craft of traditional construction – including glass fibre – in exactly similar circumstances. Thirdly, we wished to gain firm first hand experience of the material in use, knowing that our chances of selling craft made of Seacrete would depend entirely on our ability to put before potential buyers irrefutable evidence of its properties.

Our first season with the Seacrete cruisers out on hire satisfied us that Seacrete was everything that we had hoped it would be and more followed into our holiday fleet. The boats had a tough time during those early years. One was rammed by a two ton yacht travelling at around 5 knots. Another was struck amidships by a 3 1/2 ton sloop travelling at around 10 1/2 knots. A third suffered an explosion which blew the cabin top 50 feet into the air and the mast 200 yards, while during the winter of 1962/3 two cruisers were locked in 18 inches of ice for over two months.

Whilst at the time we did not enjoy seeing our boats subjected to this sort of thing, we were delighted with the evidence the mishaps they suffered produced. The ice-bound boats suffered no damage at all; while those subjected to ramming and the explosion incurred damage so minor in character, compared with what would have happened to them had they been made of any other material, that the merits of Seacrete were proved beyond all doubt.

It is not by accident that the facts obtained during those early years, coupled with a straightforward statement of the physical properties of Seacrete as established by independent laboratories, still forms the basis of our sales literature today.

A major breakthrough was obtaining the approval of Lloyds Register of Shipping – after two years of tests – and the building of a cruiser classed 100 A.1. by Lloyds. In January 1967 Lloyds produced their own rules for ferro-cement craft, thus giving the material international recognition. Seacrete is now also approved by Bureau Veritas, is accepted for grants by the United Kingdom White Fish Authority and is approved by the Food and Agricultural Organisation of the World Health Organisation in Rome.

In the light of experience gained in building over 150 ferrocement hulls I make the contention that ferrocement – of which Seacrete is a specialised form – is the logical material from which to build fishing and commercial craft, for the following main reasons:

1. *Monolithic Structure.*

   The ability to build hull, decks, bulkheads, floors, and engine bearers, fish tanks and bulwarks in one piece, resulting in a monolithic structure of immense strength which actually increases in strength with age.

   This is only possible in ferrocement.

   Photograph A shows a 46-ft. trawler with all those items listed built in one piece in Seacrete.

2. *Ease of Construction.*

   Ferrocement craft can be built without highly skilled labour. This is not so in the case of timber or steel. No expensive plant is necessary, which is the case with steel construction and to a lesser extent with timber construction.

   It is not necessary to use a mould for ferrocement construction, as in the case of building in glassfibre, and no temperature controlled shop is necessary.

   The process and technique lends itself readily to "one off" construction and also to local manufacture in less sophisticated countries.

3. *Raw Materials.*

   The raw materials necessary for ferrocement construction (with the exception of the steel mesh) are cheap and usually readily available in most countries. There is a dearth today of good quality seasoned boatbuilding quality timber almost everywhere. Many countries are without steel plants. The materials for glassfibre construction are relatively expensive and sometimes require special storage facilities.

4. *Initial Cost.*

   Much misleading data has been published, usually by amateurs, on the low cost of manufacturing ferrocement hulls. There is a vast gulf between an amateur building a boat for himself and a commercial manufacturer building and guaranteeing his product. Generalisations are always dangerous but a ferro-cement hull may be expected to cost 20 to 25 per cent less than a similar hull in timber or steel, but this is only half the story. The engine, sterngear equipment and superstructure, of course, will cost the same.

Over-all saving may not be more than 4 to 7 per cent, but this is great because you also get a better boat.

To give an indication: the materials and man hours to construct the 46-ft. trawler in photograph A, including hull, floors, engine bearers, bulkheads, fish tanks, decks and bulwarks were as follows:

Materials U.K. prices, cost £545

Man hours, 2752

Figures for the 30-ft. boat hull in photograph B were as follows:—

Materials, U.K. prices, cost £191

Average man hours, 1051

5. *Maintenance.*

Unlike steel, ferrocement is immune to rust and corrosion. Unlike timber it will not rot and is immune to marine borers. Unlike glassfibre, ferrocement has proven ageing qualities. Ferrocement does not require painting except to enhance appearance.

6. *Strength.*

The ultimate tensile strength of Seacrete is 5340 psi, and because a mesh reinforcement is used it will have this tensile strength in all directions. The tensile strength of wood is approximately 4000/10,000 psi along the grain and negligible across the grain. The tensile strength of a wooden hull is also diminished considerably by the fastenings and the fact that the grain often runs out. In ferrocement hulls there are no fastenings and the tensile strength is accordingly uniform.

Compressive strength of the material without reinforcement is about 7200 psi after 7 days, and 12,225 psi after 28 days, and continues to increase with age far in excess of wood.

Any fishing vessel must be strong enough to withstand rough treatment in harbour, where it will inevitably be subjected to buffeting by and rubbing against neighbouring craft or the quayside.

