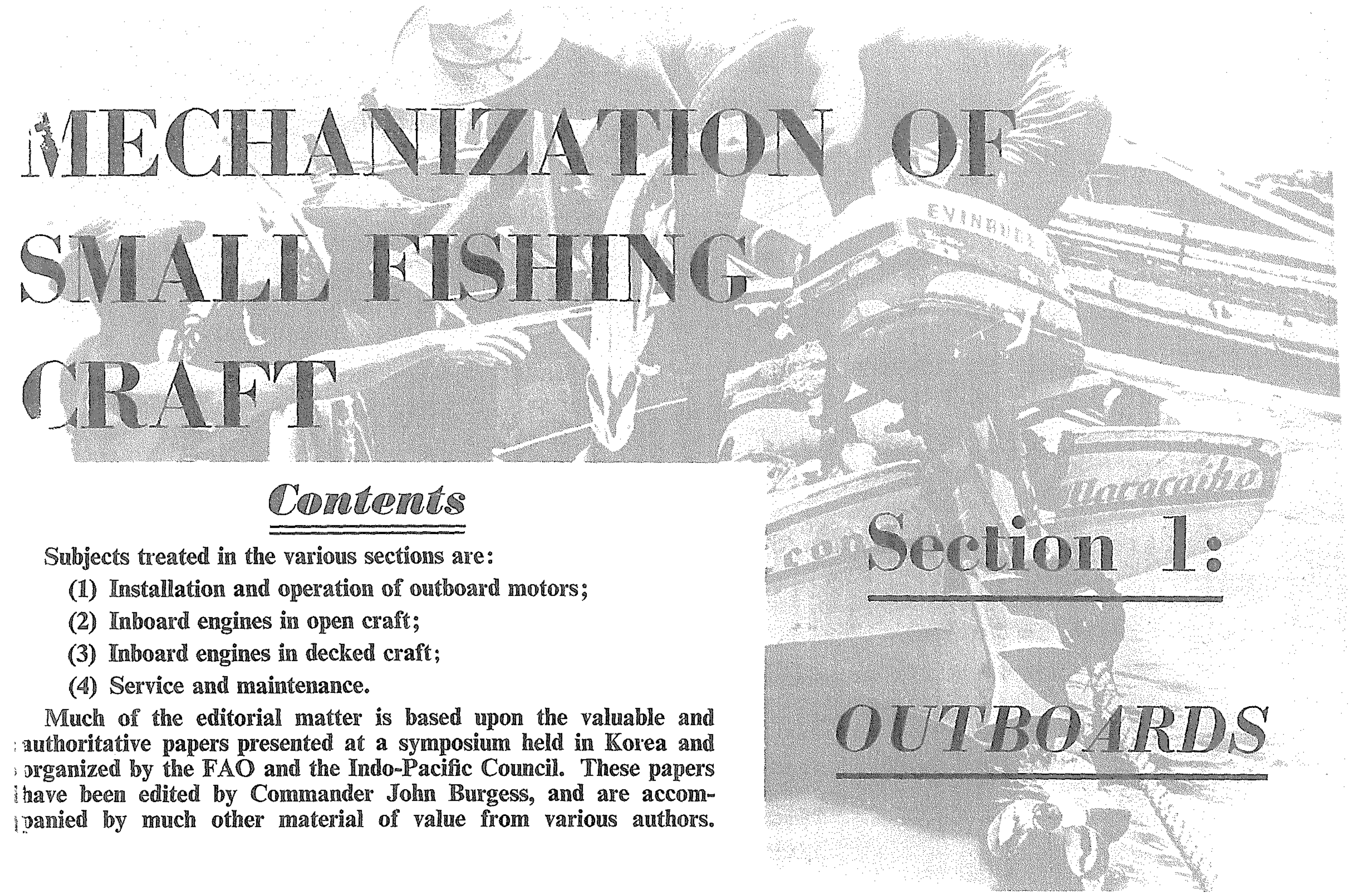
MECHANIZATION of SMALL FISHING CRAFT

1. *Outboards*
2. *Inboard Engines in Open Craft*
3. *Inboard Engines in Decked Craft*
4. *Servicing and Maintenance*

MECHANIZATION OF SMALL FISHING CRAFT



Contents

Subjects treated in the various sections are:

(1) Installation and operation of outboard motors;

(2) Inboard engines in open craft;

(3) Inboard engines in decked craft;

(4) Service and maintenance.

Much of the editorial matter is based upon the valuable and authoritative papers presented at a symposium held in Korea and organized by the FAO and the Indo-Pacific Council. These papers have been edited by Commander John Burgess, and are accompanied by much other material of value from various authors.

Section 1: OUTBOARDS

Foreword by Dr. D. B. Finn, C.M.G.

Director, Fisheries Division, FAO

It has become a tradition for the three sections of FAO's Fisheries Technology Branch—Boats, Gear and Processing—alternately, in each biennium, to organize a large technical meeting with the participation of both Government institutes and private industry. It all started in 1953 with the Fishing Boat Congress having sessions in Paris and Miami, the proceedings of which were published in "Fishing Boats of the World." *A Processing Meeting followed in Rotterdam, Netherlands, in 1956, and a Gear Congress was organized in Hamburg, Germany, in 1957. A second Fishing Boat Congress was held in Rome in 1959, the proceedings of which were again published in* "Fishing Boats of the World: 2."

Those two fishing boat congresses were, in a way, rather comprehensive, trying to cover the whole field of fishing boat design and also attracting participants from different backgrounds. This was not a disadvantage, because people having different experiences were mutually influencing each other and were induced to see further away than their own limited world. However, the tendency was also to have specialized meetings, covering smaller subjects and, therefore, FAO welcomed very much the International Economic Conference on Small Craft for Fisheries and Transportation, which was organized by Outboard Marine Corporation in New York in 1960. FAO organized a Research Vessel Forum in Tokyo in 1961 and, in Gdansk, Poland, a Fishing Vessel Stability Meeting in 1963.

The FAO-sponsored Indo-Pacific Fisheries Council organized, in 1962 in Seoul, Korea, a symposium on the mechanization of fishing craft, and FAO contributed in 1963 to the United Nations Conference on Science and Technology in Geneva, with a paper entitled " Mechanization of Fishing Craft " by Jan-Olof Traung, and which was reprinted in Fishing News International, *Vol. 2, No. 2.*

The third FAO Technical Meeting on Fishing Boats will be held in October 1965 in Göteborg, Sweden, and this conference will be especially concerned with smaller units of 100 gross tons or less, especially those for developing countries. It is felt that larger fishing vessels can be left out this time because the British White Fish Authority organized a symposium on the use of diesels in 1962 and on stern trawling in 1963, and there were regional technical meetings on fisheries in Ostend in 1960 in Scheveningen in the Netherlands in 1961, and there will be a new one in Scheveningen in 1964.

The IPFC symposium on the mechanization of fishing craft attracted a number of valuable papers. The decision of Fishing News International *to reprint suitable parts of these papers and to supplement this material with additional contributions is highly commendable because it will create a very good lead into the work of the third FAO Technical Meeting on Fishing Boats, 1965, in Göteborg, Sweden.*

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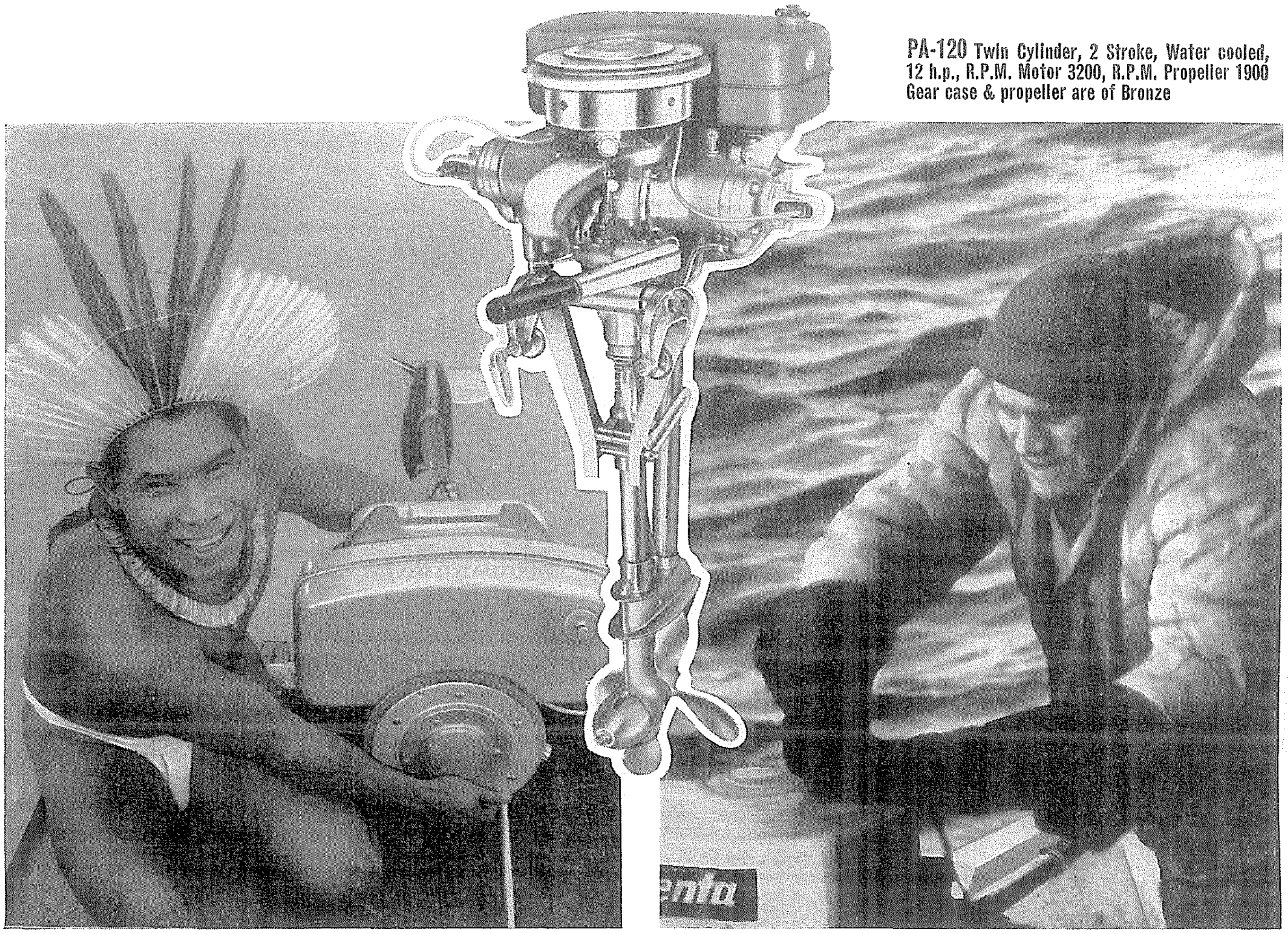

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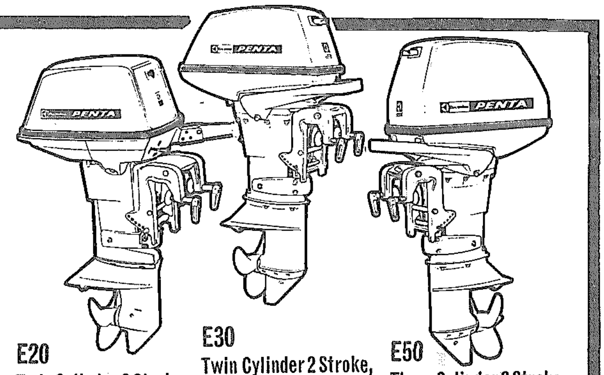

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THE IMPACT OF OUTBOARD MECHANIZATION ON DEVELOPING FISHERIES

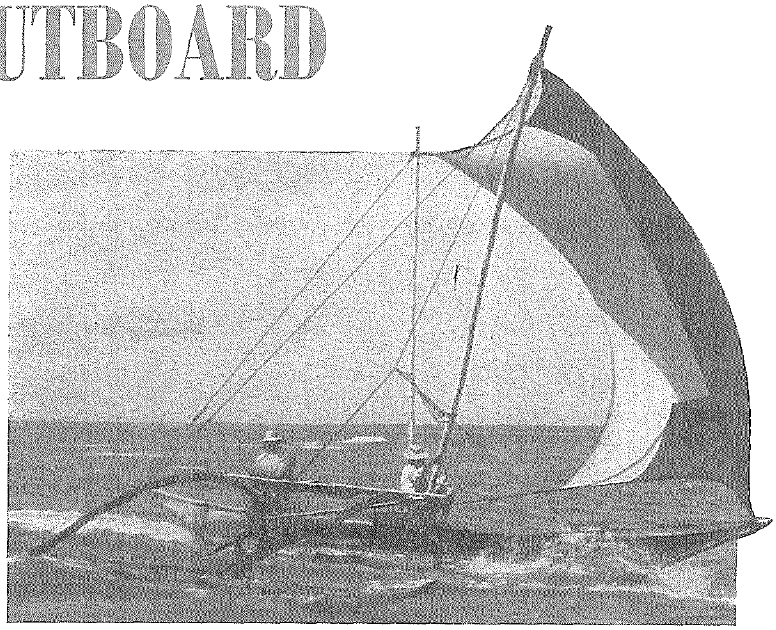


FIG. 1: *Common local boat in Ceylon is the* oru. *The bottom is a dugout with two high boards on top as gunwales. This symmetrical craft, when tacking, uses either end as bow; always keeping the outrigger to windward. Under sail, up to* 10 *and* 12 *knots have been reported. During calms, the oru is extremely awkward.* (*FAO photograph by Erik Estlander*)

The concept of outboard mechanization to aid fishermen in developing countries did not have an easy birth. The outboard motor was associated in too many minds with pleasure craft, water ski-ing and taking the family for a Sunday " drive " on the lake. Memories arose of frustrated minutes at the starting cord of a balky motor, and the long row home. Economists pointed to the fairly high cost of petrol and the less expensive fuel costs of diesel power. (Frequently it was forgotten that high petrol costs stem from high road taxes; that millions of motorists rely daily on petrol-fuelled engines; that diesel engines are much more expensive, tend to have higher maintenance costs than outboards and do not run quite as smoothly as the petrol-fuelled engines.)

Some teams of fishery workers questioned the step-by-step approach towards greater mechanization that outboard power enables. These teams thought it best to invest in heavier boats and engines from the start, in controlled programmes with pilot projects and plenty of training. This approach, based on long-range development plans towards achievement of modern commercial fishing fleets, has also found success in some areas.

But the step-by-step approach of using outboard mechanization to explore the promise of future heavier mechanization slowly won converts. It was conceded that there was more than one way to encourage fisheries development and that outboard mechanization was worth a try.

As Mr. Mogens Jul, then Chief of the Technology Branch of FAO's Fisheries Division, said in 1953:—

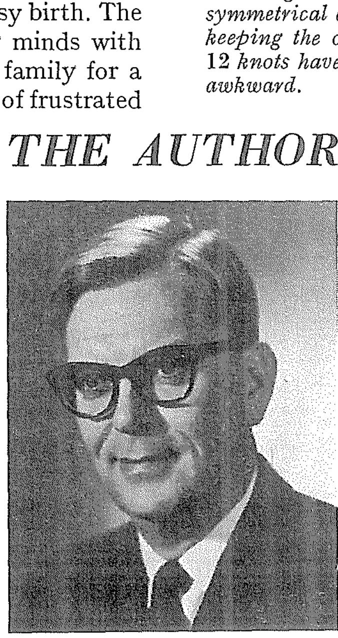
" Some have said that the factory ship is the fishing boat of the future. People have also said that the airplane is the means of transport of the future. Both may be true, but only in this sense: for a long time to come, the world will probably have cargo lines, river barges, bicycles and mules, as well as airplanes. In the same way, we will have factory ships along with trawlers, purse seiners, long-liners, catamarans and other fishing craft."

In time, those who were thinking about mechanization in fisheries, began to think of outboard-powered fishing craft as the motorbikes of the industry.

The outboard motor is not new. This year is the 100-year anniversary of the first patent, which was taken out in France. By 1896, the first commercial model was available in America. In 1907, the French " Motogodill " was introduced into Sweden, where it was known as the " power rudder." These motors were rather strange contraptions, but the basic and lasting concept of the modern outboard was derived from the custom-made models of a Norwegian–American, Ole Evinrude. His original model of 1909 weighed 62 lb., developed ½ hp and cost U.S. $62 (then about £13).

The basic single-cylinder design did not change until about 1945. Meanwhile, a two-cylinder outboard was developed in 1921, a four-cylinder model in 1929 and the power/weight ratio of all models was constantly improving.

THE AUTHOR



Jan-Olof Traung, Chief, FAO Fishing Boat Section

Since 1945, considerable work has been done towards reducing vibration and improving efficiency by putting the power plant on flexible mountings and experimenting with various propellers. The modern era of outboards began about 1950, with the introduction of the first gear-shift models, electric starting for larger models, remote control, and the separation of the fuel tank from the engine which was demanded as power was increased.

World production of outboard motors in 1963 was about 500,000 units at ex-works prices of approximately U.S. $160 million (£56 million). Most of this production is used for relaxation, but the small fraction of outboard "workhorses" is steadily increasing. They are now used by shrimp men in the Gulf of Mexico, oystermen on Chesapeake Bay, Eskimo seal hunters in the Arctic, Choco Indians in the Panamanian jungle. In 1954, it was estimated that 15,000 outboards were in use in Malaya; 10,000 to 15,000 in British Borneo. The trend continues as the advantages of outboard power are increasingly recognized.

The smallest modern outboards weigh no more than a pair of oars; the largest can drive a light boat at a mile a minute. Outboards have the lightest weight-for-horse-power ratio of any kind of marine power. Their horse-power costs less than diesel horsepower. Outboards do not require permanent engine beds, piping tanks, separate wiring, separate propellers, stuffing boxes and separate steering gear. There is less danger of fire, since in usual operation the spark plug, fumes and carburettor drippings are out over the water and the main fuel tank may be some distance from the engine.

Outboard boats require no harbours, a factor which, in itself, indicates the usefulness of outboard power in the developing countries. Another such factor is that inboard

Fig. 2: Many fishing craft in India, Ceylon, Brazil and Ecuador are simply log rafts. They are called catamarans in India and kattumarams in Ceylon (from the Tamil name kathu maram *or "tied logs"). The two-hulled craft of entirely different type used in Polynesia are also called catamarans, probably because they were also tied together.*

(FAO photograph by Erik Estlander.)

engines require comparatively strongly built boats, but many very primitive boats can be mechanized with out-boards.

On a trip to Ceylon in 1951 to investigate possibilities for fisheries development, everything I saw seemed to point to one conclusion—here was the ideal place for the outboard to become an important factor in fisheries development.

Ceylon at that time had not a single mechanized fishing craft. But the Government was most interested in improving their fishery because there were many reports of good resources. Fisheries biologists and administrators had surveyed conditions in the island. They had stated that no existing craft could be mechanized and that the only way to improve the fisheries was to introduce new types of craft. A variety of boats from several countries was suggested.

There were hardly any fishing harbours in Ceylon and the fishermen were not used to any type of machinery or tools, not even simple winches, not even a screw-driver. The people were keen and basically good fishermen but did not even know the use of a pulley to ease their work when hoisting sails. The halyard was simply drawn up over a piece of wood.

Basic Craft

There were three basic types of craft on the island. In the north there were a couple of hundred plank-built, displacement-type boats called *vallams*. Elsewhere there was a total of several thousand *orus* (dugout) and log rafts. The rafts were similar to the Indian catamaran; the largest version used mostly in the north was called *kattumaram* and the smaller southern version called *theppam*.

It was easily determined that the northern vallams could be mechanized in inboard engines.

The oru (Fig. 1) consists of a lower part, being a dugout, with two planks forming the over part. The craft is symmetrical, has outriggers on one side, and when tacking it uses either end as bow, always using the outriggers on the windward side. We thought it would be comparatively simple to mechanize these with outboard engines if there was a long distance between the power head and the propeller.

The log rafts (Fig. 2), which were always very low in the water, were more difficult to visualize mechanized. But it was suggested that, at least for the calmer periods when these craft could not use sails, mechanical power would be an advantage. There were more than 10,000 orus, kattu-marams and theppams in Ceylon, and it looked to me as if the outboard motor was going to revolutionize Ceylonese fisheries overnight.

It did not take long to prove me wrong. FAO had bought three motors of various types and had shipped them to Ceylon for experimental trial with local boats. The results were not encouraging, to say the least. The report was that the motors did not work well, were unreliable when they did work and that the Ceylonese rejected them completely. One motor was shipped back to Rome in a state of disrepair. Perhaps the motors were misused, or were improperly serviced, or perhaps they were just inferior

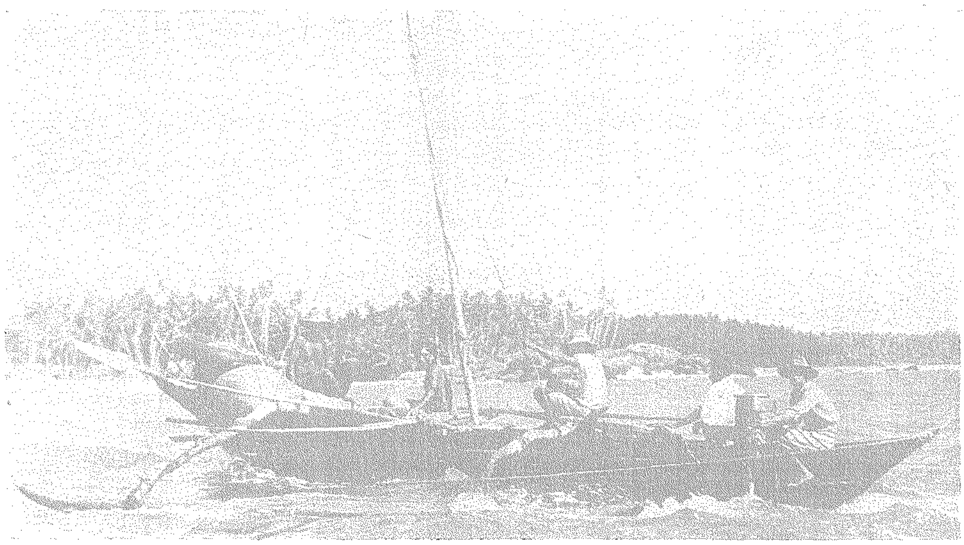


FIG. 3: *One of the first Ceylon orus mechanized with an outboard engine.* (*Photo: Ray de Zylva.*)

motors from the start. Whatever the reason, the Ceylonese outboard mechanization project had resulted in a still-birth.

At the same time the inboard mechanization of the vallams was more successful and very soon the fishermen got interested in this type of improvement in the productivity of their craft.

Through different channels, such as the Colombo Plan, engines found their way to the island. Fishermen were helped to purchase such inboard engines on easy terms and the Government was running a great number of courses in engine operation and maintenance. In this programme, FAO assisted by sending to Ceylon a marine engineer, Mr. Einar Kvaran from Iceland, who developed a technique to get across to the fishermen how to operate and look after their engines.

However, only the few hundred vallams could take inboard engines. Meanwhile, the thousands of orus, kattumarams and theppams went unmechanized. Some fisheries experts tried to mechanize an oru with an inboard engine. They placed an engine high up over the rail and tried to transmit its power to a propeller by chain.

Several years later, in 1955, I was attending a fisheries meeting for FAO in Tokyo. By chance, I was sharing a room with Mr. E. R. A. de Zylva, then Director of Fisheries for Ceylon, who told me that the mechanization programme with inboard engines on the orus was not successful. We went over the unfortunate first experience with outboards and I said I could not understand the failure. I said I could not understand the motors not working, since one of them was the same type that I had been operating successfully since my father had presented me with an outboard motor on my eleventh birthday.

Mr. de Zylva agreed to try outboard mechanization once again in Ceylon. This time, ten motors were to be used—seven working and three in reserve. The reserve motors would immediately replace any of the seven that did not function, or for minor repairs, parts could be interchanged to keep at least seven motors in continuous operation.

FAO then made a mistake through an administrative decision not to favour one make only, which resulted in three different makes of motors being sent for the experiment. The result was that some motors did not fit the boats, preventive maintenance was impossible, the parts were not interchangeable, and once again, outboard mechanization was a bad word in Ceylonese fisheries. Despite this, a few boats were mechanized. (Figs. 3 and 8.)

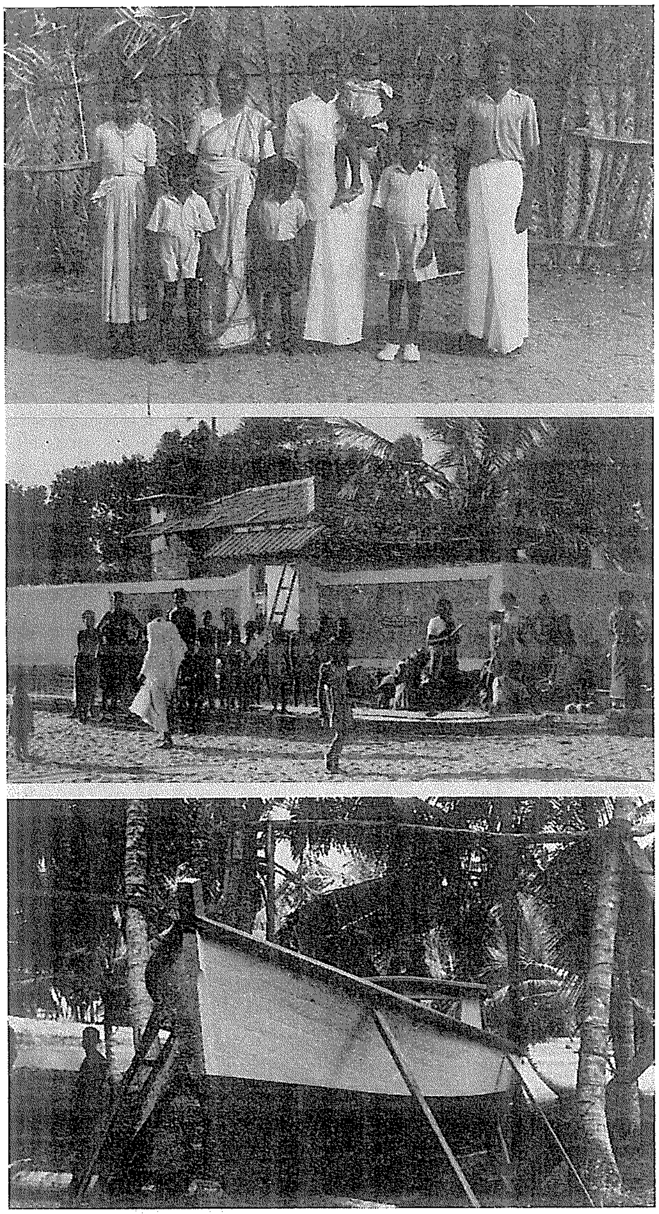
But only seven years later, there were about 860 outboard motors in use in Ceylon. How did this come about? As happens so often, it was largely the fortunate accident of having the right men in the right place at the right time.

One of the right men was Erik Estlander, a Finnish naval architect, who had many years' experience with outboard motors. FAO sent Estlander to Ceylon in 1959 to design better fishing boats and to explore once again the possibilities for outboard mechanization.

The other was Einar Kvaran who had come to the island as FAO marine engineer to train the fishermen in the use of inboard engines. He had followed the failures with outboards and he was worried why this should happen to this simple type of engine. He kept writing long letters to Headquarters and we had long discussions both during my subsequent visits to Ceylon and his stopovers in Rome. He decided that this third venture must succeed.

Another of the right men was the Ceylonese extension officer, T. Paramanantharadja, who was assigned by the Government to assist Estlander. He quickly learned the essential points of servicing two outboards that Estlander had obtained from a Swedish manufacturer for new tests. The other right men were one or two Ceylonese fishermen, a cut above the average in that they were willing to keep using the motors despite the jibes of their fellows. They borrowed more nets from their neighbours and went further out from shore. While Estlander, Kvaran and Paramanantharadja kept the motors running, these fishermen brought in the fish.

After 18 months of mechanized fishing, one of the outboard fishermen, Nagendram, had paid for his engine, which he bought on easy terms and had moved his family out of a thatch-walled house (Fig. 4) into a modern bungalow (Fig. 5) with profits from improved fish catches. After a further six months, Nagendram bought a modern $27\frac{1}{2}$ ft. boat (Fig. 6) with inboard diesel, thus giving him



FIGS. 4, 5 & 6. TOP: *Fisherman Nagendram outside his thatch-walled hut with his family before he got an outboard engine. He lent his large catamaran to FAO experts for tests with outboards, and bought an engine in* 1961. CENTRE: *Only* 18 *months later, Nagendram and his sons outside the new house he built on the site of his old hut. His belief in motorized fishing has rewarded him.* BOTTOM: *A* $27\frac{1}{2}$*-ft. fishing boat with an inboard diesel engine built to the order of Nagendram, who made enough money with outboard-powered catamarans to take up more long-range operations.*

(*FAO photos by Eric Estlander*)

the opportunity to work with 50 nets as against 18, the maximum his kattumaram could carry.

Using synthetic fibre nets in combination with outboard power, the few Ceylonese fishermen with motors were bringing in three times, sometimes up to ten times, as many fish as before. The scoffing by fishermen without motors decreased dramatically. Within a few years, most of the opposition to outboard power was finished.

Ceylon now has 860 engines in operation and many thousand more will no doubt be introduced within the next few years. Of these 860 engines only a very few, less than 30, were introduced to Ceylon by aid schemes. The rest were brought in through private channels. Private enterprise, once it was demonstrated to the fishermen that this type of machinery was good, was quick to assist in introducing engines in spite of Ceylon's disadvantages in obtaining foreign currency.

Thus 12 years after the third thoughts of outboard mechanization for Ceylon, the tide against the idea had turned and the outboard was gaining a reputation as an earning tool in the struggle to develop fisheries and raise living standards.

Aside from the satisfaction derived from this success, the Ceylon project gave FAO the "ammunition", in the form of comparative data, which was to help foster other outboard mechanization projects. One of the greatest previous difficulties had been lack of concrete evidence, of real records showing catches and income before and after outboard introduction.

The Statistical Officer, Mr. G. N. de Silva, of the Department of Fisheries, Colombo, was very energetic in collecting statistics on boats with and without engines. His figures are shown in Tables 1 and 2.

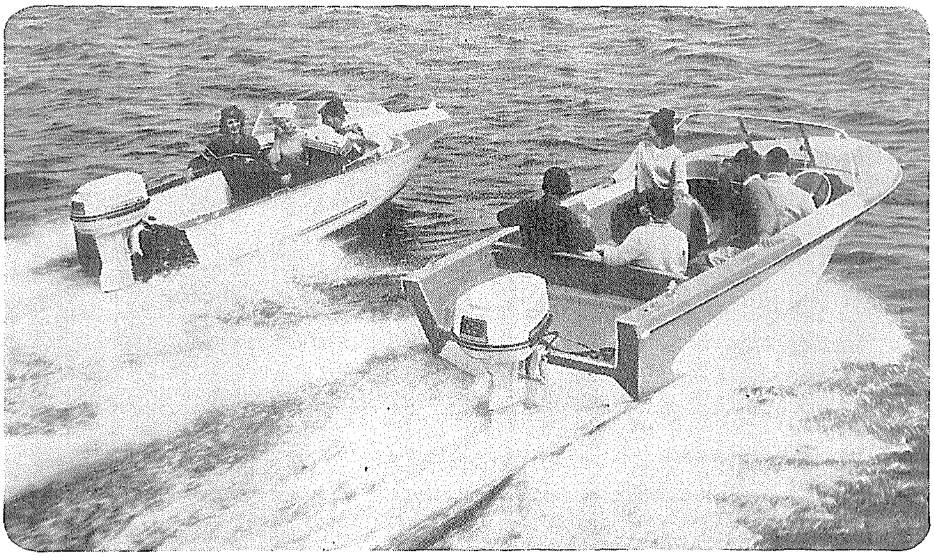
The figures are based on the operation of 20 craft, both powered and non-powered in the two areas. The average number of days fished does not show any marked difference between the powered and non-powered kattumarams and theppams, for the powered craft it is 22 days per month and for the non-powered 20 days. The powered craft sometimes used sails as well.

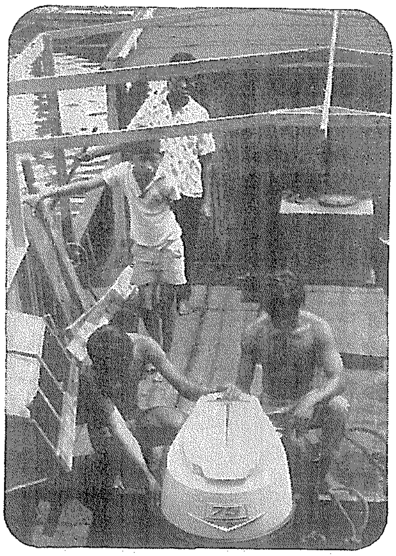
This kind of success stems to a great extent from the will of the individual, not only to survive, but to progress. FAO has been quite cautious about making claims for progress as a result of mechanization, but even cautiously we can say first, that mechanization almost always increases the catch and the fisherman's income, and does this quickly, and second, that in combination with the

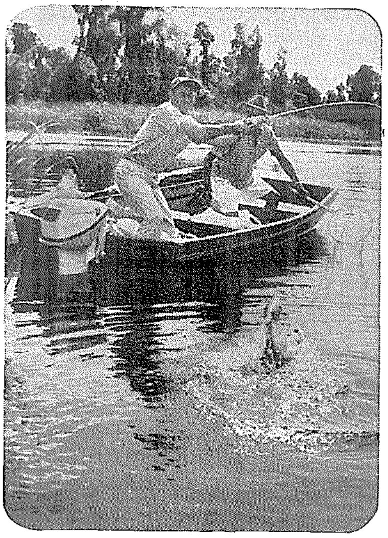
Table 1

	Mechanized Kattumarams, Jaffna, 1962		**Non-powered Kattumarams, Jaffna, 1962**	
	Catch in lb. per day's fishing	*Value in Rupees*	*Catch in lb. per day's fishing*	*Value in Rupees*
January	50·6	40·50	22·1	16·60
February	62·5	47·00	16·5	13·20
March	43·2	45·40	18·6	17·70
April	42·4	43·20	12·5	12·40
May	63·5	57·20	20·1	17·70
June	82·0	63·10	24·6	19·70
July	94·7	72·00	22·3	18·60
August	136·5	99·60	40·2	28·50
September	121·4	106·80	32·3	28·40
October	92·3	72·00	22·1	15·90
November	111·2	80·00	17·3	11·20
December	62·4	41·20	18·9	12·70
Average per month	1765	1410	446	353
Average Fishing days per month	22		20	
Times non-powered	3·95	4		

Mechanized boats: 1961, 47; 1962, 69; 1963, 80.







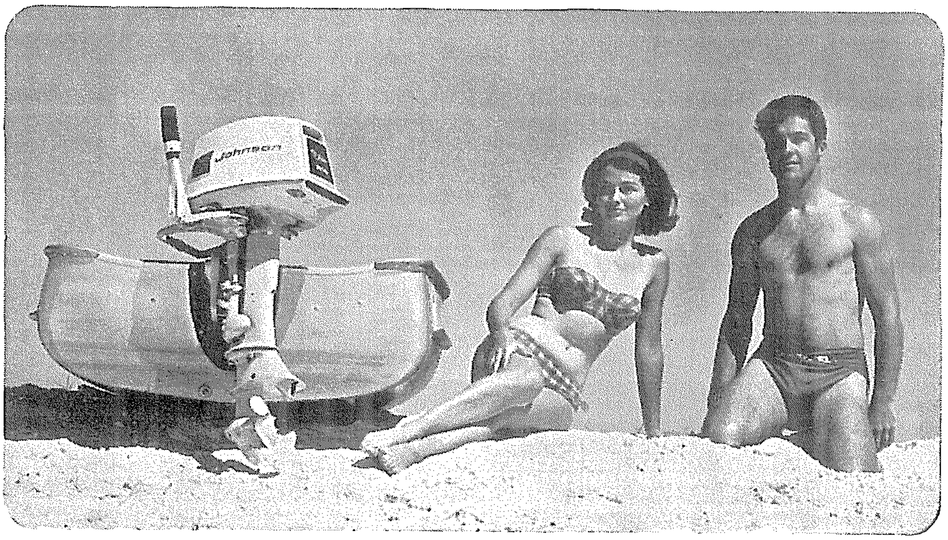


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Table 2

	Mechanized Theppams, Negombo, 1962			Non-powered Theppams, Negombo 1962	
	Catch in lb. per day's fishing	*Value in Rupees*	*Value less fuel expenses*	*Catch in lb. per day's fishing*	*Value in Rupees*
January ..	96·3	47·80	35·10	21·8	12·20
February ..	78·6	32·90	21·20	19·3	7·10
March ..	60·5	21·60	16·50	17·3	8·60
April ..	62·5	24·60	17·30	11·2	5·30
May.. ..	35·0	34·30	21·50	25·9	8·70
June ..	81·4	30·40	23·70	43·2	14·70
July ..	44·7	22·50	12·70	15·1	11·20
August ..	33·1	33·10	23·30	12·2	4·50
September	46·0	48·10	34·60	5·5	5·90
October ..	50·0	25·40	15·40	17·2	7·60
November	55·6	38·30	30·00	17·1	10·50
December..	24·5	15·60	7·30	7·6	5·60
Average per month ..	1225	688	473	356	170
Average Fishing days per month	22			20	
Times non-powered	3·44		2·78		

Mechanized boats: 1961, 52; 1962, 171; 1963, 200.

introduction of modern gear, such as nylon nets and modern fishing techniques, fish catches may be increased by an average of 300 per cent.

In 1960, Mr. B. R. Sen, FAO's Director-General, launched the world-wide Freedom-From-Hunger Campaign. This campaign (originally for five years; now extended) was to draw world attention to problems of hunger and malnutrition and to help suffering nations to find solutions. It was to operate on three fronts: information and education about the problems; research to intensify the search for solutions; and action to develop specific projects to speed food production. One of the projects is outboard mechanization of existing local craft.

As part of this project Estlander, who had had such good experience in Ceylon, was transferred in 1962 to FAO Headquarters as Naval Architect (Mechanization) in the Fisheries Division's Fishing Boat Section. Outboard companies had pledged more than 2,000 motors to the Campaign. It became Estlander's job to determine how to best use these gift motors to increase fish production in protein-deficient areas.

To the end of 1963 he had travelled in 22 countries to study possible sites for small outboard mechanization pilot projects. In each country the investigational procedure varies slightly but, basically, Estlander makes these approaches:—

(1) Talks with Government and FAO representatives to determine interest;
(2) studies boat types which might be mechanized;
(3) determines strength of fishermen's organizations and their capability to undertake the responsibility of caring for and distributing motors;
(4) determines facilities for servicing, maintenance and storage of motors;
(5) determines facilities for marketing;
(6) determines facilities for boatbuilding.

When drawing up the original proposal for the FFHC outboard mechanization plan, the FAO Fishing Boat Section had plenty of experience in mechanization projects, not only in fisheries, but also in related fields in agriculture. The consensus after studying many such projects was that, in many cases, they had failed so far as repayments were concerned.

If the mechanization projects under the FFHC were to have any chance of succeeding, and considering that the resources for these projects did not come from Government contributions but from voluntary contributions from firms and civic authorities, it was felt that we should try to invent a new system to induce fishermen to pay for their engines and thus prove that mechanization was an economic success.

Development of Idea

The idea developed that if we gave, say, ten engines to a fishermen's co-operative or association consisting of 50 members, we would in fact be giving each member one-fifth of an engine. If we then told the co-operative that these engines were theirs and that they could use the proceeds from the sale of such engines for anything worthwhile for the good of their community (such as a school, a road or repair shop for engines, or even a hospital), these fishermen would then really feel the engines to be their own.

The co-operative would then be very careful when allocating the ten engines to see that they went to the best fishermen. Also they would then certainly see that these ten fishermen paid for the engines because the repayment came to the co-operative and not to some Government official, even if his idea was not to tax the fishermen, but to pay the money into a revolving fund for their further benefit.

As FAO progressed with this kind of philosophy, Estlander's work load increased until, in early January, 1964, the " project board " in his office looked like this:—

FAO Freedom-from-Hunger Campaign Outboard Mechanization Programme

Country	*Engines needed*	*Engines available*	*Total FFHC contribution U.S. $*	*Current situation*
Zanzibar ..	10	10	6,132	Operational
Togo	28	28	18,015	Operational
Dahomey ..	50	50	30,346	Operational
United Arab Republic ..	85	85	45,932	Operational
East Pakistan..	360	285	291,000	Operational
India (1st stage)	335	335	169,760	To start in 1964
India (total project) ..	1,760	—	—	Planned for 1965 and 1966
Tanganyika ..	60	30	—	Under preparation
Nyasaland ..	40	—	—	Under preparation
Northern Rhodesia ..	100	—	—	Under preparation
Chile	200	100	—	Under preparation
Haiti	100	75	—	Under preparation
Dominican Republic ..	100	75	—	Under preparation
Brazil	190	90	—	Under preparation
TOTAL ..	3,418	1,163	561,185	

Development of mechanized fleets in Indo-Pacific fisheries

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IN most countries of the Indo-Pacific Region, a programme of mechanization was initiated after the Second World War and efforts undertaken by different Government agencies have met with varying degrees of success depending on local economy, suitability of boats, organization and planning, adequate financing and the response from fishermen. Many mistakes have been committed, but many valuable lessons have also been learnt. The mechanization of indigenous craft has enabled fishermen to operate in offshore waters previously inaccessible to them, to save time in going to and from fishing grounds and to fish for longer hours.

Difficulties

Most countries have experienced and are experiencing difficulties in supply of marine diesel engines, fishery requisites, lack of communication between production and consumption centres, provision of certain rules and regulations relating to shipping ports and custom clearance of vessels, lack of special shore facilities for landing and berthing of mechanized vessels, high cost and duty on oil, lack of financing facilities to co-operatives for purchase of equipment, storage and marketing and also shortage of technical personnel.

The progress of mechanization in the region is indicated in Table 1 by the number of mechanized boats operating.

India

Mechanization of fishing craft was initiated in India in the First Five Year Plan period. The maritime State Governments launched programmes for mechanization of indigenous craft and/or of improved designs of fishing craft with the experience and guidance of naval architects procured under Foreign Aid programmes during the past 10 years. By the end of the First Five Year Plan about 650 boats were mechanized in India, most of which were in Bombay State. Due to incentives offered in the shape of technical and financial assistance by the Central and State Governments, new designs of mechanized boats have been developed in the States of Gujarat (700), Maharashtra (1,400), Mysore (60), Kerala (180), Madras (110), Andhra Pradesh (60), Orisso (15) and West Bengal (6). The totals of mechanized boats shown in brackets amount to 2,531.

Some of the designs drawn up earlier have already been improved in some sectors with the experience gained in the operation of different types of fishing gear. This programme has already attracted the attention of most fishermen in the states and there is great demand for the new

Table 1
Progress of Mechanization

Sr. No.	*Name of Country*	*Number of boats Mechanized*	*Remarks*
1.	Ceylon	500 boats (1960)	The majority are 26-footers; the boats are given to fishermen on hire-purchase system.
2.	Japan	165,000 boats (1958)	Total number of boats, in Japan, is 400,000. Forty per cent. of the boats are mechanized, of which 84 per cent. are below 5 tons.
3.	Korea	4,900 (1959)	Total number of boats is 38,000; 13 per cent. of the boats are mechanized, of which 75 per cent. are below 3 tons.
4.	Malaya	3,123 inboard, 4,761 outboard (1959)	Total number of boats is 22,263; 35 per cent. of the boats are mechanized, of which 60 per cent. have outboard motors and 40 per cent. have inboard motors.
5.	Netherlands—New Guinea	50 boats	Total number of vessels is about 110. Over and above, dug out canoes are mechanized with outboard motors.
6.	Pakistan	220 boats (1960)	About 180 are gill netters and 40 are stern trawlers.
7.	Philippines	1,198 boats (1959)	Non-powered boats are only 279 and so 81 per cent. are mechanized. Most are dug out canoes.
8.	Hong Kong	2,366 boats	Mainly trawlers, liners, seiners and collecting vessels.
9.	Vietnam	1,700 boats	Total number of fishing boats is 37,000, only 5 per cent. of which are mechanized.
10.	India	Above 2,500 boats	Total number of boats is estimated to be 89,000, of which about 2·5 per cent. have been mechanized.

designs. A provision of Ls. 555,000 was made in the Second Five Year Plan for this programme and in the Third Five Year Plan, it has been increased to Ls. 25,000,000.

F.A.O. experts provided under ETAP for naval architecture, fishing and fisheries engineering, training and fishing harbour science have advised the Governments in the mechanization of indigenous craft, modifying the existing ones and introducing new types and also facilities for berthing and landing. The U.S. Government under the T.C.M. have provided equipment to the value of $2,200,000.

Under the Indo-Norwegian Project engines and boats were given to fishermen of the State of Kerala at subsidized rates. More than Ls. 20,000,000 had been spent till now on the various programmes by the Indo-Norwegian Project.

* * *

Fishing boats constitute a major investment in the country's industry and with mechanized fishing, they will probably represent the largest single investment. Designs cannot, therefore, be looked upon as an isolated problem. It is integrated with the development of all phases of the industry.

Development of fisheries has to go through step by step approach, as the fishermen are not educated enough to understand the implications of mechanization. Under this programme, the mechanization of existing crafts was therefore taken as a first step. A list of existing types of boats in India is given in Table 2.

The States of Gujarat, Maharashtra, Madras, Andhra Pradesh and West Bengal were fortunate in having some craft suitable for mechanization. In other areas, the craft had to be modified and in certain cases drastically altered. The Lodhias and Machwas of Saurashtra coast, Satpati and Versova types of Maharashtra, Tuticorin of Madras, Navas of Kakinada of Andhra Pradesh and Batchari of West Bengal were mechanized successfully in the early stages.

It has been found that some of these, even though suitable for mechanization, are capable of improvement without making drastic alterations. These alterations were made to suit the installation of engines, fitting of the propeller and rudder and arrangement for deck equipment.

Many boats in India like Machwas are very well developed from the modern naval architectural point of view. However, they could be improved by sharpening the stern post, modifying the distribution of displacement, introducing strong and lighter construction of boat and by provision of suitable deck equipment to increase working efficiency and to provide more comfort.

At present suitable designs have been developed in India to meet the requirements of different regions and conditions of fishing. Training for Fisheries Department technical officers was given in design and construction of suitable types of craft. Modern building yards have been constructed by most State Fisheries Departments to enable local builders to follow improved designs. Co-operative and private yards are now coming forward to take up construction of improved types of fishing boats on commercial lines.

Table 2
List of Existing Types of Fishing Boats in India

Sr. No.	Place	State	Name	Characteristics	Length
					feet
1.	Jamnagar	Gujarat	Machwa	Plank built square	31
2.	Veraval	,,	Lodhiya	,, ,, ,,	35
3.	Malia	,,	Flat bottom boat	Carvel planked double ended	18
4.	Surat Billimora	,,	Gujarat Machwa	Plank built	
5.	Satpati Bassein	Maharashtra	Bombay Machwa	Carvel planked	47
6.	Bombay	,,	Hodi	Double ended carvel shaped; outrigger used	22–40
7.	Ratnagiri	,,	Pattemar	Stern rounded two masted	
8.	,,	,,	Ratnagiri type outrigger canoe	Dug out canoe	
9.	,,	,,	Ratnagiri Machwa	Single masted lateen rigged	
10.	Honavar	Mysore	Beppa dug out odam	Dug out	
11.	Kozhikode	Kerala	Odam-dug out and small dug out	Dug out canoe, no rudder	20–40
12.	Cape Comorin to Ramned and East Coast	Madras, Andhra Pradesh and Orissa	Catamaran	Raft type	20–40
13.	Tinnevelly	Madras	Vallam	Boat canoes, sides round	27–40
14.	Tuticorin	,,	Tuticorin	Plank built both ends sharp	29
15.	Kilakarai	,,	Kilakarai boat	Dug out canoes with outrigger	
16.	Pamban to Muthupet	,,	Palk Bay and Strait boat	Dug out with long plank as outriggers. Plank built also are there	
17.	Vizakapatam	Andhra Pradesh	Masula type	Planks stitched	
18.	Masulipatam and Kakinada	,, ,,	Navas	Narrow and keelless boat	31
19.	Kakinada	,, ,,	Shoe Dhoni	Wide and flat forward and foredecked	31
20.	Calcutta	West Bengal	Batchari boats	Stern as high as bow	28–60
21.	,,	,, ,,	Chot boats	Carvel planked	34
22.	Diamond harbour	,, ,,	Diamond harbour boat	The boat has a foredeck and aft deck	20

With the construction of new types of boats and improved gear, it is necessary to train young fishermen in this operation and maintenance. Local fishermen were not used to marine diesel engines, nor to deck equipment for handling gear. It was therefore imperative to provide adequate training to a sufficient number before they were supplied with mechanized boats.

At present there are 12 training centres in the different states of India, which extend these facilities to over 450 fishermen a year. The centres were organized with the guidance of experts provided by F.A.O. and the Indo-Norwegian Project, and now taken over by the State Fisheries Officers.

* * *

Further steps have been taken in the development of fishing boats by improving new designs, after carefully conducting experiments and tests and following actual experience. The development of Pablo boats and Prototype surf boats are best examples.

The Pablo boats designed on the basis of Danish built vessels, sent to India by FAO in 1953, were modified and improved upon by naval architects in 1956, 1958 and 1960. These newly designed boats are now fairly successfully operating in Kerala, Madras and Mysore.

The need for developing a suitable boat to operate from surf beaten coast was raised by FAO as early as 1949, and with the assistance of FAO Indo-Norwegian Project, the Government of India and State Government a series of trials were made with four types in 1960. These trials are of particular interest to under-developed countries, as they deal with different boats used for various beaches, weather and surf conditions, etc. On the basis of these trials, it has been recommended that a pilot project should be undertaken in a co-ordinated manner for assessing the economic possibility of these boats in different countries.

New designs have already been improved in the States of Orissa, Kerala, Madras, Mysore, Maharashtra, Andhra Pradesh and Gujarat. The sizes are becoming larger and, in the development of these designs, the programme has been closely co-ordinated with the Crafts Design Section of the Central Institute of Fisheries Technology at Cochin. A list of new fishing craft which have been further improved is given in Table 4.

* * *

New types of fishing boats have been designed in Ceylon, Korea, Netherlands, New Guinea, West Pakistan, Hong Kong and Indonesia. Hong Kong boats are suitable for mechanization but considerable improvements have been made to increase efficiency. In West Pakistan, the deck arrangements for trawlers ranging from 30–70 ft., have been improved for operating a trawl winch and providing insulated fish holds. In Ceylon, 26 and 32 ft. boats have been developed for gill netting.

* * *

Outboard motors were used for a long time mostly to serve limited requirements. During the last 10 years, these motors have been used in mechanizing small craft. They have been found to be successful in countries like Malaya, Chile, Ceylon, West Indies and in some countries in Africa. In Malaya, 65 per cent. of the boats have been mechanized with outboard motors; in Ceylon it has been demonstrated that a boat fitted with an outboard motor can catch seven times more than an unmechanized boat.

In India, the first outboard motor was fitted in Jaleswar (Saurashtra coast) in 1953. The result of the operation attracted other fishermen and there are now over 300 boats fitted with outboard motors on the Saurashtra coast. These engines have proved economical only in Saurashtra in India.

The fishing boat building industry in India operates mainly on a cottage industry basis. Building yards exist in Madras, Gujarat, Mysore, Kerala, Andhra Pradesh and Orissa, but some yards are not exclusive for fishing boats. Most small yards carry out traditional methods of building.

Construction methods can be improved by applying principles of naval architecture. Special courses of training in fishing boat design and construction at the Central Institute of Fisheries Technology, Cochin, where officers from various states have received training, have contributed to the development of boat building practices. Provision has been made in the Third Five Year Plan for the establishment of yards either by the Government or by co-operatives or private sector in most of the states.

* * *

Even though sufficient interest has been created among fishermen in the advantages of mechanization, and there is increasing demand for such craft, it is important to see that the number of designs is restricted to a few efficient and standard types. This aspect is now engaging the attention of the State Fisheries Departments and the Central Institute of Fisheries Technology. With standardization, it will be possible to construct a larger number of boats at cheaper rates and to handle them on a commercial basis.

It has been found necessary to establish a central institution for undertaking research on fishing craft and the Government of India established the Institute for Fisheries Technology in 1957, its Craft Wing dealing with problems connected with hull design, design of new boats, testing for performance and stability, selection of engines and propellers, improvement of building practices and selection of timber, etc. The officers in charge of craft and gear in the different states are closely co-ordinated with the investigations. Seminars and symposia are arranged periodically for exchange of experience and knowledge.

* * *

Government extends public credit facilities in all countries of the Indo-Pacific Region, directly or indirectly, for mechanization and/or improvement of craft. In some states of Australia, Indonesia, Japan and the Philippines, there is a kind of legislation pertaining to organization of

Table 3
New Fishing Boat Designs

Sr. No.	*State*	*Type of Boat*	*Length*		*Characters*	*Remarks*
			ft.	*in.*		
1.	Madras ..	Inland fishing boat	15	0	V-bottom open boat for oar and outboard propulsion	Speedy and sturdy boat for lakes and reservoirs. By 1959 10 boats had been built
2.	Orissa ..	,, ,, ,,	22	0	For stern trawling	For operation in reservoir fisheries for trawling with an engine of 10–15 hp
3.	Madras ..	Pablo boat	24	7	Danish type with shallow draught for gill net fishing	Speedy boat and well suited for Coramandal coast. By 1958 about 50 such boats were operating. 10 hp Seffle engine.
4.	,, ..	Open fishing boats ..	22	0	Transom stern, outside rudder. Used for gill netting	This is further improvement on Pablo boat to reduce the cost by 20 per cent. Engine used is 8–10 hp
5.	Gujarat ..	Machwa	28	0	An improved design of Machwa to suit local conditions	The boat was installed with 17 hp Daiya diesel engine. Fishing was successful
6.	Madras ..	Coastal fishing boat	30	0	A further improvement of Pablo boat. Stern is transom, giving more deck space	Bigger type. Engine used is 20–25 hp. Successful for long lining and drift netting, with engine driven winch
7.	Madras and Kerala	,, ,, ,,	31	9	For the fishermen's training centre. It was specially designed to take up 30 hp BUKH engine with controllable pitch propeller	Fitted with winches and heavy trawl gallows on the aft deck. Five more have been built for the various training centres
8.	Kerala ..	Shrimp trawler ..	32	0	Designed for stern trawling with 36 hp engine	This is to investigate the possibilities of using shrimp trawl on the west coast. The design was modified later
9.	Bombay Maharashtra	Monsoon boat ..	44	0	Strongly built, of Satpati type with shallow draught; fully decked; engine used is 45–50 hp and for trawling 60-80 hp	For fishing in the Kokan area during monsoon. A winch was fitted to be driven from the main engine. The boat has a fish hold of 4 tons capacity with cork insulation and thick cement ceiling for hold. This was built by Maharashtra Government
10.	Madras ..	Surf boat prototype, 1954	20	0	Measuring 20 ft. × 5 ft. 9 in. × 2 ft. 1 in. with engine of water cooling system. Transverse system	It was successful in negotiating moderate surf but proved to be too heavy for hauling on the beach

Government Credit Institutions or provision of specific financial assistance by Government to the industry.

In Hong Kong, there are three funds, two of which are administered by fish marketing organizations. Philippines provides loans for craft and engines through the Farmers & Fisheries Bank. In Malaya loans are advanced through co-operative societies, and in India loan and subsidies are granted through the State Fisheries Departments and co-operative organizations. In Japan, the Agriculture, Forest and Fisheries Financing Corporation extends loans to fishermen.

