Report No. 1 to the Government of India on Fishing Boats

AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 1958
Report No. 1

to the

GOVERNMENT OF INDIA

on

FISHING BOATS

Based on the work of

Paul B. Ziener,
Kjeld Rasmussen

Naval Architects

Rome, 1958
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I. INTRODUCTION

Under an agreement made in 1953 between the Government of India and the Food and Agriculture Organization of the United Nations the Government requested, among other fishery workers, a naval architect

"to advise and assist the Government on problems of boat design arising out of related technical assistance in small craft mechanisation and gear technology".

Mr. Paul B. Zierer (Norway) was appointed to this post with the following terms of reference:

1. To advise on improvements to available boats with regard to design, construction, safety rules and engineering

2. To advise on mechanisation of available boats

3. To design new, improved types of fishing boats

He was especially instructed:

(i) to study Indian fishing craft used all along the coast, in order to get an overall knowledge of the typical boats in operation, and to make measurement drawings of the lines of such boats, especially those suitable for mechanisation;

(ii) to make a survey of the conditions under which the various fishing craft are operated, and to study the manner in which the gear is handled;

(iii) to study local boat-building yards, including repairs and servicing facilities for engines, in order to determine to what degree fishing boats can be built within the country, and whether more advanced construction methods are needed;

(iv) to study the availability of boat-building materials, especially as to quality, sizes, prices etc., of timber and available fastenings, i.e. bolts, screws etc.;

(v) to study sea and wind conditions during different times of the year.

It was emphasised that his main activities should be concentrated on the following:

(a) to give ad hoc advice on the improvement of fishing boats and engine installations, selection of optimum propellers, etc., and on equipping boats with auxiliaries for easier handling of the fishing gear;

(b) to assist in the mechanisation of available boats;
(c) to design a number of new improved fishing boats. These should be designed, if possible, along the lines of existing boats, in order to facilitate their introduction.

(d) to make proposals for improvements in boat-building yards, i.e. equipping them with machine tools and woodworking machinery, with facilities for engine repairs and maintenance etc.

After initial briefing in Rome, Mr. Zioner arrived at New Delhi on 22 September 1953.

The Government of India arranged that the expert should spend certain periods in the following maritime States: Saurashtra, Bombay, Madras, Andhra, Orissa, West Bengal. The periods he spent in the various States up to 15 June 1958 are given below:

<table>
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<tr>
<th>Year</th>
<th>Location</th>
<th>Date From</th>
<th>Date To</th>
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<td>16 December</td>
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<td></td>
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<td>1 May</td>
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FAO/58/10/7991
Central Fisheries\nTechnological Research\nStation, Cochin 16 June - 5 January 1958

1958

Mysore 6 January - 13 April

It was soon found that the demand for advice in this field was more than one man could possibly handle, and in 1955 the Government of India requested FAO to send a second naval architect.

FAO appointed Mr. K.K. Rasmussen (Denmark) who, after initial briefing in Rome, arrived at New Delhi on 29 January 1956. His terms of reference were the same as those for Mr. Zicker. Mr. Rasmussen worked as follows:

1956

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<td>Madras</td>
<td>1 March</td>
<td>1 May</td>
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<tr>
<td>Saurashtra</td>
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<tr>
<td>Madras</td>
<td>19 September</td>
<td>21 &quot;</td>
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<tr>
<td>Andhra</td>
<td>28 &quot;</td>
<td>16 January 1957</td>
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1957

<table>
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<th>State</th>
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<tr>
<td>Madras</td>
<td>16 January 1957</td>
<td>2 June 1957</td>
</tr>
<tr>
<td>New Delhi</td>
<td>3 June 1957</td>
<td>4 &quot;</td>
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The total approximate periods spent by the two experts in the various States is therefore:

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<tr>
<th>State</th>
<th>Ziener</th>
<th>Rasmussen</th>
<th>Total</th>
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<td>New Delhi (Central Govt.)</td>
<td>1 1/2</td>
<td>1 1/2</td>
<td>3</td>
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<tr>
<td>Cochin</td>
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<td></td>
<td>6 1/2</td>
</tr>
<tr>
<td>Saurashtra</td>
<td>3</td>
<td>4 1/2</td>
<td>7 1/2</td>
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<tr>
<td>Bombay</td>
<td>6</td>
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<td>Mysore</td>
<td>4 1/2</td>
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<td>4 1/2</td>
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<tr>
<td>Madras</td>
<td>15</td>
<td>6 1/2</td>
<td>21 1/2</td>
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<td>5 1/2</td>
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<tr>
<td>Orissa</td>
<td>2 1/2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>West Bengal</td>
<td>2 1/2</td>
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<tr>
<td></td>
<td>43 1/2</td>
<td>16</td>
<td>59 1/2</td>
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FAO/50/10/7991
In addition, some 5 months were spent in the preparation of this report- the remainder of the time was spent on leave.

II. SUMMARY

Findings

Indian fishing boats are built in a great many different types and sizes. In some areas, especially the northwest coast, there are fairly good construction facilities for building improved boats. These facilities, however, would be inadequate should there be a considerable development of the fishing industry. Fishing boats already comprise a great investment in the fishing industry, and with more mechanised fishing they will probably represent the largest single investment. The design of fishing boats cannot be looked upon as an isolated problem. It is integrated with the development of all phases of the fishing industry, e.g. the resources, the introduction of new fishing gear, and the development of the markets.

Recommendations

During the assignment, a number of suggestions were made for ad hoc improvements in design and construction of fishing boats. Special emphasis was laid on the mechanisation of existing boats. New types of small open fishing boats, equipped with winches for handling fishing gear, were designed and prototypes were built. Counterparts were trained to design small fishing boats and this indicated the possibilities of training intelligent men, who possess some technical background, in the technique of fishing boat design. The Government subsequently acted upon the recommendation to organise a training centre for such men.

Some Implications of the Recommendations

For success in the Government's efforts to develop the fisheries through the introduction of new types of boats in great numbers, an improvement in the ways and means of financing boat construction, the development of facilities for maintenance of hulls and engines, and of landing facilities, is essential.

III. IMPORTANT WOODEN BOAT TYPES IN INDIA

Hornell (1920), when he investigated the designs of Indian coastal craft, observed a correlation of particular designs with regions of the coast line which are characterised by some clearly marked physical features. The amount of overlapping was insignificant. The prevalent designs of fishing craft are the same to-day in these regions as they were hundreds of years ago. The regions are:

- The north-west coast, comprising Kutch and Kathiaway
- The Bombay coast southward to Mangalore
- Malabar and Kerala
- The Gulf of Mannar
- Palk Bay and Strait
- Coromandel Coast
- Telugu Coast
- Bengal Coast
- The Andaman and Nicobar Islands
Each region has its own boat types, its own characteristics of weather, climate and coast formation. The north-west coast is arid and stony, with physical and climatic conditions closely approximating those of Arabia; Arab boat designs are dominant and characteristic. In Bombay, the same types are mingled with others, Indian in origin, and Southward in the much indented coast that stretches to Goa and Mangalore, the Arab influence is replaced by indigenous and Polynesian types, but revives partially in Malabar where, though the Malayali adheres to the indigenous dug-out design, the Arab type is largely built at those Mapilla centres where the strain of Arab blood is appreciable, as for example at Calicut, Beypore and Pennani.

Turning Cape Comorin, the Polynesian and indigenous boat types have held their own successfully against the Arab. The former influence is found best developed in the north-west corner of the Gulf of Mannar and universally in Palk Bay and Strait; elsewhere on this section of the coast, indigenous designs of catamaran and canoe are well-marked and unusual.

Northward of Point Calimera is the real home of the catamaran, a truly Indian type, specialised for use upon the surf-beaten Coromandel and northern Telugu coasts. Here the catamaran and masula boat must continue to hold their own, wherever there are no harbours of refuge, such as Madras, Masulipatam, Kakinada and Vizagapatam.

In Bengal, the smaller coast craft are variations of Ganges dinghies and of dug-out canoes.

River craft are types apart and, throughout India, are all archaic in their general features, closely resembling ancient Egyptian and Mesopotamian types.

1. **The North-West Coast Boat Types**

Trade with the Persian Gulf and the south of Arabia has existed here from time immemorial, and it is therefore natural to find Arab influence in boat and ship design. Whether in the great kotia, or in the humbler machwa of the fisherman, or in the coasters known as mauris and dhangis, the same principal characteristics are seen. The lateen sail is used. The boats have a great forereaching bow; a deep forefoot and a rakings stern. The machwa is entirely open and undocked, whereas the kotia has a high castellated decked poop and a properly laid main deck.

The universal lateen rig is wider and stouter in form than the loftier and more elegant felucca-lateen of the Mediterranean. The Arab pattern of cutting off the fore angle of the sail is mostly followed, so that a short perpendicular edge or luff of several feet in length is given below the heel of the yard. The kotias, mauris, dhangis, and some of the larger machwas, have both main and mizzen masts. The former is a stout heavy spar, stepped nearly amidships, with a great rake forward to enable it to carry the weight of the heavily yarded sail in the right place. The mizzen is a much smaller spar with a less pronounced rake forward. There is usually only a foresay and a pair of stays on either side. The yard is hoisted by a stout halyard passing from the fore side through a sheave at the masthead with an enormous three-sheave wooden block stropped to the end. The purchase leads to another large four-sheave block placed just in front of the poop.
The builders lavish much skill and care upon the kotia. The bottom, to about the water line, is sometimes coppered, but generally is coated with a white pitch, carried upwards in a wide sweep on either bow. Above this, the hull and the poop superstructure are soaked and scoured after every overhaul with oil of red-brown colouring. The bow is low and unobtrusive. The great kotia is admirably fitted for deep-sea service.

At several of the larger ports of the North-West coast the building of kotias and machwas is an important industry, despite the fact that nearly all the timber has to be imported from the Malabar coast. They are built chiefly at Mandvi and on the Kathiawar coast, e.g. at Veraval. The kotias, ranging from 50 to 80 ft. in length and up to 150 tons in size, trade with Cochin and Calicut to the south and as far as Zanzibar to the west.

Figs. (1) to (3) show a large kotia under construction in Veraval in 1956. The lines of this vessel are, from a naval architectural point of view, quite efficient, and the boat will be able to maintain a relatively high speed with moderate engine power. This was the first kotia built at Veraval to be mechanised, the engine being installed at Bombay. The men building these large vessels could well be used for building fishing boats, if properly supervised.

The machwa is the principal fishing boat type. As "machwa", in the language of the Sind sailor, really means "fishing boat", it is understandable that the boats vary in form and size from place to place and that local names are used throughout the area.

This type is found both in a broader version with transom, and in a leaner, narrower one with a pointed, raking stern. For a typical example of Jamnagar machwas see Fig. (4), and for a bigger machwa built at Veraval, see Figs. (5) and (6).

In some places, such as Varaval, the lean and narrow version is called lodhia and only the broader version with transom is called machwa. The rig of the machwas is mostly the Arab lateen, single masted. The lodhias, however, have two masts with smaller sails of a different pattern.

The machwas and lodhias have recently been built in certain localities in slightly bigger and stronger versions, under the "Grow More Food" scheme of the Government of India. Approximately 120 of these boats were built in 1952-1955 and distributed to fishermen. They are a modified local type boat. Typical examples are shown in Figs. (7) and (8). The main dimensions are:

<table>
<thead>
<tr>
<th></th>
<th>Halar Machwa</th>
<th>Veraval Lodhia</th>
</tr>
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<tbody>
<tr>
<td>Length o.a.</td>
<td>31' - 0&quot;</td>
<td>35' - 0&quot;</td>
</tr>
<tr>
<td>Breadth</td>
<td>8' - 6&quot;</td>
<td>8' - 0&quot;</td>
</tr>
<tr>
<td>Depth</td>
<td>4' - 0&quot;</td>
<td>3' - 9&quot;</td>
</tr>
</tbody>
</table>
They are built of Indian teak (Tectona grandis), and used for gill netting on the Kathiaway coast. Fishing is mostly done by a crew of four, using 8 to 12 nets, in open waters.

The construction methods of the different boat types do not vary greatly. They are built with grown frames, roughly cut. Planking is fastened to the frames by black iron nails, clinched on the inside. A number of longitudinal stringers are spiked to the frames inside. Indian teak is used almost exclusively for planking and other straight pieces, while local-grown hardwood is used for frames and knees. Fig. (9) shows a typical lochlin drying her gill nets.

These boats do not have the complicated planking seam assembly found in the boats further south in the Bombay area. The planking is, however, fitted into a groove in the stem and stern, which prevents the planks springing out, even if spikes holding them to stem and stern rust through. Fig. (10) shows this system.

A specific local type in the Maliya flatbottom prawn fishing boat (Fig. 11). These are primitive craft, double-ended, flat-bottomed and carvel planked. They are built of local wood, mostly Babul (Acacia catechu, rarely Acacia arabica). Dimensions are: Length o.a., 18 to 22 ft.; beam about 4 ft. 4 in.; depth, 2 ft. 2 in.

These boats carry a short mast and a small square sail. Approximately 200 are used for prawn fishing in the shallow backwaters of the Gulf of Kutch. Manoeuvred by 2 or 3 fishermen, they operate stake nets. The cost of the boat is approximately Rs. 500/- (January 1954), and possibly at the time of writing (June 1957) about Rs. 700/- to 800/-. A few boats are mechanized by outboard engines from 4 to 6 h.p.

An experiment with mechanising dugout canoes has been carried out in the Varaval area where, in any dugouts of the Malabar type, operating from the open beach, have been provided with outboards, from 3 to 5 h.p. It is worth noting that the fishermen do not take proper care of the engines, which consequently do not last as long as they would if they maintained with care.

2. The Bombay Coast Boats

Here, within the comparatively short range of 650 miles, from the head of the Gulf of Cambay to Bhalkali at the southern limit of North Kanara, there is a considerable diversity of coast, with a corresponding variety in the coastal craft. These boats show essential differences from the Arab types of the North West coast.

For 150 miles, in the northermmost or Cambay section, shoal water and sandy bottom extend far to sea, and there is not a single harbour that can afford shelter to fishing craft. The estuaries along this coast are also rapidly silting up. The people here combine coastal trade with fishing, which necessitates large boats. The type is a large machwa of carsful construction. There are about 270 in all, ranging from 10 to 20 tons cargo capacity, manned by a crew of eight men. The fish resources in their...
home waters being limited, the great majority of these boats go to the south Kathiawar coast for three months in the fair weather season, and take to the carrying trade when fishing becomes unprofitable. The boats are unmanned, save for a short length at the stern. The stem is sharp and raked strongly, the stern truncate, with a slight rake. As cargo boats, they carry two masts, both with the Arab lateen, and heightened their freeboard by means of temporary mat and bamboo weather-boards.

The mizzen is not stepped when the boats are fishing. A sheave fitted in a slot in the stemhead is used when riding to the nets. The temporary weather-boards are also removed and the boats are stripped to the gunwale to have the advantage of the lowest freeboard possible when hauling their great nets. In all Arab and Western style boats the planking is laid edge to edge, and made watertight by caulking. However, in the Gujarat machwas, built at Bulsar, Billimora and adjacent ports, the edges of the planks are grooved to fit one another closely, and in the grooves are laid strands of cotton and a layer of putty. The latter is made by boiling together a mixture of resin and oil, which is subsequently hammered into a pasta-like mass. The planks are then drawn together by lashings passed through holes bored in adjoining strakes and made taut by means of wedges driven in between the lashing and the planks. When drawn sufficiently tight, long iron nails are driven through the planks and the ribs, the projecting inner ends being beaten down to serve as clamps. At the same time the planks are also edge-nailed. This method of construction makes the repair of damaged planks difficult.

Small open boats of the same general design, of 3 to 10 tons cargo capacity, are used for inshore fishing. They are manned by a crew of three or four.

The larger craft, used solely for cargo purposes in this region - Cambay to Bombay - consist of the battela and the padag. Both may be described briefly as large editions of the Bulsar fishing machwa. Battelas range from 40 to 100 registered tons, and padagos from 30 to 60 tons. Both are ordinarily two-masted, but occasionally a very large battela carries a third mast right aft. Both carry a long jibboom inclined sharply upwards. High-peaked, rather baggy lateens are favoured.

Battela and padag are both square in the stern, which is little raked; the larger battelas have a counter, together with a rudder trunk. All have means for erecting temporary weather-boarding - a feature characteristic of all Gujarat boats, whether they are battelas, padagos or fishing machwas. The battela forms a link between the kotia on the one hand and the more southern pattamar on the other, the stern part of the hull being closely related to the kotia, whereas the rig, particularly in the greater rake of the masts, the cut of the sails, and the presence of a jibboom, resembles that of the pattamar.

3. Konkan Coasters

From Bombay to North Canara and, indeed, as far as Mangalore, an entirely different type of coaster is seen, the pattamar, a design which
is indigenous and influenced only slightly, or not at all, by European and Arab types.

Pattamars are readily distinguished by their great sheer fore and aft, the long curved overhang of the bow, their great beam in the quarters, particularly when, as in the true type, the stern is rounded, and especially by their concave keel. The forecastle and the heak aft are deeper than midships. The two masts have a great rake, the main mast often being nearly as long as the foremast. They carry a long slender jibboom rigged in or out, as required, and, in the largest size, a third short mast right aft. The great relative length of the aftermast is noteworthy. Its sail is larger than in the Arab type boat and, instead of being seldom set when off the wind, - the Arab habit - it is in constant use and figures as a principal and not an accessory sail.

These boats, unlike kotias and baggalas, are essentially coasters and fair-weather craft, hence we find neither permanent bulwarks nor properly laid deck. When required, a temporary bulwark of matting and bamboo is employed, further protection for the cargo and crew being provided by a pent-house structure, thatched with coconut leaves, between the masts. Fore and aft, there is a short length roughly planked over, the remainder being lightly covered with split bamboo laced together and laid on the athwartship beams; it is just strong enough to support a man's weight. The true type is found among the smaller sizes, which come chiefly from Ratnagiri and Rajpur. In the larger sizes, foreign influence is apparent in the transom stern, and in the short raised poop, and in the plain oiled treatment of the hull.

Pattamars are built chiefly at Konkan and Kanarese ports. They range up to 180 registered tons, but the majority are less than half this size.

This type has undoubtedly developed from the large fishing boat still used at Ratnagiri and Rajpur which, in turn, is evolved from a spread and built-up dug-out. The Pattamars has also many points of resemblance to the old style coasting craft of Ceylon, as typified in the Yatradhoni - especially in the character of the bamboo-decking, presence of a jibboom, and in its evolution from an outrigger fishing boat. Comparison enables us to see how far the Pattamars has evolved; the original square sails became a square-headed lug, and then, by reduction of the luff, the Arab lation of the present day. Similarly, the jibboom increased in size and importance, and from the sawn planking a bolt-secured hull has developed. The original primitive form of rudder has been retained completely exposed outside the stern, the tiller fitting over the rudder-head. The palm thatched pent-house cabin is another well-marked feature.

4. Konkan Fishing Boats

The section of the coast from a little north of Bombay and to as far south as Jaigarh or Jaigad, a few miles north of Ratnagiri, is generally rocky, and is provided - except in the north - with numerous good harbours, bays and coves to shelter the fishing boats. The machwas in this section are large for the same reason as those of the Gulf of Cambay.
their need to go far to reach the fishing grounds. A fine sea-boat is a
necessity and, in the larger boats from the ports in the vicinity of Bombay,
the fishermen have adopted a modification of the pattamar type coaster for
operating in offshore waters. A typical 7-ton Bombay fishing mahwa
measures 47 ft. in length overall, with a beam of 11 ft. and depth of 3 ft.
The bow is long and rakish, with great overhang and considerable sheer,
so that the actual keel length is short in relation to the overall length.
It is a shallow and boxy craft with great buoyancy, both forward and aft,
and well adapted to the conditions of the coast.

The rig consists of a large mainmast and small mizzen, both with
considerable rake forwards; the sails are the usual pattamar latoons.

Like its large brother, it possesses a temporary deck which is laid
when necessary. These boats approach the Bombay boats in size, the larger
ranging from 10 to 15 tons' cargo capacity with crews of from 10 to 12 men,
and the smaller from 5 to 10 tons, with proportionately fewer hands aboard.

A good type of fishing boat is that from Satpati. Figs. (12) and
(13) show the lines and construction drawings.

This is a common type also in Versova, Bassain, and nearby fishing
villages. It is in different stages of development, but is generally of
handsome lines, excellent seagoing qualities, and fast under sail. There
are approximately 1,000 such boats, ranging from 30 to 45 ft. overall length.

The mode of construction is seen from the drawings. The hull is
locally built from Sag (local teak) or Acacia catechu, with all curved
pieces (stem, frames, etc.) of Babul (Acacia arabica). The mast and yard
are built of Poon (Calophyllum inophyllum).

Fastenings are of iron. The planking is laid carvel fashion, but
the seams are rabbeded in V-form, and packed with wool soaked in swaist oil
and Singapore resin. Planks are edge-nailed and also nailed to the frames.

These boats are considered the best fishing boat type on the Indian
coast, but they are only used around Bombay. When fishing with bag stake-
nets for "Bombay Duck" and other bottom fish, the sailing boats are manned
by 9 men operating two or three nets. When fishing with bottom gillnets
for Ghol, Dira and Indian Salmon, a crew of 7 or 8 men handle the 60 to
75 nets.

The coat (1957) of a 44-ft. boat with rig and sail is approximately
Rs. 8,000/-, and for the biggest size, 45-ft., Rs. 9,000/-.

About 800 of these boats have been mechanised without great changes
to their original hull form. When fishing with bag stake-nets, the number
of crew and nets is the same as for sailing boats. When fishing with gill
nets, the number of nets is increased to 100 or 110, handled by a crew of
7 men. The range of operation is far greater for the motorised boats,
which is reflected in considerably higher catches.
Bombay harbour shelters a host of smaller single-masted machwas of similar construction, together with still greater numbers of small, double-ended, canoe-shaped fishing boats carrying a single mast and a lateen. All these small craft come under the general name of body, but the men themselves have distinct terms to distinguish varieties which possess some special detail or, more frequently, to indicate the exact work they do. A typical body may be anything from 22 to 40 ft. in length, and 2½ to 6 ft. in beam. The boat, a widened copy of the ordinary West coast dug-out, called tonli in Bombay, built up of planks; indeed, the very small boats are actually dug-outs. An ordinary rudder is fitted to the stern post by lashings, or sometimes, by iron gudgeons and pintles. The stem and stern are curved at about the usual angle adopted in dug-outs. These boats are open but, from the stem to a point just abaft the mast, a weatherboard about one foot high is fitted along the gunwale to keep out the seas and spray. At times they use an outrigger similar to that used by the smaller Ratnagiri boats, to increase stability. Bombay marks the northward limit of the habitual use of outriggers on the west coast of India.

From Bombay to Jaigarh, some 100 miles south, machwas and bodys of the Bombay type continue to be the characteristic fishing craft. The coast from Jaigarh southwards to the Kanaresque border is particularly favourable for fishing, the shore line being indented with creeks and sheltered coves, and with numerous harbours and estuaries which provide shelter for fishing craft and coasters of every size and description. The bottom, right to the shore, is usually sandy, hence inshore net fishing is practised far more than northward of Jaigarh.

Ratnagiri and Rajpur are the two great fishing centres. For deep-sea work, the fishermen employ a bony single-masted lateen-rigged machwa of low freeboard, while for inshore fishing they use outrigger canoes of varied form and size.

The deep-sea boats are of three sizes, and many of them fish for part of the year, usually on contract, on the Kanaresque and North Malabar coasts, regularly sailing as far south as Mount Delhi, and occasionally to Cannanore.

These boats are employed almost exclusively in drift-netting. The two larger sizes are single-masted lateen-rigged open boats, very broad in the beam, with long overhanging bow, round stern and raked stern post. To facilitate handling of the nets, they have comparatively low freeboard; both fit a weatherboard when heavily loaded, and both depend on a single mast and single sail. The smaller of the two large Ratnagiri boats returns daily to port, but the larger, used in deep-sea shark and ray fishing, frequently keeps to sea for several days.

The smallest type of Ratnagiri deep-sea boat is an extremely interesting development of the outrigger canoe. The basis is a dug-out canoe, which, having first been softened, has the sides cautiously and slowly spread by means of wedges till they attain a distinct flare. On the flared edges a series of strakes, also flaring outwards, is raised till
the slab-sided crank dug-out is changed to a beamy and fairly roomy boat capable of carrying a quite heavy load of fish. A single outrigger is rigged in the usual manner and the boat carries a latoon sail.

All these boats carry a very small outrigger canoe as not tender. In this canoe, the original dug-out is left unspread; it can readily be dismounted, and therefore can be easily taken aboard and stowed.

The larger boats have evidently been modelled upon the built-up canoe form, the outrigger being dispensed with as soon as increasing beam gave sufficient stability.

The Ratnapuri and Kanarese pattamar coasters are, in turn, cargo carriers designed on the same general lines. The Ratnapuri type of single-masted fishing machwa and two-masted coasting pattamar exist side by side with outrigger canoes, built-up outrigger boats and ordinary creek dug-outs, but after Malwan, a little to the north of Goa, the Ratnapuri machwa dies out completely, most of the fishing being done by outrigger boats and canoes, and operations being confined almost entirely to the inshore waters. The largest outrigger, the rampan is used in beach seaweed. This is merely a long, deep, widely-spread canoe-shaped boat fitted with an outrigger to give stability. Stem and stern are nearly similar, no mast is carried, the boat being rowed as the net is shot.

South of Goa, the number of true dug-outs employed in fishing rapidly increases, and boquy dug-outs are very numerous especially at Kumpta, Bonavar and Mulki. They are the same as the odam dug-outs of Malabar. They are of considerable size, from 1 to 3 tons' load capacity, and each normally carries a crew of 8 men. In South Kanara these canoes are still more in evidence, whereas the outrigger boat is seen only in the case of the rampan boat, which is of comparatively recent introduction on this section of the coast. The murdeshwar boats are similar to the more northern machwas, about 35 ft. in length and therefore somewhat smaller. Little is to be learned from a study of other craft of the Kanarese fishermen. Either they are outrigger boats borrowed from their northern neighbours, or primitive dug-outs from the south.

5. **Malabar and Kerala Boats**

The dug-out, and its counterpart in planks, have the field entirely to themselves in this long stretch of coast from Cannanore to Quilon. The former is a beautifully fashioned craft, the latter—like the Mangalore lighter—rather ugly. The dug-outs are more numerous, and while they range in size from a tiny one-boy canoe to the big odam with crew of eight, the plank-built canoe is usually of the large size only.

There is little variation in type. None is provided with a rudder, steering being effected by means of a big paddle on one quarter, used for propulsion as well as control. For have a sail; when they do, it is either a small square one or a spritsail.
Fig. (14) shows a small Malabar dug-out. These are made along the Kanara coast, and exported in great numbers from Calicut and adjacent ports to other States on the west coast and even to Aden and East Africa. They are used both for creek and inshore fishing, driven by cars and, occasionally, by a small sail. They have no rudder. Cast nets, hand lines, and bottom gillnets are used from these dug-outs and in certain districts, small shore-carts. Sizes vary from 12 to 40 ft. and more, typical sizes being 20 x 1 ft. 8 in. x 1 ft. 6 in., and 24 ft. x 3 ft. x 1 ft. 6 in.

Scooped out from a single log, they are mostly made of Mango wood (Mangifera indica), Jarval (Parkia unduliflora) or Jungle Jack (Artocarpus hirsuta). As big logs are getting scarce, the quality of recent dug-outs has declined, and it is rare to see a new dug-out which is not patched in several places. Prices have also greatly increased; they vary according to size and distance from site of production. Costs are: in Calicut, Rs. 450/- to 900/-; in Kollam, Rs. 800/- to 1,600/- (June 1957).

The logs, partly scooped out, come by river from the interior forests and the finishing work is done on the coast by boat carpenters. Production of these boats is on the decrease, and it is foreseen that the industry will lose its importance within a few years. The total number of such boats is probably about 9,000.

Figs. (15) and (16) show a larger Malabar sailing dug-out. It is used for sea fishing on the Kanara and Konkan coasts, and consists of a dug-out more than 20 ft. long, provided with one strake (rarely two) of planking for raising the free-board. Wider than the common paddling dug-out these boats are especially shaped for carrying a fairly big sail. Cars are used, up to 10 in number, plus a steering car. The size of a typical boat is: Length, o.a., 32 ft.; length outside rabbit, 30 ft.; extreme beam, 4 ft. 2 in.; depth (inside), 2 ft. 4 in.; sail area, 176 sq.ft.

The number of such boats is probably 700. They are used for handline and longline fishing in open waters, and for carrying catches from the rampan nets to shore. In certain parts they are also used for drift nets and small shore seine.

The life of these boats is very long. Some have been in use for more than 100 years, and are still good. The bigger dug-outs of up to 40 ft. length are mostly made of Mango wood (Mangifera indica). The plank strake on top may, however, be Jack (Tectona grandis). The cost of such boats ranges from Rs. 1,800/- to 3,000/- (June 1957).

Beach lighters, the equivalent of the masula boats of the East coast, are again mostly flat-bottomed enlargements of the plank-built fishing canoe, but the large cargo lighters, which have often to carry cargo to steamers in the outer anchorage at Calicut, are sea-worthy craft roughly reproducing the Arab features of raked bow, deep fore-foot, sharp raking stern and large latten sail. They are undocked, without poop, and are indeed but large editions of the single-masted Bombay machwa.

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In South Malabar, in Cochin and in Kerala, where an extensive inland water trade exists by virtue of the great network of backwater channels in the low footland skirting the Ghats, particularly fine dug-outs are employed. Compared with the coast canoes, they are wider and more roomy; that they are not used on the coast is due to their great weight, which would prevent easy beaching. They are undecked, but cargo and passengers are securely protected against rain by an arched roofing of cadjans made partly in sliding sections for ease in loading and unloading.

The Malabar shipwrights are renowned as among the best of their craft in India, so much so that they are in demand as foremen shipwrights in the building of lighters, schoonors and brigs at every shipbuilding centre on the south-east coast from Tuticorin to Negapatam.

6. Gulf of Mannar Region Boats

The dug-out canoe finds its supremacy challenged as far north as Quilon by small catamarans of primitive form, constructed of 4 to 5 logs tied together raft-fashion. From Quilon southwards both forms of craft exist side by side as far as Colachel, where catamarans of improved form - "boat-catamarans" - appear, and finally ousted both the dug-out and the raft catamaran. Between Colachel and Cape Comorin the coast is particularly exposed and surf-beaten throughout the year, and is also bare of any landing place suitable for dug-out canoes. Beyond the Cape the same form of catamaran is numerous for over 100 miles, ending only at Mukkur in the Ramnad district. Many fishermen also use a second type of craft - the "boat-canoe" - which consists of a Malabar dug-out spread by wedges and heightened by flared 9-10 in. wash-strakes. The two types exist side by side, save at a few very exposed centres, such as Cape Comorin, and both are worked exclusively by Parawas. Nowhere else in India is either type found. The boat catamarans vary little in size (Fig. 17). They are normally worked in pairs, one usually being slightly longer and wider than the other. i.e. 23-ft. long by 3-ft. wide, as against 20 3/4-ft. by 2 1/2-ft. The central log of the three of which they are made is the stoutest; all three are shaped and fitted together in such a way that the central log fits keel-wise at a lower level than the other two, which rise sufficiently high to form a trough-shaped hollow. At each end, the logs are planed flush on the under surface to give an easy entrance. The three are held in position by a transverse two-horned block of wood at either end, where the logs are fastened securely by coir ropes passed through grooves cut in the sides of the logs. Usually two men form the crew, using short lengths of split bamboos. In this they differ from the Coromandel catamaran men who use broad-bladed paddles of two designs. When paddling, which they do as seldom as possible, they frequently stand up, spooning the water rather than rowing or paddling.

Unlike Coromandel catamarans, the logs are kept permanently fixed together; they are neither painted nor oiled.

A small triangular-type sail is used to carry the craft to and from the fishing grounds. This is fitted to the head of a diminutive spar, 10-ft. in length, set up with a strong rake forward right in the bow, i.e. at the end which functions as such - both ends being almost identical. A light bamboo yard of considerable length (34-ft.) carries the tanned cotton sail (Fig. 18). Mast and sail are common to each pair of catamarans, the mast being stepped in the larger craft, while the sheet is led to the stern of the smaller one, the fore end of which is lashed to the other. The two craft
do not lie quite parallel to one another when sailing, but diverge slightly aft. This particular form of catamaran appears to be favoured on this coast rather than the wider craft seen further north, as affording greater stability on the short cross seas that prevail in this region. On the other hand, the great surf rollers that are frequent over long stretches of the Coromandel coast can be ridden over much more safely by a wide raft than by a heavy, deeply keeled craft. The Comorin and Tinnevelly coast is also fairly well dotted with little coves and bays, which give just enough security, even in bad weather, for the safe beaching of these catamarans.

Catamarans are used almost exclusively when fishing with the madi valai. This deep-water net or boat seine is shot from two partner catamarans across the path of shoaling fish. The almost total absence of freeboard in the catamarans enables this net to be hauled with an ease not possible in high freeboard boats.

Boat-canoes are used exclusively for other forms of fishing on the Tinnevelly coast. They are termed hallams or vallams, similar to the terms used by Arabs for dug-out canoes and boats of canoe form - long, narrow and keelless.

The essential differences between these canoe-boats and the ordinary Malabar dug-out is that the original dug-out has been spread and its sides raised, so that considerable stability is acquired. These boats are designed primarily for sailing, and in a fair wind they have a good speed. Close hauled, they perform badly because they lack keel, having retained the original, rounded bottom of the dug-out.

The mast is of medium height and is fitted nearly amidships. The rig is a single short and wide lug, not unlike the square sail from which it is clearly derived. Except in the larger types, no mizzen is carried. Owing to the high freeboard and the low thwarts, good stability is obtained. A large rudder is employed, fitted with gudgeon and pintle; it descends considerably below the rounded bottom and thus, to some extent, reduces the disadvantage of lack of keel. It is strange that the use of a leeboard is unknown or unpractised.

There are various sizes of these vallams. The largest, about 40-ft. long, having crews of 7 or 8 men each, are used in line fishing, 7 to 10 miles off shore; a slightly smaller size, about 27-ft. long, is used in off-shore drift netting and by divers engaged in the chank fishery, while still smaller ones are used for inshore line fishing and netting. At Tuticorin, some of the largest size are used also to carry stone.

The bulk of this work is however done by large plank-built boats, constructed on similar lines. Average dimensions are: Length 34-ft., beam 6½-ft., depth 2½/4-ft., with a load capacity of about 2 tons. Usually they have the same rig as the dug-out type, but when on a coasting voyage they generally fit a short mizzen carrying a small lug.

A fine fleet of sailing lighters and coasters has been created at Tuticorin. When coastal steam traffic developed about the middle of the last century, several square-sterned sailing lighters of English lines, rigged as small schooners with fore and aft sails and jibbooms, were brought to the port. The trade apparently was lucrative because some of the local
boat-owners began to build other lighters. They rejected the English model which was unhandy in going alongside steamers; instead, they followed in simplified fashion the lines and rig of the Arab buggalas which at that date regularly called at Tuticorin. The boat-builders, while adopting the raked stem and stern and lateen rig, made both stem and stern sharp. The model did not serve over-all and gradually the rake of stem and stern was reduced till to-day both are almost vertical and the mast, instead of being raked forward, is now raked very slightly aft and is fixed at about one-third the length from the bows. The present-day lighter appears as though it had evolved directly from the plank-built canoe used in the coral-stone trade, which is untrue, as shown above. Originally the Tuticorin lighters introduced by English firms were known locally as "boats" (boatu), but now the vernacular term of dhoni is used.

A typical Tuticorin fishing boat is shown by Figs. (19) and (20). About 400 of these boats are in use. They are long and relatively narrow, with nearly vertical stems and sterns. The sheerline is almost straight, and both ends of the boat are sharp. The hulls are easy to build, and local grown, curved wood is readily available at low cost. A peculiarity in their construction is that the frames are not carried up to the gunwale, but cut away at the sheer plank. This uppermost plank, which is very broad, is framed with a separate, short piece not fastened to the main frame, and mostly at some distance from it. One mast is carried, and the sail is a sort of lugger, not found elsewhere. It was developed locally, like the lighters.

A typical boat has the following main dimensions: Length o.a. 29-ft., breadth 6-ft. 3-in., depth 2-ft. 11-in., reg. tonnage 2.9, and sail area 330 sq. ft.

The boats are locally built of Bunkeak (Lagerstroemia lancelolata), and Portulaca (Theophrasia) is used for the grown, curved wood of stem, stern and frames. Fastenings are of iron.

About 130 boats use driftnets and have a crew of 5 to 6 men. About 100 boats are used for handlining and trolling, and are manned by 7 or 8 men. Sixty boats are employed in pearl oyster diving.

The cost of a boat, including rig and sail, is about Rs. 2,000/-.  


The fishermen of Kilakarai and the neighbouring villages on the south coast of Ramnad district, at the north-west corner of the Gulf of Mannar, constitute the main diving force in pearl fishing in Ceylon waters. This may have determined the outrigger canoe as the type of boat to be adopted for general fishing purposes. The true Ceylon outrigger is largely used for trolling, the boats being imported from Ceylon. Those used in other methods of sea-fishing, while adopting the outrigger principle, are modified in several details for more general use.

Two varieties of these modified outriggers exist, the one using a single pole to the outrigger, the other rigged with the normal two. The hull is a simple Malabar dug-out canoe, usually with a narrow wash strake added vertically - not flared. The rig is a simple squat lug sail similar to that of the Tuticorin fishing canoe. No attempt is made to spread the canoe, so
it can be used without an outrigger only in calm weather. The outrigger is smaller than the Ceylon type, and boom pole or poles are weaker; each consists of a single pole without fascine strengthening. A very simple device enables those outriggers to be unshipped instantly. They can be rigged out on the other side of the boat, thus avoiding the dilemma of the Sinhalese who can never say which end of a canoe is the head without looking at the direction in which they are sailing! The Kilakarai boats can therefore employ a rudder. The device for attaching the booms inboard on the one side, and to the outrigger on the other, is a form of the Spanish windlass, normally used for bending a plank into position and holding it there until secured. In the present instance, the loop end of a ring of rope or grommet is passed through a hole, either in the gunwale or in the outrigger float, the boom pole is laid over this, and the looped ends of the grommet are brought up at each side and over the pole; the end of a short rod or stake is passed through the two loops, and then by the simple device of twisting the two loops round one another by means of the rod, the two main parts are bound together with the greatest possible tightness. The free end of the locking rod is then seized to the gunwale or the boom, as the case may be, and if the various parts are sound, this lashing will maintain attachment under any ordinary violence. Its chief advantage lies in the rapidity with which it can be operated. A couple of seconds suffice to release the boom, and scarcely more are required to reship it.

Large carvel-built boats, long and narrow, designed on the lines of a dug-out canoe, are used for pearl-fishing. They accommodate many men and, because of their length and narrowness, are easily rowed. Both ends are sharp.

