axes of the working rollers F, F¹, F², are arranged and adjusted in the same way. But as these cylinders require at times to be shifted through extremely small distances, each of them is furnished with a small piece of iron, f¹, which moves in a slit in the framework, and, being provided with a screw and two nuts, regulates the supports to a great nicety. The two movable supports, g, of the discharging cylinders G, G¹, G², requiring only to be regulated horizontally in order to keep the proper distances between their teeth and those of the drum, are furnished with small screws, which are moved forward and backwards by means of the nuts g¹, which bear against the fixed pieces. These supports, adjusted on the thickness of the arms, are cast in one piece with the right and left plates of the frame. The intermediary wheels, U¹, R, R¹, are mounted on the pivots, k, fixed by bolts, and forged with a stay, or flange, at right angles, in which is a slit into which the bolt enters, and is thus easily adjusted.

The two supports a² are keyed on to the circumference of the circular part of the frame B¹, and in which the two feeding cylinders a and a¹, Fig. 1, are mounted; the fixed supports at the end of the arm B² are cast with the frame, and in these move in three, on three horizontal axes m, nine cylinders K, which draw the carded slivers; and the cast iron squares n¹, Fig. 2, fixed on the three iron traversers n, which cross the whole width of the machine and serve as guides to the pressure cylinders K¹. The funnels I, which narrow up the slivers delivered by the doffing knives, and the springs of the rubbers y, which are continually cleaning the rollers of the pressure rollers of the take-up cylinders, are supported by the traversers n, of which we have just spoken; these are cast with little brackets, on which rest the thin plates n¹, which serve to support the oblique rods n², which serve again as guides for the slivers, and conduct them under the cylinders L and L¹ of the rotary gills. These, again, have at the extremities of their axes special support b bolted on to arm B², and by which they can be raised.

Finally, in the interior of the drum, to stiffen its axis, are iron stay rods secured with bolts and nuts; in certain cases the bolts get detached, and cause mischief by breaking the points of the screws which fix the wood of the card to the drum; and, on account of the usual construction of the engine, it has to be taken all to pieces to repair the interior; but, in some instances, a manhole is formed in the drum which gives admission to the interior by removing a few pieces.

THE THEORY OF THE CARDING ENGINE.

The tow is first laid out on the endless aprons in such a manner that a given quantity shall always occupy the same space. The aprons carry it to the feeding cylinders, which seize and convey it to the drum, which, turning at the rate of 160 to 180 revolutions per minute, attacks and breaks the fibre and carries it on to the next rollers.

It will be seen by the direction of the feeding rollers that

TOW AND JUTE CARDING ENGINE.—FIG. 1.