In some advanced countries in the West, commercial banking institutions, co-operatives and non-institutional lenders are of importance as suppliers of credit. However, in countries of the Indo-Pacific Region, the Government participates directly in the administration of financial

Table 4
Improvements upon the Newly Designed Boats

Sr. No.	*State*	*Type of Boat*	*Length* *ft.*	*in.*	*Characters*	*Remarks*
1.	Kerala ..	Open fishing ..	25	0	Open boat prepared on the lines of Pablo boat; transverse stern with a sharp forebody; engine, gear and catch space are in the middle	It will work in all harbours, inlets and sheltered water. Mainly used for gill netting and long line fishing. Eight boats had been built by March, 1959
2.	,, ..	Multi-purpose fishing	32	0	Based on the design of 32 ft. shrimp trawler. Fully sharp forebody, engine installed aft with generous fish hold. Cork insulation with proper air circulation. Engine is 40 hp, with accessories for electrical starting, fuel lift pump, power take off for winches, etc.	Used for trawling, purse seining and gill netting, six such boats have been built.
3.	Madras ..	Training vessels ..	38	0	Flush deck transom stern, engine installed amidships. Space has been provided for trainees and crew to stay, and small fish hold is also provided. Deck equipment consists of trawl winch, gurdy gallows, etc. There will be all navigation equipment	It is for demonstration purposes and suited for all methods of fishing. The engine is of 50 hp
4.	Kerala ..	Trawler purse seiner	40	0	Engines are installed in front. Aft is wide so as to give sufficient buoyancy. The buttocks are flat and draught is kept to a minimum. Engine used is of 60 hp, and the deck is equipped for stern trawling and purse seining	For operation in the west coast for shrimps, sardines and mackerels.
5.	Mysore ..	Shrimp trawling ..	24	7	This is a modification of the Pablo boat.	This type is used in Mysore for stern trawling
6.	Kerala and Madras	Open fishing ..	30	0	Modified boat of the 25 ft. type to suit trawling with small nets	It is used in the fishermen's training centres at Madras, Kerala and Mysore
7.	Mysore ..	Training centre boat	31	9	This is a modification of the coastal fishing boat mentioned in item No. 7 of statement No. 2, and is designed for trawling only. Special features are a lower deck aft, no cockpit and a small fish hold	For training centre trawling and purse seining
8.	Madras ..	Surf boat prototype 1955	18	3	A lighter boat than the prototype 1954, having the same shape. A 3½ hp air cooled diesel engine was used	It was found to be of too light construction and would have to be reinforced
9.	Madras and Kerala	Surf boat prototype 1957 BB-57	24	0	A further modification of prototype 1955. Clinker planing, steam bent frame. An air cooled diesel of 15–18 hp was proposed on the port side with shaft parallel to the central line	This was tried in several places. Slight modifications were made here and there based on experience. The main difficulty was beaching the boat as it was so heavy
10.	Madras ..	Surf boat prototype 1958 BB-58	24	0	Further modification of the above, with more beam and more freeboard aft. An air-cooled 10 hp engine is installed	Under trials
11.	,, ..	Surf boat prototype 1959 BB-59	24	0	Plywood construction and a hard chine hull. A 10 hp diesel engine is installed off centre	Trials to be conducted
12.	Mysore ..	Training boat for Mysore	28	0	This is designed to take 20 hp marine diesel engine, which is too powerful for 25 ft. boat and too weak for 30 ft. vessel.	
13.	Andhra Pradesh	Training centre trawler	47	0	This vessel was designed on the basis of 30 ft. vessel	

loans. The Fisheries and Co-operative Departments are normally the agencies through whom financial assistance is extended to fishermen. These loans are further channelled through a co-operative organization or co-operative banks.

Loans for the fishing industry are provided by governments in various ways, such as funds provided from general revenues, those appropriated from specific sources of income and others raised as special levies. But funds are allocated under the budget of the government agency administering the loan. Even under the system, different methods are adopted. Some countries make a lump sum appropriation; some have revolving funds wherein the money collected through the repayment of loans, could be used again and again.

In certain cases, the government administers loans, where finances are received from abroad in the form of loans and gifts. Special banking institutions also administer credit, which are financed by government, but this will be in the form of short-term loans. For mechanization of fishing craft and construction of boats, the loans required are of long-term nature.

In India, the bulk of public loan capital is provided by the Ministry of Food and Agriculture, to be administered by State Governments. The Government of India and State Governments have set aside certain amounts for development under Five Year Plans for granting loans and subsidies.

The loan funds are mainly administered by the State Fisheries Departments, which vary slightly from State to State.

In some States like Gujarat and Maharashtra, loans and subsidies are granted directly to the fishermen. In Madras, Kerala, Mysore, Orissa and Andhra Pradesh, mechanized boats are constructed by Government Departments at Government or private yards and then distributed to the fishermen in kind.

In all loans and subsidies, fishermen have to execute agreement with the Government for repayment of the loan in instalments over a period of five to seven years—not counting the non-fishing season.

Rates of Interest

In India, on loans issued by Central and State Governments, the rates of interest charged vary from 4 to 4½ per cent. Interest charged by State Governments to the fishermen on the loans issued to them would be from 5 to 5½ per cent.

Insurance of the mechanized boats by fishermen is insisted on by State Governments with a view to safeguarding both parties' interests. In most States, fishermen have to insure the boats and assign the policy to Government against loan. In Maharashtra and Gujarat, the interest rates charged on loans are 5 per cent. on the boat insured and 9 per cent. on those not insured.

In Kerala, the State pays the premium towards insurance, but this amount is recovered in instalments before the boat is actually handed over to the fishermen on full repayment. It has been found essential to provide for insurance of fishing boats at reasonable rates of premium, especially when the fishermen do not have adequate security in the form of immovable property and also to safeguard the loan granted by Government.

Repayment of Loans

Loans for engines and boats are to be repaid in a period of five to seven years. The amount is recovered in eight to 10 monthly instalments every year, with the interest due. No instalments are recovered for two to four months in a year during the off season. The District Fisheries Officers closely watch repayments and if there is any default, a penal interest of 1 per cent. is charged on the outstanding amount. If the recovery is very irregular or if there is any default, legal action is taken against the party under " Arrears of Land Revenue Act." Fortunately, such cases have been very few.

Method of loan recovery varies from state to state. In some it is made directly from the fisherman or co-operative society of which he is a member. In Mysore and Kerala recovery is effected by the value of a certain percentage of the boat's catch.

In India, the grant of financial assistance in the form of loan and subsidy was introduced in 1950 and continued to date with the object of providing the fisherman some relief from the high cost of equipment like engines, and also to give him an incentive to take to improved boats and gear. Subsidies are granted for the construction of improved fishing boats, mechanization of craft and fishing methods and on fuel.

The rate of subsidy on hull is 25 per cent., on engines 33⅓ to 50 per cent., on winches and gurdies 25 per cent. The Government has offered 16 Np. per gallon of diesel oil consumed by a mechanized boat, subject to a ceiling of Ls. 150 per boat per year as a central share, and subject to the condition that the state would meet an equal amount of subsidy. The quantum of subsidy given by different states on these items is shown here:—

Name of Item	*Government of India*	*Government of Maharashtra*	*Governments of Kerala, Madras, Andhra, Orissa and Mysore*	*Government of Gujarat*	
				2nd plan	*3rd plan*
	%	%	%	%	%
1. Mechanization of fishing craft:					
(a) Inboard engines	50	50	50	33⅓	40
(b) Outboard motors		(No outboard motors)		33⅓	25
2. Improved designs of boats ..	25	25	25	25	25
3. Winches, gurdies and accessories	25	25	25	12½	25

OUTBOARDS IN TROPICAL FISHERIES

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One of the world's most peculiar fishing craft is the straw canoe. Almost identical types are used on Lake Chad in Africa and Lake Titicaca in South America. Such craft can be mechanized by outboards but, in this particular case, it was felt that it was too small and vulnerable to be practical. (*FAO photo by Curt S. Ohlsson.*)

AT present 75 per cent. of the world's total fish production is by seven countries: Japan, the United States, China, Russia, India, the United Kingdom and Canada. The remainder of the world, including the nations where animal proteins are in extraordinarily low supply, contribute less than 25 per cent. of the total. It is in this latter area particularly that the outboard is now being employed as a vital workhorse to increase production.

During the past ten years they have been directly responsible for the improvement of many fishery programmes around the world, and in some instances their use has resulted in production increases amounting to 1,000 per cent.

The following accounts give a good idea of the extent to which outboards are helping to increase production in the less developed fisheries of the world.

Outstanding Examples

Government officials of the US and the Republic of Panama have described outboard mechanization programmes of two Panamanian fishing villages as outstanding examples of international achievement.

After one and a half years of effort, development of the fishing co-operatives of El Higo and El Farallon, Panama, has been pronounced a resounding success. The improvement of the economic conditions of fishermen in those areas arose from the balanced collaboration of American government and private industry, working with the Panamanian government and private business groups to provide assistance for fishermen.

Panamanian fishing methods are often primitive, and the " cayucos " or fishing boats are small unstable dugout canoes without sails, which prevent fishermen from venturing far out to sea or handling a large net. Before the advent of the outboard motor, the general method was to secure one end of the net to the beach, the other to the boat, and to make a semi-circle with the boat, returning the net to shore. Once back on the beach, the fishermen would pull the two ends of the net and haul in the catch.

Faced with these conditions and the disorganization of the fishing villages, officials felt that the outboards could not be granted outright to fishermen who had never handled them before, who had no idea how to repair and maintain them or how to market the additional catch obtained. It was decided the most logical solution would be the formation of co-operatives.

By October of 1961 the organization of these in El Higo and El Farallon was well under way based upon the use of 16 outboard motors ranging from 18 to 25 h.p.

Today, with improved boats, modern outboard motors, and the substitution of nylon drift gill nets for the older, cumbersome beach nets, the co-operatives have increased their daily catch of fish to 1,091 lb., compared with 192 lb. obtained with older gear.

Philippines

An era of better living is dawning for many communities of the Philippine Islands where the outboard motor is replacing oar and sail as mainstay of trade, commerce and communication.

Typical is the Rizal Province of the central island of Luzon, an agricultural and fishing region bordering on the large inland lake of Laguna de Bay.

For centuries, villages of the area, properly called mabarrios but referred to as barrios have been almost isolated from the outside world. Even in recent years most barrios in the Laguna de Bay area of Luzon were reachable only by boats propelled with the traditional oar and sail. Today, thanks to 10 h.p. outboard motors supplied to the Philippines Community Development Programme by the International Co-operation Administration, higher standards of living are made possible.

Accelerated commercial application of the outboard motor on the village or barrio level, officials believe, will correct a deficiency that forces the nation to import at least $16,000,000 worth of fish annually, although the Philippines have perhaps one of the richest coastal fishing grounds in the world. In recent years, using traditional sail and oar, they have been as much as 28 per cent. short of the fish that could have been consumed. But now, having converted from sail and oar to outboard motors, they are reporting phenomenal increases in fish production.

CARE, since late 1959, has advocated and taught the use of the motor throughout the islands. Today, convoys of from 30 to 50 boats are towed by one outboard boat to new grounds, in one typical case increasing fishing time from two to six hours, decreasing daily travel time from ten to three hours, and reducing total working hours of fishermen from 12 to nine hours daily. More important, villagers are getting more vitally needed protein in their diet and the additional capital accruing from increasing sales is raising the general standard of living.

Demand for outboard motors continues to increase in the Philippines. In spite of currency and import restrictions, more and more of the engines are being used. Makers of three of the most popular outboard motors report that 1961 exports to the Philippines surpassed those of peak 1960. CARE officials report that overall fish production increases on the barrio level average from 20 to 40 per cent. when the single motor is used for the village convoy system.

The use of outboard engines on specially designed 20 ft. deck fishing canoes has been recommended by H. E. van Pel, late fisheries officer of the South Pacific Commission, as an important step in the mechanization of fishing canoe fleets. He recommended the outboard powered outrigger canoe in response to studies which show that small commercial fishing craft are often unsuited to many Pacific islands, where passage is frequently made through reefs across which surf breaks. Other factors favouring the outboard canoe over the inboard-powered fishing boat include the lack of harbours at many locations as well as weather factors which require the boat to be removed from the water overnight.

French Polynesia

More rugged canoes of the general type advocated by Mr. van Pel and equipped with outboard motors have proved so efficient through the 125 islands and 1,544,408 square miles of French Polynesia that the picturesque sailing canoes have almost disappeared from the contemporary South Pacific scene.

Modernization of fishing boats in French Polynesia is spurred by heavy fishing pressures in areas near centres of comparatively dense population. In Tahiti where the lagoon waters are constantly furrowed by the fishermen's canoes, grounds have reached an alarming state of exhaustion. There are now few fish there, and all very small, a sure sign of extreme overfishing. In Bora Bora and Raiatea, where the fishery supplies the local market and some fish is also airfreighted to Papeete, the exploitable stock is already decreasing alarmingly.

Officials agree that the lagoons could not sustain more extensive fishing than is at present practised. The favourite fishing method is underwater fishing carried out with spearguns made in the Chinese workshops of Papeete. In the hands of such excellent divers as the Polynesians, their spearguns have almost completely exterminated some species in certain areas.

The outrigger canoe powered by an outboard is today the most popular craft in French Polynesia. With this boat, fishermen practise underwater spear-fishing near the reefs, deep-line fishing in the ocean, trolling, and pearl-shell diving. Another type of craft is known by the English word, " boat," 13 to 25 ft. long and propelled by outboards of 3 to 40 h.p.

No Exports

Except for mother-of-pearl shells gathered in the Taumotu and Gambier Islands, all marine resources are used exclusively by the Polynesians and none are exported. Individual islands generally supply their own or local markets and the rest is sent to Tahiti, the main island where 36,000 of the 72,000 residents of French Polynesia live. Lately, a mixed system of fish transport has come into being to supply the large market of Tahiti. Flying boats and outboard-powered launches rush the fish to Papeete, largest city of the islands. On each trip from one to two metric tons of fish are packed in metal containers.

Fishery officers of the Caribbean Organization noted during a recent conference that in spite of the great advances made in the development of fisheries in recent years through the mechanization of fishing boats with outboard motors, and by the application of other advanced techniques, much still remains to be done to make the unit territories self-sufficient in fish requirements.

Commented the report: " In recent years, the emphasis in fisheries development schemes has been on the mechanization of fishing boats. The use of outboard gasoline engines has made great progress, especially in Jamaica (stimulated by a government loan system) and Trinidad (achieved by the industry itself without government loans). In Trinidad and Tobago, for example, mechanization progressed from 6 per cent. in 1946 to 62 per cent. in mid-1959 and to 75 per cent. at the end of 1960, including 982 outboard engines and 146 gasoline and diesel inboard engines; in Jamaica the total number of outboards has risen from 450 in mid-1959 (16 per cent. of the fleet) to 722 in mid-1961."

The other unit territories of the Caribbean Organization all have mechanization schemes in operation, providing loans for the purchase of complete boats, or engines only, on a hire-purchase basis.

Rudimentary training in engine operation is given by fisheries personnel to fishermen obtaining engines through government loans in Antigua, Barbados, Dominica, Grenada and Jamaica. On the latter island, mechanics are trained in the maintenance and repair of outboards and then stationed in the main fishery centres to service local equipment.

It is common knowledge that although the people of the unit territories of the Caribbean Organization are among the world's biggest fish eaters, they are woefully distant from self-sufficiency in fish protein in spite of recent outstanding gains. Member nations must continue to make great advances in the mechanization of their fishing industry to reduce imports of dry-salted, pickled and canned fish—which account for most of the fish consumed in the Caribbean area although the waters are teeming with marine life.

The following figures show production as percentage of consumption in unit territories: Antigua, 32·1; Montserrat, 9·4; Barbados, 43·7; Jamaica, 13·4; St. Kitt-Nevis-Anguilla, 18·8; Dominica, 20·1; Grenada, 28·6; St. Vincent, 30·0; Trinidad/Tobago, 36·0; St. Lucia, 24·1. Major fish-producing nations of the world, such as Japan, the United Kingdom, Canada, Peru and the US provide the larger percentage of fish protein consumed by member territories of the Caribbean Organization.

Puerto Rico

Puerto Rico's department of Agriculture and Commerce recently reported " The Commonwealth's programme for small fishing craft mechanization has been functioning so successfully that the administration contemplates seeing the island's entire fleet fully mechanized by 1965."

Felix Inigo, Director of the fish and wildlife section of the Commonwealth's Department of Agriculture said, " Puerto Rican fishery reserves can still be further developed. One of the first steps in attaining a significant increase in production is to continue to expand our small craft mechanization programme thereby assisting fishermen. By so doing, they will be permitted to devote more time to fish, extending their radius of operation into new, more productive banks, presently out of reach of oar and sail."

Puerto Rico's annual fishing production is estimated to be in the area of 6,000,000 lb. with a wholesale value of more than $1,000,000. This fresh fish comes from adjacent Puerto Rican waters, and is harvested by a fleet of 1,091 boats, of which 365 or 33 per cent. are now mechanized. Prior to the creation of Puerto Rico's Fisheries Loan Programme, in which fishermen can borrow money to finance outboard purchases, there were only 913 licensed fishing craft. Of this amount, 210, or only 23 per cent. were motorized.

During the fiscal year 1958–59 fishermen purchased 21 motors under the terms of the Fisheries Loan Programme. During the 1959–60 period they acquired 116 additional units, bringing the combined total to 137 motors. The total value of these motors was $37,714·00, of which $33,738 was lent by the government, while the fishermen supplied the balance as down payment.

A study was conducted by Puerto Rican authorities in order to evaluate the effects of mechanization with the following results: The average fisherman's weekly catch increased from 134 lb. prior to mechanization, to 201 lb. thereafter, an increase of approximately 50 per cent. Annual fish production increased 1·75 tons per fisherman after mechanization.

Puerto Rico's Fisheries Loan Programme was recently extended to include other phases of the industry. These include the expansion and improvement of an already existent boat yard, and furnishing inland transportation facilities for fish wholesalers. Also, supplies and other related materials are sold to fishermen at cost price, at special stores established for this purpose.

Ghana

During the past few years many changes have taken place in Ghana and one of the major improvements has been the expansion of fishing activities involving outboard motors. Many of the outboard-powered fishing boats are based at the new harbour of Tema.

The role of the outboard motor is equally important at fishing villages along the entire shore line of Ghana, where mechanized fishing canoes with small crews are returning with larger catches. At many villages, the canoe can be put back to sea for a second profitable trip in the same day.

Much work was put into preliminary mechanization activities by the government of Ghana, by commercial firms, and others interested in the advancement of the industry. Trials were made and the correct engines selected and imported—a large number supplied by the Ghana Consolidated Machinery and Trading Company, which has 60 years' of experience in Africa. Then came the problem of inducing the fishermen to try the engines and depart from the traditional method of hand propulsion by paddles.

The former Fisheries Department, now the Ghana Fisheries Corporation, worked closely with the Ghana Consolidated Company and fishermen soon learned the outboard motor meant a great improvement in their living standards.

To bring the benefits of the modern two-cycle engine to fishermen who in many cases had little contact with mechanical devices, GCMT established special service and instruction facilities. The fishermen of Ghana soon mastered the rudiments and intricacies of the modern outboard motor and today the problem has been largely overcome.

Many fishing communities now have their own outboard mechanics who previously were truck mechanics. More extensive repairs are carried out in the well-equipped workshops of GCMT at Accra, Kumasi, Tamale, and Takoradi. These workshops also served as a training ground for neophyte mechanics of various commerical firms and government agencies.

Especially reassuring is the knowledge that after-sales service by the GCMT beach service units in all areas of the coast ensure engines will be rapidly repaired and returned to service. Also extremely active in fishing mechanization programmes is the Compagnie Francaise de l'Afrique.

Of great assistance in helping Ghana to implement her fishing mechanization and modernization programme have been specialists of the United Nation's Food and Agriculture organization.

OVERCOMING PROBLEMS

on Boat Design, Servicing and Fuel Costs

JAN-OLOF TRAUNG

FIG. 7: *Outboard mechanization in Jamaica has been very successful. Dugouts have been developed to suit outboard propulsion, having transom sterns and a flat run aft.*

OUTBOARD mechanization is by no means problem-free. But the problems are capable of solution, given enough enthusiasm, co-operation, financial support, and patience. There are still problems with the boat types to be mechanized, the method of servicing motors, the problem of high fuel costs, even problems with the motors.

On the latter point, compared to a pleasure outboard, a motor for commercial craft should have better protection against spray, as commercial boats are used in all weathers, longer distance from power head to propeller and lower r.p.m. of the propeller.

The longer power head-to-propeller distance is necessary for the usually higher freeboard of commercial boats, and to help reduce " racing " when the propeller comes out of the water as the boat pitches in heavy seas. Most outboards are made from a transom height of 15 in. There are longer versions for 20-in. transoms, but FAO has found that, in some cases, a length of 30 in. to 32 in. is necessary for fishing boats. There are now such " long " outboards on the market.

Important Variations

For fishing boats, the propeller and its r.p.m. have important variations from pleasure craft. The most efficient propeller for a pleasure cruiser, fast-planing at 15 to 25 knots, should be of comparatively small diameter and should run at high revolutions. On very high-speed craft it is even necessary sometimes, by suitable gearing, to increase the revolutions so that the propeller will work faster than the crankshaft. In such cases the propeller pitch is normally much larger than its diameter. Many makers are producing units with the engine making about 4,500 r.p.m., and equipping it with a propeller which has about the same diameter as pitch.

But the slower fishing boats have quite different needs. To be efficient, the propeller revolutions should be much lower and the ratio between propeller pitch and diameter such that diameter is comparatively large, while pitch is small. The optimum ratio between pitch and diameter for fishing craft is about 0·6.

When a standard outboard with propeller running at 2,600 r.p.m., with a pitch/diameter ratio of 1, is placed on a heavy fishing boat, the motor will be overloaded at full throttle. A higher gear ratio is needed to reduce propeller r.p.m., plus a suitable propeller. To achieve this would require a comparatively expensive new design of the underwater part of the outboard and most makers consider this uneconomical. However, better propeller efficiency would be obtained if the manufacturer would choose a propeller for the present 2,600 r.p.m. with a larger diameter than pitch. By using the correct pitch/diameter ratio and without reducing the r.p.m. more than normal, it is possible to increase the thrust of a fishing boat by 35 per cent. Table 3 shows suitable fishing boat propellers.

For light fishing craft, such as canoes, which are sometimes semi-planing and run at high speeds, outboard motors with comparatively high-speed propellers have been readily accepted. Fig. 7 shows a fast canoe from Jamaica. But in mechanizing heavier fishing boats, only those with low propeller r.p.m. have been truly successful.

Table 3

Propellers with best efficiency for heavy type fishing boats

Fast Pleasure Boat Diameter × pitch (inches)	*Heavy Fishing Boat Diameter × pitch (inches)*
6 × 6	7½ × 4½
7 × 7	8¾ × 5¼
8 × 8	10 × 6
9 × 9	11¼ × 6¾
10 × 10	12¼ × 7⅓
11 × 11	13¾ × 8¼

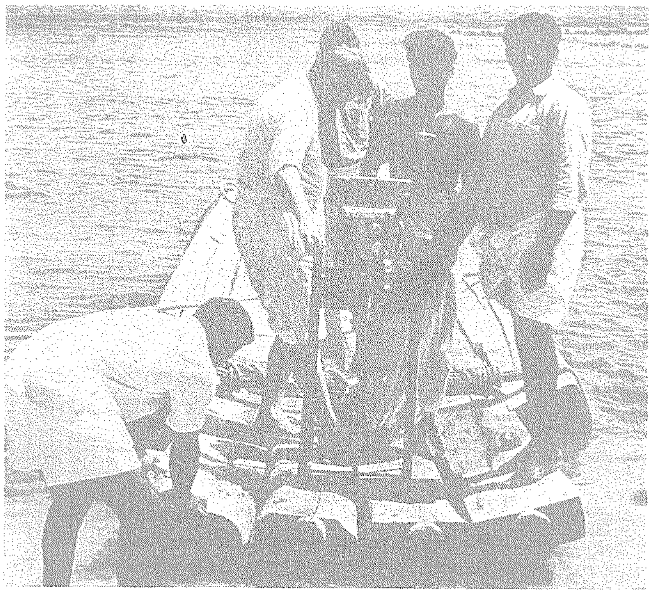


Fig. 8: Powering a large kattumaram in northern Ceylon. The motor has to be placed on a special pedestal to keep the power head away from the water. (FAO photo by Jan-Olof Traung.)

Fig. 9: Outboard powered theppams being made ready to leave shore at Negombo in Ceylon. These craft leave in the afternoon, venture out to sea and return the following morning. (FAO photo by Erik Estlander.)

Outboard manufacturers might consider selling two versions: one with the normal pleasure boat gear ratio and another with a higher ratio and very long shafts. Many fishermen would soon discover the advantages of the second type.

Not all boat types are suitable for mechanization. It is possible to attach a motor to a Ceylonese kattumaram (Fig. 8), or the smaller theppam (Fig. 9), a Ghana dugout (Fig. 10), a Dakar pirogue (Fig. 11), and get more efficiency than with paddle or sail. Some craft can be mechanized, but are just too small and unstable to be improved.

A better boat design obviously will result in higher efficiency, greater safety for the crew and more hold space for the catch. Improved boat design is a second step towards greater mechanization. Some of the desirable characteristics of a boat to be used under outboard power are:—

(1) Big enough to be able to carry a great number of fishing nets.
(2) Small enough to be able to be beached by a dozen fishermen.
(3) Shaped so that the craft can be safe enough in open sea.
(4) If possible, with an insulated fish hold.

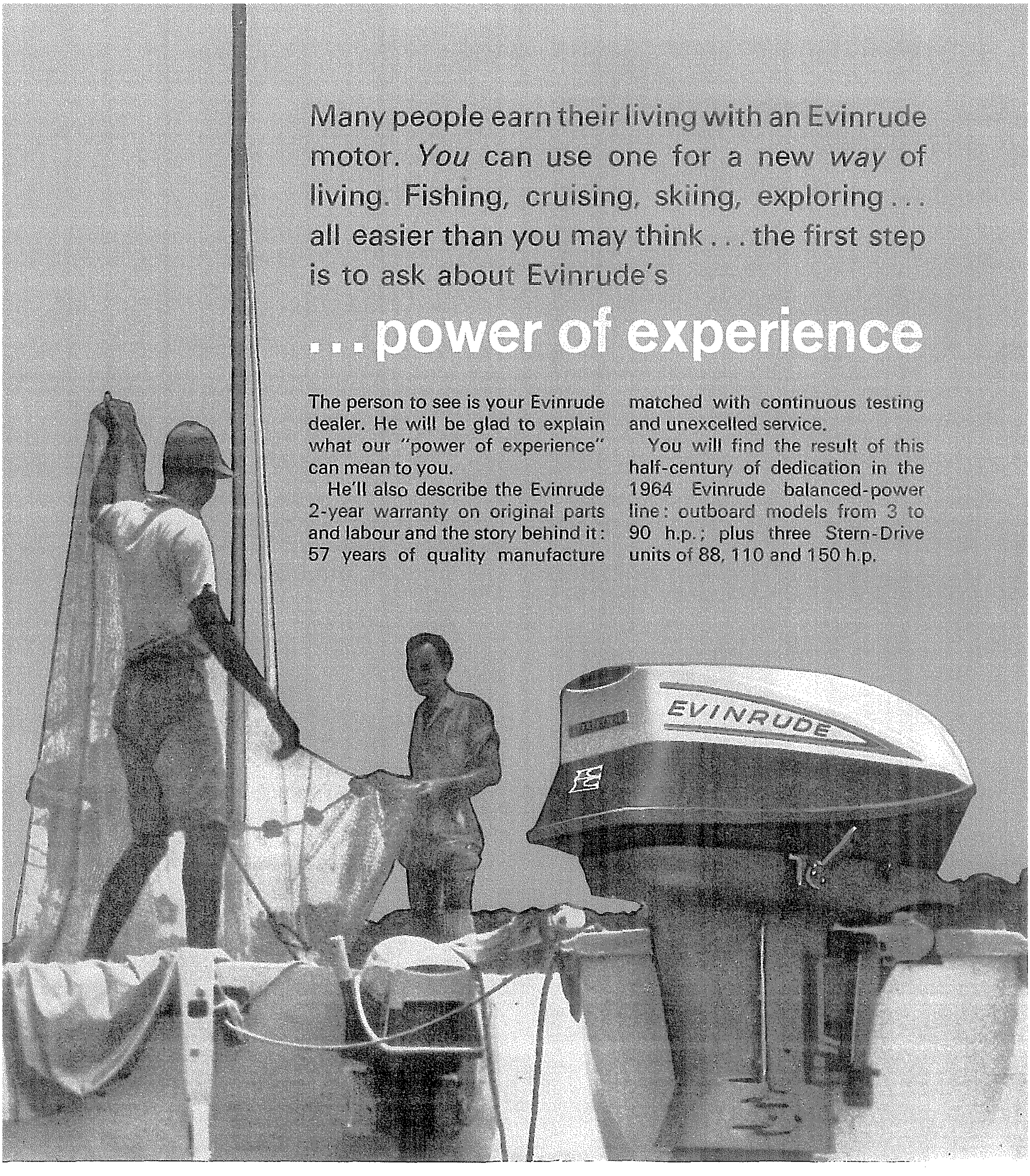
FAO naval architects have produced several designs which incorporate many of the best features for outboard boats in several parts of the world. Fig. 13 shows a 21-ft. outboard boat recently developed in the FAO Fishing Boat Section which is thought to be rather efficient for gill-netting. It is suggested that the boat be built of plywood, since marine quality plywood is being made in many developing countries. It could also be made, but perhaps would be more costly, of glass-reinforced plastic, and would then be free from much maintenance.

Fig. 14 shows another example of an outboard-powered craft which was developed for lake fishing.

Another architectural-engineering problem, the positioning of the outboard motor, has been the subject of much discussion.

In Jamaica, where many outboards are used on dugout canoes, the canoe builders have modified their double-ended canoes to have a transom stern (Fig. 7). The engine is then placed outside this transom and this has worked

Fig. 10: Fanti fishermen in Ghana and neighbouring countries are well known for their efficiency. They soon took to outboard power and often have to keep the engine protected in a water-tight sack when passing through surf. For propulsion in calmer waters engines are usually placed on the side. (FAO photo by Curt S. Ohlsson.)



EVINRUDE

OUTBOARD MARINE INTERNATIONAL • NASSAU, BAHAMAS • BRUGES, BELGIUM

FIG. 11: *Senegalese fishermen have developed a method of placing the outboard in a well inside their pirogues. The well is being studied here by Peter Gurtner, FAO Naval Architect (right) and Roland Andersson, FAO Boatbuilder, at Kayar. (FAO photo by Curt S. Ohlsson.)*

very well in the short choppy seas created by the trade winds around Jamaica. Jamaica is fortunate in having sheltered bays for harbouring fishing craft, so beach landing is not of great importance.

The dugouts of Jamaica are of a very advanced design and FAO has many times recommended a study of these when making dugouts in other parts of the world.

Experiments have been made in Jamaica to equip these dugouts with inboard engines of kerosene or diesel type. This has not been accepted favourably by fishermen for several reasons. These inboard engines take up valuable space and make the craft more heavy and cumbersome to handle.

With inboard engines, one has to have a separate rudder which gives far less manœuvrability than the outboard which has positive steering. In the operation of small craft in choppy seas, this lack of manœuvrability makes their use impossible.

In Ghana beach landing and going out through the surf is a great problem and there the outboard is frequently kept in a watertight sack during the landing and launching and is placed on the side of the canoe (Fig. 10). In about 2 per cent. of the landings, the craft capsize in the surf. In Gujarat State in India, where outboards are used on dugout canoes on the side (Fig. 15), an FAO expert suggested shifting it to the stern, which was very well accepted.

In Senegal, outboards are placed in a well inside the boat (Fig. 11). This makes it very handy to operate the outboard and to lift it into the well. Many feel, however, that such a well decreases the available space for fishing gear and they have some doubts about the resistance created by the hole in the canoe bottom.

Wells are also used on outboard powered fishing craft in U.S.A. Many different types of wells have been suggested which claim advantages of low water resistance. An American professor of naval architecture is at present undertaking research to find out the influence of differently shaped wells on resistance, and it is hoped to have a report from him at the third FAO technical meeting on fishing boats in 1965.

The design of wells has been studied too little. It is not only a question of their size and shape, but also of their location fore and aft on the craft. It is well known that along the bottom of every craft under speed there are positive and negative pressures and, therefore, it would be a great advantage if one could place these wells in the best position from the point of view of pressure. One object of the U.S. tests will be to study this point.

From the beginning of the idea of outboard mechanization, the problem of servicing has been one of the biggest. Obviously, it is vitally important to keep motors running

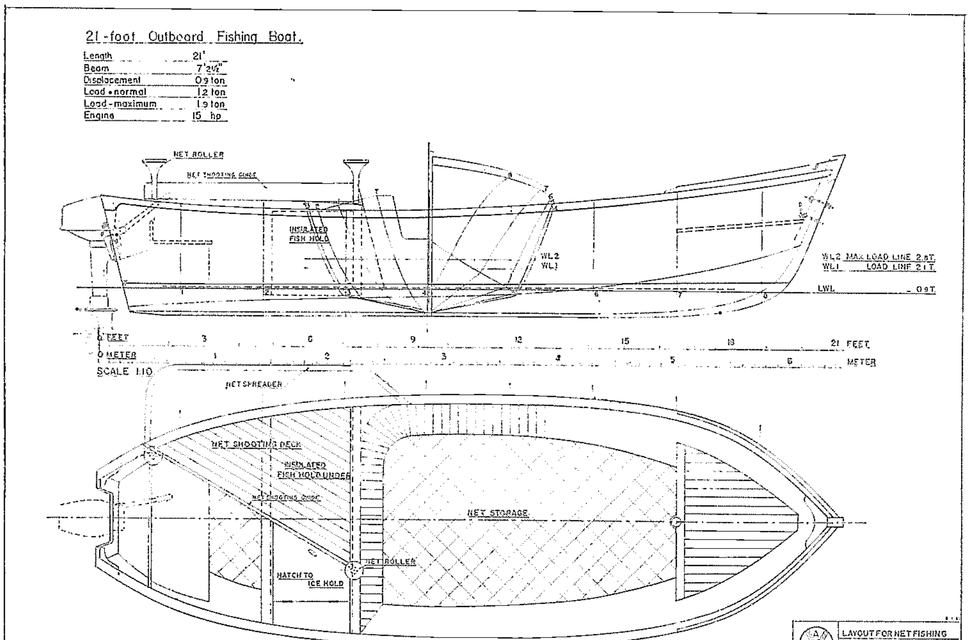


FIG. 13: *Drawing of a 21 ft. boat suitable for outboard propulsion. It is laid to handle a maximum number of gill nets and to set them in the quickest possible way. The boat is designed for wooden construction, but would also be very suitable for glass-reinforced plastic.*

if the confidence of fishermen is to be gained. These servicing and maintenance difficulties should be recognized, but not exaggerated. Two factors should be remembered: (1) Outboard motors are more simple to repair and care for than diesel engines, and (2) the outboard is basically a motor-scooter engine and familiarity with scooter engines is developing with the introduction of scooters and motorbikes as inexpensive land transportation in many countries.

In Singapore, when the Government found many outboards inoperable due to lack of maintenance, a mobile repair unit was formed. The Singapore Mobile Unit is a van with a full set of tools, manned by a mechanic and an assistant mechanic, who is also the driver. The annual cost of the repair van, its maintenance, tools and salaries for the two mechanics is about £1,450 (U.S. $4,000).

When the unit started operations in 1953, an estimated 50 per cent. of the motors were out of commission. By June, 1956, only 10 per cent. of the motors were out of commission at one time, and most of these simply needed general overhaul. Table 4 gives a review of the activities of the unit. When the scheme first started, each village was visited every three and a half months. Later, as repairs became fewer and easier, the unit visited each village every one and a half to two months. Spare parts were sold at cost to fishermen up to 1959.

Table 5 shows the number of outboards licensed in Singapore from 1950 to 1962. The number has dropped gradually from the peak in 1959 due to fishermen switching over to inboard diesels and partly to others switching over to land jobs because of the progress of industrialization.

From 1960 the mobile repair unit also gave talks in fishing villages on marine inboard engines.

From January, 1962, the routine visits to fishing villages were discontinued and fishermen wishing to get service were recommended to telephone to the Fisheries Control Point in Singapore so that the repair unit could answer the call immediately. This gave the fishermen a more prompt and satisfactory service, once they had got used to regular maintenance.

The figures given under Maintenance and Minor Repairs in 1690–62 in Table 4 cover both inboards and outboards.

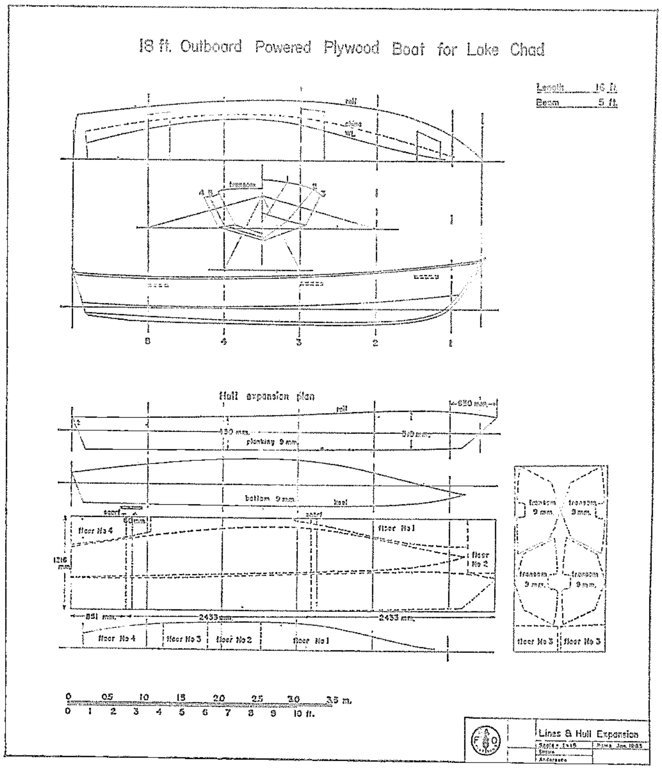


FIG. 14: *This plan shows hull expansion so one can utilize standard-size plywood sheets in the most economic way.*

Although there is no way to assess the educational value of the unit, many groups of fishermen, and even their children, have learnt to make simple repairs. The necessity for the van carrying a large supply of spare parts has also decreased, since dealers have brought down prices and are now selling direct to fishermen.

In other areas, Governments have similar arrangements for servicing motors. In Nyasaland, the Government has a repair van going around the Lakes. On the other hand, industry should not wait for Government initiative in selling and servicing outboard motors. Many private hire-

Table 4
Summary of work done by the Singapore Mobile Unit

Period	*No. of days in operation*	*No. of Villages visited*	*No. of Engines brought in for repairs*	*Value of spare parts sold*	*No. of fishermen taught*			
					Maintenance	*Minor Repairs*	*General Overhaul*	*Total*
				U.S. $				
1953 (June to Dec.)	129	51	219	282·50	200	11	3	214
1954	245	130	433	356·00	200	11	3	214
1955	243	208	319	96·30	104	39	10	153
1956	242	281	232	94·40	55	46	12	113
1957	245	294	154	41·45	38	27	10	75
1958	248	271	120	·10	12	37	13	62
1959	250	286	127	·03	*40	*31	*11	*82
1960	289	336	151		134		17	151
1961	285	329	138		115		23	138
1962	294	361	308		144		64	208

* No new persons trained. These persons have gained experience in previous years already. They attended only as a refresher course.

Table 5
Progress of Mechanization in Singapore

Year	*Fishing Craft with Outboards*	*Year*	*Fishing Craft with Outboards*
1950	11	1957	488
1951	80	1958	620
1952	377	1959	639
1953	413	1960	603
1954	413	1961	526
1955	477	1962	486
1956	501		

purchase sales have been successful, in Tanganyika and Trinidad for example. Such schemes have excellent chances for success in places where the industry is also willing to train fishermen in operation and maintenance.

Another problem with outboards is the high cost of fuel. But, discounting road taxes, the price of petrol should be less than about 50 per cent. higher than the price of diesel oil. And even if a petrol engine does consume more expensive fuel and more of it per developed horsepower, the price of the engine is much lower because of its simpler design and mass production. Thus, in terms of total investment, it would take thousands of hours before the higher fuel price would offset the less expensive cost of the engine.

However, elimination of the road-tax component in the price of petrol would be a great encouragement to development of outboard mechanization. Some Governments have recognized that these taxes should not be levied on fishermen and farmers. But most Governments are still reluctant to grant tax privileges to certain occupational groups.

A good way of turning heavily taxed petrol to the benefit of fisheries is practised in Jamaica. By November, 1963 (after seven years' operation), the Jamaican Fisheries Division had delivered 1,057 outboards to fishermen on long-term payment arrangements, for a total value of £134,210 (of which £121,940 already was repaid). The normal price of petrol was four shillings per Imperial gallon, but fishermen were allowed to buy it tax-free for two shillings. If a fisherman did not meet the instalment payment on his motor, he was asked to pay an extra shilling per gallon for fuel.

The cheaper fuel was a good incentive towards keeping up motor payments. But even the defaulters had to pay only three shillings, which meant they were still interested in buying from the Fisheries Division fuel supply. As the petrol was already mixed with oil, there was little risk that it would be used for non-fishing purposes. In total, 1,872,600 Imperial gallons had been sold. Incidentally, that amount of fuel had produced some £1,000,000 worth of fish.

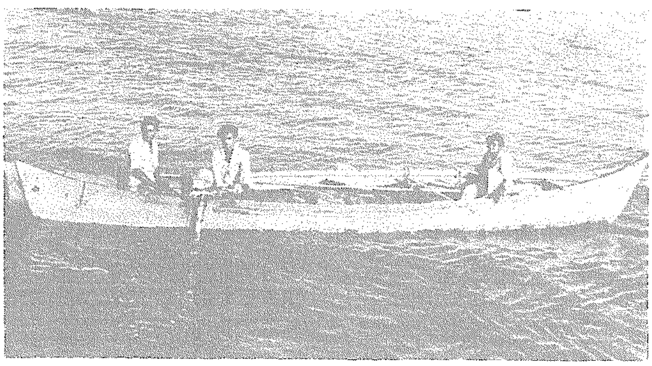


Fig. 15: *Outboards are now used in Indian fisheries only in the north-western state, Gujarat. Outboards are placed by a rather simple arrangement on the side, but interfere somewhat with handling gear over the gunwale.*

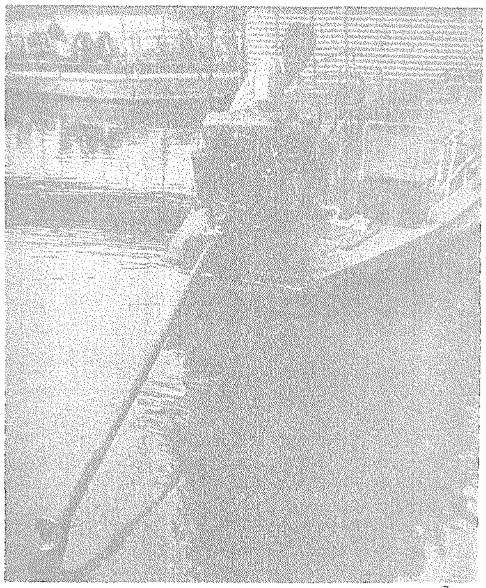


Fig. 16: *In Thailand many boats are propelled by stationary petrol engines with shafts and propellers added. This system is inexpensive and has become popular, mainly for inshore use. (FAO photo by Peter S. Hatfield.)*

Due to resistance against petrol as a fuel for fishing boats and due to the difficulties in modifying existing petrol taxes, it has been felt desirable for a long time to see the development of a diesel outboard motor. A few prototypes have been demonstrated, but there seems no way to produce these motors at a cheaper cost than a comparable inboard diesel. It seems more realistic to plan for the rational utilization of petrol-powered, or possibly kerosene-powered outboard motors.

Interesting Development

There has been an interesting development in Thailand during the last few years, where local firms have converted stationary petrol engines for marine use. Fig. 16 shows how the crankshaft has been extended and equipped with a propeller. This move has produced very inexpensive units which have worked especially well in inland waters.

In its work on outboard mechanization, FAO is now able to say that the outboard has proved a valuable tool for certain stages of fisheries development. Much remains to be done.

But, even so, fishing with the "motorbike of the industry" seems a good prospect for hundreds of thousands of tropical fishermen who now must merely watch the distant grounds and wonder what luck they will have today with paddle and sail.

MECHANIZATION OF SMALL FISHING CRAFT

Section II: Inboard engines in open craft

Development

PHASES IN THE TRANSITION TO MECHANIZED VESSELS

P. GURTNER

FOUR distinct phases of development may be observed during the transition from non-mechanized indigenous boat to fully mechanized, small fishing vessel.

(a) Mechanization

By this we mean the simple addition of motive power to the otherwise unchanged indigenous boat. The power would be in the form of an outboard or an inboard marine engine, the choice for the latter being widened by the availability of both petrol and diesel engines, while the outboard motor would be a petrol engine in the absence, as yet, of a suitable diesel outboard.

This sounds simple, unfortunately it is not. The boats, with which we are concerned here, have normally been built as sailing or rowing boats, and their construction is rarely strong enough longitudinally to support the installation of an engine, the stresses set up by the engine in motion and the interaction between propeller and hull. It will, therefore, normally be necessary to strengthen the hull structure of the boat to avoid costly breakdowns.

Should an inboard engine be considered, the hulls will have to be strengthened by the addition of substantial floor timbers (timbers running across the keel and tying the two halves of the boat together, so to speak), by the fitting of a number of internal stringers, as nearly as possible following the bulge of the bilge if such is apparent, and the introduction of long engine bearers or engine stringers, securely fastened to the hull through the floors.

An outboard motor would require less substantial strengthening, but in this case the fittings required to attach the motor to the hull will have to be very strong, and made in such a way that they can absorb the greater part of any vibrations set up by the motor in motion. It will also be recognized that a flimsy mounting for an outboard motor might easily result in the loss of the motor at sea.

Before any such mechanization is attempted, the boats considered should under all circumstances be inspected by an expert. It is not possible to mechanize just anything successfully, and certain types of craft will more readily adapt themselves to an inboard mechanization, while others, like catamarans, could only be considered for outboard use. Further, it will be important to assess the possibilities of the boat under consideration for mechanization regarding an effective increase of its returns after mechanization. The economics of the operation must be considered, since the addition of an engine to an indigenous boat often represents an investment equal to or higher than the original cost of the boat, and it is evident that the resulting catches of fish must be considerable in order just to pay for the engine. If this is all that results, mechanization would hardly be called for. But it should also have the secondary result of allowing the fishermen concerned slowly to increase their standard of living and pave the way for any one of the later phases of development.

(b) Design Adaptation

The natural step to follow any pure mechanization programme would be an attempt to improve the boats in a given locality by adapting their design to the installation of an engine. This would mean the provision of sufficient longitudinal strength members from the beginning, as well as the possible readjustment of the boat's dimensions to make it really suitable for mechanical propulsion.

To mention a concrete example; the Tuticorin canoe from Madras State in India was first mechanized by installing small, air-cooled diesel engines internally. The operation proved to be a success, and the boat was then redesigned, retaining its local flair almost completely, but being nevertheless transformed into a good power boat, with increased beam, a narrow transom stern, increased longitudinal strength and considerably more space for fishing gear and catch. This improved boat could still be constructed without difficulties by the builders of the original sailing canoe.

This approach offers a number of considerable advantages since it allows the introduction of a well-conceived boat which nevertheless closely resembles what the fishermen have been used to. It had been thought at one time that this was so important, that design adaptation of indigenous craft would easily become the only successful way of introducing efficiency and greater capacity of boats into the traditional coastal fisheries in many countries.

However, this development phase depends entirely on the initial availability of a boat that lends itself to being improved and expanded in the way described above. It is hardly credible that any headway could be made by trying to redesign the catamaran rafts from the Indian East Coast, or for that matter the outrigger canoes from Ceylon. A dug-out canoe is still a dug-out canoe, even if one changes its ends somewhat, and it is not probable that it could be developed into an efficient, mechanized boat.

It is certainly interesting to note that in India the design adaptation of indigenous boats was successful in only three areas, Tuticorin as mentioned above, Kakinada on the East Coast, where a large number of redesigned Nawahs were built with good results, and the coast of Gujarat and northern Bombay, where a great variety of local sailing boat types have been first mechanized and then gradually changed in design until they now represent quite modern boats of somewhat traditional exterior appearance.

West Pakistan is a further example of a successful application of this phase, where the excellent Bedi boats have been redesigned and can now be called modern, efficient fishing boats.

(c) Foreign Designs

In places where no local boats could be found for mechanization, it has often been tried to introduce foreign designs in order to establish quickly a mechanized fleet. While this is definitely a tempting thing to do, it is also a very dangerous one, not least as the selection of the type of foreign vessel to be introduced has often to be made by insufficiently experienced people. This phase can be executed in two ways, by introducing complete boats, built and purchased abroad, or by just buying a design and having the boat built locally. Of the two, the second way of doing it holds less dangers than the first, since it will at least assure that the finished boat will be built according to local custom, will be constructed of tropical timbers in a tropical country and will therefore generally be more resistant to the attacks of rot, borers and white ants than if built of say, Norwegian or Pacific pines and similar timbers. Bringing in a foreign design would also force the planning authority of this development phase to consider carefully whether the contemplated boat could at all be constructed locally. Should this not be the case, a dangerous jump in the development sequence seems apparent, and it will be better to abandon the idea for a more modest start.

Again, it is not easy to select a design in a foreign country and try to popularise it in a far-away, awakening fishery. There is no guarantee whatsoever that a successful boat from the North Sea will also be successful in the Arabian Sea or the Bay of Bengal, not least because the boat for the latter oceans does not need to be as heavily constructed as the one for the former. A strict takeover of a certain design could then easily result in a terrific waste of timber, could even result in a very unsound boat due to the difference in specific weight of the timbers used. If it turned out to be reasonably successful, it could even have the further disadvantage of convincing the conservative fishermen that this was the real thing, and any later attempts at introducing a better planned, better conceived boat of true national origin could well meet with considerable resistance on the part of the fishermen.

To import ready-made small, wooden boats does not seem to be a good idea, as it lacks any possibility to control construction and layout for best possible use in the country of destination. We believe that it should be possible in practically all countries to construct locally small, wooden boats of at least up to 45 ft. If no such possibility appears to be at hand, it may be argued that the particular community is not yet ready for a jump from its indigenous craft to the more modern, inboard mechanized boat, and the training of boatbuilders would become of first rate importance.

On the other hand, one may advocate the importation of larger vessels, such as steel trawlers or purse seiners for experimental purposes under strict control, if no substantial ship building industry is available locally. This is, however, outside the scope of this paper, as it touches the complex problems of introducing advanced industrial methods into the fishing industry.

It must be recognized that this development phase has been adopted in the past usually in cases where a rapid introduction of modern boat material was felt to have been necessary, and then again the boats introduced have often been equipment aided, presented by one or other aid-giving agency or in the framework of bilateral aid agreements. It is encouraging to note that in very few instances have foreign designs or boats been deliberately contracted for by development planning Governments, and that if this was done for special reasons, the operation was conducted with the greatest care and under competent technical guidance.

(d) New National Types

Wherever possible, we advocate this last development phase as the one that will bring the most lasting success and will be of great importance in a developing industry in providing continuous employment for the boat building industry, while at the same time developing this industry and training its workers to become highly qualified specialists.

Obviously, developers of new, national fishing boat types will have to consider modern trends elsewhere, will have to watch closely the needs and capabilities of the local fishermen (to avoid giving them too advanced a tool to start with) and will have to be done in closest collaboration with such national institutions as fisheries research stations, oceanographic laboratories, fisheries training institutes, etc. The work should under all circumstances be entrusted to an experienced naval architect who knows the prevailing local conditions and is capable of taking into account any limitations that might be imposed by the geography or human element of the area for which the boat is to be planned.

It has been found by experience that fishermen are generally quite ready to accept a completely new type of boat, provided any experimentation involved is not to be carried by them. They want the finished product with a guarantee that it will work. Recognizing this, it will also be seen that it should no longer be necessary to develop distinctly local types of boats, but that the development approach should be more on a regional basis. This is definitely borne out by experience in India, where it was seen that the whole coast line of the sub-continent could be divided into four separate zones, each demanding a distinct zonal approach in boat development; the concept of a separate boat for each distinguishable fishermen's community was found to be untenable.

The development of new, national fishing boat types is always a time consuming affair. It is largely a matter of trial and error, since it is not possible to design a boat on paper and furnish it with a guarantee that it will be a success, without having observed its performance under operating conditions. It is the naval architect's job to see to it that he comes as near to the optimum with the first prototype, and, if he is sufficiently experienced, he will often hit the mark with the first try. But since we speak of development, and planned development at that, it will be most important not to sit back and relax when the first prototype has been reasonably successful, but to improve immediately upon it. Thus the perfecting of even such a small boat as the 25 ft. open boat in India took almost seven years, beginning with the introduction of the 24 ft. 7 in. Pablo boats way back in 1954 and ending with the production of the third 25 ft. design in 1961.

Naval architects are a funny lot; they are hardly ever satisfied with what they produce, and they firmly believe that what seems good enough today may well be improved upon tomorrow! This can be hard on the planners at times, but it should be borne in mind that only this ever-searching approach will guarantee the eventual production of an optimal boat for a particular region and purpose.

In conclusion it may be said that each of the four phases described above might have its place in the development of a fishing industry, but that we feel that phase (*c*) should be employed as sparingly as possible, to avoid the technical pitfalls it conceals and also, not least important, because of its generally exacting demands on the foreign exchange situation of countries employing it.

Phase (*a*) would be extremely important to get the interest in mechanized fishing started, to build up an engine consciousness with the fishermen and to establish beyond doubt that much could be gained by seriously looking into further development steps.

Phase (*b*) appears to be the natural follow-up on phase (*a*) if a reasonably good boat for further development can be found. It should also naturally be introduced side by side with (*a*).

Phase (*c*)'s solely justifiable application may be in cases where fast results are important, or where bigger boats than could be produced locally are required for limited experimental or exploratory fishing projects to determine the need and the extent of fisheries development.

Phase (*d*) should be attempted wherever possible, and the following two articles deal specifically with this aspect of development of a national fleet.

Is there a way to cut your fishing costs?

(For 1964 Johnson offers 17 ways)

Take the case of the two Ceylonese fishermen in the picture. They used to sail and paddle to their fishing grounds. And they came back with 13 pounds of fish. That's worth 13 rupees in their currency. Then they got their Johnson. Now they get to their grounds in a fraction of the time and they average 140 pounds a day or 140 rupees of income.

But chances are you've already powered your operation. How can *Johnson* power help you? By giving you the power and performance you pay for. Dependably. Johnson take the time and spend the money to engineer maximum dependability in every motor that bears their name.

For example, look what we do to give you dependable performance in salt water. Drive shafts are stainless steel. Die-castings are specially coated four times. Pivot bearings are sealed. Coil and condensers are moisture-proof. Switches, starters and generators are marine sealed.

These are a few of the reasons why Johnson can offer you a full 2-year warranty covering original parts and labour on their complete line of motors—17 sizes from 3 to 150 h.p. One of them will cut your fishing costs.

Find out what Johnson can do for you. Visit your Johnson dealer. Or write a letter outlining your fishing operation. We'll make a study and send you specific recommendations on how Johnson can increase your fishing profits. There's no obligation of course. Address your letter to Outboard Marine International; Nassau, Bahamas or Bruges, Belgium.

Johnson is first in dependability

DESIGN CONSIDERATIONS—I

IT is evident that the geographical location of the country, and even the region in that country, for which a new type of mechanized fishing vessel is to be developed will have a considerable influence on the design. The broad geographical or climatic classification of the country, such as tropical, sub-tropical, temperate, will decide already a number of important features of the boat (general arrangement, accommodation, ventilation) as well as give an indication regarding the materials to be used for its construction. Tropical and sub-tropical countries generally border oceans where the warm salt water encourages electrolytic decay of ferrous metal surfaces as well as devastating attacks on timber surfaces by marine borders and other organisms. These facts will definitely have to be borne in mind when selecting the materials.

The geographical situation also has a considerable bearing on the wind and weather conditions to be expected, and these in turn can materially influence the design of a vessel. In this connection it is noted that countries with specific monsoon or other rain and storm seasons in the IPFC region will do well to examine carefully the nature of the fisheries that could be profitable during those seasons, before they embark on the development of vessel types ostensibly designed to extend a particular fishery into, or right through, such a monsoon season.

It was found, for example, that small trawlers designed specifically for shrimp fishing along the south-west coast of India need not be all-weather boats, able to stand the roughest of the south-west monsoon weather; these boats trawling for shrimp during the pre-monsoon months in close proximity to their home ports are by necessity rather small and it would be quite difficult to design them so that they could fulfill their rôle all the year round. Luckily, for the designer, he is spared this dilemma, since the shrimp does not show up near the coast during the monsoon season but would presumably only be found far off-shore.

As outlined earlier, fishing vessels of a modern conception need not follow the example of the traditional craft and be different in conception from village to village along the coastline. It is possible to plan vessels on a regional basis, but it is then important to consider very carefully the extent of such a region.

A distinct region in the sense the word as used here will be an area of a country in which the same or very similar fishing methods are principally employed, where the traditional craft show the same basic construction features and differ only in unimportant details, where largely the same timbers are or will be used for boat construction. Thus, to use India as an example, the country could be divided into five distinct zones: Gujarat and Maharashtra States, Mysore and Kerala, Madras State, Andhra Pradesh, Orissa and West Bengal.

This break-up satisfies the above-mentioned conditions, and experience has shown that it was indeed necessary to think in regional terms when designing boats in India. It is likely that a country of smaller extent than India would not show such a multitude of boat building zones, a thought that is borne out by the fact that Ceylon could be treated as an entity, as could West Pakistan, with East Pakistan naturally forming its own boat building zone.