In and around Pamban, a typical carvel-built boat called Rameswaram or Pamban type "Machwa" is found, at present essentially a carrier boat, with raised bow, transom stern and high freeboard. The boat is heavily built with low draught for landing on the coral beaches, and it is propelled by a standing log very similar to that used by the Tuticorin lighters. The mast is carried straight, at approximately one-third the length of the boat. This type of boat would probably be very close in general appearance to the transom stern boats FAO is trying to introduce into South India. Much work remains to be done in the way of mechanising the design and adapting it for fishing purposes.

8. Palk Bay and Strait Boats

The region from Pamban to Kuthupat has a very distinctive type of fishing canoe. It comes into the class of outrigger canoes, but instead of stability being obtained by a float boomed out on one side, the outrigger consists of a long heavy plank, laid athwart a dug-out canoe or a carvel-built boat (both are used), so that each end projects outboard a considerable distance on either side. By loading the balance board on the weather side with one, two, or three of the crew, a very efficient counterweight is obtained.

Two main varieties exist, the southern form, used from Rameswaram to Ammapatnam, halfway up the west side of the bay, and the northern one,
seen chiefly at Adirampatnam, Muthupet, and the neighbouring villages on the northern shore. The hulls of the former may either be dug-out canoes or, when large, carvel-built plank boats of the same general form. The rig is a square-headed lug, set on a mainmast stepped a little forward of amidships. The outrigger consists of a long plank of heavy palmyra wood, stayed only by a shroud on either side, led to the mast-head (Fig. 21). In any but the finest weather the lee shroud is transferred to the weather side of the outrigger plank which then has two shrouds—one at the far end, the other some distance inwards. At the same time, the lashing of the plank is loosened and the plank is run out some distance further on the weather side, giving a lop-sided appearance, but increasing the counterpoise leverage. The shrouds give grip to the men stationed on the weather end of the plank.

In the northern varieties, the hull is usually narrower and longer, generally with a quaint three-masted rig unique among Indian coast craft. The longer types, called vela vathai, are found at Muthupet, and, instead of being dug-outs, are narrow carvel-built boats of canoe form (Fig. 22). The average length is 43 ft. with beam of 4½ ft. and a depth of 2½ ft. The crew usually consists of five men.

Of the three masts, the short foremost (13½ ft. long) is stepped right in the bows, the mainmast of 22 ft. a little forward of amidships, and the mizen (14½ ft.) fairly far aft. Only the mainmast is furnished with stays, one on each side to the projecting end of the balance board and one aft. The masts are square-headed lugs. The balance board, kadiyu, about 17 ft. in length, is a plain plank, as in the southern forms; depending on the weather, some of the crew—in emergency all four—stand outboard on the weather section to prevent capsizing. The bottom is rounded and is without a protruding keel because of the shallow home river. Leeway is counteracted by a large leeboard. With a good wind, these long narrow boats under full sail are accounted the swiftest in these seas. The rudder is large and powerful, attached by pintle and gudgeon at the lower end by a coir lashing below the tiller. Nearly 200 of these boats are used in not fishing from Muthupet and the adjoining villages.

At the neighbouring port, Adirampatnam, the fishing boats are generally shorter. The majority are dug-outs fitted with wash-strakes and balance boards and, while they occasionally use three masts as at Muthupet, they usually employ the mainmast only: (Fig. 23) less frequently they also have a mizen. The characteristic features are the use of a pair of quarter steering-boards instead of a fixed rudder, and a compound balance board. The former have the shape of lee-boards. One is attached on each quarter by a loose lashing passed under the end of the sternmost thwart. The steersman sits right aft, on a short decked space, and manipulates the quarter steering boards with his feet. The sea is very shallow and muddy for a long distance from Adirampatnam, which makes trouble over the use of a fixed rudder, hence the survival of a peculiar variation of the quarter paddles used before the invention of the fixed rudder. In addition, a leeboard is used.
The balance board or kudau, is exceptionally long. In the largest
boats, which run to 37 ft. in length, it is fully 34 ft. total length.
Unlike all the balance boards hitherto described, this type consists of
three sections. A median portion, 19 or 20 ft. long is laid athwart the
boat immediately in front of the mainmast, with a terminal flattened or
bladeshaped section 6 to 7 ft. long, added at either end. The latter is
thinned and broadened at its further end, and slightly twisted, so that
the forward edge is depressed a little. The splicing is done by over-
lapping the ends, which are secured in place by (a) a stout square peg
passed through both in the centre of the splice, and (b) a rope lashing
tightened by means of a Spanish winch. Usually two side stays pass from
the mast-head on each side to the balance board, one being attached a
short distance outboard, where the terminal blade is spliced to the main
plank. In others, only one stay is used on either side. In all other
boats, the balance board is heavy and straight. Here it has a droop down-
wards on either side. Its position is permanently fixed, and there is no
jockeying with it in rough weather beyond the loading of the weather
section with one or more of the crew. All the attachments of the balance
boards, both to the gunwale and to the blade terminals, are made by means
of the looking device.

The plank-built omoes, palagai kattu vattai (Fig. 24) are made
almost identically to the dug-outs. Sometimes, they have a second and
shorter balance board, about 7 ft. long, abreast the mizzen mast. This
has no stays leading to the outboard ends, and the crew never perch upon
the weather end, as they do on the main board. Even this is less loaded
with men than with other weights. The principle of the balance pole is
here most perfectly utilised.

The dug-out form is fitted with a high wash-strake, about 9 in.
deep, down to the slightly tumble-home edges of the dug-out gunwale.

There are about 90 of these boats in Adirampatnam, 60 being dug-outs,
the remainder plank-built. The size of the latter ranges from 18 to 37 ft.
with a beam between 2 and 3 ft. and a depth of 2½ ft. Very light draft
is necessary as long stretches of mud have to be passed before the shore
is reached. Usually, each boat has its own channel and at low water these
long channels, 2 to 3 ft. wide, make the mud flats look like a great railway
yard with many sidings.

Kodikarai is an important fishing centre, an easy distance from the
good fishing grounds of Falk Strait. The cobble, a heavy transom-sterned
boat, is used in fishing. It carries the largest and heaviest of any
balance-board surviving in India (Fig. 25). The local name is kalla dhoni,
which means "thief-boat". The explanation is that, "like a thief, this
boat runs very fast".

The hull has fairly heavy bows. Aft is a low decked-in poop, a foot
or so higher than the freeboard. The transom stern is nearly vertical;
the large rudder is hung on a built-out stern post, heavily strengthened
with stout battens, to a distance of about 4 ft. Three square sails are
carried by three masts. The very short foremast is fixed, without stays,
right in the bows, with a well-marked rake forwards; the mainmast and the mizen mast are almost vertical. The outrigger is of the balance-board type seen in the southern Falk Bay fishing boats, though relatively much shorter. It consists of a heavy palmyra plank laid athwart the gunwales. It projects a few feet outboard on each side.

9. Coromandel Coast

Along the whole of the west coast, the true catamaran is the characteristic fishing craft. Except for some 1,400 big sewn-plank boats (casula boats) used in shore line fishing on the Madras coast, 1,000 nasula or palava boats in Andhra-Pradesh, and various forms of backwater and river boats which only occasionally venture seawards, the catamaran is dominant from Cape Calimere. The surf-beaten, sandy coast that runs with few interruptions from Pondore to Orissa scarcely knows any other sail but the brown triangle of these non-going rafts. Their Tamil name — kathu marum, or "tied logs", has become an English word. It is estimated there are 11,000 catamarans on the Madras coast and 17,000 on the Andhra-Pradesh coast.

Apart from the boat catamaran in the extreme south, two distinct types of catamaran exist, the finer and more elaborate model being found on the Coromandel coast, from Cape Calimere to the delta of the Kistna, and the other somewhat more primitive type further north.

The general type consists of a variable number of definitely shaped logs of definite relative proportions, tied together raft-wise. To these main elements are added a number of accessory pieces in the shape of stem points and, sometimes, a rowing-rail.

The Coromandel catamarans possess very considerable elegance in their proportions and lines (Fig. (26). The best developed form is seen in the large mariva marum used in fishing with the thuri, edu and paintha vilai nets. This catamaran consists of four long, and narrow logs, carefully fitted together, side by side, and securely lashed in position fore and aft. The middle pair project aft about 4 ft. beyond the outer logs, forming a conveniently narrow place for the paddling steersman who squats between the soles of his feet which are stretched backwards straight out along the plank. At the fore end where the four planks end at the same level, the outer two are worked down laterally leading forwards, and the end is then finished off in a sharp, upwardly curved prow by the addition of two narrow wedge-shaped stem pieces. The total overall length is 25½ ft. with an extreme breadth of only 3½ ft. (Fig. 26 a and b).

A rowing rail made of two bamboo is fixed along the port side in the following manner. The fore ends are inserted under the lashing around, and securing the fore-ends of the logs, while the after ends are secured loosely within a ring of rope passing also around the outer plank. To maintain the bamboo rail at a proper height, a plank stretcher, 10-in. high
by 8-in. wide, shaped on its lower edge to fit the curved contour of the catamaran log, is wedged upright. To prevent wearing through of the bamboo rail, a short length of stake is lashed on the rail. In this are two coir loops to take the rowing paddles. An ordinary crew consists of three men but, on occasion, an extra man may be carried. In this case, two row on the port side, one paddles forward on the starboard bow, while the steersman squats at the stern, plying his paddle right or left as required. The rowers each have a little transverse seat, resting loose in a groove on the bottom of the catamaran.

When using the thuri valai not proper to this type of catamaran, a second and smaller craft, called chirna maram (small logs), is required to assist. This is of simpler design, consisting of 3 logs only with a single beak-shape stem piece. The middle plank projects aft beyond the others by 70 cm foot and a half. There is no rowing rail. The overall length is 21-ft., the width 2-ft. 4-in. The crew consists of two men.

When there is a favourable wind, the larger of the pair of thuri valai catamarans puts up a small lateen sail rigged in the manner already described for the boat catamarans of Cape Comorin. As with the latter, the smaller of the pair ties up alongside the larger one, which alone carries mast and sail.

The irukka maram (Fig. 27) variety is chiefly used in drift net fishing. This is very similar to the periya maram, but consists of five logs instead of four, the middle or odd log being the longest, projecting a some distance beyond the inner lateral log which, in turn, projects beyond the outer lateral pair. The stern ends, therefore, in a series of steps. The beaked prow is formed of three stem pieces, on which is hooked a single-fluke wooden anchor with stone-weighed shank. A rowing rail is present and mast and sail of the usual type are fitted. This variety is used singly and not in pairs or double pairs, as in thuri valai and edu valai fishing.

A simpler and shorter form, constructed of five logs, without a beaked prow, sail, or rowing rail, is used in line-fishing, and is called thundil-maram or "hook-catamaran" (Fig. 28).

The largest form of catamaran used on the Coromandel coast is the great kolamaram or "flying-fish catamaran", found chiefly along the shoreline of the Tanjore district. In operation only during the clear-water season of July and August, it is more of the primitive raft and less of the carefully designed sea-craft than any of the beaked forms already described. For construction, two or even three periya marams or erukka valai marams are untied and usually seven of the longest logs are selected and tied side by side, rigidity being obtained by lashing two cross poles over each end. A stem is formed, as in the periya maram and other forms, by lashing five stem pieces at the fore end. Two short masts, each hoisting the usual triangular catamaran sail, are stepped in holes in the outside log of whichever side happens to be leeward, one forward, the other two-thirds aft. Then, with sails hoisted, this craft, manned by seven men, boldly ventures out of sight of land, heading for the kala pani outside of the 100-fathom line, in search of shoals of flying-fish. The amount of food and water taken is exceedingly limited, and if no shoals appear within the first day, the men are obliged to turn and set a course for home. Sometimes they
make such an amount of leeway, in spite of the use of two large leeboards, that they reach the coast 20, 30 and even 50 miles to the north of their port of departure. If they happen to have a haul of fish aboard, it is by this time fit only for manure.

Besides the catamaran and teppalu, there is the so-called masula boat, known as padagu or salangu, a large open boat used in shooting shore seines and also as a cargo lighter among Coromandel fishermen. Its range extends along the whole of the east coast northwards of Cape Calimere. On the Coromandel coast, it is short in proportion to its beam and depth; a rather small example measured at Pondicherry was 28-ft. long, 8-ft. beam and 4-ft. deep. In the Vizagapatam and Godavari districts, the boats frequently range to 40-ft. and more, with beam and depth about the same as in the southern districts. As the masula boat never goes far from shore, mast and sail are not used. A crew, varying from 8 to 12, provides the motive power with paddle-sweeps not less than 12-ft. in length. Steering is done with a very long and powerful sweep, 14 to 15 ft. long, suspended in a coil grommet from the projecting head of the stern post.

These boats have no frames and floors, and the planks are joined together and stitched with coir yarn, with strips from stalks of palm leaves placed over the joints inside to make them watertight. Transverse stiffness is provided by a number of 2$\frac{1}{2}$ to 4-in. round thwarts, and occasionally by small fore and aft decks.

No iron is used in the hull. A narrow keel, 4 to 5 in. high, projecting about 2-in., is usually used. There are no bulkheads; stem and stern are raked considerably, and both are somewhat bluff in their curves. Freeboard has to be very high, as the boats have to pass through heavy breakers and, in consequence, the loads they carry are light in relation to their apparent capacity.

10. **Telugu Boats**

Another type of catamaran or teppalu (which is the Telugu word for rafts) is in use north of the Kistna and Godavari deltas entirely by Telugu fishermen. This type is best developed in the region north of Kakinada. The teppas here are up to 22-ft. long with 4-ft. 6-in. beam, made of four logs, the bottom logs being up to 20-in. in diameter.

The washboards along the sides have a height of about 13-in. amidships. These teppas are similar to an open boat in outward shape, with their rounded bottom logs and the washboards pointed towards, and joined nicely, to the pointed beak-piece at the fore end. They give good protection to crew and catches and go comparatively far off the coast. Triangular sails are used as for the Coromandel catamaran, with the mast stepped 1$\frac{1}{2}$ to 2-ft. abaft of the stern piece joint. Near the aft end, the central log or logs are provided with slats or protruding planks to hold balance or lee boards. Paddles 5-ft. in length are used in calm weather. Logs and washboards are tied together by coir ropes. When the teppas are beached they are unlashed for drying, mostly in two, occasionally in three, pieces. The washboards, however, are never unlashed from the side logs. Further north in the Trikakulam district the teppas are not so well developed. The length here is from 14 to 19 ft., beam from 2$\frac{1}{2}$ to 3$\frac{3}{4}$ ft. Cheaper varieties of wood.
are used, and the thickness of logs is less than 16 ins. This is probably partly due to the risk of damaging the logs on submerged rocks. The washboards are only 3 to 4-in. high. A catamaran from the Ganjam coast is shown in Fig. 29.

This type of boat attains its greatest development, both as regards size and economic importance, in the seining masula, which works in some districts around Vizagapatam. Here it is considered the most valuable asset of fishermen, as these men have vigorously developed the use of the shore seine and, without roomy boats, would be unable to carry and handle the great length of net requisite to effect large-scale operations.

The craft are very cheap to construct and repair as they require very inexpensive material. When a plank cracks, holes are simply drilled on either side of the crack, and stitched with palm leaf stalks.

There are about 1,400 masulas along the Madras coast and 1,000 along the Andhra-Tradesh coast. They cost between Rs. 300 and 1,100 (1957) depending on size, quality of wood, and local labour costs.

Next to the catamarans and the masula boat, the navae form an important class on the East coast. About 600 navae are used by the fishermen of the Godavari Delta in the area around Masulipatam. There are another 1,100 navae operating in the East Godavari district at Kakinada.

Fig. No. (30) shows the sail plan of a 31-ft, 10-in. Masulipatam navae (Fig. 49, Ch. V, A. (h) (i). It shows a typical construction plan.) The navae are used for drift nets, bottom set nets, and for long lines and stake nets.

This type is a striking example of the ingenuity of Indian boat-builders in developing boats for difficult shallow water conditions. It is a shoal draught, very narrow and keel-less sailing boat, built without much variation to the following measurements: Length o.a. 31-ft. 10-in., breadth 5-ft., depth 2-ft. 4-in., reg. tonnage 2.7.

The keel-less, rockered bottom, with rounded bilges, is excellent for navigating by sail, paddles or poles through shallow backwaters and muddy passages. It is also strong enough to land the boat with full load on hard sand-beaches, even in surf.

Locally constructed of Godavari teak, the boats have heavy framing and strong longitudinal stringers in three or four places on each side.

They are fast-sailing boats. Two masts are used in order to accommodate the lateen sails and keep the centre of gravity of the sails. The main sail has a high peak to catch the wind above canal and river sides when navigating in the delta where only a mainsail is used. A leeboard is used.

Fig. (31) shows a typical Kakinada navae. The crew usually consists of 4 men, but varies with the type of gear. The gear itself also varies much in size and number according to the season, only gillnets being used throughout the year. Other fishing methods are shore-seine, boat-seine, hooks and line. A typical boat has the following dimensions:
Length o.a. 35-ft. 2-in., breadth 6-ft. 5-in., depth 2-ft. 9-in., reg. tonnage 4.4

It is a narrow, roundbottom boat without a keel, heavily framed and carvel planked, with a short fore deck and longer after deck. It carries one mast and a lateen sail, and has a removable leeward. Built locally of Godavari teak with iron fastenings, the boat with mast and sail costs about Rs. 1200/-. An interesting use of the nava is found at Uppada, north of Kakinada. Here the ordinary Kakinada nava, although of a somewhat smaller type, is used as a surf boat. This development started only a few years ago, when there was a very good season for beach seining after some bad seasons which led to the neglect of the beach seine boats (masula boats). They were out of repair when the good season came and it was suggested that some navas be got from Kakinada to take out the beach seine.

It was found that the navas could go through the surf. Smaller navas soon appeared, to replace the catamarans in ordinary fishing. To-day there are about 50 in use. They all have a length of about 21 to 25-ft. and a beam of 5½-ft. to 5-ft. 10-in.

In the seaward creeks of the delta of the Godavari river, and especially at Kakinada, some 2,700 fishing craft called shoe-dhonis, ply their trade. The name well describes their appearance. Wide and flat forward, with a sharp stem and strongly flared bow sections, they narrow greatly aft and have a transom stern (Figs. 32 to 34). The fore part is decked in and has spray boards. Roughly two-thirds of the length aft has tumble-home sides and is also decked in for 3-ft. from the stern; the well is narrow and restricted. It is protected by a high transverse coaming where it meets the foredeck. The steersman squats on the little aft deck, and steers by means of an oar, about 12-ft. in length, working in a wooden rowlock built into the centre of the stern. This oar is also used in sculling when there is no wind.

The boats are driven by long bamboo poles in shallow reaches and canals, and, in this case, the broad foredeck is the "stern" on which one or two men can stand firmly and use the poles, pushing the boat stern first. A study of the plans will show the obvious advantages of this bow-and-stern shifting.

The very narrow slot-way in the deck, just enough for the feet, prevents too much rainwater from entering the boat. The dimensions of a typical shoe-dhonis, which varies little in size, are: length o.a. 31-ft. 2-in., breadth 5-ft. 2-in., depth mid. 2-ft. 3-in. Local wood, Godavari teak (Tectona grandis), is used for construction, with iron fastenings. All boats are well maintained, and thickly coated with tar and fish oil at short intervals. Their life is said to be 30 years or more. The cost of a shoe-dhonis is about Rs. 800 to 1,500. (1957).

The hull has a deep forefoot merging into a fin-keel, 6 to 8-in. deep beneath the mast; the aft is nearly flat-bottomed and has almost identical lines as the same part in a planing speed boat. Narrow teak planks are used for the hull, nailed on ribs of any sort of wood. The forward deck is considerably wider than the aft, usually by a foot. In one case the measured dimensions were: -- overall length 26-ft., forepart, bow to aft side of coaming 8½-ft., beam at fore side of mast (at coamings) 3-ft. 7-in., beam aft of mast 2-ft. 8-in., depth 2-ft.
A rather lofty square sail hung from a bamboo yard, is used, hoisted to the head of a 19-ft. mast, set upright, immediately abaft the transverse coaming. Its head measures 10\(\tfrac{1}{2}\)-ft., the luff 14\(\tfrac{3}{4}\)-ft. and the foot 10-ft.

The shoë-dhoni of the Godavari creeks is perhaps even more distinctly indigenous to India than the catamaran. Hornell considered the form of the shoë-dhoni as unique among boats, and especially interesting, as he considered its prototype to be the curious palmyn-palm dug-out, found on the upper reaches of the same river system. These craft, frequently used as double canoes called sangadam, consist of two butt sections of palms roughly hollowed out on one side and lashed together parallel, but at some distance apart, by means of two bamboo poles (Fig. 35). The butt end of each dug-out being bulbous, one extremity is wide, whereas the other is narrow and truncated, as being part of the cylindrical stem. One of these dug-outs, copied in planks and with a keel added below the fore end, which corresponds to the bulbous butt, gives approximately the design of the shoë-dhoni. A further proof of its inland origin is the tall mast and high and narrow square-sail, well adapted to reach over the low banks of rivers and creeks, but with too high centre of gravity of the sails for sea-going craft of this type. They are very fast with a fair wind, but are said to be poor sailors when beating, in spite of the deep fin-keel and forefoot—a fault due, apparently, to the type of sail employed.

Ziener has heard from the older inhabitants of Kakinada that the shoë-dhoni appeared there about 50 years ago, there being no craft before that time with any resemblance to it, and from which it could have developed. There are now about 2,800 shoë-dhonies fishing with stake nets in Kakinada Bay and in the mouth of the stream. Thus, it is essentially an estuarine fishing boat. Hornell also maintained that the boats were definitely local, not being found even in the adjacent delta of the Kistna.

During the last war, some of these fishing boats were provided with powerful outboard motors and used for other purposes, and obtained quite high speeds. However, the fishermen did not consider such motorisation to be of advantage for fishing.

11. Backwater Boats

Backwater boats on the East coast are generally either dug-out canoes, or rough and usually clinker-built reproductions. The latter are the craft principally used for fishing on Pulicat Lake and the Madras backwaters. The clinker-build is noteworthy as, apart from this area, the style is only found in Orissa. Iron nails, clinched on iron washers, are used to fasten the planks together. There are numerous large undocked barges running to 20 tons' load capacity for cargo carrying on the coast canals. They are broad and flat-bottomed, with the length 3 to \(3\frac{1}{2}\) times the beam. They are built in the same manner, and on the same lines, as the fishing boats, but with a strongly marked "swim-bow". This is simply a punt bow with a rounded instead of truncated end. The stern is similar in shape so, to support the rudder properly, a strong heel is run out from the bottom of the boat to hold the vertical stern post. These canal boats frequently carry a coach roofing over nearly their whole length, supported on uprights set along the gunwales. The rig is a light cotton sprit-sail, triced high up and carried on a fairly lofty spar stepped in a tabernacle above the deckhouse roof. Karimanal, at the south end of Pulicat Lake, is one of the chief building centres. For convenience, the boats are constructed upside down.
Many of the Chilka Lake fishing boats are considerably larger than those in use on Pulicat Lake: they are simply planked-up boats of canoe model.

Primitive catamarans made up of any old logs, roughly tied together, are extensively used by cast-net fishermen on backwaters, particularly in the Tamil districts. The logs are usually those discarded by sea-fishermen.

The ordinary dug-out canoe is not greatly in evidence on the Coromandel coast backwaters, being both difficult to obtain and expensive.

Outrigger canoes are numerous on a backwater near Cuddalore. They are also frequently used on the Vellar River near Porto Nova. Each is formed of a small dug-out, usually about 16-ft. long with a 22-in. beam, having a normal outrigger float, boomed out by means of two poles, to a distance of 5-ft. from the canoe. They are used, generally, in conjunction with cast nets; mast and sail are never used. This extension in the range of the outrigger is particularly interesting. It is in use at various places along the coast line from the Pakistan border in the north-west to a point well north on the Coromandel coast in the south-east.

12. Sea-going Ships on the East Coast

Many fine ships, from 50 to 300 registered tons, were engaged in the Indian coasting trade a few years ago. The baggala and pattamar were run so cheaply that other ships were never able to compete with them. In the Bay of Bengal, this competition was not severe. There has always been much carrying trade between Bengal and Burma and between South Indian and Ceylon ports, and a fine fleet of brigs, barques and dhonis found these runs remunerative until the regularity and insurance advantages of steam traffic almost drove the slow and irregular sailers off the sea. Coringa and Tellavevu, near Kakinada, and Masulipatam, were the most famous of the old Indian ship-building ports. Some of the small ports on the Ramnad coast also turned out a fair number of medium and small craft, chiefly, however, of the dhoni class. Even to-day shipbuilding is carried out at these ports which have become reduced in number and size, not on account of lack of skill on the part of the present-day builders, but because of the difficulty which owners experience in earning remunerative freights with large tonnage sailing vessels.

Sometimes wooden brigs and schooners are seen in the East coast harbours. The larger three-master Maldivian trader, showing Portuguese influence, reproduces many of the outstanding features of the fifteenth century caravels used by Columbus.

13. Laccadive Islands Boats

The sailing craft of the Laccadives lacks the diversity of form seen in the sister isles to the south. 'It is a little lateen-rigged modification of the pattamar, combining the simple bow of the southern type with the lofty, highly ornamented poop of the northern or kotia design.' The lines sweep forward in graceful curves to the overhanging bow.
The poop cabin is large and roomy, with a stern galley built out aft and on the quarters. The hulls are put together without nails, the planks being sewn together along the edges with coir twine, a device both economical and of practical value in imparting elasticity, invaluable to boats which are always liable to ground when entering the shoal entrances of the home lagoons.

The rig is a single medium-sized latsen sail, carried on a stout mast, well raked forwards; sometimes a small mizzen, also latsen rigged, is added.

The island fishing boats and skiffs are somewhat different. The stern is generally rather low and the bow has often an exaggerated rise, terminating in a high upturned pointed beak (Fig. 36).

14. **Andaman Islands Boats**

It is surprising to find both the primitive dugout and a well-designed single outrigger canoe in these islands.

The simple dug-out is the type adopted for the larger-sized canoes; the outriggers have, normally, smaller hulls, fashioned on identical lines. The shape of the dug-out, both when used alone and as the hull of an outrigger canoe, is distinct from all Indian peninsular types, approximating closely the Australian type. Instead of the invariable sharp ends, the ends of Andaman canoes are rounded, and the bow is prolonged horizontally forward, to form an overhanging shelf or platform which gives footing for the harpooner on the look-out for turtle and great fish. A corresponding, but more reduced, projection is present at the stern.

The outrigger frame is single. The float is connected with the hull by multiple booms, varying in number according to the size of the dug-out - never less than three, or more than twelve. The booms are slender poles, secured at their inner ends by being passed through holes in the sides of the dug-out, close to the edge - a peculiar method never seen in India, but found in the same or some variant form in the outriggers, both single and double, of North Queensland, Australia.

The connection effected between the float and each boom is indirect, by means of three short stanchions. These are inserted in line, longitudinally, upon the upper surface of the float. The middle stanchion is vertical, its upper end lashed to one side of the extremity of the boom. The outer ones converge, their upper ends passing beneath the end of the boom, lashed thereto with rattan on each side of their vertical companion. The upper ends project irregularly beyond the upper surface of the boom.

15. **Nicobar Islands Boats**

The Nicobar Islands outrigger canoe is radically different from that of the Andamans, only 90 miles distant. The outriggers are better built and more elegant in form and never possess more than two booms.
These canoes are fitted, according to size, with one to four bamboo masts, each supported by four widespread stays of rattan, and on these are hoisted latrien sails with a short tack of about 12-in., made of cotton or pandanus leaves. The masts are never stepped on the hull of the canoe, but always on one of the crossbars or thwarts.

In the case of the largest three-masted canoes, the fore mast is placed in the bows, and well forward of the fore outrigger boom. The main and mizzen masts are stepped between the two booms, the mizzen just forward of the aft boom. All the masts are vertical and short, the main being a little longer than the others. The yards are longer than the masts.

The chief peculiarity of these canoes is the form of the outrigger. The booms are invariably two in number, lashed above the gunwales at their inner ends, each being connected with the long float by means of three pairs of divergent stanchions, crossing beneath the boom. The stanchions of the fore pair slope outwards and backwards; those of the mid pair away from one another, while those of the aft pair pass outwards and forwards. The upper extremities of the stanchions project conspicuously above the boom, the length being often nearly equal to that between the boom and the float. The stanchions are rod-shaped, the lower ends pointed and inserted in holes in the float, without lashing. The upper ends are lashed to the boom with rattan.

16. **River Craft**

Less ingenuity is shown in evolving designs for local needs in the general types of Indian river craft. The simplest are the plantain-stem catamaran of Tanjore and Bengal, the chatty-raft of South India, the round coracle of the Cauveri and Tungabhadra, and the double palm dug-out of the Godavari.

In Tanjore and in Bengal, plantain (banana) stems are valueless as soon as the fruiting age is passed. In these districts, the plantain-stem catamaran consists of 5 or 6 stems, roughly trimmed at the ends and fastened together raftwise by a skewer of wood or thin stake at each end, passed through the series from side to side. Banana leaf stalks, i.e. the "stems", are full of tiny cubical air spaces, and these give considerable buoyancy to the structure. This catamaran is the simplest form of raft that serves for the moment—a thing to be cast aside almost as soon as used.

The chatty-raft, while equally primitive, is still more ingenious. As seen at Vellore, it consists of two ordinary earthenware pots (chatties) turned upside down and connected, tandem fashion, by means of a stick, lashed on each side of their necks. A space of some 2-ft. is left between the pots, and on this fragile frame a man can sit astride when the craft is "launched" into the water. This raft is used at Vellore Fort to reach the water-lilies.

The Indian coracle probably preserves the original type... It consists of a very large, wide-mouthed, circular, flat-bottomed basket. The sides are comparatively low. A common size is fully 12-ft. in greatest diameter at the mouth, the bottom being smaller. A hide covering is stretched and fitted over the outside to exclude the water. In Tanjore and along the course of the Cauveri, the coracle was once extensively employed as a ferry boat but, as bridges are built, it is going out of use. This coracle differs considerably from the Arab guffa.
17. **Ganges Delta Boats**

The Ganges, from Benares to the sea, is a good example of a busy inland waterway. Two endless processions of craft of all sizes, but in the main of one general type, pass continuously up and down.

They are called *batchari* boats, whether used for fishing or as rice carriers. The stern is as high as the bow, to give the steersman a clear outlook. Usually bow and stern are sharp, and very raked. The overhangs of bow and stern together are usually 50\% to 55\% of the overall length of the boat. See Figs. (37) and (38).

The fishing boats may or may not have a roofing amidships, and some carry a high spritsail set well forward towards the bow, not aft as in the little sampan *dinghis*. In the absence of a keel, they sail with the wind only. This type, manned by 3 or 4 men, is much in evidence during the *hilsa* season, when a long procession of the boats can be seen drifting rapidly down stream with nets submerged, while another procession is sailing or rowing upstream with decks encumbered by the huge bamboo crescent trap-mouths of their sangle net.

About 6,000 *batchari* boats are in use. The size varies from 28-60 ft. over-all length, the 42-ft. length being the most common. Figs. (39) and (40) show a typical *batchari* boat with the following dimensions: length o.a. 43-ft. 5-in; breadth 4-ft. 4-in; depth 1-ft. 9-in. These boats are locally constructed of teak. The planks seams are rabbeted and fastened with double-pointed, flat iron nails which, when in place, form hooks that hold the planks together. Hooks are placed both outside and inside of the plank, rather tightly. This type of fastening is good for teak planks and in no case has been found lacking in strength. Nailing is done at an astonishing rate, one man finishing 100 nails in about 7 mins. If copper rivets were used, the same number of fastenings would take two men about 50 Minutes. Moreover, copper rivets would cost six times as much as the flat-iron nails.

The life of the *batchari* boats is said to be 30 to 40 years. They are used for a great variety of fishing - purse seine, drift nets, bag nets, stake nets and dip nets. They are open boats, but generally covered from gunwale to gunwale with a decking of split bamboo sticks on which the fisherman can sit. The bigger boats have a light house of bent wooden arcs covered with bamboo mats, placed nearly amidship. None of these boats is mechanised.

Fig. (41) shows the lines of a typical *chof* boat, a local fishing boat type of the Hooghly River. It has short overhangs and high freeboard. It carries a small, square lateen sail, but is mostly propelled by oars; a steering oar is used.

The *chof* boat is used for the heavier types of fishing gear, such as purse seine, shore seine and bag net. They do not vary greatly in size or shape. The average craft has the following dimensions: length o.a. 34-ft; breadth 8½-ft; depth, moulded, 3-ft. 8-in; displacement, empty, approx. 3 tons; displacement, loaded, approx. 6 tons.

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Locally built of teak, the boats are carvel planked on built-up frames. Fastenings are of iron. There is no fixed deck, but a loose decking of split-bamboo rods, athwartships. There may be about 500 of these boats.

Another interesting boat is the Diamond Harbour boat (Figs. No. 42 and 43). This is a local type of the Hooghly River delta, and is used mainly for cargo although sometimes also for fish carrying. The boats vary greatly in size, from about 24-ft. length up to 50-ft. and more. They are built of teak, with carvel planking on built-up frames and are quite strong.

The boats have a fore deck and after deck, but the cargo hold, which occupies about 60% of the length of the boat, is undocked and covered with loose planks only. A folding mast is used for passing under bridges, and a small, square lateen sail is carried. None of these boats is mechanised.

18. Conclusions

This description of existing fishing boats and related small craft is based to a large extent on Hornell's "The Origin and Ethnological Significance of Indian Boat Designs" (Memoirs of the Asiatic Society of Bengal, VII (3), 139-190, Calcutta 1920), as well as on the observations of the experts. The account is somewhat uneven as it does not cover every stretch of the coast. It is presented, however, to provoke more studies, which are needed if a well-rounded picture of Indian boat types is to be obtained. In order to stimulate progress in fishing boat design and construction, good knowledge of existing types and construction methods is essential. From a naval architectural point of view, priority should be given in measuring and analysing the following important Indian types of boats:

- Kutch fishing machwa*
- Salaya dhow (Saurashtra)*
- Broach flatbottom boat*
- Gujarat Wahans (several)*
- Murdeshwar-Kanara planked machwa
- Masula boat (Podhow).
- Kairampani boat
- Maribale boat
- Pattabale boat
- Andhra surf nava (smaller Kakinada nava)

- Konkan fishing machwas
- Hodys of Southern Bombay
- Ratnagiri fishing pattamar
- Ratnagiri outrigger canoe
- Rampan boat
- Balasore surf boat
- Ganges dinghy
- Barisal boat
- Several inland fishing boats
- Fishing boat types of Kerala

* Since this report was first drafted these types have been measured and drawings made by Mr. P.B. Sapre, Veraval.

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IV. BOAT BUILDING FACILITIES

Indian fishing boat building is mainly a "cottage" industry of small units, present wherever fishing is carried out. There seems to be little, if any, exchange of experience even between neighbouring boatyards. That may explain, at least in part, the great divergence in quality of designs and building methods. Except for a few cases, such as with the Malabar canoes, no regular trade in fishing boats has been developed between the maritime states.

Despite this isolation, several types have emerged well suited to the local conditions of weather, harbours and fishing, and to the economic structure of the fishing communities they serve. Indian fishing craft are, as a rule, reasonably well-built. Fishing boats can be built, mechanised and equipped by means of existing facilities which are often under-estimated. These facilities are:

1. Shipbuilding Yards for construction of steel or wooden vessels and advanced marine engineering, organised as corporations:

   **Bombay:**
   - AF&CO Private Ltd.
   - Alcock, Ashdown and Co. Ltd.
   - Dixon and Co. Ltd., H.I.
   - Herman and Wohatta (India) Private Ltd., B.R.
   - Mazagon Dock Ltd.
   - J. Stevenson and Co.
   - Shaparia Dock and Steel Co. Ltd.
   - The Varuna Shipbuilders Ltd.

   all with capacity for boats of up to about 200 tons

   **Calcutta:**
   - Calcutta Landing and Shipping Co. Ltd.
   - Clepock Boat Co.
   - Comar Docking and Engineering Works
   - Garden Reach Workshops Ltd.
   - Hooghly Docking and Engineering Co. Ltd.
   - India General Navigation and Railway Co. Ltd.
   - Rodda Craft

   **Cochin:**
   - Messrs. Brunton and Co. Engineers Ltd.

   Boats of up to about 200 tons

   **Vizakhpatnam:**
   - Hindustan Shipbuilding Yard

   Vessels up to 10,000 tons

These yards are modern and well-equipped, capable of building steel or wooden fishing boats and mechanising them with all kinds of machinery and fishing equipment. The yards so far have rarely been called upon to build fishing craft, although recently some have been entrusted with contracts by State Governments and private fishing companies. Their experience in building small fishing craft is not extensive, but if fishing boats are ordered from these yards, and designs submitted, first class construction can be expected.
As an example of the interest shown in fishing boat building, it may be mentioned that the AFEO Shipbuilding Yard in Bombay recently built a modified version of the Bombay type of fishing boat, powered with a diesel engine, for use as a demonstration boat.

The Hindustan Shipbuilding Yard, Vizagapatnam, is fully occupied with the construction of large merchant cargo ships, and is at present not interested in building fishing boats.

2. **Cottage Boatbuilding**

"Cottage" boatbuilding is found wherever fishing boats are in use, and is often based on century-old experience in building local fishing craft. In spite of their primitive methods, this industry, due to low wages and overheads, is still capable of building boats cheaper than yards equipped with modern machinery and skilled staff. The price quotations for boats are about 50 to 65 per cent of those of the commercially established shipyards, but the quality of work is, of course, lower. A great asset of the cottage boatbuilding is its location at places where there is reasonable fishing activity. There is also the experience and ingenuity which the builders often demonstrate in exploiting local materials and labour. The decentralised activity of the cottage boatbuilding is invaluable for maintenance and repairs. Any fishing boat can be repaired and overhauled in its own port or near its fishing ground, without delay.

If cottage boatbuilding could be mechanised to some extent, and expanded to cover the field of simple marine engineering - which may require incentives or help from the Government - it would be able to service a fishing fleet of small and middle-sized craft.

Because of the strictly local character of cottage boatbuilding, the carpenters have developed great skill in handling the local building materials. The ability of Indian craftsmen to work accurately and skillfully is demonstrated in some local boatyards. Certain boatbuilding families have kept the standard high for generations (at Kutch, Billimora, Ratnagiri, West and East Bengal), while even within the same localities the craftsmanship of others is poor.

The cottage boatbuilding represents high practical boatbuilding skill and a thorough knowledge of local conditions of fishing and trade; it lacks, however, knowledge of naval architecture, and boat drawings are understood and appreciated only in certain areas.

3. **Special Observations for Different Regions**

Boatbuilding on the north-west coast is, in general, satisfactory. At Salaya and Veraval and Mandvi in Kutch, boats of good craftsmanship are built and the skills here should be employed for further development. The best boat building is found at Billimora, Surat and Bulsar, where wood is available from local forests.

The standard along the Coromandel coast, with the exception of the Tuticorin area, is comparatively low. Most boats, among them fairly big cargo vessels for the coastal trade, are built at Cuddalore by local contractors. Building of smaller boats is carried out along the coast.
on a "cottage industry" level. In Madras port, wooden barges are built for the loading and unloading of ships. They are built by the Port Authority, and for their use only. No private boatbuilding yard exists at present for the construction of mechanised fishing boats.