Geography or rather hydrography of the area will have an important bearing on such decisions as maximum draft for the new boat. This dimension can be severely restricted by existing obstacles and by such man-made features as harbour entrances, canal depths. In the case of boats intended to use navigable river mouths to reach their moorings, it is of great importance to study the water depth available at these river mouths under all conditions, to ensure that boats will not run aground every so often. As a rule it will be safe to try to keep the drafts of small boats as low as possible, but this desirable restriction is also often in conflict with the need to accommodate a large diameter propeller for optimum towing efficiency.

Prevailing wind and sea conditions will also influence the design to a certain extent, especially as far as the hull shape is concerned and more specifically the shape of the forebody. Wave lengths and periods would not normally be of great importance when designing small boats, as it is extremely rare that these boats would encounter waves of such short length that they will become dangerous due to a build-up of synchronous motions. As soon as vessels of between 60 ft. and 100 ft. length are considered, however, the incidence of ocean waves in this size group over considerable periods of time in the area of operation will have to be studied.

Study of Status

A careful study of the status of the fishing industry in a particular area for which a new boat will have to be developed can only be recommended to the boat designer. Should a development be harmonious and well fitted into the general economical development of a country, it will be important to ensure a smooth transition from traditional, indigenous craft to modern mechanized boats.

The break-up into development phases already shows this thought, and it is felt that the safest course of action is indicated by a consecutive application of phases (*a*), (*b*) and (*d*). Should the basic conditions required for phases (*a*) and (*b*) not be met (availability of suitable indigenous craft), the introduction of fully mechanized, modern boat types will have to be attempted with greatest care and beginning with very small boats that do not represent too large an investment capital that might severely overtax the capabilities of the fishermen and would need state help of very great magnitude (in the form of subsidies and loans).

Likewise the introduction of modern boats will have to go hand in hand with the introduction of modern fishing methods and the gear required for increased catch efficiency. Thus it appears of utmost importance that boat development schemes should first be started in localities where capable fishermen can be found who would be able to take fullest advantage of the improved basic tool that will be put at their disposal. The combination of fishermen training centres with boat development projects is definitely a very good idea and should be encouraged wherever possible. Such combined projects would have the decided advantage of becoming catalysts in a developing industry and their influence would spread very fast with every batch of trainees leaving the establishment and being re-absorbed in the industry.

It is clear that experimentation with new boats and gear cannot be left to individual fishermen, definitely not in a fishery that suffers from chronic lack of capital and extremely low profit margins. It is in these cases that the state, the government, will have to assume the financial responsibility for any desired experimentation, be it in the form of boat or gear development or the introduction of radically new fishing methods.

It appears that it would be money well spent, if the development of an efficient fishing industry were not only attempted through the setting up of modern, scientific fisheries institutes, but if these were complemented by the equally important practical institute, entirely devoted to experimentation with new boats, methods and gear.

Economics

Modern, mechanized fishing boats are expensive to build and to equip, and it will pay to consider carefully how their increased investment value will influence the fishing industry in a given locality or area. The cost to build a boat of say 30 ft., equipped with a 20 h.p. diesel engine, will be perhaps as much as 10 times the cost of a canoe type boat of equal length. Naturally the modern boat, with its diesel power and greatly increased volume capacity has a considerably increased catch capacity. It is, however, necessary to establish in this context what should be done in addition to assure the overall supremacy of the mechanized boat.

Any modern, mechanized boat will be able to be utilized to its full capacity only if it is equipped with maximum efficient gear for the kind of fishery to be practiced. A mechanized boat utilizing inefficient gear and possibly the wrong method for a particular fishery could be at a great disadvantage vis-a-vis the indigenous craft employing the same gear and method in the same locality, simply because the mechanized boat would probably not increase its catches sufficiently to be able to show a profit.

It is thus of great importance to realise that boat development schemes should normally go hand in hand with those of gear development, and that with the new boats the proper fishing methods and gear handling techniques should be introduced. This points again, to a certain extent, towards the desirability of coupling boat development and fishermen training.

Mechanized boats, if properly equipped and utilized, could easily land catches eight to ten times as big as those landed by indigenous craft of about equal length. In addition to larger daily catches to be expected, the mechanized boat will also fish for more days in a given season, and in peak seasons in coastal fisheries might even make two trips a day instead of the indigenous craft's one.

While this is naturally the result to be worked for, the greatly increased landings of fish could possibly create distribution difficulties in areas where no storage facilities exist or where there are no fish processing plants available to take care of any surplus on the local market. It is not very likely that such increased landings will present any real problems in developed places such as Bombay, Veraval, Cochin, Madras and Calcutta in India for example, but the danger is very real if mechanized boats are concentrated in fishing villages that are not yet connected to a definite distribution chain, be it by road or rail or even by sea. In such cases a wrong move in the development could easily turn out to be a step backwards, and damage so incurred is very difficult to correct.

Experience has shown that boat costs are generally underestimated in places where the introduction of mechanized boats is taken up as a new venture, and planners are often hard-pressed to get reasonable figures for budgetary purposes in cases where state aid is planned. It is naturally not possible to give exact figures regarding the cost of boats that could be rigidly applied in all countries of the IPFC region; boat building costs fluctuate from country to country and often, especially in a big country, from coastal area to coastal area. They are largely dependent on the cost of the basic materials used, such as timber, fastenings, paint, marine hardware, the cost of engines, which may vary considerably in view of different import policies and customs regulations, the cost of labour and general overhead costs in a boat building establishment, such as land rent, electricity, charges for water, etc.

An attempt is made here to show the relative importance of these groups in the make-up of the cost for a 25 ft. open fishing boat built in South India in 1960. These figures are approximations, but they might help prospective planners to appreciate the importance of keeping in mind the whole complex and not only to calculate on material costs.

The total cost of the 25 ft. boat, excluding engine, is taken as Rs.8,500. The break-up presents itself thus:

Timber	30%	Rs.2,550
Fastenings, Paint, Copper	20%	Rs.1,700
Labour	35%	Rs.2,975
Profits, Overhead	15%	Rs.1,275
	100%	Rs.8,500

This shows how important the labour charges are, even though the daily wages for carpenters in a boatyard in India are very low. The general advance of work is very slow though, and since the yards are rarely in any way mechanized they employ a great number of daily labourers. The figure for fastenings, paint and copper plating is very high too, but it must be kept in mind that these 25 ft. boats are riveted throughout with copper rivets over washers, that exclusively copper rod bolting is used and that all screws are imported brass screws. Copper sheet of marine quality is extremely expensive in India.

It appears that considerable savings could be made if cheaper fastenings were used, if copper sheathing could become redundant by employing a much cheaper chemical bottom protection, and by introducing labour saving devices in the yards (not necessarily devices designed to cut down the number of labourers employed, but electric hand tools for example, to cut down the time used). It does not appear possible at present to save much on the timber bill which anyway, with 30 per cent. of the total is not excessive. Profits and overhead at 15 per cent. seem low, but they will tend to rise slightly as soon as the yards become more mechanized and will have to depreciate power tools, as well as running up higher monthly electricity bills with these tools in use. However, the increase should not be too marked on this post, provided the installation of power tools remains within reasonable limits.

To help judge the overall cost of a projected boat within reasonable limits of accuracy, a further set of figures is given here. These are based again on boat building prices in India during 1959–61 and could naturally be different in other countries. The costs given are for boats without engine; no electronic equipment is included, nor are trawl winches, power gurdies, net rollers or the like. The cost figures are based on two vital dimensions of the boat, length in the waterline and displacement when ready to go to sea. They are only valid within limits for boats of normal proportions and should under no circumstances be applied to projected boats of extreme dimensional relations or shapes.

As a base to these cost figures, a coefficient made up by the waterline length divided by the cube root of the displacement volume is computed. This length/displacement ratio is an indication of the boat's relative weight, i.e. a high ratio represents a lightly built boat, while a low ratio indicates a heavy boat. Costs were then computed for a series of boats on a cost per cu. ft. displacement basis, and these are shown in the table. Knowing the length of the boat contemplated, the approximate length/displacement ratio will help to find the displacement, which, multiplied by the cost per cu. ft. figure will indicate the approximate cost of the boat. The reader will note in this connection that boat costs do not rise in a linear relation with length, but in a cubic relation, i.e. by volume rather than by length. Costs are given in Indian rupees.

Length	$L/V^{1/3}$	*V cu. ft.*	*Cost/cu. ft.*	*Total cost*	*Weight*
25 ft.	5·4	100	110	11,000	light
	5·0	125		13,700	medium
30 ft.	5·3	183	115	21,100	light
	4·9	230		26,500	medium
35 ft.	5·0	345	120	41,400	light
	4·6	440		52,800	medium
	4·8	540		64,800	light
40 ft.	4·4	760	120	91,000	medium
	4·0	1000		120,000	heavy
	4·8	830		103,500	light
45 ft.	4·4	1080	125	135,000	medium
	4·0	1430		179,000	heavy
	4·7	1200		156,000	light
50 ft.	4·3	1580	130	205,000	medium
	3·9	2110		275,000	heavy
	4·7	2100		294,000	light
60 ft.	4·3	2730	140	382,000	medium
	3·9	3650		512,000	heavy

It will be evident that it pays to build boats of light weight construction, naturally provided they are soundly designed and conceived for this. The above table gives reasonably accurate results for India as is shown below for two boats that were built in 1961 and the price of which can be compared with the table result. The one boat is a 36 ft. shrimp trawler built according to an FAO design developed specifically for the shrimp trawling industry in Kerala; the other is a 36 ft. shrimp trawler built according to a foreign design and to foreign specification (northern European) for the same purpose. Both are equally powered and fish with the same gear. Their waterline length is about 33 ft.

Length	$L/V^{1/3}$	*V cu. ft.*	*Cost/cu. ft.*	*Total cost*	*Remarks*
33 ft.	4·8	330	120 Rs.	39,500 Rs.	medium heavy construction
	4·3	455		54,700 Rs.	very heavy construction

The cost figures shown represent well the actual cost of the two boats, which was Rs.40,000 for the lighter and about Rs.60,000 for the heavier boat. The larger difference from the table value for the heavier boat is mainly due to the fact that it was built in a bigger yard with larger overheads and was fitted extensively with elaborate marine hardware equipment not generally used in the area of construction.

When cost figures for fully equipped boats are required for budgetary purposes, the supplied cost of engines, stern gear (propeller, shafting and stern tube), winches, transmissions, electronic machinery, refrigeration machinery, fishing gear as well as such items of equipment like galley outfit, life saving appliances, charts, compass, anchors and chains, will have to be added to the hull cost figure. It is not possible to give an approximation for this additional cost item, since the equipment may vary considerably from boat to boat, and the cost of major items like engines depends very much on customs duties levied on imported engines, and is thus different from country to country.

DESIGN CONSIDERATIONS—II

ANYBODY engaged in fishing boat development work in a specific area must naturally be concerned with the boat building potential of the area. It would be bad policy to introduce boats which could not at all be produced in the area, or possibly in the immediate neighbourhood, and any careful approach in the development of small boats will have to take stock of the availability of the three main parts that make up a boat building industry —materials, boat yards, craftsmen.

It is of greatest importance for the designer in newly developing areas to know exactly what materials will be available for construction. Not all timbers are good boat building timbers, and then not all timbers that are useful for building dug-out canoes or log-rafts are suitable for the construction of modern type mechanized boats. Timbers have to be essentially of high strength, easy workability with such tools as planes, saw and chisels, possibly of low shrinkage and resistant to marine borers, not too heavy, available in sufficient length and girth and last, but not least, not too expensive and in ample supply.

If suitable timbers are not found in the area, it will have to be investigated where they could be found, which investigation also entails a study of transportation costs and modes of transport. Naturally, the complete lack of good boat building timbers will often mean that boat building in that area is very little developed and boats built there could easily become expensive due to the need to bring timbers from far away.

Materials Study

A study of locally available boat building materials will also comprise the evaluation of less basic materials, such as plywood, hardboards for various uses in the boats, of modern materials such as aluminium sheet, plastics of many kinds, glass fibre mat and synthetic resins. All these materials may sooner or later be of importance in an awakening boat building industry, and it is as well to be aware of their availability and to keep track of the general development of the materials market.

A word of warning about some of these materials. Plywood should only be used for marine construction work if it is truly of marine quality, meaning multi-ply and bonded with seawater resistant resins. If this quality is available, it will be found very useful and often money saving, for such parts as wheelhouse planking, bulkheads, cabin facings and sunroofs.

Considerably Advantageous

Many modern materials of the plastic and fibreglass range are now coming into use in boat building industries. These materials can offer considerable advantages over more conservative materials, but they are very often not readily available as yet and must be imported, thus being subject to heavy import duties that render them even more expensive. Furthermore, they often require considerable skill in proper application, without which they tend to become very bothersome after some time and will not stand up to strenuous service on small fishing boats. It is felt that the use of these materials in small fishing boats, especially in tropical and sub-tropical countries, needs to be carefully investigated before their application can be unreservedly recommended.

Metals of many descriptions are also of great importance. All fastenings used, nails, rivets, screws, bolts, drifts, etc., should be of corrosion resistant materials, or should at least be corrosion protected, in the case of iron fastenings by hot-dip galvanization. The same applies to metal fittings, such as eye plates and bolts for the rigging, mast bands and goosenecks, rigging screws, cleats and clamps, cable rollers, hawse pipes, anchor fittings, etc. All these can be made profitably of galvanized iron or mild steel, while it will be of advantage to cast rudder fittings and sterntube flanges, as well as propellers, of bronze. If the boat's bottom is to be copper sheathed for protection, the copper sheet has to be tacked on with copper tacks, not aluminium or brass tacks, or even iron ones!

Paints of marine grade are probably available in all countries bordering on the sea, but it will be well for the designer to acquaint himself with the makes and types of paints on the particular local market, as well as of such products as antifouling compounds and timber protection liquids. The use of the latter would appear of great importance in tropical countries, where timbers have a tendency of being attacked by borers, bark beetles, white ants and the like, and where the life of a boat could be greatly extended if the timbers used in its construction were properly treated during construction to avoid early decay and destruction of vital parts.

International Trend

It is true that in a number of countries steel is successfully displacing the more traditional wood even for fairly small boats. This is particularly the case in Holland, but increasingly so in Denmark and other European countries. It is difficult to say why this should be so, one reason naturally being reduced timber supplies, in the case of Holland at least. Another reason, although perhaps not generally acknowledged, is certainly to be found in the rigid adherence to outmoded construction methods and scantlings which increase the price of wooden boats beyond that of comparable steel constructions and therefore tend to undercut the possibility to compete with the steel building industry.

We firmly hold that a revision of the scantling rules at present in force in many countries, coupled with the application of modern production methods, could cut off a considerable slice from the high price of wooden boats and could make wooden boat building a highly competitive industry again.

Points to Consider

While this reasoning would hold true particularly in Europe, there are other important points to consider in this connection when the question wood or steel is brought up in the countries of the IPFC region. We consider it inopportune for this region to embark on steel fishing boat building projects for boats below 65 ft. except, perhaps, for countries possessing a very well developed steel industry.

It must be remembered that most countries in the region have considerable natural timber supplies that can be utilized for boat building.

We observe that small fishing boats will be employed in areas where maintenance facilities for steel boats would be lacking, an extremely important point along the coasts of tropical and sub-tropical countries, where steel boats require absolutely rigid adherence to maintenance schedules to avoid dangerous corrosion damage.

We are sure that a sound design development with a view to introducing step by step modern building methods and modern material treatment (bent frame construction, laminations for example) will keep wooden boat prices lower than those for steel boats, at least up to a limit. It is naturally not easy to establish this limit, but at present we feel it to be in the neighbourhood of 65 ft. overall. This means that small boats are cheaper built in wood, are easier maintained, are important products for small scale industries and thus of importance in any developing economy.

Boatyards

A study of available boatyards and their facilities will constitute an important part of the basic observations required before starting a boat design project in a given locality. Boatyards previously used to constructing indigenous craft will often be too limited in size and equipment to handle modern boats successfully, and extensions will have to be undertaken in these cases. However, since we strongly advocate a step by step approach it will be best to let the yards grow as the demand for boats grows.

It is advisable to start any boat development project in a locality with an established boatyard that can handle the boats foreseen for the immediate future. This will facilitate a strict control of the yard's activities by the personnel charged with the development of the boat designs and will assure better adherence to their instructions.

To avoid possible financial disappointments during the first development stages, it will be of advantage not to embark on too ambitious a programme of boatyard construction or extension, before the types to be built ultimately are well established and known. It is best to try to utilize the available construction facilities and improve them step by step, at least as long as no large scale boat building programmes are taken up. In this way the yards will become an integral part of the fishing boat development and they will only expand according to need.

It should be remembered that boat building is a capital-starved industry, working on extremely small margins of profits and usually relying on partial advance payment for orders to be able to lay in stocks of materials and to pay labour at regular intervals. If large numbers of boats are ordered, as will often be the case with government orders, a sensible system of staggered payments should be agreed upon, and it appears unreasonable to ask small boatyards to deposit securities against payment of advances. The staggered payments should be so calculated that the boats under construction represent sufficient security during their progress to completion.

One important aspect of financing is the need to provide developing yards with development capital. If the yards are to build low priced boats, they will not find it possible to make their profits sufficiently high to reinvest substantial sums in improvements to the yard, in timber and other material stocks and in facilities for their workers. It would be useful if governments who decide to invest in boatyards would do so by giving small industries development loans to the existing yards rather than by creating new, state-owned boat-building facilities. They would in this way assure a better utilization of the existing facilities as well as avoid getting entangled in the administration of such marginal production centres as yards.

Experience has shown that it is extremely difficult for any government to run a boatyard efficiently—for a multitude of reasons—and it may be expected that this would apply to countries whose governments would have great difficulties in finding experienced personnel for the running of such yards.

Craftsmen

The availability of good carpenters and joiners is of first importance for the success of any boat development scheme. It is thought that skilled carpenters are generally available in most countries in the East, but it may not always be simple to find them and regroup them in the boat building industry. In many countries boat building has been a traditional industry for hundreds of years, only to decline and deteriorate during the last century or so. In these countries one will often find definite families or tribes who were hitherto engaged exclusively in boat building activities.

Their present day members may be found in the building trade as house carpenters, as cabinet makers or in the newly important handicraft industries. If this type of labour is available, it will not be difficult to build up a modern boat building industry, since all that is needed is some supervision in the yards and a little training for these rehabilitated workers.

In the absence of an actual or concealed labour force that can be mobilized for a new boat building venture, the process of forming the necessary professional men will be more complicated, as it will entail very detailed training of carpenters in the exacting trades of ship's carpentry and joinery.

What will have to be undertaken in most cases, however, regardless of whether a boat building labour force is already available or not, is a thorough training of the workers in the art of reading drawings. Modern, efficient boats have to be built according to drawings, and the interpretation of a naval architect's drawings is usually not the strong point of traditional builders. It is of utmost importance that these drawings are accurately and correctly interpreted.

The quality of the labour to be entrusted with the construction of a new type of boat might in many cases have a noticeable influence on the design proposed, if it is prepared on the spot and taking all the various influences mentioned in this chapter into fullest consideration. It will be seen that it would be most unlikely to find a design that would be adjusted to the particular circumstances of a given country if this design was purchased abroad, or if it was prepared by somebody not acquainted with the country and the prevailing conditions in its fishing industry.

It will also explain why we do not generally recommend the adoption of a design that was prepared in and for Ceylon, for example, in any other country of the region, without one of FAO's naval architects having had a chance to study that country's fishery set-up on the spot, to decide whether the Ceylon design could be adopted successfully, or whether a different approach would be called for.

Open fishing craft with inboard engines

JAN-OLOF TRAUNG

ONE important question which has to be discussed carefully is the problem of the minimum economic size of fishing craft for an inboard engine. The minimum possible size is perhaps 18 ft. (5·5 m.), with an air-cooled mini-diesel of, say, 3½ to 5 hp.

Many fishing craft are built to a length of 20 to 22 ft. (6 to 6·7 m.) with somewhat larger inboard diesels, but it is doubtful whether even this size is economic.

While 18 ft. hardly permits any decking, the 22 ft. size permits a small fore-deck and perhaps even a combined roof and engine hatch.

In general construction, disregarding the increased cost of material, a wooden box, for example, can be made 50 per cent. larger with no increase in cost. Roughly the same type of argument applies to boat construction, if the general arrangement and layout is unchanged. It is not necessarily easier to make a boat small. On the contrary, small boats with light scantlings very often require better craftmanship and more precise work in fastening and in other connections.

Material Costs

Thus the number of working hours to produce an 18 ft. open boat will not necessarily be smaller than the number of hours to produce a 24 to 25 ft. (7·3 to 7·6 m.) boat. Naturally, there will be an increase in the cost of material. But the larger boat will not necessarily require a larger engine, because increased length often offsets the increased resistance caused by greater hull weight.

While it is possible to build small boats for inboard engines, it is obvious that the engine occupies a comparatively greater proportion of the volume of the boat and creates a real obstacle for the crew. At the same time it is becoming more and more obvious that outboard power is the logical choice, not only for the majority of existing craft in developing countries, but also for smaller types of fishing craft in developed countries.

David D. Beach describes, in "Fishing Boats of the World: 2" (Fishing News (Books) Ltd.), the use of outboard-powered commercial fishing craft in U.S.A. The larger of these are 25 to 28 ft. (7·6 to 7·8 m.) long and have comparatively large fore-decks and small roofs.

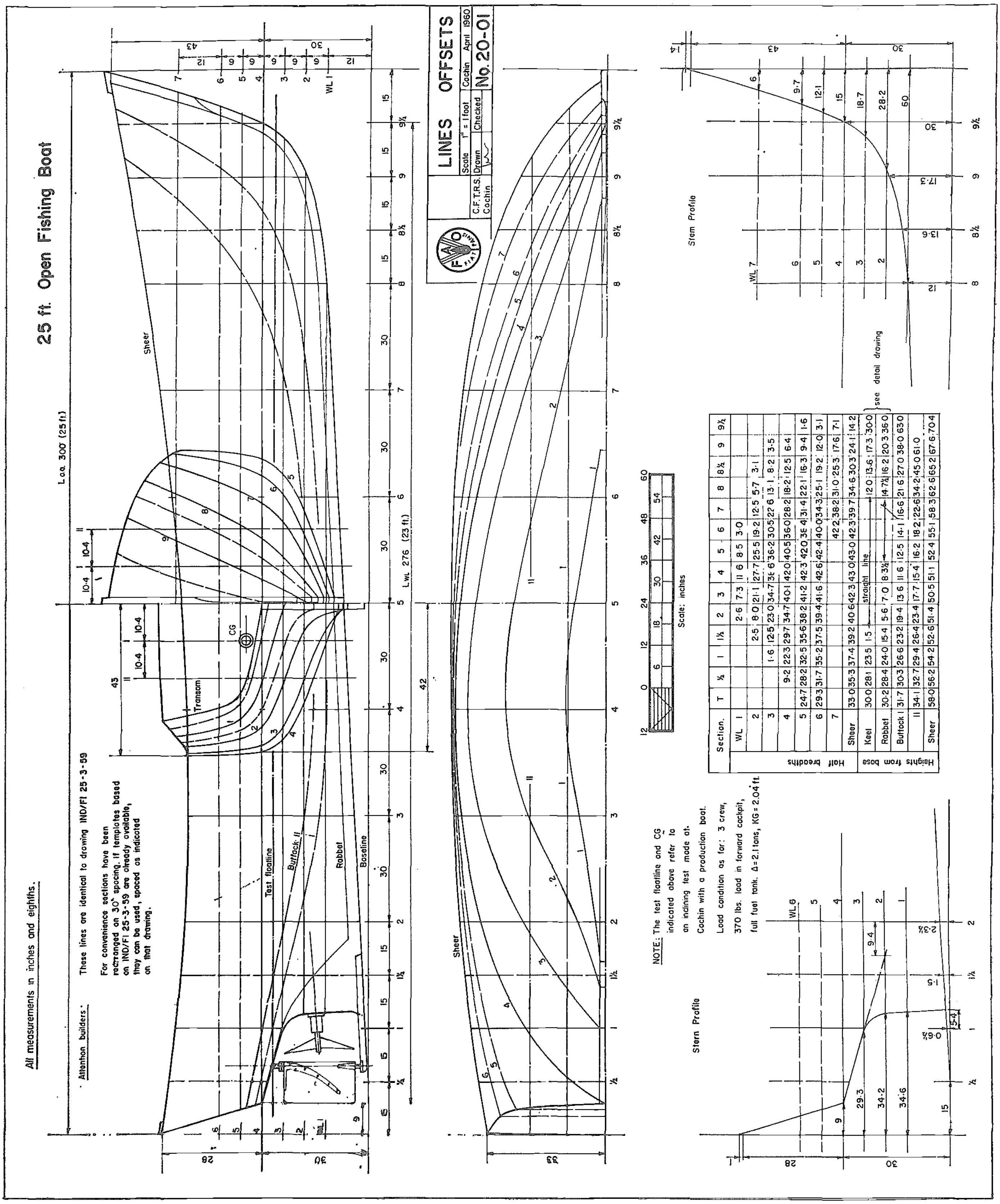
Hardly Practical

It has been the experience of the Fishing Boat Section of FAO that it is hardly practical to build a new fishing craft of less than 25 ft. (7·6 m.) for use with an inboard engine. Many of these *have* been built and it has been felt that even this length is too short to permit an adequate layout for several different fishing methods.

Figs. 1, 2 and 3 show lines, construction and details, as well as alternative layouts, for a 25 ft. (7·6 m.) open fishing boat developed by FAO naval architect, Peter Gurtner, while working in India. These drawings incorporate the experience gained from the construction of a great many similar boats throughout some seven years.

FAO had imported into India several Danish and Norwegian-built boats to be used by her master-fishermen as fishing platforms rather than prototypes for future construction. These boats were first copied by Indian boatbuilders and then improved upon with assistance of FAO naval architects to make them suit Indian conditions. The present three drawings are the final outcome of this work.

A study of Figs. 2 and 3 will show that very few arrangements have been made for handling any specific type of



Section.		T	½	1	1½	2	3	4	5	6	7	8	8½	9	9½
Half breadths	WL 1					2·6	7·3	11·6	8·5	3·0					
	2				2·5	8·0	21·1	27·7	25·5	19·2	12·5	5·7	3·1		
	3			1·6	12·5	23·0	34·7	36·6	36·2	30·5	22·6	13·1	8·2	3·5	
	4		9·2	22·3	29·7	34·7	40·1	42·0	40·5	36·0	28·2	18·2	12·5	6·4	
	5	24·7	28·2	32·5	35·6	38·2	41·2	42·3	42·0	38·4	31·4	22·1	16·3	9·4	1·6
	6	29·3	31·7	35·2	37·5	39·4	41·6	42·6	42·4	40·0	34·3	25·1	19·2	12·0	3·1
	7									42·2	38·2	31·0	25·3	17·6	7·1
	Sheer	33·0	35·3	37·4	39·2	40·6	42·3	43·0	43·0	42·3	39·7	34·6	30·3	24·1	14·2
Heights from base	Keel	30·0	28·1	23·5	1·5	straight line						12·0	13·6	17·3	30·0
	Rabbet	30·2	28·4	24·0	15·4	5·6	7·0	8·3½				14·7½	16·2	20·3	36·0
	Buttock I	31·7	30·3	26·6	23·2	19·4	13·6	11·6	12·5	14·1	16·6	21·6	27·0	38·0	63·0
	II	34·1	32·7	29·4	26·4	23·4	17·7	15·4	16·2	18·2	22·6	34·2	45·0	61·0	
	Sheer	58·0	56·2	54·2	52·6	51·4	50·5	51·1	52·4	55·1	58·3	62·6	65·2	67·6	70·4

FIG. 1.

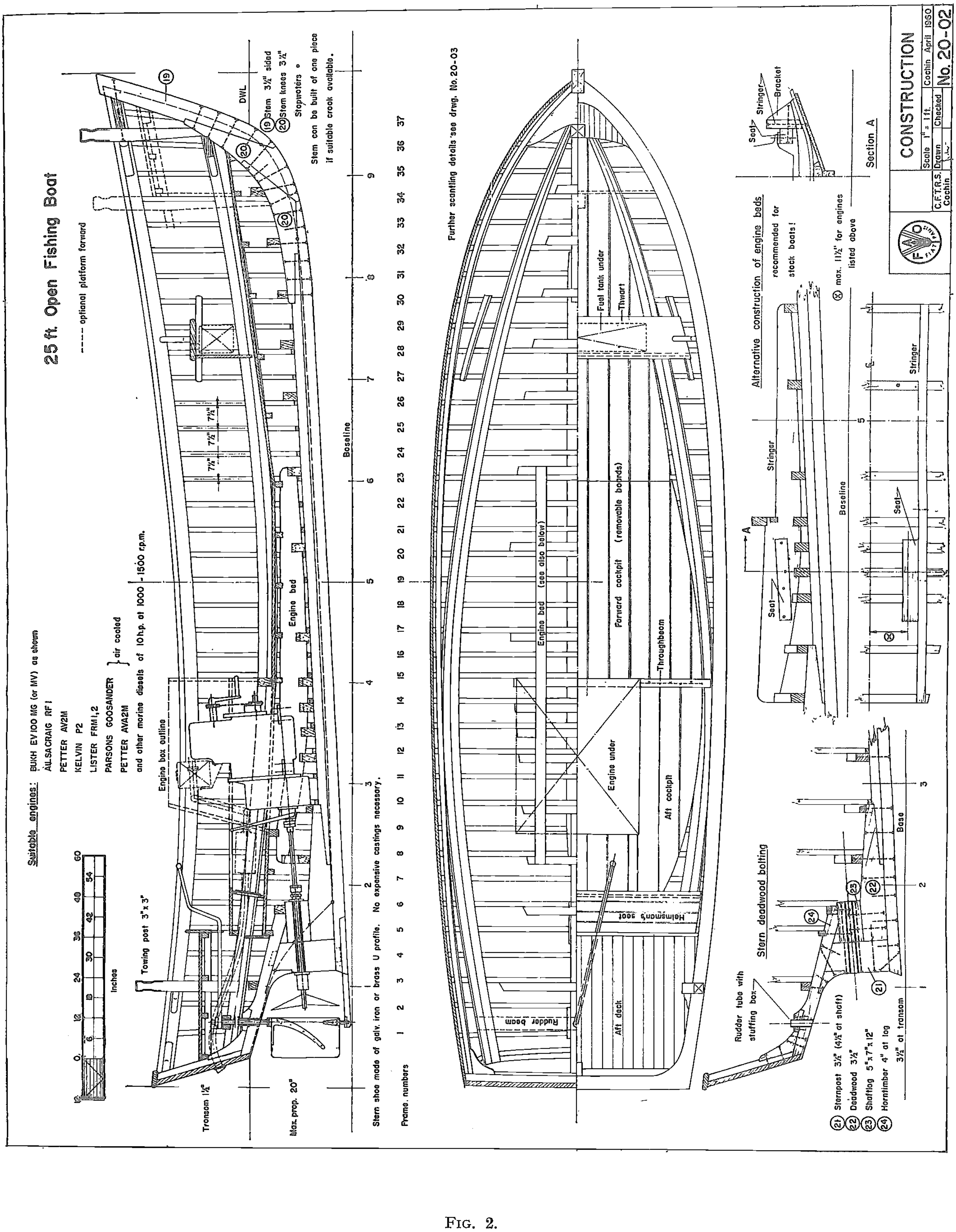

25 ft. Open Fishing Boat
---- optional platform forward
Suitable engines: BUKH EV100 MG (or MV) as shown
AILSACRAIG RF1
PETTER AV2M
KELVIN P2
LISTER FRM1,2
PARSONS GOOSANDER
PETTER AVA2M
air cooled
and other marine diesels of 10 h.p. at 1000 - 1500 r.p.m.
Inches
Towing post 3" x 3"
Transom 1½"
Max. prop. 20"
Engine box outline
Engine bed
Baseline
DWL
Stern shoe made of galv. iron or brass U profile. No expensive castings necessary.
Frame numbers
19 Stem 3½" sided
20 Stem knees 3½"
Stopwaters
Stem can be built of one piece if suitable crook available.
Further scantling details see drwg. No. 20-03
Fuel tank under
Thwart
Engine bed (see also below)
Forward cockpit (removable boards)
Throughbeam
Engine under
Aft cockpit
Helmsman's seat
Rudder beam
Aft deck
Alternative construction of engine beds recommended for stock boats!
max. 11½" for engines listed above
Stringer
Seat
Section A
Bracket
Stern deadwood bolting
Rudder tube with stuffing box
Base
21 Sternpost 3½" (4½" at shaft)
22 Deadwood 3½"
23 Shaftlog 5" x 7" x 12"
24 Horntimber 4" at log 3½" at transom
CONSTRUCTION
Scale 1" = 1 ft.
Cochin April 1960
C.F.T.R.S. Cochin
Drawn
Checked
No. 20-02

FIG. 2.

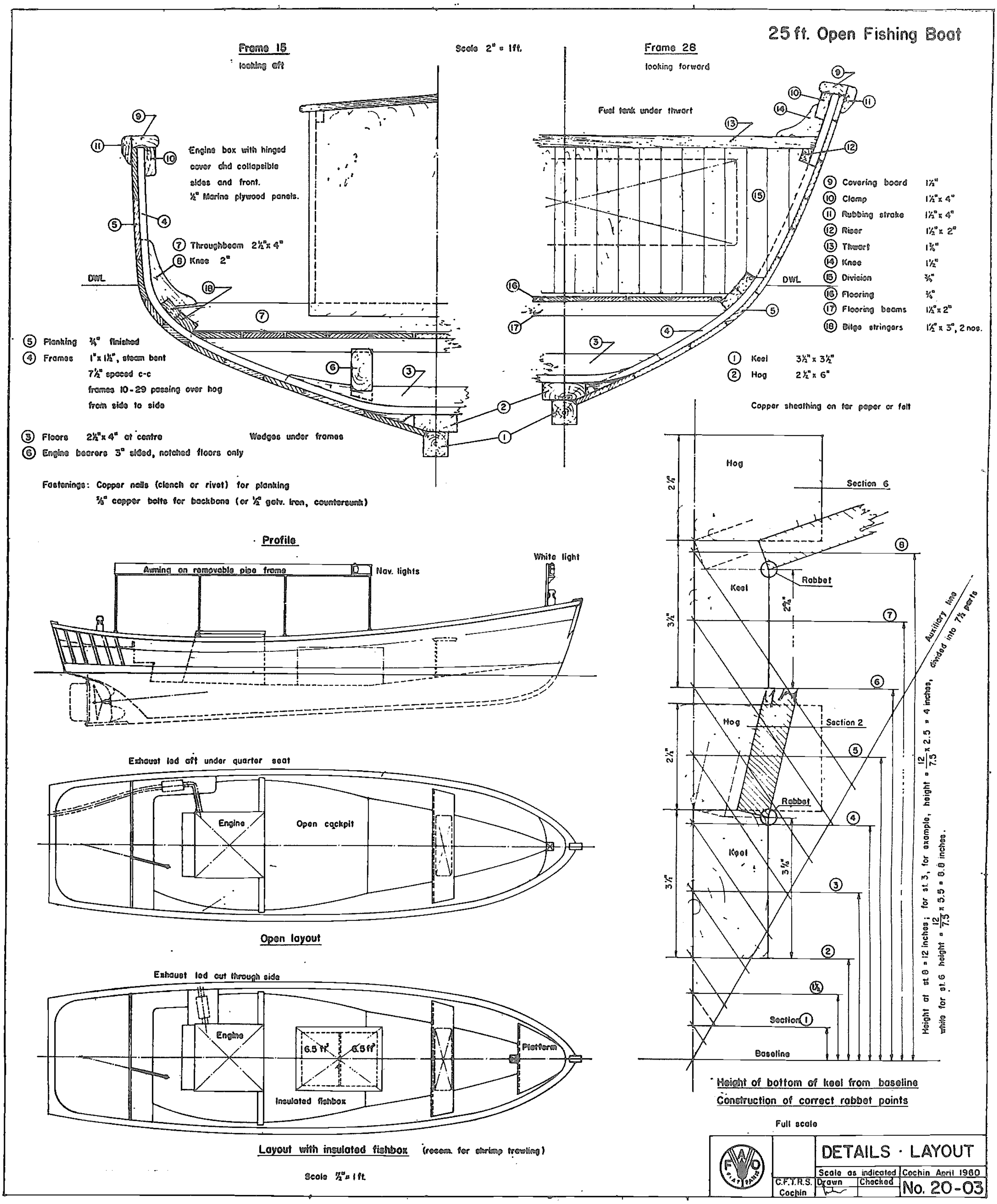

25 ft. Open Fishing Boat
Frame 15
looking aft
Scale 2" = 1ft.
Frame 28
looking forward
Engine box with hinged cover and collapsible sides and front.
½" Marine plywood panels.
Fuel tank under thwart
⑦ Throughbeam 2½"x 4"
⑧ Knee 2"
DWL
⑨ Covering board 1½"
⑩ Clamp 1½"x 4"
⑪ Rubbing strake 1½"x 4"
⑫ Riser 1½"x 2"
⑬ Thwart 1½"
⑭ Knee 1½"
⑮ Division ¾"
⑯ Flooring ¾"
⑰ Flooring beams 1½"x 2"
⑱ Bilge stringers 1½"x 3", 2 nos.
① Keel 3½"x 3½"
② Hog 2½"x 6"
Copper sheathing on tar paper or felt
⑤ Planking ¾" finished
④ Frames 1"x 1½", steam bent
7½" spaced c-c
frames 10-29 passing over hog
from side to side
③ Floors 2½"x 4" at centre
Wedges under frames
⑥ Engine bearers 3" sided, notched floors only
Fastenings: Copper nails (clench or rivet) for planking
⅝" copper bolts for backbone (or ½" galv. iron, countersunk)
Profile
Awning on removable pipe frame
Nav. lights
White light
Exhaust led aft under quarter seat
Engine
Open cockpit
Open layout
Exhaust led out through side
Engine
6.5 ft³
6.5 ft³
Platform
Insulated fishbox
Layout with insulated fishbox (recom. for shrimp trawling)
Scale ⅞" = 1 ft.
Hog
Section 6
Rabbet
Keel
Auxiliary line divided into 7½ parts
Section 2
Section ①
Baseline
Height at st 8 = 12 inches; for st. 3, for example, height = 12/7.5 x 2.5 = 4 inches, while for st. 6 height = 12/7.5 x 5.5 = 8.8 inches.
Height of bottom of keel from baseline
Construction of correct rabbet points
Full scale
DETAILS · LAYOUT
Scale as indicated
Cochin April 1960
C.F.T.R.S. Cochin
Drawn
Checked
No. 20-03

Fig. 3.

fishing gear. These boats are mostly being used for dragging a small trawl, which is simply hand-hauled. The boats can also be used for gillnetting, for example, with drift nets and bottom-set nets, as well as for handlining and longlining. The range is normally limited to shallow waters within sight of the coast.

Fig. 3 shows the boat with an insulated fish box, with a capacity of 13 cu. ft. (0·37 cu. m.). This emphasizes the need, even in such small craft, to keep fish protected from the hot sun. Fig. 3 also shows an awning, a most important part of the equipment on a tropical fishing boat, but which greatly restricts crew mobility and fishing efficiency.

Using Figs. 1 to 3, plus a careful building specification, such boats can be built to a good standard and the Government of India, through its Central Institute of Fisheries Technology in Cochin, has published these drawings in a booklet entitled "25 ft. Open Power Fishing Boat."

Perspective Views

Another way to illustrate for local builders the shape of the boat to be built is shown in Fig. 4, which shows perspective views of the lines of the 25-footer, prepared using a special perspective drawing machine developed for building houses.

Fig. 5 shows a somewhat smaller boat of entirely different design, made by Kjeld Rasmussen (Denmark) when he worked as FAO naval architect to the Government of Trinidad. His job was to develop a small—and cheap—inboard powered boat for shrimp trawling in the Gulf of Paria and the drawing shows how he intends to handle the 25 ft. hand-hauled nylon trawl.

Fig. 6 shows the V-bottom lines, with a tunnel to decrease the draught as much as possible. This drawing was made as a design study and Rasmussen suggested building and trying a prototype before production.

The V-bottom design for small boats has much to offer, especially if they are built of marine plywood, which is now being made in increasing quantities. (This work is promoted by the FAO Forestry Division.) FAO frequently recommends using marine plywood because it is high quality material. Similarly, FAO recommends steambent frames which many people argue are better, but much more expensive, than sawn frames. But, it is impossible to steambend frames which are not of good material. Thus, in using a more expensive method of construction, there is an automatic check on quality, which often means economy in the end.

Unfortunately, unscrupulous builders try to save when building larger boats on government contracts by using inferior, insufficiently dry timber, by not using sufficiently protected fastenings, and by other cost-cutting measures.

Plywood construction used in conjunction with glass-reinforced plastic chines is specified for the beach boat shown in Fig. 7, and produces extremely strong construction. This 24-footer (7·3 m.) shows an interesting off-centre engine arrangement. It was originally developed to get the propeller on the side of the keel because it was found impossible to make the rudder fitting sufficiently

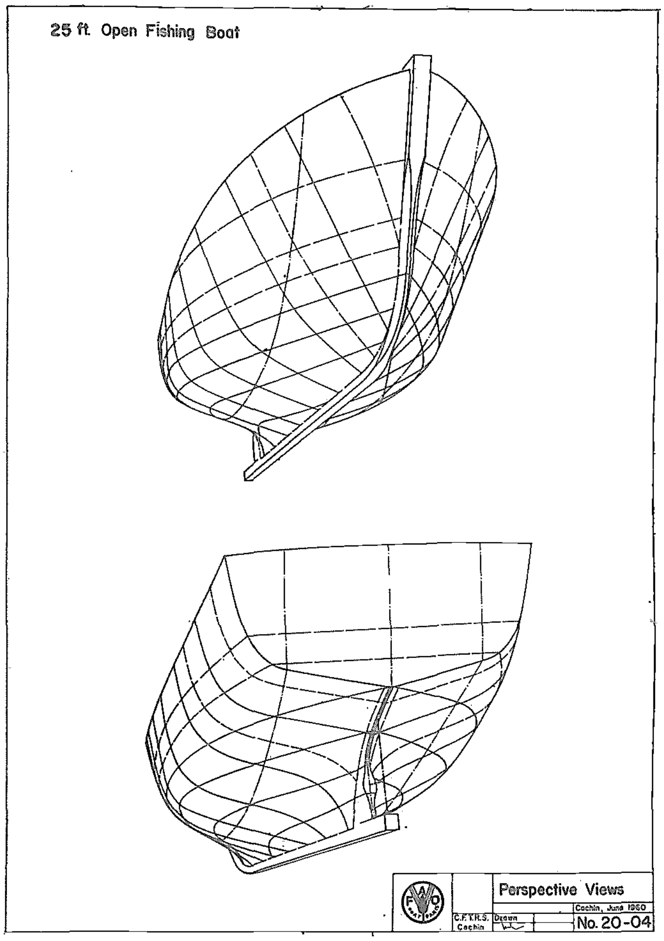


FIG. 4.

strong when the boat was being beached. This produced an added advantage; a clear passageway from the helmsman to midships, where the fishing gear is normally stored.

Again, this 24-footer shows the efforts we take to make boat size economical. Earlier, beach boats of 18 to 20 ft. (5·5 to 6·1 m.) had been developed but although they could be handled much more easily on the beach, they could carry only a few nets and fishing was not sufficiently profitable.

With the box philosophy of construction cost in mind, a larger version of the 24-footer (Fig. 8) was developed by Curt S. Ohlsson (Sweden), working as FAO naval architect on the development of boats for Lake Chad, Africa. This boat is 30 ft. (9·15 m.).

Fig. 9 shows a typical inboard-powered open craft which was an improvement on existing craft. It is a 25 ft. (7·7 m.) launch, suitable for two-boat purse seining and beaching and was designed by Howard Chapelle, the famous U.S. yacht and small craft designer, now Curator of Transportation at the Smithsonian Institution, Washington, D.C., while working as FAO naval architect in Turkey. It retains the typical sheer used by the Turkish fishermen and is an example of how FAO naval architects sometimes study a good local type and introduce improvements.

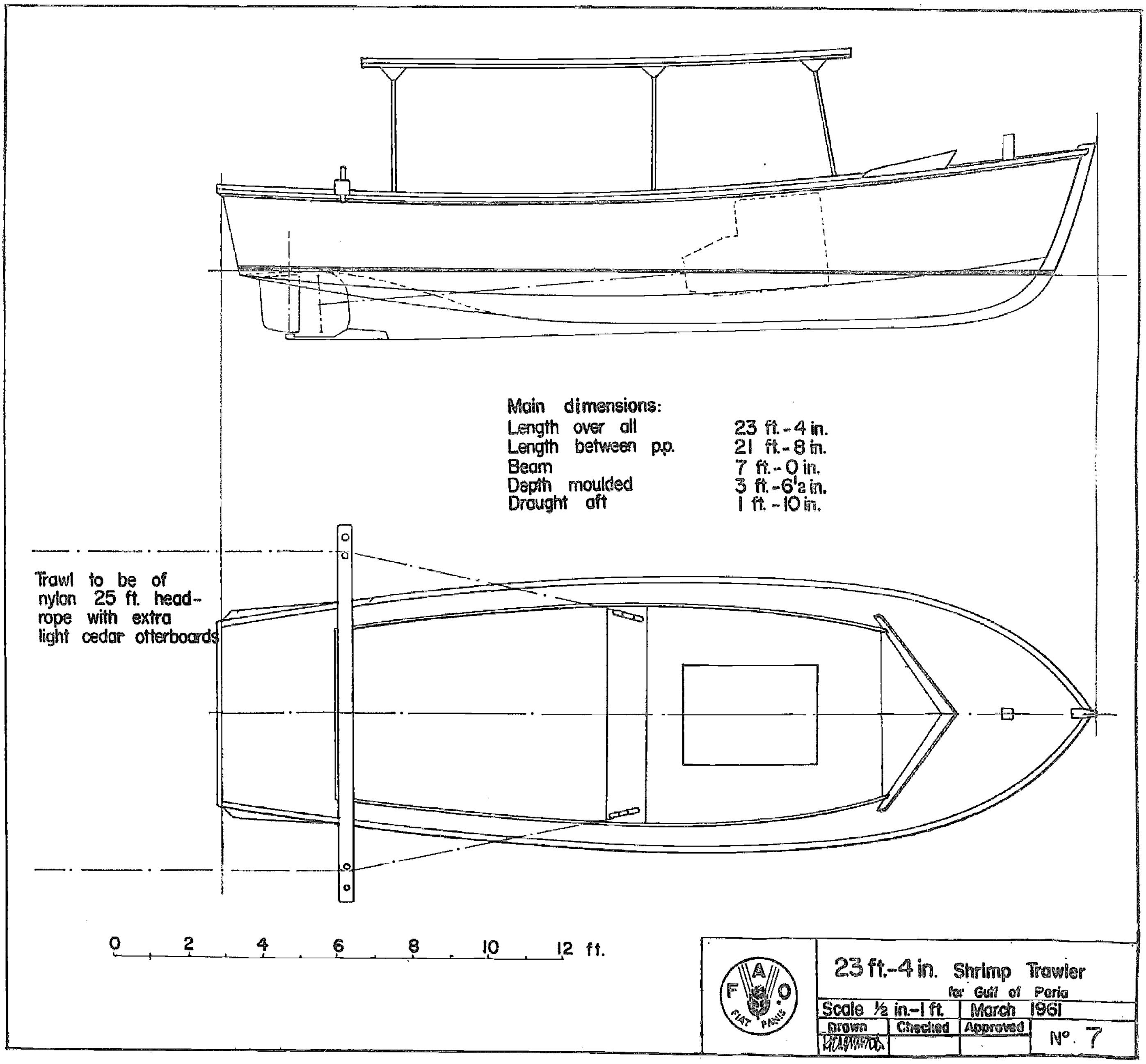


FIG. 5.

It is obvious that any boat with an inboard engine must be 24 to 25 ft. long to be practical. Figs. 10, 11 and 12 show a somewhat larger size which is necessary to vary the inside arrangement and obtain a few alternatives.

These figures show a 27½ ft. (8·4 m.) hull, 8 ft. 4 in. (2·54 m.) wide and built in great numbers in Ceylon. It was designed by Erik Estlander, another of FAO's naval architects. The size was determined to give the largest boat for the maximum Government load, which was £1,000 ($2,800). Elsewhere in this volume Mr. Estlander has described the engine bed arrangement in these boats and gives a construction plan.

Fig. 10, type A, shows a normal arrangement with the floor comparatively high at waterline level. On the front thwart a line hauler can be arranged, to be driven from the main engine, the casing of which is rather large, so that the crew can get inside to tend the engine. However, the casing does restrict movement from the helmsman's place aft to the fishing area midships. The boat has no facilities for storing the catch.

Incidentally, only one boat was equipped with a line hauler and that created great difficulties in installation. It is felt impractical to drive a line hauler from the main engine in small boats. Perhaps an independently-driven line hauler would solve the problem.

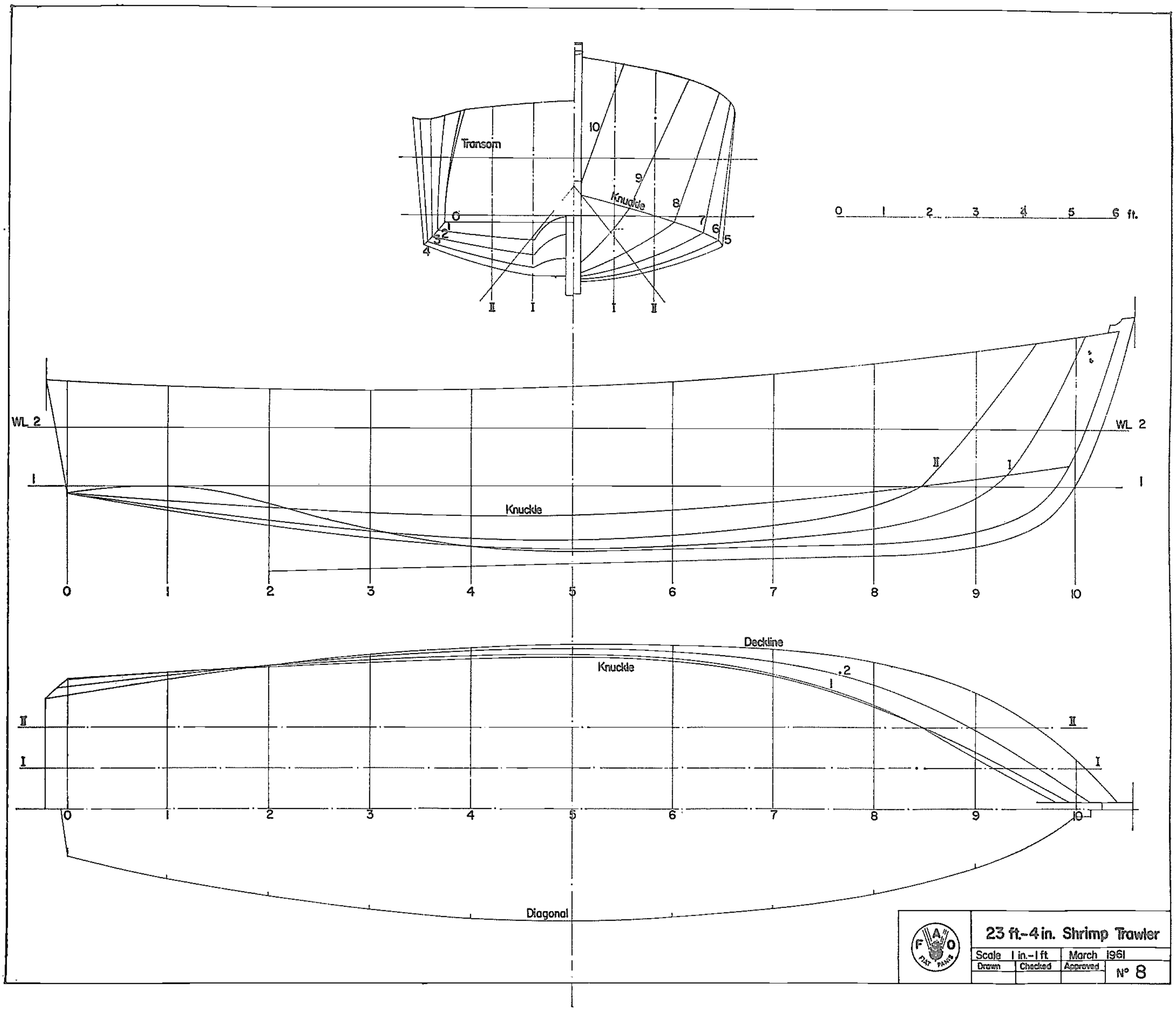


FIG. 6.

Fig. 11, type B, shows a layout where the floor has been lifted to provide for a small fish hold, part of which has even been designed to be insulated. This type was not very well received by the fishermen who reported an uneasy feeling when standing on the higher floor; their own centre of gravity was too far from the waterline and the sides of the boat formed a kind of bulwark since they were too low.

It also shows the difficulty of arranging sufficient space for storing gear and catch in small boats. The boat has a high foredeck with some space for shelter and stores.

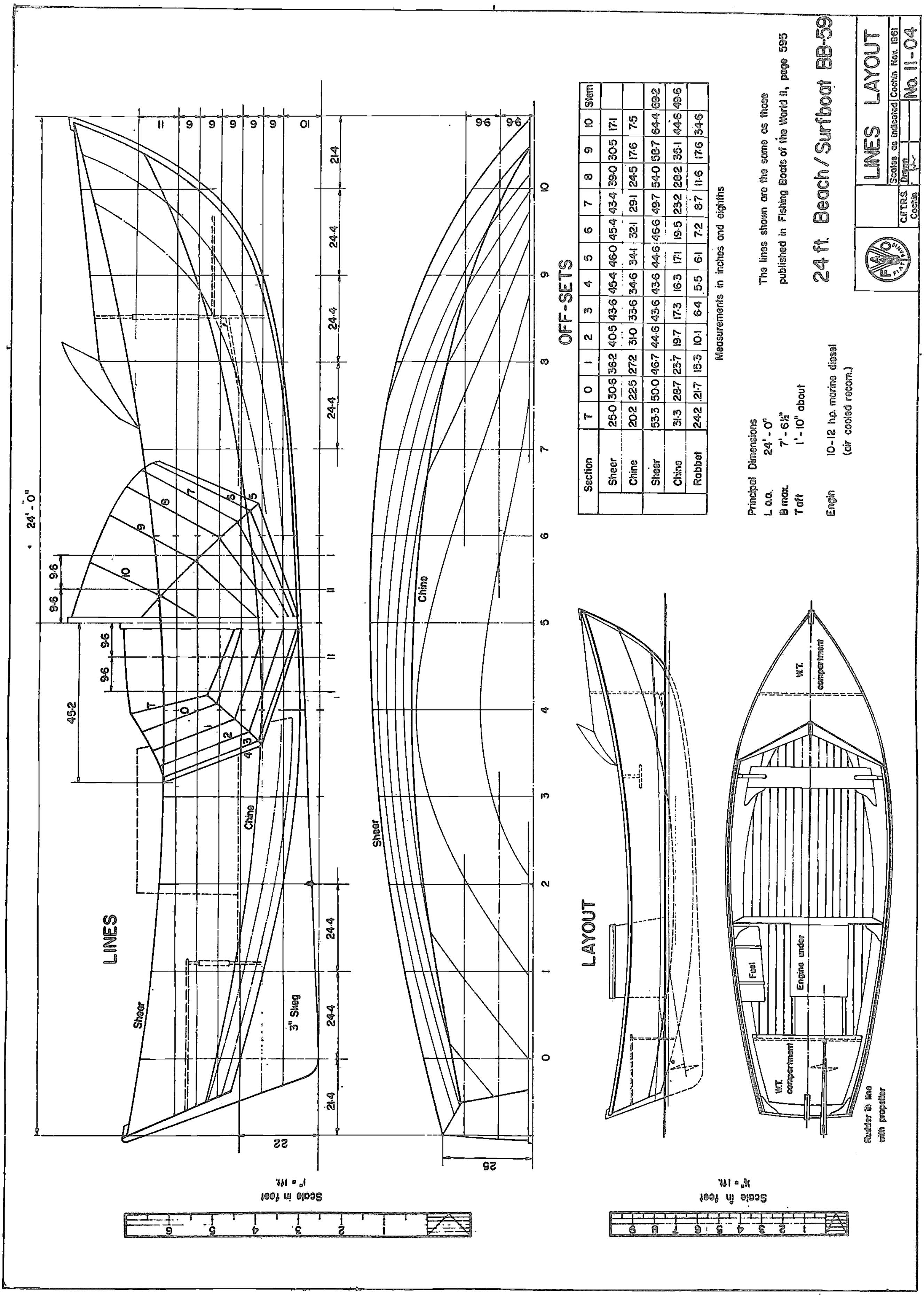
Fig. 12, type C, shows the same hull developed to suit gillnets. The floor amidships is lower than in type A. The foredeck is also somewhat lower and is extended aft to facilitate shooting. The engine hatch is modified and a chute is arranged alongside the engine.