At Tuticorin there are many boatbuilders, and some families have carried on this trade through generations. They build craft from small canoes to cargo boats of 100 tons and above, in the open on the beach. Some of the contractors understand boat drawings, and a few make such drawings from half models. Workmanship varies according to the individual builder, and ranges from fair to excellent. Designs and detailed construction plans would have to be submitted for building of mechanised fishing boats, but there is no doubt that Tuticorin boatbuilders are able to build such boats.

As the "cottage" boatbuilding of Madras was considered poorly equipped for construction of mechanised boats, the building of ten small, motorised fishing "luggers" was undertaken by the Fisheries Department, starting 1948. These Governmental boatbuilding activities were valuable as they stimulated interest in small-boat building.

The general impression of the experts is that the standard of boatbuilding along the Telugu coast is high, and that there exists a large capacity for construction of moderately-priced and well-built fishing boats. In the central part of this coast, and also at Vizakhapatnam, there are skilled boatbuilders able to construct any kind of boat if a design is provided.

It is in the East Godavari district, especially around Kakinada and Masulipatam, that "cottage" boatbuilding is developed to its highest degree. Plank-built boats are used in great number, and the builders are kept busy all the year round. Hyderabadi and Godavari teak wood, used for boat-building, is brought down from the interior on the extensive river and canal system, is in good supply and is comparatively cheap.

Most of the craft built in Kakinada Port are barges, ranging from 40 to 60 tons. They are used for iron ore transport from the port to the steamers lying 2 to 5 miles off the coast. Fishing boats are mainly built in the surrounding coast districts, of which Talarevu is the most important. Here, from time to time, several contractors build cargo boats for the canal system around the Godavari delta. Similarly, all the fishing boats used in the Kakinada area are built here where workmanship is of high quality.

Neither barges nor fishing boats are built according to plans; the builders have, by trial and error, found suitable types and keep to them. There is a great interest among the boatbuilders in learning about modern methods of construction (see below for building improved models of navad).

A boatbuilding industry of certain importance exists at Cuttack, Orissa. A small Government shipyard, with slipway for about 100 reg. ton vessels, takes care of repair and general maintenance of the different canal and estuary inspection boats, dredgers, sand barges, etc. It is fully occupied with such work and is not available for fishing boats.
Several boatbuilders and contractors concentrate on wooden boat building, and this industry has a long tradition in Cuttack. The most important yard for wooden boats seems to be the Orissa Docking and Engineering Works, Cuttack. This yard works from drawings. The workmanship is good, and the yard has some experience in the installation of engines. Three fish carrier launches, designed by the experts, were built at this yard.

The size of the Mahanadi canal locks is 60 by 18-ft, and the minimum depth of the canal is 4½-ft. Consequently, this limits the size of boats that can be built in Cuttack and pass the canal out to the sea.

The standard of boatbuilding in West Bengal is high, and boat construction is organised as a highly efficient cottage industry. Fisheries development schemes should be able to benefit by obtaining inexpensive and well-built fishing boats.

Repair facilities for wooden hulls are found everywhere in India, which is certainly the reason why commercial fishing boats in all the places visited were well maintained.

4. **Boatbuilding Materials**

(a) Woods. Boatbuilding woods available in India are among the best in the world. The Indian boatbuilder's chief concern, when selecting wood for his boats, is their resistance to sun, rot and borer worms.

First and foremost among the boatbuilding woods comes the Indian teak grown in the Central and Southern States. However, its relatively high price has resulted in extensive use of many local kinds of "country wood".

The "country woods" are known by different names according to the locality, and their scientific denominations are usually not known by the timber merchants. Only a few of these "country woods" are used throughout India.

The question of the study of the different kinds of Indian woods, with a view to cheaper and lighter boat construction, was taken up by the experts with the Indian Forest Research Institute at Dehra Dun. One result of this correspondence is the recommendation of three timbers, mentioned below, worth trying for surf boats and similar boat types:

1. **Mangifera indica** (Mango)
2. **Ailanthus excelsa**
3. **Autiaris toxicaria**

As these timbers may not be naturally durable, the Institute has recommended treatment with a mixture of creosote and fuel oil.

All the three timbers are available in sufficient quantity in the South zone, and should be easily obtainable from Madras or Kerala States. (For further information regarding detailed sources of supply, the Utilization Officer, Forests, Chersauk, Madras, or the Chief Conservator, Forests, Travancore Cochin, Trivandrum, should be contacted.)
In Bombay State, the timber used for boatbuilding is almost exclusively Indian teak from Malabar, but with the addition of locally grown woods, especially the crooked timber used for frames, such as Batul (Acacia arabica and Acacia catechu).

The big forest resources of the Malabar region play an important role in the supply of boatbuilding timbers for the West coast (Kerala and Karnataka States). Malabar teak (Tectona grandis) is considered the best Indian teak and is sold elsewhere in India.

Mango wood (Mangifera indica), grown all over India, is used for the Malabar dug-outs and for outrigger canoes. So are Jermala (Tetraneles nudiflora), grown locally along the West coast, and Aineee (Artocarpus hirata). Aineee and Bontaak (Lagerstroemia lanceolata) are used in ordinary boatbuilding, as substitutes for teak, as they are cheaper. Aineee has also the advantage over teak of being considerably lighter. Bontaak is in great demand by Arabs trading at West coast ports; they use it for the construction of their dhowes. The resistance of Aineee and Bontaak against rot, fungi and marine borers is not, however, equal to that of teak. Red cedar (Cedrus deodara) is grown in northern India and sold at many places throughout India. Although not greatly used in local boatbuilding along the West coast, except at certain places for cars and light inboard structures, it is one of the most durable of the Indian woods, and its use should be encouraged.

For masts and yards, the Poon (Calophyllum tomentosum) is much used on the west coast and in the south.

In the main boatbuilding area of Madras State, at Tuticorin, the same types of wood are used as on the West coast. In fact, much of the wood used at Tuticorin comes from the West coast. A typical local wood called portia or "poovarasu" - is in good supply and is used extensively for frames and knees. It is a crooked timber. Several kinds of good and cheap boatbuilding woods are obtainable from the Andaman Islands through a Government timber import office at Madras, but the supply is not well organised.

Hyderabad teak and Godavari teak is mostly used in Andhra Pradesh. Godavari teak can also be obtained as crooked timber for frames and knees. Yelli (Hardenckia binata) is sometimes used, as a substitute for teak, in planning for cargo barges built at Kakinada. It cannot be used for the thinner planed fishing boats as it is likely to crack when cut too thin. Matti (Terminalia tomentosa) is hard and heavy and is used for keels and lower planks in heavy cargo craft generally. It is also used, because of its hardness, for lining the holds of barges engaged in transport of iron ore. Its general trade name is Laurel, and it grows all over India. Acacia or Babul (Acacia arabica) is used to a certain extent for frames and knees in Bombay State. Bandor (Adina cardifolia) is a dense and comparably light wood, but is not used much in boatbuilding. It would, however, be suitable for inboard use in boats, if its price is reasonable.

The woods used for boatbuilding in Orissa are the Byasal (Pterocarpus marsupium), sold locally under the name of Pissal, and the Sal (Shorea robusta) - very popular because of its cheapness. Teak is also in good supply. Because many of the boatbuilding woods in Orissa do not season
well, partly because of the humid climate and partly because of the nature of the woods, unseasoned wood is very often used. Local boatbuilding has therefore developed the lataplate or clinker planking, Orissa being the only part of India where it is commonly used. This method is stated to be the only way to use Bysaal and Sal for boatbuilding. In any case, clinker construction is a completely satisfactory method. Gambhari is a less used lighter local wood. A builder in Cuttack considered it good enough for inland vessels, there being no danger of attack from marine borers. He nevertheless recommended the use of preservatives against rot.

(b) Price of Woods. Boatbuilding woods are not cheap, compared with prices in other countries. Teak, especially, is expensive as it is an export product, and its price on the inland market is influenced by the world market price.

Malabar teak, in good sized logs, can cost as much as Rs. 20 to 22 per cu.ft. in Madras, while it may be at least Rs. 5 cheaper on the West coast (1957).

Good Gadavari teak, as sold on the East coast, costs Rs. 12-16 per cu.ft. in logs.

The price for imported Burmah teak is, of course, higher than that of Indian teak and, although the quality is better, Burmah teak is very seldom used for construction of fishing boats.

The woods used as substitutes for teak are substantially cheaper. Thus, the price for Aineo logs is in most places Rs. 9 to 15 per cu.ft. and Benteak only Rs. 4 to 12 per cu.ft.

Inquiry in Orissa showed that Sal could be bought for Rs. 6 per cu.ft. and Gambhori for only Rs. 4 per cu.ft. (1956).

The possibility of using more of the really cheap local woods to a greater extent in boatbuilding, especially if an efficient preservative were applied, should be investigated.

(c) Plywood is not used for the construction of Indian fishing boats. An attempt to introduce it for light inland fishing boats is being made with the design of a fast fish carrier boat for Orissa, described later in this report. The craft is not yet built.

An inquiry was held among Indian producers of plywood to find out the extent to which marine plywood is being produced in India. The inquiry gave the following result:

Plywood Products, Sitapur, is the first plywood factory in India to manufacture liquid phenol formaldehyde, synthetic, resin-bonded plywood. Since 1942, it has supplied marine and aircraft plywood to the Indian Government for important defence work. It has also supplied large quantities of marine and aircraft plywood, and was the only firm in India to supply jettisonable petrol tanks made from phenol formaldehyde, synthetic, resin-bonded plywood. The marine plywood was made according to British specification No. R.B.P. 3266-E.
The timber species used at that time were Sissoo (Dalbergia) and Toon (Cedrela toona). The plywood made from both these species was found suitable for pontoons, assault boats, floats, etc. Toon wood is of light density (30 lb. per cu.ft.), but a combination of both species has been found the most suitable for ship building.

Just after the war, British specification No. 1088 came in force. This, like the war emergency specifications, does not set down strength requirements, except for the timber species and water resistance tests. By looking at the species specified, it is clear that different density grades of plywood, suitable for various portions of a marine craft, were intended.

The Indian Defence Department issued a specification – I.W. 2980 – for marine plywood, and later IND/85/527, which calls for a very high standard of material. Marine plywood manufactured to this specification should have:

Dry sheaf – 300 lb. per sq. in. minimum

Wet test – after 3 hours boiling, 200 lb. per sq. in.

Dry heat – for 4 hours at 100 to 105°C, and test for delamination

Mycological test – for two weeks, and no delamination at edges, and giving 200 lb. per sq. in. shear strength

The Indian Standards Institution has also drawn up a marine specification, on the lines of the Indian Defence Department specification, which is in the process of finalisation.

There is a shortage of Sissoo and Toon, which were once available in good supply, but Kanju (Holoptelia integrifolia), white Siris (Albizia procera), and Rosewood (Dalbergia latifolia) make plywood which, in the Standard Institution’s opinion, should be suitable for various constructions of marine craft and also for paneling, ceiling, etc. Plywood of Kanju is extensively used for shuttering work in concrete forms.

The marine plywood made of Kanju, Siris and Rosewood can be supplied according to British Standard Specification No. 1088/44 (as amended by B.S.S. 1088/51).

Hot pressed liquid phenol formaldehyde, synthetic, resin-bonded material is the only plywood made in a maximum size of 6 x 4-ft. and 1\frac{1}{8}-in. thick.
Typical prices in August 1955 for standard sizes up to 6 x 4-ft. were:

- 1/2-in. 5 ply Rs. 4-11-2 per sq. ft.
- 3/8-in. 5 ply Rs. 2-1-6 " " "
- 1/2-in. 7 ply Rs. 2-14-9 " " "
- 5/8-in. 7 ply Rs. 3-5-0 " " "
- 3/4-in. 9 ply Rs. 4-2-6 " " "

Sizes 8 x 4-ft. cost 10% extra. Sizes up to 12 x 4-ft. can be produced with scarf joints.

The Indian Plywood Manufacturing Co. Ltd., Dandeli, manufacture marine grade plywood to any requirement, and has been supplying plywood of marine grade to the Defence Department of the Government of India for repairing and building pontoon boats and bridges, assault boats and other marine craft. This plywood is made to Indian Defence Department Specification No. IND/08/527.

Glues used are of the synthetic resin type, hot pressed, based on phenol formaldehyde. The glues conform to the draft Indian Standard Specification No. Doc. RDC. 20(123) Pl. Type BWP (boiling water proof).

Normally, boards up to 8 x 4-ft. are made, the standard sizes being 8 x 4-ft., 8 x 3-ft., 7 x 3-ft., 6 x 4-ft. and 6 x 3-ft. The intermediate sizes can be obtained by specific orders.

Bigger boards can also be supplied as one piece components, in sizes up to 40 x 4-ft., with scarf jointed veneers, as provided in the British Standard Specification.

The firm has no standard price list for marine plywood. The prices vary, depending upon the size and quantity of the boards ordered and the stock position of the raw materials. Typical prices in August 1955, for standard boards of 8 x 4-ft. maximum size, were approximately:

- 1/2-in. 5 ply Rs. 1-10/- per sq. ft. F.O.R. Dandeli
- 5/16-in. 5 " Rs. 1-12/- " " "
- 3/8-in. 7 " Rs. 1-14/- " " "
- 7/16-in. 7 " Rs. 2-2/- " " "

The Western India Plywood Limited, Malabar, are manufacturing marine plywood to Indian Defence Department Specification No. 527.

The timbers used are either all pali or pali cores and cross bands and white cedar faces.

The glue used is synthetic resin of the phenol formaldehyde type.
The maximum sizes of the boards that could be supplied would be 8 x 4-ft. and the maximum thickness 1-in.

The phenol formaldehyde type glue is resistant to the wood preservatives used by the fisherman. The Indian Defence Department Specification for marine plywood calls for impregnation with sodium pentachlorophenol. This impregnation is done during the process of manufacture.

The glue is said to be borer worm repellent, but this should not be taken as a guarantee, and further treatment, for example with creosote, is recommended. Plywood is unaffected by petrol, diesel oil and lubricants.

5. Fastenings for Boats

Iron is commonly used for fastenings, such as nails, spikes, and hooks. They are not galvanised. Black iron nails in teak wood stand up for a long time due to the oil in the wood. In West Bengal, where boats have an exceptionally long life, the iron nails in the boats are replaced after 30 years.

Boat nails are made locally. Prices vary in different localities, an average being Rs. 45/- to 50/- per maund (82 lb.), up to Rs. 80/- per maund.

In most parts of India, nails, rivets and screw bolts are used in the conventional way. However, in some areas, special ways of using these fastenings have been developed. The hatchari boats of West Bengal are nailed with flat, double-pointed nails, as shown in detail on Fig. (40).

North of Bombay, the builders have a tendency to use through bolts with the nuts outside. Foundation bolts of engines are found protruding below the bottom of the hull with nuts and lock-nuts. Recommendations were made to have the nuts inside.

In boats built for the Government (fisheries inspection launches, experimental fishing boats, etc.) the fastenings are usually of brass and copper.

Prices: Brass bolts with nuts ... about Rs. 6/- per lb.
Copper rivets with washers   " Rs. 4-8-0 per lb.

6. Rigging Material

The common material for standing and running rigging for fishing boats is coir rope, made of coconut fibre. Ropes are a "cottage industry" product, generally of good quality and cheap. Average price (1956), 8 Anna per lb. Only in Kathiawar, where there is no coir industry, is the price about 12 Anna per lb.

Stainless steel ropes for rigging, and trawl wires, are supplied in the more important ports. Price (1956) for 3/8-in. diam. flexible trawl wire is 9 Anna per running foot. Blocks, turnbuckles, hoisting and anchor chain, etc., are available at the same ports.
7. Sails

Indian-made cotton sailcloth is commonly used for sails on fishing boats. It can be purchased in current thicknesses and at reasonable prices at all ports. Cloth of 10 ounces, width 28-in., coats (1956) Rs. 1-0-0 per yard.

The sails are cut and sewn by members of the fishing communities who specialise in the work. Sails are tanned with the same extract of the bark of acacia catechu, terminalia tomentosa, etc. as is used for fishing nets, varying with the coastal area.

Sails of bamboo mats are used on the North East coast. They are made in the fishing villages by members of the fishing families. Unlike cotton sails, they are not affected by sunlight and do not easily rot.

8. Preservation of Boat Hulls

There are no reasonably priced modern wood preservatives and paints. Centuries-old indigenous methods are still in use. On the West coast the fishermen apply fish oil, usually mixed with resin, to the boat hulls, above and below water. For underwater use, it is often mixed heavily with lime. On the East coast, tar is more frequently used, alone or mixed with shark liver oil. Vegetable oils, such as custard oil, are also used to some extent, but these are subject to increasing prices, as export trade in the oils develops.

These indigenous wood preservatives have little or no protective qualities, especially against marine borer worms, unless they are applied frequently. They are therefore not as economical as commonly supposed.

Custard oil is exported for use as an ingredient in the modern and highly efficient antifouling paints for boats and ships. When such paints are imported to India again, their price is beyond the fishermen's reach. The Government of India has asked for suggestions as to how to use the custard oil, the price of which is increasing. No concrete suggestion can be given, but it is recommended that the question be studied by the Central Fisheries Technological Station, Cochin.

It is further suggested that creosote be used extensively. This, mixed with oil such as kerosene (5 parts of creosote to 1 part of oil) gives a very good and economical protection to structural members against rot, and to the bottom planking and exposed keel and posts against attack by the seaworm. The creosote-and-oil mixture should be applied by brush to the bottom, in place of the usual primer paint coat. The mixture should be allowed to dry, after which the anti-fouling paint should be applied. Care must be taken not to use creosote on the topsides, as it will leak through the paint and cause discolouration. Creosote could also be used during construction on the keel, posts, frame-heads, shear clamps, and wherever natural ventilation of the hull structure is restricted. Creosote should not be used on the hold lining or ceiling as it would contaminate the cargo.
Worm damage occurs most commonly in keel-bottom and at the stern and stern posts where the anti-fouling paint is scraped away in beaching or hauling. Creosoting would be the cheapest method of preventing such damage when building, and in general maintenance. Worm-shoes, with tar paper between keel and worm-shoe, and the shoe and keel painted with creosote before the anti-fouling paint is applied, would be serviceable in large fishing craft. The worm-shoe should be of the same width as the keel and at least 1½ in. in depth, spiked to the bottom of the keel.

Copper paints, antifouling compounds and marine paints, are in most cases used by Fisheries Departments for their inspection launches, prototype fishing boats, etc. If copper bottom paint is renewed every three weeks, protection from borer worms can usually be achieved.

Copper sheathing is also used on Government fishing and inspection boats, but not by the fishermen. Copper sheets and tacks are available at all major ports.

Re-caulking is carried out once a year on West coast boats not having rabbeted planksaeams. Caulking material is oil or cotton with pitch. Caulking on rabbeted planksaeams is permanent and rarely requires repair. The material used is composed of Singapore resin, sweet oil and wool.

Prices (August 1955): Coal tar, Rs. 15/- to 20/- per maund (82 lb.)

Copper sheets, 22 gauge, Rs. 260/- per cwt.

Copper tacks, about Rs. 4-8-0 per lb.

9. Engines

The types of marine engines bought for different fisheries development schemes or, privately, by fishermen and fishing companies, are diesels and semi-diesels. In some places, gasoline outboard engines are also used. Not a single inboard gasoline or kerosene engine was seen by the experts, although it is stated that some exist.

Diesel engines are mostly of English make and are marketed by large firms, many with branch offices and service stations in different ports. Semi-diesel engines are only marketed by a few firms, and the representation and service offered are generally not so good as for the diesel engines. Stocks of marine engines are found in Bombay, Madras and Calcutta.

As a rule, adequate marine engine service is found in and near the bigger ports only, and is non-existent in many fishing districts. Imports are restricted, and importing firms maintain that they have increasing difficulty in obtaining spare parts for engines already sold and in operation. A few types of stationary and automotive diesel engines are manufactured in India, and it is understood that some of these firms are studying the possibilities of producing marine engines in the power range suitable for fishing boats. It is recommended that the Government stimulate them in their efforts.
10. Mechanical Workshops

All-round repair workshops are found in or near almost every harbour and port where mechanised fishing is introduced. The ports are usually specially equipped for marine engine work, and the harbour facilities will in most cases only suffice for current repairs on semi-diesels and minor overhaul jobs on diesels.

The staff of most of these workshops have little or no experience with marine engines. However, in many harbours of importance for fishing, the Port Authorities keep their own mechanical workshops where remarkably good marine engineering is carried out by experienced personnel. It would be very valuable for the mechanisation work on fishing craft, if a closer cooperation could be established between the local Port Authorities and the Fisheries Departments.

11. Diesel Fuel and Lubricants

The diesel fuel available in India is suitable for the small engine units of present fishing boats, especially the Hi-Speedol for high speed diesel engines, which is commonly used.

<table>
<thead>
<tr>
<th>Approximate Specifications</th>
<th>Hi-Speedol</th>
<th>Light Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity, 60°F.</td>
<td>0.843</td>
<td>0.845</td>
</tr>
<tr>
<td>Viscosity SSU at 100°F.</td>
<td>35/45</td>
<td>36/45</td>
</tr>
<tr>
<td>Flash, °F. (minimum)</td>
<td>150</td>
<td>175</td>
</tr>
<tr>
<td>Sulphur % (maximum)</td>
<td>1.25</td>
<td>1.50</td>
</tr>
<tr>
<td>Carbon residue (Conradson)</td>
<td>0.02</td>
<td>0.80</td>
</tr>
<tr>
<td>Cetane number (minimum)</td>
<td>45</td>
<td>23</td>
</tr>
<tr>
<td>Calorific value, BTU/lb.</td>
<td>19,500</td>
<td>19,500</td>
</tr>
</tbody>
</table>

The ignition qualities are very good; the sulphur content is high.

Lubricating oils of the required specifications for diesel engines are available wherever diesel fuels are sold.

Supply of diesel fuels and lubricants is inadequate in many districts where motorised fishing is to be initiated. In such places, distribution must be arranged so as to meet the new requirements.

12. Recommendations

The experts gave much ad hoc advice in the field of boatbuilding. Several boats were built according to their drawings, to train carpenters in the use of drawings and of improved methods of construction, and to train the counterparts of the experts in the supervision of boatbuilding. During such work the experts also discussed improvement of equipment and of management methods. Recommended specifications for the equipment of a small boatbuilding yard and for a marine engine service are given in
There was also discussion as to the desirability of establishing Government-run boatbuilding yards to build commercial fishing boats and to maintain existing ones. The construction of small wooden boats in most countries is a rather marginal business. It will only show reasonable profit if run as a business organisation by men having a personal interest in that profit. It is suggested that the Government consider two possible courses: either (a) establishing its own commercial boatyards, or (b) stimulating private interests to improve their present boatbuilding methods, increase the capacity of their present plants, and even to establish new boatbuilding yards. A great number of such privately owned yards, competing with each other, might then guarantee sufficient boatbuilding capacity, and competition would keep prices at a reasonable level.

In order to assist boatbuilding yards, a Government can do much by placing orders for fishing boats which could then be sold to fishermen on easy terms. In this way, it would not be necessary for the boatyards to finance the fishermen. Industrial loans to boatyards might be desirable, so that they could acquire machinery which would ultimately lead to lower production costs. Furthermore, a Government can help greatly by giving direct technical assistance to boatyards by running courses for boatyard owners and selected staff in the reading of drawings, by on-the-spot instruction, and by extension work.

V. MECHANISATION OF EXISTING BOATS

In a country such as India, it is not necessary to discuss the advantages of mechanising existing fishing boats to enable them to go further afield to make bigger catches, earn more money and so raise the fishermen's standard of living. The initiative of Dr. S.B. Setna, then Director of Fisheries of the State of Bombay, in mechanising the Bombay fishing craft, is one of the best examples of a successful mechanisation programme. It is also an example of the hard work required to get it to operate on its own merits. It is true that conditions in the State of Bombay were favourable e.g. the availability of good boats, the existence of engine importing firms with maintenance facilities, and a wise Government financing and subsidy scheme. The main reason for the success, however, was not the physical facilities available, but the spirit, energy and commonsense with which it was initiated and managed during the initial period before the individual fishermen fully realised the benefits of mechanisation.

There are still too many unknown factors in India's fisheries to make it possible to predict the future development of boat types, boat sizes, engine sizes, fishing methods, etc. Due to this uncertainty, and considering also experience elsewhere, it seems as if the fastest development would be through a step by step approach, rather than by the sudden introduction of large, complicated and expensive machinery. The mechanisation of existing boats is, in the main, a temporary step. Once fishermen have engines in their boats and earn more money, they are likely to want larger boats. Then is the time for modifying the design to suit better the installation of engines and the new fishing methods. The requirements for a successful mechanisation scheme are:
Fisheries Departments staffed by energetic men with a good understanding of commercial fisheries

Boats which can take an engine

Engine installation and maintenance facilities

Financial facilities

Training of Fishermen

There appear to be six types of Indian fishing boats suited as they now are for mechanization:

<table>
<thead>
<tr>
<th>West Coast</th>
<th>Estimated Total</th>
<th>Boats that can be Mechanised</th>
<th>Average h.p.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maliya shrimp boats</td>
<td>200</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>Lodhias and Machwas</td>
<td>600</td>
<td>350</td>
<td>8</td>
</tr>
<tr>
<td>Satpati/Versova boats</td>
<td>2,000</td>
<td>1,200</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>East Coast</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuticorin Boats</td>
<td>400</td>
<td>150</td>
<td>5</td>
</tr>
<tr>
<td>Navas of Andhra</td>
<td>2,800</td>
<td>1,200</td>
<td>10</td>
</tr>
<tr>
<td>Batchari boats</td>
<td>6,000</td>
<td>3,000</td>
<td>10</td>
</tr>
</tbody>
</table>

Other boat types might also be mechanised, but the experts do not believe it would be an economic proposition at present. Many small fishing boats, such as dug-outs and canoes, might also be mechanised by outboard motors.

1. Review of Various Engine Types

(a) Outboards

Much can be said about using outboards in the mechanisation of a fishing fleet. Unfortunately, most types are manufactured for use in pleasure boats and they are, therefore, light, and the r.p.m. are too high for efficient use by heavy fishing boats. There are, however, some heavy duty makes. New models have lately appeared with all underwater parts made of bronze and with longer vertical shafts. This would make them more suitable for use on fishing boats, which normally have relatively high freeboard.

The experience of using outboards in fisheries has been controversial from country to country. In the Scandinavian countries and in the U.S.A., thousands are used on small fishing boats. In so-called underdeveloped countries, especially in Malaya and Chile, outboards have been used for some years.

In Malaya, different makes, mostly British and American, are used. The outboards are sold to the fishermen on easy terms and with Government subsidy. Experience shows that the fishermen like them very much, and they have been very quick to convert their boats for the installation of
outboards, which have considerably reduced sailing time to and from the fishing grounds. The development has been:

<table>
<thead>
<tr>
<th>Year</th>
<th>Fishing Vessels with Outboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>11</td>
</tr>
<tr>
<td>1951</td>
<td>80</td>
</tr>
<tr>
<td>1952</td>
<td>377</td>
</tr>
<tr>
<td>1953</td>
<td>413</td>
</tr>
<tr>
<td>1954</td>
<td>413</td>
</tr>
<tr>
<td>1955</td>
<td>477</td>
</tr>
</tbody>
</table>

However, engine maintenance raised problems, and the Fisheries Department had to procure a special repair van to service the engines in about 40 fishing villages. On average, ten to twenty fishing villages are visited each month, and 30 to 40 demonstrations are carried out. Spare parts are sold at cost to the fisherman. When the repair unit started operations in 1953, it was estimated that 50% of the outboards were out of commission. In June 1956 it was reported that about 10% of the engines were out of commission at any one time, and most of them would simply require a thorough overhaul.

In 1954, when there were 413 outboards, the repair unit was working 245 days. It serviced the villages 130 times, and the engines were brought 433 times for repair and spare parts, the total cost being US $3,355, or 82 cents per engine. In 1955 there were 470 outboards in the region. The unit worked 243 days and visited the villages 208 times, but the engines were brought in only 390 times for repair; which accounted for a total of only US $3,96 for spare parts. When the scheme first started, each village was visited once every 3½ months. Now, as repairs are fewer and easier, the unit makes a faster turn-about and visits each village every 1½-2 months.

These figures show that the unit has helped to teach fishermen to maintain their engines better, and to bring down the operation cost, in spite of the fact that gasoline in Singapore costs US cents 49 (2.33 Rs.) per Imperial gallon, compared with US cents 19.8 (0.94 Rs.) for diesel oil.

The Singapore Mobile Unit consists of a van containing a bench with a full set of tools. The Unit is manned by a Chief Mechanic and an Assistant Mechanic, who is also the driver. The approximate capital and annual costs are:

1. **Capital Cost**
   - Motor van with bench: 2,120
   - Complete set of tools: 183
   - **Total: 2,303**

---

*FAO/50/10/7991*
(ii) Maintenance Cost per Year

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Licence fee for van</td>
<td>100</td>
</tr>
<tr>
<td>Fuel and lubricating oil</td>
<td>267</td>
</tr>
<tr>
<td>Servicing and repair of van</td>
<td>84</td>
</tr>
<tr>
<td>Garage, maintenance</td>
<td>43</td>
</tr>
<tr>
<td>Tyres</td>
<td>133</td>
</tr>
</tbody>
</table>

627

(iii) Salaries

<table>
<thead>
<tr>
<th>Role</th>
<th>Salary (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chief Mechanic</td>
<td>1,730</td>
</tr>
<tr>
<td>Assistant Mechanic/Driver</td>
<td>1,170</td>
</tr>
</tbody>
</table>

2,900

US $ 3,527

If 20% depreciation is calculated for the van, or US $460, the yearly costs are about $4,000, or less than $10 per engine serviced— but this reckoning does not account for the van's educational value.

In Chile, about 330 fishing boats had small outboards in 1952. These are of the heavy duty, slow speed type, and their mode of introduction differs from that in Malaya. A private merchant started importing outboards many years ago, and he sold them to fishermen without any government assistance. Naturally, it took a long time to get the engines introduced; no fisherman, except the most successful, being able to buy them as the merchant could not provide long-term payment facilities. Those who did, had to pay the cost entirely themselves and, naturally, had every reason to take great care of their engines. The result in Chile is that outboards are said to run for at least three years without any major repairs becoming necessary, and this would speak highly of the reliability of any type of engine.

During the last five years in St. Louis, French Senegal, West Africa, about 300 outboards of a French make have been installed in canoes, thus mechanising about one-third of the local fishing fleet. They are placed in a well airtight so that when the canoes are landed through the surf, the propellers are swung up, thus preventing them from fouling the bottom. During the first year, the maintenance cost of an engine was sometimes as much as $40 (Rs. 200), but the manufacturer had a representative on the spot who taught the fishermen to maintain their engines and, especially, to run them in fresh water for five minutes after each day's fishing. A
community storehouse was erected where the engines were stored when not in use, and before long the maintenance cost was reduced to about £10 (Rs. 50) a year. The fishermen soon discovered that the outboards enabled them to extend their fishing time considerably. The engines make the voyage easier through the surf and out to the fishing grounds, and increase the net income of the fishermen by at least 30 per cent. The engines are now sold to the fishermen on an instalment plan on the advice of a committee of fishermen, but only a fisherman with a good record and known as being honest, can obtain this loan. The care with which the engines are distributed has been, and is, of great importance for the success of the scheme.

About one-fifth of the fishing craft in Ceylon would be easy to mechanise with inboard engines. The rest are narrow outrigger canoes, catamarans and other types, including flat-bottom beach seine boats and teppams (small log rafts). In 1951, FAO suggested trials of such craft with outboard motors, and sent a few outboards of various makes for the experiments. Apparently the time was not ripe then for the introduction of outboards, and it was soon reported that the fishermen did not like the various makes. Simultaneous efforts to mechanise some of the full-shaped craft with inboard engines were, however, quite successful. This success prompted the fishermen to try and find out whether or not the majority of the craft considered unsuitable for inboard mechanisation in the conventional way could be mechanised in another way. FAO again suggested outboards, and sent nine engines, three each of a different make. While these tests are not yet completed (June 1958), the fishermen in some places have adopted a 4 h.p. heavy duty type of outboard, have bought six of them and have ordered six more. There seems to be a great interest in the island for the further supply of this particular type of engine. Furthermore, individual fishermen have ordered a number of outboards of higher output.

Three of the 4 h.p. engines so far bought had their shafts extended by 16-in. and one by 12-in. The engine is a low revolution unit, working at approximately 800 r.p.m., as against the average 1800 r.p.m. of normal pleasure-boat type outboards. The price is Ceylon Rs. 1,425, which includes spare parts to the value of Rs. 371. This sum is paid by an initial deposit of Rs. 500 on the receipt of the engine and eight monthly instalments of Rs. 115.

The owners of these engines have been operating with long lines or drift nets, which they have been taught to use by the craftsmen of the Department of Fisheries. A few sample records of comparative catches of the outboard mechanised canoe fishing, using improved gear, and non-mechanised canoes fishing with normal local gear, are given below.
<table>
<thead>
<tr>
<th>Date</th>
<th>Centre</th>
<th>Mechanised Weight</th>
<th>Mechanised Value</th>
<th>Non-Mechanised Weight</th>
<th>Non-Mechanised Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>17/9/57</td>
<td>Ambalangoda</td>
<td>80 lb.</td>
<td>Rs. 75/-</td>
<td>20 lb.</td>
<td>Rs. 30/-</td>
</tr>
<tr>
<td>18/9/57</td>
<td>&quot;</td>
<td>150 &quot;</td>
<td>Rs. 179/-60</td>
<td>10 &quot;</td>
<td>Rs. 10/-</td>
</tr>
<tr>
<td>21/9/57</td>
<td>&quot;</td>
<td>95 &quot;</td>
<td>Rs. 81/-</td>
<td>10 &quot;</td>
<td>Rs. 8/-</td>
</tr>
<tr>
<td>22/9/57</td>
<td>&quot;</td>
<td>140 &quot;</td>
<td>Rs. 125/-</td>
<td>12 &quot;</td>
<td>Rs. 10/-</td>
</tr>
<tr>
<td>24/9/57</td>
<td>&quot;</td>
<td>160 &quot;</td>
<td>Rs. 170/-</td>
<td>15 &quot;</td>
<td>Rs. 10/-</td>
</tr>
<tr>
<td>27/9/57</td>
<td>&quot;</td>
<td>210 &quot;</td>
<td>Rs. 236/-</td>
<td>12 &quot;</td>
<td>Rs. 10/-</td>
</tr>
<tr>
<td>21/9/57</td>
<td>Balapitiya</td>
<td>350 &quot;</td>
<td>Rs. 190/-</td>
<td>&quot;</td>
<td>Rs. 15/-</td>
</tr>
<tr>
<td>22/9/57</td>
<td>&quot;</td>
<td>230 &quot;</td>
<td>Rs. 130/-</td>
<td>Other boats:</td>
<td>Rs. 20/-</td>
</tr>
<tr>
<td>23/9/57</td>
<td>&quot;</td>
<td>180 &quot;</td>
<td>Rs. 105/-</td>
<td>&quot;</td>
<td>Rs. 6/-</td>
</tr>
<tr>
<td>26/9/57</td>
<td>&quot;</td>
<td>500 &quot;</td>
<td>Rs. 223/-</td>
<td>&quot;</td>
<td>Rs. 25/-</td>
</tr>
<tr>
<td>27/9/57</td>
<td>&quot;</td>
<td>205 &quot;</td>
<td>Rs. 117/-</td>
<td>&quot;</td>
<td>Rs. 10/-</td>
</tr>
<tr>
<td>28/9/57</td>
<td>&quot;</td>
<td>190 &quot;</td>
<td>Rs. 90/-</td>
<td>&quot;</td>
<td>Rs. 10/-</td>
</tr>
<tr>
<td>29/9/57</td>
<td>&quot;</td>
<td>600 &quot;</td>
<td>Rs. 280/-</td>
<td>&quot;</td>
<td>Rs. 18/-</td>
</tr>
<tr>
<td>21/10/57</td>
<td>Kalutara</td>
<td>50 &quot;</td>
<td>Rs. 50/-</td>
<td>30 lb.</td>
<td>Rs. 33/-</td>
</tr>
<tr>
<td>22/10/57</td>
<td>&quot;</td>
<td>50 &quot;</td>
<td>Rs. 68/-</td>
<td>10 &quot;</td>
<td>Rs. 15/-</td>
</tr>
</tbody>
</table>

It is further reported that a catamaran fisherman has purchased a 15 h.p. outboard with a short standard shaft. Although this is a higher r.p.m. type, he is very satisfied with the way it pushes his craft along. This is the first catamaran in Ceylon which has been mechanised with an outboard.

In Thailand, standard stationary U.S.-made gasoline engines are equipped with an impeller-type propeller. These units are extremely inexpensive and are widely used by small craft sailing on the canals. This type might be very useful for mechanisation of many canoes, especially as the propeller unit could easily be manufactured in India.
General experience indicates that, if the fisherman has to pay most of
the cost of an engine himself, he is more likely to take good care of it,
and that only the fishermen with the highest income will be in a position to
acquire an engine. This tends to exclude the less successful fishermen,
who might in any case not have the necessary intelligence nor the initiative
to look after a piece of machinery. This is a point which has bearing on
the policy of encouraging fishermen to change from using outboards to
inboard engines. If they do not possess the intelligence and initiative
to operate and maintain outboards, they will be even less fitted to operate
and maintain inboard engines.

Outboards have several advantages. They are fairly cheap to buy;
they cost very little to instal (there are no engine beds to be laid, no
 tanks to instal); there is a reduced danger of fire compared with inboard
gasoline engines, because the engines are outside the boat; they can be
removed during sailing, therefore the propeller does not cause undue
resistance; and they can be taken home by the fishermen after work, so
there is no need for him to have to guard the boat. The ease of removing
the engine also facilitates maintenance. A big advantage is that out-
boards can easily be maintained by mechanics familiar with car or motor
scooter engines, as the technique is much the same. The outboard has,
however, one great drawback, and that is the high price of its fuel—
gasoline. On the other hand, if the size is limited to 4 h.p., which is
powerful enough to push almost any of the smaller types of Indian boats at
a reasonably good speed when there is no wind, the fuel consumption is no
more than one-third of a gallon per hour.

It is, therefore, recommended that the use of reliable heavy duty low
speed outboards, of about 4 h.p., with 12 to 20-in. extended shafts and
bronze underwater parts, be encouraged in existing boats which are not large
enough to take an inboard engine. Such outboards will show fishermen the
importance of engine power and lead to the introduction of a full-scale
mechanisation programme.

(b) **Gasoline Engines**

Gasoline engines are generally modified car engines equipped with a
larger oil sump, modified cooling water system and a reverse gear, sometimes
a reduction gear. A bearing to take up the propeller thrust is also
necessary. Gasoline engines are easy to maintain as they can be repaired
in almost any garage. They are also cheap, of low weight, and the delivery
time is usually short. However, the price of gasoline is generally high
because of Government taxation, and there is a greater danger of fire, even
if the engines are properly installed. Tax exemption would always solve
the question of the high price of gasoline, and in many countries, such as
the U.S.A. and Canada, where such tax exemption for fishermen exists,
gasoline engines are used to a large extent in small fishing boats. In a
few countries, black marketing of the fishermen's gasoline has reached
such proportions that at least one Government has felt it necessary to
subsidise the fishermen to instal oil engines and remove the tax exemption
on fishermen's gasoline.

Even if the fire hazard could be minimised by proper installation and
the efficient ventilation of fuel tanks and space under the floors of the
boat, it is recommended that inboard gasoline engines be avoided because
open cooking fires are sometimes used. Some boats are also old, and may easily "work" so much at sea that a gasoline pipe could break and cause leaks, resulting in explosions and fire.

(c) Kerosene Engines

Kerosene engines are generally of the same design as gasoline engines. Some of them are simply converted car engines with a separate kerosene carburetor. They are usually started on gasoline. When the engine reaches its working temperature, the kerosene carburetor is switched in. The gasoline carried on board can therefore be reduced to a very small quantity and can be stored above deck. Kerosene engines are small and of light weight. They are almost as easy to maintain as gasoline engines, and can be serviced by car mechanics. Kerosene is normally not more expensive than high grade Diesel oil.

Some manufacturers specialise in small kerosene engines for boats. They are widely used in fishing boats in the Scandinavian countries and Great Britain. One advantage of kerosene engines is that they do not vibrate very much, and therefore do not need such heavy foundations as oil engines.

(d) Semi-Diesels

Semi-diesels are slow-running, heavy duty oil engines, usually with few cylinders. They are mostly of the two-cycle type and contain very few moving parts which may wear out and need maintenance. They are relatively inexpensive, dependable, and burn the cheapest fuel. They have to be pre-heated to start, but that takes only a few minutes, and does not necessarily mean a delay because, while waiting, there are many things to be done on a boat before it leaves the jetty. Semi-diesels with one or two cylinders sometimes start in the wrong direction but, with some skill, it is quite simple to reverse them without stopping the engine. The fuel spray angle on some types must be adjusted for high and low loads, which also requires some skill. Semi-diesels are very popular in fishing boats in Scandinavia, and they are also extensively used in many other countries, such as Portugal, Malaysia (Singapore) and Japan. They are, however, heavy, rather bulky, and vibrate more than kerosene or diesel engines, and it is advisable to use them only to mechanise strong boats and where an adequate supply of spare parts is available.

(e) Diesels

Diesels are to-day, theoretically, the most efficient prime movers for fishing boats. They work, however, under very high pressure, and several of their parts are made with such precision that, as a general rule, they should be repaired only by someone who is a trained Diesel mechanic, and who has access to the appropriate tools and spare parts. The repair facilities for diesels in most fishing villages appear to be inadequate and, when assisting fishermen to buy specific makes, it should be ascertained beforehand that adequate repair facilities really exist for the type in question. The initial price of Diesels is high, and smaller sizes need top-grade diesel fuel, which is relatively expensive. They have a low fuel consumption per horse power, as compared with other engines.
but such an engine has to run for a considerable number of hours before the higher cost of investment — as compared with kerosene engines or semi-diesels — is offset by the lower cost per running hour.

2. Relation between Boat, Engines and Propeller

When deciding on the size of an engine for a certain fishing boat, it should be remembered that the resistance, and thereby the required engine power of boats, does not increase in proportion to the speed, nor does it increase as a square of the speed, as it does with vehicles. A typical Satpati boat, having a length in the waterline of about 38-ft., and a beam of about 11-ft., with a draft of 4-ft., has a displacement of about 13.2 tons. Such a boat in calm water requires — according to the model tests made at the ship testing tank at the Central Water and Power Research Station in Poona — the following engine output:

<table>
<thead>
<tr>
<th>Knots</th>
<th>B.H.P.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2.6</td>
</tr>
<tr>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>6</td>
<td>10.9</td>
</tr>
<tr>
<td>7</td>
<td>21.0</td>
</tr>
<tr>
<td>8</td>
<td>45.0</td>
</tr>
</tbody>
</table>

These figures show that this large and heavy boat will make 4 knots in calm water with a very small engine, say of 3 h.p. But to make 50% higher speed, or 6 knots, about four times the output, or 11 h.p. would be required, while to increase the speed from 6 to 7 knots, the engine power would have to be doubled. This h.p. would also have to be doubled to increase the speed from 7 to 8 knots and, while a speed of 9 knots has not been investigated, it would most probably require very much more than twice the engine power at 8 knots. In addition, at such high engine power, a propeller with optimum diameter would be impossible to accommodate, so that it would be necessary to select a small propeller diameter with low efficiency.

All boats have similar resistance characteristics. Up to a certain speed, the resistance increase is relatively moderate. It is possible to give all boats a reasonable speed with very moderate engine power, but when it comes to adding those extra knots, a very heavy increase in engine power is required. This means not only that the engine will be too large and load down the boat, but will also consume very much more fuel.

The trend of the resistance curve of a fishing boat does not depend on its absolute speed in knots, but on the relative speed, or the speed-length ratio, which is calculated from the formula:

\[
\text{Speed} = \sqrt{\text{Floating length of the boat}}
\]

The speed-length ratio is also called Froude's Number, and in the feet measuring system it is normally written:

\[
\frac{V}{\sqrt{L}}
\]

where \( V \) = speed in knots, and \( L \) = length in feet.
For the Satpati boat in question, 38-ft. at the waterline, the speed length ratios for the various speeds are:

<table>
<thead>
<tr>
<th>Knots</th>
<th>$\frac{V}{\sqrt{L}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>.65</td>
</tr>
<tr>
<td>5</td>
<td>.812</td>
</tr>
<tr>
<td>6</td>
<td>.975</td>
</tr>
<tr>
<td>7</td>
<td>1.14</td>
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<td>8</td>
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With the help of the speed length ratio, boats of various lengths can be compared at the same relative speed. The Satpati boat running at 8 knots has a speed length ratio of 1.3. This corresponds to 13 knots for a 100-ft. trawler, or 43 knots for a passenger liner like the United States. It is impossible, in spite of all the naval architecture development work in the field of larger trawlers and especially that of large passenger liners, to give a 100-ft. trawler 13 knots with reasonable output of the engine, or to bring the United States up to 43 knots. 8 knots, or a speed length ratio of 1.3 is, therefore, a very high speed and, for practical purposes, quite uneconomic.

Fishing boats are seldom driven faster than a speed length ratio of about 1.0, even if slightly higher speeds are obtained during delivery trials when they are dry, have a light displacement, and no load. A speed length ratio of 1.0 would correspond to the following speeds:

- Boat length, in ft: 20 25 30 35 40 45 50 60 70 80 90 100
- Speed, in knots: 4.5 5 5.5 5.9 6.3 6.7 7.1 7.75 8.35 8.9 9.5 10

In other words, the average cruising speed of a fishing boat should be about the square root of its length at the waterline. Naturally, with especially good lines, transom stern, etc., 10%-15% higher speeds could be obtained, particularly on trial runs. But to aim at considerably higher speeds, say 20%-30% higher, is not realistic, and will lead to the selection of an engine that is too powerful and too expensive.

Power is expressed in horse power which, according to the metric system, denotes the work of lifting 75 kilos 1 metre per second and, according to the British, 550 lbs. 1 foot per second. 1 British h.p. = 1.014 metric h.p. Although this definition is a simple one, many "different" horse powers are used to determine the size of a propulsion plant in ships. The most important ones will be mentioned here.

(i) **Shaft horse power (S.H.P.)** is the power delivered to the propulsion shafting. It is the sum of power required to overcome the resistance of the vessel, the losses at the propeller and the losses in shaft bearings and stuffing boxes.

(ii) **Indicated horse power (I.H.P.)** is used in connection with reciprocating types of machinery (usually with steam engines) and is the power corresponding to the main effective pressure in the cylinders and the piston speed. It is greater than shaft horse power (S.H.P.) because
of the losses in the engine and in any bearings, thrust blocks or transmission gear there might be between the engine and the propulsion shafting.

(iii) Brake horse power (B.H.P.), usually applied to diesels, denotes the power delivered at the engine coupling. It is greater than the shaft horse (S.H.P.) by any bearing and transmission losses there might be between the engine and the propulsion shafting.

In addition to these main definitions, the naval architect also works with the effective horse power (E.H.P.), which is the power that would be required to tow the vessel, and the delivered horse power (D.H.P.), which means the horse power at the tail end of the propeller shaft that is outside the hull.

There is a "difference" between the power developed by a steam engine and a diesel. The steam is more flexible and permits more overloading and therefore one has the feeling that, with a steam and diesel engine of the same brake horse power, the horse power of the steam engines is "stronger".

Diesels are labelled with a "nominal" horse power rating by the manufacturer, and although it should represent the brake horse power which the engine should be able to develop continuously, it gives the naval architect the greatest difficulty because there are so many different methods of rating the B.H.P. To-day there are three main methods of rating marine diesels.

(a) British Rating. The output stated in accordance with British Standard Specification - 649/1949 - does not, as such, show the power reserve of the engine, but stipulates an allowed increase and decrease of the rated load (increase 10% for 1 hour output; decrease 10% for continuous 24 hour running). In addition to the intermittent (1-hour) output, normal (12-hour) output, and continuous (24-hour) output, engines are sometimes also rated for the automotive output, representing a short period output. An engine which by its manufacturer was rated to have a 12-hour output of 35 B.H.P. had an automotive output of 40 B.H.P., a 38.5 B.H.P. one-hour output, and a 32 B.H.P. 24-hour output.

(b) U.S. Rating. Commercial standard, CS 102-B - 42, of the National Bureau of Standards, Washington D.C., uses ratings for the peak, intermittent and continuous output. The Standard stipulates: Peak horse power is a maximum horse power which the engine will develop and maintain without drop in speed for at least one minute, with a reasonably clean exhaust when the engine is in proper adjustment. The peak horse power is to serve as a guide only to surplus power available in the engine as stipulated by the manufacturer". The 35 B.H.P. engine discussed under (a) was rated by the manufacturer to have a peak output of 47 B.H.P., an intermittent output of 40 B.H.P. and a continuous output of 32 B.H.P.

(c) German Rating. The proposed German rating, DIN 6270, specifies one peak output, one intermittent output and two different ratings for continuous running. The peak output is the top output of the engine which must be maintained for fifteen minutes without occurrence of mechanical or thermal stresses. By comparing the peak output with the continuous output, the power margin of the engine is determined. 1-hour
rating is the allowed intermittent output during a total of one hour's continuous, or six hours' interrupted, running. For long-time running, the German standard gives two different ratings, one when no increase of output is allowed, and one for continuous running where intermittent output is allowed. The 35 B.H.P. engine previously discussed will, according to this rating, have a peak output of 45 B.H.P., a continuous output of 32 B.H.P. and a long-time rating with intermittent increased loading of 40 B.H.P., and without intermittent increased loading of 38 B.H.P.

In the example where the manufacturer made the ratings the continuous B.H.P. for any of the systems was 32 B.H.P. but the peak B.H.P., according to the U.S. rating, was 47 B.H.P. or 47% greater. Many makers label their engines with the peak output. Others are very conservative, and the horse power they claim for their engines might even be an understatement of the power possible under continuous operation. The makers of semi-diesels, in particular, seem to under-rate their engines with the effect that the fishermen, while agreeing that the engine is "stronger" than comparable diesels, are somewhat disturbed by the considerably higher fuel consumption. This higher fuel consumption is not only due to the slightly higher specific consumption of semi-diesels, but also to the fact that the fishermen might be using 20%–30% more horse power than they realise. The cylinder volume and the mean pressure are good measures for checking the way manufacturers rate their engines, and when there is a question of purchasing a large quantity of one type, such details might first be considered.

It is therefore necessary to estimate the output of the engine for continuous heavy-duty operation, which should also include an allowance for tropical operation. Such estimates must be made by a person with experience of the type and make of engine in question.

Wind and waves call for higher horse power than calm water conditions. If the boat has a fixed blade propeller, one could avoid overloading the engine by reducing the r.p.m. Another way would be to select a screw which would not be fully loaded when the boat is running in calm water, but tended to be loaded in a certain average size of sea. If the propeller is selected for a power of about 70% of the selected horse power, a good average might be obtained. This will, however, not permit the highest possible speeds during trials in calm water. On the other hand, it will prevent overloading of the engine by crews who are not mechanically-minded.

It is not difficult to get a propeller working reasonably well, but the selection of a propeller working with the highest possible efficiency requires experience, some calculations, and actual observation of the performance during a well-programmed trial, and subsequent adjustment if necessary. Fishing Boats normally operate at a speed which is at the high slope of the resistance curve. A rather considerable decrease in power delivered by the propeller to push the boat forward will, therefore, not mean a comparable decrease in speed, and therefore a badly selected propeller is not too obvious by mere visual observation. The result does, however, show up in high fuel consumption, higher engine wear and loss of profit.
Manufacturers of marine engines normally list a certain propeller diameter in their leaflets, and the standard propellers they sometimes deliver with the engines must naturally be a compromise because of the great variety of boats these propellers have to fit. The suitability of such propellers should be checked. If the resultant revolutions and the fuel consumption of the engine are carefully studied during a trial, it could be determined whether the pitch of the propeller was too small or too large and, if unsuitable, a new propeller could be ordered.

There are different ways of selecting the dimensions of a propeller and, for large commercial cargo vessels, a propeller calculation is a rather complicated procedure. Fishing boat propellers, however, can be selected rather easily if the following details are known:

a) the effective power required by the boat
b) the power characteristics of the engine
c) the speed of advance of the propeller

The effective power (E.H.P.) is the power required to tow a boat, in other words the power required to overcome the water resistance, or the power of the engine less the losses in the propeller. If the efficiency of propulsion is 50%, the required brake horse power of the engine (B.H.P.) must therefore be twice the E.H.P. The effective power is best determined by making a model test, which can be done at the Central Water and Power Research Station in Poona. Such a test will give information about the power requirements of the hull at various speed/length ratios. The results can be expressed in non-dimensional values and, in this way, they can also be used for similar hulls of the same general type, that is, having the same coefficients determining hull resistance. The most important of these are the prismatic coefficient, the location of the centre of buoyancy and the angle of entrance. Naturally, the shape of the boat as such, whether it has a transom stern or a cruiser stern, and the length-displacement ratio, also play an important role. The effective power can also be estimated from published results of model tests with similar hulls, such as has been done in FAO Fishing Boat Tank Tests, and finally, it can be estimated from full-scale trials of boats.

The speed of advance of the propeller is the speed at which the propeller is working. It is the speed of the boat minus the wake, which always exists behind a boat. This wake naturally varies for different types of hulls, but a good average value for small fishing boats is 25% of the speed. With these particulars, it is possible to use propeller diagrams, e.g., those developed by Troost, published in several textbooks and simplified in the Caterpillar Propeller Calculator.

When a propeller has been so selected, it is still important to carry out a full-scale trial over a measured distance at various r.p.m. of the engine, so that a fair curve of the results can be drawn. It might then be necessary, in spite of care taken in the calculation, to change the propeller for one with a somewhat different pitch. Here a Government has
an important role to play, both in helping the fishermen to select proper propellers, in checking their actual performance and in establishing a kind of propeller bank, which would make possible the exchange of propellers between the different boats having slightly different speeds, wakes and power requirements.

When considering the type of propeller to be driven by a certain engine, it will soon be found that the r.p.m. of the propeller plays an important role in the efficiency of propulsion. High r.p.m. and small propeller diameter give low efficiency of propulsion and correspondingly higher fuel consumption and less speed. On the other hand, low r.p.m. engines are costly to purchase and require much large propeller diameters that they cannot be fitted under a normal hull. By making calculations, using propeller tables, it is possible to study the effect of varying r.p.m. and to arrive at the best possible economic conclusion.

3. **Installation**

(a) **General**

Generally, the manufacturers provide detailed instructions as to how their engines should be installed, and these should be followed as carefully as possible. The following notes might offer some additional and useful suggestions.

When a boat is to be mechanised, it is most practical to make a wooden pattern of the selected engine so as to see its actual size and the best way of installation. With this pattern, and the dimensions of the propeller, the exact position of the engine should be ascertained, and whether the propeller should be placed in the centre line of the boat or at the side of the stern timber. A simple instrument, based on the principle of communicating pipes, is useful for comparing heights inside with those outside the boat. A half-inch rubber hose is fitted at both ends with glass pipes, and the hose is drawn through a hole bored through the planking. With one glass pipe used outside, and the other inside, and water in the hose, the heights can quickly be determined and then, using also the wooden pattern of the engine, the best location of the shaft line can be decided.

When the type of installation, centre line or side, is decided, a narrow hole should be drilled where the shaft tube will pass the hull and through this a wire or line can be run to represent the centre line of the shaft. Then, again, the engine should be checked to see that it is easily accommodated, and a study should be made to see how the engine beds must be fitted.

Having thus decided on the installation in general, the hull should then be strengthened so that the engine can be installed. All unnecessary timbers in the area of the engine beds, etc., should be removed. The old frames have to be inspected, and any that are rotten should be replaced. If possible, additional frames and floor timbers should be put between the present frames. A simple way of strengthening the boat, both longitudinally and athwartships, is to place a heavy keelson on top of the floor timbers, stretching well fore and aft of the engine.
The planking should then be securely fastened to the frames throughout the region of the engines. Spikes bent on the inside of the frames might suffice. Where necessary, the seams of the planking should be re-caulked.

The engine beds can then be made. Most engines require beds placed in the long-ship direction, but Kelvin engines, for example, require athwartship beds. The wire or line running through the shaft hole representing the centre line should be used to set the beds at the correct angle. The position of the top of the engine beds in relation to the shaft line and the placing athwartship of the beds can be found from the engine catalogues or installation drawings delivered by the manufacturers. Careful measuring and levelling with a carpenter's level is essential. It is best to set the top of the beds a little lower - 1/16 or 1/8 of an inch - than called for in the installation dimensions. This will permit the use of thin metal shims or strips when lining the engine. The beds should rest on the top of the floor timbers, which should not be notched deeper than one inch. Floors and beds should interlock. The beds should fit the inside planking of the vessel, between the frames, if possible. The beds should be bolted to the floor timbers, after making certain that they are parallel and lined up correctly. The planking is spiked from the outside into the parts of the beds between the frames.

If the engine beds are high, shocks or braces should be placed against the sides to prevent lateral motion. With kerosene engines, it is desirable to have a drip pan underneath the engine. This is a shallow metal pan, preferably of copper, with a turncock at one end, used to catch any leakage, or overflow, of fuel. The turncock should be off centre and should be at the low end. The pan should be long enough to reach from a little forward of the engine fly wheel to a little aft of the coupling, and must fit in between the engine beds. The depth depends on the height and shape of the engine beds. If possible, the distance between the bottom of the pan and the engine should be 5 or 6 in. Felt stripping should be inserted between the floor timbers and the bottom of the pan, and at the sides, to prevent the pan from rattling or drumming.

Before the engine bed is built, the final hole through the stern timber, or through the planking in the case of a side installation, should be bored to fit the stern tube. But first the bolts and fastenings in the stern timber in the way of the propeller line must be removed. The final boring of the stern tube is rather difficult, and to prevent weakening the stern timber unnecessarily, no more wood than is essential should be bored out. The hole must not be burnt out, as that would weaken the timber. In centre line installations, it is preferable to bore the hole from the outside towards the inside of the boat but, in the case of side installations, it might be more practical to bore from the inside, using the engine beds as a jig. In centre installations, the jig can be made out of two heavy battens fitted on each side of the stern timber parallel to the shaft centre line and a few inches below it. The hole for the stern tube should be started with a single cutter auger bit in the after part of the stern timber. A cross-piece, made with a notch, can be used to support the long stock of the auger to keep it in correct line when boring. If a hole is used in place of a notch, a sight line should be struck on the cross-piece.
The hole to start the boring should be about two inches deep, then the bare foot ship auger bit, welded to a long stock or brace, can be used to complete the boring. When boring a long hole, the bit should be pulled out several times so that the chips may be removed from the hole. If the bit and its stock are correctly lined up, there should be little trouble in getting a true hole. After boring, the hole can be reamed by using a piece of iron pipe of the right diameter and roughing its surface with saw cuts, opened with a cold chisel. The longer the buttons are extended abaft the stern timber, the more accurate the boring is likely to be; but the stock on the auger would also have to be that much longer and this, in practice, fixes the position of the cross-piece. The size of the hole is naturally governed by the outside diameter of the stern tube.

This boring for the stern tube, as described above, is suitable for smaller boats and for boats where the deadwood is not longer than about 2-ft., but when boring for stern tubes of longer lengths, it will pay to use electrical equipment.

The advantages are, firstly, that proper drill bits can be welded to the extension rod, the end of which is made to suit the chuck on the drill. Secondly, it is possible to use a jig, on which the drill can slide, with better results than when boring by hand. Thirdly, it is easier to alter the direction of the drill if, for some reason, it gets out of alignment during the operation. When boring by hand, it is very difficult to get the hole right again once it has gone wrong. Last, but not least, the work is done very much quicker with electrical equipment, and the extra cost is thus soon repaid.

It pays to drill a pilot hole first, of about ¾-in. diameter, and rig up a line representing the centre line of shaft, and check inboard to see if the inclination is right, before drilling the hole with the final diameter.

It also often pays, for greater accuracy, to use a boring bar of steel. The diameter of the steel rod should be in accordance with the length of stern tube. For a 2-ft. stern tube, it should be 7/8-in., for 3-ft. it should be 1-in., and for 4 ft, 1 1/8-in. etc.

A pilot hole is made with the electrical drill in the normal way, but with a slightly bigger diameter than that of the boring bar. Then the line marking the centre line of shaft is rigged up, also in the normal way, except that the line should go through two bearings for the boring bar. There should be one bearing just inside the deadwood and one just outside. Both are secured to the deadwood, so that the line is centred in the bearings. The bearings can be made of little pieces of brass pipe with the same inside diameter as the rod, or they can be a piece of metal drilled with a hole to suit the rod. In both cases, these places are welded or soldered to the base plates that are fastened to the deadwood.
The main advantage of using a boring bar is that it makes a straight hole, and that it corrects any little misalignment in the pilot hole. It is also better to drill big holes with a boring bar, as big drill bits are very expensive. The boring bar is nothing but a shaft holding a cutter of tool steel which scrapes the hole bigger when the bar is turned and moved inwards slowly. The cutter is held in a hole in the bar by a lock screw. The bar rests in the two bearings with the cutter just outside the hole when the operation starts. The boring bar must rest on the bearings throughout the operation, so it must have sufficient overlength to still rest on the outside bearing when the cutter has scraped through to the inside end of the stern tube. This means that the steel rod must be more than double the length of the stern tube.

The boring bar can be turned by an electric drill or by hand. If a drill is used, care must be taken that the bar is not pushed through too fast, as this might damage the cutter. The outside bearing is often made with a nut, and the outer end of the bar is threaded so that, when turned, the cutter moves inwards, guided by the threading in the nut. In this case, an electric drill can only be used if the threading is very fine, and the drill very slow-running. Mostly, therefore, it is easier to have ordinary Whitworth threading on the bar and use a good hand brace for turning. It is necessary to move the cutter back and forth several times, with the cutter set out, little by little, until the required diameter is reached.

When installing the stern tube in existing boats, it may be feasible to put in a new floor timber well forward of the stern timber where the inside stuffing box of the stern tube is fitted. This will result in an intermediate bearing between the aft part of the stern post and the engine proper. Furthermore, it is desirable to have such a new floor timber, as the forward side of the stern timber will be too narrow for fitting the stuffing box. The new timber should be carefully fitted against the planking, and when the stern tube, with its flanges, has been fitted through the stern and the floor timber, the space between the two should be filled with pitch or other suitable material so as to assure watertightness. While boring the stern timber, and fitting the stern tube, care should be taken to see that the propeller line is kept exactly as originally planned.

At this point, the engine should be placed inside the boat to try out the alignment of stern tube and engine beds. The propeller shaft is then fitted into the shaft tube, and the engine is placed in its approximately correct position on the engine beds. The propeller shaft and couplings should be handled with care. Any damage will prevent proper alignment.

One has to study the most practical way of installing fuel tanks and drawing the pipes between the tank and the engine, and the pipes for the cooling water and exhaust line. When these details have been decided, the engine is removed to facilitate the installation of the tanks etc.
The alignment of the engine is in two stages: first, after the boat is launched, but before the trial run, and second, two or three weeks after the trial, the reason being that a boat in water has always a somewhat different shape than when on land. In any case, the shape is always changed, however slightly, when the timber has swollen. Actually, the alignment should be checked from time to time throughout the life of the boat.

Lining up the engine and shaft is not an easy task; it requires both care and patience. It is done by shifting the engine until the faces of the coupling halves and the propeller shaft are in contact all round their circumference. The alignment of the faces should be tested with feeler gauges. Metal shims should be inserted, if required, between the engine flanges and the engine beds to make the final adjustment of height or angle, or it might be necessary to shave a little wood off the engine beds. The difference in gap between the faces of the coupling halves should be less than 0.002-in. If the alignment is to be considered satisfactory. Strips of paper inserted round the faces of the coupling will serve instead of a feeler gauge; when the engine is properly lined, it will take the same amount of force to pull out the strips from between the closed faces. Test by revolving the shaft with the engine half of the coupling stationary. The faces should be closed throughout the complete turn.

(b) Tanks

If no fuel tanks are delivered with the engine, the simplest and least expensive tanks would be standard oil-barrels. They could be placed on deck, connected by flexible pipes to the engine. Tanks should rest on wooden supports or shocks firmly bolted or spiked to the beams and frames, and should bear on the tanks for at least one fourth of their circumference. A tank might be held in the shocks by iron straps, with the ends bolted, lagged or screwed to the shocks or hull timbers.

If the space under deck permits, specially made round tanks, which are less expensive to manufacture, or shaped tanks, might be installed to make the best use of the space, but they are often difficult to make fast. When fitting a shaped tank, the top should not be carried close to the underside of the deck beams. It should be at the level of the underside of the clamps so as to leave sufficient room for fitting filling pipes from the deck and for their inspection. The bottom of a shaped tank should be flat, and rest squarely on a suitable foundation. It is best to make a pattern showing the exact size of the fore and aft end of the tank and the position of deck connection before the tanks are made, so that there is no interference with deck beams. A shaped tank must be set on solid shocks, and the faces held in place by solid straps or timbers.

Large tanks should always be made with baffles or inside bulkheads, so that the fuel will not smash against the walls and damage the seams, and make an unpleasant noise.
If the tanks are made of steel, the sides towards the hull should be painted. Copper tanks are not recommended for diesel fuel because they are difficult to tin inside. If they are used for other fuels, they should be carefully supported, as they are relatively weak. It is especially important that the backs of such tanks are provided with full support.

Every tank should have a filler pipe of at least 2-in. diameter leading to the deck. There should also be a ventilation pipe (of at least 1/2-in. diameter) leading to the top of the rail, and finishing in a gooseneck covered by fine gauge mesh. The outlet should be fixed at least 3-in. from the bottom to allow water and dirt to collect underneath the opening. This will prevent it being easily sucked into the engine. At the lowest possible point there should be a cock to allow the water and dirt to be flushed out. In large tanks there should be man-hand holes to enable the tanks to be cleaned.

The manufacturer's instructions should be consulted as to whether the engine has to be gravity-fed or whether the fuel pump on the engine can take fuel from a level lower than the pump proper. If the tank is placed somewhere in the middle of the boat, low down, it might be necessary to use a small daily service tank to feed the engine, or to apply low air pressure in the tank itself for raising the fuel to the pump. Under the pressure feed system, the pipe from an air-hand-pump leads to the top of a tank. 1-lb. per sq. in. air pressure will raise the fuel about 20-ft. Pressure as low as this obviously entails no risk of bursting a tank and, whether the gravity or pressure feed system is used, a tank that will stand 10-lb. per sq. in. is safe. Under this system, the fuel pipe to the carburettor or the fuel pump is led from the top to the bottom of the tank end, of course, the pressure forces the fuel up this pipe. A few strokes of the hand pump at long intervals are enough to maintain the pressure, which should be checked by a gauge. The ventilation pipe must be fitted with a valve so that it can be shut off.

(c) Fuel Pipes

Fuel pipes should be of copper, and the line chosen between the tank and carburettor/fuel pump should, firstly, give ample protection from damage, and, secondly, the greatest possible degree of flexibility. In every piece of machinery there is some vibration, and even the best balanced engine is no exception to the rule. Vibration always makes copper brittle, and fuel piping, rigidly held, is apt to break, either close to the carburettor/fuel pump or the tank. To provide the necessary amount of spring to obviate this risk, one or two loops should be put in the pipe at each end. These loops should be horizontal, not vertical, as a vertical loop tends to form a trap for the collection of dirt and gives rise to air locks.

A gasoline drip should be avoided even in an open boat, in a decked boat it becomes a serious source of danger. An additional safeguard is a gauze-covered drip tray beneath the carburettor, with a drain cock from which any accumulation of gasoline or kerosene (although little or no danger exists with the latter) may be drawn off.
But prevention is better than cure. Leakage usually occurs when a boat is left at moorings with the fuel tap turned on. The level of the jet in the carburettor is virtually the same as that of the float chamber, so that the least motion of the vessel causes a slight overflow, and this is the cause of most leakages. The fuel cock should always be turned off when the engine is shut down, or, better still, the cock should be inter-connected with the ignition switch, so that the fuel is automatically cut off when the engine is stopped.

A stoppage in the carburettor jet or fuel line is one of the most frequent causes of engine failure. A very large strainer should always be fitted in the fuel pipe. The best practice is to fit a pair of filters, arranged so that one can be shut off for cleaning while the fuel feed proceeds through the other.

(d) **Ignition Fittings**

Dampness is the greatest enemy of electric ignition, and the installation of batteries, coils, magnetos, etc., should, in all cases, be arranged with the primary object of keeping them dry. The heat of the exhaust creates a dry zone in the neighbourhood of the exhaust pipes, and this should be taken advantage of wherever possible, remembering always that none of the gear should be so close as to be damaged by heat.

In fact, most of the points to be observed are of a negative character for, apart from the question of dampness, no battery, coil or magneto should be exposed to oil thrown off any part of the engine, nor should they be immediately below a water pipe in case they should be subjected to the drip from a leaking joint.

Just as much care should be taken with the wires of the circuit, particularly on the high tension side. The insulation should be ample, the length of the wires reduced to a minimum, and they should be neatly led through fibre tubes of ample size. Nothing looks worse than loose wires straggling over an engine, and, apart from appearance, they are very liable to be damaged.

(e) **Cooling Water Piping**

Copper pipes should be used, and they should be bent to shape in fair, easy curves, with flanges brazed on to form joints at the sea and pump connection to the engine cylinders. When the pump is installed separately from the engine, there should be a rubber connection between this casting and the main delivery pipe to allow for vibration. With good clips, there need be no fear of leakage, and a paste of red lead, white lead and boiled oil is useful for painting the surfaces of joints and packing. Asbestos board, rubber-canvas, etc., are convenient packing materials.

An easily accessible sea-cock should be installed on the suction side of the pump. This is a most necessary fitting, and the cock should always be closed when the boat is to be left at moorings. Otherwise, any unnoticed defect may sink the boat. It is also a great convenience if it becomes necessary to break a joint below the waterline.
The water intake is often in the form of a combined scoop and strainer. The position under the boat should be chosen with the greatest care to ensure a free supply of water. Generally speaking, the best place is near the keel and as far amidship as possible so that no amount of pitching will bring it out of the water.

Undoubtedly the greatest trouble with cooling water circulation is from weeds. There always remains the possibility of a choke, and means of clearing the intake from inside the boat should, if possible, be provided. This can be done by having two filters inside the boat, but having couches between them and the planking. They are combined into the engine line by a 3-way cock. To clear the intake of weeds, one filter is cut out by two of the couches and the filter cleaned, if necessary, while the engine is running.

A refinement which offers advantages, by avoiding internal corrosion of an engine and enabling it to be maintained at the most efficient operating temperature, is the closed fresh-water-circuit cooling system. A pump is employed to circulate the fresh water. A heat exchanger, usually of the multiple-tube type, is included in the circuit. Another pump delivers salt water through the heat exchanger, thereby cooling the fresh water. A simple form of closed circuit is sometimes arranged by circulating the fresh water through a pipe outside the boat alongside the keel, no seawater pump being employed.

(f) Exhaust

Disposal of the exhaust is one of the most difficult problems connected with an engine installation. Silence, low temperature and absence of back pressure are the three essential features of a good system, and it is by no means easy to combine the three qualities at a moderate cost or without the use of heavy and space-requiring pipes.

The exhaust line should not be smaller than the size of the exhaust manifold flange outlet, and should be so arranged that a following sea or heavy rain is prevented from getting into the engine through the exhaust pipe and valves. From the engine to the point of discharge through the stern the fall should be as gradual as possible. Under no condition should the elbow connecting the manifold to the exhaust line be less than 135° for, if a sharp bend is brought into the line, there is danger of back pressure.

To eliminate vibration in the exhaust line, there should be at least one flexible section and, in some cases, the entire line is made of flexible metallic hose similar to the flexible steam hose. Used for many purposes aboard the larger type of steam-driven vessels, if the exhaust line is of more than average length, two flexible sections should be included. Every care should be taken to avoid any depressions in the line which might fill with water and obstruct the free flow of gases.

The water discharge pipe of a marine engine should always be at the highest end of the exhaust manifold. The water is then carried by a pipe to the exhaust pipe at the after end of the engine. In this position, it overflows from the water jackets at the highest point. If the water discharge pipe were taken from the after end of the manifold, which is the lower part of the engine, steam pockets would form in the forward jacket.
passages. Such pockets would cause overheating of the engine and fractures of the cylinder walls and head.

Exhaust pipes must be cooled or insulated to prevent the heat from causing a fire in the boat. One method is to cover the pipe with asbestos or a similar insulator; a minimum thickness of one inch is recommended, although two inches is a better guarantee against fire. If the pipe is supported by one or more brackets, screwed into the boat's hull, then small pads of an asbestos material should be placed beneath the base of each bracket.

A second method is to introduce the cooling water from the engine exhaust manifold circuit into a water jacket surrounding the pipe. Another, and more popular, method is to introduce all the cooling water into the exhaust line at a point a little beyond the connection between the exhaust pipe and the manifold flange.

This last system can be used only in downward sloping pipes, and it might be difficult in most existing boats, but it has the effect of a silencer, as the steam caused by the cooling water coming into contact with the hot exhaust gases helps to break up the sound waves of the engine explosions. In the water-jacketed type of exhaust, the water flows along the outside of the exhaust pipe until it almost reaches the end of the line where it enters the exhaust pipe proper through a series of holes bored in the pipe. These holes should be of sufficient size and diameter to allow the water to flow into the exhaust line without backing up the line and impeding the water's circulation through the engine.

There is one drawback to the popular system of piping the cooling water directly into the exhaust pipe: the exhaust gases contain very corrosive elements which, when mixed with water (especially salt water) form certain acids that are detrimental to the metal of the exhaust pipe. Cast or wrought iron pipes, however, or exhaust hose - the latter made specially for such jobs - do the work very satisfactorily and without much corroding.

(i) Vertical Exhaust. If the engine is mounted in such a way that a vertical exhaust pipe must be used, a water-trap type muffler should be installed in the vertical section of the exhaust pipe. After passing through this water trap, the water should be directed over the side or into the exhaust outlet pipe.

(ii) Horizontal Exhaust. If the engine is mounted below the water line, a very practical method is to place a rising length of exhaust pipe for the first section that will lift the pipe high enough to allow a gentle slope to the atom. For the distance of the rise and for a short section on the downward sloping side, the exhaust pipe should be water-jacketed and, at that point, the water can be introduced into the exhaust pipe to act both as a coolant and as a silencing element.

Drains should always be fitted to the lowest point of all jackets and, in some cases, where there is a rise and fall in the jacketing pipe, two drains should be fitted, one at either end.
(iii) Silencers and Mufflers. Silencers are often fitted to exhaust lines and, where used, the exhaust line is usually water-jacketed between the engine and the silencer. The cooling water is let into the silencer, where it circulates through the chambers and helps to reduce noise, and is then discharged through the tail pipe. Dry silencers are particularly useful in boats where the engine is mounted below the water line, which makes it impossible to have a gradual slope from the exhaust manifold to the over-board discharge point. However, there are many types of silencers and all are designed for specific purposes which, in most cases, they fulfill satisfactorily.

Where silencers are not used, and the exhaust bark is too noisy, mufflers often help to reduce the noise. Mufflers are easily fitted at the extreme end of the exhaust pipe, and usually take the form of a series of baffles which break up the sound waves. In some cases the baffles take the form of spiral-like pieces of metal, in others, of a series of punctured baffle plates; and there are other types. But most mufflers call for the unit to be clamped on in much the same way as a piece of flexible hose is introduced into the exhaust line to relieve vibration. Mufflers are located at the discharge end of the exhaust pipe, and should not be placed near the engine, or anywhere along the line except at the extreme end.

When a boat is not under way, the exhaust line discharge point should not be under water, as the gases cooling in the exhaust lines contract and can create a vacuum which would suck water into the line, whence it can find its way into the engine. Following soon, too, can flood an exhaust line if the end of the pipe is below the water level.

It is usual, on small craft, to carry the exhaust to the stern, although a point nearer the engine can be used, if desired. An outlet too close to the engine is not advisable, as a very short exhaust pipe does not effectively silence the noise. A "wet" exhaust is generally preferred to a "dry" one, and on many modern engines the silencer or injection fitting is bolted directly on the water. A "wet" exhaust reduces the noise and keeps the pipes cooler; if properly installed, there is little risk of water going into the engine.

(g) Manoeuvring Gear

To make the installation as simple as possible, it is suggested that all the manoeuvring gear should be fitted to the engine proper. One man can easily operate these by merely watching the helmsman at the tiller, or the tiller can be made longer so that the helmsman can operate the engine himself.
(b) Starting

It is suggested that all the engines, if possible, be hand-started in order to avoid having batteries on board which require generators for re-charging and introduce a complication of electrical details. These might become soaked and thereby put out of order. Large engines should preferably be air-started to avoid the complication of electrical equipment.

4. Proposals for Mechanization

The experts spent much time in discussing with the local fisheries officers the possibilities of mechanizing existing boats. They made certain proposals and gave a considerable amount of ad hoc advice and in-service training to counterparts, and they also helped in checking installed engines as well as supervising the installation of the first engine in new types of boats. The following is an example.