Even these $27\frac{1}{2}$ ft. (8·4 m.) boats are generally criticized in Ceylon as being too small. No doubt they are very limited in operation because they cannot handle the catch too well.

When discussing the size of boats, one should define the expected absence from port in hours. Often there seems to be a large exaggeration of requirements which forces naval architects to provide many types of sleeping arrangements which are perhaps only going to be used as fish holds or stores.

Work is now going on in Ceylon to develop a 38 ft. (11·6 m.) boat for longer range operation. In India the next largest boat is a 32 ft. (9·8 m.) decked version which has turned out to be quite popular. Some such decked boats will be discussed in a later article.

A study of the drawings of these open fishing boats shows that all boats have transom sterns which, naturally,



Section		T	0	1	2	3	4	5	6	7	8	9	10	Stem
	Sheer	25.0	30.6	36.2	40.5	43.6	45.4	46.0	45.4	43.4	39.0	30.5	17.1	
	Chine	20.2	22.5	27.2	31.0	33.6	34.6	34.1	32.1	29.1	24.5	17.6	7.5	
	Sheer	53.3	50.0	46.7	44.6	43.6	43.6	44.6	46.6	49.7	54.0	58.7	64.4	69.2
	Chine	31.3	28.7	23.7	19.7	17.3	16.3	17.1	19.5	23.2	28.2	35.1	44.6	49.6
	Rabbet	24.2	21.7	15.3	10.1	6.4	5.5	6.1	7.2	8.7	11.6	17.6	34.6	

Fig. 7.

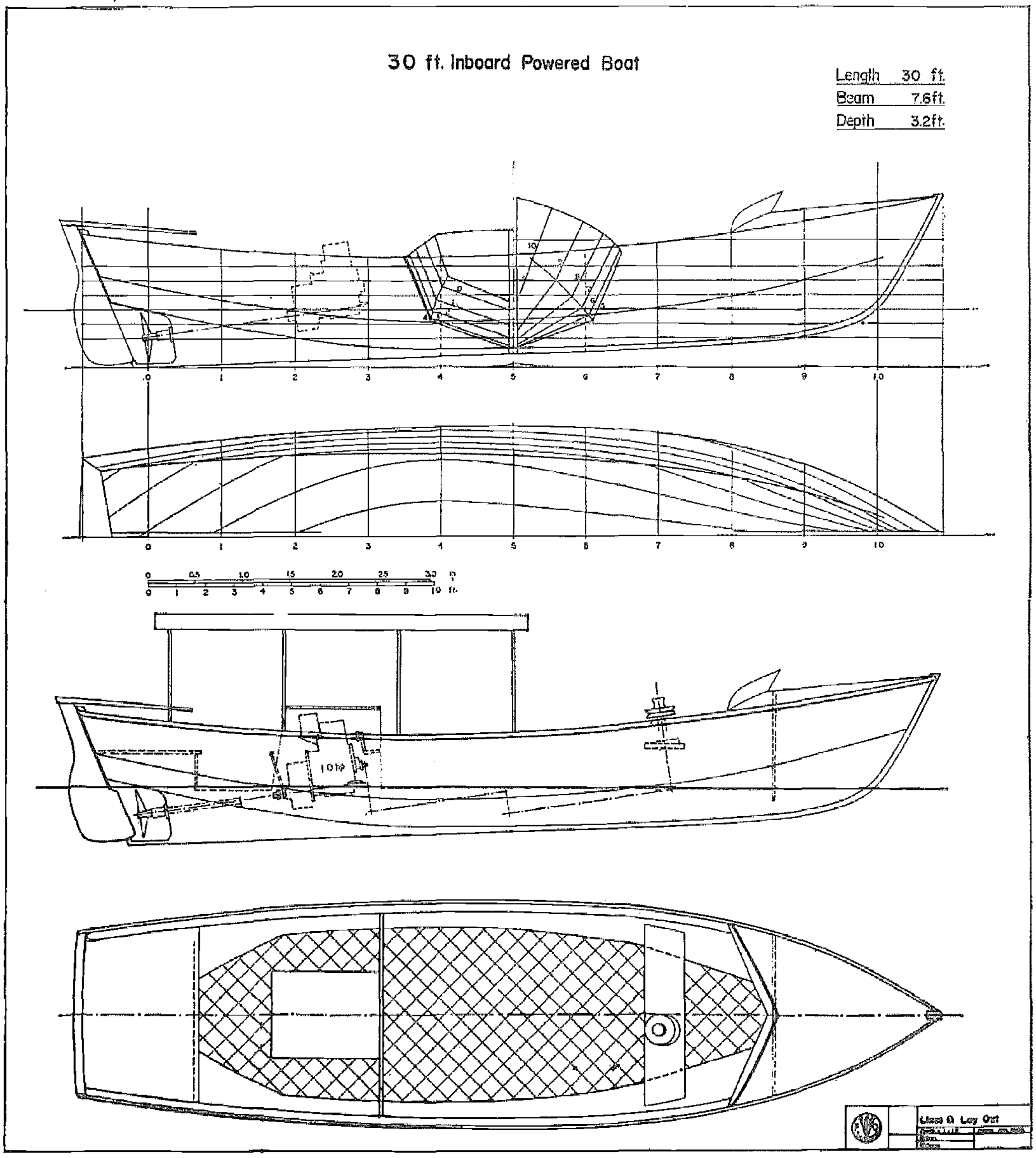


FIG. 8.

reflect the experience of FAO naval architects. Particularly for such small boats, a transom stern is the best to produce speed, to make the boats seakindly, and to provide better working space and less expensive construction.

Surprisingly enough, all boats have inside rudders, except the V-bottom 24 ft. and 30 ft. ones (8·6 and 9·5 m.) (Figs. 7 and 8), and Chapelle's beach boat (Fig. 9). In view of all the complications of rudder shaft tubes, bearings and steering arrangements, the author has tried to advocate the simplification of outside rudders (Figs. 7, 8 and 9). Still it has been a general local desire to have such inside rudders. Might this be traced to the influence of launches used by British merchantmen ?

Einar Kvaran, FAO marine engineer in Ceylon, is dealing in another article with the choice of engines.

To make small, inboard-powered, open fishing craft as inexpensive as possible, very often gasoline or kerosene engines are being used. They are less costly and take up much less space. That type of propulsion is particularly popular for inboard engines in Scandinavia, Canada and Australia. In certain countries, kerosene is less expensive than diesel fuel because it is widely distributed to villages for lighting and cooking and very often is not subject to luxury tax.

The same argument as for outboard engines, that they are easier to maintain by local mechanics, is also valid for these ignition type engines. Such engines should be more seriously considered for developing countries than they are at present.

It has often been suggested that FAO should develop a number of standard designs for fishing boats, each to use a maximum number of fishing methods. The reader will notice from the drawings shown here that FAO has not attempted to standardize its designs as our experience has been that standardization, as a key to increased

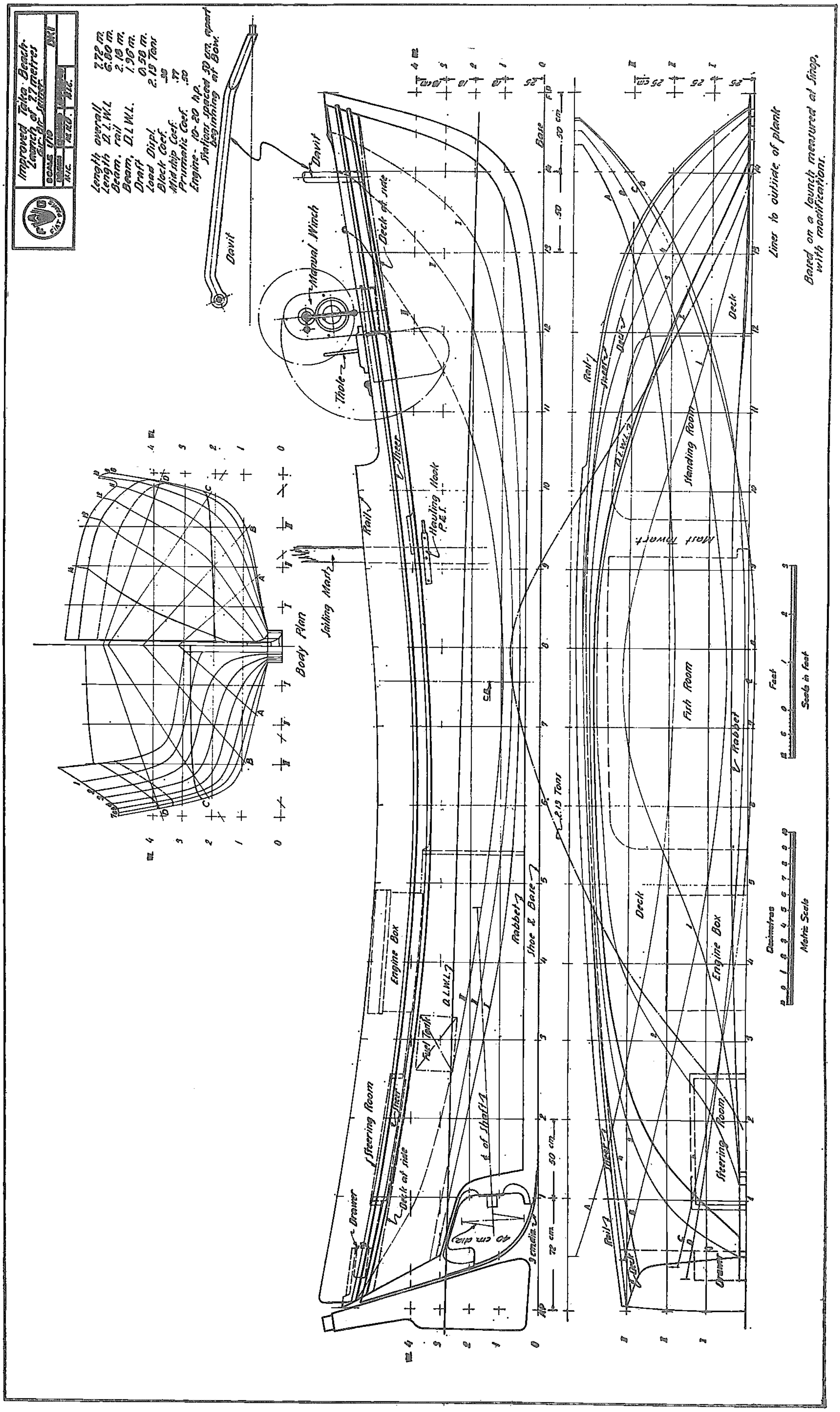
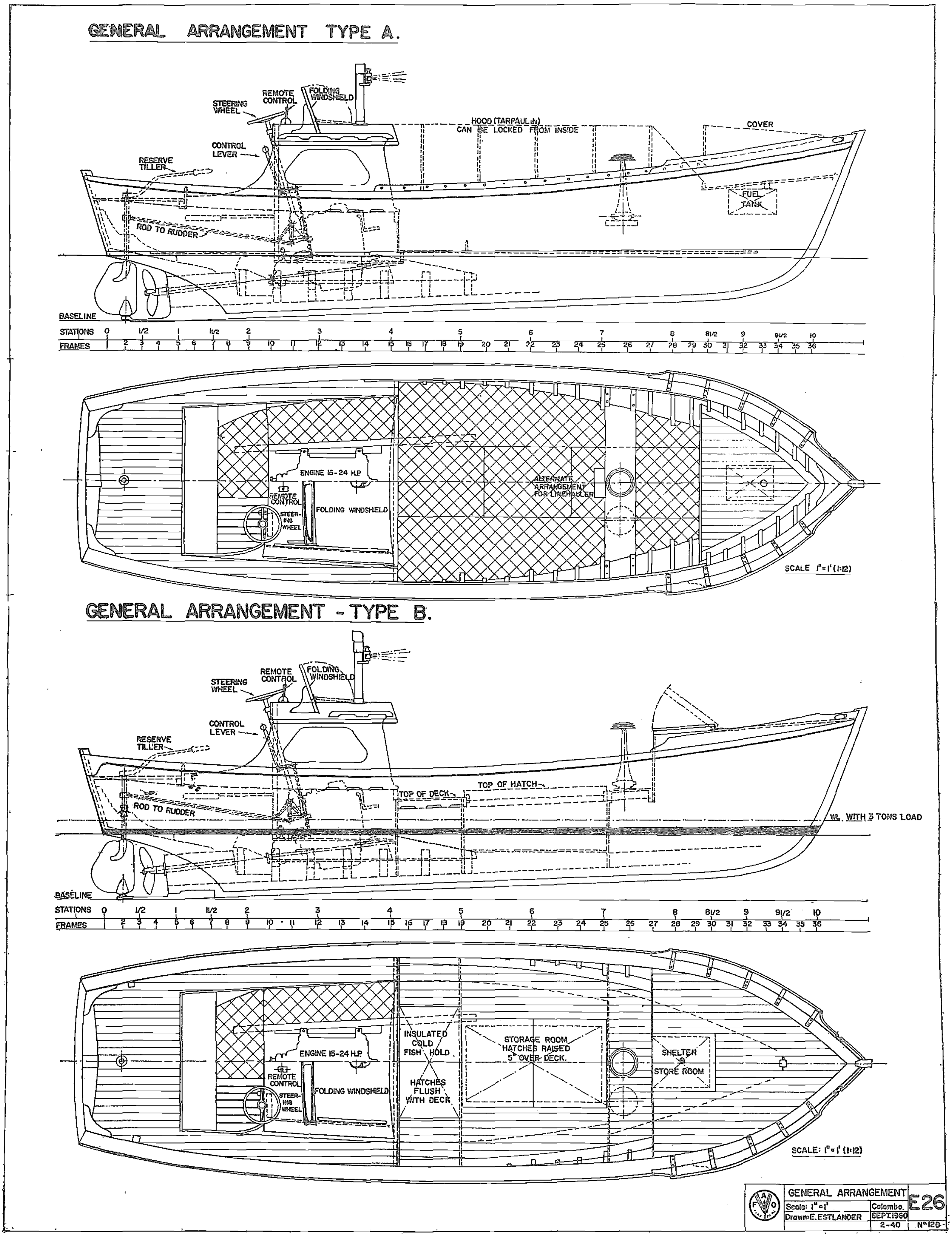

Length overall 7.72 m.
Length D.L.W.L. 6.80 m.
Beam, rail 2.18 m.
Beam, D.L.W.L. 1.96 m.
Draft 0.58 m.
Load Displ. 2.19 Tons
Engine - 10-20 h.p.
Stations spaced 50 cm. apart beginning at Bow.
Davit
Manual Winch
Thole
Body Plan
Sailing Mast
Hauling Hook
Rail
Deck at side
Engine Box
Steering Room
Fuel Tank
Drawer
Rabbet
Shoe & Base
Fish Room
Standing Room
Mast Thwart
Deck
Lines to outside of plank
Based on a launch measured at Sinop. with modifications.
Scale in feet
Metric Scale

FIG. 9



FIGS. 10 (*top*) and 11.

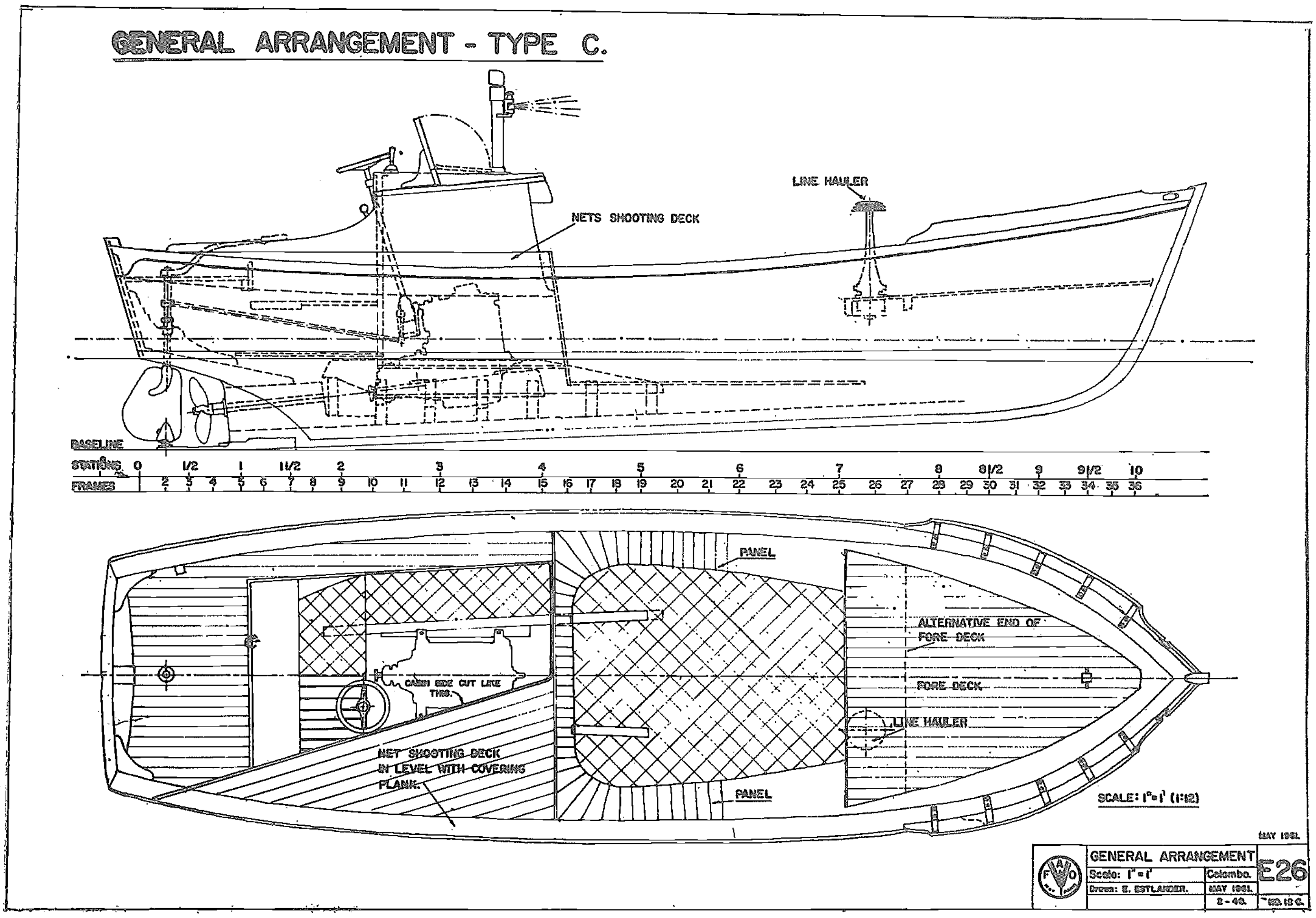


FIG. 12.

efficiency and decreased costs, does not quite fit the lock in all cases.

For example, in those instances where lack of time and manpower forced FAO to suggest that a design for one country be used in another, without modification, local conditions had a great influence. Limitation of local loan facilities restricted boat size and limitations of local shipyards narrowed the choice of types of construction. Aside from these practical problems, boats developed for one set of conditions have caused difficulties when used under a second set of circumstances.

Unnecessary Expense

The hundreds of boats built in India to drawings 1 to 4 would not have become a single shilling cheaper if a great number of boats had also been built in Ceylon, Trinidad or Chile to those same drawings. This is because the experience gained by boatbuilders elsewhere is no help to the Indian boatbuilders. On the contrary, the following of a " foreign " design might easily cause unnecessary expense because of the different conditions compared with those in India.

The subtle trouble with standardization is that the idea is suffering from success. In dozens of development problems, standardization of hardware has been the correct solution and it has become a catch phrase, a banner, a movement. A great many key people, especially administrators, have jumped on the standardization bandwagon.

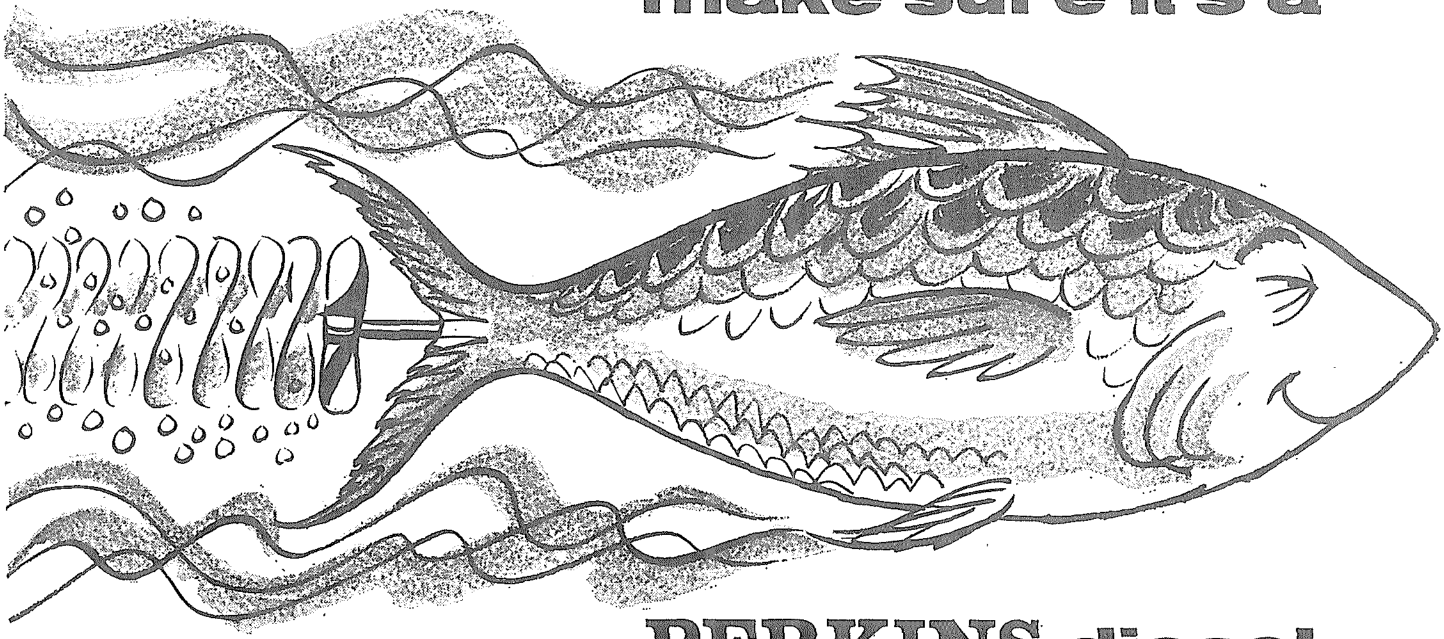
Fallacious

In boat designing, this is fallacious. Standard boat designs are no cure-all for a developing fishing industry. On the contrary, standardization can freeze or retard development by perpetuating boatbuilding habits which have outlived their usefulness.

Each design problem deserves particular study. Governments should not force standardization simply because the prospects look good on paper but should confine themselves to providing sound technical advice. For this purpose, drawings for dependable boats and machinery might be developed and it may even be advantageous for governments to order such boats in large quantities to build up the fishing fleet.

But there is a very strong complementary duty for governments to ensure that it has people trained to understand small-boat design and that these technicians, if necessary, can modify government prototypes and adapt them to changing local conditions.

make sure it's a



PERKINS diesel

Wherever you go—around the French coast, off the shores of Ceylon—you'll find more and more fishing boats are powered by Perkins diesels. For these are the engines that you can rely on in all climates and conditions, that give you extra economy because they cost less to run and service.

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Please write for the name and address of your nearest distributor, or for literature and specifications. Ask also for a copy of "Marine Diesel News".

SOME PERKINS MARINE DIESELS FOR THE FISHERMAN

	BORE	STROKE	No. OF CYLS.	SWEPT VOLUME		CONTINUOUS S.H.P.	R.P.M.	WEIGHT (DRY) LB
				LITRES	CU./INS.			
P3.144(M)	3½″	5″	3	2,36	144,3	21/30	1,200/2,000	1,002
4.270(M)	4¼″	4¾″	4	4,42	269,5	40/58	1,200/2,000	1,150
6.354(M)	3⅞″	5″	6	5,8	354	51/90	1,200/2,250	1,280
T6.354(M)	3⅞″	5″	6	5,8	354	102/120	1,800/2,250	1,445

Perkins Engines Ltd · Peterborough · England

P642(A)

Selection of marine engines under 50 h.p.

FUNDAMENTAL CONSIDERATIONS AND ECONOMIC FACTORS

E. KVARAN
FAO/ETAP Marine Engineer,
Department of Fisheries,
Colombo, Ceylon.

A comparative study was undertaken in 1954 for the Inland Waterway Sub-committee of the Economic Commission for Asia and the Far East of the various types of marine engines for use in inland water transport craft in the countries of Asia and the Far East. This study is available as United Nations Publication Sales No. 4955.11F2. It contains valuable observations on various types of marine power plants.

IN its simplest form the selection of an engine for a given craft may consist of buying what is known to be good. If one knows that a certain make of engine is giving good service under circumstances similar to those contemplated, that it is well represented locally, and that the price is reasonable, there is no need to seek further, and even run the risk of disappointment. Individuals generally make their selection in just such a way, often with excellent results.

The development of a fishing fleet usually implies the use of public, co-operative or corporate funds, and specific justification for a particular selection is usually required. It is one objective of this paper to assist those making the selection of a marine engine for small craft and to present the selector with background material which can be used to justify the selection, as is necessary if cheaper engines of the same output have been by-passed.

Of even greater importance than the selection of engines is their maintenance after installation. The best of engines will fail if grossly neglected or abused, and the successful operation of any fishing fleet will depend to a large extent on the quality of the maintenance given to the engines and other equipment.

At present inboard diesel engines are the most satisfactory for general use in fishing boats. They will, therefore, be the main subject of the following, with a brief section devoted to outboard motors, and with only passing reference to other engine types.

Fundamental Considerations

The factors entering into the selection of an engine to power a given hull can be divided into three main groups, albeit with considerable overlapping, technical, economic and intangible factors. Broadly speaking the technical factors relate to the suitability of the engine for the proposed use, economic factors govern the choice between technically acceptable alternatives, and intangibles reflect outside influences which may have a profound effect on the final selection.

A rational approach to the problem would entail the following steps:—

(1) Determination of the basic type of engine to be used. This is usually a technical problem, as the economics of it may be said, somewhat dogmatically, to have been solved already for most common cases at least. (It is assumed that the boat type has already been selected.)

(2) Determination of the power requirements. This is technical in so far as determining the relationship between the power and speed is concerned, and economic in selecting what speed range will be chosen.

(3) A comparison of available engines on a technical basis to limit the choice to those most suitable.

(4) An economic comparison of the operation using technically satisfactory engines.

(5) Modifications, if necessary, due to intangible factors.

This sequence is somewhat flexible, in particular the consideration of intangibles may enter at a very early stage and thus limit the number of makes to be considered from the outset.

These steps will be treated separately in greater detail in the following.

The selection must be made from a few basic types of engines and drives. Inboard engines may be petrol, kerosene, semi-diesel or diesel. Outboard motors are at present petrol or, in a few cases, kerosene engines, although the advent of the diesel outboards may be hoped for soon. There are, however, some diesel engines available driving outboard type propeller units and thus giving the advantages of a diesel outboard for certain limited applications.

Outboards

Outboard motors are very cheap, light, portable, retractable and easily installed. For certain types of craft and for certain applications these advantages are so great as to make the outboard motor the automatic choice. This is particularly true when the fleet is to be built up by the mechanization of existing craft, many of which are narrow, flimsy and completely unsuitable for inboard engine installation while they will readily take an outboard. For beach landing of light craft the outboard also offers specific advantages: the use of the propeller for steering in a surf is superior to a rudder and the retractability of the engine permits the landing to be made as for a non-mechanized craft.

In shallow, narrow or fouled waters the outboard may also show to great advantage, due to the ease with which it can be lifted out of the water and to the automatic safety feature of the self-tilting arrangement of this drive.

The low first cost and the low installation cost make the outboard especially attractive where rapid mechanization is desired with limited funds.

The servicing of an outboard can in many places be easier to arrange for than that of its main rival, the inboard diesel, due to a wider dissemination of experience in repairing petrol engines than diesels, as well as lesser demands for precision work for the former type of engine.

The main disadvantages of the outboard are lack of ruggedness and durability, high fuel consumption and the use of high priced fuel (in most localities). These drawbacks need not be serious in cases where the engine is primarily an auxiliary or is used for short or comparatively infrequent trips. The high price of petrol is in most countries due to taxation, and the use of this fuel may be a convenient way of recovering investment by the government in facilities for the fisheries industry.

Inboards

Three types of engines are used as inboard engines: carburettor engines, semi-diesels and diesels. The first may use petrol or kerosene as fuel while the latter two use various grades of diesel fuel oil. Semi-diesels have never gained appreciable popularity in the Indo-Pacific area due largely to the inherent difficulty of starting most engines of this type, and to their tendency to be " temperamental " in the hands of inexperienced operators, a trait shared by many outboard motors. As this type of engine appears to be disappearing in other areas, it is unlikely that it will play a significant part in the development of fishing fleets in the future.

The following advantages may be claimed for carburettor engines: light weight, small size, low first cost, widespread maintenance experience and relative simplicity of repairs. The main disadvantages are high fuel consumption, expensive fuel and the unreliability of the ignition system and carburettor, particularly when used in a humid salt laden atmosphere. For the diesel engine the main advantages are low fuel consumption, particularly at part load operation, cheap fuel, reduced fire hazard due to less volatile fuel and absence of electrical ignition, increased reliability of operation, longer life, longer period between overhauls. The main disadvantages are greater weight and size, higher first cost and the need for more highly trained mechanics.

Diesels

In the present context, fishing craft of up to about 10 gross tons are of interest. A 10-ton fishing boat would probably be powered by an engine of 50 hp or less, unless specifically designed for speed, and engines of over 50 hp will not be considered. Most diesels of 30 hp or less can be started by hand and this is a convenient criteria of approximate engine size; engines which can be started by hand will be considered " small," while those requiring a starter will be considered " large."

The engine will also be divided into arbitrary speed groups, under 1,200 rpm are slow speed, 1,200–1,500 rpm, medium speed, and over 1,500 rpm, high speed. It may be noted in passing that this division would be most unsuitable, if engines of a much larger size were to be considered. Even for engines in the range under consideration, it is a crude classification, and the comparative speed of engines will be considered further below. The engines will be single acting, solid injection, naturally aspirated, and may work on either the two-stroke or the four-stroke cycle.

Most diesels of less than 50 hp are made to operate on the four-stroke cycle as this generally yields more power per unit weight. Engines should, however, be considered on their individual merits and an otherwise satisfactory engine should not be rejected just because it uses a different system from the majority.

Economic Factors

The first question to be answered is: what should be the power of the engine? This looks like a technical question, but in reality it is not. The corresponding technical question is: what power is required to give a certain speed? If we know the answer to the second question, for a number of different speeds, it is possible to construct a speed-power curve giving the power required for any speed.

The determination of this relationship for a given craft is not a simple matter. It will be assumed that this relationship is, however, known either as a result of speed trials, model testing, calculations, past experience or an inspired guess. It will still remain to decide which point on the curve shall be selected for full speed operation. This choice is, or should be, an economic one. High boat speed means greater investment in the engine, greater operating costs and may mean a reduction in pay-load due to the added weight of the engine. In extreme cases it may mean that the life of the hull is shortened because of the added stress at high speed.

Against this is the added earning power of the boat, because in fishing, as much as in any other field, time is money. The value of this time must be evaluated in a reasonably realistic way, which will depend on the type of fishing the boat is to be engaged in. Many types are severely limited in time. Drift netting, bottom set netting, longlining, and others are usually carried out during certain hours of the day, and the power of the engine is not a factor in the actual operation. In such cases a higher speed means a reduction of travelling time to and from the grounds but would not affect the total catch of the boat, unless it must race others for the most favoured grounds.

It might, on the other hand, have a great bearing on the price received for the catch, if there is a question of catching the market or making connections with other means of transporting the fish to market. In any case a higher speed would mean an increase in the time the crew could spend ashore, but unfortunately a very low value must be placed on added leisure, above and beyond the time required for adequate rest and servicing of the boat and gear.

In contrast to this, a burst of speed of only a few minutes' duration while, say, purse seining might pay for the difference between a relatively high powered and a low powered engine. For bottom trawling and some types of trolling a moderate increase in speed may spell the difference between success and failure, by making possible the capture of species which otherwise, by and large, would escape. For these fishing methods a reduction in travelling time could also be converted to increased fishing time.

If an analysis of the earning power of the boat indicates that "over-powering" is economical the design of the hull itself should be reconsidered. (Over-powering refers to the condition where a large increase in power is required to gain a small increase in speed.) Additional expenditure on the hull, particularly an increase in length, may permit the desired speed to be obtained with a smaller engine, and thus give a larger boat with the same speed for the same total price.

Calculations to determine the optimum speed of a small fishing boat can seldom be made with any high degree of accuracy so for this purpose it is sufficient to know the general type of engine to be used, the average price per horse-power, fuel and lubricating oil consumption, maintenance costs and depreciation rate for this type of engine. The price per hp and the cost of fuel varies considerably with the locality and would have to be obtained from quotations and prevailing rates. The other factors can, for preliminary calculations of this kind, be taken from the following table:

Engine	*Fuel consumption*	*Lubricating oil consumption. Percentage of fuel*	*Life expectancy (years)*	*Maintenance. Percentage of engine cost*
Diesel	0·45 hp/hr	2	7	12
Petrol (inboard)	0·70 hp/hr	3½	5	15
Outboard ..	0·85 hp/hr	5	3	18

The value of the increased catch or price due to higher speed would have to be based entirely on local conditions using either data from past experience or the calculations which underlie the justification for the establishment of a fishing fleet, modified if necessary to take into consideration the fact that the extra fishing may not be carried out under optimum conditions.

Many small fishing boats, when operating within the speed range that may be considered normal for their size (say a speed-length ratio of 1·2 to 1·5) require an increase in installed power of 100–200 per cent. to increase their speed by one knot. It should be apparent that even crude economic calculations should be able to reduce this very wide range of power requirements to a much narrower band, even if not down to a single absolute value.

TECHNICAL CONSIDERATIONS

THE technical factors which will be considered here are those on which information can usually be obtained from bulletins and manuals concerning a particular engine or by looking at the engine in a show room. Generally speaking, these are external characteristics of the engine, but provided the engine is built to a sound design these characteristics are the ones which are of the greatest importance from an operating point of view.

(1) **Crankcase types.** Every diesel has an external skeleton, a strong, rigid framework which encloses the main moving parts and usually contains the oil supply as well. The manner in which this structure is built up may or may not be significant in the choice of an engine. The most common types, for small diesels, are:—

(*a*) *Monoblock.*—The cylinder walls, crankcase and sump are made from one piece.

(*b*) *Tunnel type.*—The crankcase and sump are one piece, with a removable cylinder on top. In both these constructions, the crankshaft is withdrawn from one end of the engine.

(*c*) *Bed plate type.*—The sump and lower half of the crankcase are one piece. The upper half of the crankcase and the cylinder may or may not be one piece. The significant point here is that the crankshaft rests on the bed plate. It is removed by lifting after the overlying parts have been removed.

(*d*) *Removable sump type.*—The crankshaft is suspended from bearings in the crankcase. The engine is turned on its side, or upside down to remove the crankcase.

For engines which can be readily removed from the boat, either by manpower or by virtue of good maintenance facilities the choice of frame type is of minor importance. If major overhauls must be carried out on board it is important to ascertain that space and equipment are available to permit the dismantling without undue difficulties. Roughly speaking, types (*a*) and (*b*) involve the removal of the relatively light gearbox to permit shaft withdrawal, type (*c*) entails the removal of the somewhat heavier crankcase and cylinders, but requires little longitudinal space, while type (*d*) requires the removal of the whole engine from the engine bearers. All types require removal of the flywheel.

(2) **Engine mountings.** A marine engine should have a low centre of gravity, and the propeller shaft should also be low to permit the propeller to be submerged as deeply as possible, or to be as large as possible. At the same time the engine bearers must be high, to give a firm foundation. These ends are achieved by attaching the engine mountings fairly high on the side of the engine. If the engine is mounted well forward in the boat, there is usually no problem involved in getting the engine low enough. In many fishing boats, however, the engine must be placed as far aft as possible to conserve space, and the type of engine mounting may become a critical factor. Marine versions of stationary engines are sometimes unacceptable merely because the mountings are at the bottom of the crankcase.

Closely related to the height of the mountings are the width of the mountings, particularly at the stern end, and the permissible angle of installation. It is obviously easier to push an engine aft, if it is narrow and can be tilted to an appreciable angle.

If the design of the hull presents an installation problem, engines with removable mounting feet should be given special consideration. In the case of a bulk order redesigned feet can often be obtained at little or no extra cost.

(3) **Flywheel.** In certain engines the flywheel interferes seriously with the engine bearers. This may necessitate the use of much heavier foundations than originally planned. With a very large flywheel which cuts the bearers deeply it may prove difficult to avoid excessive vibration.

The flywheel may be enclosed or exposed. If the engine house is to be used as accommodation for the crew, an exposed flywheel may prove to be a source of danger or inconvenience. On the other hand the markings on an enclosed flywheel, which are useful for valve and pump timing are not as readily accessible as on an exposed one.

(4) **Bearings.** Three types of bearings are available in diesel engines, thick wall bearings, thin wall bearings and ball or roller bearings. The first two types are hard shells—usually steel-lined with softer bearing metal, white metal. They may be either whole, i.e. circular or split, i.e. made of two semi-circular parts. The thin wall bearings are precision made and require no adjustments for fitting, but the shaft must be ground within close limits of the correct size. Thick wall bearings must be carefully scraped and fitted to the shaft by an experienced fitter, but the size of the shaft is not critical. These bearings can also be adjusted, within limits, by removing shims to take up wear. From the standpoint of long life without attention precision bearings are superior and have therefore become a natural choice where good maintenance facilities are available and a regular overhaul schedule is to be adhered to.

For the operation of individual craft at remote localities, but with good fitters or mechanics, thick wall bearings would be indicated. It must be appreciated that such hand fitting of bearings and shafts may take days per engine. Ball and roller bearings are used only to a very limited extent in diesels, although they are almost universal in marine gearboxes. The main reason appears to be that it is difficult to make split ball or roller bearings, and most designs call for at least one split main bearing and all bit end bearings must be split unless the crankshaft can be disassembled into component parts. It is nevertheless surprising that the use of roller bearings as main bearings in single cylinder engines is not more widespread, as these have given excellent service in semi-diesels for a long time. Even two cylinder engines can use them, if designed without a centre main bearing.

(5) **Combustion chambers, injectors.** A wide range of combustion chamber types have been developed, with associated injectors, and almost every descriptive bulletin for a diesel engine will stress that the combustion chamber of that particular engine is the best. The design of the combustion chamber is indeed of great importance, but good results can be obtained with a variety of types, and all the virtues of a given type may not necessarily be realised in an engine using that particular construction. From the operator's point of view, the design of the combustion chamber has bearing on the following features:—

Ease of starting.
Quietness and smoothness of operation.
Fuel consumption.
Length of time between injector and top overhauls.
Propensity to smoke.

Apart from the fuel consumption, which will be discussed later, the other items are all so variable that experience with the engine in question is required to enable a judgement to be passed. Knowledge of the general type of combustion chamber used will not permit deductions with any degree of accuracy.

(6) **Fuel pumps.** Most diesels use fuel injection pumps of the jerk jump type, i.e. Bosch, C.A.V., Bryce or other makes operating in a similar manner. In engines of two or more cylinders the choice of jerk pump lies between multi-unit pumps and individual pumps for each cylinder. Again the choice is primarily based on service facilities. Multi-unit pumps require adjustment and calibration with special equipment and highly trained personnel. Individual pumps can be repaired and adjusted in the field by less skilled mechanics, but with some loss of efficiency, which will be reflected in uneven loading of the cylinders and increased fuel consumption.

(7) **Crankshaft.** The design of the crankshaft is based on specialized engineering calculations. It is wise, however, to ascertain whether the crankshaft conforms to the specifications of Lloyd's or some other large insurance organization, particularly in the case of converted stationary or vehicle diesel engines.

(8) **Fuel specifications.** Most small diesels, particularly high speed engines, are designed to operate on light grades of fuel oil. A considerable economy may in some cases be effected by buying an engine which can burn a heavier, cheaper grade of oil. This economy will, of course, evaporate if this cheaper grade is not readily available.

If the fuel is to be obtained through normal retail outlets, the lighter grades are usually much more readily available, due to the use of such fuel by diesel engines in most vehicles. Switching from one grade of fuel to another may result in reduced efficiency of the engine, unless the timing is adjusted each time, due to the varying combustion characteristics of the different fuels.

(9) **Vibration.** Apart from faulty installation, such as misalignment, weak engine bearers, unbalanced pulleys, etc., vibration in a marine engine stems from the inherent unbalance of reciprocating parts and from the combustion forces. Counterweights are used on all small diesels, and counter rotating weights on single-cylinder engines are a further refinement which reduce vibration due to reciprocation to a minimum.

In general slow speed engines vibrate more than high speed, primarily because they must produce more power per firing stroke, and therefore require heavier engine foundations. This problem is further aggravated by the fact that slow speed engines also require larger flywheels which tend to interfere with the engine bearers. Single cylinder engines tend to vibrate more than multi-cylinder of the same speed and power. This is, however, one of the many problems where personal acquaintanceship with the engine in question is important, as there are exceptions to these generalizations, and no bulletin will admit that the engine is other than exceptionally smooth and free from vibrations.

(10) **Weight.** For many applications light weight is essential. This is true for fast light craft and also for many existing craft which may be mechanized. Excessive weight is never desirable in itself, with the possible exception of bottom trawling from a small boat, when the weight of the engine may help to prevent the propeller from rising too much out of the water. The specific weight, the weight in lbs. per horse-power, varies very widely, and for marine engines in the size range under consideration it may be less than 15 lb. per hp or more than 100.

In general, slow speed and low powered engines have a high specific weight while high speed and high powered engines are comparatively lighter. Slow speed engines must produce more power per firing stroke than high speed ones of the same output. This implies a larger cylinder volume and also heavier connecting rods, bearings, crankshaft, etc., to resist the larger forces, a heavier flywheel to store kinetic energy at a slower speed and hence a heavier engine. Since the makers of slow speed engines cannot compete on the basis of specific weight, they have less inclination to use light weight materials or structures and the gap between the high and low speed engines is thus further increased. The main justification for the use of heavy, slow speed engines lies in greater life expectancy and reliability.

(11) **Cooling system.** Small marine engines may be water or air cooled. If water cooling can ever be justified for diesels, one would expect this to be in the marine field with its unlimited supply of water readily available. Despite this, air cooled engines have enjoyed increasing sales particularly in sizes up to 30 hp. The main reason is a reduction in weight and increased simplicity and reliability. In many cases, air cooled engines are cheaper than water cooled, but this is by no means universal. It does, however, appear that when a given manufacturer produces both air and water cooled engines of the same size, the former are definitely cheaper and air cooled engines may in such cases have the advantage of cheapness in addition to the advantage of buying a well established brand.

The best system for air cooling a small engine is by means of a flywheel fan, which does not add any moving parts to the engine. Belt driven fans, although necessary for larger engines, do add more moving parts, which are subject to considerable wear, and thus detract from the advantage of air cooling. The main disadvantage of air cooling is the need for air ducting, particularly in tropical climates where this ducting corrodes fast. The ducting also forms an undesirable obstruction in small engine rooms, and may make access to certain parts of the engine difficult. Air cooling is most advantageous when the engine room is made sufficiently open to permit some or all of the ducting to be done away with. Other disadvantages of air cooling are that the engine and engine room tend to become hotter than for water cooling, making servicing less attractive and reducing the suitability of the engine room as accommodation space.

The main disadvantages of water cooling are that the system tends to be unreliable and to lead to excessive corrosion or blockage in the water jackets. Although sea water is readily available it is by no means the ideal cooling fluid, due to its high salt content and often to the presence of other foreign matter, particularly sand or mud. Some of the drawbacks of using sea water can be overcome by a closed circuit fresh water system, but this adds considerably to the complexity of the system, as well as to first cost, and is not generally used for engines of less than 30–50 hp.

(12) **Engine speed.** In the earlier section on diesel engine types, diesels were divided into slow speed, under 1,200 rpm, medium speed 1,200–1,500 rpm and high speed, over 1,500 rpm. This division has some actual significance for small fishing boats in as much as slow speed engines are usually directly connected to the propeller shaft, medium speed engines may be directly connected or may require a reduction gear, while high speed engines will always demand a reduction gear except for unusually fast craft, or cases where a loss of efficiency must be accepted to permit the accommodation of a small propeller.

Rotative speed is not the only criteria of engine speed. Piston speed is also important as far as cylinder wear is concerned. The product of the rpm and piston speed in ft. per min. divided by 100,000 is known as the speed factor, and is in many ways a better indication of the real speed of the engine. The speed factor will range from about 9 to 30 for engines suitable for small fishing craft. The main purpose in developing high speed engines is to reduce the weight and price per horse-power. The available data for these items correlate much better when compared on the basis of speed factor than rpm. For small diesel marine engines including gearboxes, the following approximate relationship holds for the specific weight and speed factor:—

$$\text{lb/hp} - \left(\frac{-\text{speed factor}}{100} \right)_{e} \quad (4 \cdot 66 - \cdot 0258 \text{ hp})$$

A few illustrative values are given below:—

Specific weight—lb/hp			
Speed factor ..	10	20	30
10 hp	77 lb/hp	68 lb/hp	60 lb/hp
20 hp	58 lb/hp	52 lb/hp	45 lb/hp
30 hp	45 lb/hp	40 lb/hp	35 lb/hp

The price per lb. is reasonably constant for engines of the same size so it is obvious that the speed factor is important as far as the cost of the engine is concerned, and it will enter into the economics of engine selection.

(13) **Accessibility.** The importance of considering the accessibility of the crankshaft has already been pointed out, but this is by no means the only part to which ready access is desirable. The whole fuel system should be easy to get at as well as other parts requiring regular attention such as filters, air cleaner, rocker arms, timing marks and gearbox adjustments. Accessible does not necessarily mean the same thing as exposed. It is preferable to have, say, enclosed rocker arms which are lubricated by the engine lubricating oil system than open ones requiring hand oiling. But it should be possible to reach all the parts requiring frequent attention, simply by removing covers intended for that purpose, without stripping down piping, exhaust manifolds, air ducting, etc. When inspecting an engine in a show room or examining illustrations every effort should be made to visualize the engine as it will be when actually installed in a particular boat.

Closely related to accessibility is the possibility of interference between parts of the engine and the hull, particularly the engine bearers. Any parts which require the engine bearers to be out are undesirable. Apart from the weakening of the bearers, which can usually be allowed for, such parts prevent the engine from being shifted along the bearers, as may be necessary when removing the engine, particularly without adequate hoisting tackle. They can also interfere with periodic realigning of the engine.

ACCESSORIES

A NUMBER of accessories are required with an engine and these are of the greatest importance to the man in charge as much of the routine servicing has to do with the accessories, as well as the ease of working the engine.

(*a*) *Oil changes*. The most important item in servicing is changing oil. In small boats this may be unnecessarily difficult and in particular dirty. The installation of an oil pan under the engine is often recommended. For marine type diesels, with sumps that come down between the bearers and the floors, this is usually, practically speaking, impossible. A pump for removal of the oil is, therefore, highly desirable, to avoid the necessity of flooding the bilges with oil at each change. A permanently mounted pump is preferable, and in the absence of an oil pump the location of the drain plug is important. It must be accessible and it should be at the lowest point of the crankcase, which is often not the case in marine versions of stationary engines.

(*b*) Next in importance to regular oil changes is the *care of filters*. Although they perform somewhat different functions, strainers, pre-filters or settling bowls, lubricating oil filters and fuel oil filters will all be treated together in this section. All should be readily accessible. Strainers, which can only be reached by removing the sump, are of little value unless a very highly organized maintenance system is provided for. Filters may be divided into three main categories.

Renewable element filters require that a new element be fitted each time the filter is serviced. For lubricating oil filters this is usually at every or every second oil change and for fuel oil about twice a year. The replacement elements can be rather costly, say approximately the price of one to two gallons of lubricating oil. Unless it is likely that the elements will in fact be renewed as specified, these filters are not desirable, as dirty elements are worse than none. When regular renewal can be counted on, renewable element filters are superior to other types.

Cleanable elements can be used for a number of oil changes, or even more or less indefinitely. Although not as efficient as renewable elements they are cheaper to maintain and can be kept in reasonable condition without appreciable stocks of spares. Whether they are cheaper in the overall economy of the engine is a moot point. Cleanable filters would be indicated where all servicing is carried out by special service units, which do not also carry spares.

Autoclean or plate type filters can be cleaned by the turn of a handle and occasional drainage of dirt. They will not, however, withstand prolonged neglect, as water which will accumulate will spoil the plates. This type is to be preferred where it is desired to avoid replacement parts as much as possible, provided the operators can be depended on to give the very minimum attention required.

(*c*) *Starting systems*. Engines up to about 30 hp are usually hand started. Those of 30 to 50 hp are commonly started by air or electric motor.

Air starting is much heavier than electric and would normally only be considered in conjunction with slow speed engines. For reliable, trouble free operation it is most important that the instructions for the use of the air system be followed in every detail.

If electricity is required on board for other purposes such as lighting, radio or echo sounders, the addition of electric starting is not expensive. If at all possible it is recommended that alternate hand starting be provided, to avoid loss of fishing time due to the very common electrical troubles, especially under tropical conditions.

The majority of engines being considered here will be hand started and the type of starting equipment may be of considerable importance, particularly because of the effect it may have on the engine room accommodation. Whatever arrangement is adopted, it is important that the man cranking the engine be able to stand in a position permitting maximum effort to be made. Even small engines, which normally require very little effort, may be difficult to start when in poor mechanical condition.

The simplest kind of hand starter is a retractable handle on the flywheel. All it requires by way of maintenance is a little oil or grease to prevent the handle from sticking. If neglected, it can turn into an extremely dangerous protrusion on the flywheel, which will break a log without even changing the beat of the engine. The main disadvantages of this starter are that it can only be used on a forward mounted, exposed flywheel and that the turning radius is large and low. The latter point implies plenty of space for body movement and a very low level to stand on.

Variation

A variation of this kind of starter is a cranking handle which slips on to the end of the crankshaft. The only virtue this has over a flywheel handle is that it is a little safer, as it will release automatically when the engine starts.

A slight improvement for small engines which are easily turned is to attach the handle to the camshaft. This will give a faster speed to the crankshaft and will be higher than the first two types. All three starters mentioned so far have the disadvantage that the engine must be started from the forward end, thus adding length to the engine room which might otherwise be more profitably utilized as hold space.

A raised hand starter is preferred for hand starting. It consists of a free-wheel on the crankshaft on which is mounted a chain wheel. This is in turn driven by a second chain wheel near the top of the engine. The second wheel is mounted on a shaft which is turned by the crank handle and the crank handle may be located at either end of the engine. If the engine is installed amidships the location may be immaterial. If installed aft, starting at the aft end will save space. Starting from either end is useful when the engine is difficult to start, as two handles can then be used simultaneously.

The details of the raised hand starter are important. There should be provision for tightening the chain, as this will become slack in time; the parts of the free wheel should be accessible for freeing in case they become stuck due to negligence in servicing; the system should be robust, in particular the raised shaft should be well fastened with respect to end play; the handle should be removable, to avoid accidents due to the " kick " of the engine when stopping; the bearings should be grease lubricated (not hand oiled); if there are grease nipples fitted, a grease gun to suit should also be provided. For some reason (actually to avoid rotating grease cups) some engines have only one grease nipple on the whole engine, that which feeds the free wheel, and the makers apparently do not feel that they need supply a gun for just one nipple. (And indeed one would suffice for a number of engines.)

Vital Part

The decompressor is a vital part of the hand starting system and is also useful when working on an electric or air started engine. Usually, the decompressor is mounted so as to open the exhaust valve. This is particularly desirable if the air cleaner is such that it would tend to collect and hold fuel oil which would be blown out of the inlet valve while cranking. Three different locations are used for the decompressor, namely on the rocker arms, push rods or under the cam-followers, leading to progressively lower mounting on the engine. It may be held in place by hand during cranking, it may be released by pushing a lever, or it may release automatically after a certain number of turns.

Each type will demand a certain posture from the man starting the engine, and the arrangements around the engine must be such as to make this position natural. In multi-cylinder engines it is desirable to decompress each cylinder individually, as this permits the operator to know when to apply maximum effort. This is particularly true for flywheel starting handles. Automatic decompressors, unless they can also be manually operated are not desirable. Boys or small men often have difficulty in getting the engine up to speed in the number of turns provided by the manufacturer. Decompressors which change the valve timing while starting assist in easier starting by increasing the air charge in the cylinder.

Decompressors which are removed with the rocker box cover are a source of minor irritation when adjusting the engine, particularly if considerable manual dexterity is required to refit them.

(*d*) *Air cleaners.* The need for an effective air cleaner on a marine engine depends on the operating conditions. Engines operating far from shore and with adequate ventilation make very small demands on the air cleaner, especially slow speed engines which are less sensitive to dust. This does not mean that a poor quality air cleaner should be fitted, as these are often much worse than nothing.

A dry, wire mesh air cleaner when used under tropical conditions will rust quickly, and eventually most of the wire will wind up inside the cylinders, even if the cleaner is washed periodically as recommended in the instruction book.

A simple baffle, which expels the heavier dirt particles through abrupt changes in air flow direction is far superior to a dry wire cleaner.

Dry air cleaners with cloth or plastic elements are quite satisfactory, as are those with paper elements, if provision for regular renewal is made.

The most effective air cleaners, from the point of view of dust removal are oil bath cleaners. At least three types are available. Overhead (automotive type) are the least desirable as they tend to rust above the oil level, and in a rough sea there is a definite danger of sucking the oil into the cylinder, which can have disastrous results. These cleaners are not well suited to operate at an inclination, the usual condition on a small boat. Underslung oil bath air cleaners have none of the disadvantages of the overhead type, but tend to be somewhat bulky.

Compact and Simple

Centrifugal oil batch cleaners, in which the dirt is spun out by centrifugal action and then captured by the oil bath are compact, simple and effective and it is surprising how seldom this type of cleaner is found.

(*e*) *Speed control.* It is desirable in a small boat that one man be able to control the engine and tiller at the same time. If the engine is installed aft, or if the boat is steered by remote control, this is usually easy to provide for, but nevertheless the location and type of speed control is important. A speed control lever on the front of the engine borders on the ridiculous but is not rare. If remote control of the speed is required, the engine controls should be such as to lend themselves to this modification. In any case the speed control should be robust, with oiling points easily accessible and preferably having some oil retention properties. Bowden cables require frequent attention in the tropics and rods are to be preferred. Speed lever mountings resembling miniature ships telegraphs, are excellent. Any type of positive positioning of the lever is preferable to a system based on friction, unless first class servicing can be expected.

(*f*) *Cooling system elements—water cooling.* A generous sized sea water strainer should be provided, and of a construction which permits easy cleaning even after prolonged neglect. There are many types of water pumps available. As this is an item which can be expected to give periodic trouble a type which can be easily repaired is desirable. For slow speed engines piston pumps are a good choice, as they usually give advance warning before failing completely, and will often respond, at least temporarily, to very crude repairs.

Carrying Spares

Flexible rubber impellers are suitable for high speed engines, but spare impellers should be carried, as they usually fail completely and without warning when they do go. Exchanging impellers is the work of but a few minutes. At present these pumps are limited to rather small sizes, usually up to about 20–25 hp. Gear type pumps using rubber or composition gears, driven by external metal gears are available in larger sizes and have the same quality of being relatively unaffected by sand or dirt. Repairs are, however, not so easily effected.

Gear pumps using metal wheels are not desirable for sea water as they tend to wear out quickly, and repairing them is usually a matter of re-machining the housing as well as replacing impellers, so they cannot be repaired at sea. Centrifugal pumps are dependable but their flow characteristics are not well suited to diesel engines as the output at slow speed is many times less than at high speed.

Water cooled exhaust manifolds and silencers are very desirable although they do add somewhat to weight and price. In a small engine room the danger of accidental burns is greatly reduced, and under tropical conditions, the engine room remains considerably cooler. The life of the exhaust manifold and particularly the silencer is greatly extended by water cooling.

Good skin fittings for the water inlet and outlet should be provided.

Preferable

In air cooling for small marine diesels, flywheel mounted fans are preferable to belt driven fans. There should be provision for fastening the air ducting to the engine if its use is contemplated.

(*g*) *Instruments.* Various gauges and meters may be supplied with small engines, but strictly speaking none are indispensable. In order of importance the instruments are: oil pressure gauge, cooling water or air thermometer, tachometer, oil thermometer, revolution counter (usually marked in terms of hours of operation). All are prone to go out of order, particularly if connected by long pipes or cables to an instrument panel. Vibration is the great destroyer of instruments, but flexible mounting of the instrument panel often makes this worse. It is recommended that each instrument be mounted as close to the point of measurement as possible, and provided that the dial is turned in the proper direction for easy observation, this is as satisfactory as panel mounting, and much more reliable.