(a) The Case of the 20 Lodhias and Machyas

Zioner spent a considerable time working on those boats, which had been ordered before his assignment by the then Government of Saurashtra at the boatbuilding yards in Satpati, Billimora and Bighri in the Konkan area. He first went to the boatbuilding places in 1954. He found that the Lodhias built at Satpati had been altered in the hull shape against the drawings, and he recommended that for further orders a man who understood boat drawings and could make full scale templates, should go to the yard to reproduce the plans accurately. In the boats built in Billimora and Bighri, Zioner found certain weak details in construction of the framing. Some inconsistencies in the planking strokes indicated that the builders were not able to enlarge the plans accurately to the full size. Zioner recommended that the plans should be re-drawn to a bigger scale, which he also did later. He also recommended that the stern post should be sharpened as much as possible, so as to give the best flow of water to the propeller. He made a general observation that the centre of buoyancy of the lines was too far forward, and he prepared a new lines plan having better distribution of the displacement. In January 1955, fourteen of the boats arrived at Vereval and Zioner took them out to sea, one by one, for thorough testing and trimming. He found many faults, especially with regard to foundation bolts for the engines and their alignment, and he adjusted their injection equipment, lubrication and reverse gear. The report on his work is typical of what can be gained by having qualified technicians check the construction of fishing boats. He found, and recommended:

1. A change made by the Satpati builders in the direction of lines resulted in their boats being about 3-knot slower. The boats built according to plan in Billimora and Bighri were drier and more sea-kindly than those built at Satpati, because the full forebody near the water level shipped more spray and pounded harder. Similarly, the full lines of the aft body caused a drag of water and also a twisting of the planks, which made the boats leak near the stern. Zioner recommended that future boats should only be built by contractors who were willing to build according to the drawings submitted.
(ii) He found that the buttressed seams of the planking which were of the standard of builders north of Bombay, were difficult to caulk and numerous leaks had to be stopped. He recommended that future boats should be built with ordinary butt planking seams which would be easier to caulk and recaulk. This would reduce costs because labour would be cheaper and the planking could be reduced in thickness by $1/3$ in.

(iii) He stressed the importance of sharpening the stems, especially the thick storm posts.

(iv) Big, rough and unfinished logs of wood were placed underneath the bottom of the Satpati-built boats to take the engine foundation bolt heads. They are unnecessary and objectionable because of their resistance in the water, and they were one of the reasons why the Satpati boats were slower than the boats built at Billimora and Bighri.

(v) The Billimora and Bighri boats have their keel extended under the rudder pintle which permits ropes and floating matter to slip off. This is important in crowded harbours where many ropes between boats and land have to be crossed. The Satpati boats had a groove between the keel and the rudder which caught such ropes, and it was recommended that such construction be avoided in future.

(vi) Zieher's general observation was that the engine installations had not been made with sufficient care and skill. The bolting, especially, both of the wooden engine bearers and the engine, was inefficient. For future installations he recommended:

a) Not to mix iron and brass bolts in the foundation bolting, as the iron bolts deteriorate rapidly due to galvanic action.

b) All through bolts should be placed with heads outside the hull and nuts inside, not with nuts outside, as soon on several of the boats.

c) Log screws should not be used for bolting down one-cylinder engines. Those used on the boats were ineffective because vibration had loosened them, and it was recommended that they should be replaced by bolts.

d) Engine bearers should be bolted firmly to frames and floors and these again firmly to the keel. Engine bearers should not be counter sunk into the frames more than to lock them. On the Satpati-built boats they were counter sunk too much, thus weakening the frames where rigidity is most important.
e) The shaft log should be made as short as possible to avoid a long stern tube.

f) Flanges to stern tubes should be placed on the surface of the shaft log so that they can be inspected and adjusted, and easily unscrewed for the removal of the tube. On the Satpati-built boats, the flanges were sunk into the wood so that the fitting between the flange and the wood could not be checked. In fact, the stern tubes on the Satpati-built boats were found to be bent, due to incorrect fitting between the shaft log and the flanges.

g) There should be liberal clearance between flywheel and other moving parts of the engine and the hull.

h) Iron bands supporting fuel tanks and air bottles should not lie directly against these containers because sea water coming in between will corrode the material and the vibrations will accelerate the process. Canvas, well soaked in paint, should be placed between to prevent metallic contact.

i) Due consideration should always be given to the change of engine alignment when a boat goes into the water. This is not only because of the drying out of the engine bearers, but also because of changes in the hull shape, as the planking swells more amidships than at the ends. Engine alignment should therefore always be adjusted when the boat is launched, and for some time afterwards.

(b) Lodhias and Machwas

In Saurashtra, Ziener recommended mechanization of the boats built during 1952 and 1955 under the Government's "Grow More Food" scheme, and of similar boats. The GMF boats had the following dimensions: length over all, 31 ft.; breadth, 5\(\frac{1}{2}\) ft.; depth, 2 ft. 5 in. They were all built to the same plan, and of the 120 boats 80 were considered fit for mechanization. The hull shape is favourable for engine propulsion, even if the lines are somewhat too fine at the stern so that the engine and fishing gear must be placed well forward. Stability is good. Construction is strong enough to take an engine of 5 or 6 h.p., but because some boats were weakly built and badly joined, inspection of each boat was recommended as necessary before deciding to mechanize. It was hoped that the result of the mechanization would be that three additional gillnets could be used, while employing one fisherman less, thus increasing catch and earnings per man.

* Note: These observations were made in a specific case, but they are applicable to engine installations in general.
Rasmussen supervised the installation of the first engine—a 6 h.p., 900 r.p.m., SABB, type B, semi-diesel. This engine weighs 445 lb. and has a controllable pitch propeller. The engine was installed in co-operation with his counterpart, Mr. P. B. Sapre, but, due to the monsoons, trials could only be made in the Vedarval harbour. The speed was judged to be about 6 knots, but it was not actually measured. Later, it was reported that 20 such engines were installed in boats in Vedarval, Probandar, etc. The drawing, Fig. (44) shows the installation of the first engine.

(c) Bombay Mechanisation

The mechanisation programme was in full progress in Bombay when this FAO project started. Engines were sold by the manufacturers direct to the fishermen and the fishermen’s co-operatives, with the Government simply approving the purchases before giving the subsidies. The experts were therefore not requested to work specially on the mechanisation of such boats. During the study of existing boat types, however, Zienor made some general recommendations, such as the use of longer engine beds and putting the engines into large enough engine cases to facilitate inspection and repairs. He also recommended sharpening the stern timber to permit a free flow of water to the propeller. Zienor found that propeller selection had not been given much attention. Standard propellers supplied with the engines were used in all cases, without checking to ensure that they did not overload the engine.

(d) Pattamara

It was Zienor’s opinion that the pattamara of Ratnagiri would be somewhat difficult to mechanise because it would be necessary to make great changes in the hull. He made some proposals, Figs. (45) and (46). Mechanisation would require replacing the stern post. Handling on beaches would be simplified if extra fillers pieces could be used on the curved keel to straighten it. Zienor further recommended using light and low-built engines, having as little height from shaft to engine top as possible because of the shallow depth and thwarts. Such engines should preferably be two-cylinder or more, of about 1,000 r.p.m. and 20 to 40 h.p., according to the size of the boat.

(e) Kamara Dugouts

Wide dugouts (Boppu type) with good buoyancy in the aft portion could be mechanised experimentally.

The necessary modifications of the hull can be made by any skilled boat carpenter. They consist of:

(i) Addition of wooden skog under the stern. This should be of ample thickness for passing the stern tube of the propeller and permitting bolts to be passed each side of the tube. A suitable thickness would be 3-3/4-in., but this is dependent on the shape of the stern part of the dugout, and on how the joint between hull and skog is cut. As maximum thickness is only required at this joint and where the propeller shaft passes, the wood should be faired off in other parts so as to conform with the hull shape.
and allow a good flow of water to the propeller. The contour of the skeg outside the stern line (the dotted line) should be as shown in Fig. (47).

The skeg should be bolted to the boat with \( \frac{3}{4} \) in. bolts, iron or, preferably, brass if economy permits. Bolts should be driven from underneath, and the heads well countersunk. The bolts must be painted and paint or waterproof glue must be applied to the surfaces of the joint. Inside the hull, where the nuts and washers come, the wood must be squared to give a good base under the washers. The ends of the skag should be secured to the hull with \( \frac{3}{4} \) in. drift bolts or big nails. The hole for the shaft should be marked and lined up after location of the wood. It can be \( \frac{1}{2} \) in., not more, and should be bored from the outside.

(ii) Two engine bearers of hard wood, 3 in. thick and sufficiently high to form a bed for the engine, should be accurately formed to suit the hull where the engine holding-down bolts come. A \( \frac{3}{8} \) in. bolt should be put through each and through the hull, and screws should be used where convenient. The engine bolts, \( \frac{3}{4} \) in., should also go through to the outside of the bottom, with conveniently inclined heads. They must be marked and drilled after the true position of the engine is fixed and must be square to the engine flange.

(iii) A suitable wooden block for mounting the thrust bearing and reversing lever must be fitted and thoroughly bolted to the hull.

The engine recommended is a Lister Diesel type AD of \( 3 \frac{1}{2} \) h.p. at 1800 r.p.m., aircooled, with controllable pitch propeller. These engines are also delivered with fixed blade propellers and reverse gears, which are to be preferred to the installation indicated.

An iron, or preferably brass, ring of \( 2 \frac{1}{2} \times 5/16 \) in. and about \( 11\frac{1}{2} \) in. inner diameter should be placed around the propeller for protection, as shown in the drawing. The upper part should be a V-bracket for screwing to the stern, and it should also be firmly fastened to the skag.

In Fig. (47) the engine is located in a position where the standard length propeller shaft of \( 4\frac{1}{2} \) ft. can be installed without cutting it.

If necessary, the propeller shaft (both the solid shaft and the outer tube-shaft) may be shortened by cutting to required length. A perfect alignment of the engine with the propeller shaft is important.

A rudder should be fitted. Mast and sail can be carried.

During his assignment to the State of Mysore, January to March 1968, Zionor, among other things, assisted in carrying out the first mechanisation of a beppu-type dugout. With his three counterparts, he selected a suitable dugout, which was placed at the disposal of the Government by the
fishermen. The boat was measured and drawings were made by the counterparts, showing the installation of a 30 1/2 h.p. air-cooled Lister engine. The engine was installed at the Government boatyard and during one of the last days of his assignment to the State, the boat was launched and tested. It was found that the engine was of adequate power and gave the boat a speed of 5.7 knots in calm water. Fishing trials will be made with the boat.

(f) Tuticorin Boats

150 of the 400 existing Tuticorin boats were considered by the experts to be suitable for mechanisation. The boats are sharp and narrow and the aft body is fine but with less buoyancy than could be desired to carry an engine. The engines must not, therefore, be too heavy and should be placed rather far forward, as otherwise the freeboard aft will be too low.

The framing is rigid, but the longitudinal strength is insufficient in many boats. The latest boats also show poorer workmanship. Boats should therefore be closely examined, ensuring that they are strong and well built, before engine installation is attempted.

An average sized boat, Marit or Maria Santingapappan, was purchased by the State Government to investigate mechanisation possibilities. This boat has an overall length of 29 ft., a breadth of 6 ft. 3 in., and a depth of 2 ft. 11 in. Drawings were prepared to demonstrate how two different types of engines could be installed.

A Potter diesel, type AV2M, 10 h.p. at 1500 r.p.m., was installed in 1955 because such engines were supplied by the TCA 1952 Programme. The engine proved to be far too heavy and powerful for the boat, resulting in an uncomfortable trim by the stern, as foreshadowed by Zienar. The boat was modified at the stern to take the propeller in the centre line. Unfortunately, this modification, in spite of specific sketches made by Zienar, was not done with the necessary care. The aft body of the boat has rather an unsuitable shape for good resistance properties. Furthermore, the boat, which did not originally have sufficient longitudinal strength to take a heavy engine and sustain the torque and vibration set up by the engine, was not equipped with special heavy engine bearings, resulting in misalignment of the propeller shaft, which was not remedied and, consequently, the engine suffered heavy damage.

In 1958 the decision was taken to try mechanisation again with a smaller and lighter engine and in April 1958 the Marit was equipped with an 8 h.p. Solo petrol/kerosene marine engine. At the same time another Tuticorin boat was installed with a 30 1/2 h.p. air-cooled Lister engine. A preliminary report on this mechanisation was given to the Government of Madras on 5 May 1958 by Peter Gurner, FAO naval architect, who will present a complete report after the boats have been in operation for some time. The first results were promising.

(g) Catamarans

As those craft are rafts with the "deck" continuously awash, they cannot be equipped with an inboard engine, but it should be theoretically possible to mechanise those with an outboard motor mounted on some kind of pedestal. In fact, it is reported that a few craft have been temporarily
mechanised in this way, but they work out of river mouths. Unfortunately,
mechanisation of the very large number of catamarans working in surf
conditions on the West coast is not feasible. The only possibility of
carrying out mechanised fishing from the long surf-beaten coasts seems
to be in the development of a surf boat.

(h) Navas

The 2,800 navas, both the Kakinada and Masulipatam types, are strongly
built. About 1,200 might be mechanised without important modifications.
The construction details and handling of the two types of navas vary a
good deal, and the mechanisation must be dealt with boat by boat.

The hull shape is quite favourable for mechanical propulsion, especi-
ally as regards speed. The stability of the Kakinada type is good and
mechanisation should not have an adverse effect. The Masulipatam type is
narrower and the stability would only be maintained if the engine was placed
low and not too far aft. The navas are well built, as a rule, but there
are exceptions, and care should be taken to select only the strong boats
for engine installation.

(A) Kakinada Navas

Engines should be 10 to 15 h.p. and light-weight. A 10 h.p.
engine should not exceed 750 lb., and a 15 h.p. not 900 lb. 900 m.p.h.
or more, would meet these requirements and also the requirement of a
rather small diameter of the propeller, due to the necessity of
minimising the draught. Engines of high r.p.m. should have reduction
gear. The possible speed is estimated to be nearly 7 knots with a
10 h.p. engine and, when loaded with 2 tons of fish, about 6 knots.
The 15 h.p. engine should give a speed of about 7 knots with a load of
2 tons of fish. The following modifications are required:

1. A wooden keel of 5½ in. maximum width should be bolted under-
neath the stern part of the hull, and a log, 6 in. wide,
should be bolted inside, as indicated in Fig. (48). These,
shaped as per plan, should take the stern tube of the propeller
shaft, the keel piece acting also as a protection for the
propeller.

2. If the motor is of a single cylinder type, two or more addi-
tional floor timbers should be fitted under the motor,
preferably in such a way that the holding-down bolts of the
engine pass through them.

3. Longitudinal engine bearers of good quality wood, at least
3½ in. thick and with a height corresponding to the location
of the motor, should be carefully adjusted to, and bolted over
the existing and the additional frames.

4. A rudder should be fitted to the boat. A very cheap and
effective arrangement is possible, as shown on Plan, Alt. 1,
if the overhanging steering car stand is out away and a
transom stern fitted.
If the fisherman should wish to retain the characteristic storm, a more complicated and expensive arrangement, as indicated in drawing Alt. II, can be used. It consists of a rudder blade of hardwood, 1-1/8 in. thick, fixed to an iron or, preferably, bronze shaft of 1-1/4 in. diameter, which, through a rudder shaft tube with suitable packing, is extended up above deck where a tiller is fitted.

The rudder alternatives shown are only meant as a guide to reasonable solutions. Other arrangements may be equally good.

The first boat was equipped with a 10 h.p. Potter diesel and, during Zienert’s assignment to the State of Andhra Pradesh from March to May of 1955, the boat was tried out at sea and found satisfactory. The result justified the recommendation that the Kakinada navas should be maintained as a local boat type, and should be modified step by step, becoming a larger mechanised boat with improved sea-going ability.

(B) Nasulipatam Navas

These boats must have a good speed in order to go outside the delta. This calls for rather strong engines with comparatively large propellers located well below the water surface. On the other hand, the characteristic hull shape and the shallow draught must be maintained for entering the canals and creeks where the boats are beached. A possible solution seems to be an arrangement by which the propeller can be lifted to keep it in a safe, elevated position during launching and beaching.

There are several Japanese diesels on the Indian market and they have propeller equipment of this kind. Among them is a 1-cylinder diesel of 8 to 12 h.p. and 900 to 1,000 r.p.m., which is recommended as an experiment. Spare parts are said to be available from stock in major Indian ports. In Fig. (49), a Japanese diesel of 8 h.p. at 900 r.p.m. (maximum 10 h.p. at 1,000 r.p.m.) is shown. The standard propeller is 3-bladed, diameter 16 in. and pitch 11 in., which is a suitable size. This motor will give the boat, with about 1 ton of fish load, an economical speed of about 5$\frac{1}{2}$ knots. Reverse gear is recommended.

The location of the engine should be determined with due consideration for providing ample working space for fishing and for the inclination of the motor, according to the factory’s instructions, should not exceed 11° from the horizontal when the stern is squatting under speed. In no case should the motor be placed further aft than indicated in the drawing. It can, however, be placed further forward so as to reduce the angle of inclination. The motor should be installed as low as possible.
Two longitudinal engine bearers of hardwood, about 3 in. thick should be bolted firmly over four or five frames. For protection of the universal joint and part of the shaft when the boat is being beached, two side locs should be bolted under the bottom, as shown in Fig. (49). Wooden blocks should be provided inside the stern for mounting the lifting mechanism of the propeller.

If a long standard stern tube is ordered, a wooden log could be fitted above the bottom board between the frames and be firmly bolted to each side, but with no bolts in the centre line where the hole for the shaft comes. This would be the easiest and cheapest installation in a yard where boat carpentry is good.

If the stern tube delivered with the motor is short, it could be fixed to a bronze or brass bottom plate by soldering, as indicated in Fig. (49). The plate should have the shape of the bottom planking and should be thoroughly screwed or bolted. The stern tube should be as near as possible to the universal joint.

A sail, on the foremost only, should be carried for emergencies. It can be smaller than the present mainsail and, to obtain balance without the aft sail, the mast should be stepped vertical.

(i) Batchari Boats

The great fishing population of West Bengal depends almost exclusively on the nearly 6,000 batchari boats. In their different sizes, they perform almost all kinds of fishing in estuaries and they also serve as fish carriers alone or in combination with fishing. When tides, wind, current and winds are adverse, fishing is hampered. It is recommended that a few batchari boats be installed with engines to ascertain whether mechanisation would be an economical proposition.

Batchari boats are well built and the lifetime is said to be 30 to 40 years. Figs. (39) and (40) show the lines and construction details of a typical small batchari boat. Such boats should not be provided with too powerful engines. Displacement is a true measure of the size of the boat and, despite their great overall length, the displacement is small and the boats are really very small. A boat of 40-ft. length with a displacement of 0.6 tons empty, to 1.4 tons loaded, would only require a 4 to 5 h.p. engine to obtain approximately 5 knots with a fish load. It would not be economical to increase the speed by the use of stronger engines.

The batchari boats operate in heavily silted waters and are hauled up on muddy beaches. Water-cooled engines would therefore be liable to be troubled by silting of their cooling water pumps. Air-cooled engines seem to be more suitable. The small boats requiring 4 to 5 h.p. should have engines developing this power, preferably at 1,200 r.p.m., and in no circumstances more than 1,800 r.p.m. A 4 h.p. engine should not weigh more than 300 lb., and a 5 h.p. engine not more than 500 lb. Fig. (50) shows a 3½ h.p. engine with a controllable pitch propeller equipment. A fixed blade propeller can also be used if the engine has reverse gear. Fig. (51) shows a retractable type of propeller of Japanese make which, in some cases, might be of advantage. These propellers should, however, be run at less than 1,000 r.p.m.
Batchari boats of 40 to 45 ft. overall length, with beam of 6 to 7 ft. and depth of 2\1/2 ft., are used both for fishing and fish carrying. Occasionally, they have to run against strong currents, and westerly squalls might force them to seek harbor rapidly. Such boats should, therefore, be fitted with relatively powerful engines. Air-cooled diesels of 10 to 15 h.p. with maximum 1,800 r.p.m. and 1.5:1 to 2:1 reduction gear would be desirable. A reverse gear or controllable pitch propeller is necessary. A 10 h.p. engine should preferably weigh not more than 500 lb. and a 15 h.p. engine not more than 600 lb. If a retractable propeller is used, the installation can be as shown in Fig. (51), Alts. I and II.

It is important to have easy hand-starting on these engines, and electric starting is not recommended. A power take-off for driving a winch is desirable.

The larger batchari boats of 50 to 55 ft. overall length, with a breadth of about 8 ft. and a depth of 3 ft., will require lightweight diesels of 15 to 20 h.p. at up to 2,000 r.p.m. and a reduction gear of 2:1 ratio. These engines could be either air-cooled or water-cooled, although air-cooled engines seem preferable. Lighter type semi-diesels, having an r.p.m. of about 1,000, might be considered. Fig. (52) shows schematically a 14 h.p. air-cooled engine in a 51-ft. boat used for purse seining and drift net fishing. A basket around the propeller, to prevent nets getting caught by it, is recommended, although this is not shown in the plans.

If water-cooled engines are used, cooling water must be circulated through the closed system of pipes outside the hull, below the water.

It is felt that the larger batchari boats would benefit more by motorisation than the smaller ones. An increase in fish production would be most noticeable for the large boats which are used for purse seining, drift netting, and seine and drag netting in the foreshore waters of the Sundarbans between Sagar and Thakuran Island. The boat approach to the project of motorisation of batchari boats would naturally be to install engines in a few experimentally and try them in actual fishing. Mechanical propulsion as such is not technically difficult, but it is hard to predict to what extent it might influence the handling of fishing gear and open up possibilities for using new fishing methods.

(j) **Chat Type Fishing Boat**

The chat hull form, at normal speeds, requires less power to propel astern than ahead. A simple test, towing a boat both ways at the same speed and measuring the resistance with a dynamometer, would convincingly prove this. In other words, if motorised, the actual stern should preferably be the bow, and vice versa.

There might be a reason for the design of this boat type that has developed through centuries, but it was not possible to get a satisfactory explanation. The fact remains, however, that the fishermen are accustomed to run their chat boats with the deep and very full on ahead. A suggestion to run the boats astern first must seem to them a queer idea which they probably would not accept without a convincing demonstration.
The technically correct solution is to install engine and propeller in what is now the bow. This will result in less resistance, better weight distribution and improved sea-worthiness, simple engine and propeller installation, and will make the boat more useful for the kind of fishing it now performs.

The average shot boat has the following dimensions:— length overall 34 ft., breadth 9½ ft., depth moulded 3 ft. 8 in., displacement empty approx. 3 tons, displacement loaded, approx. 6 tons. The lines drawing, Fig. (41), corresponds to such a boat. There is no great variation in size and shape of the shot boats, and the drawing can be considered as typical.

The boats are built of teak, carvel planks on built-up frames. The planks are not rebated to stem and stern, which makes the ends weak. There is no stiff keel, but a considerable deadrise to the bottom gives some longitudinal stiffness. This construction is satisfactory for oar and sail propulsion, but it will not be strong enough for engines, which should be quite powerful to take advantage of the nice running lines of these hulls. Reinforcements are necessary, and the type and power of the engine must be selected in relation to the strength of each boat. The necessary modifications of the hull will be:

1. Reinforcement of stem and stern with apron and inner stem wood, possibly check pieces, for improved fastening of planking. It will be better still to remove stem and stern and replace them by new ones that can be rebated. This is especially desirable for the stern, as a new piece can be given the necessary thickness and moulding for taking the propeller shaft stern tube.

2. Strengthening the bottom throughout with well fitted floor timbers.

3. Fitting engine bearers over the floor timbers, as far as possible aft and forward of engine, not only for mounting the engine, but also for longitudinal stiffening of the bottom over at least ⅔ of its length.

There is a certain lack of initial stability in the shot boats, which is noticeable in the empty condition when nets and floats are carried on one side. The installation of an engine will improve the stability, and the lower the engine is mounted in the boat, the better. A dock, or a cover over the engine, should be lightly built.

It is difficult to give dimensions for the strength members recommended; they must be determined individually. While strengthening of stem and bottom is a simple boatbuilding matter, the thickness and shape of the stern and the dimensions of engine bearers depend more on the type of engine and stern gear, and will vary greatly.

It is recommended that a rudder be substituted for the steering oar in the motorised boat. A simple and cheap rudder arrangement is shown in Fig. (61).
For fishing with drift nets, purse seine and bag net, a maximum speed of 6 knots unloaded and 5 knots with 60 mounds of fish, may be sufficient. The engine should be a marine diesel or semi-diesel of 12 to 15 h.p. If desired for longer fishing trips and quick transport of the catch, the maximum speed can be driven up to about 7 knots by installing a light engine of 20 to 22 h.p.

Engines with one cylinder, especially semi-diesels with low revolutions, will probably set up strong vibrations which most of the existing chot boats cannot stand. Engines with two or more cylinders give less vibration and should therefore be used. The revolutions per minute may conveniently be 750 to 1,000, if the engine is coupled directly to the propeller. If higher than 1,200, a reduction gear should be used for bringing the propeller r.p.m. within the above figures for direct drive.

The propeller can be of the controllable pitch type or fixed. If a fixed blade propeller is used, the pitch should be, roughly, about 12 in. for 800 r.p.m., and about 10 in. for 1,000 r.p.m.

Engines should have a power take-off for driving a net winch, or at least be of such design that a strong and reliable power take-off can be rigged up. Engines should be installed far aft and deep down in the boats leaving the middle and fore parts for gear, fish and working space.

Existing chot boats should, if mechanised, fish inshore waters only, as they now do. For offshore fishing, stronger and modified hulls are required.

(k) Diamond Harbour Boats

The Diamond Harbour boats are a local type of the Hooghly Delta not used for fishing, but occasionally as fish carriers, Figs. (42) and (43). They are, however, suited for fishing operations and can be mechanised without any other modification than a new and thicker sternpost. The hull form of the best boats is similar to that of good fishing boats in many parts of the world. It is recommended that an experiment with motorisation be made with a medium-sized boat selected for good hull shape and finish. Such a boat would be suitable for mechanised fishing, especially if equipped with net winch, rollers, etc., and could extend operations to the lower and rougher estuaries and the sea.

A mechanised Diamond Harbour boat would also prove useful as a fish carrier in the lower and rougher reaches of the Sundarbans, especially if fitted with an insulated fish hold. However, the characteristics of the Diamond Harbour type are those of a hard-weather fishing boat, rather than of a fast carrier boat. It is possible that, with further development, its use as a fishing boat will be lasting, but as a fish carrier only transitory. Therefore, too much emphasis on its development as a carrier boat may not be justified.

If productive fishing throughout the year is established in the lower Sundarbans, there will be a need for special carrier craft capable of collecting and transporting the catches faster to the assembly points, and more economically. It is possible to design such boats with sufficient speed but it would be premature to make the design now.
The Diamond Harbour boats very greatly in size, from about 24 ft. to 50 ft. and more. The most convenient size of an experimental fishing boat would be about 30 ft. overall length. A part of the present cargo hold would have to be sacrificed to give space for the engine, but the greater part would still be available as a fish hold, possibly insulated so that the boat could also be run experimentally as a fish carrier.

The engine should be a marine diesel of about 25 h.p. which, through a suitable reduction gear, should give the propeller 700 to 800 r.p.m. The engine should have a power take-off for driving the net or trawl winch.

As a boat must be selected, and the whole installation will depend very much on its size, shape and storm construction, no specific recommendations can be given at this stage. The basic modifications that must be made to the boat are:

1. A new storm post, possibly also storm knee, of form and dimensions to suit the propeller and storm gear to be installed.
2. Engine foundation of wood.
3. Suitable wooden foundation for net or trawl winch.
4. Most probably a new rudder.
5. Possibly lining and insulating the fish hold.
6. Transmissions for power from engine to winch,
7. Net rollers, trawl gallow, fairleads, etc.
VI. NEW BOAT DESIGNS

1. Modifications of Present Boat Types

There has always been development in the design and construction of fishing boats in different parts of the world, and no fishing boat type will ever remain permanent. Boats everywhere are modified step by step based on experience gained in their operation and that of boats in other localities, and by applying more and more the laws of naval architecture which generally have remained unknown to fishing boat builders until recently. The fisherman or fishing boat builder, who has no knowledge of naval architecture, is naturally reluctant to change the design he knows for another which he is not sure will result in an improvement. With better communications and increased international cooperation, fisheries journals now publish many more articles about fishing boats used in other parts of the world. Fishermen on the high seas also get an opportunity of studying boats from other regions working the same grounds. Conditions today are, therefore, more favourable to the spread of ideas for improvements in design and construction, etc., and, as fishermen normally complain about their hard life at sea, they are not so reluctant to accept new ideas if given a convincing demonstration. This is in spite of their statements that they have the best fishing boat type in the world—one that was developed by trial and error for their particular waters and conditions.

The view more widely accepted today is that the factors influencing the design of many fishing boat types in various parts of the world were not so much local conditions as mere chance. The American West coast purse seiner, having its wheelhouse and engine forward, is not the product of an intelligent study of the working of the purse seine from the stern, but merely a tradition from the time when the gillnet fishing boat was first mechanized. These boats were handling the net from the stern, so the logical place for the engine was in the bow. Then the boats grew in size took on new fishing methods, and the result is the modern purse seiner. The very full and round Swedish fishing boat type is a development of some smaller sailing fishing vessels which had a large boom. As the price of fishing boats in Sweden is determined by the over-all length, the fishermen always insist upon very buoyant boats in order to get as much value as possible for their money. The result today is a fishing boat which compares rather unfavourably in sea-going qualities with its Danish and Norwegian neighbours. This does not prevent the Swedish fishermen from publicly announcing that their fishing boat is the best in the world, even though when on the high seas and seeing the boats from the neighboring countries, they begin to have their doubts. And they are today more ready to accept suggestions about a change in the design.

No doubt the development of fishing boat design will lead to an increased interchange of opinion and experience between different regions and different nations. This will make it possible to improve individual boats and also to introduce completely new designs.

Many boats in India, especially those from the north-west, the mahonas with transom stern are, like their Pakistan sister boats, the bodies very well developed from a modern naval architectural point of view. Still, they could be improved by sharpening the stern posts, by modifying the distribution of displacement, by introducing lighter and stronger construction.
methods and, naturally, by mechanical propulsion and winches for handling their fishing gear, insulated holds for fish, and a modified general arrangement to increase the working efficiency of the crew and improve comfort.

Similarly the boats north of Bombay, such as those from Satpati, could be improved in many small details which would all add up to greater efficiency, larger catches and bigger profit for the operators.

When an area has a fishing boat type which is suited for mechanisation it is sometimes easier to introduce the new type step by step as such boats must be constructed by builders used to the old type. In India most of the boats from the north-west, those from Tuticorin, the navas, the bhatchari, chet, and the Diamond Harbour boats, can be modified to become fishing boats of comparatively high efficiency. In other places, where dug-outs, canoes and outboard motors are used, it seems to be advisable to introduce new types of boats at once. The question then is whether these new types should be introduced from other areas in India or from abroad. This is naturally a question of judgment, but to introduce to the Mysore coast a completely new "foreign" type, such as the Pabla, which has already proved good operating off the Madras coast, might be more successful than to introduce a local type from another State, such as the navas. On the other hand, if the Satpati type is being developed into a successful boat for the lighter periods of the monsoon, it might be quite efficient, working off a large harbour on the East coast.

The work of the exports has been very much of an ad hoc nature, trying to modify boats on a step by step basis wherever possible, and also designing new types on demand. Up to July 1957 a number of such new types were designed which might be of great value in places other than those for which they were evolved.

(a) Satpati Boat

During his 1954 assignment to the State of Bombay, Ziefer had an opportunity to study the Satpati boat. He found that if the rabbet in the stem post was located further forward, one would be able to sharpen the lines in the forebody without any loss of buoyancy. Furthermore, sharpening the foremost part of the stem post, would result in better cutting of the water by the stem post. This proposal was later taken up when the lines of a typical Satpati boat were to be tested by the model tank of the Central Water and Power Research Station in Poona. The very slight modification, which involves no extra cost, is shown in Fig. (53). The subsequent model testing at Poona showed that the resistance, and thereby the fuel consumption, would decrease by 13%.

(b) Tuticorin Boat

Of the same length and the same way of construction, the Tuticorin boat can be improved for engine propulsion by increasing the breadth and depth. The depth amidship should be only slightly increased but, with the use of a sloping keel, the draught at the stern could be increased to permit the propeller to be fitted well below the waterline. The buoyancy of the aft ship would thus be increased to counteract the weight of the engine. Such modifications would, without spoiling the speed qualities, result in a drier and more seaworthy boat, with increased loading capacity.
An example of such a modified boat is found in Fig. (54). The dimensions are: length over-all 29 ft. 4 in., breadth 7 ft. 1 in., depth moulded 3 ft. 1 in.

The alterations are moderate. The beam could with advantage have been increased considerably more, but if that were done in the first new design, the fishermen might get the feeling of a much altered boat with unfamiliar movements and period of roll and they might not appreciate the change. The development to greater breadth should, therefore, go by steps. A semi-diesel engine of 12 to 15 h.p. is shown in Fig. (54). Fig. (54) also shows the installation of a "Patter" diesel type AV2M (of 10 h.p.). To ascertain best possible speed with only 10 h.p., the new hulls should not be built too heavy.

The fisherman may find, after getting used to engine propulsion, that boats of bigger size will be better for longer fishing trips. A further step forward would therefore be to encourage the building of boats up to a length of about 35 ft. and a breadth of about 9 ft. and the installation of engines of 15 to 20 h.p. Another improvement would be a transmission stern. It was, however, felt premature to design such a boat during Zienor's 1954 assignment without knowledge of the trend of development of Taiticorin mechanised fishing. Subsequent development in fact indicates that "standard" designs and even the surf boat might be most suitable.

(e) Navas

During Zienor's first visits to Kakinada in 1954 he found that the navas type was suitable for developing into mechanised fishing boats. He specially proposed that new boats be made wider. Accordingly, 10 wider navas were constructed for the Fisheries Department by the boatbuilder in Talluru. Five of these boats were equipped with 10 h.p., one-cylinder semi-diesels, and five with 10 h.p., two-cylinder diesels. It was found that the boats with the one-cylinder engines vibrated more and, after trials, extra longitudinal strengthenings were built in, which reduced the vibration but did not, however, make them comparable with the boats with the two-cylinder engines.

Having pronounced flat bottoms, the mechanised boats did not behave well when driven into heavy head seas, a condition for which they had not been developed, as they were sailing boats which did not go very close to the wind under sail.

During Roebuck's assignment, in September 1956, it was decided to develop the navas a further step, and a boat was planned which should have better sea-going qualities. It was also decided to provide the boat with a line and net-gurdy in order to introduce mechanised fishing. The boat was meant to be used in experimental fishing and for simultaneous training of fishermen. The design was undertaken by the Assistant Director of Fisheries, Craft and Tackle, Kakinada, who made the drawings in Figs. (55) and (56) under instruction from the expert as part of his training programme. Appendix 4 gives the specification for construction.

To improve the hull form, and make it more sea-worthy, it was necessary to do away with the flat bottom and adopt a V-shape. Secondly, it was considered necessary to have a proper keel which, together with the V-shaped bottom, should give the boat the necessary longitudinal stiffness which was somewhat lacking in the first mechanised types.
The boat was therefore designed with a through-going keel and a V-shaped bottom, the characteristic above-water shape of the navas, however being retained, except for a transom stern, which had already been accepted in the first improved models.

The beam was increased only slightly compared to the first improved navas. The deck was made with loose sections, to ease stowage of catch and gear below.

(d) Estuarine Fishing Boat

A request was made for the design of a fishing boat for use in the Mahanadi estuary, Cuttack, and the local boats were studied so that a design could be proposed which would be easy for the local boatbuilder to construct.

Trial fishing had been carried out with some Danish-built 24-ft. boats, and with the Fisheries Department boats, which had shown that trawling was practicable. However, the depth of the Danish boats, being nearly 3 ft., proved too much for their use in the estuary.

Clinker construction is the only satisfactory way of using the local pie-sal wood. The local boats have V-bottoms with a slight deadrise, and it was decided to give the new design similar lines and construction (See Figs. (57) and (58)). The main dimensions are: length over-all 25 ft. 5 in., breadth 7½ ft. depth 3 ft. 1 in., draught 1 ft. 10 in. A diesel or semi-diesel of about 15 h.p. is recommended. Such a boat will be able to use a small trawl, purse seine, bag net and gillnets.

(e) Shot Boat

Fig. (59) shows a drawing of a modified shot boat, designed specially for mechanisation. This boat is only half a foot wider than the original but the beam should preferably be made still wider even if the other main dimensions remain unchanged. This would give the boat better initial stability and increase the carrying capacity. It is recommended that the keel, stem and stern of new boats be rabatted for the planking, as in the case of the Diamond Harbour boats built in the same region.

The engine recommendations made in the Mechanisation chapter, V.4(j), are also valid for the modified boats. They will be strong enough to be equipped with the inexpensive and reliable one-cylinder semi-diesels. Both two-stroke and four-stroke engines of one to two cylinders can be used. Controllable pitch propellers may be of advantage for certain fishing operations.

2. New Types of Fishing Boat Designs

(a) 15-ft. Inland Fishing Boat

Fig. (60) shows a light V-bottom open boat for oar and outboard propulsion. This boat was originally designed at the request of the Madras Fisheries Department and is an easily constructed boat. It has turned out to be a speedy and sturdy work boat for lakes and reservoirs. Up to June 1958, ten such boats have been built.
(b) 22-ft. Inland Fishing Boat

Figs. (61) to (63) show a small inland fishing boat, intended for fishing on dam reservoirs, such as Hirakud Dam, Orissa. As the stocking of fish has only recently started in Hirakud Dam, and because of the experimental nature of the project, it was decided to design only a small boat. The main dimensions are: length over-all 22 ft., maximum beam on planking 6½ ft., maximum draught 1 ft. 10 in. The boat is intended primarily for trawling over the stern and an engine of 10 to 15 h.p. should give sufficient power. Appendix 5 gives the specifications for construction.

(c) 24-ft. 7-in. Fishing Boat, so-called Pablo Boat

On the Coromandel coast, from Tuticorin to Madras, boats must have a shallow draught, in most cases less than 3 ft., for safe crossing of the sand bars where considerable surf develops. They must also have a relatively high carrying capacity as heavy fishing gear is used because of the strong currents on the fishing banks. To counteract the attack of marine borers which is severe in those waters, the boats should also be light enough for easy beaching without mechanical devices. For the time being, and until better fishing harbours are opened, it seems that mechanised fishing boats should not exceed 30 to 35 ft. in length.

In 1953 FAO sent to Madras two Danish built open motor boats, 22 ft long, 7½ ft. beam, 3 ft. 3 in. deep, and equipped with 10 h.p. semi-diesel for experimental and exploratory fishing. They were provided with a power-driven net winch and are called Dan boats. FAO fishery engineer Illugason quickly proved that this was a good general type and an economical size, and there was soon a demand for more boats of the same type. Zienor had, during his time in Chile before he joined FAO, designed a similar type with an over-all length of 24-ft. 7-in., 6-ft. 11-in. beam, 2-ft. 6-in. depth, and 2-ft. 9½-in. draught, with somewhat sharper ends, and a lower freeboard than the Dan boats. One of such design was built at the Madras Fisheries Department boatyard. FAO supplied a 10 h.p. Sefflo semi-diesel and the boat was launched in September 1954 and given the name "Pablo", being Zienor's first name in Spanish. Subsequent fishing operations showed that it was a successful boat, and many were ordered. By June 1957 29 such boats had already been built and were in operation and by July 1958 about 50 were operating. The price, with a 10 h.p. diesel but excluding the line hauler, was (June 1958) Rs. 15,000.

Fig. (64) shows the lines of the vessel, Fig. (65) the construction and Fig. (66) the details of the rudder. The drawings show in sufficient detail the construction, but it is also important to remember that a gurdy for hauling lines, nets, etc., should be installed in the fore part. The boat has proved to be fast and sea-kindly. The shallow draught permits its use from small river outlets. Undoubtedly, a transom stern, instead of the present stern, would provide a larger deck aft. It would also result in less resistance, with corresponding higher speed, and, similarly, the sea-kindliness of the boat would be improved. The idea in introducing the present design with cruciver stern was not to depart too much and too abruptly from the Danish built boats which had proved so satisfactory and gained the confidence of the fishermen.

FAO/53/10/7991
(d) **22-ft. Open Fishing Boat**

A design for a 22-ft. open fishing boat was requested by the Madras Government in 1956 as it was felt necessary to develop a cheaper boat than the 24-ft. 7-in. Pablo boat.

It was estimated that a 22-ft. boat with transom, with a simple outside rudder, galvanised bolts and fittings (but with copper rivets as plank fastenings), and without a covering board and half deckings, would be about 20% cheaper. The engine should be from 3 to 10 h.p. The catching power of the boat is estimated to be equal to that of the Pablo boats. The lower initial cost would make it possible to interest more fishermen in the purchase of a mechanised fishing boat, especially under the prevailing Government rules regarding subsidy and loans on hull and engine.

The design of a first prototype (Figs. (67) and (68) was undertaken by the counterparts in Madras (Channanoss and Kuriyan) as part of their training programme. Appendix 6 gives the specification for construction. The construction of the first boat was started in April 1957 and gave the counterparts an opportunity to follow and supervise the work they had carried out on the drawing board. Trials, and experimental fishing, were in progress in June 1958 and will be reported later.

In consultation with F&O Fisheries Engineer Illugason working in Madras, it was decided to lift the floor boards about 2 ft. from the top of the gunwale, and have a large working deck, from which the nets could easily be hauled in. (It was not planned to provide the boat with a net gurdy).

(e) **28-ft. Mackwa**

Zioner's work in conjunction with the then Marine Product Department in Saurashtra in 1954 gave him a good knowledge of the local boats, and it was agreed that he should design a modified boat which would be suitable for a 10 h.p. engine. Figs. (69) to (71) show the resulting lines, construction and rudder drawing. Only one boat was built by a fish merchant. It was later equipped with a second-hand 17 h.p. Dayna diesel which was installed under the supervision of Rasmussen. Unfortunately, no experts were in Veraval when the boat was tried, but it is reported that the boat is now fishing.

(f) **30-ft. Coastal Fishing Boat**

Where the 24-ft. 7-in. Pablo type boat can work economically, a somewhat larger boat might give still better results. A design was made of a 30-ft. craft with 20 to 25 h.p. diesel or semi-diesel engine. The cost will be about 75% more than for a Pablo boat.

The main dimensions are:— length over-all 30-ft., breadth 8-ft. 2 in., depth 4-ft. 1-in., draught maximum 3-ft. Figs. (76) to (79) show the lines, construction and details of the boat. This type is designed with a transom stern, thus differing from the cruiser stern on the 24-ft. 7-in. Pablo boats. The transom stern gives more deck space aft, and is more efficient with regard to speed and sea-keeping.

F&O/58/10/7991
The limited draught will permit the boat to operate from shallow harbours and river mouths. It is intended for long-lining, not and travel fishing, and should have an engine-driven winch. A 25 h.p. engine is advisable for travelling. A controllable pitch blade propeller is desirable although a fixed blade propeller with low pitch can be used for efficient towing.

In June 1958, 12 such boats had been built and the price, including a 20 h.p. diesel, with line hauler, was Rs. 23,000.

(g) 31-ft. 9-in. Coastal Fishing Boat

It was intended that the first Fishermen’s Training Centres in Cochin and Tuticorin in 1956 should use the 30-ft. coastal fishing boat design and equip them with available 30 h.p. Buch diesels. It turned out that this engine was too large and heavy for the 30-ft. boat and a slightly larger design had to be made to fit the engine, especially its large diameter propeller. Figs. (76) to (79) show the lines, construction, keel, and deck and gear arrangement of this training centre boat. Two such boats were first built, both with 30 h.p. Buch engines, one having a controllable pitch propeller and the other a fixed blade propeller. The boat with the controllable pitch propeller was tried on a measured distance and found to make a maximum speed of 7.5 knots. It was judged that the boat with the fixed blade-propeller obtained the same maximum speed. During towing, however, the advantage of the controllable pitch propeller was felt, and the boat so equipped undoubtedly had the best towing speed. The boats sailed by their own power from Cochin, where they had been built, to Tuticorin, and they behaved well in the cross seas around Cape Comorin. The weather boards aft of the fore deck on the original boat were somewhat too low and they have been increased as Fig. (79) shows. It also shows the installation of the main engine, the fishing winches, and the heavy trawl galleys fitted on the aft deck.

Up to June 1958, 5 more such Training Centre boats have been built. Current price (June 1958), including a 30 h.p. engine but without the line hauler on other fishing installations, is Rs. 26,500.

(h) 32-ft. Shrimp Trawler

To investigate the possibilities of using a small shrimp trawler on the west coast, a design study was made by Rasmussen after consultations with Illugason, who had studied the conditions relating to shrimp tawling during his work there. The following main dimensions were chosen: length overall 32-ft., length between p.p. 26-ft. 8-in., maximum breadth on planking 9-ft. 10-in., and maximum draught 3-ft. The draught was limited as the vessel is also meant to be operated from shallow river mouths.

Very complete and detailed drawings were made consisting of lines, construction, keel, general arrangement, sections, various engine installations and curves from the hydrostatic calculations. An engine of 36 h.p. was considered necessary for tawling. Various engines of 36 h.p. and slightly stronger were studied. As no such boat had been built up to June 1958, and further experience had been gained from the operation of similar sized small trawlers, Gottberg was instructed to initiate a modified design using the design study as a basis and also endeavouring to incorporate the 30-ft. Coastal Fishing Boat Design into one type.

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Apart from trawling, which is done over the stern, the new design will be made so that the boat can be fitted for gillnetting and purse seineing. A net gurdy must be installed in the foreship for gillnet operations and a purse line davit must be fitted in the forward quarter for purse seineing.

(i) 44-ft. Monsoon Fishing Boat

No sea fishing is undertaken in the Konkan area during the monsoon period, except for the large deep-sea trawlers operating from Bombay harbour. There is, therefore, very little fish on the market and any attempts to increase supply would be welcomed by the consumers and would also be a profitable proposition. Thus the Bombay Fisheries Department requested Zienor in 1953 to design a boat suitable for fishing during periods of calm weather in the monsoon months from June to September.

After study of weather conditions, possibilities of leaving and entering the small local fishing ports during the monsoon period, and listening to the opinion of the fishermen, boatbuilders and local fisheries officers and pilots, it was found that the task was difficult, but not impossible. Highest possible seaworthiness is the all-important requirement on which there can be no compromise.

Shallow draught is necessary for leaving and entering the small ports in a seaway. A fully decked boat of the Satpati type was considered to meet the requirements, provided that it be strongly and expertly built.

Plans of such a boat were made (Fig. (60) to (83)) and submitted in February 1954. The main dimensions are: length over-all 44-ft., length in waterline 41-ft. 5-in., breadth 11-ft. 6-in., depth moulded 4-ft. 8 in. engine power 40 to 60 h.p.

Installation of a semi-diesel engine of 45 to 50 h.p. was suggested because of its robustness, simplicity and dependability under the severest conditions.

Studies were also made of the installation of a diesel engine, and a review of different engines already introduced in the Bombay region pointed to the following makes as suitable:

- Ailsa Craig RF2-6, 60 h.p., 2:1 reduction gear
- Gardner 5LW, 60 h.p., with 2:1 reduction gear

Special attention was given to the length of the engines and the width and depth of their reduction gears, which determine the aftermost location possible. The speed with any of the above-mentioned motors would be about 8 knots with full load. If the boat should be trawling mainly, engines of 60 to 80 h.p. might be advisable.

A net winch (No.1 "Nordic" Trading Co., Hirtshals, Denmark) of convenient type and size was recommended for installation. It should be driven from the main engine by belt drive with a suitable reduction for obtaining 25 to 30 r.p.m. of the hauling sheave. The transmission shaft should be of steel, 1¼ in. diam., supported by bearings in such a way that the slight
deformations of the wooden hull in a seaway would have little effect on the alignment of the shaft. Connection to the winch may conveniently be made with a universal coupling.

The hold takes approximately 4 tons of fish and ice. Insulation should be 2 in. cork plates laid in bitumen (asphalt). The cork can be laid directly against the wood on the underside of hatch and deck and coated with bitumen on both sides. On the sides and floor, a ceiling of soft wood of 7/8 in. thickness should be laid on the frames and floor timbers in such a way that air circulation from the bilge between frames to the top is possible. This ceiling should be tight, preferably caulked and thickly coated with bitumen, or other suitable compound. An inner ceiling is required which may be of 3/4 in. soft wood (cypress, pinewood or other), coated with bitumen on the cork side, and the surface of the hold varnished with special fish hold varnish.

The recommended arrangement of ceiling and insulation is shown in Fig. (83). Instead of an inner ceiling of wood, a 3/4 in. thick cement ceiling on wire mesh can be used if preferred. The thickness of the cement cover should, however, be increased to 2 in. on the floor. On the bulkheads, the 2 in. cork should be laid against the wood and an inner ceiling applied as for the sides. An air duct should be formed along both sides of the hold for ventilation of the space between the insulating walls and the hull. Free flow of air through these ducts must be provided by cutting openings in the knees at hatch beams, and ample openings provided in the bulkheads at each end of the ducts.

A deep and ample pump sump must be provided, as shown, to collect the water from the fish and melting ice. A special pump, engine or hand operated, must discharge the water outboard. Cork plates are available on the market in 2 in. x 1 ft. x 3 ft. size. About 410 sq. ft. are required and about 3 cwt. of bitumen.

It is recommended that, in order to ensure complete success with this new boat type, provision be made for a higher cost, and that the first boat be built by one of the best wooden boatbuilding yards. Appendix 7 gives a specification of the wood required for construction.

3. Surf Boats

When the fisheries of India are fully developed, the majority of the boats will, of course, be based on centres with facilities for landing fish accommodating fishing boats and maintaining them, but to envisage such development is to look a very long time ahead. Meanwhile, a great part of Indian fishing is carried out from surf-beaten beaches, and this is likely to continue for many years to come. Mechanised fishing in India has had some success where conventional boats can easily be mechanised and where they can be used from sheltered landing places. It is most difficult, if not practically impossible, to mechanise catamarans and canoes, which rules out existing craft on very long stretches of the coast. Thus, the introduction of a mechanised surf fishing boat seems to be the logical step to take.

Since 1950, when FAO employed its first naval architect, there has been a constant search for a suitable motor surf fishing boat which could be used under conditions such as those in India. Such a type was not found, and it was evident that a special type had to be developed.
The experts, as well as Headquarters officers, have spent a considerable time developing a suitable type of surf fishing boat for Indian conditions. In 1952, FAO employed, as a special consultant, Hans K. Zimmer, naval architect, of Bergen, Norway, who made a thorough survey of beach boats used in Europe. A summary of his findings is given in "Fishing Boats of the World", p. 31. At the same time, enquiries were made about similar boats used in North America.

Fishing from more or less protected beaches is carried out in many parts of the world, notably in West Africa, Portugal, Denmark and the U.S.A. Portugal, Denmark and the U.S.A. are using boats with engines most of which work from protected beaches without much surf. They should therefore be called "Beach Landing Boats" instead of "Surf Boats", and their design is not of much help in developing a surf boat for India.

On the whole, motorised beach boats in other countries are large and expensive at first cost. They require, normally, rather expensive shore installations, such as large winches, to haul them up on the beach. In Denmark, such modern winches cost as much as $20,000, and the Government subsidises the fishermen up to 90% in their purchase, which is still cheaper than building fishing ports.

The Fisheries Service in Nigeria has lately started to develop a motorised surf boat. They ordered a 20-ft. aluminium V-bottom boat, equipped with a gasoline engine, in the United Kingdom, which was tested for the first time in November 1956 in a moderate surf and behaved well. The fishermen had a number of criticisms to make of the layout, from the fishing point of view, and it was also considered desirable to have a diesel instead of a gasoline engine. It was decided to carry out further trials to find out possible weaknesses, and then to report the results to the builders and have another prototype built. Unfortunately, few trials seem to have been done since. It is understood that a second prototype would cost about £1,500 because of the expense of construction in aluminium. It is therefore proposed to build the second prototype of marine plywood.

The advantage of using aluminium in a surf boat is not only lightness, but also the fact that the engine can be installed in a water-tight box with air-intake and exhaust reaching higher than the rail. If such a boat is equipped with flotation tanks of adequate size, it can therefore be totally submerged by breaking surf without the engine stopping. This is a great advantage, compared with wooden construction.

FAO has tried to stimulate boat designers in different parts of the world to work on the surf boat problem. Erik E. Stender of Denmark developed a boat, using wheels when moving on the beach, (see "Fishing Boats of the World", pp. 293 and 254). His idea was seconded by the well-known American naval architect, George Nickum, who had carried out similar work with large craft for the U.S. Army. A small prototype boat of Stender's design was built in Denmark in 1953 and is reported to have worked satisfactorily. A United Kingdom firm is at present interested in building a 22-ft. boat, incorporating these ideas, which might be placed at FAO's disposal for thorough trials under realistic surf conditions.

The India-Norwegian Project in Quilon has done considerable work in developing small boats to work from exposed beaches. They use boats of rather heavy construction and with relatively full ends. Furthermore, they...
use small, heavy semi-diesels, and they seem to have difficulty in moving the boats along the shore. They have tried different types of winches and railways. They have also tried out decked boats.

The FAO experts have tried three prototypes in India. The first had a length of 28-ft., breadth of 5-ft. 2-in., and a depth of 2-ft. 1-in. and was built in 1954 by the Madras Fisheries Department. It was equipped with a water-cooled engine and was tested for a short period during the autumn of 1954. The boat proved to be too heavy to be handled by manpower on the beach, and there was difficulty with the water-cooled engine in that sandy water got into the cooling water pump and damaged it. The trials indicated, however, that this boat could stand considerable surf.

A second but lighter prototype was accordingly designed, having essentially the same shape but being only 18-ft. 3-in. long, 5-ft. 5-in. wide and 2-ft. deep. Boats were built to this design in Saurashtra and Andhra, as part of boat-building training. FAO ordered three hulls at a commercial boatyard to test them with different engines, so as to find out the power required. Trials with the first of the boats were made in the autumn of 1955 and with all three in the spring of 1956.

The first boat was equipped with a 3½ h.p. air-cooled diesel. While the boat passed a moderate surf successfully, it was felt that a stronger engine would be necessary to pass a normal surf safely. Furthermore, fishing operations showed that such a small boat could not carry as many nets as some of the large catamarans, and handling of the boat on the beach was still difficult.

The 1956 trials were carried out in Madras by the experts, together with Illugason, and E. R. Kannan, FAO Marine Engineer in Ceylon. The object was to compare three different types of engines, and study the handling of the boats on shore with the help of simple, hand-operated winches, rollers, etc. The experiments with different types of engines were not successful. Controllable pitch propellers were used to reduce the weight of the power unit but they did not operate well. As a result, it was concluded that reverse gear with fixed blade propellers should be used even though heavier. It was found that 6 h.p. was adequate power for this size of boat. Handling the boat on the beach with simple, hand-driven winches proved to be much easier than carrying it by sticks or dragging it by hand over the sand. The experiments indicated that a larger and heavier boat could be used with special beach handling gear. The development of simple but efficient beach gear was considered to be a most important problem.

Arrangements were made for having local fishermen test the boats using their own gear (Vali-Wala, jangot, handlines). Carrying this light gear, the boats could be operated off the open beach with moderate surf about the same as the catamarans could. The boats proved, however, not to be efficient enough fishing tools when using the local gear and this use of the boats was given up as financially unsound.

Next the boats were tested with bottomset nylon gillnets. They could carry only 4 to 5 nets which was insufficient from the financial point of view. During these trials with the gillnets grave difficulties were encountered in passing the surf off Mahabalipuram beach, the boat filling completely with water on at least one occasion, when Illugason narrowly managed to cross the bar in moderate surf. Outside the port the boat was
bailed and the engine restarted. On another occasion when the surf was slightly greater Illugason deemed it unsafe to haul in the nets before going to shore. Illugason gave 4 days demonstrations with the 3½ h.p. Lister boat, using bottom-set gillnets. After this the boat was left with a local fisherman who operated it with FAO nylon nets for about one month, before Illugason had to go to the west coast. When he returned he found that the boat had not been used during his absence, except for a few occasions when it was used for collecting fish from the catamarans at sea to bring the catch more quickly to the market. In the meantime the other two boats were not being used as no interested fishermen were found.

In order to induce local fishermen to operate the first boat from the exposed beach Illugason offered the boat and FAO nylon nets free of charge i.e. not charging the rent or share of the catch as normally done.

Even so it was found difficult to persuade the fishermen to operate this boat as a "surfboat". One fellow who had proved a particularly energetic and able fisherman, started operating the boat but he avoided the open beach and landed in lee of the Madras harbour, explaining that he was afraid of losing his catch. After persuasion he made an attempt to operate from the open beach but with the result that the boat was badly beaten in the surf damaging the rudder shoe. After this experience this group could not be persuaded to operate from the open beach but the boat was indeed operated for several months from the sheltered Royapuram beach in lee of the Madras harbour where also Illugason had kept the Dan boats and from where all (11) existing Pablo boats in Madras operated.

From April 1956 to November 1957 boat No.1 fished during 11 to 26 days per month, monthly catches being from 1200 to 7000 lb. operating 5 bottom-set FAO nylon nets. This seemed to indicate that the boat could operate reasonably efficiently from the sheltered beach. However, the fishermen were entirely unwilling to operate the boat as a surf boat.

This was the last attempt, previous attempts having had much the same fate. Therefore the failure of the Madras fishermen to grasp the opportunity of using this boat free of charge as a surf boat cannot by any means be explained by its small size limiting the number of nets to be carried. The small size was mainly a handicap when operating the boat on equal footing with the Dan boats or Pablo boats where a realistic rent was charged.

In June 1956 a number of meetings were held at FAO Headquarters between Eiener, H. L. Chapelle (FAO Naval Architect in Turkey) Gartner (then a Headquarters naval architect), Hilmar Kristjansson, Chief of the Fishing Gear Section, and Jean-Olaf Trang, Chief of the Fishing Boat Section. Chapelle, incidentally, had considerable experience with surf boats in the United States. As a result of the joint discussions, a new prototype, 24-ft. long, 6-ft. 4½ in. wide and 2 ft. 7 in. deep, equipped with a 15 h.p. diesel, was designed. The stronger engine ensured sufficient power reserve during launching, and gave the boat sufficient towing power when running out nets and using small trawls. Unfortunately, lack of money at that time made it impossible to have a prototype built. In the meantime, the design was sent for review to all FAO boat experts in India and elsewhere, and to a number of naval architects, such as Hans K. Zimmer of Norway, who was co-operating with FAO. The design was thoroughly discussed with the Manager of the Gold Coast Boatyards Ltd., Sekondi, Ghana, who had spent a considerable time trying to develop a surf boat for Ghana.
conditions. As a result of correspondence, comments and discussions, a new
design was drawn up in May 1957 at headquarters, again in close co-operation
with Chapello. The design is for a boat 24-ft. long, 6-ft. 10½-in. wide
and 2-ft. 11-in. deep.

In 1957 the Indo-Norwegian Project built one such boat in Norway for
trials at their project in Karala. FAO also built a boat in Ghana, which
was tested there in February 1958 and showed promising results.

The Indo-Norwegian Project in Quilon organised a Surf Boat Symposium
from 3 to 8 March 1958, in co-operation with the Government of India. The
Norwegian-built, FAO-designed prototype was tested, together with Norwegian
boats. It is understood that the Government of India will publish the
proceedings of the meeting.

It was agreed at the Symposium that it would be necessary to test the
FAO prototype over a certain period to find out possible mechanical or
structural weaknesses. It was also suggested that the Indo-Norwegian
Project should build two modified boats, using a simplified, and thereby
cheaper, construction, and water-cooled engines, but no such construction
had been started by June 1958. The Government of Madras decided in March
1958 to build a boat which should be somewhat wider than the FAO design.
Gurtner prepared the necessary drawings.

At present it is impossible to release any final design of a surf boat
for Indian conditions as much work remains to be done before an economical
and practical size of boat is developed.

A surf boat must, according to Zienor’s studies, be able to face the
following type of surf:

**Madras Beaches**  A 7-ft. high breaker, plunging type, 15 to
18 seconds period, breaking at a distance of 140 to 300-ft.
from shore.

Remarks: The highest surf waves, 14-ft. (Hydrogr. Dept.
British Admiralty) break at about 1,000-ft. from the beach.
Wave heights of 5-ft. are connected with rough weather
outside, but allow fishing. At 7-ft. and above, the
breakers go near to the bottom. One day, three 22-ft.
breakers struck bottom in estimated 8-ft. breakers, and
were torn to pieces. Fixed skegs and propellers can be
used.

**Andhra, Southern Contai, W. Bengal and Southern Madras Coast
Beaches**  One of the 5-ft. high waves, plunging type, 15 to
16 seconds period. Rather steep waves, breaking at some
distance (150 to 400-ft.) from shore, or over shallow
sandbars at river outlays. Skegs are possible.

**Andhra, Northern Beaches** Two to three 7-ft. spilling
waves; two to three 5-ft. plunging waves; period about
16 seconds, breaking at a distance from shore. Hull
with skeg, fixed propeller, etc., can be used. Boats
can be big and deep.

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Oriaca Beaches: Three to four 6-ft. plunging waves, periods 16 to 19 sec. Very steep when nearing shore; seem to increase in orbital velocity and hit hard directly on the beach. Waves fairly uniform. No fixtures, such as skags, propellers, etc., possible, hardly even a rudder. Flat, broad and buoyant boats of fairly big sizes can be used. Retractable propeller necessary.

Quilon Beaches: Four to five plunging waves up to 6-ft. high, steep, irregular. Periods of 9 to 13 sec.

Remarks: In bad weather, the surf waves rise to 9-ft. The lowest waves are nearest to shore. The beaches near Quilon are very flat, and boats suffer much at launching and landing.

The following surf might be faced with a larger surf boat:—

Madras Beaches: As given for Madras above.

Quilon Beaches: Not higher than already detailed, 7-ft. and 6-Ft. respectively, because a certain risk is already there. If a boat is caught directly under such breakers, nothing can save it. It will be broken down, irrespective of the means of propulsion. Moreover, fishing is difficult under such surf conditions. It would be desirable, however, to face the same surf with greater safety, by greater manoeuvrability, for instance, so that the boat could avoid coming under the breaker.

With regard to the other regions:—

Andhra, Ceylon, etc., and Northern Andhra Beaches: The boat should be able to face surf 1-ft. higher than previously described, for safety. May not increase fishing time.

Oriaca Beaches: Facing higher waves seems to be a launching problem (on the beach) and not a question of propulsion.

4. Fish Carriers

(a) 17-ft. Fish Carrier

Figs. (84) and (85) show a small fish carrier of round bottom construction for use with a 10 h.p. outboard motor. It was originally designed for carrying fish along the 15 mile Mahanadi canal from the lower reaches up to Cuttack. As a certain amount of time is lost whenever the boat passes through a lock, it is of advantage to have a fast boat to reduce total transportation time. The boat does not take great quantities of fish, but in the region fish is a high-priced article, and fast transport is an economical proposition. A round bottom boat is somewhat less affected by load and trim changes, but it will not be as fast as a V-bottom design. A round bottom boat is an advantage when it can be used in the usual Cuttack manner. Appendix 8 gives the specifications for construction. Three such boats have been built.
(b) **17-ft. 2-in. Plywood Fish Carrier**

This boat was also designed for fish carrying along the Mahanadi canal. It is a faster boat than the round bottom type previously described at a speed of 7 1/2 knots with a 10 h.p. outboard motor is expected. The boat, however, is more affected by load and trim changes than is the round bottom design. The Indian Plywood Manufacturing Co. has supplied the material free of charge to the Fisheries Department in Orissa, but it is not known whether a prototype has been built. Figs. (86) and (87) show the lines of construction.

(c) **23-ft. V-Bottom Fish Carrier**

In West Bengal there is a great need for motorised fish carriers. FAO Report No. 347 on the development of the Sundarban Fisheries recommended the introduction of such craft for collecting the catches from the fisherman and bringing them to receiving points. The report recommended, in addition to the mechanization of the Diamond Harbour boats previously described, a new type for the transport of local fish. Fig. (88) reproduces the proposed 23-ft. boat which is of a light V-bottom construction.

It can easily be built of 3/8 in. marine plywood, or planked with approximately 3/4-in. boards of suitable local woods. If the boat is kept light in weight, it will prove to be very handy for work in the shallow creeks and over mud flats where local craft are now used but, due to its high freeboard, this hard chine boat will be much more seaworthy.

It can be powered with a light-weight diesel or semi-diesel engine of 5 to 20 h.p. The power requirements depend on whether the boat is meant for travelling long distances against the current in bringing fresh fish to assembly points. The boat should be equipped with a removable mast, auxiliary sail, four oars and oarlocks, and a light anchor with large flukes for holding firmly on soft mud bottoms.

(d) **22-ft. 8-in. Fish Carrier**

About 16,000 lb. of fish are caught per day at Chilka Lake, Orissa, and landed at Balugon, Chandrapur and Rambha, where there are ice plants and packing facilities. The Fisheries Department had three 15 h.p. semi-diesels in stock and wanted three carrier boats with insulated fish holds to take about 5,000 lb. fish each. Figs. (89) to (91) show the resulting design, having the following main dimensions: length over-all 29-ft. 8-in. breadth 8-ft. 2-in. depth moulded 2-ft. 6-in., draught, loaded 2-ft. 3-in., displacement, loaded, 6 tons, fish hold capacity 180 cu. ft. insulated.

An investigation of the depth of water at the landing places and on the shallow areas in the middle of the lake indicated that the carriers must have very shallow draught. The slow running semi-diesels have large diameter propellers, and it was therefore necessary to design the boats with a tunnel stern in order to keep the draught at the permitted value.

Appendix 9 gives the specifications. Construction of three carriers was started at Cuttack in January 1956.
(e) **Marine Fish Carriers**

As the marine fisheries develop, there will be an increasing demand for transport of fish along the coast from places where big catches cannot be consumed to places where the demand is great.

Some of the most important factors when preparing a design for a fish carrier are: economic size, economic speed, suitable hull construction and insulated or non-insulated hull, and the type of insulation.

When considering the size, it is important to note that, as carriers of goods by sea, marine fish carriers come under the rules of the Indian Merchant Marine Department, which require life-saving equipment. Carrier vessels of 40-ft. and longer overall must carry a lifeboat, in addition to extra life-saving equipment, and the lifeboat must be supplied from a builder approved by the M.M.D. Carrier vessels below 40-ft. are exempt.

This often means that a high price must be paid for the lifeboat, compared to the price of the vessel, especially if the carrier is only little longer than 40-ft., and it is one reason for designing fish carriers in a size just below or substantially above 40-ft.

Fig. (92) gives an idea of such a carrier just below 40-ft. overall, designed to carry 10 to 12 tons of fish and ice. Such a vessel will usually be of the most economic size in areas where fish transport is only developing. A speed of 7 knots should be obtainable with such a boat, installed with an engine of about 50 h.p.

In certain areas, the local types of fishing boat, that is, the improved mechanized version, can be used as fish carriers, with certain alterations in construction and general arrangement. The Satpati area would in this respect, provide a good example.

The question as to whether fish carriers should be insulated can hardly be answered in general terms. It is a matter of the construction of the vessel. Vessels which are roughly built should not be insulated as they will work as much in a sense that the insulation will develop cracks and leaks. It is also a matter of the skill of the workman, as the insulation must be done very carefully to obtain good results. Apart from ensuring plenty of ventilation between the hull construction and the insulation - bad ventilation invariably will lead to rot in the wooden parts - it is most important to prevent moisture penetrating the insulation, as this will rob the material of its insulating properties. The material must be impregnated and protected so that, firstly, the melting water from cargo does not leak into it, and, secondly, the condensation of water from the humid air on the outside of the insulation does not penetrate it.

Figs. (93) to (96) show an insulated fish carrier with a capacity of 20 tons of fish and ice, designed for areas where fish carrying is well developed and where speed is important. This carrier is designed for a cruising speed of 8½ knots with a 75/100 h.p. lightweight high-speed diesel. The hull is also light. Such a vessel must be built at a yard where drawings are understood. Furthermore, the engine installation requires more knowledge than is normally possessed by the local boatbuilder, his experience being limited to small open fishing boats. The high cost of such a vessel, compared with vessels of local types of the same size and built for the same purpose, will be justified by the longer life of the boat and the lighter displacement will give higher speed for a given engine output and load of fish.
The materials were considered for hold insulation, cork and a light-weight plastic. Cork is one of the best-known insulation materials and, although imported, is very widely used in India. The experience gained from a cork-insulated fish carrier in Sauroshtra indicates, however, that the cork deteriorates after some years, although processed to make it resistant to moisture. A thin sheathing of aluminium could be used to keep the condensed water outside the insulation away from the cork. But this method was considered to be too complicated and expensive for this vessel because of the complex structure of the hold sides.

The second material considered, and the one shown in the design, is a light-weight plastic manufactured in India by R. A. Cole Ltd., Bombay, under the trade name Thermocole. This material is only one-eighth of the weight of cork, is rot-proof (fully resistant to bacterial and fungus growth) and does not absorb water. Therefore, condensation water would not penetrate. It is important to set up the Thermocole slabs carefully in a special glue and the manufacturer should be consulted before the insulation is started.

The size of the hold was determined by the volume in cubic feet per ton of fish and ice. To establish this volume, investigations were made partly by working out the data used for existing fish carriers in Sauroshtra and partly by consulting recent works on the subject.

The rate used in the local fish carriers is as low as 40 cu. ft. per ton. It was assumed that the future will call for better quality of fish, i.e., more ice used, and a figure of 50 cu. ft. per ton fish and ice was adopted. The hold is designed with a capacity of 1,000 cu. ft.

Aluminium alloy was considered the best hold lining. Wooden lining could probably be used even in a tropical climate, provided it was kept well painted, but there is the danger that the crew would not keep it well painted. Once wood has become wet it is very difficult to dry out. A local fish carrier provided an example of what happens: the wooden lining of its fish hold had a well-developed fungus growth.

The hold bottom is of corrugated aluminium alloy, strong enough to withstand the pressure from the cargo. No insulation is considered necessary for the hold bottom because of the constant flow of ice water melting into the bilges through holes in the lining.

If desired, a tank can be installed in the aft part of the hold to collect the ice water instead of letting it melt into the bilges. The tank must be connected to the bilge pump system by a three-way cock, and a strainer must be provided so that the bilge pump does not become clogged.

Regarding the aluminium sheathing in the hold, it would be advisable to obtain recommendations from the manufacturer of, or agent for, the aluminium so that a proper sea-water resistant alloy is used. It is also very important to make sure that the alloy is clearly separated from other metals and wood, otherwise corrosion will take place. Appendix 10 gives a specification for construction.
5. **Tug**

Tugs tow canoes to and from the diving grounds in the Tuticorin pearl fishery. The present tugs are due to be replaced. The Madras Fisheries Department investigated the possibilities of having a tug built abroad but it was found that the prices were too high and Zienor was requested to make plans for a 44-ft. tug. He investigated the working conditions on the spot and, as a result, made a design study, the drawings of which are shown in Figs. (97) to (100), (lines, construction, general arrangement, suggested cabin layout). Specifications for the construction of this tug are given in Appendix II.
VII. INFLUENCE OF FISHING METHODS ON DESIGN

In the foregoing the improvement of existing boats, the introduction of new designs, and the equipment of boats with propulsion engines, have been discussed. Complete mechanisation is, however, only achieved when the fishing gear is also handled by mechanically driven winches. In many parts of the world sailing fishing boats were equipped first with mechanical gear-handling facilities, and only later with propulsion units. The reason why the reverse has been the case in India is partly because the introduction of new fishing methods has taken place side by side with efforts to improve the fishing fleets.

Few of the designs in this report show exactly how fishing gear should be handled. The only exceptions are the 31-ft. 9-in. coastal fishing boat and the 44-ft. monsoon fishing boat. In addition, considerable study on the handling of gear has taken place in the design studies for a surf boat prototype and a 32-ft. shrimp trawler. Unfortunately, the latter two designs are not ready for release with this report.

The 31-ft. 9-in. coastal fishing boat was designed exclusively as a training centre boat, and the fact that it can handle a number of different fishing methods does not, of course, mean that this dock arrangement is to be recommended when building commercial fishing boats. In commercial fishing there is usually one type of fishing which is most important in the area concerned, and it is necessary to design the dock layout to conform with the fishing method. However, examples of the handling gear as shown in the training centre boat might be useful in building improved types of fishing boats in the future.

The fact that the new designs presented in this report show few arrangements for handling fishing gear does not mean that such arrangements are unnecessary. It only reflects the uncertainty as to what fishing methods should be used, and great stress should be laid upon dock layout and arrangement in future so as not to build fishing boats in a harbour launch style. New designs of 25-ft. and 32-ft. boats have been initiated, and it is recommended that various dock arrangements should be made for these boats to meet the demands of different fishing methods.

Winches for handling fishing gear, such as line haulers and trawl winches, are simple mechanisms, and they can be made easily and economically in the small engineering shops in India. It is recommended that a study be undertaken of the winches in use on various fishing boats, that detailed drawings be made of their construction, and that the engineering shops be encouraged to construct and sell such winches. An example of a small line hauler, which is extremely simple to make, is given in Fig. (101). Such a winch was constructed in Madras and has worked perfectly, with the exception of some gearing which was not made according to the drawing.
VIII. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

In all fishing nations, the fishing boats are the most expensive part of the equipment in the industry. In India, even though the fishing boats are mostly small and unmechanised, their total value is quite considerable. The 80,000 or so fishing boats have an average value each of Rs. 1,000, and represent a total of no less than Rs. 80,000,000. Thus India's fishing boats are of approximately the same value as those of a large fish producing nation, such as Canada. As these boats are developed, mechanised, or replaced by larger, powered, craft, in order to increase and improve fish production, their value will probably increase relatively faster than the total catch. India's total marine fish production today is said to be about 600,000 tons, and to have a landed value of Rs. 500 per ton; thus the total value of the catch is Rs. 300,000,000, and the annual catch is roughly four times the value of the boats. In a so-called developed fishery, the value of the boats is sometimes about the same as the value of the annual catch. The reason for the difference in India is partly that the price of fish per ton is higher, and partly that a considerable amount of fish is caught without the use of fishing boats, for example by beach seines.

In the future, quite considerable sums will be spent on fishing boats to replace not only boats which are too old, but also boats which are uneconomical to operate, and to pay for engines, fuel, repairs, etc. The total annual amounts necessary to maintain, develop, and operate the Indian fishing fleet will probably soon exceed Rs. 10,000,000.

It is evident that where such large sums are involved, the Central Government and the State Governments can do much to help the fishermen in the wise utilisation of the money.

2. Recommendation for Central Government Action

(a) Craft Wing of the Central Fisheries Technological Station

FAO suggests that the most effective way in which the Central Government can stimulate the over-all improvement of fishing vessels is to strengthen their services dealing with the development of fishing boats and gear. A Central Fisheries Technological Station with a Craft Wing was established in 1957 in Cochin. It is important that the Wing be fully organised as soon as possible, and that its leader be given sufficient authority to carry out the requisite improvement work vigorously and effectively. The classification of the post should be such as to attract the most qualified Indian technicians.

The Wing must be manned by versatile, capable and imaginative men able to appreciate the differences between the problems in the various parts of a country as large as India. An important phase of the organisation is therefore, to train a few men who already have a thorough knowledge of naval architecture (such as graduates from Kharagpur) in the special field of fishing, so as to give them practical experience of the requirements of fishing boats with regard to engineering and fishing methods employed.

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Such training might best be done "in-service"). The trainees should work at the Station, aboard local boats, go fishing in them, and design new boats; they will thus gain a thorough knowledge of the technique of improving fishing boats. Some of the best trainees might then be given fellowships to study in other countries, so as to help them understand that successful boats can be built in many different ways, and need not be very complicated in design. A few trainees might afterwards be employed permanently at the Wing, and the rest in senior positions, by State Governments.

The Wing must also have a number of technicians, draughtsmen, etc. to carry out less qualified work. They can be recruited from among the students at the designers' courses.

All naval architects and technicians should be under obligation to go to sea frequently in commercial fishing boats of various types and sizes, to keep in close contact with problems in the industry.

(b) Programme of Work of the Craft Wing

The Wing should have the following general programme of work:

1. Continuous contact with local craft and boatbuilding activities in order to give ad-hoc advice on improvements.

2. Motorisation of boats and mechanisation of hand handling.

3. Introduction of new craft.

There are many different ways in which this work can be carried out, many of which are already under way:

A. Liaison with Craft and Tackle officers of State Governments (correspondence, travel by Station officers and conferences in different fishing centres, with demonstrations).

B. Special working projects, such as:

(i) To improve hull design (in co-operation with the Ship Model Laboratory at the Central Water and Power Research Station, Poona)

(ii) To design and test prototypes of interest to several States (such as monsoon and beach landing boats, etc.)

(iii) To measure and study marine engine performances.

(iv) To assist in proper propeller selection.

(v) To improve boat building methods.

(vi) To promote the use of Indian timber

(vii) To develop techniques and standards to ensure safety at sea

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C. Training courses for:

(i) Designers
(ii) Boat builders
(iii) Instructors in engine operation

D. Financial Aid

At present the States obtain funds from the Central Government, which they use in giving financial aid to the fishermen - normally up to 50% of the cost of the hull and of the engine. In order to convince the fishermen that the advice of the Craft Wing is sound, it is recommended that the Wing be consulted before the State schemes and subsidy are approved. Furthermore, the Craft Wing might be empowered to make suggestions and to recommend special loans and subsidies for the improvement of private boatyards, to enable them to build improved boats in larger quantities, to service marine engines, etc.

(c) Extension Work

With the improved boats the fishermen will be able to catch more fish per man and thereby increase the supply of food. The work of the Craft Wing should aim at convincing the fishermen that improvement of boats, including mechanisation, will raise their standard of living, and at showing them how to build such boats. The Craft Wing should work in close cooperation with the proposed Extension Wing of the Station, which must have specific instructions as to how to deal with the important boat questions. The following are only a few suggestions, some of which have already been successfully tried out by the Central Government in India:

(i) Central demonstrations (leading people in fishing communities should be invited to come to central places to observe and study demonstrations of improved boats)

(ii) Technical consultations (State Craft and Tackle Sections and the equipment industry, such as engine manufacturers, should always feel free to ask for advice and should be given sound recommendations)

(iii) Production of publications, handbooks, films showing the benefit of mechanisation, maintenance of engines, boat building, etc; visual aids, such as models, pamphlets and diagrams, to be used by State Craft and Tackle Sections.

FAO/50/10/7991
(d) **Training**

The organisation of courses for boat designers, such as the one held 1 July to 31 December 1957 in Cochin, would play an important part in developing the Craft Wing of the Central Fisheries Research Station and in bringing about a similar development in the State Fisheries Department. Suggestions for a curriculum are given in Appendix 3. The students could spend, say, one month each at a fishing centre, such as Vernala, Satpati or Bombay, so as to acquire knowledge of different boats and make them sufficiently flexible for their coming assignments. They might also spend some time in Poona. Also, refresher courses for boat designers might be valuable.