Alternate Check

If no oil pressure gauge is provided, it is necessary to find an alternate check on the working of the lubricating oil system. Usually, this is the lubrication of the rocker-arms, which can only be seen by removing a cover. For this reason it is definitely recommended that an oil pressure gauge be provided. All other meters should be regarded as luxuries which warrant only modest expenditure. If closed circuit fresh water cooling is used, the operating temperature of the engine is higher than for the more common direct sea water cooling, and checking the water temperature by hand becomes dubious, so in this case a water thermometer is also desirable.

(*h*) *Silencers.* The desirability of a water cooled silencer has been mentioned earlier. This may be achieved by water jacketing or by injecting cooling water into the silencer. If weight is not important, cast iron silencers can be expected to give long service. The more common uncooled sheet metal silencers burn out so fast that justification for their use is doubtful, and in most cases a straight exhaust would be preferable and cheaper. If they are used they should be well lagged, both to prevent danger from burns and to prolong life.

(*i*) *Gear boxes.* It has been suggested that industrial engines coupled for forward driving only can give a considerable saving, but this view is not supported here. For satisfactory operation a marine must have a forward, neutral and reverse drive for the propeller. In neutral, the propeller should stop rotating completely. These three operating conditions can be met either by gearboxes or controllable pitch propellers in conjunction with a clutch. Controllable pitch propellers are particularly good when extremely slow speed is desired at times, such as when hauling lines or nets. These have reached a high degree of development in a few countries, notably Scandinavia, and are always worth considering when purchase from long established makers is contemplated.

Most small marine engines are equipped with gearboxes. There are a great variety of these and space does not permit a comparison of individual types. Fishing operations often impose severe strains on the gearbox. In particular clutches are often slipped for prolonged periods when working the gear, and these should, therefore, be of more generous dimensions than the power of the engine might indicate. This is particularly the case for cone clutches which are supposed to be self adjusting. Many gearboxes use plate clutches for the ahead drive and brake bands for reverse. The adjustment should be simple to carry out, and a single adjusting ring is preferable to two or three adjusting screws for the ahead drive, unless competent mechanics are available for making all adjustments.

Separate Lubrication

Separate lubrication of the gearbox from that of the engine will reduce the danger of clutch plates sticking due to dirty engine oil, and at the same time it will protect the engine from abrasives in the event of excessive wear due to slipping the clutch. It will also usually afford a certain measure of economy, as the gearbox oil can be used about three times longer than the engine oil.

(*j*) *Stern gear.* Three types of stern gear are met with in small fishing boats, in terms of the mounting of the bearing closest to the propeller: Lifting, strut or deadwood types. Lifting stern gear, in which the propeller can be raised for beaching the boat, is usually used where the beaching takes place in relatively calm water, as the propeller must be stopped before it is raised, and the boat is pulled up by manpower or a winch without assistance from the propeller. This system requires a universal joint outside the hull, and rapid wear of this joint and of the propeller bearing are to be expected due to lack of lubrication and uncertain alignment. Its use is only recommended where conditions favour this type of landing as a regular operational feature.

Strut mounting is usually found in fast boats, or in craft with two propellers. The advantage is that this arrangement permits free flow of water to the propeller and along the hull. The propeller is exposed and, therefore, in danger in shallow or fouled waters, and it is also likely to interfere with fishing gear being operated from the boat or in the path of the boat.

Mounting the propeller bearing on the dead wood, shaft log or stern post is the most common arrangement in small fishing craft. This system usually includes a stern tube and inside bearing. If protected by a skeg, it gives fair protection against gear or beaching, and if necessary it can be enclosed in a cage to exclude nets completely, but at a loss of some propulsion efficiency.

The lifting and strut installations call for water lubricated bearings, i.e. rubber or wood. The dead wood mounting can also use these as well as grease lubricated bearings, which are usually lined with white metal although brass bearings are sometimes used for cheapness.

Water lubricated bearings require a definitely positive flow of water, a requirement unfortunately often overlooked. If they are countersunk into the dead wood a short life must be expected. Similarly, if they are used inside the hull, water pipes should be provided to give a flow of water through the bearings.

Water Exclusion

Grease lubricated bearings need grease cups, or preferably pumps of ample size to keep the bearing well fitted with grease. Here the object is to exclude water as much as possible, and oil seals on the outside not only help keep the bearing well packed with grease but are instrumental in excluding sand and dirt which otherwise enter when operating in reverse gear.

All bearings should provide a large bearing surface and this should be renewable without the need for removing the propeller tube or the bearing housings. Recommended types are white metal inside the hull and rubber outside. The combination calls for rubber bearings which are grease resistant as some grease from inside will find its way to the outer bearing. This arrangement has given excellent results in conjunction with high grade stainless steel shafts.

(*k*) *Power take-off.* If the engine is intended to drive a winch, generator or other auxiliary, the arrangement should be considered before purchasing the engine. The savings from a cheaper engine may disappear if it does not readily lend itself to performing the duties that are expected, in addition to powering the craft.

(*l*) *Tools, installation fittings and extras.* A number of items are required to complete the installation of an engine, apart from the engine, gearbox and sterngear. In many localities these can be readily obtained, but their value must not be overlooked when comparing prices. This applies equally to tools and other extras which may be desired. In remote areas the absence of any necessary fittings may make installation very difficult and expensive.

Of these items the fuel tank is the most important. The capacity should suit the requirements of the fishing operations, taking into consideration ease of refilling. For prolonged fishing it will not be possible to provide a large enough tank by using gravity feed, so a fuel lift pump will be required. For shorter periods of operation gravity feed is preferred due to its greater simplicity and reliability. In any case provision for settling out of dirt and water and their easy removal is essential.

The tools and spare parts provided differ greatly in both quality and quantity with different engines. The quality of the tool is difficult to assess from a printed list, and if possible the tool set should be inspected before purchase, to form some idea of its value. Extras, such as flexible mountings, electric starting, thermostats, remote engine control and so on should be evaluated in terms of their usefulness for the proposed installation, rather than at their quoted prices.

Economic Comparison of Suitable Engines

Diesel engines.—First cost. The price of a diesel will depend primarily on its power. It will also depend on the weight of the engine, which is intimately tied up with its speed, particularly if this is measured by the speed factor (rpm times piston speed) rather than rpm alone. The price will depend as well on the quality of the engine, the accessories supplied with it, the rate of duty applicable, and the pricing policies of the manufacturers and the agents.

In early 1961, a comparison of the retail prices for single engines was made in Colombo, based on 46 models of 13 different makes, of which 42 were 30 hp or less. The engines included a wide range of speeds and types and may be taken as typical of " small " diesels. Although the data scattered rather widely definite correlations between weight, speed factor, horse-power and price were obtained, and although the numerical values of the price will no doubt be different in other places the other relationships will probably hold fairly well for the IPFC region.

Price will be given in terms of US $ retail; the original calculations were made in terms of Ceylon rupees, and values which had been rounded off originally, now appear with a number of decimal places not justified by the data.

Weight per horse-power +

$$\text{lb/hp} = \left(1 - \frac{\text{Speed factor}}{100}\right)_e (4\cdot66 - \cdot0258\ \text{hp}) \quad (1)$$

Price per lb.:—

$$\text{US\$ per lb.} = 1\cdot25 + 0\cdot0145 \times \text{hp} \quad (2)$$

Contrary to expectation, the results for air cooled and water cooled engines overlapped to such an extent that separate weight or price formulæ did not seem justified. A simple average, disregarding size and speed did, however, give a slightly higher price per lb. for air cooled engines.

Examples

Fig. 1 gives the price of engines of different powers and speeds, based on the above formulæ. The increase in price per lb. with size results from the associated increase in number of cylinders. Increasing the number of cylinders adds comparatively much fully finished material which is

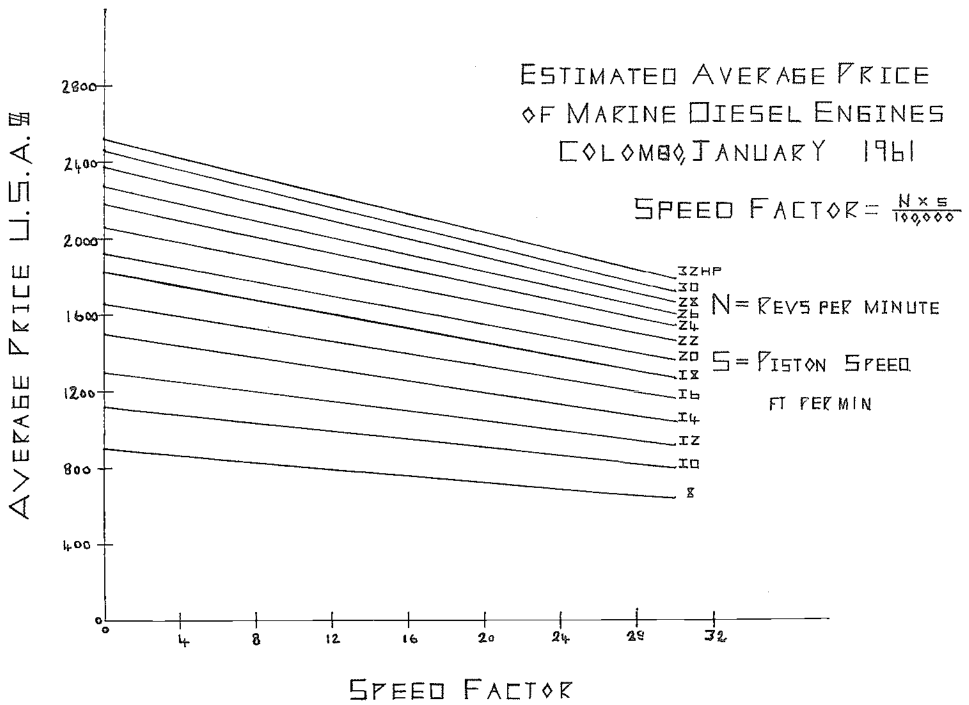


FIG. 1.

expensive. The decrease in weight per horse power will more than compensate, giving a lower price per horse power for multi-cylinder engines of a given basic type than for engines with one or two cylinders.

Fig. 1 shows that for any given power, high speed engines will on the average, be cheaper than slow speed. The prices include reduction gearing to give approximately the same propeller speeds for all types. The question immediately arises whether high speed engines (speed factor over 20) should not be the automatic choice, particularly as other advantages can also be claimed for them such as light weight, compact size and smooth operation. Hand starting may also be easier due to the smaller air charge to be compressed to produce the first firing stroke.

Definite Advantages

Definite advantages can, however, also be claimed for slow speed engines (speed factor 9 to 12), while medium speed engines (speed factor 12 to 20) will fill an intermediate position. The most significant claim made for slow speed engines is long life. This expectation may not be realized in practice if the engines are cruelly neglected by inexperienced operators, in which case a short life will be obtained from any diesel, and the slow speed engines may not show any superiority as, by and large, they depend more on good field servicing and less on workshop maintenance than faster engines.

Given reasonably trained operators and field repair staff, and in the absence of well equipped workshops and regular overhaul and replacement schedules, slow speed engines are worth the extra price, and it is felt that the prices given in Fig. 1 form a reasonable basis for comparison after they have been adjusted to conform with local rates. For example, a 20 hp diesel with speed factor 10 has a graph price of US$1800, while the same size with speed factor 30 is priced at US$1400. Two engines which each cost say 85 per cent. of these figures would be considered comparable buys. If one costs say 90 per cent. of the graph price and the other 75 per cent., the purchase of the former would require further justification on the basis of the technical considerations already discussed, or of other economic factors.

Comparisons

Weight to be given to technical factors: When comparing engines one would expect that the more expensive ones will show superiority with respect to the technical factors already discussed and the question is posed as to how much these are worth in terms of hard cash. It is possible to assign somewhat arbitrary values in monetary terms or in percentages to these items. The differences between the totals for different engines should represent the amount or percentage which it is justified to pay more for one engine than another. Assigning values to the different factors is difficult, as one man's meat is another man's poison and the intended use, the type of craft and the maintenance facilities all influence the desirability of a particular feature.

A simple procedure, and quite satisfactory is to assume that the technical factors excluding accessories make up 25 per cent. of the value of the engine and the accessories make up another 25 per cent. Each item listed in the chapter on technical considerations (plus any others, etc.) is given a rating of 0, 1, 2 or 4, and the accessories are treated in the same way. The totals for different engines will give a reasonable indication of how much more can be paid for one engine than another.

It is of course assumed that the engines have already been screened for suitability, and that the choice here is between engines which are acceptable, but to a different degree.

Depreciation

The life of a marine engine will naturally depend on the servicing and repair facilities available. As has already been indicated, these factors will affect different types of engines to different degrees. Very little information is available on the actual life expectancies and the following table is to be taken as a rough indication only.

Life expectancy in years of small marine diesel engines:

Speed factor	*Workshop facilities*		
	Poor	*Fair*	*Good*
10	6·0	7·0	8·0
20	5·1	6·4	7·5
30	4·3	5·9	7·1

These life expectancies are considerably lower than the values usually given for diesel engines, which for small engines are commonly 10 to 12 or even 15 years, but during the initial stages of the fleet development a high mortality rate must be expected.

Maintenance Costs

It is difficult to give figures for the cost of maintaining a fleet of engines, both because data are hard to come by and conditions vary very greatly. The annual repair bill for a given engine will vary from year to year as well. In general it will lie between about 8 to 12 per cent. of the value of the engine when new, although complete reconditioning will cost more, even twice as much. If a complete servicing and repair schedule is made for the fleet the maintenance costs, barring accidents, can be calculated with some degree of accuracy, but such schedules will always be subject to revision in the light of experience. It is recommended that a single value be adopted for the purpose of engine selection, that is that no differentiation be made between engines of different types as far as expected maintenance costs are concerned, unless the differentiation is based on actual existing facilities which may favour a certain type of engine.

Operating Costs

The main items in the operating costs are fuel and lubricating oil. These can be estimated from the rated fuel and lubricating oil consumption, including the lubricating oil used for oil changes, and the cost of filter elements.

These items should not be leaned on too heavily in making a selection between different engines, as it must be expected that the engine will not always be in peak condition. For comparison purposes it is advisable to use only $\frac{2}{3}$ or $\frac{1}{2}$ of the calculated savings from an engine due to lower fuel or lubricating oil consumption, to allow for failure to change oil regularly and for poorly adjusted injections and pumps, as these tend to equalize the consumption.

Intangibles

The purchase of an engine which has been tried and proven, produced by well established manufacturers, and sold by agents with a good reputation and adequate spares and maintenance facilities will go a long way to alleviating many difficulties which may otherwise be expected in the process of building up a fishing fleet. This is not to say that new engine makes should not be considered carefully. But unless such engines offer definite technical or economic advantages over established brands it would be rash to invest in them on a large scale " just to see."

The purchase and working policies to be followed whilst building up the fleet can also have direct bearing on the engine selection. If bulk orders for engines of more than one size are to be placed, the selection of a make which offers a range of suitable engines with a varying number of identical cylinders with interchangable parts would be indicated, particularly if the stocking of spares and the provision of maintenance is to be the responsibility of the fleet management.

Bulk orders may also introduce further benefits which are sometimes difficult to include in a direct comparison of engines such as free servicing, field maintenance units, training of operators or mechanics or more favourable stocking of spare parts. The choice of an engine already in widespread use as a stationary or vehicle engine may offer similar advantages.

A different kind of intangible would be well established preferences or prejudices amongst operators. Any engine will give much more trouble in the hands of a man who has no faith in it, than if it is run by someone who believes it is the best available. Considerations of this sort may be of negligible importance in the case of a fleet which is to be centrally directed by one authority, but can be significant if the fleet is to consist of small individually controlled units.

The existence of a large number of mechanics trained or experienced in the maintenance of a particular type of engine or of facilities particularly suited to a certain engine type might also influence the selection in favour of that type of engine while good training facilities would tend to have an equalizing effect between established and introductory types.

The tabulation of intangible factors would be greatly extended, but the above will serve to show that the rational selection of engines is not something that can be worked out on paper to the final degree of accuracy.

ENGINE BEDS FOR SMALL FISHING BOATS

Erik Estlander

TO obtain the best performance from a boat, the space taken up by the engine should be as small as possible, to allow more working area for the fishermen and maximum space for gear and catch. This often means that the engine is fitted in the aft end where, however, it is difficult to find space for a well developed engine installation.

The propulsion machinery in a fishing boat consists of the engine, stern gear, and propeller which should all be built into one common foundation system. This presumes that the keel, shaft log and engine foundation are built as one rigid unit. One of the most common causes of engine troubles in small fishing boats is vibration resulting from poor installation of these three components. The compact arrangement of outboard engines causes few installation troubles and must be one of the reasons for their popularity.

Vibrations

Vibration in a boat is caused by the engine, propeller, and the shaft.

(A) Vibration in the *engine* (properly fitted and properly working) occurs for two main reasons:—
  (1) unbalanced quantities;
  (2) the pressure when the piston is moving down during the expansion stroke. In a well balanced engine this factor is by far the strongest. This pressure will affect one engine bearer more than the other, and will give the engine a slight tendency to go out of alignment for a moment.

(B) Vibration in the *propeller* occurs from:—
  (1) unbalanced quantities or shape, and/or;
  (2) The wake behind the stern post. Therefore the stern post has to be " streamlined " as much as possible and the propeller bearings outside the stern tube should project more than 4 in. beyond the shaft log, to give the water a better flow.

(C) Vibration in the *shaft* is caused by:—
  (1) taking up vibrations described in (A) and/or (B);
  (2) misalignment of the shaft, especially if there are more than two bearings between propeller and engine. The shaft may be misaligned when a dry boat is launched, and a slight deformation occurs in the shape of the boat, or
  (3) if the shaft is bent or underdimensioned or the engine beds are wrongly designed, there will be vibration in the hull.

Engine Beds

To eliminate engine vibration it is necessary to connect the two main engine bearers through a rigid system of floors to the keel. The engine bearers should be long, about $2\frac{1}{2}$ times the length of the engine and the floors supporting them should be made in one piece with the bearers bolted well to the floors. It is considered unnecessary and undesirable to cut the engine bearers so that they follow and touch the planking. The propeller thrust can normally be ignored.

In wooden boat building the principle applied when connecting members is that the friction occurring between these members from the pressure of a bolt, screw or other securing means should " glue " or " weld " them together into a solid unit. The bolting has therefore to be arranged with this objective.

To illustrate what has been said above, the $27\frac{1}{2}$ ft. fishing

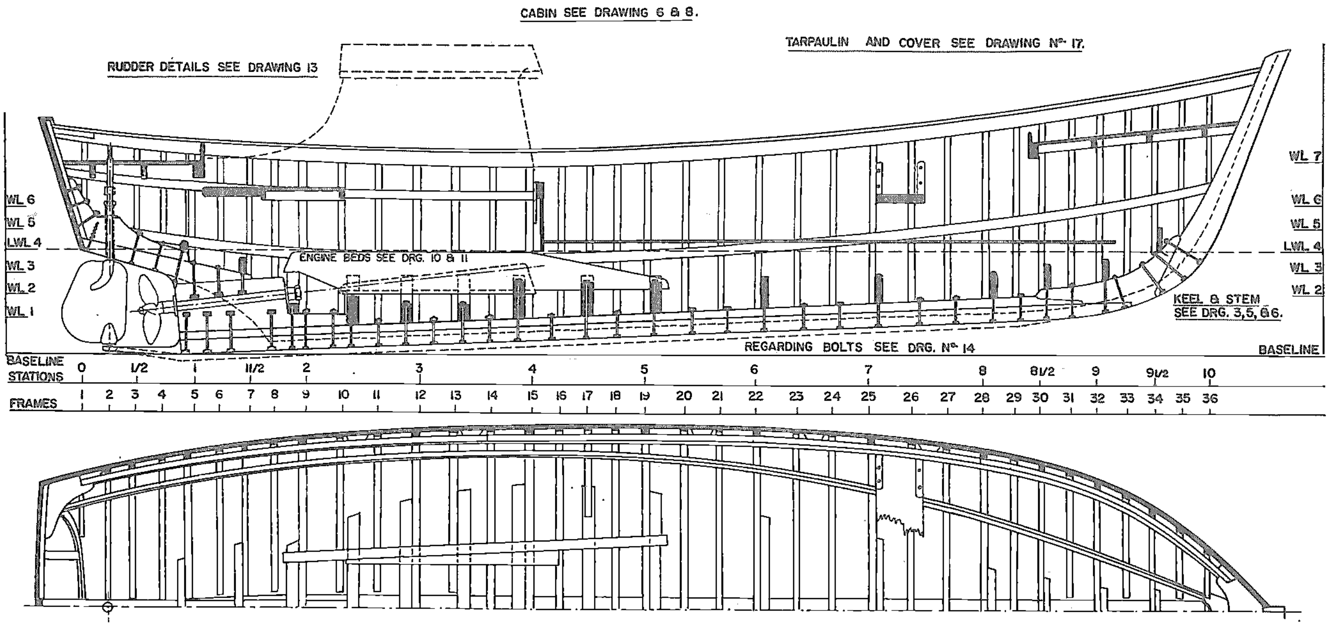


FIG. 1.

boat developed in Ceylon for net fishing and longlining can be studied. The boat is designed to carry a maximum of 50 drift nets. Because the size of the boat was limited by the conditions of the Government's loan scheme, space was very restricted and the engine had to be put as much as possible in the rear. Working conditions are in many ways very hard, since the fishermen have to go over shallows and reefs where the boat touches the bottom in the breakers. This will lead to a misalignment of the engine and stern gear if they are not built as a "compact unit" on a common foundation. The general arrangement of the boat is shown in Fig. 1.

Figs. 1 and 2 show how the engine beds are arranged. The main engine bearers are not parallel, permitting a closer connection to the floors in the rear part of the boat. At the same time the " parallelogram effect " disappears. These main engine bearers overlap the shaft log, thus making a rigid connection between engine and stern gear. The shaft angle is between 6 and 7½ degrees depending on engine make. The distance between the inside of the shaft log and the engine flange is only 15 in.

As this is a question of the mass production of boats where several types of engines will be built in, the engine beds have been arranged so that the engine rests on separate seats, well connected to the engine bearers, and through-bolted to the floors. The engine beds are common to all makes of engines and are, therefore, built in before the planking of the boat. Only the engine seats are put in afterwards to fit different makes.

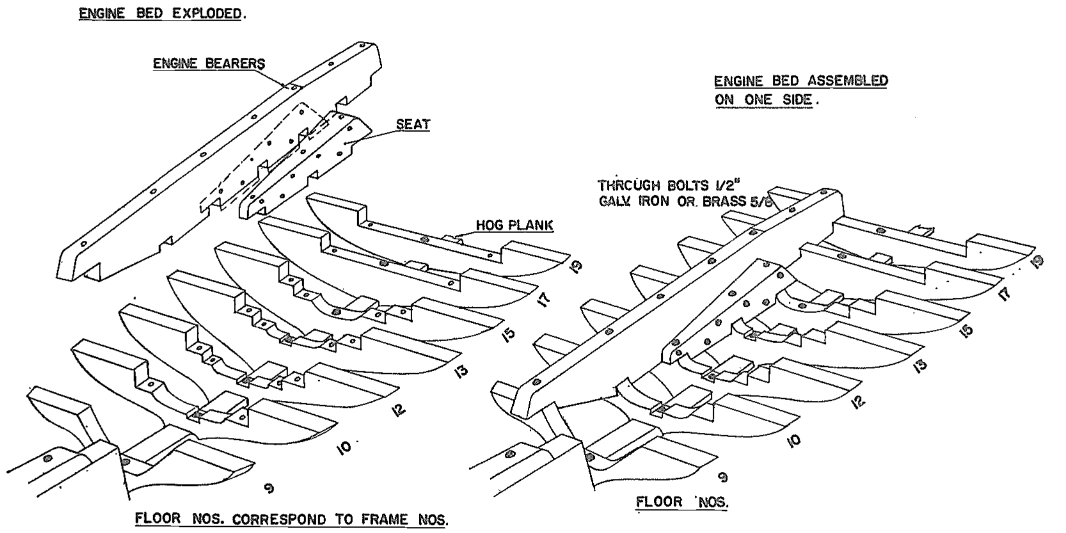


FIG. 2.

This type of engine bed has another advantage, namely, that if the engine foundation is fairly narrow and the flywheel in the fore end of the engine has a large diameter, as for instance in some of the Japanese engines, this will not cut off the main engine bearers. A disadvantage is that for realignment of the engine it has sometimes to be lifted fairly high to get the necessary shims underneath, as the main engine bearers protrude above the level of the seats.

Engine Design

Another problem to which the engine manufacturers do not seem to give full attention is that an engine has often to be installed in the aft end of the boat, where the space is very narrow. If the feet on which the engine rests are low, they will in reality leave little or no wood for the engine beds or seats. In extreme cases the engine has been taken farther forward to get them built in, thereby reducing fishing space. Figs. 3 and 4 show random examples of how different engines fit into these engine beds, approximately at station 3, where the aft engine feet are usually situated.

Many more examples could be given. The feet of some engine types must be turned upside down to get more clearance aft for the engine seat. Sometimes completely new feet for the engines have to be made locally. The correct feet arrangement on engines is to have the aft feet higher up than those in the fore-end thus giving more wood for the engine seat. Many American petrol engines designed for planing hulls, have the engine feet arranged at an angle of about 6 to 9 degrees to the crank shaft. This can be very easily realized for many engines if the aft feet are loose pieces fitted to the engine by bolts.

Important pieces of engine equipment such as strainers for the cooling water, oil filters, dynamos, etc., should be arranged so that they can be easily installed or removed without cutting pieces from the seats or main engine bearers. For engines fitted in the centre or fore end of the boat there are no such engine bed problems, as there is plenty of space to develop a system of longitudinal transversal members. The problem in such cases is to get the engine bearers connected to the shaft log so that misalignment does not occur due to rough handling of the boat, when going through breakers.

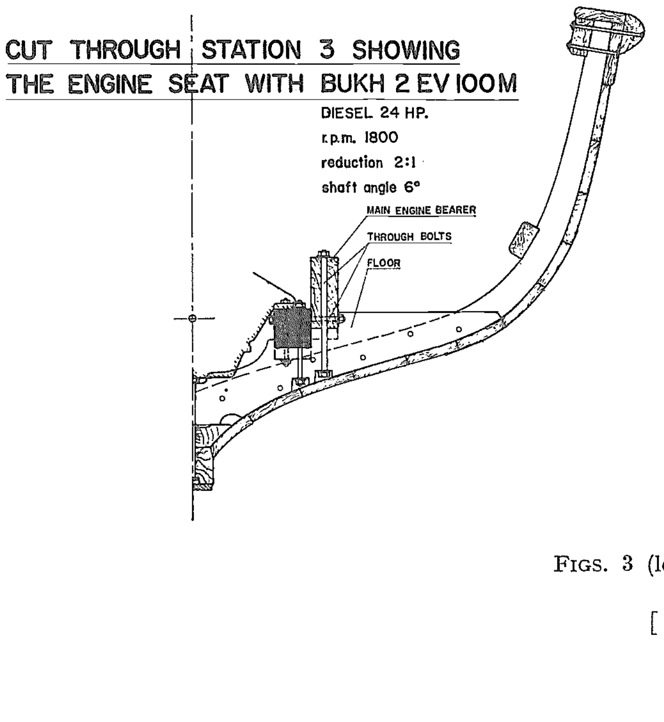
Sterngear

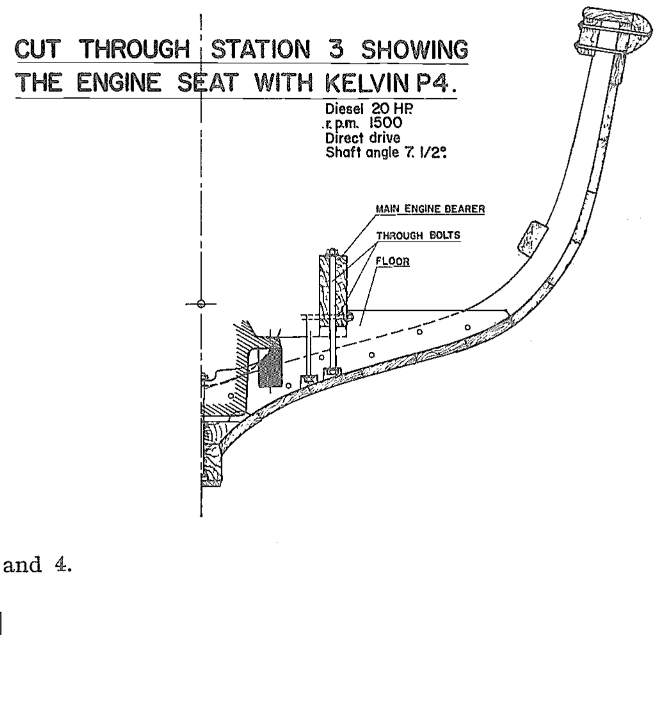
One further problem when building in engines in the aft end of small boats is that the distances between propeller bearing or sterntube inner bearing and the engine is so short that the slightest misalignment will cause big stresses on the sterntube inner bearing and propeller bearing.

If the distance between propeller bearing and the engine aft bearing is so short, no bearing in between is necessary, and therefore the sterngear inner-bearing should be left out and replaced by a flexible stuffing box. (Fig. 5.)

Recommendations

1. When designing small fishing boats, the engine beds, including shaft log, have to be incorporated into the backbone of the boat at an early stage, since they are important members in the backbone construction of the boat.
2. The engine manufacturers should agree upon a standardizing of marine engine foundations for engines of the same size along the following lines:—
    (*a*) The engines should not have more than two pairs of feet, one at the very fore end of the engine, and the other just after the last cylinder, not fixed to the gearbox. It is not advisable to have the transversal combustion pressure delivered to the engine beds via the gearbox. In small fishing boats, engines have often to be installed or realigned under unfavourable circumstances, and it will be easier to align two pairs of feet rather than three.





FIGS. 3 (left) and 4.

EVINRUDE

OUTBOARD MARINE INTERNATIONAL • NASSAU, BAHAMAS • BRUGES, BELGIUM

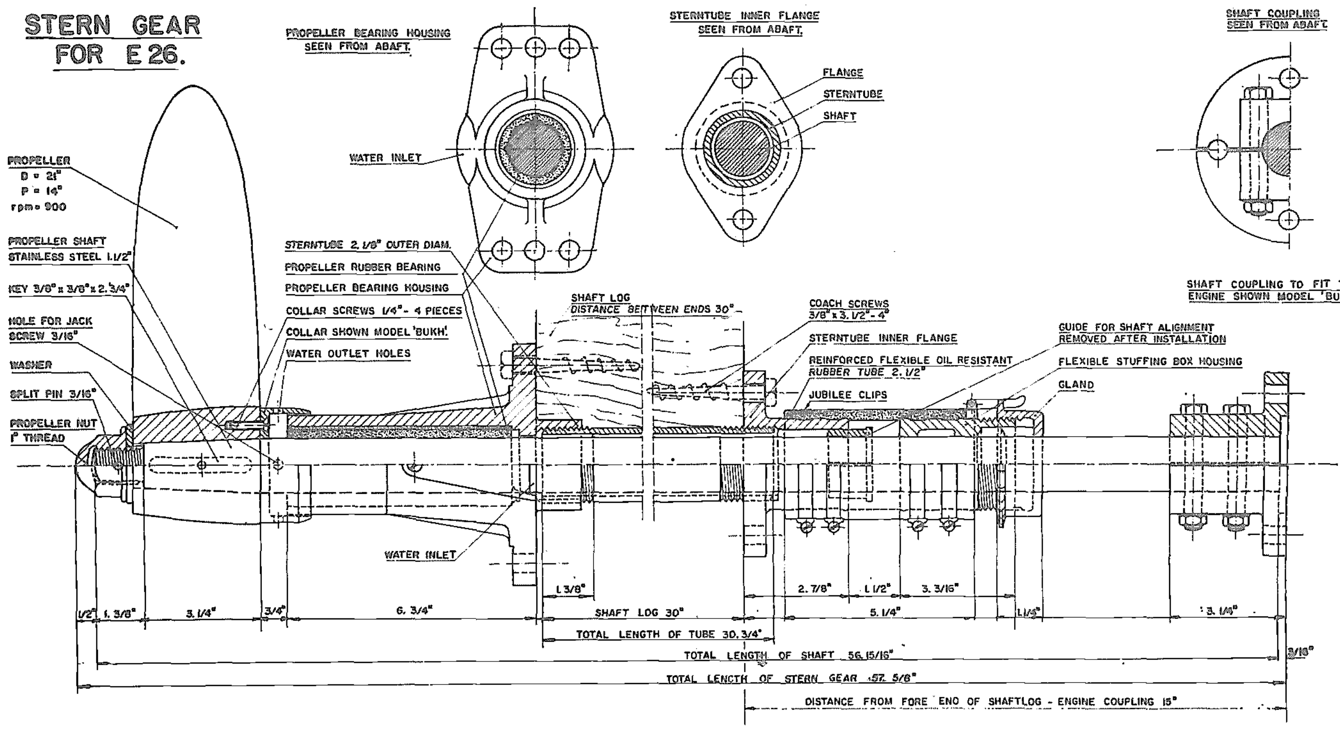


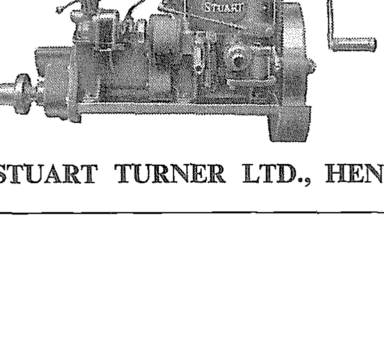
FIG. 5.

(*b*) The level of the feet or foundation should be 2 in. or 3 in. over the propeller shaft level, but will depend on whether the engines have reduction gear or not.

(*c*) If the gear feet are separate pieces bolted on to the crank case, feet with a 4 in. higher level can be delivered as an optional extra to fit an engine built into the aft of the boat.

(*d*) A guide to the distance between fastening bolts for one- and two-cylinder engines with an output of 8–12 hp per cylinder and 1,500–1,800 rpm (covering a wide range of makes) is:—

Transversal ...	20 in., maximum 22 in.
Longitudinal—	
one-cylinder ...	12 in., maximum 16 in.
two-cylinder ...	18 in., maximum 22 in.



(*e*) Instruments and equipment should be so fitted to the engines, that they can be removed or handled without having to cut higher engine beds, since they are members in the longitudinal stiffening system of the boat. Bolts, and not studs, should be used for the fastenings.

(*f*) Arrangements for remote control, especially for the gearbox should be standardized and simplified.

(*g*) It should be possible to start the engine at both ends. This is essential for engines built in aft in small fishing boats, as a live bait tank, a closed fishhold, etc., have to be built just in front of the engine. If the engine is built in the middle or fore end of the boat the engines have mostly to be started at the fore end, depending on accommodation arrangements.

3. (*a*) The diameter of the propeller should not be too big. Small fishing boats often operate in shallow water which limits the space for the propeller. If the pitch/diameter ratio for engines with a reduction 1 : 2 is taken to 0·6–0·7 it also covers special cases where the water is very shallow, while still allowing work with an economical efficiency.

(*b*) The propeller bearing should be shaped so that it projects well behind the deadwood to produce ample clearance between the deadwood and the propeller.

(*c*) Rubber bearings have shown good results in sandy waters provided they are well flushed with clean water, and should be considered as standard fitments.

MECHANIZATION OF SMALL FISHING CRAFT

Section III: Inboard engines in decked craft

PROBLEMS WITH SMALL DECKED FISHING CRAFT

JAN-OLOF TRAUNG

THERE are obviously a great many reasons for decking larger fishing craft, besides providing protected space for crew and fish. For a sailing vessel, a deck increases the angle it can heel over. Thus a deck increases a boat's ability to carry sails and, thereby, its speed.

The larger mechanized boats generally weigh so much that they will sink if flooded, the weight of the engine being more than the buoyancy of the timber. Here again, a deck is important because it will prevent flooding if the hatches are closed.

The story is not the same for small boats. Here, decking may have several disadvantages. For example, a deck will make the boat heavier and harder to handle on the beach. As most boats under 40 ft. are used only for day trips, a deck may be an unnecessary luxury, since there is no great need for elaborate crew and cargo protection. The crew needs no sleeping quarters and fish could be stored in separate insulated ice boxes.

Seakindliness

A decked boat might easily feel less seakindly than an undecked boat. Because the centre of rotation of any boat is approximately at the waterline, fishermen working in an undecked boat with their feet on the floor a couple of feet *under* the waterline, will have their centre of gravity approximately at the centre of rotation of the boat. However, if there is a foot or two of freeboard, the fisherman's centre of gravity, when standing on deck hauling gear, might be 5 ft. above the centre of the boat. This brings about a very different feeling when the boat is rolling.

It is generally thought that all people react to roll and roll accelerations in the same way. But it is becoming increasingly clear that people will call a roll pleasant or comfortable and confidence-inspiring when it is somewhat like the movement they have been used to in the past.

For example, it has been observed that people used to larger ships very often complain strongly about the behaviour of small fishing vessels which are considered by fishermen to have a pleasant roll. It is really only when fishermen are transferred from one boat to another of roughly the same size that they are in a position to judge whether the roll is better or worse. We have experience in FAO of how boats of the same design brought complaints from canoe fishermen and master mariners, but fishermen, who had similar sized fishing vessels before, thought these boats quite good in the seaway.

Are fishermen qualified judges of fishing vessel behaviour? A fisherman during his lifetime might have personal experience of working on, say, only ten fishing boats, all perhaps roughly the same size. It is, therefore, much less logical to accept the judgments of fishermen than to refer the question to boatbuilders with a wide experience of very different boats, or naval architects who measure boat behaviour scientifically, determining metacentric height, range of stability, period of roll, accelerations and other factors.

One additional problem with the movements of a ship is that people tend to get used to a particular behaviour and, as a softer roll gives less acceleration, people have nothing against the roll becoming soft. This is the behaviour many people would like. The unfortunate fact is that a ship with less stability will have a softer roll.

One frequently sees boats in which deckhouses have been made too heavy and other weight has been added high on the superstructure. The customer who orders such a boat and who is accustomed to such boats, will find this one very comfortable. The feeling of comfort invariably leads to a false sense of security and a feeling that the boat is quite stable. But this happy situation will be upset with the arrival of someone whose background is not with the same size and type of boat. To this person, the roll gives an awkward, unsure feeling.

If independent measurements are taken, it usually would be found that the period of roll has been permitted to increase so much that the ship is unsafe.

Smallest Size of Decked Craft

There is a " smallest practical size " for decked fishing boats, and to find it one must know how boats move in a seaway.

As was explained in the article about open fishing craft p. 35, it is not impossible to build very small open fishing boats for inboard engines, but it would not be economical. Similarly one could build boats with a length of 26 to 28 ft. with a deck but it would certainly not be a practical boat on which an experienced fisherman would want to work.

Over the years FAO has developed and introduced a number of open boats about 30 ft. in length. Existing boats have also been decked. When a decked boat had to be designed, it was felt that an overall length of 32 ft. would be the very shortest one would want to build. A great number of such boats have been built in India during the last five years and the type seems to be coming somewhat more popular than the 25 ft. open boat illustrated in the earlier article. This is in spite of the fact that the 32 ft. types are two and a half times more expensive and only day boats. One reason for the interest in them is the marked increase in number of fishing days per year afforded due to their ability to work under heavier weather conditions than smaller open boats.

Fig. 1 shows the profile, deck and underdeck arrangement of the boat, illustrating how the engine is placed in the bow and drives, by an overhead shaft, a trawl winch placed aft of the wheelhouse. The mast is placed comparatively far aft in order to handle the light shrimp trawl which is used from these boats.

Fig. 2 shows the lines characterized by a good flare in the forebody and carried right to the midship section. Furthermore, the boat has a very wide transom stern to give the most possible deck area aft but still has enough V-shaped sections so as not to create slamming when the boat is pitching in choppy seas. The illustration indicates that both the stem and stern posts should be sharpened as much as possible because it has been found from many model experiments that such sharpening contributes very much to lowering resistance and permitting a good flow of water to the propeller.

It is also important when designing small boats that one studies all " corners " of the boat, that is that one makes a number of sectional drawings to see that all the space is utilized in the best possible way and also makes sure that the construction is specified to be as labour-saving as possible. Fig. 3 gives such sections and Fig. 4 shows longitudinal cut as well as plan views of the deck beams and interior of the hull.

Detailed drawings sometimes frighten boatbuilders because they believe a boat is more difficult to construct from such drawings than from a simple lines drawing, with perhaps a keel shown and a list given of the most important scantlings of the hull members. This is most unfortunate because building a boat to detailed drawings is not any more complicated. Since the designer has taken the time to show all the details, this means that he has also investigated that the boat can be built in a practical way without putting up bulkheads and having to take them down again, and other similar construction problems.

It is always extremely important to ensure on the drawing table that the engine can be fitted in a simple way so that it will be easy to reach for maintenance and operation (see illustration on page 89). When designing fishing boats, one naturally has to make designs so that a number of different engines may be used. However, there is always a danger that the ultimate user is going to choose an engine which is going to weigh considerably more or less than the one calculated for. This might create difficulties if the designer is not consulted when such changes are made.

In the article about open craft, standardization was discussed and I tried to emphasize that boats built to the same drawing in different countries doesn't necessarily mean that they can be made less expensive, arguing that boats should be built for local circumstances, using local material.

Different Fishing Methods

There is always a cry for standardization of boats so that they can carry out a multitude of fishing methods from the same basic hull.

When developing the 32-footer illustrated by Figs. 1 to 4, it was thought at one stage that by developing an alternative design with the engine and wheelhouse aft and the fishhold in front of the engine, it would be possible to get a small boat suitable for gillnetting. Gillnetting is increasingly important in many areas because of the increased catch possible with synthetic fibre nets and because gill-

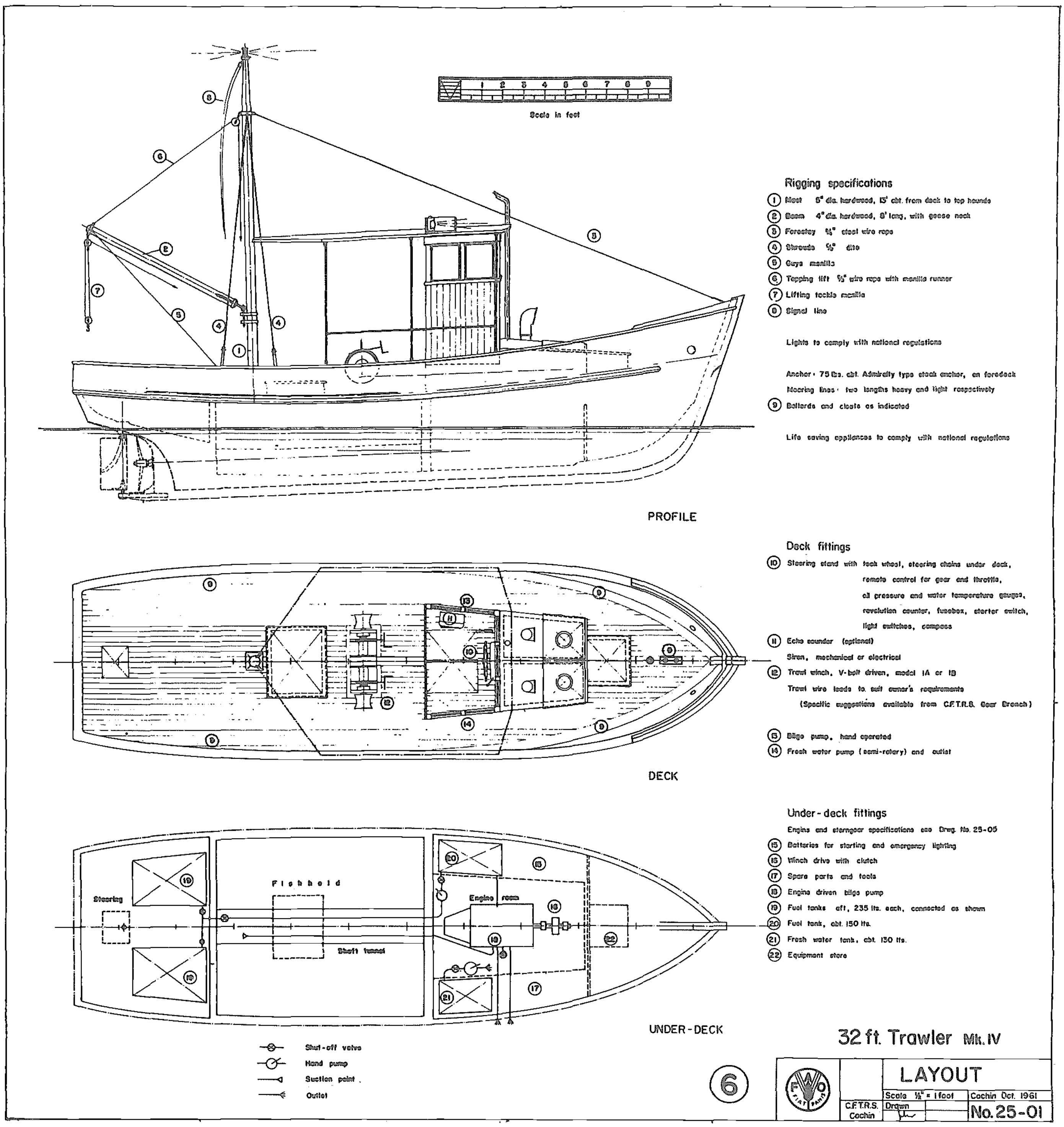


FIG. 1.

netters who operate at the beginning and end of the monsoon get much valuable fish which others miss. The 32 ft. decked boat would also be able to carry considerably more nets than the previous open boats which have been used.

However, when work started on modifying the layout as illustrated in Fig. 1, it was soon found that it would be more profitable to have an entirely new design for this type of fishery. This boat, which was going to carry a much larger load in nets and fish than the previous type, which specialized in shrimp trawling, had to have more reserve buoyancy forward to retain a reasonable trim even with a full fish load. Also, in order to improve handling while drifting, a deeper forefoot had to be arranged and therefore the drag of the keel had to be reduced. All this meant that the flare forward had to be reduced as shown in the lines drawing, Fig. 5.

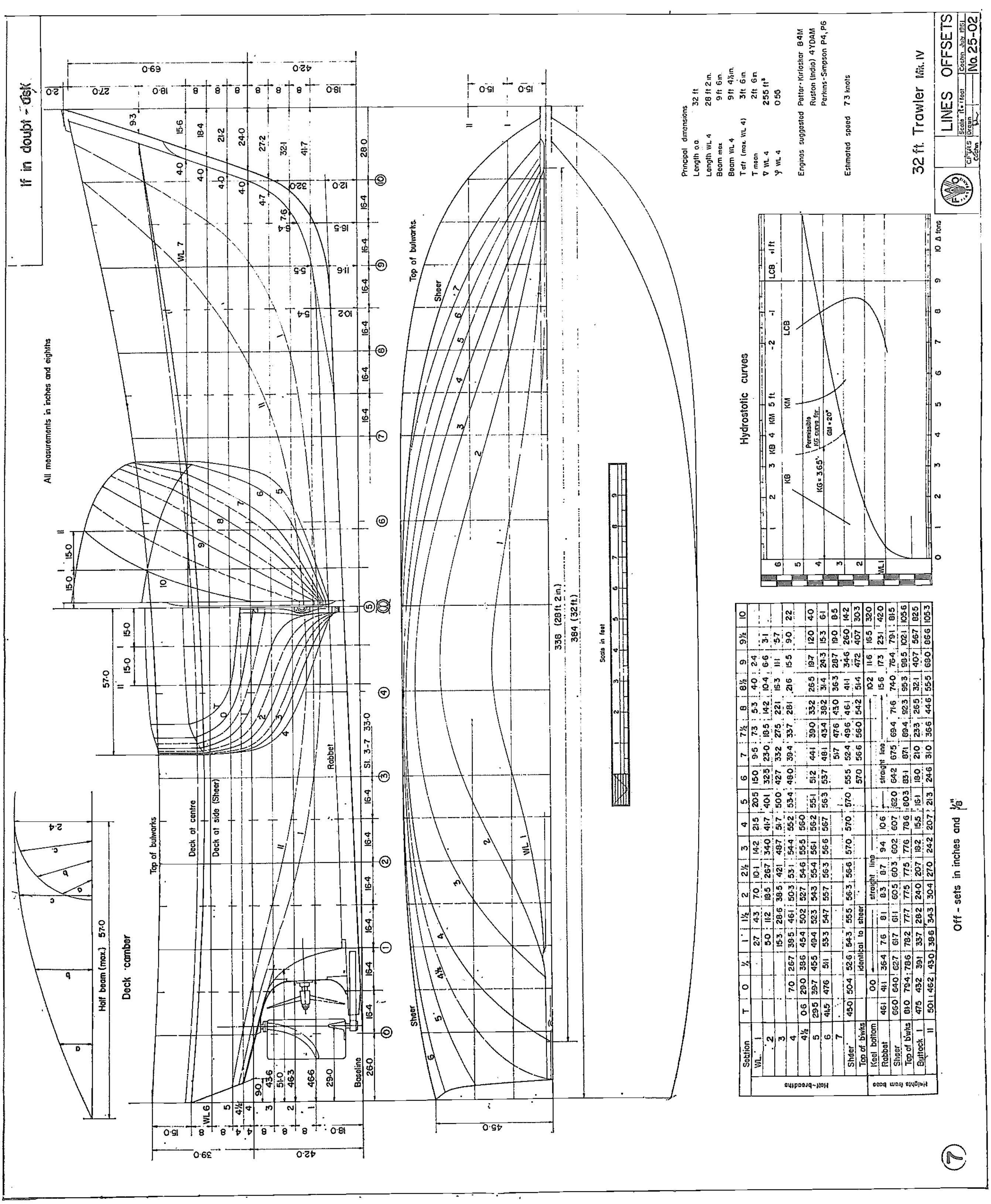


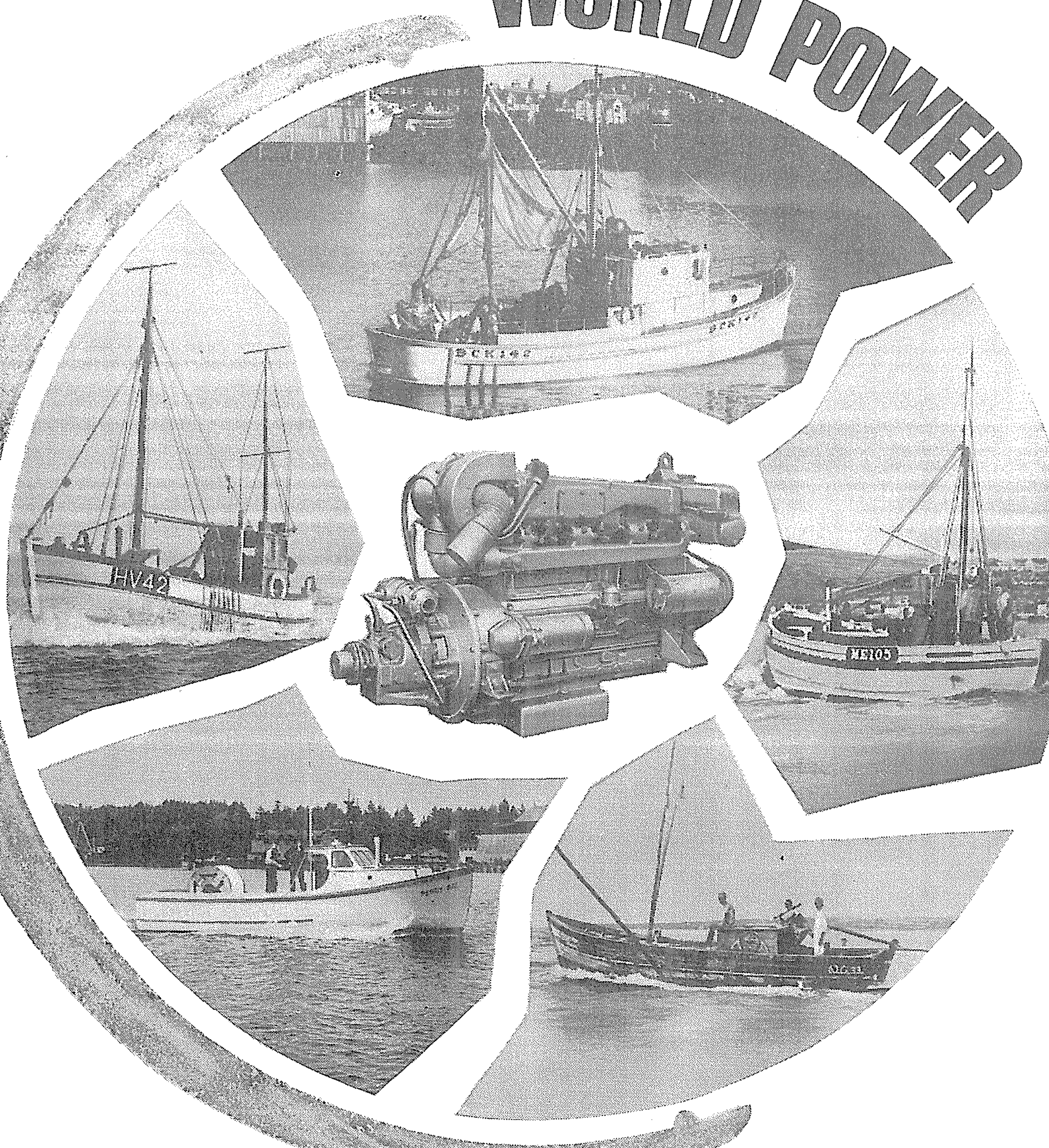
FIG. 2.

The drawings illustrated in Figs. 1 to 5 were developed by FAO naval architect Peter Gurtner, when working with the Central Institute of Fisheries Technology (CIFT), Cochin, Kerala, India. During that time Mr. Gurtner developed a number of designs of fishing boats of different sizes. The 25-footer illustrated in Figs. 1 to 4, in the previous article about open craft, is just another example.

Summary

The drawings presented show two basic differences in fishing vessel design, having the engine either forward or aft. This is determined by the type of fishing method used.

WORLD POWER



Fishing craft differ greatly from ocean to ocean. But power is power anywhere. You ask of an engine that it gives you the right power for the job. That it gets you from harbour to fishing ground cheaply. That it doesn't let you down. That it needs an absolute minimum of servicing. That it occupies no more space than is necessary. All of which argues a Perkins diesel.

You choose a Perkins diesel because it has behind it the resources of a world leader in diesel engine production. The research and development which constantly improve designs is followed by rigorous testing and proving. Moreover, because Perkins companies and distributors are spread throughout the world, you can get parts and service wherever you are.

PERKINS MARINE DIESELS

21-135 S.H.P.