(e) **Government Regulations**

All mechanised boats fall automatically under the requirements for life-saving apparatus, etc. The present regulations hinder the development of the fishing industry, and are out of line with similar rules in other countries. It is understood that the Indian fisheries authorities are well aware of the fact, and that the problem was in fact taken up at the All-India Fisheries Conference in Madras in September 1956. FAO recommends that a committee, composed of representatives from the fisheries service and industry, be set up to prepare new draft regulations, to be presented to the Government for consideration.

Mechanised fishing boats must leave and enter harbours, and are therefore involved in considerable formalities regarding customs clearance, etc. This also hinders development, and should be investigated.

(f) **Import of Engines and Spare Parts**

It is recommended that the regulations for importing engines for fishing craft should be made as easy as possible, at least until suitable engines of a number of competing makes are built in India.
<table>
<thead>
<tr>
<th>No.</th>
<th>Type of Boat</th>
<th>Type of Illustration or Drawing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Veraval Khotin</td>
<td>Photo</td>
</tr>
<tr>
<td>2</td>
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<td>&quot;</td>
</tr>
<tr>
<td>3</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>4</td>
<td>Jamnagar Machwa</td>
<td>&quot;</td>
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<tr>
<td>5</td>
<td>Veraval Machwa</td>
<td>&quot;</td>
</tr>
<tr>
<td>6</td>
<td>&quot;</td>
<td>&quot;</td>
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<tr>
<td>7</td>
<td>Malhar Machwa</td>
<td>Lines and arrangement Lines</td>
</tr>
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<td>8</td>
<td>Veraval Lodhia</td>
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</tr>
<tr>
<td>9</td>
<td>Grooved rabbet</td>
<td>Photo</td>
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<tr>
<td>10</td>
<td>Veraval Lodhia</td>
<td>&quot;</td>
</tr>
<tr>
<td>11</td>
<td>Maliya prawn boat</td>
<td>Arrangement</td>
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<tr>
<td>12</td>
<td>Satpati boat</td>
<td>Lines</td>
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<td>13</td>
<td>&quot;</td>
<td>Lines and arrangement Sail plan</td>
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<td>14</td>
<td>Malabar dugout</td>
<td>Lines and arrangement Sketch (Hornell)</td>
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<td>15</td>
<td>Malabar sailing dugout</td>
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<td>16</td>
<td>&quot;</td>
<td>&quot;</td>
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<tr>
<td>17</td>
<td>Boat catamaran</td>
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<tr>
<td>18</td>
<td>Pair of boat catamarans</td>
<td>&quot;</td>
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<tr>
<td>19</td>
<td>Tuttucin boat</td>
<td>&quot;</td>
</tr>
<tr>
<td>20</td>
<td>&quot;</td>
<td>&quot;</td>
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<td>21</td>
<td>Tirupalakud balance-board canoo</td>
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<td>22</td>
<td>Muthupet balance-board boat</td>
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<td>23</td>
<td>A Dirampathnam canoe</td>
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<td>24</td>
<td>&quot; balance-board boat</td>
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<td>25</td>
<td>Kodikarai kalla dhoni</td>
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<td>Madras catamarans</td>
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<td>Irudka</td>
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<tr>
<td>37</td>
<td>Batchari-boat</td>
<td>&quot;</td>
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<tr>
<td>38</td>
<td>&quot;</td>
<td>&quot;</td>
</tr>
<tr>
<td>39</td>
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</tr>
<tr>
<td>40</td>
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<td>&quot;</td>
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<tr>
<td>41</td>
<td>Chot boat</td>
<td>Lines</td>
</tr>
<tr>
<td>42</td>
<td>Diamond harbour boat</td>
<td>Construction</td>
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<td>43</td>
<td>&quot;</td>
<td>Mechanisation</td>
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<td>44</td>
<td>Veraval Lodhia</td>
<td>Actual stern construction</td>
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<tr>
<td>45</td>
<td>Ratnagiri Pattammar</td>
<td>Mechanisation</td>
</tr>
<tr>
<td>46</td>
<td>&quot;</td>
<td>&quot;</td>
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<tr>
<td>47</td>
<td>Malabar sailing dugout (Boppu)</td>
<td>&quot;</td>
</tr>
<tr>
<td>48</td>
<td>Kakinada nava</td>
<td>&quot;</td>
</tr>
<tr>
<td>49</td>
<td>Masulipatam nave</td>
<td>&quot;</td>
</tr>
<tr>
<td>50</td>
<td>35 to 40 ft. Batchari boat</td>
<td>&quot;</td>
</tr>
<tr>
<td>Type of boat</td>
<td>Type of Illustration or Drawing</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>---------------------------------</td>
<td></td>
</tr>
<tr>
<td>51: 44-ft. Batchari boat</td>
<td>Mechanisation</td>
<td></td>
</tr>
<tr>
<td>52: 53-ft.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Modified Boats**

| 53: Cattera | |
| 54: Tatharri | |
| 55: 34-ft. nova | |
| 56: | |
| 57: 25-ft. 5-in. Estuarine fishing boat | |
| 58: Cloth boat | |

**New Boats**

| 59: | |
| 60: 15-ft. inland fishing boat | |
| 61: 22-ft. dam reservoir boat | |
| 62: | |
| 63: | |
| 64: 24-ft. 7-in. Pablo boat | |
| 65: | |
| 66: | |
| 67/68: 22-ft. Transom stern fishing boat | |
| 69: 28-ft. Machna | |
| 70: | |
| 71: | |
| 72: 30-ft. coastal fishing boat | |
| 73: | |
| 74: | |
| 75: | |
| 76: 31-ft. 9-in. coastal fishing boat | |
| 77: | |
| 78: | |
| 79: | |
| 80: Moinsoo boat | |
| 81: | |
| 82: | |
| 83: | |
| 84/85: 17-ft. fish carrier (R-bottom) | |
| 86/87: 17-ft. 2-in. fish carrier (V-bottom) | |
| 88: Bengul fish carrier | |
| 89: 29-ft. 8-in. fish carrier | |
| 90: | |
| 91: | |
| 92: 40-ft. fish carrier | |
| 93: 51-ft. | |
| 94: | |
| 95: | |
| 96: | |
| 97: Tug | |
| 98: | |
| 99: | |
| 100: | |
| 101: Linchauler | |

**Modification of foreship**

Lines and arrangement
Lines
General arrangement
Lines
General arrangement

**Lines**

Construction
Installations
Lines
Construction
Rudder
Lines / Construction
Keel
Rudder
Lines
Keel
Construction
Deck and gear arrangement (FAO plate 88/102)
Lines
Lines
Construction
General arrangement
Lines / Midship section
Lines / Construction
Lines
Construction
Fish hold

**Lines**

Construction
Section
General arrangement
Lines
Construction
General arrangement
Suggested cabin layout
Appendix 1

Suggested Equipment and Machinery for a Boatbuilding Yard at Satpati

Roofs, moldloft, slipway, workshop, storerooms and operators' quarters as per plans and specifications prepared by Public Works Department.

Machinery for Wood Preparation:

1. Power band saw for logs up to 2-ft. diameter, belt-driven, not provided with automatic feed, any suitable type, power requirement not to exceed 6 h.p.
2. Thickness planer, heavy duty, to take planks up to 4-in. x 16-in. (width 24-in.), power requirement max. 4 h.p.
3. Universal saw arbor 1-in. x 12\(\frac{3}{4}\)-in., ball bearings
4. Sharpening machine for handsaw blades

Equipment for Boat Assembling:

1. Portable electric drill, 3/4-in. with column
2. " " " \(\frac{1}{2}\)-in.
3. " " " circular saw, 6-in. diameter
16. Screw (or steel bar) clamps, 10-in. gap
4. Steel bar clamps, 30-in. gap
6. Boatbuilder's chain clamps with planking and keel hooks for planking 7/8-in. and upwards

Machinery for Engine Repairs:

1. Lathe, 12-in. central height, 6-ft. length, automatic thread gear-box
1. Drilling machine, column type, 16-in. gap, for drill, max. 1\(\frac{3}{4}\)-in.
1. Drilling machine, small, 3-in. drill
1. Grinding machine, column type, size 2-in. x 8-in.

FA0/50/10/7951
1 Simple electric welder, about 10 kw.
1 Saw machine, 15-in. blade, in oil bath

Equipment for motor installation and repair:
1 Patent tackle for 2 tons lift
1 " " " 1 ton lift
1 Pipe vise, 3-1/2 in.
1 Pipe threading device up to 3-in. pipe
1 Threading device, Whitworth, 1/8-in. to 1-in.
2 Machinist's vices, 6-in. and 5-in.
1 Blacksmith's equipment: hard, anvil, hammers, etc.
1 Stillson wrench, 4-in.
1 Complete set wrenches to fit 1/2-in. to 1-1/2 in. bolts, preferably both American and English
1 set of Pipe wrenches for 1/2-in. to 2-in. pipe dia.
2 Soldering irons and soldering material
1 Valve grinding tool set, grinding compound

Tools: Drills, files, cutting tools, saw blades, etc., for the machinery and for hand.

It is supposed that carpenters' and mechanics' hand tools are provided by those same operators.

1 Fire protection equipment
1 First aid installation

Power plant:

Power requirement would be --
for boystyard, approx. ................ 9 h.p.
and for mechanical workshop ......... 6 h.p.
if the electric welder is not used
at the same time as the bandsaw. 15 h.p.

Further, additional power may be
desired for electric light in the
yard and workshop and for using
welder in hardest working hours .... 4 h.p.

TOTAL: 19 h.p.
Transmissions from power plant to the different machines cannot be specified at present and this leaves some uncertainty as to the total power requirements.

It is supposed that a Diesel-electric power plant will be used, and its output can be estimated to 20 h.p.

Appendix 2

Suggested equipment for a marine engine Servicing Station at Hatpeta

1 Lathe, 12-in. central height, 6-ft. length, automatic thread gearbox

1 Drilling machine, column type, 16-in. gap, 1-1/4-in drills
1 "    " for 3/4-in. drill max.

1 Chaping machine, 14-in. stroke

1 Saw machine, 15-in. blade, in oil bath

1 gas welding equipment

1 blacksmith's outfit (hors with mechanical blower, anvil, hammers, tongs, etc.)

1 grinding machine, column type, disc, 2-in. x 8-in.

1 chain tackle (differential) for 2 tons lift

2 jacks for 1 ton

1 pipe vice, 3½-in.

1 threading device for pipes up to 3-in. threads

1 threading device, Whitworth 1/8-in. to 1-in.

3 machinist's vices 6-in., 7-in., 8-in.

1 Stillson wrench, 4-in.

1 complete set spanners for 3/8-in. to 1½-in. nuts.

1 set box spanners for 3/8-in. to 1-in. nuts

1 set pipe wrenches for tubes of 1/2-in. to 2-in.

2 sets hand tools for oil engine mechanics

1 big blow torch

FAO/50/10/7991
1 small melting crucible
1 Diesel injector nozzle tester
1 equipment for soldering, hard and soft solder
1 balance weight (scale) up to 20 lb.

2 revolution counters

Instruments for measuring:
- steel measuring tape
- calipers
- dividers
- scales
- straight edges
- squares
- micrometers
- water levels
- thread gauge

Trial run equipment:
- Test tank for fuel with 3-way cock
- Burette for fuel measurement
- Stop watch
- Exhaust gas thermometer

Electrician's outfit:
- Suitable volt and ampere meters
- Battery charger
- Battery service equipment

Tools:
- Drills, files, sawblades, high speed cutting
tools, valve grinding tools, valve spring lifters, shims

First aid kits, goggles for welders and grinders,
Fire extinguishers

Library:
- Marine engineer's handbook
- Caterpillar propeller calculator
- Conversion tables, gauges, mathematical
tables, etc.

Instruction books for all the different
gines in use in the area

Stocks:
1) of necessary materials for running of
the workshop machinery.
2) of spare parts, etc., for the engines
to be overhauled and repaired
Power requirement

The power requirement for the station (not including electric light) will be about 8 h.p., somewhat dependent on the arrangement of the power transmissions.

If power cannot be drawn from a main source, a Diesel-electric power plant would be indicated.

Work beyond the capacity of the specified equipment, namely the adjustment of Diesel fuel injection pumps and nozzles, would presumably be done by a special Diesel testing plant.

Appendix 3

Training of Fishing Boat Designers

A boat designer must in his continuous effort to improve the fishing fleet, closely observe the trend of development of gear, harbour facilities, boatbuilding progress and also the results of exploratory and experimental fishing and research in the locality for which he is to design boats.

He must further take advantage of the local fishermen's traditions and aptitudes. His work is not an office job. It is very much extension work and can only be carried out satisfactorily in close and continuous contact with boatbuilders and fishermen, and it is important that the boat designer familiarize himself with the fishing methods by going fishing.

If fisheries officers with experience in craft and tackle in their respective states are selected for training, sufficient basic knowledge in small boat design and marine engineering might be imparted to them in a course of comparatively short duration, perhaps as short as six months, depending on their educational background.

After training, these officers would have a better technical background for taking care of boatbuilding and mechanisation schemes. They would also be fully qualified for carrying out mechanisation of local craft.
The participants should be Fisheries Officers with long experience in fishing. The course should also be open to fishing boat builders.

The curriculum would comprise:

(a) Principles of technical drawing, blueprint reading
(b) Small wooden boat design and building
(c) General calculations pertaining to boat design
(d) Small marine engines and their installation

Such a course will suffice for the training of:

1. Fishing boat designers with pronounced theoretical/practical vacation for local development work
2. Government Fisheries Officers, technically trained for liaison and supervision work.

**TIMETABLE**

**First 2 months**

<table>
<thead>
<tr>
<th>Weekly</th>
<th>Duration</th>
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<tbody>
<tr>
<td>Drawing work</td>
<td>10 hours</td>
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<tr>
<td>Marine engineering</td>
<td>4 &quot;</td>
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<tr>
<td>Naval architecture lessons</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>Boatyard practice, mechanical workshop</td>
<td>8 &quot;</td>
</tr>
<tr>
<td>Fishing methods, gear</td>
<td>4 &quot;</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>30 hours</strong></td>
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**Next 2 months**

<table>
<thead>
<tr>
<th>Weekly</th>
<th>Duration</th>
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<tbody>
<tr>
<td>Drawing practice</td>
<td>10 hours</td>
</tr>
<tr>
<td>Engines, theory</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>Building materials</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>Yard practice</td>
<td>6 &quot;</td>
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<tr>
<td>Pract. engineering</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>At sea</td>
<td>4 &quot;</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>32 hours</strong></td>
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**Last 2 months**

<table>
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<tr>
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<tr>
<td>Calculations</td>
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<tr>
<td>Boatyard management</td>
<td>4 &quot;</td>
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<tr>
<td>Electronic equipment</td>
<td>2 &quot;</td>
</tr>
<tr>
<td>Mechanical workshop</td>
<td>4 &quot;</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30 hours</strong></td>
</tr>
</tbody>
</table>
Simplified Naval Architecture

DRAWING:
(a) Principles of technical drawing
(b) Explanation of use of drawing equipment, and exercise in simple sketches, especially as applied to fastenings, screws, bolts, etc.
(c) Lettering of drawings
(d) Practice in "blue print reading"
(e) Principles of naval architectural drawing, preliminary exercises, scales, main dimensions, etc.
(f) Drawing on wall (by instructor) lines of small wooden boat with step by step explanation of the different considerations that lead to the design
(g) Each trainee to draw lines of a small boat with given dimensions and type
(h) Application of calculations already taught, for midship area, volume, etc., and drawing of displacement curve. Coefficients
(i) Copy of a complicated lines drawing to a different scale
(j) Measurement of local boat and making lines drawing
(k) Drawing on wall (by instructor) construction drawing of small boat with step by step explanations
(l) Each trainee to make keel-stern drawing of his already made lines, with fastenings and all details

THEORY, CALCULATIONS
Definitions of main characteristics, showing their use in calculations, registering and classifications
Simpson's Rules, calculations of areas and volumes
Calculations of areas and displacement of a boat, with and without planimeter
Coefficients
Weight calculations
Principles of stability
Sail centres and relation of sail to hull
Mechanical propulsion: definitions of speed, horsepower, ratios, resistance. Rough estimate of HP and speed. Propeller efficiency, etc.
Simplified explanation of tank tests
Inclination tests with calculations
Trial runs, data computation

MARINE ENGINEERING
Combustion process
Fuel oil data
Lubrication oil data
Diesel injection systems, testing, adjusting
Cooling
Thrust and its absorption
(m) Each trainee to make complete construction drawing of his boat

(n) Each trainee to make weight calculation and draw displacement curve for different loads, and check trim

(o) Sail plan with centre of sail pressure and lateral centre. Suggestions for improvements

(p) Detail drawings of boat parts, incl. engine foundation drawing

(q) Rudder hinges plans, quadrants, shafts, mast and boom fittings

(r) Some practical ways of making current curves, deck beam crown, mast and spar plans, etc.

(s) Simple slipway plan

(t) Each trainee to dedicate rest of time to boats and their improvement in his particular State, under guidance of the instructor.

Drawing pertaining to Marine Engineering:

(a) Drawing of power transmission to not winch

(b) Arrangement of engine control to remote place on the boat

(c) Schematic arrangement of fuel lines and tanks on diesels with repulsion injection

(d) Arrangements of engine bolting to different foundations and hull shapes

(e) Drawing of graphs of fuel consumption, r.p.m. speed, etc., for trial run data

(f) Eventually, studies of special mechanical problems on boats from the trainer's district.
**Main dimensions**

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
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<td>34-ft. 0-in.</td>
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<tr>
<td>Length between pp</td>
<td>31-ft. 6-in.</td>
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<tr>
<td>Beam on planking, max.</td>
<td>8-ft. 10-in.</td>
</tr>
<tr>
<td>Beam on planking, rail</td>
<td>8-ft. 6-in.</td>
</tr>
<tr>
<td>Depth at midship section</td>
<td>4-ft. 2-3/4-in.</td>
</tr>
<tr>
<td>Max. draft to H. 3</td>
<td>2-ft. 10-in.</td>
</tr>
<tr>
<td>Displacement to WL. 3</td>
<td>5.33 tons</td>
</tr>
</tbody>
</table>

**Hull specification**

- **Keel:** Took sided, tapering along rabbeting, from 7-in. aft to 6-in. at stem and to 4-in. at bottom. Moulded according to pattern.

- **Stern:** Took. Upper piece 4-in. sided, moulded according to pattern, lower piece 6-in. sided, moulded according to pattern. Upper and lower piece assembled with knees 4-in. sided, and secured with 4 1/2-in. galv. iron screw bolts.

- **Hog piece:** Took 2-in. sided. Moulded, 9-in. aft, 8-in. at stem. Keel and hog assembled with through-going 5/8-in. galv. screw bolts.

- **Transom:** 1 1/2-in. Took. Transom secured to hog piece by 5 1/2-in. galv. iron screw bolts.

  All fitting surfaces in keel assembly should be treated with wood preservative before assembly, and bolts dipped in tar and packed under the heads.

- **Planking:** 1 1/6-in. Took as finished.

- **Floors:** Took and Acacia 2 1/2-in. sided, secured to keel with spikes and driftbolts.

- **Bent timbers:** Took and Pandan. Rivetted to planking with copper rivets.

- **Gunwale:** 1 1/4-in. x 4-in. Took. Gunwale secured to transom and stern by 3-in. knees.

- **Bilge stringer:** 1 1/4-in. x 4-in. Took.

- **Deck stringer:** 1 1/4-in. x 4-in. Took. All longitudinals should be well fastened to frames and planking.
Dock beams over holds: 2 1/2-in. x 4-in. Bandara. At bulkheads, 2-in. x 4-in. Spiked to deck stringer. Further secured to planking with knuts of forged iron 2-in. wide, 3/4-in. at throat and tapering to 1/2-in. Each knut fastened to beam and planking with 3/8-in. screw bolts.

Floor boards over hold: 1-in. Bandara made in loose sections for easy handling.

Dock beams aft: 2-in. x 3-in. Teak.


Beams for floor boards in cockpit aft: 2-in. x 3-in. Bandara.


Bulkheads: 1-in. Teak.

Engine foundations: 4-in. Teak.

Engine casing: Cornorposts, 2 1/2-in. x 2 1/2-in. Teak. Beams, 1 1/2-in. x 1 1/2-in. Teak. Side and top planking, 1/2-in. Teak.

Foredeck and washboard: 3/4-in. Teak.

Mooring bit: 4-in. x 4-in. Teak.

Floor boards in fore cockpit: 1 in. Bandara on 2 in. x 2 in. beams of Bandara.

Rudder: Teak 2-in. sided. Moulded according to pattern. The portion below waterline streamlined and well faired.

Engines: 20 h.p. Bulk diesel type 2 EAM 1500 rpm, reduction gear 2:1

Not garvey type Nordic No. 1 Separate bilge pump should be connected to the engine.
Appendix 5

22-ft. Inland Fishing Boat

(Plan Nos. 61, 62, 63)

Hull Specification:

<table>
<thead>
<tr>
<th>Keel</th>
<th>Teak</th>
<th>3 1/2-in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaft log</td>
<td>&quot;</td>
<td>To suit stern tube</td>
</tr>
<tr>
<td>Stem</td>
<td>&quot;</td>
<td>3 1/2-in.</td>
</tr>
<tr>
<td>Knee at stem</td>
<td>&quot;</td>
<td>3 1/2-in.</td>
</tr>
<tr>
<td>Transom</td>
<td>gambharti</td>
<td>1 1/4-in.</td>
</tr>
<tr>
<td>Keel at Transom</td>
<td>teak</td>
<td>3-in.</td>
</tr>
<tr>
<td>Frames</td>
<td>gambharti</td>
<td>1 5/8-in. molded</td>
</tr>
<tr>
<td>Floors</td>
<td>&quot;</td>
<td>1 5/8-in.</td>
</tr>
<tr>
<td>Planking</td>
<td>1 in.</td>
<td></td>
</tr>
<tr>
<td>Scion buttons</td>
<td>teak</td>
<td>1/2 in. x 1 3/4-in.</td>
</tr>
<tr>
<td>Engine bearers</td>
<td>&quot;</td>
<td>4-in., long as possible</td>
</tr>
<tr>
<td>Deck clamp</td>
<td>gambharti</td>
<td>1 1/2-in. x 3-in.</td>
</tr>
<tr>
<td>Deck beams</td>
<td>teak</td>
<td>1 1/2-in. x 2-in.</td>
</tr>
<tr>
<td>Deck planking</td>
<td>gambharti</td>
<td>3/4-in.</td>
</tr>
<tr>
<td>Covering board</td>
<td>teak</td>
<td>3/4-in.</td>
</tr>
<tr>
<td>Coaming board</td>
<td>&quot;</td>
<td>1 in.</td>
</tr>
<tr>
<td>Fender</td>
<td>&quot;</td>
<td>2-in. x 3-in.</td>
</tr>
<tr>
<td>Chine</td>
<td>gambharti</td>
<td>1 1/2-in. x 3 1/2-in.</td>
</tr>
<tr>
<td>Floor boards</td>
<td>1 in.</td>
<td></td>
</tr>
</tbody>
</table>

To substitute teak, other kinds of good and durable wood can be used.

Engine: 12 h.p. SAAB semi-diesel. As the 2-bladed 23-in.
standard variable pitch propeller cannot be used without altering
the keel construction, as shown on plan No. 62 (and exceed the
requested minimum draught), the engine supplier must be consulted
as to what smaller diameter variable pitch propeller can be
supplied for the engine. The engine drives a simple double
caphead winch, placed on a platform aft of the engine, and arranged
for trawling over the stern (see installation plan). The winch is
best manufactured locally. Any reputable engine works will be able
to produce a winch, preferably driven by another gear, if given the
particulars concerning engine power available and required speed of
haul.

FA0/50/10/7991
Appendix 6

22-ft. Fishing Boat

(Plan Nos. 67, 68)

Keel: 4-in. x 7-in. Tank, Aince or Bontouch.

Stem: 4-in. sided, moulded according to stem pattern. Tank or Aince.

Stern: Sided 5-in. around stern tube, tapering to 4-in. at top end and at keel. Moulded according to stern pattern.

Knee Forward: 4-in. sided. Moulded according to pattern. Tank or Aince.

Knee aft: 5-in. sided. Moulded according to pattern. Tank or Aince.

Keel stem and stern construction should be bolted with 1/2-in. galv. iron screw bolts with nuts inside and top of bolts rivetted to look nuts.

Keel and stern assembly is further secured by two flat irons 1/4-in. and 3/8-in. rivets as shown on keel drawing. Plates and bolts to be galvanised.

Floors: 2 1/2-in. Tank or Aince or other suitable hardwood. Height 3-in. at upper end, 4-in. at keel stroke. If crooked timber is not available the floors should be made in two pieces and assembled with a cross-piece 1 1/4-in. thick by copper rivets.

Transom: 1 1/4-in. Tank or Aince. Fastened to stern by screws and 4 3/8-in. galv. iron screw bolts.

Planking: 7/8-in. as finished Tank or Aince. Where necessary, planks should be hollowed to fit curvature of construction mould.

Bent frames: 1-in. x 1 1/2-in. Tank. 7 1/2-in. centre to centre. Planking and bent frames to be assembled with copper rivets.

Bent frames in fore ship should be spaced so at gunwale that they run "square" to planking with top and pointing forward.

Bilge stringer: 1-in. x 4-in. Tank. For midship position, see drawing. Bilge stringer should go throughout the length of the boat.

Deck stringer: 1 1/2-in. x 3 1/2-in. Aince. Should extend only as far as necessary to carry the beams.

FAO/58/10/7991
Gunwale: 1 1/2-in. x 3 1/2-in. Ainco. Secured to stem and transom with knees. The shifting of the joints for the three longitudinal members should be carefully considered.

Deck beams: 2 1/2-in. x 3-in. Ainco. 2-ft. 3-in. centre to centre. Every other beam should be secured to planking with knees on top of beams rivetted to planking and beams with through-going rivets.

Deck: 7/8-in. thick Red Cedar should be made in loose sections easy to handle. Each section must be provided with a hole for lifting. There should be at least 1/8-in. clearance between all sections.

Hoeing bit: 4-in. x 4-in. of hardwood tapped into knoe forward, and bolted to beam at top. This beam should be well fastened to gunwale.

Motor casing: 3/4-in. Red Cedar. Made in sections so that the casing can be dismantled easily.

Floor boards aft: 3/4-in. Red Cedar.

Seat aft: 3/4-in. Red Cedar.

Fender: 1 1/2-in. x 2 1/2-in. Bontecq.

Thwart: 2-in. x 5-in. Ainco. Position as shown on drawing. Should be well secured to planking and gunwale with a knoe each side.

Engine: 3 1/2-in. sided. Suitable hardwood. Should extend longitudinally as shown on drawing, and fit closely to planking and frames. Fastened with through-going 1/2-in. screw bolts of galv. iron.

Rudder: 1 1/2-in. Ainco. Well rounded on edges.

Engine is a 8 h.p. SABB diesel type G, with 1500 r.p.m. and 2:1 reduction gear, which gives the 16-in. propeller 750 r.p.m.

The net weight of the engine is 485-lb.

The estimated speed of the boat is 6 knots.
### Specification of Wood for Monsoon Fishing Boat

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity/Dimensions</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keel:</td>
<td>1 piece 7-in. x 10-in. x 24-ft.</td>
<td>21.4 cu. ft.</td>
</tr>
<tr>
<td></td>
<td>1 piece 7-in. x 10-in. x 20-ft.</td>
<td></td>
</tr>
<tr>
<td>Keelson:</td>
<td>1 piece 7-in. x 5-in. x 23-ft.</td>
<td>9.7 &quot;</td>
</tr>
<tr>
<td></td>
<td>1 piece 7-in. x 5-in. x 17-ft.</td>
<td></td>
</tr>
<tr>
<td>Stem:</td>
<td>7-in. x 12-in. x 11-ft.</td>
<td>6.4 &quot;</td>
</tr>
<tr>
<td>Apron grown knees:</td>
<td>7-in. x 7-in. x 11-ft.</td>
<td>3.8 &quot;</td>
</tr>
<tr>
<td>Sternpost:</td>
<td>8-in. x 30-in. x 6-ft.</td>
<td>10.0 &quot;</td>
</tr>
<tr>
<td></td>
<td>7-in. x 16-in. x 6-ft.</td>
<td>4.7 &quot;</td>
</tr>
<tr>
<td>Deadwood:</td>
<td>7-in. x 7-in. x 8-ft.</td>
<td>2.7 &quot;</td>
</tr>
<tr>
<td>Transom:</td>
<td>2-in. x 10-in. x 35-ft.</td>
<td>4.9 &quot;</td>
</tr>
<tr>
<td>Transom frames (curves):</td>
<td>2-in. x 2-1/2-in. x 5-ft. x 2</td>
<td>0.3 &quot;</td>
</tr>
<tr>
<td>Frames (curves):</td>
<td>4-in. x 5-in. x 8-ft. x 18 pcs.</td>
<td>20.0 &quot;</td>
</tr>
<tr>
<td></td>
<td>4-in. x 5-in. x 6-ft. x 36 pcs.</td>
<td>30.0 &quot;</td>
</tr>
<tr>
<td></td>
<td>4-in. x 5-in. x 8-ft. x 34 pcs.</td>
<td>38.0 &quot;</td>
</tr>
<tr>
<td>Bilge stringers:</td>
<td>2-in. x 4-in. x 180-ft.</td>
<td>10.0 &quot;</td>
</tr>
<tr>
<td>Deck clamps:</td>
<td>2-1/4-in. x 8-in. x 100-ft.</td>
<td>12.5 &quot;</td>
</tr>
<tr>
<td>Fender lists:</td>
<td>2-1/2-in. x 8-in. x 100-ft.</td>
<td>14.0 &quot;</td>
</tr>
<tr>
<td>Planking:</td>
<td>1-1/2-in. x 11-in. x 15/18 ft., 95 planks</td>
<td>185.0 &quot;</td>
</tr>
<tr>
<td>Deck:</td>
<td>1-1/2-in. x 3-1/2-in. x 1270-ft.</td>
<td>46.5 &quot;</td>
</tr>
<tr>
<td>Covering board:</td>
<td>1-1/2-in. x 12-in. x 14-ft. x 8</td>
<td>14.0 &quot;</td>
</tr>
<tr>
<td>Deck beams:</td>
<td>5-in. x 7-1/2-in. x 12-ft. x 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-in. x 7-1/2-in. x 10-ft. x 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-1/2-in. x 7-1/2-in. x 12-ft. x 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-1/2-in. x 7-1/2-in. x 10-ft. x 2</td>
<td>37.0 &quot;</td>
</tr>
<tr>
<td></td>
<td>3-1/2-in. x 7-1/2-in. x 9-ft. x 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-1/2-in. x 7-1/2-in. x 6-ft. x 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-in. x 6-1/2-in. x 8-ft. x 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3-in. x 4-1/2-in. x 4-ft. x 9</td>
<td></td>
</tr>
<tr>
<td>Hatch longitudinal beams:</td>
<td>4-in. x 5-in. x 4-ft. x 6 pieces</td>
<td>3.3 &quot;</td>
</tr>
<tr>
<td>Hatch transverse:</td>
<td>3-1/2-in. x 10-in. x 7-ft. x 4 pcs.</td>
<td>6.8 &quot;</td>
</tr>
</tbody>
</table>
Motor casing boxes: 4-in. x 5-in. x 7-ft. x 2 ... 2.0 cu. ft.
Poop hatch casing: 2-in. x 6-in. x 10-ft. ... 0.8 " "
Cockpit boxes: 3-in. x 3-in. x 7-ft. x 3 ... 1.3 " "
Horizontal nose: 14 number of 2-1/2-in. thickness, grown curves.
Vertical knees: 8 number of 2-1/2-in. thickness, grown curves.
Breasthook: 1 number of 3-in. thickness, grown curves.
Stern side knees: 2 number of 2-1/2-in. thickness, grown curves.
Uprights at engine bulkhead: 2-in. x 2-1/4-in. x 28-ft. 0.9 cu. ft.
Engine bulkhead: 3/4-in. x 8-in. x 55-ft. ... 2.3 " "
Fore bulkhead: 3/4-in. x 8-in. x 35-ft. ... 1.5 " "
Twas bulkhead: 3/4-in. x 8-in. x 55-ft. ... 2.3 " "
Cockpit planking: 1-in. x 6-in. x 100-ft. ... 4.2 " "
Engine bed: 5-in. x 12-in. x 10-ft. x 2 ... 10.1 " "
Hatch covers: 1-1/2-in. x 7-in. x 42-ft. ... 3.1 " "
Engine house beams: 1-3/4-in. x 2-1/4-in. x 4-ft. x 5 ... 0.7 " "
Engine house sides: 1-1/2-in. x 12-in. x 65-ft. ... 8.1 " "
Engine house roof: 3/4-in. x 6-in. x 13-ft. x 4 ... 1.6 " "
Stunners: 3-1/4-in. x 3-1/2-in. x 64-ft. ... 5.1 " "
Bulwarks: 1-in. x 5-in. x 180-ft. ... 6.0 " "
Rail cap: 2-in. x 8-in. x 16-ft. x 6 ... 10.7 " "
Rudder hardwood: 1-1/2-in. x 14-in. x 14-ft. ... 2.1 " "
Filling pieces, butt blocks, battens, etc. ... 12.0 " "

Woods of different kinds and qualities will amount to 580 cu. ft.

(An estimate based on prices at Sotpati, November 1954: logs of planking wood at Rs. 10/- per cu. ft., for kaul Rs. 14/- per cu.
ft. and for ribs Rs. 40/- per khandy of 8 owts., and a waste per-
cent of 40, will show a cost of wood of approximately Rs. 8,000/.)
Appendix 5

Specification for the construction of

**FAST FISH CARRIER BOAT FOR 10 h.p. OUTBOARD ENGINE**

(Plans 84 and 85)

**Main dimensions:**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all</td>
<td>17-ft. 0-in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth</td>
<td>5-ft. 4-in.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth</td>
<td>2-ft. 1-in.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The hull to be built of selected and well seasoned Sap wood and first class workmanship throughout, and in accordance with the attached drawings.

**Keel:**
2-1/8-in. thick along the rabbet, diminishing to 1-5/8-in. at the under side.

**Keelson:**
7/8-in. x 3-1/4-in. bolted to the keel and each bottom frame with 3/8-in bolts.

**Stem:**
Sided 2-1/8-in. and molded as per plan, of grown carved wood bolted both to keel and keelson.

**Transom:**
1-in. thickness, with framing 1-1/8-in. x 2-in. at sides and bottom, and a grown knee 1-1/2-in. in the centre which fastens it to the keel.

**Plankings:**
Selected and seasoned wood, 5/8-in. if carvel and caulked, or 1/2-in. if clinker. If completely seasoned wood is not available, the local method of plankings with half laps can be used.

**Ribs:**
5/8-in. x 1-1/8 in. to be placed at a distance of 11-1/4 in. centre to centre. They must be of suitable, not too seasoned wood, and be bent by heating. Ribs that crack must be discarded.

**Floor frames:**
1-1/8 in. x 2-1/2 in. to be placed on every second rib, and bolted to keel. Suitable scupper holes to be made for the bilge water, either side of keelson.

**Gunwale stringer:**
1/2 in. x 2-1/4 in. laid on inside of ribs from stem to transom. If in two or more lengths, scarf joints must be provided.

**Gunwale cap:**
1/2 in. x 2-3/8 in. on top of ribs and stringer as per plan. If in several pieces, scarf joints must be used.

**Side stringers:**
For thwarts, 7/8 in. x 2-1/2 in. from stem to transom. The dimensions can be reduced towards stem for easier bonding.

FAO/58/10/7991
Thwarts: 3/4-in. x 8, two in the middle part of the boat, and 8 at aft. Suitable stanchions to be placed underneath. G.I. knees.

Fender list: (Rubber slats), half-round 1-1/4 in., to be placed outside as per plan, from stem to transom at the height of the inside stringer.

Deck: 1/2-in. thickness on light beams to be laid in the bow for a length of about 3 ft., with bulkhead with door and lock.

Grating: Light and strong wood to be laid over the floor frames in convenient lengths, from transom to fore bulkhead.

Fastenings: To be of copper, brass or bronze.

Painting: Good marine paint, three coats, the colour to the Fisheries Department's choice.

Awning: Aft for protection of the engine operator, and another in the fore part from bulkhead to the middle of the boat.

Belaying cleats: At bow and stern for mooring lines.

Appendix 2.

Specification for the construction of

FISH CARRIER LAUNCH

(Plans Nos. 89, 90, 91)

Main dimensions:

<table>
<thead>
<tr>
<th>Description</th>
<th>29-ft. 8-in.</th>
<th>8-ft. 2-in.</th>
<th>2-ft. 8-in.</th>
<th>2-ft. 3-in.</th>
<th>6 tons</th>
<th>180 cu. ft.</th>
<th>6 knots</th>
<th>7 knots, approx.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breadth</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth molded</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draught, loaded</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displacement, empty</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Displacement, loaded</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulated fish hold</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed with engine 15 h.p. on load</td>
<td>...</td>
<td>6 knots</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot; unladen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The hull is to be constructed from local boatbuilding woods, preferably Oak or local Teak.

The hull Fastenings should be copper, brass, bronze or other non-corrosive material.

First class workmanship required.

FAO/58/10/7991
Details of construction:

**Flat keel plank:** 1-1/4 in. from stem to propeller tunnel as per plan, in not more than two lengths carefully and strongly joined. To be heated for bending to the required curved shape at bow.

**Keelson:** 2-1/2 in. x 3-1/2 in. as per plan, bolted through each bottom frame with 3/8 in. bolts, with nuts or clenched over washers.

**Frames:** Bottom frames of 1-5/8 in. x 2-1/2 in., except under the engine foundation where they should be 2-1/4 in. x 2-3/4 in. Side frames 1-1/8 in. thick, breadth at bottom 4-in. and at top 3-in. spiked to bottom frame. In engine compartment the bottom and side frame connection should have triangular stiffeners as dotted line on plan.

**Chine stringer:** 1-3/4 in. x 2-3/4-in. along the chine from transom to stem. Can be tapered down in dimensions at bow for facilitating bending.

**Stem cross wood:** 3-1/4 in. x 7-1/2 in., including crown for dock curve, 1-in., rabbed to take deck and bottom planking.

**Bottom planking:** Of selected and well-seasoned wood. Thickness 1-1/4 in. and width of planks not more than 7 in. Carvel planking with caulking of seams preferred. If local supply of wood should not be seasoned and suitable for carvel construction, means must be provided for securing a permanently strong and watertight planking. The planks forming the bend at the bow must be boiled or steamed for giving the shape. Longest possible planks should be used and the planks butts should be spaced wide apart from each other. If plank joints come under the engine, they should have butt blocks of same thickness as the planks and double row of rivets in each plank.

The planking which corresponds to the propeller tunnel must be erected with the greatest care, and templates should be made and lined up with the radius indicated in different sections on the plan. Additional inner framing set up as needed.

**Side planking:** Of selected wood, 1-in. thick. Carvel planking with caulking preferred. See remarks under Bottom Planking.