Perkins Engines Limited
Peterborough · England

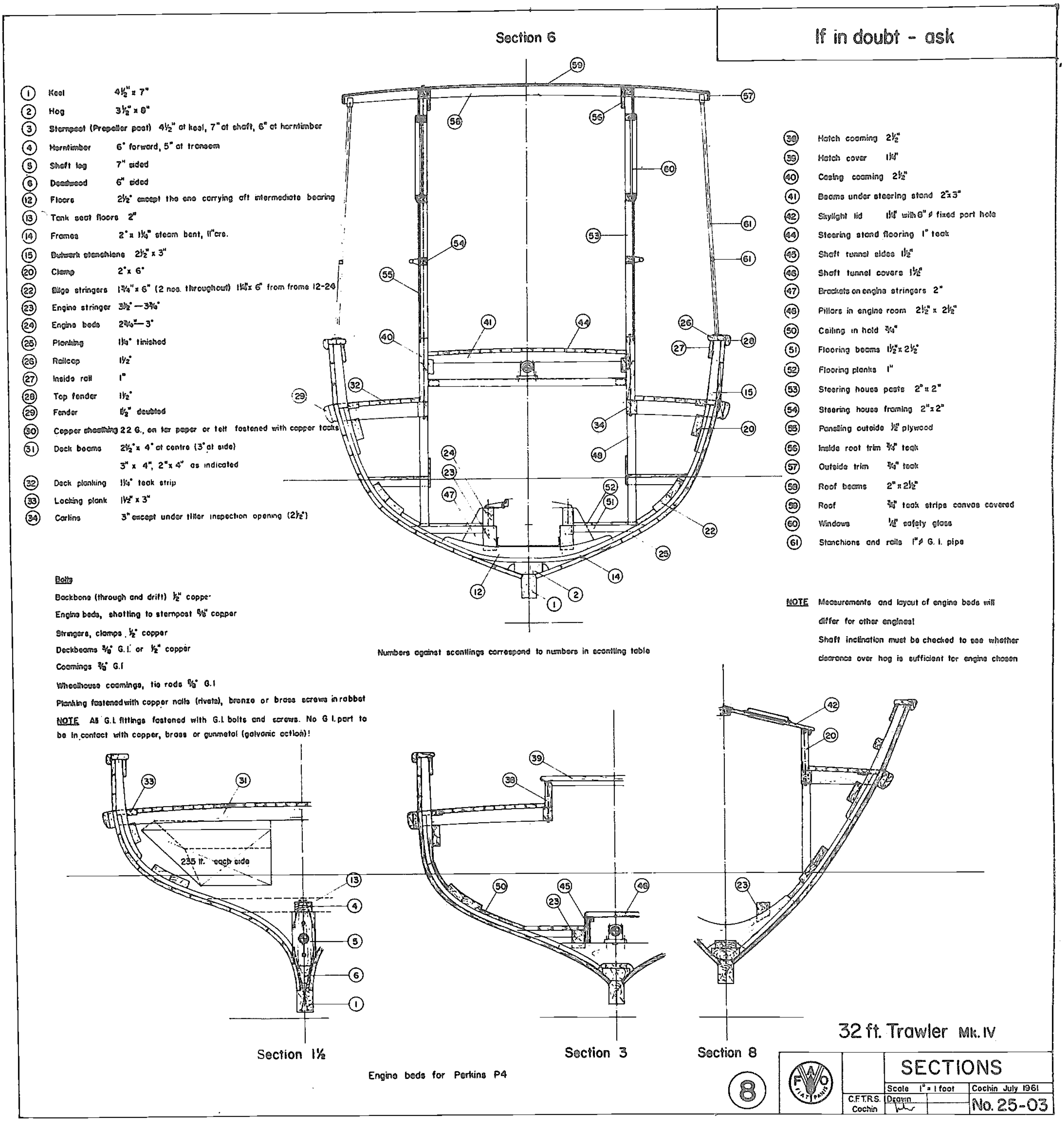
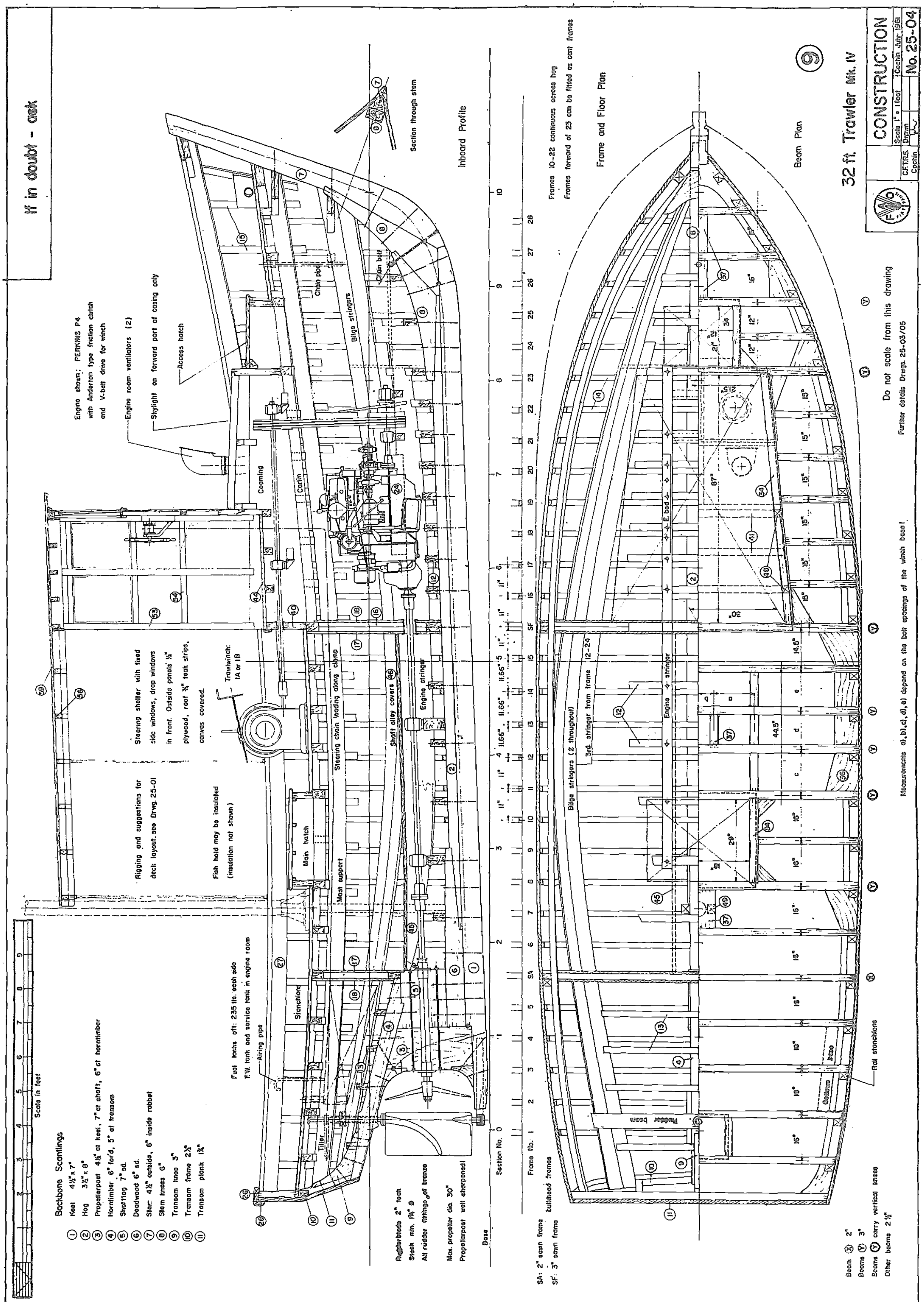


FIG. 3.

In decked fishing boats, there are thousands of possibilities. Already many small decked boats have been shown, particularly in Canadian fisheries magazines, demonstrating practical arrangements using a minimum of labour. As many as possible of these are reviewed in FAO's World Fisheries Abstracts. In the future, quite certainly, the ingenuity of all naval architects who are now employing themselves more and more with the problems of very small fishing boats will develop designs which will get better and more profitable for the user.

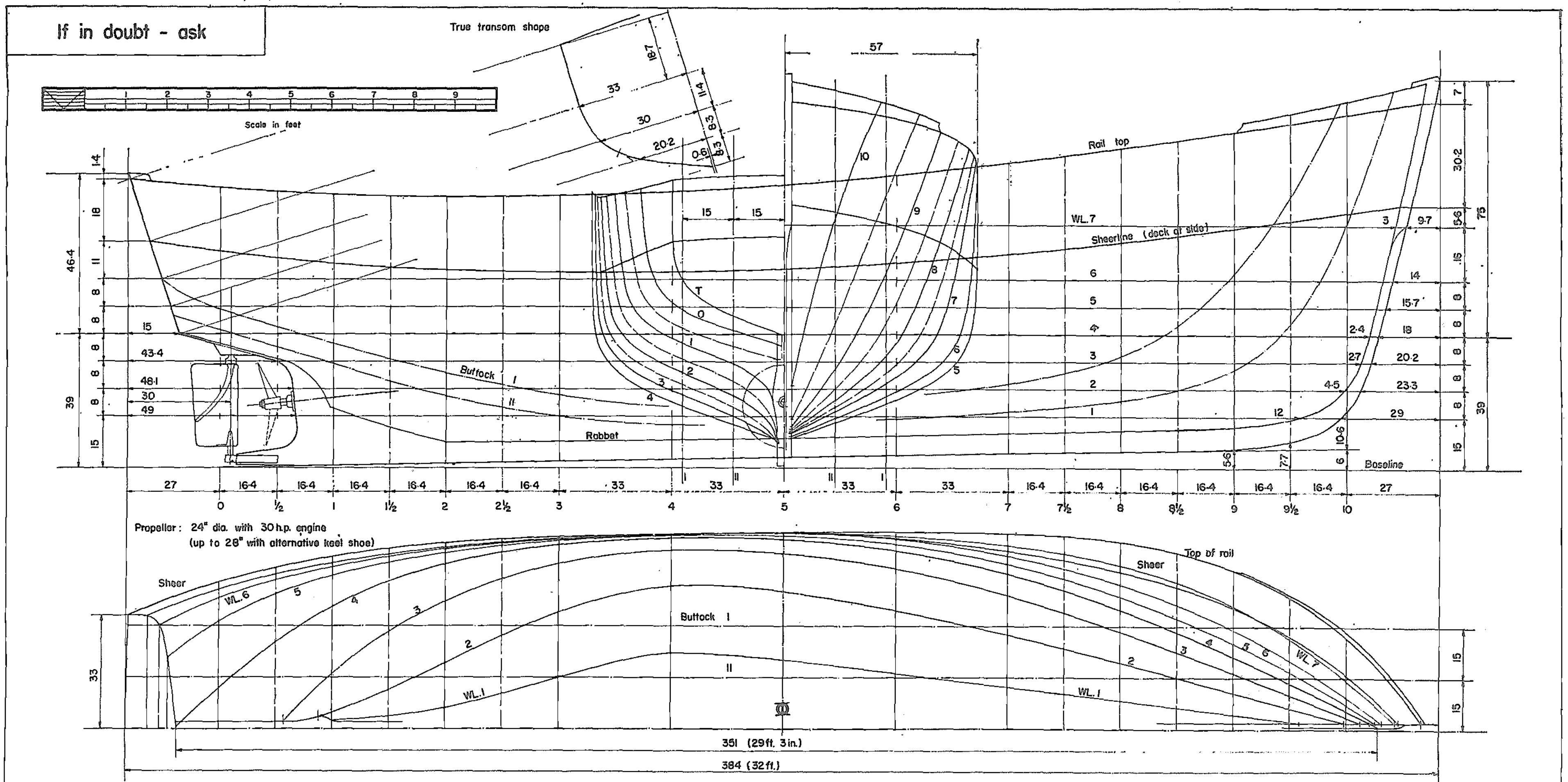
To try to standardize the design of those smaller boats now would just be to stop further development. Fortunately, that will not be possible. Who has jurisdiction over all those young naval architects who are becoming more and more interested in fisheries? And who can stop the world's small boat fisherman from wanting new and different boats, based on experience with the types now in use?



If in doubt - ask
CONSTRUCTION
32 ft. Trawler Mk. IV
Scale 1" = 1 foot
Cochin July 1961
C.F.T.R.S. Cochin
Drawn
No. 25-04
Do not scale from this drawing
Further details Drwgs. 25-03/05
Inboard Profile
Section through stem
Frame and Floor Plan
Beam Plan
Backbone Scantlings
① Keel 4½" x 7"
② Hog 3½" x 8"
③ Propellerpost 4½" at keel, 7" at shaft, 6" at horntimber
④ Horntimber 6" for'd, 5" at transom
⑤ Shaftlog 7" sd.
⑥ Deadwood 6" sd.
⑦ Stem 4½" outside, 6" inside rabbet
⑧ Stem knees 6"
⑨ Transom knee 3"
⑩ Transom frame 2½"
⑪ Transom plank 1¾"
Scale in feet
Engine shown: PERKINS P4 with Anderton type friction clutch and V-belt drive for winch
Engine room ventilators (2)
Skylight on forward part of casing only
Access hatch
Steering shelter with fixed side windows, drop windows in front. Outside panels ½" plywood, roof ¾" teak strips, canvas covered.
Rigging and suggestions for deck layout, see Drwg. 25-01
Fish hold may be insulated (insulation not shown)
Trawlwinch: 1A or 1B
Fuel tanks aft: 235 ltr. each side
F.W. tank and service tank in engine room
Airing pipe
Coaming
Carlin
Chain pipe
Chain box
Bilge stringers
Engine stringer
Shaft alley covers
Steering chain leading along clamp
Mast support
Main hatch
Stanchion
Tiller
Base
Rudder blade 2" teak
Stock min. 1¾" D
All rudder fittings of bronze
Max. propeller dia. 30"
Propellerpost well sharpened!
Section No.
Frame No.
SA: 2" sawn frame
SF: 3" sawn frame
bulkhead frames
Frames 10-22 continuous across hog
Frames forward of 23 can be fitted as cant frames
Bilge stringers (2 throughout)
3rd. stringer from frame 12-24
Engine stringer
E. bed
Rudder beam
Rail stanchions
Measurements a),b),c),d),e) depend on the bolt spacings of the winch base!
Beam ⊗ 2"
Beams Ⓨ 3"
Beams Ⓥ carry vertical knees
Other beams 2½"

FIG. 4.

If in doubt - ask

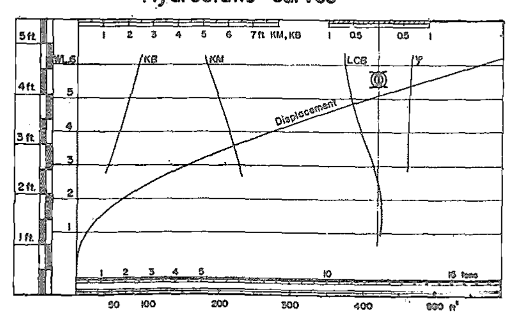


Off-sets

		T	0	½	1	1½	2	2½	3	4	5	6	7	7½	8	8½	9	9½	10
Half breadths	WL. 1				2·4	3·7	6·1	10·1	15·0	21·7	20·1	16·2	12·1	10·2	8·1	6·2	4·3	2·5	
	2				5·7	11·3	19·0	26·7	34·2	41·3	39·6	34·3	27·3	23·2	19·3	15·0	10·6	6·4	
	3				16·3	28·1	37·0	43·3	47·7	51·5	50·6	46·5	38·6	33·6	28·3	22·3	16·3	10·1	3·4
	4	0·6	11·5	25·4	35·4	42·6	47·5	51·1	53·1	55·3	54·6	51·5	44·7	40·0	34·5	28·1	21·1	13·5	5·3
	5	20·2	31·2	39·1	44·4	48·3	51·1	53·1	54·6	56·2	56·1	53·6	48·0	43·6	38·5	32·2	25·1	16·7	7·4
	6	30·0	38·1	43·2	47·1	49·7	52·2	53·7	55·2	56·4	56·5	54·7	50·0	46·5	41·7	36·1	29·0	20·1	9·5
	7										57·0	56·0	53·1	51·0	47·3	42·4	35·6	26·3	14·2
	Sheerline	33·0	40·5	45·0	48·2	50·6	52·6	54·2	55·3	56·4	57·0	55·4	51·6	49·1	45·6	41·3	35·3	27·1	15·6
	Rail top	33·0	42·6	46·7	50·2	52·4	54·1	55·2	55·7	56·5	57·0	57·0	56·6	56·1	54·4	51·3	46·2	38·4	26·6
Height from base	Keel bottom		0	←					Straight line						→	5·1	5·6	7·7	16·6
	Robbet	39·3	35·3	31·5	17·3	12·0	7·3	7·4	7·5	8·1	8·5	9·2	10·1	10·3	10·6	11·3	12·0	14·2	24·0
	Sheerline	66·0	63·2	61·2	59·5	58·4	57·6	57·2	57·1	57·2	58·1	60·0	62·4	64·1	66·0	67·7	70·1	72·3	74·6
	Rail top	84·0	81·6	80·5	79·6	79·2	79·1	79·2	79·4	80·5	82·6	85·5	89·2	91·2	93·5	95·7	98·3	100·6	103·4
	Buttock I	55·0	46·0	40·6	36·3	31·6	27·6	24·2	21·2	18·0	18·5	21·0	24·5	27·6	32·5	42·4	57·0	79·4	
	II	44·3	40·1	35·4	30·2	25·2	21·0	17·5	15·0	12·5	13·1	13·3	16·3	17·6	19·6	23·0	29·0	41·7	72·7

All measurements in inches and eighths

Hydrostatic curves



Principal Dimensions

L o.a.	32'-0"
L WL.4	29'-3"
B max.	9'-6"
B WL.4	9'-4¼"
T aft (WL.4)	3'-3"
Δ light	7.5 tons abt.
Δ loaded	9.5 tons abt.
φ WL.4	0.59
Engine	abt. 30 h.p. (Ruston 3YDAM shown)

32 ft. Fishing Boat Mk. I

LINES

CFTRS Cochin — Scale 1" = 1 foot — Cochin Nov 1961 — Drawn — No. 26-02

(12)

FIG. 5.

DEVELOPMENT IN HONG KONG

W. D. ORCHARD
Fisheries Officer, Co-operative Development & Fisheries Dept. Hong Kong

THERE was no Fisheries Department in Hong Kong prior to the outbreak of the Second World War. The licensing of fishing craft then, as is still the case now, was conducted by the Marine Department. Although district officers in the department responsible for the administration of rural areas kept a general watch on landings during the main fishing seasons as these affected the economy of the villages within their respective districts, no particular Government department, or departments, were responsible for fisheries development. The fishing industry was at that time financed and largely controlled, by the " Laans " or fish wholesale merchants. None of the fishing craft were mechanized. The industry was in a primitive state of development, with the fishermen perpetually in debt to the Laans, and, consequently little or no progress was made.

During the period of the Japanese military occupation (December, 1941, to August, 1945), the Japanese authorities created a marketing scheme under which all fish caught were required to be landed in specified areas and to be disposed of at Government markets. This resulted in a breaking of the financial hold which the Laans previously had over the fishermen.

Following the reoccupation of Hong Kong by the British in 1945, it was decided that the Government should continue to operate the fish marketing scheme created by the Japanese military authorities and thereby prevent the industry from slipping back into the hands of the Laans but, at the same time, to plan in such a manner that the local fishermen could be collectively organized through co-operative societies for the day that they would be able to assume responsibility for the ownership and management of the marketing organization, or simply Fish Marketing Organization (F.M.O.) as it is more commonly known, was created. Although administered by a small nucleus of Government servants in a department now called the Co-operative Development and Fisheries Department, the F.M.O. is financially self-supporting and all expenses are met from a small percentage deduction (6 per cent.) made on the sale of fish through the markets.

The installation of the first auxiliary engines to go into local wind-driven fishing junks took place in 1947. These two diesel engines went into a pair of large deep sea sailing trawlers, owned by the then top trawler skipper in Hong Kong. The engines were purchased with the aid of a loan from the F.M.O. This mechanization experiment proved successful and the example was followed by other fishermen. By March 31, 1949, a total of 17 vessels with auxiliary power were operating out of Hong Kong.

In December, 1953, a Government administered loan fund of GB£50,000 (US $140,000) was established to assist in the mechanization of fishing craft, the capital being received from the Colonial Development and Welfare Fund, partly in the form of a United Kingdom loan and partly as a grant. Individual loans granted to fishermen were limited to GB£625 (US $1,750) each, for the purchase and installation of diesel engines. Loans were also granted for the fitting of locally made capstans. Loan repayments were made through the F.M.O., in the form of additional percentage deductions taken from the proceeds realized from the sales of fish caught by the borrower.

By arrangement with the F.M.O., a number of local business houses, representing diesel engine manufacturers, sold engines to fishermen on deferred payment terms. As in the case of both the F.M.O. and Government loan funds, repayment of the cost of the engines was effected by percentage deductions from the sale of fish caught.

By March 31, 1954, a total of 357 mechanized fishing vessels were working out of Hong Kong. This figure was more than doubled during the following year and, by the end of March, 1955, a total of 750 vessels had been mechanized. During the subsequent six years up to 1961, engines were installed in a further 2,770 boats; the numbers of operative mechanized vessels as at March 31 on each of these six years, sub-divided into boat types, are recorded in Table 1.

Table 1
Numbers of mechanized Hong Kong based fishing vessels as at March 31 each year

	1956	1957	1958	1959	1960	1961
British registered (steel) deep sea trawlers ..	13	11	9	9	8	10
Japanese type (wooden) deep sea trawlers ..	19	19	10	11	14	14
Deep sea junk trawlers ..	53	58	76	77	88	92
Junk shrimp trawlers ..	120	177	280	303	341	385
Junk inshore trawlers ..	35	95	192	216	248	298
Deep sea junk long liners..	51	56	66	68	45	51
Inshore junk long liners ..	270	479	734	744	985 (Inshore junk long liners and Junk hand liners combined)	1,271 (combined)
Junk hand liners	15	41	55	60		
Inshore purse seiners ..	281	429	634	634	681	704
Ku Peng T'eng (drag seiners)	16	14	12	12	*	*
Pa T'eng (purse seiners) ..	8	23	49	47	42	35
Junk gill netters	9	32	82	93	211	584
Fish collecting junks ..	78	90	88	83	84	76
TOTALS	968	1,524	2,287	2,357	2,747	3,520

* Included among gill netters.

Factors affecting the Mechanization

The following notes concern some of the main background factors which affected the mechanization of fishing craft in Hong Kong. The details are not recorded in a set order of importance for much that is described proceeded simultaneously.

(1) *Owner/operated fleet*

The greater part of the vessels in the fishing fleet, estimated at well over 90 per cent., were owner/operated by the individual families of fisherfolk. This meant that most applicants who sought loans to acquire engines started with their vessels as tangible assets. Groups of fishermen owner/operators, all wishing to mechanize their junks, were able mutually to guarantee each other.

Arrangements were made with the Marine Department whereby the junk licence books of fishermen who had either obtained loans to buy engines or, who had purchased engines on deferred payment terms, were endorsed accordingly. Such vessels, although still remaining the property of the fishermen, could not be sold until the loan or purchase price of the engine had been recovered. Mortgages on vessels were rarely taken out.

(2) *Initiative of the fishermen*

The fishermen appreciated the benefits that mechanization of their craft would have for them. They also possessed the initiative to apply for loans and to seek advice about mechanization. These qualities among the fisherfolk, together with their natural intelligence, ability to work hard, frugal way of life and inherent sense of honesty, all made the mechanization of fishing craft in Hong Kong a comparatively simple task.

(3) *Affect of the Fish Marketing Organization*

The F.M.O. led the way in providing cheap credit loan facilities for fishermen and, by providing an efficient means whereby repayments could be collected, also inaugurated arrangements under which commercial firms were able to sell engines to fishermen on deferred payment terms.

Other advantages for the fishermen brought about by the F.M.O. included a fair financial return for the fish caught by selling at auction, and, the issue of cash memoranda to the fishermen in which were quoted the correct weights and the unit prices obtained. The relationship between such matters and the purchase of diesel engines may be obscure, but the point is that for the first time in their history the fisherfolk were independent and knew what their financial positions were. At the same time schools were created, largely with F.M.O. funds, for the education of fisher children. Instead of being treated as a backward section of the community, the fisherfolk suddenly found themselves on a social level with the land population. Furthermore, in many cases the fishermen were actually living at a higher economic level than their " lander " counterparts. It was against this background of what might be termed a social revolution that the fishermen were recognized as good customers for the purchase of diesel engines.

(4) *Suitable types of vessels*

Although the Hong Kong fishing junks have been evolved over the centuries as sailing vessels, and these craft were all built by traditional rule-of-thumb methods without plans, experience has shown that nearly all the various junk types used could be satisfactorily mechanized with inboard diesel engines for auxiliary propulsion. The shapes of the hulls, the strength of the materials used, and the construction methods employed, all rendered the vessels capable of being mechanized.

Some difficulties over engine installation were encountered in the early days but these were overcome. For example, on account of the low rise of stern which left insufficient space for proper propeller clearance it was often necessary in the smaller size craft to install the engine at a slight angle to the fore and aft centre line of the boat, in order that the propeller shaft should project from one side. In the case of larger vessels, sufficient propeller clearance was obtained by arranging for a long projection of tail shaft to be supported externally by " A " brackets.

In examining fishing junk hull form, Yuan (1956) commented that it was remarkable that the local junk has essentially all the coefficients within the range of current practice throughout the world. He also pointed out that there were, however, several points which could be improved upon by considering stability, seakindliness and resistance. Yuan concluded that mechanization could not be done properly without some alteration to the form of hull. Many refinements in junk hull form have taken place in recent years and a higher propulsive efficiency has been attained with newly built boats but, as we are now considering only the original mechanization of the sailing craft, it is sufficient to record that the mechanization of junks with auxiliary power succeeded.

(5) *Insistence on " full " diesel engines*

The Hong Kong Government has always insisted that local fishing craft should be powered with only " full " diesel engines. This meant that all forms of petrol and vaporizing oil engines (including petrol outboard engines), and, " hot bulb " semi-diesel engines, were excluded. The main reason for this prohibition was the increased fire risk involved with petrol and other type engines. The Chinese fisherfolk often use the same vessels as both floating homes and for operative fishing. Large families live on board their vessels under cramped conditions. Cooking is done over open wood fires and the stowage of highly inflammable petrol or kerosene anywhere on board might easily result in accidental fires. Also, in the event of a typhoon threat or actual storm, all local craft try to take shelter in typhoon anchorages where there is considerable congestion and little or no room in which to manœuvre.

Under these circumstances an outbreak of fire could quickly spread to destroy possibly all the boats in that particular anchorage and cause great loss of life. There were a number of additional reasons why the introduction of diesel engines, as against other types of engines, was preferred. It is the intention in this paper, however, to deal only with the actual experience obtained in Hong Kong and, as mechanization with diesel engines proceeded smoothly, this decision is thought to have been wise.

(6) *Availability of engines*

Adequate supplies of diesel engines of many different makes, together with spare parts, the necessary stern gear and all other ancillary equipment needed, were fortunately available at reasonable prices to meet the needs of the fishing industry. Hong Kong being a free port, there was no import duty or taxes on engines. Diesel and lubricating oils were also readily available and the oil companies were not slow to establish distribution centres in the main fishing ports, where " duty-free " and " duty-paid " oils were available.

Furthermore, commercial firms were anxious to sell their products to the fishing community. Government and the F.M.O. encouraged these sales by a number of different means, one way being the periodical holding of fisheries exhibitions where fishermen were able to see the various engines available, and to obtain information as to cost, horse-power, fuel consumption, etc.

(7) *Engine selection by fishermen*

The policy with regard to choice of engines was that the individual fisherman could select whichever make and type of " full " diesel engine he might fancy. In the case, however, of a fisherman applying for a Government loan, consideration was given by the Fisheries Department to the size of boat and intended method of fishing; and, although the fishermen were given freedom of choice, applicants were encouraged to acquire well-known engines with a suitable gear reduction and of adequate horse-power for the work envisaged. The reason for this more or less unrestricted policy was to safeguard against the possibility of a fisherman objecting to meet his financial obligation in the event of subsequent engine trouble, on the grounds that he had been told to accept a particular engine.

(8) *Engine installation facilities*

Yet another requisite for the successful mechanization of the fishing fleet which was fortunately fulfilled in Hong Kong, was the availability of marine engineering shops staffed with fitters possessing the mechanical skill to install the engines correctly. As soon as appreciable numbers of fishing craft started to be mechanized, small commercial engineering shops, in many of which the proprietors (mostly fish dealers and blacksmiths) were already well known to the fisherfolk, " mushroomed " into existence in each of the main fishing villages.

Numbers of skilled fitters, many of whom had been trained in the large dockyards or other modern machine shops, were attracted to employment in the small new engineering establishments. Some local sales representatives of diesel engine manufacturers also assisted by opening workshops of their own, or by arranging for their technical staff to watch the work carried out at the time of engine installation; chiefly to ensure that the engines and propeller shafts were correctly aligned.

Because of the relatively high cost of installing engines, gearboxes and tail shaft assemblies with precision, even today many of the installations are not, unfortunately, carried out to as high a standard as might be desired; the boat owner usually seeking to get the work done at the cheapest possible price.

One particular type of diesel engine, most commonly used in the 4 and 8 hp ratings, which has recently attracted attention in Hong Kong, is sold with a separate outboard propeller attachment for clamping on to the transom of the boat. The outboard attachment, which embodies a gear-shift with forward, neutral and reverse positions, is driven from the engine by flexible " V " belts. The difficulties involved in aligning the engine and propeller shaft correctly in orthodox installations are thereby overcome. Furthermore, in the case of the smaller junk type fishing craft which do not possess a large keep and have no skeg, the advantages in being able to tilt the outboard attachment manually either when beaching the boat or when the propeller has become fouled with matter, are obvious.

(9) *Training of engine operators*

Government appreciated that the transition from sail to power could not be completed overnight but would possibly require several generations to accomplish. Some immediate control over the qualifications possessed by fishermen diesel engine operators were, however, necessary for safety, and highly desirable to ensure that the newly acquired engines would be properly run and maintained. The minimum in examination requirements was accordingly laid down by the Director of Marine and these were enforced as sympathetically as possible.

The official reasoning was that as long as the engines were used to provide auxiliary power only, the fisherman would be able to return to port under sail should his engine fail. In the case of a sailing junk with an engine of under 50 bhp, it was not necessary for there to be a qualified engineer on board provided a person holding the Local Master's Certificate (i.e. a coxswain's certificate) was in command. A special series of lectures on small diesel engines, with particular reference to maintenance, was included in the training courses for coxswains.

In a fishing junk with an engine of between 50 and 150 bhp, both a coxswain and an engineer were required. The Marine Department examination for a certificate of competency as an engineer on board a bona fide fishing vessel was, however, based on a modified syllabus, derived from the requirements for launch engineers of cargo and passenger carrying motorized craft.

A higher certificated standard of efficiency and more previous experience (the same as those called for on other types of motorized commercial craft), was required of diesel engine-drivers employed on fishing vessels with engines of over 150 bhp.

Transition in Japan and Korea

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THE Japanese Government attaches great importance to the mechanization of the country's fishing fleets, as it contributes to the development of the fisheries and reduces fishermen's manual work while increasing their incomes.

Most fishermen in Japan are engaged in coastal operations in Imah craft and their incomes are usually lower than those of the deep-sea fishermen. Accordingly great efforts are being made to solve the many technical and seanomic problems involved in the mechanization of their boats and to keep their operators abreast of developments.

Engines were first installed in Japanese fishing boats in 1905. Experience with them soon showed the all-round benefits—increased safety, less manual labour and increased production—resulting from their use. Research establishments and engine manufacturers in Japan intensified their efforts to evolve the most imitable engines for fishing fleets.

Table 1 (JAPAN)
Transition of powered fishing vessels and catches

Years	*Number of powered vessels*	*Total fish-catches*	*Years*	*Number of powered vessels*	*Total fish-catches*
	1,000 *boats*	1,000 *tons*		1,000 *boats*	1,000 *tons*
1912	1	1,649	1937	66	4,041
1913	2	1,974	1938	68	3,677
1914	2	1,977	1939	72	3,681
1915	3	2,032	1940	75	3,526
1916	3	2,206	1941	69	3,833
1917	3	1,969	1942	71	3,601
1918	3	1,842	1943	73	3,356
1919	4	2,249	1944	68	2,458
1920	6	2,482	1945	57	1,824
1921	6	2,177	1946	60	2,107
1922	7	2,450	1947	88	2,285
1923	9	2,475	1948	106	2,518
1924	11	2,626	1949	120	2,761
1925	13	2,843	1950	129	3,373
1926	16	3,071	1951	129	3,930
1927	21	3,248	1952	131	4,823
1928	25	3,096	1953	135	4,598
1929	31	3,129	1954	139	4,541
1930	36	3,186	1955	144	4,907
1931	42	3,376	1956	152	4,772
1932	45	3,556	1957	157	5,407
1933	49	4,064	1958	165	5,506
1934	53	4,272	1959	171	5,884
1935	57	3,977	1960	168	6,192
1936	62	4,330			

Until recently the tendency has been for electrical ignition engines to be installed in boats under 10 tons; semi-diesels in craft between 10 and 50 tons; and diesels in vessels over 50 tons. At the end of 1960 168,000 powered craft were engaged in fishing in sea or inland fisheries. Of these some 150,000 were below 10 gross tons.

The main factors which have contributed to the progressive mechanization of Japanese craft have been the improved techniques employed by engine manufacturers and the direct and indirect measures taken by the Government to encourage mechanization. The latter has established fisheries experimental stations to give technical guidance; provided funds for the acquisition of improved equipment; inaugurated training schemes for engineers; provided assistance for the construction of sheltered boat harbours; and helped to establish an efficient marketing system.

The enlargement of powered craft, and their modernization has made possible the developments of fishing grounds which could not previously be exploited. Diesel engines have played a big part in this owing to their higher power/weight ratio, lower fuel costs and greater simplicity than electric ignition or semi-diesel engines. Improvements in the design of diesels have been effected, making them suitable for installation in all types of craft, and their prices have been progressively reduced. Further improved engines, such as supercharged and exhaust impulse diesels are now in production and, though at present only suitable for use in larger craft, are expected to be designed for use in smaller craft before long.

Besides diesels, outboard petrol engines are extensively used in Japanese fishing boats.

Increased mining and industrial activity in Japan since the war has brought about a shortage of labour. And this has made it more than ever necessary to press forward with the mechanization of fishing boats in order to conserve labour. Productivity in the fisheries has to be maintained and increased with a decreasing labour force.

Progress in all aspects of mechanization has kept pace with motorization—particularly in bigger vessels. These

Table 2 (JAPAN)
Transition of total number of fishing vessels
(Unit: 1,000 boats, 1,000 tons)

		Tidal waters fishery					*Non-tidal waters fishery*			
		Powered vessel			*Non-powered vessel*		*Powered vessels*		*Non-powered vessel*	
Year	*Total number*	*Total tonnage*	0–5 *ton vessel (number) tonnage*	0–5 *ton vessel (number) tonnage*	*Number*	*Tonnage*	*Number*	*Tonnage*	*Number*	*Tonnage*
1956	150	1,209	123	222	237	237	2·2	3·1	27	13
1957	155	1,340	128	230	220	217	2·4	3·4	26	12
1958	162	1,393	136	244	209	207	2·6	3·6	25	11
1959	167	1,456	143	258	211	204	2·8	3·8	18	9
1960	165	1,564	142	259	195	177	2·9	3·9	17	8·7

are invariably equipped with trawl winches, net or line haulers, or whatever mechanical equipment is required in a particular fishery. Similar equipment, suitable for use in smaller craft, is being designed and manufactured on an increasing scale.

Until recently most winches and haulers, etc., were motor driven or belt driven from main or auxiliary engines. Now, deck machinery in new vessels is, as often as not, hydraulically driven.

Radio and radar sets, fish finding echo sounders, power blocks, etc., are fitted in all larger vessels as a matter of course today. The Japanese Government is taking all steps to encourage the use of such instruments in smaller craft whenever it is economical to do so.

Table 3 (JAPAN)
Replacement with diesel engines of small type fishing vessels less than 5 gross tons
(Unit: 1,000 boats)

Year	*Total number of vessels*	*Ratio of fishing vessels with diesel engines*
1953	106	7·6
1955	115	12·3
1958	136	27·0
1960	142	41·0

In Korea two-ton netters are the oldest traditional type of boats still in use. The majority depend on sail but a percentage use both sail and power.

Lack of fishing ports unaffected by a big rise and fall of tide has had a great influence on the development of the hull form equipment and other characteristics of these vessels.

(1) Because of its simplicity in construction, a hull form with single chine and transom stern has been adopted. Since the fishing grounds are in shallow waters, restrictions on draft (d) of the boats is important; ^{d}mean = 1·31 metres including the keel. The fact that the boats have to sit on deep mud out of water at ebb tides has resulted in adopting a very much wider keel amidships at about 1·20 metres. An unusually wide beam of about 4·6 metres in relation to length (L) of 16 metres on deck and to the depth (D) of 1·51 metres because the boats evolved from sailing craft and the desire to obtain wider working area on deck, and larger capacity of fish holds against the limited depth and draft, as well as greater stability. Thus the boats have unusual hull form ratios of principal dimensions, which are approximately as follows:—

$$L/B = 3{\cdot}48, \quad L/D = 10{\cdot}6 \quad \text{and} \quad B/D = 3{\cdot}05,$$

where B denotes breadth of the boat.

(2) For motorization of the stow netters, semi-diesel

Table 4 (JAPAN)
(Composition of powered fishing vessels on tidal waters 1960)

	Diesel						*Hot-bulb*						*Electric ignition*					
Size of vessel	*No. of vessels*		*Gross tons*		*H.P. per vessels*	*H.P. per tonnage*	*No. of vessels*		*Gross tons*		*H.P. per vessels*	*H.P. per tonnage*	*No. of vessels*		*Gross tons*		*H.P. per vessels*	*H.P. per tonnage*
	No. of vessels	%	*Gross tons*	%			*No. of vessels*	%	*Gross tons*	%			*No. of vessels*	%	*Gross tons*	%		
Tons																		
0–0·9	8,031	11·9	6,259	0·6	4·0	5·10	553	1·6	446	0·1	3·9	4·89	23,598	37·0	17,485	20·4	3·7	5·0
1–2·9	40,998	61·0	73,962	7·3	7·3	4·05	9,536	27·6	19,846	7·0	7·9	3·80	38,156	59·9	60,751	70·8	5·8	3·6
3–4·9	9,160	13·6	34,687	3·4	16·5	4·37	9,814	28·4	39,005	13·8	12·7	3·20	1,755	2·7	6,371	7·4	10·1	2·8
5–9	1,936	2·9	13,681	1·3	30·6	4·33	6,012	17·4	43,670	15·4	22·2	3·06	199	0·3	1,229	1·4	12·6	2·0
10–14	591	0·8	6,522	0·7	50·8	4·14	3,358	9·7	42,286	15·9	39·8	3·16			11	0	14·0	1·3
15–19	525	0·8	9,527	0·9	88·8	4·89	3,060	8·8	55,161	19·5	62·3	3·46						
20–29	589	0·9	17,198	1·7	129·8	4·44	1,029	3·0	27,530	9·7	84·8	3·17						
30–49	1,548	2·3	61,595	6·1	161·3	4·05	969	2·8	37,629	13·3	111·7	2·88						
50–99	2,917	4·3	225,603	22·3	251·4	3·25	257	0·7	16,954	6·0	154·1	2·34						
100–199	471	0·7	70,007	6·9	358·3	2·41	3	0	344	0·1	193·3	16·80						
200–499	397	0·6	133,936	13·2	796·7	2·36												
500–	150	0·2	357,341	35·4	2,581·9	1·08												
Grand Total	67,253	100		100			34,581	100		100			63,709	100		100		

Table 5 (JAPAN)
Transition of fishing vessels by type of engine
(Number of vessels)

	Total	*Steam*	*Diesel*	*Semi-diesel*	*Electric ignition*
At the end of					
1950	127,566	60	5,336	48,458	73,212
1951	127,296	46	8,629	46,955	71,666
1952	129,048	45	9,301	47,426	72,276
1953	133,203	43	11,592	46,493	75,075
1954	137,125	35	14,425	46,675	75,990
1955	142,265	33	19,380	45,987	76,865
1956	149,950	41	24,274	45,539	80,096
1957	154,560	46	33,705	43,202	77,607
1958	162,090	42	43,621	41,812	76,615
1959	167,743	42	52,927	39,221	75,553
1960	165,602	49	67,253	34,591	63,709

Note: Powered fishing vessels on tidal waters.

engines, hot-bulb type of about 20 to 40 hp have been used because the fishermen are accustomed to them and like their reliability, easy handling and easy maintenance. Also along the west coast there are many small workshops capable of making the parts and reconditioning the engines. With power of 20 hp, a boat speed of about six knots may be expected but actual speed is less than that due to the use of an inadequate propeller. In order to supplement the low speed attained with the engine against the strong tidal current, boats still use both the engine and sail.

Fish Holds

The fish holds consist of four compartments, each of which is sub-divided by a longitudinal detachable partition wall along the centre line of the boat. The capacity of fish holds is about 24 cu. metres in total, and about 20 M/T of fish can be stored in bulk. The fish holds do not have thermal insulation.

(3) Yellow-corvenias which are the main catch of the stow-netters are not oily fish and can be easily salted and dried for storage. Also the weather is mild during the spring and autumn when fishing is best. The boats are away from their home ports for 12 to 15 days, and during the main fishing season are serviced by fish carriers. These vessels usually carry salt instead of ice for the fishing fleet when the weather is especially warm.

Deck gear consisting of a capstan and two winches is of a very primitive type and is operated by man-power. The anchor of the boat is very important in the fishing operation since it is dropped into deep mud and must hold against the pull of both the boat and net in strong tidal current; it must be of sufficient size and weight to hold.

Use of a large wooden anchor has been traditional. Many fishermen have tried to replace the wooden anchor with one made of iron but so far without success. A steel anchor of the same weight as a wooden anchor drags in the mud due to shorter shank and arms, and they hate to use a heavier one. It is very bothersome to drop and weigh the conventional wooden anchor because of its size, and it occupies a large space on deck when secured. Recently some boats have been equipped with two anchors for the purpose of making two hauls at the same time with two sets of net.

(4) Up to date the majority of small fishing boats in Korea are powered by hot-bulb engines, which were originally introduced by the Japanese. Since these engines are familiar to the fishermen and can be easily serviced and reconditioned in small local workshops, the fishermen are strongly in favour of them in spite of their heavy weight, large size and lower thermal efficiency. In other words, they place greater importance on the problems of maintenance of the engines. Besides the easiness of maintenance, the engines have several merits; slow speed, easy reversals by the control of injection time, ability to idle for a considerable period with negligible consumption of fuel by the control of air damper, and comparatively flat thermal efficiency curve within a wide range of operation.

It seems that Scandinavian semi-diesels have a little better performance from the point of view of weight and fuel consumption, but they have not yet been introduced into this country. The general characteristics of the engines used for fishing boats in this country and of the Scandinavian semi-diesels are summarized in Table 6.

Table 6 (KOREA)
Characteristics of the engines for fishing boats

	Electric ignition (below 20 hp)	*Hot-bulb (below 20 hp)*	*Scandinavian semi-diesel (below 200 hp)*	*Diesel, not super-charged (75 to 500 hp)*
Cycle	4	2	2	4
Piston speed m/sec	3·0–3·5	3·6–4·0	—	4–6
Max press kg/cm³..	17–25	25	25–30	43–50
Bmep press kg/cm³	3·5–5·8	20–2·5	2·8–3·5	4·3–5·9
Mech. eff. % ..	76–81	65–82	—	76–85
Brake thermal eff. ..	24–27	18–27	28·5	33·38
No. of cylinders ..	1 or 2	1, 2 or 3	1, 2 or 3	2–6
Weight per bhp kg..	30–35	60–70	50–70	40–55
rpm	800–1000	300–900	270–600	290–430
Fuel rate gr/bhp hr	250–390	250–280	195–220	165–215
Fuel	Light oil kerosene	Heavy oil	Heavy oil	Heavy oil, light oil
I.O.	mobile oil	machine oil	machine oil	Diesel Eng. oil

The trend in some well-developed foreign countries is that the diesels have taken the place of electric ignition and semi-diesel engines for small fishing boats and, further, higher speed diesels are being adopted. This results in a considerable reduction in the initial cost, weight and engine room space, and permits greater interchangeability of parts with non-marine engines. It is, however, believed that high speed diesels are unlikely to be accepted promptly in under-developed countries because of the problems of rapid wear of running parts, the requirement of reduction gears, and of higher grades of skill required for both operation and maintenance.

EFFICIENT PROPELLER SELECTION

Jan-Olof Traung

THE Chief of the FAO Fishing Boat Section has tried to provide a text on how to select efficient propellers for fishing vessels without getting involved in difficult mathematics, but still keeping to established engineering principles. The only things necessary to understand this paper and to apply it in practice are a knowledge of fishing boats, common sense and the ability to multiply, divide, square and to work with square roots.

People have a tendency to be put off by technical papers because of their use of symbols for technical expressions. Such symbols are necessary to limit the size of the text and to be able to express certain relations in formulas. Below is the list of symbols used in the paper, most of which follow the 1963 agreement of the Tenth International Towing Tank Conference (ITTC).

B — Beam
B_P — Power coefficient based on propeller power
B_U — Power coefficient based on thrust
C_B — Block coefficient
D — Diameter
d_a — Draft one quarter from stern (not ITTC symbol)
I — Depth of propeller centre (not ITTC symbol)
J — Speed coefficient
K_Q — Torque constant
K_T — Thrust constant
L — Length
n — Revolutions of propeller per minute
n_1 — Revolutions of propeller per second
P — Pitch, power
P_B — Power, brake
P_D — Power, delivered at propeller (old DHP)
P_E — Power, effective or thrust (old EHP)
P_S — Power, delivered at end of engine (old SHP)
Q — Torque
s_R — Real slip ratio
T — Thrust
t — Thrust deduction fraction
V — Ship's speed
V_A — Speed of advance in knots (ship's speed—wake)
V_a — Speed of advance in ft/sec.
w — Taylor wake fraction
w_F — Froude wake fraction
δ — Diameter coefficient
ρ — Density factor for seawater
η — Efficiency
η_H — Hull efficiency
η_P — Propeller efficiency in the " open "

A PROPELLER can only be as good as the basic data from which it is selected. A random check of fishing boat propellers reveals that the efficiency of many of them can be increased by 5 to 10 per cent. with a corresponding saving of 10 to 20 per cent. in fuel and wear and tear of the engine. The reason is not only the use of inaccurate data for their selection, but that in many cases, no data was used.

Engine makers mostly propose certain propeller diameters for their various engine types. The designer, builder and owner usually accept these values without question, and they are happy if the pitch of the propeller permits the engine to develop its full rpm without being overloaded. In a few cases, propellers of different pitches might be tried, but usually the designer and owner are satisfied with the standard pitch. The dilemma of the engine-maker is, naturally, that he has to deliver a propeller which will prevent overloading of his engine, no matter how badly it is run. This propeller should suit all kinds of craft, varying in length and displacement.

In the selection of propellers for small craft, such as yachts and fishing boats, designers still think in terms of " economic slip." Slip-pitch design charts are still frequently used, designers often hiding them deep in their drawers. This slip concept was discarded decades ago by naval architects working with larger ships. The reason was that many series of propeller models were investigated in towing tanks, and design charts for such propeller series were made. If the proper diameter and pitch for the propeller are selected from such design charts, the most efficient slip emerges as a result. The slip varies considerably, and it is misleading to talk of any one range of slip as being the most " economic."

During the last 50 years a considerable amount has been written about the proper design of propellers, but one still finds in books for yacht designers—which are widely read by fishing boat designers—discussions about slip.

Apparent Slip

This slip is the apparent slip. It is a relation between the theoretical propeller way, that is the number of revolutions of the propeller times its pitch, and the speed of the boat. The hydraulic losses of the propeller vary according to its loading and, therefore, the apparent slip will be different for different speeds.

However, the propeller works behind a ship and the water follows the hull with a certain speed, the wake. The relation between the theoretical propeller way and the speed behind the ship is called the real slip, and the relation to the speed of the vessel is only the apparent slip. The apparent slip can sometimes even be negative at low speeds and low propeller loadings.

The following factors are the most important to know in order to select a proper propeller:

(*a*) Power requirements of the craft at the actual speed range.
(*b*) The speed of advance at which the propeller will be working, that is the speed of the ship minus the wake.
(*c*) The engine characteristics, that is the power which can be utilized by the propeller at various rpm.
(*d*) The operating conditions of the craft, increase in

resistance due to weather, fouling, loading and towing of fishing gear.

Power Requirement

The steaming speed of fishing craft is usually grossly exaggerated. Many fishermen believe that their boats are capable of as much as two knots more than they actually make. Few trials are made with fishing craft where the speed is accurately measured over a given distance with various output of the engine, and still fewer recordings are made of speeds during actual operating conditions.

With the help of results from speed trials of similar boats, it would be possible to estimate the speed comparatively accurately. It is also possible to estimate the speed from results from model experiments. More and more model tests of fishing craft are being published, and FAO has produced a compendium, " Fishing Boat Tank Tests," with such results expressed non-dimensionally. By selecting a type of hull with similar coefficients as the boat to be powered, it should not be too difficult today to calculate the effective, or tow-rope (P_E, old notation EHP) horse-power required.

Speed of Advance of Propeller

Wake fraction can be based on either speed of advance or on the speed of the vessel. Froude chose the former, and it is mostly used in the United Kingdom. Taylor chose the latter, and it is used in the United States and on the continent. For large wakes there is considerable difference, and they involve, unfortunately, great risk of confusion. The Froude wake fraction is written:

$$w_F = \frac{V - V_A}{V_A}$$

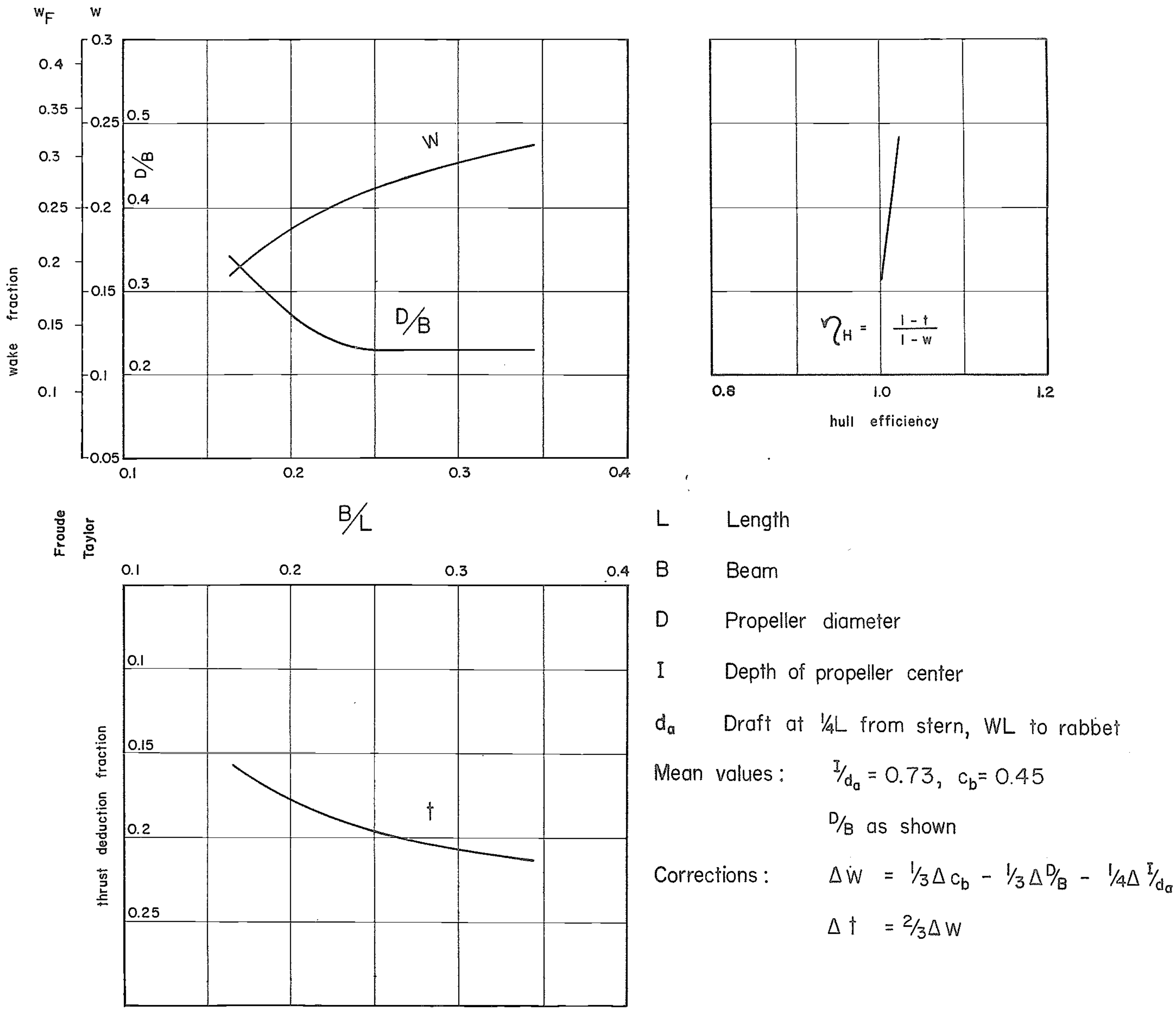

FIG. 1

the Taylor wake fraction:

$$w = \frac{V - V_A}{V}$$

where V = speed of ship, V_A = speed of advance. The relation between the two fractions is:

$$w_F = \frac{w}{1 - w} \qquad w = \frac{w_F}{1 + w_F}$$

The wake behind a ship depends not only on the shape of the hull but also on the propeller dimensions, reduced diameter tending to increase the wake. Taylor recommended the following wake deduction:

$$w = 0{\cdot}5 \text{ times block coefficient minus } 0{\cdot}05$$

This formula is quite workable. However, the block coefficient of fishing craft varies a great deal, due to their great differences in dead rise without their real fullness being necessarily different. An interesting proposal for estimating the wake more precisely was made by Astrup at the Norwegian Model Tank in Trondheim, and published in Part III—Propeller Tests, of their publication, " Model Tests with Fishing Vessels " (1952). Fig. 1 was developed after a considerable number of self-propulsion tests with 40 to 130-ft. fishing vessels. It also shows the variation in the thrust deduction coefficient, as well as the resulting hull efficiency.

Spreading of Plots

There was naturally a certain spreading of the individual plots because the tests were made with different types of propeller posts, rudders, etc., but they have not been shown on Fig. 1 as they were in the original publication. The wake deduction coefficient was selected for the same range of speed/length ratio for the different vessels to arrive at comparable wave formation. Speed ranges selected were:

130-ft. vessels	9–11½ knots
100-ft. ,, ...	8–10 ,,
65-ft. ,, ...	6½–7½ ,,
40-ft. ,, ...	5–6½ ,,

The relation between the beam and length (B/L) was found to have a greater influence than the block coefficient. Larger B/L gives larger wake deduction and the diagram was designed with B/L as parameter. The diagram is valid for a block coefficient of 0·45. If a vessel has a different value, the wake deduction coefficient should be corrected for a third of the difference from 0·45. If the block coefficient, therefore, is 0·48, the wake deduction should be increased by 0·01.

Wake Deduction Coefficient

The wake does not only depend on the sharpness of the vessel, but on the position of the propeller. The speed of the water is small behind the propeller post, therefore the wake deduction coefficient is high. Away from the centre line, the water speed will tend to be the same as the speed of the ship and the wake deduction coefficient approaches 0. Therefore, if the propeller diameter is increased, the wake deduction coefficient will decrease. The relation between the diameter of the propeller and the beam of the ship in the waterline (D/B) is therefore important, and a special curve was introduced in the diagram to show the corresponding D/B for the various B/L values. For a propeller with a different diameter, a correction must be made with the value once again being one-third of the difference. A ship having a B/L value of 0·20 should have a propeller/beam value of 0·285. If this vessel had a beam of 24 ft., the normal propeller would then have a diameter of 6·85 ft. If the diameter was decreased to 6·5 ft., the D/B value would decrease to ·271, and the wake should accordingly be increased by a third of the difference or 0·005.

Influencing Factor

The distance of the propeller from the water surface is also an influencing factor. The speed of advance is small, in other words the wake is large, at the surface and increases with depth. Accordingly, the wake deduction coefficient is larger near the surface and smaller further down. To express the depth of the propeller, Astrup took the relation of the distance from the propeller axis to the water surface when the boat was without speed, and the draft of the aft body measured from the water line to the rabbet in the keel, one quarter of the length in front of the aft perpendicular (or centre or rudder shaft). The resulting relation was called I/d_a. Astrup found that this value varied from 0·7 from the smallest craft with the largest B/L ratio, to between 0·74 and 0·78 for the largest vessels. He selected 0·73 as the mean value. If the I/d_a departs from this value, the wake deduction coefficient should be corrected with one quarter of the difference.

Fig. 1 must naturally be taken with due understanding for the fact that the wake is influenced by many more factors than some of the main dimensions of the boat. The shape of the sections, not only in the aft body but even in the fore body, has an influence on the wake, as has the presence of a wooden keel, square propeller post and, most important perhaps, the clearance of the propeller to the hull and rudder.

Square Propellor Post

A square propeller post and small clearances naturally increase the wake, that is decrease the speed of advance. Astrup found that in using his recommendations, the differences from the wake deduction coefficients determined from model tests was never more than 0·02. This has no importance for the selection of the main dimensions of the propeller, but it naturally has a certain influence on the efficiency of the propeller.

The thrust deduction coefficient mainly depends on the same relations as the wake coefficient. Individual factors might have other magnitude. An efficient streamlined rudder might reduce the thrust deduction by as much as 40 per cent., as stated by Barnaby in his "Basic Naval Architecture." Astrup therefore also gave a curve for the thrust deduction coefficient, and he recommended that these values should only be corrected by two-thirds of the corrections being made on the wake deduction coefficient. He also gave curves for the hull efficiency and the rotative efficiency. As can be seen from the figure, the hull efficiency for normal fishing boats is slightly more than 1 and could, for all practical purposes, be disregarded.

Power of Engine

The power available at the propeller of a fishing boat is often open to doubt. There are many different methods of rating small internal combustion engines. Manufacturers are more or less optimistic, and the United Kingdom, the United States and Germany have different criteria on peak loadings, continuous horse-power, etc. Some engines, especially Scandinavian semi-diesels, are even under-rated, and the individual tuning and installation of engines in fishing vessels contribute to great differences in the power available to the propeller. There is further the influence of atmospheric conditions, humidity and temperature in tropical climates and badly ventilated engine rooms. Diagrams of the relation between output and exhaust gas temperatures, fuel pump positions and fuel consumption at various rpm and loadings, would no doubt be of great help during trials in estimating the correct power.

Operation

Fishing craft practically never operate in what could be called calm water conditions and, during severe periods of rough weather, the speed of the engine is usually slowed down to avoid too violent movements of the ship. This opens up the question as to what allowance should be calculated. Some fishing vessels have to tow fishing gear and this, to a great extent, influences propeller selection. Trawlers are the best example, and they normally tow the net at 3 to 3½ knots.

When trawling for some fish, such as flat fish and shrimp, it is in some countries the practice to trawl at as low speeds as possible because, if the trawl is dragged along the bottom too fast, the fish have no time to get clear and jump into the net. But a high trawling speed is essential for strong swimmers, such as cod and herring. Large meshes in connection with high trawling speed permit a greater quantity of water to be screened with a larger catch of bigger fish. There is, however, a limit to the trawling speed with present materials. Much more than four knots does not seem to be possible. Further, at very high speeds it would be impossible to keep the trawl open—it would collapse—or its resistance would be out of proportion to any increased screening capacity.

It must be remembered that many fishing methods do not require any special great towing power, such as drift netting, long lining and trolling, even if there is a difference

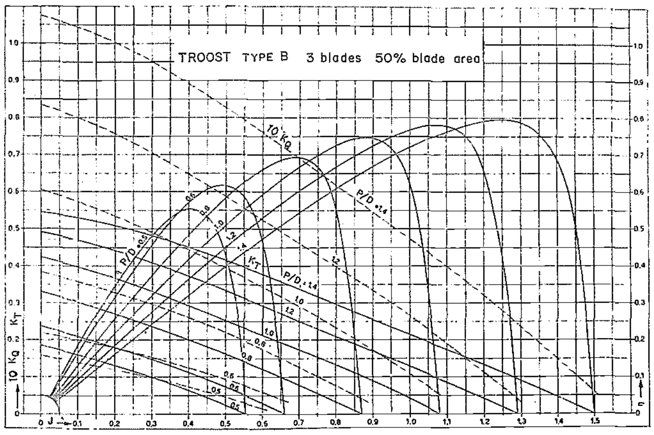

FIG. 2

in engine loading while streaming out such gear and steaming to and from the fishing grounds.

General Procedure for Selection

Systematic tests with families of model propellers having a different number of blades, pitch/diameter, blade areas, rake of the blades and types of pitch distribution and types of the blade section, have been made by many workers. Taylor and Schaffran are the most well known of the old-timers. Today perhaps the Troost propeller diagrams are most used.

During such model tests, the propellers operate in an " open " condition behind a " phantom ship " at a constant speed. The rpm of the propeller is changed during the different runs and thrust and torques are measured. From the results, coefficients for thrust and torque and the resulting efficiency are plotted over a non-dimensional speed coefficient. Fig. 2 shows such a diagram for one of the Troost series. They are difficult to use for practical propeller selection.

Taylor had already endeavoured to find a way in which the usual data known at the start of the propeller selection could be used. He did not consider the slip to be such a quantity. Taylor stated: " In practice, we need to determine a propeller which, at a given number of revolutions per minute and a given speed of advance (ship's speed minus wake), will absorb a given horse-power delivered to the propeller, or will deliver the usual horse-power needed in the case." Thus he formulated his two basic power coefficients:

(i) $$B_P = \frac{n \times P_D^{0.5}}{V_A^{2.5}}$$

to be used together with the power available at the propeller, or Delivered Horse-Power.

(ii) $$B_U = \frac{n \times P_E^{0.5}}{V_A^{2.5}}$$

to be used together with the effective, or tow rope horse-power. In these formulæ n represents revolution of the propeller per minute, P power (in horse-power) and V_A speed of advance in knots of the propeller. P_E is the effective horse-power or tow rope horse-power. $P^{0.5}$ can also be written $\sqrt{P}$ and $V_A^{2.5} = V_A^2 \times \sqrt{V_A}$, which facilitates their calculation with the help of tables or slide rules for those not used to exponential calculations with log-tables or slide rules.

Taylor also developed other important coefficients, such as delta dealing with size—

$$\delta = \frac{n \times D}{V_A}$$

where D = diameter of propeller in feet.

Fig. 3 shows the B_P diagram for Troost's three-bladed

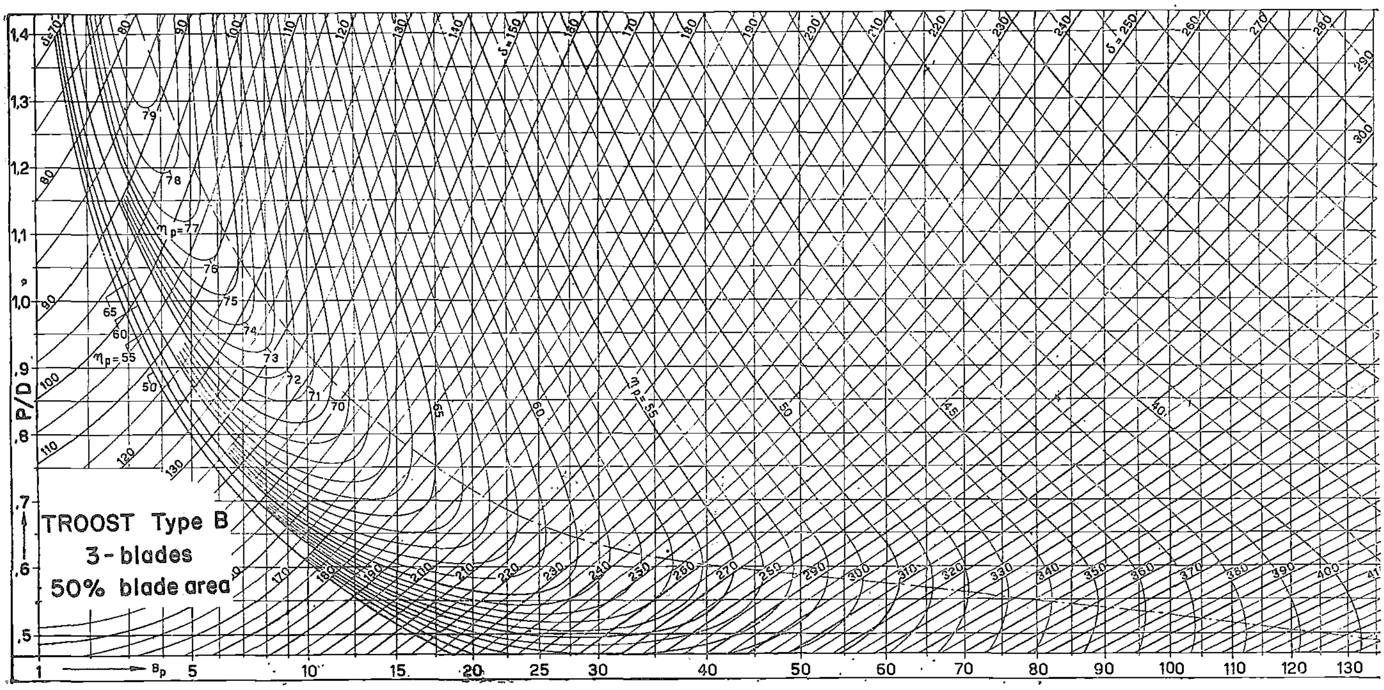

FIG. 3

propellers with 50 per cent. blade area. It is reproduced from Troost, " Open-Water Tests with Modern Propeller Forms," NECIES, Vol. 67, 1951.

It is easily found that maximum efficiency is associated with a certain relation between the pitch and the diameter of the propeller—the P/D ratio and the value at this point fixes delta, and hence the diameter. Then, with the help of P/D ratio, the pitch is easily calculated. Once B_P is determined with the help of the revolutions, the power and the speed of advance of the propeller, the limits of the possible efficiency are established. Lower efficiency, due to a small diameter of the propeller because of limitations in the propeller aperture, might be the result if an unfavourable P/D value is chosen, but it would be impossible to select a better one. With increasing B_P values, the efficiency decreases, the controlling factor being revolutions.

Example

Fig. 4 shows power curves and plots from actual operation for an 85-ft. trawler. The shaft horse-power curves at 300 and 350 rpm correspond to its three-bladed controllable pitch propeller with a diameter of 5·64 ft. The plots from the operation were made by the writer during a two-week fishing trip in the vessel which had a 450/495 hp diesel developing its full power at 375 rpm.

Selection for Maximum Power

Scrutiny of the catalogue particulars reveals that the 495 value in the power figure is for the overloading condition, 450 hp being the value for continuous operation. The power was in this case expressed in metric horse-power. Assuming the losses in the stern tube to be 5 per cent. and converting the metric horse-power to British horse-power, there would be 422 hp available at the propeller. However, the Troost values are given for fresh water conditions, and therefore the power has to be reduced:

$$P_D = \frac{422}{1 \cdot 025} = 411 \text{ hp say, } 410 \text{ hp}$$

The Taylor wake deduction coefficient was estimated with the help of Astrup's diagram at 0·2315 (corresponding to a Froude wake deduction coefficient of 0·301), and the corresponding thrust deduction coefficient of

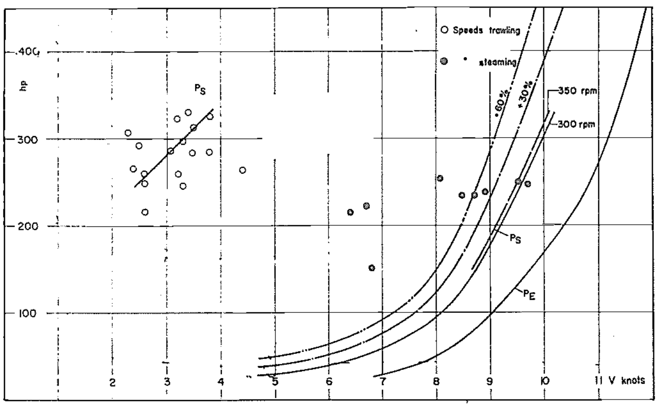

FIG. 4

0·21, gave a hull efficiency of 1·03. This latter is being neglected in the following estimates.

Troost recommends certain corrections to the rpm, an increase of 1 per cent. for service conditions, and a decrease by 2 per cent. for scale effect. This would indicate 371 rpm instead of 375 rpm to be used during the calculation, but it is also neglected.

The speed must first be estimated. For that one has to assume a propeller efficiency to determine available P_E from the P_D, so that a normal power curve from a resistance calculation can be used to estimate the speed. In this case we assume a propeller efficiency of 55 per cent., and the P_E will accordingly be:

$$P_E = 0 \cdot 55 \times P_D = 0 \cdot 55 \times 410 = 226 \text{ hp}$$

From the P_E curve in Fig. 4, this corresponds to a ship's speed of $V = 10 \cdot 7$ knots. Accordingly, the speed of advance of the propeller, $V_A = (1 - 0 \cdot 2315)V = 8 \cdot 2$ knots. The B_P value then is:

$$B_P = \frac{n \times P^{0 \cdot 5}}{V_A{}^{2 \cdot 5}} = \frac{375 \times \sqrt{410}}{8 \cdot 2^2 \times \sqrt{8 \cdot 2}} = 39 \cdot 6 \text{ or about } 40$$

The dash line in Fig. 3 indicates the P/D values with the highest efficiency. For $B_P = 40$ we get a P/D value of 0·6 and the corresponding efficiency of 56 per cent. and the delta value 260. The 56 per cent. efficiency is somewhat better than the assumed efficiency of 55 per cent. and a recalculation could now easily be done, P_E, speed and delta being slightly corrected. For the sake of simplicity, and to get more of a margin of safety, the diameter will be calculated from the present delta value.

$$\delta = \frac{n \times D}{V_A}, \text{ hence } D = \frac{\delta \times V_A}{n} = \frac{260 \times 8 \cdot 2}{375} = 5 \cdot 7 \text{ ft}$$

Accordingly the pitch is $0 \cdot 6 \times D = 0 \cdot 6 \times 5 \cdot 7 = 3 \cdot 42$ ft.

No allowances were made for weather and wind, and it is usual to make such allowances on the P_E before the propeller is calculated, 25 per cent. being often used. This is the same as 20 per cent. reduction. If this is done, 80 per cent. of 226 hp gives 180 hp, which would be available as effective power, which would give a speed of 10·2 knots, and a speed of advance of the propeller of 7·8 knots. This would correspond to a propeller power of $\frac{180}{0 \cdot 55} = 328$ hp, thus B_P would be 39·8, or still about 40. At a P/D value of 0·6 this would give the same efficiency of the propeller of 56 per cent. and delta value of 260. Hence the propeller would have a diameter of 5·4 ft. and a pitch of 3·25 ft.

Selection for Towing

The thrust has to be calculated from diagrams of the Fig. 2 type. First one must establish the permissible torque of the engine. Assuming that the engine under discussion has a torque proportional to its revolution, then

$$Q = \frac{P_D \times 550}{2\pi \times n_1} = \frac{410 \times 550}{6 \cdot 28 \times 6 \cdot 25} = 5{,}745 \text{ ft. lb.}$$

where n_1 = revolutions per second and π = pi.

First it is practical to calculate the thrust for the dead pull condition. The speed coefficient, $J = \frac{Va}{n_1 \times D}$, is then zero, because Va (speed of advance in ft./sec.) is zero. Hence from the diagram the torque constant, K_Q, is 0·022 and the thrust constant, K_T, is 0·24. The permissible rpm can then be found:

$$n_1^2 = \frac{Q}{K_Q \times \rho \times D^5} = \frac{5 \cdot 745}{0 \cdot 022 \times 1 \cdot 988 \times 4800}$$

$$= 27 \cdot 3 \text{ and } n_1 = 5 \cdot 23$$

In this equation ρ is the density factor for sea water in the feet system. With $n_1 = 5 \cdot 23$, the rpm is $60 \times n_1$ or 313. The resulting thrust is then:

$T = K_T \times \rho \times n_1^2 \times D^4 = 0 \cdot 24 \times 1 \cdot 988 \times 27 \cdot 3 \times 881 = 11{,}500$ lb. $= 5 \cdot 14$ tons, and $P_B = \frac{450 \times 313}{375} = 376$ hp. The engine is 83·5 per cent. utilized.

The thrust at trawling speed cannot be found by straight use of formulæ and it is necessary with trial-calculation to find the permissible rpm. Assume that the wake when trawling is slightly lower than when steaming, or $w = 0 \cdot 2$. Then $V_A = 2 \cdot 8$ knots and $Va = 4 \cdot 72$ ft./sec. Assume further that the engine can develop 89·5 per cent. of its rpm, then rpm = 336, and $n_1 = 5 \cdot 6$ rps.

The speed coefficient becomes

$$J = \frac{Va}{n_1 \times D} = \frac{4 \cdot 72}{5 \cdot 6 \times 5 \cdot 4} = 0 \cdot 156$$

from Fig. 2, $K_Q = 0 \cdot 019$ and $K_T = 0 \cdot 193$. The torque $Q = K_Q \times \rho \times D^5 \times n_1^2 = 5{,}720$ ft. lb., or slightly less than 5,745. The resulting thrust was calculated at 4·7 tons. If the torque had been much different, a new assumption of the rpm reduction would have to be made and the calculation repeated.

Actual Operation

During a fishing trip the writer recorded the outputs and speeds of the vessel in question without in any way influencing the skipper to take more or less power than he wanted from the engine. The record shows that he normally used 240 hp steaming at 325 rpm and that he was making 8·6 to 9·6 knots, due to the prevailing weather and wind. He used on an average 310 hp at 3·5 knots at 325 rpm during trawling. This would roughly correspond to a thrust of 3·7 tons.

The corresponding P_D (delivered power at propeller) for the steaming condition is 219 hp, and a propeller selection, without going to P_E (effective power or tow rope horse-power) to determine the speed but to use the speed actually obtained, will look as follows:

Ship's speed	V, in knots	8·6	9·6
Speed of advance	V_A, ,, ,,	6·6	7·4
	B_P ,, ,,	43·0	32·3
Pitch/Diameter	P/D value	0·6	0·625

Efficiency	η	55%	58·5%
Delta-value	δ	270	240
Diameter	$D = \frac{\delta \times V_A}{n}$	5·48 ft.	5·47 ft.

The engine would not have been overloaded if run as low as 200 rpm. Assuming, for simplicity's sake, that the same P_O was necessary, the calculation would look as follows:

V	8·6	9·6
B_P	26·5	20
P/D	0·65	0·72
η	60·5%	63·6%
δ	220	193
$D = \frac{\delta \times V_A}{n}$	7·27 ft.	7·14 ft.

Such propellers with larger diameter, and operating with about 5 per cent. higher efficiency, would result in about 10 per cent. less fuel consumption.

Trawler propellers

There are several possibilities in selecting a propeller for a trawler.

1. Select the propeller without allowance and reduce the rpm to avoid overloading the engine.
2. Select the propeller for 100 per cent rpm and 90 per cent. P_D as proposed by van Aken in " Fishing Boats of the World " (1955) and reduce rpm when necessary.
3. Allow 25 per cent. on P_E for weather; reduce rpm for heavy weather and for trawling. This corresponds to the use of 90 per cent. P_D.
4. Select the propeller for maximum thrust at 3·5 knots.
5. Select the screw for heavy " towing condition," that is, maximum dead pull at no speed.

Propellers have been selected by using Troost's diagrams for three-bladed propellers with 50 per cent. blade areas for the 450 hp engine discussed, developing its full power at 375 rpm. Due to the fact that the B_P values were always about 40 and larger, P/D values of 0·6 were chosen. The results are:

	100% *power* 100% *rpm*	90% *power* 100% *rpm*	80% *power* 100% *rpm*	*Trawling at 3·5 knots*	*Dead Pull* 0 *knots*
Steaming					
Speed in knots	10·7	10·45	10·2	9·88	9·6
Diameter in feet	5·7	5·59	5·40	5·27	5·07
Efficiency	·562	·562	·561	·565	·575
Delivered hp					
P_D utilized	410	370	328	276	240
Brake hp					
P_B utilized	450	405	360	303	264
Rpm	375	375	375	375	375
% power of engine	100	90	80	66·4	58·6
3.5 knots trawling					
Thrust in tons	4·49	4·54	4·7	4·96	4·44
Rpm	300	318	336	375	375
Brake hp					
P_B utilized	369	382	403	450	391
% power of engine	80·5	85	89·5	100	87
Dead pull (0 knots)					
Thrust in tons	4·83	4·95	5·14	5·31	5·37
Rpm	280	296	313	351	375
Brake hp					
P_B utilized	336	355	376	420	450
% power of engine	74·5	79	83·5	93·3	100

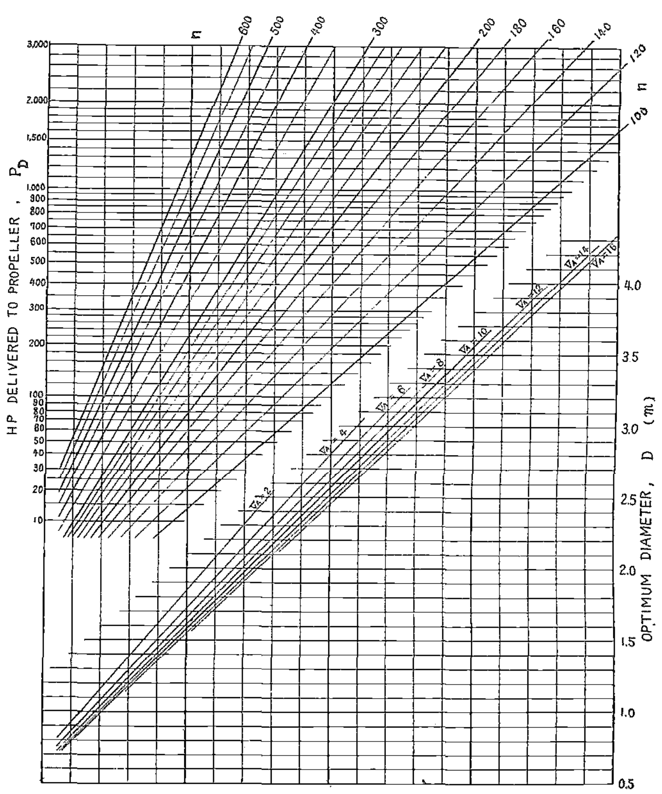

FIG. 5

A study of the table reveals that van Aken's proposal is a very practical one. In this case the trawl did not require a thrust of more than 3·7 tons and a high-speed propeller would have been sufficient; but this boat was grossly overpowered. The loss in thrust would be only 8·5 per cent. using a propeller according to the van Aken proposal, compared with the thrust of a trawler propeller. With the latter the decrease in steaming speed would be very large. It is open to doubt how much an engine is loaded during trawling, and if it is really loaded as heavily as claimed a slight decrease in speed would easily offset the lower thrust.

Further steps

Once a propeller has been primarily selected as described, one has to find out whether or not another number of blades or another type of their sections would be still more efficient. Furthermore, one has to consider the problem of cavitation and check the strength of the propeller. It would need more space than is available to give a comprehensive summary of the amount of experience gained in this respect.

It should be mentioned that many propeller series other than the Troost have been presented in B_P diagrams. The Ship Propulsion Division of the Transportation Technical Research Institute of Japan has even tested three-bladed propellers with 35 per cent. and 50 per cent. blade area, especially designed for fishing vessels. They have gone a step further and developed from the B_P diagram another

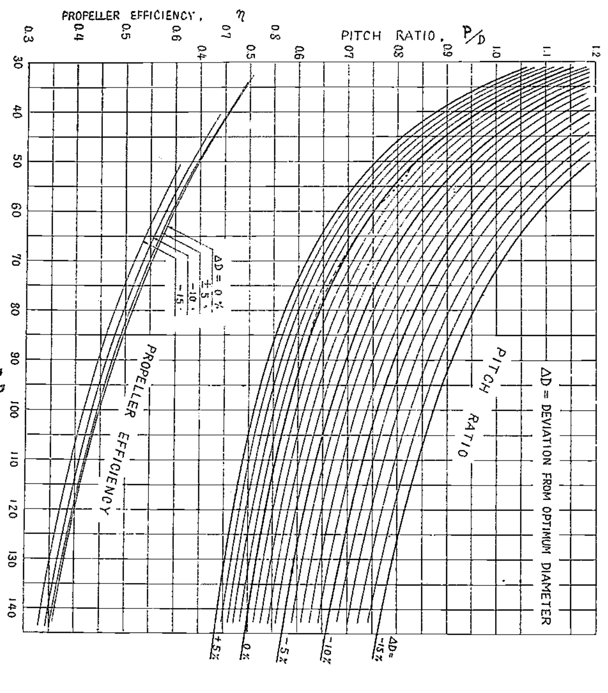

FIG. 6

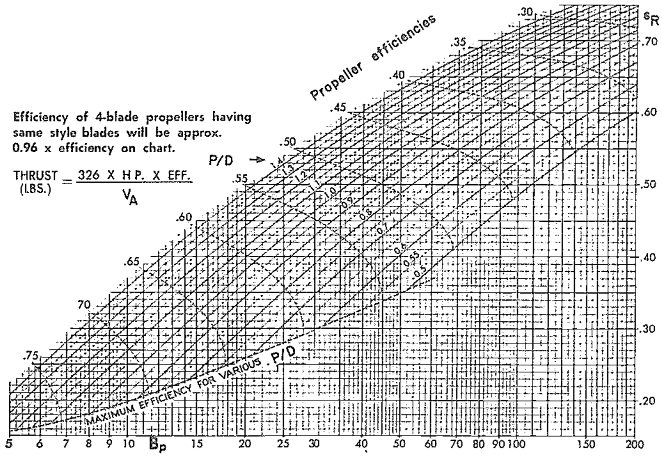

FIG. 7

diagram, such as Fig. 5, from which it is possible to establish the diameter from the values of power, revolution and speed of advance without having to calculate B_P numbers and delta values. With the help of a further diagram, Fig. 6, it is possible to establish the efficiency of the propeller so selected and the corresponding pitch diameter ratio by calculating δ from $\frac{n \times D}{V_A}$. It is also possible to see the difference in efficiency of the propeller if the diameter is increased or decreased.

The propellers according to the Japanese series show slightly less efficiency than those selected after the Troost recommendations.

A further commendable effort to ease propeller selection has been made by the manufacturers of the Caterpillar engines. They have produced a special slide rule with the help of which the B_P value can be easily calculated. With a diagram as shown in Fig. 7 the P/D value and corresponding propeller efficiency can easily be determined. Furthermore, the determination of diameter and pitch can be made with the slide rule. This Caterpillar Propeller Calculator appear to be based on Troost's test with three-bladed propellers and 50 per cent. blade area.

To find the most efficient propellers for fishing craft, it is not only necessary to utilize reliable information on propeller performance already available, but also to check the performance of the propellers in practice. It is only a combination of proper selection, careful trials and intelligent observation of performance during fishing which will enable a selection to be made of the most efficient propeller.

Much to be done

Unfortunately, much remains to be done in this respect, and the writer completely agrees with one of his friends, a propeller expert in a large marine engine firm, who once wrote: " I hope and pray that somebody will, some time, carry out special trials with these boats and perhaps tow one on an outrigger and measure the resistance."

It is not being academic to propose a bit more care in checking the operation of fishing craft; it is only economic common sense.

MECHANIZATION OF SMALL FISHING CRAFT

SECTION IV: Problems of Engine Service and Maintenance

Development

SEVEN CONDITIONS TO ENSURE SMOOTH RUNNING

E. KVARIN

THE problems of engine maintenance may be viewed from three broad viewpoints: (*a*) the detailed operations to be carried out on each engine; (*b*) the general types of facilities and staff required; (*c*) the cost of the maintenance programme.

These will vary greatly, depending on the structure and operating basis of the fleet, in particular whether the operation is centralized with respect to ownership and fishing activities, and whether the fleet is equipped with standardized power plants.

Elements of Maintenance: Definitions

Unfortunately, some confusion exists as to the meaning of various terms used in connection with keeping engines in good running order. In this paper the following definitions will be used:

Maintenance designates all activities aimed at keeping an engine in good working order. It is the most general descriptive term for work done on engines.

Servicing refers to regular routine attention given by the operator or by the shore staff for which no dismantling is necessary, except for filter element replacement. Generally speaking servicing relates to the fuel and lubricating oil systems, greasing and minor adjustments. The purpose of servicing is to prevent undue wear of the engine parts.

Overhauling refers to periodical attention during which major components of the engine are removed. A distinction is made between top overhauls and major overhauls, the latter designating more complete dismantling. The general purpose of overhauling is to clean, replace or repair parts subject to normal wear.

Repairing is a rather general term, denoting the work done to rectify troubles other than those due to normal wear, as well as the operation carried out on an individual part to make it serviceable again.

Running repairs are those which are carried out on board without significant dismantling or loss of operating time.

Reconditioning is a major overhaul during which all major components are brought back to within the dimensional limits specified by the manufacturer. These are not necessarily the same as for a new engine. (For example the crankshaft may be reground to a certain undersize.)

Inspection will here be used to designate a check of the engine by a qualified person who may at the same time have minor defects corrected, or may simply report on the condition of the engine. Inspection is primarily carried out to ascertain whether servicing is being properly conducted. (This is a much narrower use of the term than in most other connections.)

Servicing

In the case of engines of 50 h.p. or less, servicing should be the responsibility of the operators. As far as possible a regular service schedule should be adhered to. Most engine manufacturers advise that servicing be carried out on the basis of hours of operation. Although this system is desirable from the point of view of engine care it is often not particularly practicable for small fishing boats. Records are usually poorly kept, so that the hours of operation eventually becomes a matter of guess work, and it may be difficult to find the necessary time for carrying out the servicing when it is due. In many places fishing is not carried out on certain days, i.e. Sundays, Fridays, Poya days, etc.; if a small part of these days can be used for servicing, it is better to draw up the servicing schedule on this basis.

The exact recommendations of various manufacturers differ in detail. The following service schedule is suitable for most small diesel engines:

Daily servicing

Check lubricating oil level in sump.
Check oil level in gearbox, reduction gear and governor if these are fitted with separate dip sticks.
Fill all grease or oil cups or nipples.
Oil external moving parts.
Check fresh water level (if applicable).
Check oil pressure.
Check cooling water or cooling air temperature.

Four-weekly servicing (bi-monthly for outboards)

Check for loose nuts, bolts and pipe connections.
Drain water and dirt from fuel tank.
Clean fuel tank air vent.
Clean fuel filter.
Clean air filter, fill with oil if necessary.
Clean sea water valve and strainer or cooling air ducting.
Check gearbox and reduction gear oil level, if no dipstick is provided.
Clean engine externally, especially springs, levers, hand starter, bolt threads, etc., not kept clean by daily cleaning.
Check and, if possible, attend to all oil and water leaks.

Four, six or eight weeks servicing (period varies with different makes)

Inspect injector nozzle spray.
Change engine duplicating oil.
Change gearbox and reduction gear oil (usually at every second engine oil change).
Renew or clean lubricating oil filter elements.
Clean lubricating oil sump strainer.
Check tappet clearances.

Six-monthly servicing

Wash out fuel tank.
Change fuel filter element.
Flush engine lubricating system, preferably with very thin lubricating oil.
Flush cooling water system.

The hand tools supplied with the engine are in most cases sufficient for all servicing needs. Sometimes grease guns or other specialized tools such as allen keys, plus screwdrivers, etc., are not supplied and should then be provided.

Care should be taken to see that the proper grades of lubricating oil, fuel oil and grease are used, and that these are not permitted to become contaminated before use or while being added to the engine.

Cleanliness can reduce considerably subsequent maintenance and repair work. The daily cleaning of the engine is mainly a matter of wiping the engine. This will help reveal the source of leaks which should be attended to. A supply of commonly used washers will usually make it easy to stop pipeline leaks without damage due to overtightening of nuts or bolts. Gaskets for covers and side doors can usually be cut from locally available materials.

Monthly cleaning of the engine would call for more attention to details. Springs, small shafts and other parts frequently have a short life due to rust or go out of order due to dirt. Starting chains with stiff links wear out quickly and damage the chain sprockets as well if not freed regularly. Chain tighteners and starting pawls must also be kept clean to give good service. Timing marks can easily be obliterated if allowed to rust, and subsequent dismantling of the engine can be both difficult and expensive if exposed shafts, foundation bolts and the like are permitted to rust.

Overhauling

Top overhauls should be carried out at fairly regular intervals, but the condition of the engine should be taken into consideration as well as the time lapse since the last overhaul. Top overhauls are mainly concerned with the cylinder head, although some other items are attended to as well. A typical top overhaul would include:

Removal and cleaning of exhaust pipe and silencer.
Removal of cylinder head.
Regrinding of valves, checking valve springs, adjusting tappet clearances.
Decarbonizing, i.e., removing all carbon from cylinder head, cylinder and piston crown.
Cleaning of injectors and resetting the injection pressure.
If necessary, removal of pistons, cleaning of rings and checking, and bearings.
Cleaning water passages in cylinder head or cooling fins on cylinder and head.
Refitting head with new gasket, checking piston crown clearance and tightening head nuts according to manufacturers' instructions.
Checking cold starting device (if fitted).
Checking sea water pump, inlet valve and strainer.
Attending to all leaks on the engine.
Checking alignment of the engine.

The need for removing the pistons for each top overhaul differs with engine type and condition. If the compression is good and oil consumption normal, this should not be necessary, and would be done as part of a general overhaul instead. If the pistons are not removed the big-end bearings should be inspected for looseness, especially if they are of the thick wall type.

The time interval between top overhauls, as recommended by the manufacturers, ranges from 500 to 3,000 hours corresponding to about 10 weeks to over one year. Where fishing is seasonal, the schedules should be arranged to take advantage of periods of non-operation or poor fishing for this work. As far as possible each engine should begin a fishing season in good condition, even at the expense of deviating from the recommended intervals. Top overhauls are usually carried out on board the boat.

Major overhauls are required approximately once in two years. The basic objective of a major overhaul is to check and correct, if necessary, the wear of the principal parts of the so-called running gear, i.e., pistons, connecting rod and crankshaft with their associated cylinder liners and bearings in addition to the work carried out in a top overhaul. The camshaft and valve gear should be inspected at the same time, particularly valve guides and rocker arm pins. The fuel pump should be checked and adjusted preferably with specialized equipment. During a major overhaul the gearbox should also be examined closely and worn parts replaced.

A considerable number of parts are usually required for a major overhaul. At the very least all gaskets, packings and oil seals should be replaced. Many manufacturers recommend the routine replacement of other parts at this time, even if they appear serviceable. This applies particularly to items like connecting rod bolts or nuts, the failure of which would lead to a major breakdown of the engine.

Reconditioning can be carried out at the time of a major overhaul with little or no extra labour charges, although the cost of parts would be greater. The choice between reconditioning or overhauling will depend on a number of factors. If there is a replacement scheme in force by which the engines are removed and replaced by others, reconditioning would be more natural. Where the engines are either repaired on board or sent ashore to be returned to the same vessel it may not be considered economical to carry out complete reconditioning. Speaking in very broad terms, reconditioning is indicated for high speed engines, overhauling for slow.

Inspections

If the boats are to be operated by relatively poorly trained personnel, periodic inspection of the hulls and particularly the engines can be of great value in reducing the amount of maintenance work that ultimately will be required. If the boats are privately owned by individuals the inspectors will probably be able to act in an advisory capacity only. In the case of craft financed or owned by Government or large organizations the inspectors should be given considerable powers to enforce proper maintenance, particularly servicing. Such inspectors need not be highly trained, although it is a definite advantage if they are able to assist with minor adjustments and repairs. Their inspection reports will be of the greatest value in preparing work schedules for the maintenance men, apart from the reduction in work required as a result of timely intervention when an engine is being neglected or abused.

Repair Facilities

The type of repair facilities required for the engines of a fleet of small mechanized fishing craft will depend on a number of factors. Private ownership of individual boats, particularly if they are operated from a large number of widely dispersed centres, will indicate a set up quite different from that which would be required for a fleet under central management operating from one or only a few bases. Similarly standardization of engines, whether individually owned or not, would lead to different facilities compared with the operation of a wide range of makes or models.

Service or repair shops operated by private businesses, in which the marine work or the work on small engines is likely to be incidental, would differ from facilities set up by Governments, semi-public corporation, co-operative societies or the like for the express purposes of catering to fishing fleets. In the latter case it is possible that the services rendered would at least in the part be free, and that the objectives would be educational as well as mechanical.

Regardless of the type of set up, it would, however, have to cope with a fairly definite bulk of work. To get some idea of the size of the organization required, the work per engine (10–30 h.p. diesel) can be very roughly estimated as follows:

Top overhaul	2 per year	$1\frac{1}{2}$– 2	man days each time
Major overhaul	$\frac{1}{2}$,, ,,	8 –12	,, ,, ,, ,,
Running repairs	2 ,, ,,	$1\frac{1}{2}$– 2	,, ,, ,, ,,
Major breakdown	$\frac{1}{2}$,, ,,	6 –10	,, ,, ,, ,,
Routine inspection	4 ,, ,,	1/6	,, ,, ,, ,,
Total per engine approx.		12 –17	,, ,, per year.

In other words, with 300 working days per year one man would be required for every 17 to 25 engines. This would include engineers, inspectors, foremen, machinists, fitters and helpers but not clerical or office staff. If the fleet contained even a small number of large engines (not hand started) the requirements would increase rapidly.

Hand Tool Work

Assuming that adequate supplies of spare parts are available, all maintenance work on small diesel or petrol engines *can* be carried out with hand tools alone. This is, however, a costly procedure, as it involves discarding expensive parts which could be repaired or reconditioned at a fraction of the price of new parts, if suitable equipment were available.

In a number of development projects over investment in maintenance facilities has jeopardized the economic justification of the whole project. If the powers that control the allocation of funds can be counted on to show a sympathetic understanding of the need for spreading out the development and for controlled expansion, it is better to begin at a modest rate and enlarge the facilities when and if this becomes necessary. The use of internal combustion engines is now so widespread that competent organizations, capable of carrying out their repairs, can be found almost everywhere.

There may well be very valid reasons for not wishing to make permanent use of these organizations, but in the early stages of fleet development it is better to concentrate on establishing a good on-board maintenance service in the first instance and building up permanent shore facilities later.

Mobile repair vans may provide the best solution to the problem of getting the mechanics to the work site. If the fleet is widely distributed the use of public conveyances tend to be very time consuming and makes it difficult to transport all the tools which may be required or desirable.

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Development

FUELS AND LUBRICANTS FOR SMALL ENGINES

JOHN BURGESS

MARINE engines repay careful treatment. Use of the correct fuels and oils, careful running-in and maintenance will help get the best and most economical performance from them.

Outboard Two-Stroke Engines

The sectional drawing in Fig. 1 shows the cylinder, piston, connecting rod and crankcase of a two-stroke engine. The crankcase is an aluminium case closed at its outer end by the cylinder. In the cylinder barrel is a series of ports and one or more transfer passages. The ports are the means of entry and exit for the inlet and exhaust gases, and the transfer passages allow gases to be transferred from the crankcase to the cylinder. Many two-stroke engines have a flat-or-dome-topped piston as in this diagram—some types have a piston with a hump to help separate the fresh petrol-air mixture from the burnt combustion products.

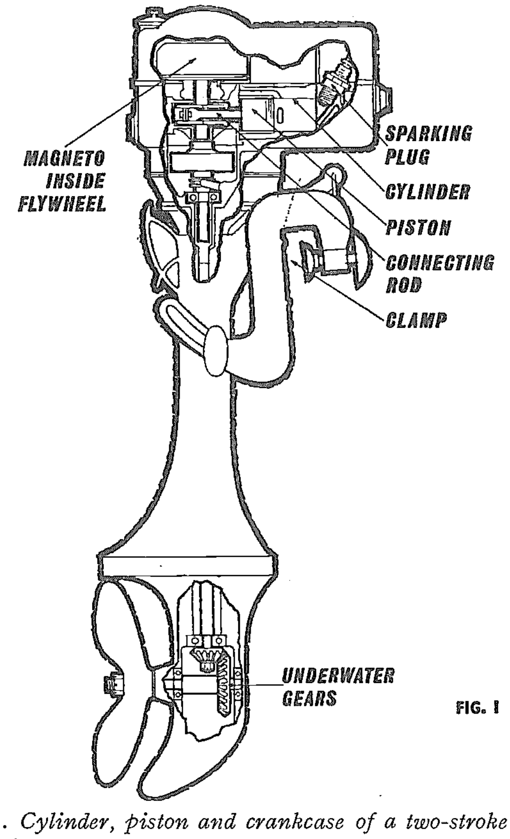


FIG. I

Fig. 1. *Cylinder, piston and crankcase of a two-stroke engine, shown in section.*

The power to drive the piston down in the internal combustion engine is obtained from the rapid burning of a mixture of petrol and air, although in the two-stroke oil must be mixed with the petrol for lubrication purposes. The petrol, in the form of a mist of fine spray, is mixed with air in the carburettor, which automatically provides the mixture in the right proportions for combustion under all running conditions.

Means of igniting the mixture is a device known as a magneto, which produces a high tension current, and a sparking plug which provides the spark. The mixture is ignited and the resulting rapid expansion of the gases drives the piston downwards.

Cycle of Operations

1. At the beginning of the cycle, there is a charge of petrol-air mixture already in the combustion chamber above the piston The piston is moving upwards and as it rises it uncovers the inlet port. The rising piston also causes a partial vacuum in the crankcase and in rushes the petrol-air mixture from the carburettor.
2. As the piston continues to move upwards it compresses the charge already in the combustion chamber. When it reaches the top of its stroke a spark at the spark plug ignites the charge.
3. As the piston is driven down, it uncovers the exhaust port, and allows the burnt gas to escape to the exhaust. At the same time it covers the inlet port and starts to compress the petrol-air mixture in the crankcase. Before the exhaust port has been fully uncovered, however, the piston starts to uncover the transfer port and the compressed mixture in the crankcase rushes up the transfer passage into the combustion chamber. The transfer of the mixture is now completed and the piston is forced upwards again by the momentum of the flywheel.
4. Just as the inlet port is uncovered, the firing cycle starts again. Many engines have twin exhaust ports and two or more transfer ports. They may also have more than one cylinder, in which case each piston drives a common crankshaft.

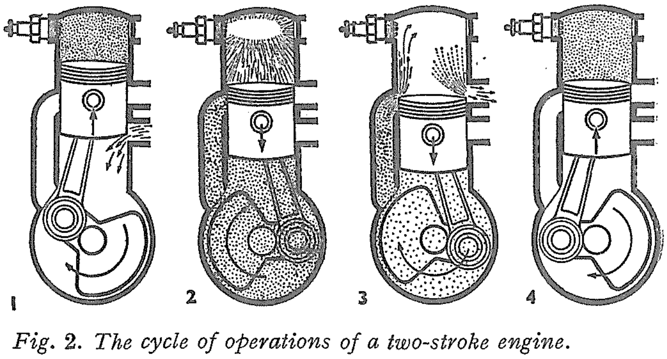


Fig. 2. *The cycle of operations of a two-stroke engine.*

Lubrication

In the two-stroke engine, the very simplicity of the lubrication system may spell trouble. No system could be more simple provided the correct grade of oils is used in the approved proportion and that it is thoroughly mixed with the petrol. The engine does the rest, introducing its quota of oil in every charge of petrol and air and passing it in the form of a petroil mist to every bearing and to the cylinder walls. Use of the wrong grade or quantity of oil or incomplete mixing, will affect the running of the engine and may also result in excessive deposits in the cylinder and the ports, leading to loss of power.

Mixing the Petroil

It is important to ensure that the correct ratio of petrol to oil is used. The correct ratio for your engine can be found by reference to the Chart at your dealer.

The oil and the petrol must be thoroughly mixed *before* being poured into the tank: any attempt to mix them after pouring them in separately will cause trouble later. Mixing should always be done in a clean, airtight container. Pour in half the required amount of petrol, add all the required amount of oil and thoroughly shake the container. Add the rest of the petrol and shake again to ensure thorough mixing. Pour the mixture into the tank, preferably through a fine mesh filter.

Lubrication of Gears

Lubrication is *vital* and the results of neglect are costly. Examine the oil level frequently; any shortage of oil will cause damage to the gears and bearings. Change the oil at the intervals recommended by the engine manufacturer. In particular, underwater gears must be given careful attention. They are heavily loaded and exposed to corrosion unless protected by the correct lubricant.

Hints on Care and Operation

A new engine should be carefully run-in, so that the various friction surfaces—the piston, cylinder and bearings—have a chance to bed-in. They will do this automatically if there is proper lubrication and thoughtful handling of the controls, especially the throttle. For the first few hours the engine should not be overworked. Restrict running to the throttle opening recommended by the manufacturer.

The engine may be given progressively more work to do until, at the end of the running-in period, it is operating at its full capacity. During the running-in period the oil content of the petroil mixture should be increased as recommended by the manufacturer.

Hints on Running

1. Always ensure that the petroil mixture is thoroughly mixed before putting it into the fuel tank.
2. Check the oil level in gear boxes and the lubrication of any underwater gears frequently. Change the oil at recommended intervals.
3. Never run the engine out of water.
4. A few minutes before closing down the engine, turn off the fuel and allow the engine to run until the carburettor is empty. This makes sure that there will be no excess of oil in the carburettor as the petrol evaporates. Restarting will then be made with a correct mixture.
5. Always check that the fuel is turned off when the engine is not in use.

Treatment of an Outboard Motor that has been Submerged

It is a good safeguard against losing the engine overboard to secure it to the boat with a length of rope. An engine that has been submerged is liable to corrode quickly, especially with sea water, if it is not either started or completely dismantled and all traces of water removed soon after it is retrieved. If it has been in salt water the only way of making sure that no further damage due to corrosion can occur is to hose it down with fresh water and then dismantle it completely.

Never attempt to start an engine that may have water in it. Water is incompressible and serious damage could be done to pistons and connecting rods. The following procedure should be followed:—

1. Remove sparking plugs and carburettor, which will require cleaning.
2. Support the unit with the plug holes downwards and turn the engine over slowly to eject as much water as possible from the cylinders and crankcase.
3. With the magneto or plug leads earthed, pour about $\frac{1}{4}$ pint of petroil mixture into the carburettor opening on the engine and turn the engine over half-a-dozen times, repeating until a pint of mixture has been flushed through the engine.
4. Turn the engine over rapidly to expel as much of the mixture and any residual water as possible.
5. Clean, dry and refit the sparking plugs and carburettor.
6. Clean out the fuel system and tank and refill with correct mixture.
7. Install the engine on the boat and carry out the starting drill. Run at moderate speed for 30 minutes to dry it out.
8. It may be necessary to clean the plugs several times before a start is obtained and it is a good idea to check whether there is a spark by connecting the H.T. lead to a clean dry plug earthed on some suitable part of the engine while the engine is turned over on the starter.
9. If there is no spark or the engine fails to start, the magneto assembly should be thoroughly dried out, particular attention being paid to the contact breaker points.
10. If, after repeated efforts, the engine still fails to start, pour about two to three tablespoonfuls of two-stroke oil into each cylinder through the sparking plug holes, and turn the engine over several times to get the internal surfaces and bearings covered in oil to prevent corrosion. The unit should then be taken, with as little delay as possible, to an authorised agent for cleaning.

The inboard four-stroke petrol engine is basically similar to a car engine, apart from the cooling system.

It is not generally realized that by running the engine at too low a temperature engine wear is increased rapidly. Condensed moisture and fuel from the cylinder walls enter the crankcase, forming a watery sludge. This may choke filters and oil pump screens, leading to loss of oil pressure and damage to the engine.

The operating temperature is normally laid down by the manufacturer. It varies according to the kind of cooling water—fresh or salt. Generally speaking, with fresh water the return water temperature should never be less than 175 deg. F. (80 deg. C.). A slightly lower temperature is necessary if direct sea-water circulation is used as salt deposits tend to form in the cooling jacket, if high temperatures are maintained for any length of time.

In shallow or muddy water the intake filter may become choked and, unless this is kept clear, overheating may occur.

A new engine should be run in carefully for the first few hours of its life. During this period it should never be run at full throttle and the manufacturer's instructions should always be followed.

At the end of the running-in period, the engine oil should be drained and replaced with fresh oil. It is advisable to check the cylinder head nuts and all other nuts and adjustments.

The routine running of the engine is simple and trouble-free. However, regular attention should be paid to lubrication, the renewal or cleaning of oil and fuel filters, and the battery. It is particularly important to renew the engine oil at the specified intervals so that contaminants which the oil holds in harmless suspension are removed. The seasonable oil bill is only a fraction of the price of a mechanical repair.

Inboard Diesel Engines

The " compression ignition " or diesel engine is the most efficient prime mover of all. It produces more power per lb. or gallon of fuel burned than any other type of engine.

It is rugged and if properly maintained, run on clean fuel and lubricated by a good heavy duty oil, will give trouble-free service for long periods between overhauls.

The fuel metering and injection system is the heart of the diesel. On absolutely accurate and consistent measurement and delivery of fuel by the fuel pump—at exactly the right timing—and on correct atomization of this fuel by the injectors, depends how much work you get from every power stroke of your engine—and for how many thousands of miles you keep on getting it.

First task of the fuel pump is to measure for each engine cylinder the exact amount of fuel it has to burn for the particular load conditions under which the engine has to operate. The multi-plunger type of pump normally fitted to high-speed engines delivers fuel to the injectors at very high pressure by means of steel plungers operating in steel barrels. The fuel is metered by means of a releived area cut out of the plunger circumferential surface, of which the upper boundary is a helix and the lower a straight groove. In one side of the barrel an inlet port is drilled and on the opposite, a spill port.

Vertical movement of the plunger in the barrel is achieved by camshaft, tappet and return spring. In its " returned " or bottom dead centre position, the space above the plunger in its barrel, and also the hellical space and grooves on the plunger circumferential surface, are filled with fuel, through the inlet port, by a fuel lift pump, or gravity feed.

On the delivery stroke this fuel is forced upwards, through a delivery valve, and via the fuel pipeline to the injector. The amount of fuel delivered is controlled by rotating the plunger, so that the point on the delivery stroke at which the helix is uncovered to the spill port allows the amount of fuel not required to escape through the latter. In the " stop " position, the axial groove will be in line with this port, so that all fuel escapes.

Rotation of the plunger may be achieved (*a*) by a " rack " coupled to the accelerator control, and engaging with teeth formed on the outer surface of a control sleeve or " quadrant." This is free to rotate around the lower part of the barrel and engages " wings " machined on the bottom of the plunger—or (*b*) in some types of pump, by an extension arm or lever attached to the plunger base.

The position of the rack is subject to an overriding control from a mechanical, hydraulic or pneumatic governor, which is an engine speed control, and is also limited by a " maximum fuel stop." Each plunger can be rotated independently by hand and then locked in the desired position, to equalize the amount of fuel which can be delivered per stroke. This is known as " calibration." It is necessary to ensure that delivery of fuel to each cylinder occurs at exactly equal intervals of crankshaft rotation.

When new, the accuracy of the pump camshaft ensures equally spaced delivery. After prolonged use, however, it may be necessary to compensate for any slight wear of either camshaft, cam-followers or pump tappets, which may have occurred.

Absolutely correct timing of injection is also obviously essential. Timing is achieved by means of a coupling on the fuel pump drive, connecting the driving shaft from the engine timing case to the fuel pump camshaft. By means of this coupling, the latter can thus be set in relation to the engine crankshaft, and injection of fuel to each cylinder arranged to commence the required number of degrees before top dead centre. This timing will vary from one type of engine to another. The engine manufacturer's instruction book will give the correct timing and show how it may be set and checked.

The important point is that just as correct calibration and phasing are essential, so is correct timing. What may be the results if all is not as it should be in these various directions ?

(*a*) Calibration

Faulty calibration or uneven delivery from the several pump plungers will result in smoke, rough running and faulty idling.

Greek fishermen prepare to mechanize a traditional fishing craft with a modern outboard motor. As the result of a programme carried out in two Greek fishing villages, Psarades and Sayades by CARE and Outboard Marine International, S.A. in co-operation with the government of Greece, fishermen of these two communities have found new prosperity from the sea.

(*b*) Maximum Fuel Stop Setting

If the maximum fuel stop on the rack or the governor is incorrectly set so as to permit more fuel to enter the cylinder than it can possibly burn, this will lead to:

(1) Smoke.

(2) Excessive fuel consumption.

(3) Premature engine failure through "ring-stick."

If it is set to give less than the correct delivery, it will cause loss of power, and it may well be, excessive fuel consumption again, this time due to having to make undue use of gears.

The maximum fuel stop should be set so that the pump delivers the exact quantity recommended by the manufacturer and sealed to prevent unauthorized alteration.

(*c*) Timing

Over-advance causes loss of power and may increase "diesel-knock." Over-retarded timing similarly causes loss of power, and may result in misfiring.

The least onerous duty of the engine oil in a compression ignition or diesel engine is simply to lubricate. Its major task is to combat fuel combustion products. The type of oil used is therefore of great importance. For maximum engine life only "heavy duty" oils should be employed. These are highly refined mineral oils containing a multi-functional additive or additives, imparting:

(1) Detergency/dispersancy.

(2) High oxidation stability.

(3) Enhanced wear resistance and protection against corrosion.

We must consider lubrication in conjunction with combustion. Somewhere near the end of the compression stroke, the fuel pump delivers through the injector a measured quantity of fuel, atomized into many thousands of tiny droplets.

Burning commences very shortly after injection. Combustion then proceeds throughout the mixture of fuel droplets and heavily compressed air present in the combustion space. Where there is an optimum mixture of fuel droplets and air, at a sufficiently high temperature, burning should be complete. The products of combustion will then be all in the gas or vapour phase. They will be carbon-dioxide, nitrogen and water vapour, and also, in the case of most fuels today, a small amount of sulphur oxides.

But the diesel engine, despite having the highest thermal efficiency of any conventional prime mover, does not completely burn all the fuel all the time in this way. In the presence of less than adequate air which can obtain under certain speed and load conditions, some of the fuel droplets that do not undergo complete combustion form small particles of soot.

These in themselves are not harmful provided not present in too high a proportion in the exhaust gases, such as would cause smoke. But they can none the less result in a "dirty" engine having heavy sludge deposits and thickened lubricating oil. The "dispercancy–detergency" function of the additive in a heavy duty oil will ensure that combustion soot is kept in harmless suspension, and thus prevent it from depositing as sludge.

A particularly troublesome result of imperfect combustion follows another kind of incomplete burning of some of the particles of fuel. In this case they tend to form gummy or lacquer-like oxidation products which, if allowed to deposit in the piston ring belt, will rapidly cause "ring-stick." The answer to this again is "detergency/dispercancy," a good circulation of oil in the ring-belt zone, and regular sump changes to ensure maintenance of adequate additive level.

When we consider the combustion process against the background of the chemical nature of the fuel, we have to take into account the effect of sulphur. In the presence of moisture and at low temperatures, certain inorganic acids are formed in sufficient quantity to cause some corrosive wear of both piston rings and cylinder walls. With heavy duty diesel engine oils, we can neutralize this acid chemically And as the additives used are "polar" to ferrous metals, they also ensure powerful protective wetting of the cylinder liner and piston rings, thus preventing this combustion acid from reaching them.

The reduction in wear of rings and liners which can be achieved with good heavy duty oils compared with straight mineral oils is most striking, as is also the difference between wear rates with one type of heavy duty oil and another of lower additive performance level.

Change-over Procedure

Detergent properties may enable an oil to loosen engine deposits already formed in the engine and, therefore, to obtain the best results, it is considered desirable, although not essential, when changing over from straight mineral oil to heavy duty detergent oils to adopt the following change-over procedure:

1. Thoroughly drain old oil when engine is hot.
2. Fill with appropriate grade of heavy duty oil and run engine under no load conditions for approximately half an hour to flush out the oil system.
3. Drain flushing charge and refill with fresh oil, clean oil filter, or fit new element in the case of replaceable cartridge type filters.
4. Run engine normally for 20/25 hours or say 500 miles, then drain and refill with fresh oil. Again clean or renew filter element according to type and thereafter follow normal drain and refill change procedure recommended by the manufacturer.

Different types of fuels are produced for use in different types of engines. One major company, for instance, markets five kinds of oil suitable for use in marine engines.

The most refined in its range is a top quality petrol designed for use in modern engines with a high compression ratio. This contains an additive to give economical power over long periods. The same additive is mixed into a slightly lower grade of petrol which can be used in most high performance engines. A third grade is a petrol intended for use in low compression ratio and two-stroke engines.

For use in diesels, it makes a high quality distillate, and for petrol/paraffin engines it makes a highly refined paraffin.

The same company, like most major oil companies, produces an extensive range of lubricants, greases and anti-corrosive oils and fluids for use with marine engines.

It makes a two-stroke oil blended specifically for petrol lubricated two-stroke engines; special oils for four-stroke petrol engines; detergent oils for diesels; and transmission oils for gearboxes and transmission systems. It makes among many others, a multi-purpose grease for the protection of underwater shafts, gears and bearings against corrosion and wear. And it also makes oils and fluids which will displace moisture from metal surfaces and coat them with a protective film against corrosion.

Given the right conditions, all fuels are highly inflammable. Great care must be taken in refuelling, particularly with petrol because heavy petroleum vapour tends to collect in the bilges.

It is essential to extinguish all naked lights and stop any spark-producing equipment, such as electric fans or motors. Smoking should, of course, be prohibited and (after refuelling particularly) if any fuel is spilled, mop it up thoroughly: the hull should be well ventilated before starting the engine or lighting stoves and lamps.

To reduce the fire risk from static electricity, it is advisable when refuelling from a pump to make sure that the metal nozzle of the delivery hose makes contact with the metal filler pipe of the tank before the flow begins.

Great care must be taken to ensure that any can or container holding petrol is clearly distinguishable from one holding paraffin, for example, diesel fuel or water.

PROGRESS IN DESIGN

ENGINES

Types, makes, prices and fuel

DEVELOPMENTS during the intersession period between the ninth and tenth sessions of the Indo-Pacific Fisheries Council in the design of new types of fishing craft were as follows: In North Borneo, in 1961 two wooden inshore trawlers were launched in Sandakan; one measured 20 m. loa, designed by William Garden of Seattle, U.S.A., and the other was a 9·1 m. stern trawler designed by Peter Gurtner, FAO naval architect. The stern trawler is operated by the government for demonstration and training purposes.

In Hong Kong, the first departure from the traditional junk design occurred in 1961 when two local fishermen commissioned the construction of a pair of modified deep-sea " Kwong-sun " type trawling junks of 26·21 m. loa. These vessels differed from the traditional junk in so far as the stems were raised and forecastles built for crew accommodation. The two traditional deckhouses normally situated on the poop deck, together with the after platform at the end of the poop, were omitted, thus providing a lower superstructure at the stern. These vessels were fitted with semi-balanced steel rudders, wheelhouses and bridge controls, and have been operating successfully.

A second pair of vessels of 26·82 m. loa were subsequently built with no poop aft which left the vessels with a clear stern for working the net, and facilitated hauling and shooting of the gear. Whereas the first two boats were built with the traditional bulbous stern and had to be ballasted to attain correct trim, this subsequent pair had improved hull forms giving a better flow of water to the propellers, and required no ballasting. On the speed trials, the second pair proved 0·63 of a knot faster than the earlier pair. A third pair of trawlers has recently been completed with a deck layout similar to the initial pair but with a greatly improved hull form.