**Transom:** 1-1/4 in. thickness, supported by framing all around and in the middle, of 1-1/2 in. x 2 1/2 in.

**Kool piece under stern:** 6-1/2 in. thick at hull, 3-3/4 in. thick at bottom, shaped as per plan. Can be made up by two or more planks one of which may serve as shaft log and be extended inside the hull for taking the inner sternbearing. The after edge must be thinned off to the size of outer sternbearing flange, and below and above the flange the edge should be thinned to 1-3/4 in. only. This is in order to give free flow of water to the propeller.

**Covering board at sides:** 7/8 in. x 8 in. of good material, cut to the curve of the side of the boat. Supporting blocks for same should be of 1-in. wood, shaped as per plan, spiked to each frame.
Coaming: 1-1/8 in. thick x 9 in. wide, curved in accordance with shear stroke of the boat.

Deck beams: As per plan, having a curve (crown) of 1 in. to 40 in. length. To be fastened to frames.

Deck: Fore and aft, 3/4 in. thick and not more than 5 in. wide planks (4 in. recommended), carefully caulked and painted.

Bulkheads: As per plan, of 3/4 in. planks and convenient framing. Fixed to the hull structure in such a way as to act as transverse binding and stiffening members.

Engine box: To be of hard wood, longitudinally laid, 5 in. x 10 in. x 8-ft. 3-in., with transverse stiffeners where required. The boxers to be carefully fitted over the floor frames and bolted through them to outside of planking with bolts of 5/8 in. dia. and nuts inside.

Engine to be bolted to the bearers by 5/6-in. bolts with big washers and nuts underneath the boxers, and nuts and lock nuts at the upper end.

Rudder and shoe: The rudder shoe should be of brass if the boat is to be operated in salt water, otherwise of steel. Must be sufficiently strong to resist bending if the boat is grounded. The rudder blade can be of hardwood, 1-1/4 in. thick, streamlined for least resistance to propeller slip stream.

The rudder shaft and its surrounding tube and the lower pintile should preferably be of brass or naval bronze, and also the upper bearing on deck. Diameter of shaft: 1-1/2 in.

Suitable rudder control by means of quadrant, galvanised chain and rods, galvanised pulleys, etc., should be carried to the steering stand in front of engine or to the fore deck, as agreed on.

Hull fastenings: To be of copper, brass or bronze throughout.

Copper sheathing: Copper sheathing of the hull and rudder blade should be made. The sheathing should cover the underwater part of the hull up to 6 in. above highest load waterline. Thickness of copper sheath must be satisfactory by local experience.

Painting: To be done with good marine paint; number of coatings and the colours to the owner's satisfaction.

Fish hold: Should have a layout as per Drawing No.91, sides, ends and cover insulated with 2 in. thick Onosite plates between outer and inner linings of wood. The Onosite to be laid in asphalt or other compound recommended by the manufacturers. The wood used for linings and floor of the hold should preferably be light but have a hard surface.

PAO/50/10/7991
The floor: The floor should be of wood 3/4-in. thick, carefully
nailed and coated with asphalt or other special fishroom compound.
Drain openings to be provided along the keelson each side, large
eight for passing the hand for cleaning, and covered with perfor-
ated board or grid.

Side and end ceilings: As per plan. For the ends the bulkheads
are the outside lining. For sides, a lining of 5/8-in. wood is to
be laid against the frames. Ventilation must be provided for air
between the frames. The 2 in. thick Onazote slabs to be laid in
asphalt or other suitable compound. The inner ceiling to be of
light, porous wood 1/2 in. thick, preferably tongue and groove.

The deck or cover: The deck or cover should be laid on the longi-
tudinal and transversal bulkheads without beams. It should be
arranged with insulation in the same way as for sides and ends.

Hatches to each compartment, 12 in. x 20 in., insulated, can be
unhinged, with lifting handles.

Top of the fish hold and the hatches should, if the climate so
requires, be covered with light canvas laid in thick paint.

Along the centre of the deck, a gangway should be provided, with
a suitable handrail on one side. Not shown on plan.

Inner dividing walls: The inner dividing walls should be of 5/8 in.
light wood, preferably tongue and groove, with suitable buttons for
stiffening. Exception is made for the second transverse wall,
counted from the bow (see drawing), which should be insulated with
2 in. Onazote between wooden layers of 1/2 in.

Installation of a hand pump from the sump of the fish hold should
be included. Before laying the floor, ample scupper holes
should be provided through the bottom frames for bilge water, to be
removed by separate pump from lowest part of the hull. Water from
the fish hold should not be allowed to mix with the bilge water in
the boat.

Appendix 10

51-Ft. FISH CARRIER

<table>
<thead>
<tr>
<th>Main data:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all</td>
<td>51 ft. 0 in.</td>
</tr>
<tr>
<td>Length between P.P.</td>
<td>47 ft. 6 in.</td>
</tr>
<tr>
<td>Greatest beam</td>
<td>15 ft. 6 in.</td>
</tr>
<tr>
<td>Depth at midship section</td>
<td>7 ft. 8 in.</td>
</tr>
<tr>
<td>Maximum draft loaded</td>
<td>5 ft. 8 in.</td>
</tr>
<tr>
<td>Total displacement to W.L.4</td>
<td>37 Tons</td>
</tr>
</tbody>
</table>

(Plans 93, 94, 95 96)
Particulars in loaded condition (to WL 4):

- **Longitudinal centre of buoyancy**: .166 ft.
- **Block coefficient**: .362
- **Midship section coefficient**: .624
- **Prismatic coefficient**: .581

**Estimated service speed**: 8.5 knots

**Hull specification:**

**Keel**: 6-in. / 8-in. Teak or equivalent.

**Keelson**: 6-in. / 6-in. Teak or equivalent. Keel and keelson to be assembled with throughgoing bolts through floor. Bolts to be 3/4-in. galvanised iron bolts, heads outside, nuts and washers tightened on keelson.

**Keelson**: 2-in. / 6-in. Suitable timber. Fastened to keel with 4-in. galvanised spikes and with tar paper between keel and keelsheo.

**Stern**: 6-in. sided. Teak or equivalent. Cut from stem pattern. Fitted to keel by knees. Bolted with 3/4-in. galvanised iron bolts as keel members.

**Stern construction**: Sided dimensions to suit stern tube. Teak or equivalent. Cut from stem pattern. Bolted with 3/4-in. galvanised iron bolts as keel members or with driftbolts where necessary. All faying surfaces in keel, stern and stern construction to be treated with wood preservative before assembly.

**Bent timbers**: 1-1/2 in. / 2 in. Suitable timber. Spaced 8-in. C. to C. Rivetted to planking with copper nails. For every third timber an extra timber to be added on top of longitudinal stringers. Rivetted with through-going copper nails to planking.

**Floors**: 3-in. sided. Cut from grown hardwood. Reinforced where possible with bent timber 1-1/2 in. / 2 in., as shown in midship section. Fastened to planking and bent members with galvanised iron screws and rivetted copper nails.

**Planking**: 1-1/4 in. garboard and kelson, 1-1/2 in. Teak. Fastened to timbers with copper nails, and with galvanised iron screws to floors, keel, stem and stern.

**Stringers**: 1-3/4 in. / 2-1/2 in. Teak or suitable timber. Fastened with copper nails. See Midship section for detail of riveting pattern.

FAO/50/10/7991
Deck clamps: 2-3/4 in. / 5 in. Teak or equivalent. Tapering at ends. Through bolted to covering board and garboard with 1/2 in. galvanised iron bolts.

Covering board: 2 in. / 10-1/2 in. Teak or equivalent.

Deckbeams: 3 in. / 4 in. at side, 3 in. / 5 in. at front. Suitable timber. Hatches and beams to be strengthened as shown. Beams forward of forward hold bulkhead 4 in. / 4 in. throughout.

Half beams: 3 in. / 4 in. suitable timber.

Hold beams: 2 in. / 4 in. suitable timber.

Deck: On top of beams 1/2 in. marine plywood, glued to beams and fastened with screws. On top of plywood 1-1/8 in. / 3 in. planking of suitable softwood.

Bulkhead in hold: Two layers of 3/4 in. T. and G. softwood set up diagonally and fastened to vertical stiffeners 2 in. / 3 in. by galvanised screws. Between layers, unbleached calico treated with raw linseed oil.

Hold insulation: 3 in. Thermocol at bulkhead and in hatchway. Under deck and at hold sides structure filled out as shown in midship section. R. A. Cole Limited, Bombay, should be consulted in all matters concerning setting up of insulation.

Hold lining: Hold lining to be sea-water resistant aluminium alloy fastened to timbers with round galvanised screws. Joints to be made watertight. If necessary, extra support must be provided for at shooting in lower portion of hold.

Hold bottom to be formed of corrugated sea-water resistant alloy and provided with holes for melting ice.

Ventilation between insulation and hull: For ventilation of space between insulation and planking, 6 goose-neck vents, 2 in. dia., to be provided each side, as shown in midship section. Alternatively, if cost allows, an arrangement with artificial ventilation is recommended, giving greater efficiency.

Partition in hold: According to local needs, partitions of wood to be set up in hold.

NOTE: All wood dimensions stated are "as finished". The term "suitable wood or timber" indicates that the best local available wood at building place should be used.
Deck Fittings, etc.

Rail stanchions: 2 in. / 2 in. angle iron welded to base plate as shown in midship section, and bolted to each boom.

Stanchions to be well galvanised.

Cows for Engine room ventilation: One 8 in. cow of galvanised plate to be provided port and starboard, as shown on construction plan, and extending to above top of pilot house.

Anchor gear: Conforming to M.H.D. requirements, anchors and chain to be provided together with suitable hand anchor winch and anchor davit with due strengthening of deck structure forward.

Mast: To carry ship's top light, wireless antenna and flood light for deck, one mast to be fitted forward stopped on deck and high enough for the purpose.

Note: If a lifeboat is to be carried on foredeck, the mast must be strengthened sufficiently and boom and lifting gear provided.

Engine Specification

Main Engine: The Main Engine to be a Perkins Diesel type 56(M) 75/100 HP with 2:1 reduction gear. Main engine should be well bedded down to engine bearers of hardwood extending well forward.

Bilge pump of suitable type to be connected to main engine. Same pump should be suitable for fire fighting purposes also.

Propeller: 3 bladed bronze propeller. Dia. 30 in.
Pitch 20 in.

Tank capacities: The capacity for fuel oil, lubricating oil and fresh water should be considered in connection with the basic requirement for a light total displacement. For this reason sufficient fuel and water for one tour Bombay - Saurashtra and back with ample margin would be desirable. If, however, fuelling is not conveniently arranged in either port of loading or port of unloading, tank capacities should be increased accordingly.

Generator Set: 1-1/2 kW. 24 volts diesel driven generator set to be provided to deliver current in general.
Batteries: Batteries 24 volts about 300 A.H. (including starting battery) to be set up either on main deck under pilot house floor or at suitable place in engine room. Ample ventilation should be provided.

Instrument panel: Instrument panel for main engine generator set batteries and general lighting to be set up at suitable place in Pilot house.

Life saving equipment:

Boats: According to the I.M.S. rules of 1956 a boat should be carried and so stowed that it can be placed in the water. If exemption from this rule cannot be obtained or is not desired, the motors must be strengthened accordingly and provided with lifting gear for the boat stowed on top of hatch.

Buoyant apparatus: Buoyant apparatus sufficient to support all persons on board to be carried.

Life-boats and Jackets: Two approved life-boats, one of which is filled with self-igniting light, and one approved life jacket for each person on board to be carried.

Fire Appliances: According to I.M.S. rules 1956, one power-operated pump (bilge pump) with hose able to reach any part of the ship should be provided. In addition, 3 fire buckets and in engine room 2 portable fire extinguishers for quenching of oil fires.

Light and sound signals: Light shapes and sound signals to be carried in conformity with the "International Regulations for Preventing Collision at Sea".

Appendix 11

Specification for the construction of DIESEL TUG FOR TUTICORIN PEARL FISHERY. (Plans Nos. 97,98,99,100)

Main dimensions:

<table>
<thead>
<tr>
<th>Details</th>
<th>Length</th>
<th>Breadth</th>
<th>Depth molded</th>
<th>Draught (max.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all</td>
<td>44 ft.</td>
<td>12 ft.</td>
<td>4 ft.</td>
<td>4 ft.</td>
</tr>
<tr>
<td>Breadth</td>
<td>0 in.</td>
<td>0 in.</td>
<td>9 in.</td>
<td>7 in.</td>
</tr>
<tr>
<td>Depth molded</td>
<td>13.41 m</td>
<td>3.66 m.</td>
<td>1.45 m.</td>
<td>1.40 m.</td>
</tr>
</tbody>
</table>

FA0/50/10/7991
Main dimensions (cont'd.)

Displacement ... ... ... 15,2 tons
Engines: "Glenifor" Diesel 80 h.p.

The tugboat is to be built in accordance with the drawings, of selected and well-seasoned boatbuilding woods, as specified below and first class workmanship throughout. The hull fastenings should be copper, brass, bronze or other non-corrosive material.

Details of construction:

Keel:
6-1/4 in. x 8 in. of Teak, in not more than two lengths, and the scarph joint not shorter than 46 in.

Hog keel:
2-1/4 in. x 10 in., Teak, preferably in one length. If made up of two pieces, the joint should not be close to the keel joint. Through-bolted and drift-bolted to keel as shown on plan, with 5/8 in. bolts.

Stem:
Sided 6-1/4 in. and molded as shown, of Teak. Bolts 3/4 in. dia.

Sternpost:
(Vertical), 10 in. x 11 in. of Teak, tapered at lower end to width of keel, 6-1/4 in. Inner wood over keel max. thickness 9 in. shaftlog 10 in. x 12 in., with hole for 3-3/4 in. dia. sternpost. Bolts 3/4 in.

Stern timber:
Sided 10 in. over the shafting, diminishing aft to 5 in. Molded as per plan. Teak. For securing this timber to the shaftlog, two bolts of 5/8 in. (each side of shaft tunnel) are arranged in the shaftlog before bolting the latter to the lower deadwood and keel. Other bolting as per plan. The stern timber, as well as the shaftlog and lower deadwood, are tapped into the vertical sternpost.

Grub beam:
Made up of several pieces, Teak or other suitable hardwood. Thickness 4-1/2 in. and width 7 in. The outer rim is a circle of 3-ft. 6-in. radius for about 50 degrees each side of centre line. It is slightly curved for giving the proper shoulertine, which must be allowed for when assembling the pieces or in thickness of wood.

Frames:
Steam bent, of suitable wood, not too well-seasoned. They will be 2-1/2 in. x 3-in. and can be made up of two layers of 1-1/4 in. thickness each, in which case the joining surfaces should be abundantly soaked in a wood preservative. If the wood used will permit such bending, the frames forward of section No. 6 should be single piece frames, bent to shape by steaming.

FAO/53/10/7991
Frames (Cont'd.) The distance between the frames is 11-1/2 in. centre to centre. Over the keel, most frames are joined with floor timbers, as indicated on plan. At the stern are four cent frames supporting the grub beam.

Floor timbers: Of hardwood, preferably Teak, 3 in. x 6 in., placed as per plan and through-bolted to hog keel and keel with 5/8 in. bolts with nut and washers. Fixed to frames with 5/16 in. carrier bolts with nuts where drilling is possible, in other parts nailed. Under the engine broader floor timbers of greater length are placed, to suit engine bed.

Bilge stringers: Two pieces 1-7/8 in. x 5 in., preferably Teak. If made in two or more pieces, these should be scarf jointed and the scarps of one strake should not be near to those of the other strake.

Deck clamps: 2-1/2 in. x 6 in. in the middle part of the boat and tapering towards the ends to facilitate bending. Teak. Should be scarf jointed over three frames, if not in one length. Bolted through frame and planking with 1/2 in. bolt in each frame. Joined to stem with breast hook.

Deck beams: Dimensioned as indicated on plan. Crown or cambor of beams 1 in. on 44 in. length of beam. Half beams to rest on clamp with their full height. Full beams to be rabbeted at ends so that correct deck height is obtained. The clamp should not be rabbeted.

Planking: 1-1/2 in. thick if of Teak. 19 strakes each side. Thick copper (or brass) boat nails (3 in.) should be used, boring for nail heads to be plugged.

Covering board: 1-5/8 in. x 3 in., Teak.

Deck planking: 1-5/8 in. x 4 in., Teak or other suitable wood. Boring for nail heads to be plugged. Caulked with cotton and putty.

Fender list: From the stem to section No. 10 of suitable hard but elastic wood, 2-1/4 in. x 4-1/2 in. Bolted to every second frame and nailed to covering board.

Rail stanchions: 2-1/2 in. x 3 in., extending 1 in. below deck, secured to clamp by screws from inside.
**Rail cap:**
2 in. x 5 in. of suitable hardwood, stanchion tenoned into the cap.

**Bulwarks:**
7/8 in. thickness, leaving 2 in. scupper opening underneath.

**Bulkheads:**
Of 1-1/4 in. thickness, tongue and groove, with necessary stiffeners. Of cheap, local wood. Not to be completely watertight.

**Inner ceiling:**
In cabin only. Thickness 1/2 in. or 5/8 in., according to kind and quality of wood used.

**Floor:**
In cabin, engine room and aft storage room, 3/4 in. local wood, on suitable straight beams fixed to frames or on top of floor timbers.

**Keel:**
Horizontal and vertical, on deck beams, to be fitted as indicated on drawing. Filling and strengthening pieces for the keel, over or under to be fitted where needed for rudder shaft, towing hook table, anchor winch, pollers, fairleads and other fastenings.

**Engine heaurns:**
Of hardwood, preferably Teak, 4-1/2 in. x 12 in. x 14 ft., to be carefully fitted and bolted to floor timbers and stenciled with cross pieces where necessary. Through bolts to outside of planking, with bevelled heads, should be used where possible.

**Deck houses:**
Hatches and skylights to be of Teak, constructed in the usual way of the region and in accordance with the plans. Special care should be taken in fastening the pantry and wheelhouse to deck beams with iron tie rods of 1/2 in. in each corner from the roof through the deck beams. Roofs of deck houses should be made of narrow tongue-and-groove planks of the thickness marked on plan and covered with canvas soaked in good marine paint.

**Towing stop posts (two):**
Of hardwood, 5-1/2 in. x 5-1/2 in., are provided at corners of engine casing. They are beaded into the bilge stringer and firmly secured to the two deck beams either side. They are further bolted to angle iron, 3-1/4 in. x 3-1/4 in., from post to post, laid on the inner side of the wall of the engine casing, as shown on plan. To this angle iron is also bolted the upper end of the towing table with the towing hook. It should also have an eye bolt for fixing the hoisting tackle when dismounting the reduction gear of the engine.

**Wooden gratings:**
1-1/4 in., should be placed over the rudder quadrant.
Rudder blade: Can be of hardwood, of 2 in. thickness, streamlined, or of steel 3/8 in. thick.

Rudder shaft: Of naval bronze, 2 in. dia. (Smallest permissible diameter 1-7/8 in.)

Should have brass or bronze tube through stern-timber, and stuffing box. Quadrant should be of plate iron and have an effective radius of 20 in. Rudder chain, 1/4 in. dia.

INTERIORS:

Chain locker: In fore peak with strong 1-1/8 in. floor and ceiling to sufficient height. If two chains and anchors are used, the locker should be divided into two compartments. Small inspection door provided in bulkhead to cabin.

Cabin: With 4 berths, seats and table, as per sketch. Lockers under berths and seats, and aft each side of water tank. Skylight of Teak, two 8 in. portlights on port side and one on starboard side. Both the skylight and portlights to be opened. Hood ventilator 6 in. as per plan. Hatch to cabin of sliding type.

Wheel house: With floor raised above deck level, as per plan. Front side has double wall, drop windows to fall between. Steering wheel, 26 in. dia. Compass, 5 in. dia. disc. Doors 20-1/2 in. opening, with window 13-1/2 in. x 21 in. Two windows looking aft, 11 in. x 17 in.

Pantry: Starboard side and, and Toilet port side, as per plan. Floor below deck level, with suitable draining. Doors 21 in. free opening.

Water tank: Approx. 260 gallons (appr. 31 in. x 31 in. x 6 ft. 3 in.), placed on fore part of engine bed as shown on plan.

Engine compartment: As per plan, with hatch and ladder on port side. Free opening of hatch 25 in. x 26 in. Three portlights 10 in. dia. on starboard side, of which one is to be opened (that nearest to bow). Two portlights on port side, of which the foremost is to be opened. Hood ventilator 8 in., as per plan. One fuel oil tank of 120 gallons to be installed each side as per plan, and one lubricating oil tank of 12 gallons.

Crew's store room: Abaft of engine compartment. Interior distribution to be indicated later. A suitable guard against the towing hawser should be provided over the hatch.
DECK GEAR:

Anchor winch: Hand operated, to be installed at the bow. Cleats, chain stoppers, bollards, etc., as needed. Cleats and bollards at stern.

Towing guard: Of 2-1/2 in. iron pipe from rail to rail as per plan, supported by two 1 in. tube stanchions as shown.

Towing hook: Of simple construction, on table of plate iron. The table to be firmly bolted to engine house and through the angle iron, and through the deck beams.

Signal mast: Of steel tube or welded steel construction on wheelhouse top, to carry the navigation lights at prescribed heights. Side lights on each side on house top. Abaft the funnel, the stern light.

Pipe rail: Of 1 in. gas pipe and suitable stanchions to be installed from bow to abaft the engine casing, as per plan. Height 30 in.

Hand rails: Of Teak wood as per plan, firmly bolted to the beams of house roofs.

Sun awnings: On suitable stanchions to be arranged. One wing each side from wheel-house to abaft the funnel, where they join to full width of hull, taking care not to obstruct the view from steering cabin astern.

ENGINE AND PROPELLER:

Engine: The engine specified and drawn in on the plan is a "Glennfior" Diesel, type DH4R, 80 h.p., continuous rating at 900 r.p.m., with a 2:1 reduction gear, giving 450 r.p.m. on the propeller.

Propeller: The factory's standard propeller, fixed blades, of 30 in. dia. and a pitch 28 in. is correct for towing, which is the main purpose of the tug. However, this propeller will not give the highest possible speed on occasions when the tug is used for inspection tours in off-season. At the end of the towing season it is therefore recommended that this towing propeller be removed; another mounted of the same diameter and 35 in. pitch, which will give the tug a speed of 9-1/2 knots, possibly 9 knots, on inspection trips.

FAO/53/10/7991
Engine and propeller (Cont'd.)

It is not recommended to use a variable pitch propeller, since towing load is constant, and towing and inspection seasons are divided.

The two-rope pull will be near to 2,300 lbs.

The fuel tank capacity is for 60 hours running at full speed.

**VARIOUS:**

**Copper sheeting:** The hull should be copper sheeted up to 6-in. above load water line.

**Rudder shoe:** A very strong rudder shoe of iron or brass should be fixed to the after end of the keel. This shoe is not shown on the plans.

**Caulking:** Should be done with the best class of caulking material and first class workmanship.

**Painting:** Paints and wood preservatives should be used abundantly during construction, and especially in all joints and scarpas where other wood than Teak is used. Painting and varnishing outside and inside the tug should be done with best marine paints, etc., colours to the owner's satisfaction.

**Navigation and life-saving equipment:** These to be in accordance with Indian Rules and Regulations.

**NOTE:** Details of construction, interior arrangement, accessories and equipment, not covered here, should be discussed with the Special Officer for Craft and Tackle, Fisheries Department, Government of Madras.
Fig. 1. Khotia under construction at Veraval 1956

Fig. 2. Khotia under construction at Veraval 1956
Fig. 3.  Khotia under construction at Veraval 1956

Fig. 4.  Typical Jamnagar Machwa 1956
Fig. 5 and 6. Larger Machwa from Veraval, built 1956. This type is also built partly for carrying cargo.
LINES & ARRANGEMENT

HALAR MACHWA

Length  31'-0"
Beam    8'-6"
Depth   4'-0"

Gear storage

Working well

Fish hold

Scale for layout plan  3 m.
LINES & ARRANGEMENT
VERAVAL LODHIA

Length 35'-0"
Beam 6'-0"
Depth 3'-9"
Fig. 9. Grooved rabbet

Fig. 10. Veraval Lodhias drying nets
ARRANGEMENT
MALIYA PRAWN BOAT
FROM SAURASHTRA

L. o. a. 20'-0"
B 4'-4"
D 2'-2"

Scale 0 1 2 3 4 5 ft.
0 1 2 3 4 5 m.
SAIL PLAN
OF INDIAN FISHING BOAT
MALABAR TYPE

D. Kenye

SCALE.

1: 10 METRES
0 1 2 3 4 5 6 7 8 9 10 FEET
Fig. 17. Boat catamaran of Cape Comorin and the Tinnevelly coast. a and c, large and small units of a pair; b, side view of a; d, transverse section near one end; e, transverse section at mid-length.

Fig. 18. A pair of boat-catamarans under sail. Tuticorin.
SAIL PLAN
OF INDIAN FISHING BOAT
TUTICORIN TYPE.

MADRAS, 31-3-1954.
Patil Phimy

1 m³
35 ft³ sp/c.
Fig. 21. A balance-board fishing canoe of Tirupalakudi, Palk Bay.

Fig. 22. A large Muthupet balance-board boat. Palk Strait.
Fig. 23. An Adirampatnam fishing canoe.

Fig. 24. Three-masted balance-board boat of Adirampatnam (Palk Strait).
Fig. 25. Kalla dhoni of Kodikarai, Point Calimere
Fig. 26. Madras catamarans. a, a Periya-maram from above; b, side view of same; c, a Chinnamaram; d, stretcher of rowing rail; e, paddle; f, section of same; g, a stem-piece.

Fig. 27. An Irukka-maram, Madras

Fig. 28. A Thundil-maram, Madras

Fig. 29. A catamaran from the Ganjam coast. a, side view to show weather-board; b, view from above.
CONSTRUCTION
INDIAN FISHING BOAT
SHOE-DHONI
FROM KAKINADA, ANDHRA STATE.

LENGTH O.A. 31½" = 9.54 M.
BREADTH 5½" = 1.40 M.
DRAUGHT 2½" = 0.70 M.

SAD NARJOL ARCHITECT

KAKINADA, NOV. 1937.
Fig. 34. Kakinada Shoe-dhoni

Fig. 35. A sangdam or double canoe, Godaveri river.

Fig. 36. A reef-boat, Laccadive Islands.
Fig. 37. Ganges Batchari boats

Fig. 38. Batchari boat under construction
Lines
"CHOT" Type Fishing Boat
West Bengal

Length oa. 34'6" = 10.50 m.
Breadth 6'6" = 1.98 m
Depth min. 5'8" = 1.72 m
Displacement to cwe = 57 tons (fm^3)

Calcutta, 20-7-1955.

P. D. Roy
F. D. O. Naval Architect

Note: Used for drift net, herringing and bag net.
Average Payload 60 Mounds.
Displacement Curve (to cwe)
INDIAN CARGO AND FISH CARRIER BOAT.

DIAMOND HARBOUR TYPE
WEST BENGAL

CONSTRUCTION

LENGTH O.A. 29' 6" - 9.0 M.
BREADTH 10' 6" - 3.2 M.
DEPTH 4' 6" - 1.4 M.
CAPACITY OF HOLD 9 M.
SAIL AREA 180 SQ. FT. (FLOOGER)

Designed July 1932.

R. Mung
First Naval Architect.

Scale 1/8" = 1 ft.
ACTUAL SHAPE OF STERN OF RATHNAMI TYPE BOAT AND CONSTRUCTION DETAILS

BOMBAY 6-1-1954
53' BATCHARI BOAT
FOR FURID SEINE AND DRIFT NETS.

LENGTH O.B. 55' 0"
BEAM 7' 9"
DEPTH 2' 10"

(MEASURED AT FALTA, WEST BENGAL.)
Altered stem construction on Satpati boat in accordance with tank tests at C.W.R.R.S., Poona.

Frames No. 1 and 2 represent the improved bow form.

All other frames are unaltered.
GENERAL ARRANGEMENT
ESTUARINE POWER FISHING BOAT
FOR ORISSA

LENGTH O.A. 25'5" 7.75 M.
BREADTH 7'6" 2.28 M.
DEPTH 3'1/2" 0.97 M.
DRAUGHT 1'10" 0.58 M.

EATON. INDIA. FEBR. 1956.

PADDY NAVAL ARCHITECT.
"CHOT" TYPE FISHING BOAT.
WEST BENGAL

CALCUTTA, 20-7-1955.

K.A.O. NAVAL ARCHITECT.

Scale

LENGTH OA. 34' 0" = 1036 m.
BREADTH 9' 6" = 2.90 m.
DEPTH MID. 3' 8" = 1.12 m.
DISPLACEMENT 54 TONS (MT).

SEMI-DIESEL ENGINE 15 H.P.
24' 7" COASTAL FISHING BOAT (Pablo-design)

Lines plan

Length o.a. 7.50 m 24' 7"
Beam 2.10 m 6' 10"
Depth 1.06 m 3' 6"
Draft, max. 0.85 m 2' 9"
Displ. empty 2.6 tons

SCALE

0 1 2 3 4 5 6 7 8 9 10 ft.

0 1 2 3 m.
24' - 7"

COASTAL FISHING BOAT

<table>
<thead>
<tr>
<th>Specification</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>7.50 m</td>
</tr>
<tr>
<td>Beam</td>
<td>2.10 m</td>
</tr>
<tr>
<td>Depth</td>
<td>1.06 m</td>
</tr>
<tr>
<td>Draft maxi</td>
<td>0.85 m</td>
</tr>
<tr>
<td>Displacement empty</td>
<td>2.6 tons</td>
</tr>
<tr>
<td>Load capacity</td>
<td>1000 Kg</td>
</tr>
<tr>
<td>Engine</td>
<td>9-10 HP</td>
</tr>
</tbody>
</table>
RUDDER SHAFT
For 28' Machwa Type

Veraval 7-2-1955
F.A.O. Naval Architect
30' FISHING BOAT FOR MADRAS
CONSTRUCTION

SCALE

SPECIFICATION:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>MATERIAL</th>
<th>DIMENSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM</td>
<td>TÁN</td>
<td>4½' 1/3</td>
</tr>
<tr>
<td>STEM</td>
<td>ÁPICO</td>
<td>4½' 1/3</td>
</tr>
<tr>
<td>ESTRECHO</td>
<td>TÁN</td>
<td>4½' 1/3</td>
</tr>
<tr>
<td>ESTRECHO</td>
<td>ÁPICO</td>
<td>4½' 1/3</td>
</tr>
<tr>
<td>SHAFT</td>
<td>TÁN</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>SHAFT</td>
<td>ÁPICO</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>MADERA</td>
<td>TÁN</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>MADERA</td>
<td>ÁPICO</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>BASTIDAS</td>
<td>TÁN</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>BASTIDAS</td>
<td>ÁPICO</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>GANCHO</td>
<td>TÁN</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>GANCHO</td>
<td>ÁPICO</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>TRENZADO</td>
<td>TÁN</td>
<td>1½' 1/3</td>
</tr>
<tr>
<td>TRENZADO</td>
<td>ÁPICO</td>
<td>1½' 1/3</td>
</tr>
</tbody>
</table>

NOTES:

- All parts to be of teak. All lines to be of copper.
- Parts connected with iron are to be galvanized.
- Parts in stem construction are to be galvanized.
- Parts in keel construction are to be painted and varnished.
- Parts in engine room are to be painted.
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RUDDER SHOE ARRANGEMENT

SCALE 1/4" = 1'

SCALE

0 1 2 3 4 5 6 7 8 9 10
0 1 2 3 4 5 6 7 in.
15 cm
31'-9"
FISHING BOAT
LINES
LENGTH O.A. - 31'-9" = 9.65 M.
BREADTH - 8'-6" = 2.59 M.
DEPTH MOLDED - 4'-5" = 1.38 M.
DISPLACED. TO C.W.L. = 5.86 TONS. (N)

MADRAS, 20-3-1956
P. T. Murray
F. O. N. A. Arch., Engineer.
DECK AND GEAR ARRANGEMENT OF THE TRAINING BOAT.

LENGTH 31' 2"
BEAM 8' 6"
DEPTH 4' 5"
DRAFT 3' 4"
ENGINE 30 HP BUKH

A. EXTRA FUEL TANK.
B. STORAGE SPACE FOR GEAR.
C. FISH AND ICE BOXES.
X. POSITION OF CREW WHEN HAULING GILLNETS.
Boat for Fishing During Monsoons

Coaser Periods

Length 0.6: 13.84 m = 45.60'
W.L. 12.40 = 41.60'
Breadth: 3.50 = 11.80'
Depth Mid: 1.42 = 4.60'
Displacement: 12.00 x 16.25

Bombay, India, Feb 1954
F.A.O. Naval Architect
LAYOUT OF MONSOON FISHING BOAT

- Insulated Fish Hold: 6m², 210 cub. ft.
- Hold: 80 gal.
- Chain
- Self Bailing Cockpit
- Net Space
- Fuel tank: 120 Gal.
- Hatch: 24" x 24"

Scale:

Length o.e.: 13.45 m = 44' 0"
LWL: 12.80 m = 41' 9"
Beam: 3.50 m = 11' 6"
Depth M.L.D.: 1.42 m = 4' 8"
Displacement: 20,000 lbs = 0, 3 Tons
40 HP semi diesel fuel for 60 hours
17'-0" FAST FISH CARRIER BOAT
LINES

LENGTH O.A. 17'-0"
BREADTH 5'-4"
DEPTH 2'-7"
DRAUGHT MID 1'-2"
OUTBOARD ENGINE 10 HP

MEASURES ARE TO OUTSIDE OF PLANNING

CUTBACK, ORANGE, 17-1-1935.

F.A.O. NAVAL ARCHITECT.
17'-0" FAST FISH CARRIER BOAT

SECTION NO. 4

Ribs 5/8" x 1 1/8"  
11 1/4" Distance C.T.C.

Keelson 7/8" x 3 3/4"

Floors 1 1/8" x 2 1/2"

Planks 5/8"

Keel 2 1/8"

FOR TEMPLATES SEE LINES DRAWING. FOR FURTHER DIMENSIONS SEE SPECIFICATIONS.
FAST PLYWOOD FISH CARRIER
LINES

Sections spaced 19\(\frac{1}{8}\)" c. to c.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length o.a.</td>
<td>17'-2&quot;</td>
</tr>
<tr>
<td>&quot; W.L.</td>
<td>15'-10&quot;</td>
</tr>
<tr>
<td>Beam</td>
<td>5'-9&quot;</td>
</tr>
<tr>
<td>Depth</td>
<td>2'-2(\frac{1}{8})&quot;</td>
</tr>
<tr>
<td>Draught</td>
<td>1'-0&quot;</td>
</tr>
<tr>
<td>Engine</td>
<td>10 h.p. outboard</td>
</tr>
</tbody>
</table>

SCALE

CUTTACK, INDIA, 19-1-1956

86
FAST FISH CARRIER BOAT OF PLYWOOD
CONSTRUCTION

LENGTH: 17'2" - 5.24 m
W.L: 15'0" - 4.57 m
BEAM: 5'3" - 1.6 m
DEPTH: 2'2" - 0.66 m
DRAUGHT: 1'0" - 0.30 m
OUTBOARD ENGINE: 10 H.P.


A. W. Williams
A.B.O. Naval Architect.
PROPOSAL FOR MECHANIZED FISHING FLEET
FOR WEST BENGAL

MAIN DIMENSIONS
L o.a. 22.3 ft.
LWL 16.7
B 13.8
T 1.97
A 1.3 Tons

FAO ROME ITALY
NOVEMBER 1954
NO. 5409

NOTE: LWL IS ONLY FOR DESIGN PURPOSES;
BOAT MIGHT FLOAT UP TO 4 IN. DEEPER
DEPENDING ON TYPE OF ENGINE AND WEIGHT
OF MATERIALS.
PROPOSAL FOR MECHANIZED FISHING BOAT
FOR WEST BENGAL

MAIN DIMENSIONS
L o.a. 22.3 ft.
LWL 16.7
B 13.8
T 1.97
A 1.3 Tons

NOTE: LWL is only for design purposes; boat might float up to 4 in. deeper depending on type of engine and weight of materials.

FAQ ROME, ITALY
NOVEMBER 1954
NO. 5409
FISH CARRIER FOR CRISSA.

LINES

DIMENSIONS
LENGTH OVER ALL  25'-8"  7.8 M
EXTREME BREADTH  8'-2"  2.49 M
DEPTH WELDED  2'-8"  0.8 M

Scales and to outside of planking. See forward the Parrel of Planking. 1" and 5/32" read must be corrected.

CUTTER, INDIA, 20-7-1932
P. R. Homer

F.R. NUNN, ARCHITECT.
FISH CARRIER FOR ORISSA.
CONSTRUCTION

FISH HOLD
INSULATED
200 CUBIC
(SEE DRAW NO. 3 FOR DETAILS.)

ENGINE COMPARTMENT.

PARTICULARS:
LENGTH 84' 6" - 8 m
BREADTH 21' 0" - 6.4 m
DRAFT 5' 0" - 1.5 m
SPEED 12 K.N.
SPEED 27 M.P.H.

SIGNED:
...
FISH CARRIER
FOR ORISSA

FISH CARRIER LAUNCH
ARRANGEMENT OF INSULATED FISH HOLD

TOTAL CAPACITY OF FISH HOLD = 180 CUB.

SCALE

SUMP

CEILING 3/4" SOFT WOOD.

LINING, SOFT WOOD 1/2" THICK, SET IN ADHESIVE.

DRAIN

CUTTEN, 26-11-1935
R.H. NAVAL ARCHITECT.

91
PROPOSED 40' FISH CARRIER.

MAIN DIMENSIONS:
LENGTH OVER ALL 39' - 10"
LENGTH P.P. 37' - 6"
GREATEST BEAM ON PLANKING 12' - 9"
DRAUGHT AFT LOADED 4' - 9"
INSULATED HOLD CAPACITY 600 CB.FT.

SCALE
0 2 4 6 8 10 20 FT.
0 1 2 3 m.

92
PROPOSED FISH CARRIER.

SCALE 1/4" = 1'-0".

LENGTH OVER ALL 51'-0"
LENGTH PP 47'-6"
GREATEST BEAM 15'-6"
DEPTH AT 8 7'-8"
MAXIMUM DRAFT 5'-8"
TUG FOR PEARL FISHERY
AT TUTICORIN.
TUG FOR TUTICORIN PEARL FISHERY, INDIA.

LENGTH 0.a. 44'-0" 13,41 m.
BREADTH 12'-6" 3,86 m.
DEPTH WATERS 4'-9" 1,45 m.
DRAUGHT (max.) 4'-7" 1,40 m.
DISPLACEMENT 15,2 tons.
"SLENDER" DIESEL 60 h.p.

SEE WRITTEN SPECIFICATIONS.
TUG FOR PEARL FISHERY AT TUTICORIN

SUGGESTED CABIN OUTLAY.
SMALL NET WINCH

Driven from flywheel pulley at motor of 800 r.p.m. maximum. Flywheel pulley diam. 6". Intermediate shaft pulley 12" diam.; intermediate shaft cogwheel 10" diam.; led winch shaft cogwheel 4" diam.

Flare bell bearing 2 1/2" or 3"

Spinnaker diam. 6". Cogwheels must be of steel, set cast iron. Long sheave will last 40 fathoms per minute of 400 r.p.m. of motor.