One-engine Power

Each of these six vessels are propelled by one marine diesel engine of 240 hp at 1,000 rpm fitted with a $3\frac{1}{3}$ to 1 reverse/reduction gear box. Construction was in accordance with traditional methods but six templates were used in each case.

There are two major problems in fishing boat efficiency in Korea.

Eighty-five per cent. of the fleet consists of small non-powered units that depend upon hand sculling or wind to get them to the fishing grounds. The loss of fishing time in this travel is one of the principal reasons for the low income of this class of fisherman. To assist in this problem, eight small boats of a slightly modified design are being constructed, in which low-cost, non-reversing air cooled, kerosene burning engines are to be installed. These boats will be demonstrated throughout the fishing areas with the object of encouraging fishermen to mechanize their existing boats.

Special Designs

In the large boat class, all vessels are basically single purpose vessels. In most cases these vessels work only during a particular fishing season then are tied up until this season returns. A steel vessel of 70 gross tons of U.S. design is being constructed which can be used as a multi-purpose boat (purse seine, trawl, long-line, etc.). This vessel will be completely mechanized in regard to deck equipment and electronics and will be used to demonstrate efficient year-round operation.

In India, special designs of boats of 7·31 m. and 9·75 m. are being constructed by State Fisheries Departments and issued to fishermen at subsidized prices. This is necessitated because some of the traditional type of fishing craft are not capable of being motorized by simple alterations economically. The Department of Fisheries, Madras State, operates a boatbuilding yard which supplied 66 new type mechanized fishing boats to fishermen's co-operative societies, district co-operative federations and groups of fishermen.

In Netherlands New Guinea, there are only indigenous fisheries, which are still in a primitive stage and as a rule form only part of the subsistence economy of the population. The inhabitants of the coast—350,000—annually land some 4,000 tons of fish. In the environs of the urban centres fisheries have developed as a result of the general development.

The native canoes have been mechanized through the use of outboard motors. Despite this progress, fisheries should not be regarded as being practised as a professional trade. Most fishermen derive their income also from other activities. Even in Geelvink Bay, where the Sea Fisheries Division has organized fishermen's groups in the various fishing villages, fishing is still considered a part-time occupation. A restrictive factor in this regard is the fact that regular work is not yet felt to be a necessity. Living requirements are still limited, and the fisherman deriving his low income from fishing feels content that he can supply himself in a satisfactory manner.

The fishing vessels now used are generally of the dug-out type, equipped with outriggers. They vary in length from 4·57 m. to 9·14 m. in width from 0·45 m. to 0·76 m., and have about the same depth. No special improvements have been introduced in this type of craft. The Sea Fisheries Division has built a number of powered wooden craft (loa 7·92 m.; width 2·13 m.; depth 0·91 m.) with insulated fish holds and Victor Vixon diesel engine propulsion.

These craft have, by way of experiment, been placed at the disposal of indigenous fishermen on a co-operative basis, the fishermen contributing 40 per cent. and the cost of operation being accounted to the Government. The objective of the experiment is to find out the results achieved by the indigenous fishermen. Thus far the results have been rather inconsistent, due to seasonal influences.

Improvements

In Pakistan, the following improvements were introduced recently in designs and construction of the mechanized fishing crafts. The mechanized fishing crafts are now generally provided with the deck in one level, a spacious wheel house and a suitable crew cabin. An inset rudder coupled to a wooden steering wheel is provided to facilitate smooth operation of the vessel and to maintain balance.

Now most of the powered vessels have an insulated fish-hold to save the catch from spoiling during the fishing operation. A power operated trawl winch and deck gear are being fitted and becoming popular for stern trawling. A further improvement has been made to build a trawler suitable for gill-netting. To achieve this objective, the cabin is located in the centre leaving the forepart for gill-netting and the aft for trawling.

Medium sized (19·81 m. to 22·86 m.) North Sea type steel trawlers were imported for trawling in the deeper off-shore waters. Two trawlers are now operating from Chittagong in East Pakistan and the other two from Karachi in West Pakistan. One of the two based in Karachi is equipped with a freezing unit to freeze approximately one ton of fish per day.

A 26·67 m. combination steel vessel has been built at the Karachi shipyard for survey work in the Bay of Bengal. The vessel is rigged for trawling, purse seining, gill-netting, etc. It set sail for Chittagong in September this year, where it will operate under the supervision of a team of FAO experts to determine the fish resources of the Bay of Bengal.

Leased Out

Negotiations are under way for construction or purchase of a similar vessel for West Pakistan.

Thirteen improved type gill-netters, one stern trawler and one shallow water research vessel have been built in East Pakistan. All these vessels have either been leased out to fishermen or sold to them on hire-purchase system. The research boat is, however, being utilized for " Hilsa Investigation " purposes.

Eleven gill-netters, two fish carriers, one shrimp trawler and one small research boat have been built for operation or Mekran Coast, West Pakistan. These boats have been given over to the Fishermen's Co-operative Societies to be worked there on a co-operative basis. The research boat is, however, being utilized for " shrimp and sardine investigations."

In the private sector, also, a number of new boats (mechanized and non-mechanized) have been built. Figures given below show the overall rate of new construction:—

	1960	1961	*Increase*
Mechanized trawlers ..	87	114	+ 27
Motorized gill-netters ..	257	292	+ 35
Sail boats	4,400	4,550	+150

In late July, 1961, a 19·8 m. shrimp trawler was ready to be launched from a shipyard in Mazatlan on Mexico's west coast for the Government of Pakistan. The vessel is a conventional shrimp trawler equipped with a diesel. It is reported that if arrangements can be made, the Government of Pakistan may order additional shrimp trawlers from Mexican shipyards. M.F.V. *New-Hope*, a 11·58 m. trawler is conducting exploratory fishing on the coasts of Sind and Karachi in the inshore waters.

Areas Surveyed

New-Hope made 45 trips, the number of actual trawling hours being 187. The operations were conducted between 2 and 4 fathom contours. The vessel surveyed areas facing Phitti, Khai and Khuddi on the Sind coasts and areas facing Buliji, Korangi and off Anchorage on the Karachi coasts. The vessel caught 3,065 kg. of shrimps and fish valued at Rs.2,226.09.

A Japanese expert under Colombo Plan, accompanied the departmental vessel on the survey trips and has tried Japanese longline on three trips staying overnight at sea. The results so far are not encouraging.

Later on the departmental vessels M.F.V. *Machchera* and *New-Hope* were both engaged in exploratory operations. *Machchera* made 15 trips, caught 1,915 kg. of fish and shrimps valued at Rs.1,688.54, while *New-Hope* made 15 trips, caught 515 kg. of fish and shrimps, valued at Rs.398.64. Despite rough conditions at sea, the vessels operated on the Sind and Karachi coast, and conducted fishing between 18·3 m. to 27·4 m. (10 to 15 fathoms) continuously in the unexplored areas.

In Mekran Coast, 10 launches have been completed and their delivery taken for fishing operations. A research vessel is under construction at Karachi Shipyard. First instalment of Rs.208,000.00 has already been paid to the firm for the construction of the vessel.

In the Bay of Bengal 85 per cent. of the construction work on 12 boats has been completed. It is expected that the construction of the boats will be completed within the stipulated time.

Two boats of the Khulna Fish Preservation and Marketing Corporation are now engaged in fishing and fish carrying operations in the Khulna estuaries. Some of the other boats are carrying fish in Chittagong, Cox's Bazar, and Khulna areas.

Summing up, it can be seen that, in general, appreciable progress is being made in the introduction of new types of fishing vessels in the region as a whole. A significant development has been the successful trials with small (about 9·1 m. overall length) stern trawlers in India and North Borneo.

Construction Techniques and Materials

Recent developments in improved boatbuilding techniques as well as introduction of new materials in the region are as follows:—

Korea does not produce the types or quality of lumber required for wooden fish boat construction. Pine, the principle domestic source of lumber, can be taken in only limited quantities because of the need for protecting and building up its forests. Fishermen prefer cedar because of longer life, resistance to salt water and ease of handling.

Thus a large quantity of the cedar-logs are imported from Japan every year. Korea is beginning to produce some steel plate and the five-year plan calls for an increase in steel production. Since suitable lumber has to be imported greater study is being made of steel boat construction. Plastic materials have not, as yet, received consideration because of their present high cost.

In Pakistan, there is no remarkable change in the construction material except that the material now used is of a superior quality. Generally the material used is teak wood and mould steel. Now the rudder is fitted with zinc plates to avoid chemical action of sea water.

Motorization Progress

Progress in the development of motorized fishing fleets in the region either by motorization of traditional craft or construction of new motorized craft is reviewed as follows:—

In North Borneo, the progress of motorization of fishing craft is shown in the table below:—

Year	*Number of fishing craft in N.B.*	*Motorized with inboard diesels*	*Outboard motors*
1959	6,290	128	4,645
1960	6,954	141	5,079
1961	7,232	152	5,816

At the end of March, 1961, there were 3,520 motorized vessels in Hong Kong. During the financial year, April 1, 1961, to March 31, 1962, 1,497 fishing junks were motorized, 108 mechanized vessels were converted to sail or to trading vessels and 285 mechanized vessels were cancelled from the register. The actual increase during the year was 1,104 making a total of 4,624 vessels in the mechanized fishing fleet.

Target of 4,000

In India, the target tentatively set for mechanized fishing boats is about 4,000 under the Third Five Year Plan ending 1966. The installed capacity for fishing boat production is about 1,000 per year. About 1 to 2 per cent. of India's fishing boats are mechanized; the present trend has been to develop new designs for boats, rather than fit up engines in the indigenous boats.

The cost of a mechanized boat varies according to its size and the horse-power of the engine. It ranges from Rs.8,000 (US$1,680) per boat of 6·7 m. in length to Rs.50,000 (US$10,500) per boat of 11 m. in length. The estimated increased landings of fish by mechanized boats are about 70,000 tons per annum. Emphasis continued to be given during 1961 to the expansion of marine fishing by mechanization of fishing craft, improvement of fishing methods and provision of facilities for landing, preservation and marketing of fish catches.

The total number of mechanized boats in India is at present over 1,750 as against 850 in 1957. Special designs of boats 7·31 m. to 9·75 m. are being constructed by State Fisheries Departments and issued to the fishermen at subsidized prices.

In 1961 there were a total of 32,733 fishing boats in Korea. Of this number, 28,677 or 87 per cent. were non-powered. In order to increase the effectiveness of the existing fishing fleet steps were taken in 1960 to provide government support for fishing boat mechanization. During 1960, 18 boats (201 hp), and 1961, 21 boats (706 hp), were equipped with semi-diesel or diesel engines under this programme. During 1962 mechanization is limited to diesel engines only and it is estimated 1,840 hp will be installed under the government support programme. This project will be continued as a part of the five-year programme for Economic Development which covers the period 1962 through 1966.

Combination Type

The Government of Korea is studying the combination type fishing boat which can be operated year around with a small number of the fishermen in accordance with the change of fishing season. As of today, one combination type wooden fishing boat of 58 tons is in commercial operation. It is a USA west coast type and can be operated for purse seine, and both longline and bottom towing net fishing.

This boat is now engaged in stern trawling for shrimp on the east coast, and it has decreased personal expenditure one-third and increased the catch by one-third in comparison with the old type boat. It can be easily changed to operate in other fisheries with change of fishing season. Most of the coastal fishing boats are small non-powered boats of less than 10 gross tons.

It is important that the efficiency of these boats be improved. In 1962 the Government will start a demonstration programme on the mechanization of small boats of less than two tons. This project will test small and simple engines of from 2·5 hp to 7·5 hp costing about 15,000 to 35,000 Won. It is hoped successful use of these engines will increase operating hours, improve quality of fresh fish, and prevent accidents from sudden bad weather.

In the Federation of Malaya, progress in the mechanization of fishing boats is shown below:—

Year	*Outboard*	*Inboard*	*Total*
1960	5,002	3,938	8,940
1961	4,841	4,824	9,665

The figures show a definite trend towards inboard engines. During the first quarter of 1962, this trend continued as only 124 boats were newly installed with outboard engines as compared with 255 boats with inboard engines. Selangor has again led in mechanization especially in new inboard engines which totalled 83 units as compared with only seven new outboard units. Perak, Malacca and West Johore also accounted for a fair share of newly licensed inboard engined craft with 47, 29 and 30 units, respectively. The increase of 29 units in Malacca has been due to the construction of new boats for the State's Kuala Linggi Fishermen's Co-operative Scheme.

Among the States on the east coast, Trengganu was the most progressive during the first quarter of 1962. Altogether 30 inboard and two outboard boats were newly licensed in this State.

Prominence

In the case of new outboard boats, Penang and West Johore figured most prominently with 40 and 25 units, respectively.

In Netherlands New Guinea, fairly satisfactory fish prices and the purchasing power of the urban centres have induced local fishermen to purchase outboard motors. The price of this equipment is, as a rule, within the means of the average fisherman and the engine can be easily attached to his canoe by sawing off the stern vertically and fixing a counter by closing the sawn-off part with a 1½ in. to 2 in. board reinforced with additional ribs.

Most progress was made in the years 1957 and 1958, when the number of craft rose from a few.

	Number of vessels 1956	1957	1958
Hollandia	4	30	35
Manokwari	—	5	12
Sorong	3	6	14

This advance is probably due to the fairly favourable fishing season.

In Pakistan, progress in mechanization has been very satisfactory. The mechanized fishing fleet now consists of 195 gill-netters fitted with inboard engine and 114 fully equipped stern trawlers.

Rapid Progress

In Singapore, the mechanization of fishing boats which was most rapid during the period 1948 to 1955 has now been stabilized. Attempts are now made by the fishermen concerned to achieve more economical operation of their mechanized craft by the replacement of old worn-out engines by new ones. The boats which were converted second-hand cargo boats have now been replaced by new vessels.

The Fisheries Mobile Unit which carried out repairs on engines at the fishing villages has now extended its field of operations to include instruction on the maintenance and repair of marine diesels. A stock of spare parts is carried by this unit for sale at cost to fishermen in case of short supplies.

ENGINES

Types, Makes, Prices and Fuel

The motorization of fishing craft with various types of engines is reviewed as follows:—

The following types of engines are used in fishing craft in North Borneo: (A) *Outboard:* Seagull, Anzani, Johnson, Evinrude, Mercury, and Gale.

(B) *Inboard:* Petter, Lister, Perkins, Gardner, Yammar, Daiya, Kubota, MWM, Bukh, and G.M.

Fuel supply is ample. Prices at Jesselton ex-pump are: (*a*) petrol, $1·08 per gallon; (*b*) diesel, $0·82 per gallon.

Servicing facilities are fair. Petrol is comparatively cheap in this country, but diesel fuel is expensive. Prices of fuel oil in North Borneo, Singapore and Malaya are:—

	M$ per Im. gallon *North Borneo (Jesselton)*	*Singapore*	*Malaya (K.L.)*
Petrol	1·08	1·91	1·97
Diesel	0·82	0·57	0·71

Engines used in fishing vessels are all of the inboard diesel type. Numbers and makes of diesel engines installed in fishing vessels during the period of April 1, 1961, to March 31, 1962, are as follows:—

Trade Name	*Engines* *No.*	*Sub-Total*	*Horse-power* *Range*	*Most Popular Rating*
(A) British—				
Gardner ..	522		24–200	60–72
Kelvin ..	11		44–240	240
Lister ..	22		18– 30	18
Rushton ..	17		11– 76	13
A.E.C. ..	2		100	100
Ailsa Craig ..	5		20	20
Meadows ..	2		112–116	112
Eufield ..	1		6	6
Shanks ..	1		10	10
Cleniffer ..	1		120	120
Perkins ..	1		27	27
Petter ..	10		10– 20	10
South Iron ..	2		22– 24	22
	—	597		
(B) Japanese—				
Daiya ..	355		3– 22	7
Yanmar ..	416		3– 16	4
Kubota ..	37		4– 20	10
Komai ..	51		13– 22	13
Malsan ..	20		3½– 8	3½
Origin ..	1		6	6
Akaska ..	2		250	250
K.W.D. ..	1		6	6
	—	883		
(C) American—				
Cummins ..	9		133–189	189
Hercules ..	2		144–160	144
Caterpillar ..	2		160	160
	—	13		
(D) German—				
Doutz ..	1		70	70
Guldner ..	2		20	20
M.W.M. ..	2		22– 44	22
Farymann ..	6		6– 23	6
Bauscher ..	1		6	6
	—	12		
(E) Swedish—				
Bolinder ..	17		11– 23	23
	—	17		
(F) Danish—				
Bukh	15		10– 36	24
	—	15		
(G) Belgian—				
De-la Meuse ..	1		12	12
	—	1		
		1,538		

Some 1,497 fishing vessels were mechanized in 1961–62, of which 41 boats were fitted with two engines each. A list of engine prices based on horse-power is given below of various engines:—

Inboard (with reverse/reduction gear box)

		H.K.$
3 hp	.. ..	1,870
4 hp	.. Range varies from	2,630– 2,830
5 hp	.. ..	2,980
6 hp	.. Range varies from	3,700– 3,900
7 hp	.. ..	3,980
8 hp	.. Range varies from	4,500– 5,350
9 hp	.. ..	4,980
10 hp	.. Range varies from	5,400– 5,860
11 hp	.. ..	5,950
12 hp	.. ..	6,500– 6,800
13 hp	.. Range varies from	6,100– 6,500
16 hp	.. ..	7,940
18 hp	.. Range varies from	7,500– 7,880
20 hp	.. Range varies from	6,000– 8,380
22 hp	.. Range varies from	8,500–10,125
40– 56 hp	.. Range varies from	12,085–17,854
70– 84 hp	.. Range varies from	20,30–25,990
110–120 hp	.. Range varies from	36,000–48,715
142–150 hp	.. Range varies from	40,000–53,830
180–200 hp	.. Range varies from	47,000–66,130
240 hp	.. ..	72,150

In addition to new engines many second-hand vehicular diesel engines are employed by fishermen to mechanize their craft. The most popular second-hand engines have horse-power ranging from 60 to 70. Some of these are coupled to original vehicular type gear boxes and some to second-hand or new marine type gear boxes. Prices of such second-hand engines depend on their condition, but range from $2,500 to $3,400 for a 48 hp to 60 hp engine and from $3,800 to $4,400 for a 72 hp engine.

Supplies of diesel fuel are available in all the larger fishing ports. Fuel oil prices fall into two categories: dutiable and non-dutiable; fishing vessels with a net-dutiable. Fishing vessels with a net registered tonnage of below 60 tons pay $279 per ton for dutiable diesel fuel whereas fishing vessels with a net registered tonnage of over 60 tons may purchase non-dutiable fuel oil at $253 per ton.

Servicing facilities exist in most ports and major overhauls and minor repairs are carried out by local engineering firms.

As stated earlier, in the Federation of Malaya, the popularity of inboard diesels is now well established. Besides their installation in newly constructed craft, more and more outboard-engine-fitted boats are changing over to inboard diesels.

In the Netherlands New Guinea, inboard engines have thus far not been used by the indigenous fishermen, whom the Marine Department has forbidden the use of petrol engines in view of the risk of fire. The wooden craft placed at the disposal of the indigenous fishermen by the Sea Fisheries Division, and which are propelled by 16 hp to 18 hp Victor Vixen inboard diesel engines, are intended as a means of training the fishermen to make efficient use of mechanical propulsion and to operate these engines.

Outboard engine prices (in Dutch Florines) are: 3 hp, 900; 5½ hp, 1,475; 10 hp, 1,685; 18 hp, 2,000; 40 hp, 2,700; 50 hp, 3,300; 75 hp, 4,300.

In the urban centres fuel is no problem. Diesel oil, petrol and mixed fuel being available in litres. Outside the towns, however, these items are harder to get or not available at all.

Prices are as follows: Fuel, mixed, fls. 0·55 a litre; petrol (gasoline), fls. 0·43 a litre; diesel oil, fls. 0·33 a litre.

The different types and makes of engines used by fishing boats of Pakistan are as follows:—

Type: Marine diesel, mostly high speed both air and electric starting.

Make: Kelvin, H.S.A., Yanmar, Bukh, Ruston, North Power, Gardners, G.M. Lister, Perkins, National Superior, Caterpillar, Atlanta, Penta, Philipino, Ricado.

Price: Prices of these engines have been procured and are given below (prices exclusive of sales tax, customs duty):—

Kelvin	44 hp ..	Rs.17,000
	66 hp ..	Rs.23,500
	88 hp ..	Rs.27,000
	120 hp ..	Rs.47,000
	132 hp ..	Rs.42,500
Ruston	75 hp ..	Rs.34,500
	112 hp ..	Rs.40,000
Yanmar	55 hp ..	Rs.18,200
	60 hp ..	Rs.18,300
	75 hp ..	Rs.25,500
	90 hp ..	Rs.28,500
Gardners	75 hp ..	Rs.24,000
	114 hp ..	Rs.38,000
H.S.A.	50 hp ..	Rs.20,347
North Power ..	90 hp ..	Rs.40,098
	40 hp ..	Rs.12,210
	10 hp ..	Rs. 4,909
Bukh	20 hp ..	Rs. 6,655
	30 hp ..	Rs. 7,700

Fuel Supply

It is adequate. A diesel pump has been installed at the fish harbour pier from where fishing boats, launches and trawlers take their supply. Oil, etc., is also provided at the pump and at other fuel stations in the city.

Price of Fuel

The current price of diesel oil is Rs.1·17 per gallon. Mobil oil is sold at Rs.10·50 per tin of one gallon.

Servicing Facilities

There is no difficulty in repairs and servicing of engines as both these facilities are available in Karachi and Chittagong. There is only one dry dock in PIDC Ship Yard, hence dock/slip way facilities are inadequate because the number of mechanized vessels which need dry docking is increasing rapidly.

Indigenous Production

During the ninth session considerable interest was expressed in the possibility of assembling or even indigenous manufacture of marine engines suitable for installation in fishing craft, and the progress made in the Region with respect to this is as follows:—

There is no assembly of engines in Hong Kong but one firm manufactures small engines for marine and land use. Some of these engines are in use in local fishing vessels.

Marine engines specially meant for installation in fishing boats have been manufactured in India since 1961. This is in addition to diesel engines manufactured in the country for a long time which, though not classified as marine diesels, could be adopted for use in fishing craft. Other ancillaries such as stern bearings of metal and rubber, etc., are also produced indigenously.

Korea began producing diesel engines in 1962 but as yet the engines do not meet the standards required for marine use. Therefore it is expected that it will be necessary to continue importing marine diesel engines for several more years. In order to encourage mechanization, marine diesel engines imported for fishing boats are exempt from sales, box, import duty, and indirect tax. However, the fuel oil used in fishing boats is still subject to all customs duties and taxes.

There are 93 engine factories located around the coast towns of Korea, and semi-diesel engines are produced sufficient to supply home demand for this type engine. However, as indicated above, the government wishes to encourage the use of the diesel engine because of its lesser size and weight and lower fuel consumption.

In Pakistan, there is no indigenous production of engines. Only the parts of engines which are imported from foreign countries are assembled.

Government Assistance

Information received on various forms of Government assistance with respect to modernization of fishing craft in the Region is as follows:—

The North Borneo Credit Corporation has given loans to fishermen, at 7 per cent. annual interest; these amounted to M$16,500 in years 1959/61.

The Government of the Netherlands New Guinea renders assistance by granting credits. These credits, e.g. for the purchase of an outboard engine, fishing gear, etc., can be applied for through a special body, the so-called " Bureau for the Promotion of Indigenous Industries." The applicant is required to supply 25 per cent. of the initial cost, which measure is intended to stimulate saving.

EFFECTS OF MOTORIZATION

Extension of Fishing Grounds and Increase in Catch and Earnings

In view of the comparatively rapid development of motorized fishing fleets in the Region, a study of the effect of such motorization is very important and information received from Governments regarding this is given below:—

In Hong Kong, mechanization has had the effect of extending the radius of activity of fishing vessels. Mechanized deep sea trawlers now fish at a depth of from 50 to 60 fathoms at a range of approximately 240 nautical miles

Whereas the activities of sailing small longliners are normally confined to Hong Kong waters, mechanized vessels of this type now venture in fine weather as far as 60 to 70 nautical miles away from Hong Kong. Catches have also been improved by mechanization and a comparison between landings of mechanized and sailing vessels is given here:—

	Company trawlers	*Traditional type junks*	*Foreign vessels*	*Sailing junks*
April 1, 1961, to Mar. 31, 1962	95,173 pic. 10·46%	589,306 pic. 64·75%	16,829 pic. 1·85%	208,806 pic. 22·94%

16·8 pic. = 1 English ton.
1 English ton = 0·9072 metric ton.

Although mechanized vessels comprise less than half the fishing fleet, they land over 75 per cent. of the total quantity sold through the Fish Marketing Organization wholesale markets.

In general, earnings of fishermen employed on mechanized fishing vessels are considerably better than those of fishermen employed on sailing vessels. The following table gives a comparison:—

	Motorized vessels		*Sailing vessels*	
	Monthly wages	*Bonus*	*Wages*	*Bonus*
	$	$	$	$
Trawler fishermen ..	110	100	40	60
Longliner fishermen ..	15	240	15	110
Shrimp trawler fishermen	100	70	No Hired worker	
Purse seiner fishermen ..	30	50	,, ,, ,,	

Because of the fleet expansion in recent years, there is a good demand for labour in the industry. There is a shortage of crews for longliners, and shrimp trawlers now find that crews are reluctant to be engaged unless the vessels possess power handled gear.

In Pakistan, there has been considerable extension in the range of operation of the mechanized fishing crafts as a result of which new fish and shrimp grounds were discovered. The range of operation of mechanized crafts is about 300 nautical miles from Karachi up to the border of Iran. As regards the shore fishing the trawlers and mechanized launches are making successful attempts to extend their fishing operations even beyond 20 fathoms.

It has been observed that as a result of mechanization of the West Pakistan fishing fleet the catch increased with an average annual rate of 2·9 thousand tons.

Year	*Production in tons in West Pakistan*
1957	83,000
1958	84,000
1959	94,000
1960	100,500
1961	102,500

During the last three or four years, fishermen's earnings have almost doubled. Four or five years ago the fishermen's average monthly income was Rs.60 to Rs.70 while now the earnings range from Rs.120 to Rs.150. Captains and mates employed on trawlers are paid a monthly salary of Rs.350 to Rs.450. Apart from this, the crew get free food during the period they are out fishing.

Fishermen definitely now have better opportunities of employment in the fishing industry.

The Marine engine and effects of climate

PROBLEMS OF SERVICING IN LESS DEVELOPED COUNTRIES

L. STENSTROM

VAST sums of money have been wasted in many developing countries during the past fifteen years because those who bought marine engines and equipment did not heed advice available on how to get the best use out of them. Others paid attention to some of the technical counsel that was received but overlooked, or were ignorant of other factors that contribute to the success of mechanization.

All marine engines require a certain amount of care, maintenance and repairs regardless of whether they are being used in a developing country or in an area that has been mechanized for decades.

Technically, there is little difference in servicing a machine in hot or cool climates; working conditions can be adverse in both. However, heat makes servicing more difficult and the need for attention more frequent in tropical areas.

Machinery in developing countries has nothing like the working life that should be obtained. Often an engine becomes too worn before half its expected life is ended.

As most developing countries import marine engines and are short of foreign currencies, it is of national economic interest to get the longest possible life from them.

Mechanization is one means of increasing production, and the machines certainly have the potential to do so, but they must be cared for. Unfortunately, this seldom happens. Short-lived and unreliable engines are due to the fact that governments overlook the need for trained men and replacement parts. Planners and legislators must come to realise this situation.

User's Responsibilities

This paper will be limited to the servicing of marine engines but in a wide sense. When analysing the matter of servicing it becomes clear that it is necessary to consider the three parties who are concerned with servicing, and the functions of each. These parties are:

(*a*) The user.
(*b*) The engine distributor.
(*c*) The government.

All tools and machines used at sea require some form of care. In the developing countries the fishermen know well how to manipulate their sail and rowboats and to do as efficient a job with them as the design permits.

The operator often has difficulty in grasping the capacity of the engine. It takes time and training to make him constantly careful in operating and looking after something that is so totally different from what he has ever handled. Frequently it is not carelessness on his part—it is ignorance, which can only be overcome by training.

The user must always be prepared to follow the service routine stipulated by the manufacturer, and should keep a small stock of replacement parts; those recommended for the purpose are often indicated by manufacturers. The user must know his engine to be able to do the servicing on it and, above all, be able to use it properly. Only fishermen who are genuinely interested in mechanization should operate machinery.

What, then is, the user's part in this division of responsibilities within a nation, to obtain the best use of an engine through proper service?

Selection of Equipment

First, the user is the one who selects the make and model. There is a saying that no equipment is better than the service given to it. This stresses the important point that a fisherman should buy only from a dealer who can give good service.

The user is often a government department or organization, and they should bear the same points in mind. Comparatively unknown makes of engines with poor or no local service facilities will perhaps cost considerably less initially, but when spare parts are not available or there are no properly trained mechanics, the original saving in price can be more than offset by poorly made repairs or engines standing idle due to lack of parts.

Proper Use

Once the engine is delivered, the owner's responsibility to himself and the nation is to use it properly. Above all, he must have enough understanding of what the engine can endure. Fast driving is, for most operations, harmful to the equipment.

Manufacturers could profitably spend more time and money on finding out what would be suitable in various countries.

Preventive Maintenance

Preventive maintenance of engines is as important as preventive medical care of human beings: they ensure that matters do not become so bad that expensive repairs are needed.

Preventive maintenance is divided into three main parts: (1) daily (or more frequent) greasing and lubrication according to instructions issued by the manufacturer; (2) frequent inspection of wearing and other parts to discover faults before damage occurs; (3) periodical and seasonal routine inspection during which the components of the machine are checked for wear and looseness, and the necessary adjustments made.

Each individual's responsibilities should be clearly laid down, supervised and carried out. Generally, the operator should be responsible for daily lubrication and for frequent checks on the condition of the machine. He should be obliged to record hours of work and services given to it. In the case of illiterate operators, this duty should be undertaken by a supervisor.

Record-keeping of this kind is essential in any maintenance scheme. Guess work leads to haphazard care; it is either too frequent, making it unnecessarily costly, or insufficient, causing higher repair bills. The importance of a periodical check by the dealer should be stressed by extension services, and others, to fishermen first to acquire powered equipment. Preventive maintenance of marine engines is undoubtedly a matter that needs much more attention and perfecting than it gets in many countries.

Repair Facilities

Some repairs are very simple and can easily be done on board; others require more complicated shop equipment which is too expensive to buy for a fishing vessel.

Major overhauls and any time-consuming repairs should be done during the slack season when speed is not important in getting them working again. With a proper preventive maintenance scheme, major repairs can be foreseen. On large projects, far from dealers' premises, users might find it more economical, convenient and safe to have their own workshops.

To strike a balance between investment in repair facilities and security of field operation is not easy. In recent years more and more dealers have established a system of unit replacements—complete engines, gear boxes, diesel pumps, injectors, etc. This enables a fisherman to replace a defective assembly of parts quickly, and with an assurance that it is in proper working condition. The system requires reasonably good communication with the supplier, but it is quicker and more satisfactory than to send the machine to the dealer, or have him come to the boat to do the job, and perhaps have to return to his base for special tools.

Pride in Machinery

This may sound like the idealism of a machinery enthusiast—such as the young man who has just acquired his first sports car. What is meant is that the owner, the user, the operator of a machine would be made to feel that his machine is a thing of which to be proud, something capable of a fine performance, if cared for.

It is a good policy for the owner to let the operator have time to keep his machine clean and make small adjustments, because a well maintained machine is always treated more carefully than one which is dirty and has loose parts tied up with wire or twine. It is also far easier for a supervisor to check its condition when clean.

Distributor's Responsibilities

The distributor occupies an important position in the marine engine service field. He is obliged by the manufacturer he represents to give customers certain services—sales, delivery, and after-sales.

The manufacturers, for their part, give distributors training on their products, a training that should include information on proper use, capacity, operation and maintenance of the engine. All this is costly and a certain number of engines have to be sold before introductory costs are recuperated. It cannot be said, however, that all manufacturers build solid foundation for the introduction of their products.

Sales Service

One of the difficulties distributors face in the majority of developing countries is the small volume of sales. It is hardly economic for a distributor to handle marine engines only. At the best it becomes merely one of the other lines for which he is an accredited agent.

He might be dealing in cars, trucks, radios and other goods and his representatives have to sell several lines. Frequently the training of these salesmen is not adequate enough to give fishermen proper service.

A fisherman, wherever he lives, requires a certain amount of technical information and, above all, information on the work and capabilities of the particular type of machine he buys. This is most important in developing countries because their fishermen probably have no experience at all of what an engine can do under the conditions found locally.

The salesman, ideally, should demonstrate an engine in a boat to give a purchaser the opportunity of making an appropriate judgment as to the value of the particular engine. This is, unfortunately, a rare occurrence.

The man demonstrating machines should be fully qualified to operate them and to describe the various functions, controls and other matters connected with the machine. A workshop mechanic is not necessarily acquainted with the field operation requirements of a machine, albeit he is highly competent to repair it.

The object of sales service is to promote sales, and this is best handled, as a long-term approach to business, by giving honest guidance to the fisherman.

Delivery Service

This includes the preparation of the machine to be ready for service by the dealer, and instructing the operator so that he is capable of handling it correctly.

This is a good system and a fair service, but if the operator is totally inexperienced, even three to four days is far from sufficient. Should that be the position, the owner should see to it that his operator has received some basic training at an organised course. The basic training should give the operator sufficient knowledge to do a good job with such machines and explain routine care and maintenance, while the dealer gives the required instructions on the specific make and model he handles.

This involves a great many things but can, in short, be termed the service the user is supposed to receive from the dealer to help him out of all troubles encountered with the machines. First thing is the dealer's obligation to maintain an adequate stock of spare parts, and a workshop with specialist mechanics. Unfortunately, this is the most common field for complaint.

The spare parts problem could be solved by dealers carrying greater stocks than are considered necessary in highly mechanized countries. This, of course, requires more capital to be invested and, frequently, more liberal government licensing for foreign currency. An increased capital outlay necessitates higher prices for the spares, at least on parts for which there is very little demand, but which should be stocked.

Fishermen everywhere nowadays give foremost importance to the spare parts supply when choosing between two or more machines of equal merit. They have learned the hard way, what it means to have an expensive machine out of action because spares are not available.

With the low number of marine engines in developing countries, it seems that a streamlining of repair services by using the replacement unit system could be achieved. Most serious breakdowns occur on hydraulic and electric systems. The components for these require skilled mechanics for their repair. Men of this class are scarce and should be concentrated in places where the biggest volume of work is done and where it pays to have specialised shop equipment to recondition components such as diesel pumps and injectors.

General Servicing Problems

Too often the distributor regards the sales of powered marine engines as he does that of motor trucks. He is not sufficiently aware of the special requirements needed for servicing marine machinery. The serious western manufacturer, keen to increase his exports, is nowadays paying a good deal of attention to this point. He organises training courses for his distributors at which this matter is dealt with, and is prepared to take little or no profit during an introductory period, hoping to recuperate in the future.

The distributor, however, is generally satisfied with low-volume, high-priced sales and is hard to convince that more capital should be invested in shops, spares and training. But understanding will undoubtedly come to him with time.

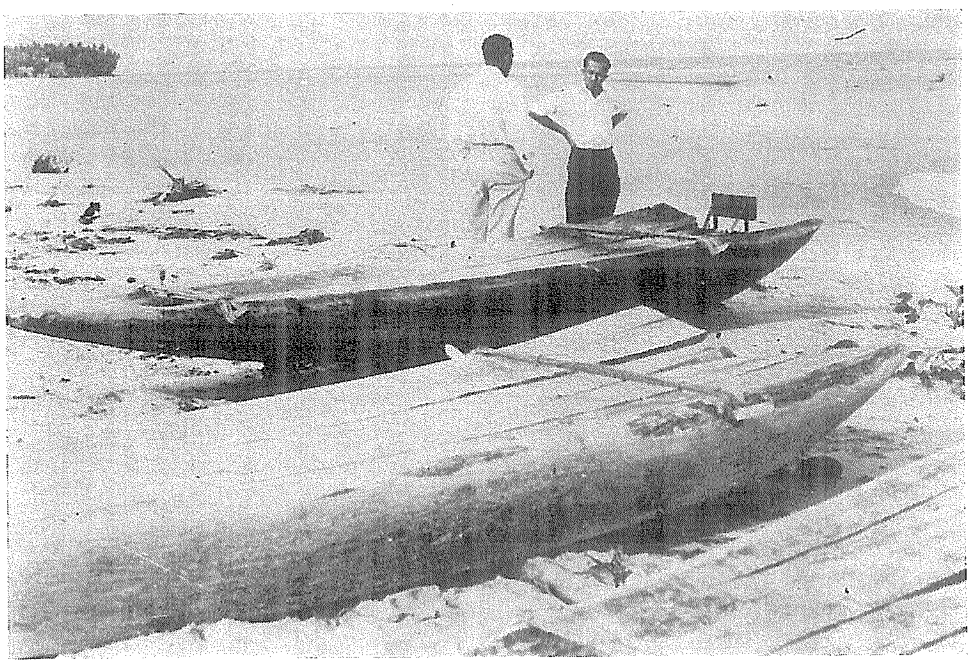
A manufacturer who wants to enter a market often faces the problem of finding anyone suitable to appoint as an accredited distributor. The number of businessmen in developing countries with sufficient economic stability is limited. To find an agent who at the same time has an interest in something so hard to sell as marine engines is even more difficult.

Unfortunately this scarcity of reputable businessmen results in little competition, even further reducing the chances of obtaining good, established repair facilities. In the more mechanized countries competition has forced marine engine dealers to develop good services. It will take time before this happens in developing countries.

Many manufacturers are trying to overcome the lack of specialised workshops and field mechanics by training master-mechanics at schools run by the manufacturer in his home country. This, naturally, can be done only on a limited scale. Training of workshop mechanics can be done satisfactorily at such schools, but the training of field mechanics or field operator instructors can scarcely be completed in a place where the type of fishing is very different from that in the students' home countries. It has also been recognised that technician level training is best done in an environment, social and technical, that is nearest to that with which the student is familiar.

Government Responsibilities

In some western countries, training of technical staff, specialized in certain branches, is considered a matter for industry to look after. In other countries, probably the



OUTBOARD STERN BRACKETS are the subject of discussion between these two officials of the Ceylonese fishing industry. They are concentrating on the relative ease by which teppams, the traditional fishing craft of Ceylon, can be mechanized through the installation of a simple wood and iron bracket.

majority, the community takes care of the basic vocational training, and industry completes the work by organizing schools in which men with a basic mechanic's training can become specialists. In developing countries the industry has very little to offer in this respect and it remains for the government to take the initiative and bear the cost of both the basic vocational and specialist training.

At the beginning of FAO's technical assistance work, governments paid little attention to the advice that mechanization programmes should start by training the staff needed in all sectors and at all levels, but nowadays this is generally better understood.

From the particular government department's point of view, when setting up training programmes, an important matter that must be first considered is the availability of leaders—university trained marine engineers who can be the planners, organizers, heads of schools, and programme inspectors. The number of men of this calibre required is not large, but some countries have none at all, or too few, to undertake these and other equally urgent tasks in development programmes. The training of instructors, foremen, supervisors, operators, field and shop mechanics, all of whom will be needed in a country that wishes to mechanize its fishing fleets successfully, needs careful consideration.

Extension

Very few developing countries have as yet any marine engineering advisory or extension service, as is common in the western world. Although most countries have an organized extension department, hardly any have a marine engineer on the staff. Such a specialist, only one for each country, could do a great deal of useful work by organizing demonstrations and short training courses, initiating and assisting in setting up joint use of machinery, and helping the government to plan for the improvement of its mechanization schemes in the various ways previously discussed in this paper.

The distributors and dealers usually have no other contact with the government than on the financial side. The marine engine adviser should be the government's technical expert to comment on the justification for licences. In countries where there is good contact between the government and dealers, the dealers have their own trade association with which the adviser can deal, discussing the various problems, complaints and matters of general concern. This is more satisfactory than the adviser doing so with individual firms.

Government Actions to Improve Servicing

The best method is possibly to limit, at least for a number of years, the number of makes of engines to be imported. A distinction should be made, however, between engines requiring skilled mechanics for servicing and precision machined spare parts, and those needing only simple spare parts, which can mostly be made in the country, and semi-skilled personnel suffice for servicing.

In calculating the stock of spare parts for a specific project the advice of the manufacturers should be sought. Their spare parts departments usually have experience of all kinds of operational conditions.

Other ways and means available to government authorities to concentrate machinery, both in regard to area and makes, is to encourage systems of joint use and by making mechanization an integrated part of settlement schemes in which training, supervision and servicing can be well organized.

Joint-use schemes, introduced in selected localities or villages, allow for concentration of service facilities, equipment and manpower, and greatly overcome the obstacles of poor communications.

Governments or regional communities should assist and encourage mechanics to start suitable enterprises. It may be difficult to interest trained mechanics to settle in a remote village, and the authorities may have to give extra incentives in order to get the right people to start on their own. One such incentive scheme is that in which trained, progressive mechanics are offered the opportunity of setting up a shop on a government loan for which repayment will not be required until the end of the second year, thereby giving time for the business to grow.

Hire Pool

A government pool or hire service operating, perhaps, hundreds of machines, needs a workshop for its own machinery, but the equipment in the workshop should be kept to the minimum. Jobs requiring specialists for diesel pump repairs and testing, crankshaft grinding, and the like, should be undertaken by commercial shops, if available.

This is for two reasons: First, that such specialists are rare, equipment is expensive and a shop for these jobs requires a continuous supply of work to be economical; second, is that the government should encourage private firms to undertake such work for the public. A government specialist workshop will limit the number of jobs for commercial shops, forcing them to increase the rates to their remaining customers. This is a serious problem in many countries where mechanization is just starting, mainly because government hire services often try to be self-sufficient in every way and thereby discourage private enterprise, which invariably is more efficient than a state-run workshop.

It has not been possible to introduce mechanization in the developing countries without state aid. Abundant labour, scarcity of capital, small output and low product prices have not given fishermen the incentive to mechanize.

Modernizing

Governments, who have wanted to encourage the introduction of powered machinery and have tried to do so by organizing and operating hire services, have disrupted parts of the ordinary commercial channels and this has resulted in diminishing the service facilities and healthy competition.

In countries where the incentive for the individual fisherman to mechanize is small, the government must assist him to modernize. The methods applied in the past have, however, not always been of the best. A long-term government policy will give quicker and better results in the end.

Some parameters for plotting fishing craft power

JAN-OLOF TRAUNG

THERE is an unconscious trend to standardize the design of fishing vessels—at least in the same country or region at the same time. Although a fishing fleet assembled in a port might look diversified, it is perhaps not always realized that boats built the same year are normally only a few classes, and within each class the main dimensions, as well as the relations between those dimensions, are almost equal. Fishing boats generally increase in size with time, but the variation, say, in horse power or gross tonnage between boats being built for a certain fishery for a certain year, is normally less than 10 per cent.

The owner might be particularly interested in having a fishing boat built of a certain length which he associates with size, but he might not realize that at the same time he is getting a ship with a beam and a draft of a certain relation to this length. This beam and draft are not only selected so as to produce the greatest possible hull for the material and labour invested, and thereby justify the cost, but also in order to give the boat the highest efficiency so far as speed and sea-kindliness are concerned, and to maintain sufficient stability.

Fineness

In order to obtain a certain speed, ships have to have a certain fineness, and as trawlers of the same class cover the same distances to the grounds, the fineness is the same which, in effect, gives a definite relation between the block formed by length, beam and depth to the tonnage of the vessel.

Length has been used as a parameter to relate to fishing power, and has shown, in some instances, very likely possibilities. It is quite possible that beam, depth or draft could have been used equally well. As a matter of fact, the height of the mast is often in a certain relation to the size of the vessel due to purely aesthetic reasons, and it would not be surprising if it could not be used for plotting the fishing power.

Length

The length of a boat can be, and is, measured in a considerable number of ways. The measurements are made either in the foot or in the metric system. When foot measurements are given, it should be remembered that some national systems, such as the Swedish and Danish, are different from the British (1 British foot = 305 mm.; 1 Danish foot = 314 mm.; and 1 Swedish foot = 297 mm.). The following are some typical measurements of ships' length used:

(a) *Length Overall* (LOA): This is normally the length from the furthermost part of the ship to the aftermost part, measurement on top of the bulwarks. It could also be the length " between rabbets " or in main deck. If the ship has extremely raked stem and cruiser stern, this measurement might be quite misleading when compared with another ship having plump line stem and a transom stern.

(b) *Length between Perpendiculars* (Lpp): This is normally used when determining numerals for the scantlings required by a classification society. Lloyd's Register's Trawling Rules measures the Lpp from the centre of the rudder shaft to the point where the main deck meets the stem profile. Lloyd's Register's General Ships Rules measure it from the centre of the rudder shaft to the stem at the load water line, which is shorter than the Trawler Rules.

The French Bureau Veritas measures the Lpp from the fore-side of the stem to the axis of the rudder post at the load water line or the overall length less 12·5 per cent. if that is longer. The Norwegian Veritas measures it on the summer load water line from the aft part of the rudder post to the far part of the stem. The Swedish Fishing Boat Rules generally measure it on a draft being one-seventh of the depth from the main deck from the foremost point of the stem to the centre of the rudder shaft.

The German Lloyd's Rules for Wooden Decked Sea Fishing Vessels measure at the load water line between the centre of the rudder shaft to the rabbet line of the stem. The Danish rules measure it at the height of the deck from the aft side of the stem to the centre of the rudder shaft. The variations are not large, but can amount to ± 3 per cent.

(*c*) *Length in the Water Line* (L or LWL): This is normally measured on the designer's water line. The designer might want this to represent either a condition with the ship ready to go to sea, that is with full bunkers and ice, or a ship fully loaded coming home with reduced bunkers and ice. In some instances the design water line is a mean of either the light or the loaded water line. The design water line is not always obtained in practice. Ships do weigh more or less than estimated. During construction, more equipment is sometimes added. It should not be granted that the design water line length is representative for the actual ship.

(*d*) *Length in the Keel.* This was a measurement much used in olden times, and is still being used in many countries by builders to determine cost and proportions of beam, draft, etc. It might be considerably shorter than LOA or Lpp.

(*e*) *Length Registered.* For administrative purposes, and for determining the gross and net tonnage of vessels, the registered length is normally given in certificates. This is sometimes taken under the deck from the aft side of the stem to the fore side of the stern post. The rudder shaft is oftentimes used as aft measurement. The difference can be 8 per cent.

Human Reason

This length is naturally quite difficult to take when the boat is complete with bulkheads, accommodation and mast, and it has been observed that the registered length can be up to 1 per cent. longer than the actual length which could be obtained from the drawings or mould loft. The reason is quite a human one, as the man in charge has to add up a number of small lengths and it is difficult to determine the endings.

It might be surprising that there are so many different ways of measuring the length of a fishing craft, but it should also be remembered that even if any one length is selected for comparative purposes, two boats so measured might be of quite different sizes. A boat with transom stern, having the same Lpp length from, say, the centre of the rudder shaft to the point where the main deck meets the stem according to the British trawler rules, might be the larger ship when compared with the same type of boat having the same essential shape but a cruiser stern.

Tonnage

Tonnage measurements are either made for weight of the ship plus load (displacement in British tons or metric tons, 1 British ton = 1·016 metric tons) or for inside volume (1 register ton = 100 cu. ft. = 2·83 cu. m.).

Light Displacement. This normally represents the boat ready to go to sea with fuel, ice, provisions and crew, expressed as the volume in cubic metres or cubic feet of the displaced water, or in weight expressed in metric or British tons.

Load Displacement. This is full load of fish and ice and with a certain part of the bunker and provisions consumed.

Design Displacement. To the L.

Dead Weight. This is the difference between load and light displacement. For a cargo ship it means the weight of bunkers, provisions, etc., and the cargo itself.

Gross Register Tonnage represents the total measured cubic content of all permanently closed spaces with minor exceptions (1 register ton = 100 cu. ft. = 2·83 cu. m.).

Net Register Tonnage is gross tonnage minus some "non-earning" spaces, for example, the spaces for machinery and for accommodation of the crew.

If tonnage measurements are to be used for the measurement of the size of fishing vessels, the gross tonnage seems to be the most representative. However, with the use of "open" whale backs, "open" shelter decks and other superstructures, designed so as not to be included in the measurements, in some fishing vessels of 100 ft. and larger and in particular with stern trawlers, gross tonnage measurements presently permitting such exclusions might be misleading.

Power

The power of trawlers in a certain fleet of fishing vessels does not normally vary much, although there is a distinct tendency to increase the power in relation to the size and to an "inflation" in the rating of engines. The 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 lb. 1 ft. 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:

(*a*) *Shaft horse power* (SHP) 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.

(*b*) *Indicated horse power* (IHP) 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 (SHP) because of the losses in the engine and in any bearings, thrust blocks or transmission gear that there might be between the engine and the propulsion shafting.

(c) *Brake horse power* (BHP), usually applied to diesels, denotes the power delivered at the engine coupling. It is greater than the shaft horse power (SHP) 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* (*EHP*), which is the power that would be required to tow the vessel, and the *delivered horse power* (*DHP*), is the 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, of a steam and diesel engine with the same brake horse power and r.p.m., the horse powers of the steam engine are " stronger."

Nominal Horse Power

Diesel engines 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 brake horse power. Today there are the following three main methods of rating marine diesels:

(a) *British Rating*. The output stated in accordance with British Standard Specification—649/1949—does not, as much, show the power reserve of the engine, but stipulates allowed increase and decrease of rated load (increase 10 per cent. for one hour output; decrease 10 per cent. for continuous 24 hour running). In addition to the *intermittent* (one-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 h.p. had an automotive output of 40 h.p., a 38·5 h.p. one-hour output, and a 32 h.p. 24-hour output.

(b) *U.S. Rating*. Commercial Standard, CS 102 E–42, of the National Bureau of Standards, Washington D.C., uses ratings for the *peak*, *intermittent* and *continuous* output. The peak horse power is to serve as a guide only as to the surplus power available in the engine as stipulated by the manufacturer. 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 h.p. engine discussed under (1) was rated by the manufacturer to have a peak output of 47 h.p., an intermittent output of 40 h.p. and a continuous output of 32 h.p.

(c) *German Rating*. The 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 15 minutes without occurrence or mechanical or thermal stresses. By comparing the peak output with the continuous output, the power margin of the engine is determined. One-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 h.p. engine previously discussed will, according to this rating, have a peak output of 45 h.p., a continuous output of 32 h.p. and a long-time rating with intermittent increased loading of 40 h.p., and without intermittent increased loading of 38 h.p.

Maximum Power

In the example where the manufacturer made the ratings the continuous h.p. for any of the systems was 32 h.p., but the peak h.p. according to the U.S. rating was 47 h.p. or 47 per cent. greater.

If the " nominal " horse power of a number of trawlers is compared according to the same rating, we must remember that this horse power is for the maximum r.p.m. recommended by the manufacturer, and that many trawler owners do not normally intend to use it.

Often trawler owners " de-rate " the engines to permit longer lifetime, decreased maintenance costs, etc. Hepton (1955) (*Fishing Boats of the World*, P. 391) suggests a 700 h.p. engine for middle water and Faroe craft when the engine will develop 600 h.p. during trawling and 500 h.p. steaming. There has also naturally to be a certain power reserve for rough weather. Möckel (1955) (*Fishing Boats of the World*, p. 328) measured the increase in engine output due to head winds when trawling at 3 knots from 410 h.p. in calm water to 770 h.p. in a wind force of Beaufort 7·5.

The actually produced brake horse power during trawling or steaming can be determined from readings of the fuel consumption, exhaust gas temperature, the position of the fuel pumps and the r.p.m., if one has at hand curves from a thorough testing of the engine by the manufacturer. A still more exact and precise way of determining the brake horse power is to have a torque metre on the propeller shaft with the help of which one can determine the twist of the shaft and then with the help of the r.p.m. determine the actual horse power.

Trawl Resistance

Unfortunately, the B.H.P.—even if properly determined—is not sufficient to determine the actual thrust developed at a certain speed in order to overcome the resistance of the trawl. The r.p.m. of the propeller influence, to a high degree, the efficiency of the propeller. It can well be that a 200 r.p.m. propeller has an efficiency of 60 per cent. and a 300 r.p.m. propeller only 50 per cent. That means that a ship with the faster turning propeller must have a propulsion engine with 20 per cent. more B.H.P. and naturally comparatively higher fuel consumption. There are further influences such as the relative efficiency of the hull shape, whether it has a good or bad water flow to the propeller, and whether the additional resistance due to hull shape or to size of superstructure in head winds is reasonable or not.

An illustration of the difficulty of using the " nominal " horse power of a trawler as a criterion for its fishing power might be illustrated by the experience of the author from a fishing trip with the Swedish fishing vessel *Lagafors* in September, 1956. The vessel had a 495 B.H.P. engine running at 375 r.p.m. Careful measurements of the speed and of the output of the engine were taken during most of the 37 hauls. The skipper normally used 250 to 330 h.p. of his engine when trawling because he did not want to " overload " it. The r.p.m. varied between 275 and 355. The speed of the ship itself varied also considerably, due to head or tail winds, and speeds from 2·4 to 3·8 knots were recorded.

In view of the different ways of rating engines and the fact that not even the " nominal " horse power is always used, it is felt that power particulars are very dangerous to use when comparing the fishing power of fishing vessels.

Fishing Power

Fishing power of trawlers naturally depends on the " area swept " by the gear, which in a way is proportional to its " gape," and to the speed of towing. A still better definition might be the amount of water screened by the trawl. This amount of water is probably not only a factor of gape and speed. After a ship we have a wake. That means that if a fishing vessel is steaming at 10 knots, the actual speed of the water at the place of the propeller might only be 7½ knots and the propeller must be designed for this speed and not for 10 knots.

Similarly if a trawl is towed at 3 knots, the speed of the water inside the trawl and perhaps also in front of it is reduced, due to the resistance of the webbing. A small-mesh trawl has, therefore, less inside speed and less screening capacity than a large-mesh trawl, with the effect, not only that less fish can be separated from the area swept, but that strong and fast swimmers might have greater opportunities of escape due to the slower inside speed.

When considering the amount of screened water as a criterion of fishing power, it is evident that a large trawl trawled at a low speed might have the same screening capacity as a small trawl with the same mesh towed at high speed. Still, the small trawl might have higher fishing power, due to the fact that larger fish cannot escape.

It is well known that the power needed to increase the speed of a ship is far from proportional to the increase in speed. In the same way, the resistance of trawls increases more than proportionately. A certain trawl required at 1 knot an output of the engine of 18 h.p.; at 2 knots, 44 h.p.; at 3 knots, 78 h.p., and at 4 knots, 116 h.p. The necessary horse power was not only due to the resistance of the trawl net as such, but to the shape of the gear—that is, the type of ground rope and the resistance of the trawl doors and lifting equipment for the head rope. Here the naval architect sees great difference in the trawling equipment.

When trawling, there is a balance between the thrust developed by the engine and the resistance of the hull, due to the weather and because of the trawl gear. If the resistance of any of these factors changes, a new balance is obtained at another speed. This speed determines to a great extent the screening capacity of the net and thereby the fishing power. Thrust aims is not sufficient as a parameter for plotting the fishing power. In order to have the work defined, speed must be introduced.

The thrust can either be determined by a thrust metre built into the thrust block of the engine or by using dynamometers on the trawl wires. This latter is the most practical and the least expensive. It might, however, certainly be difficult to request trawler skippers to measure the thrust to provide figures for statistical analysis. In this connection, it might be mentioned that the propeller itself can in a way be used as an indicator of the thrust delivered.

There is available today quite comprehensive information about the characteristics of different types of propellers and if the ship's particulars could be completed with data about the propeller diameter, pitch and number of blades, and one could obtain from the skipper for each haul information of the actual r.p.m. with which he has been running his propeller, and an estimation of the trawling speed, it might be possible to estimate the thrust actually developed.

For a naval architect, the most important characteristics of fishing boats for different fishing methods seem to be:

(*a*) *Trawlers*. Thrust developed during trawling, which is determined by engine, horse power and r.p.m. A certain engine requires then a certain size of ship.

(*b*) *Purse seiners*. Sufficient deck space for the net and sufficient accommodation for the comparatively large crew.

(*c*) *Long-liners*. Number of hooks which can be handled per hour, and range of operation.

(*d*) *Drift-netters*. Cargo capacity and number of nets which can be handled on the vessel.

* Amended version of a paper which appeared as Appendix II to a paper entitled " The measurement and analysis of fishing operations—a review " prepared by FAO Fisheries Division Biology Branch, in collaboration with Jan-Olof Traung and John Gulland and submitted as paper No. E.1 to the Joint Scientific Meeting of ICNAF, ICES and FAO, Lisbon, 27th May – 3rd June, 1957.

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