Seacrete craft being used off the beach in Kenya have demonstrated the material's enormous resistance to abrasion. This would appear to be the great weakness of glass fibre.

7. *Weight.*

The specific gravity of the ferrocement is 2.6, that of glass reinforced plastic 1.6, and that of a wooden hull, including fastenings, 0.9. Whilst in craft of less than approximately 40-ft. length over-all, a ferrocement hull with a 7/8 inch skin is generally heavier than a hull built in other materials. In the case of craft over 40-ft. over-all, when skin thickness of other materials must be increased, a Seacrete hull compares favourably in over-all weight with most wooden, glass reinforced plastic and steel hulls, particularly because no heavy internal frames are required.

Photograph B shows a 30-ft. Seacrete hull with a beam of 13 ft. with engine installed, as supplied to Kenya for completion locally into a shrimp trawler. Notice that the hull maintains shape without cross bracing.

Due to the built-in framing and inherent strength of the material, it is quite possible to obtain 11 per cent more useable space than in a similar sized craft with a hull constructed in some other material.

8. *Ease of Repair.*

Another advantage over other forms of hull material is ease of repair. Should a hull be damaged in a collision it can be repaired, in any climatic conditions except below freezing, in much less time and with less tools than in the case of any other hull material.

Photograph C shows a 34-ft. Seacrete hulled cruiser after she had been struck amidships by a 3 1/2-ton sloop travelling at 10 1/2 knots. Notice that the hull is only damaged at the point of impact. The repair including repainting, took 21 man hours.

The procedure is as follows:

The damaged skin area is chipped away until the surrounding material is sound and undamaged. It should be remembered that damage to a Seacrete hull is completely localized and confined to the area where impact took place. Once the broken ferrocement has been removed, any broken or damaged mesh reinforcement should be hammered back into its original position, and in exceptional circumstances replaced. Ferrocement mix can then be applied both to the interior and exterior of the damaged section. The exterior is left slightly proud and finally ground off. Normally a repair can be effected in one working day. Even in tropical conditions it is comparatively simple to repair a ferrocement hull, humidity being a help rather than a hindrance.

9. *Non-absorbent and Odourless.*

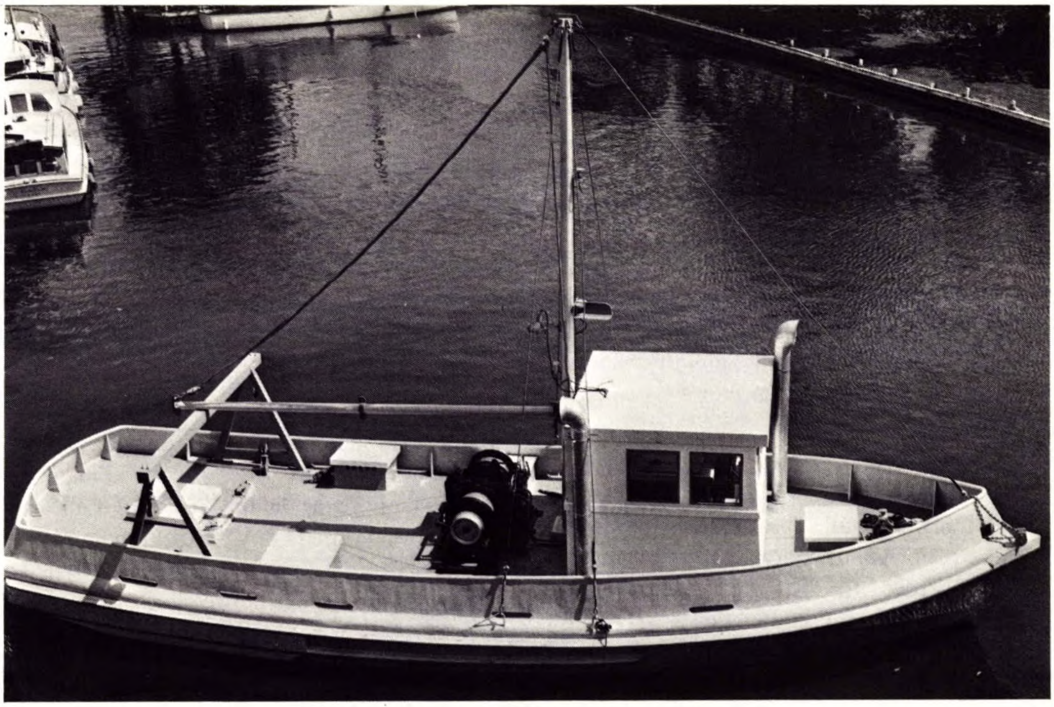
Ferrocement hulls do not absorb moisture, and therefore there is no risk of contamination by fish in fishing boats. Moreover the material is a very good insulator having a thermal conductivity of 68.88 btu/sq.ft/deg/F/hr. Consequently there is little or no risk of condensation in such hulls which are in addition completely odourless.

May I, in conclusion, give brief details of over 150 ferrocement craft built by my company.

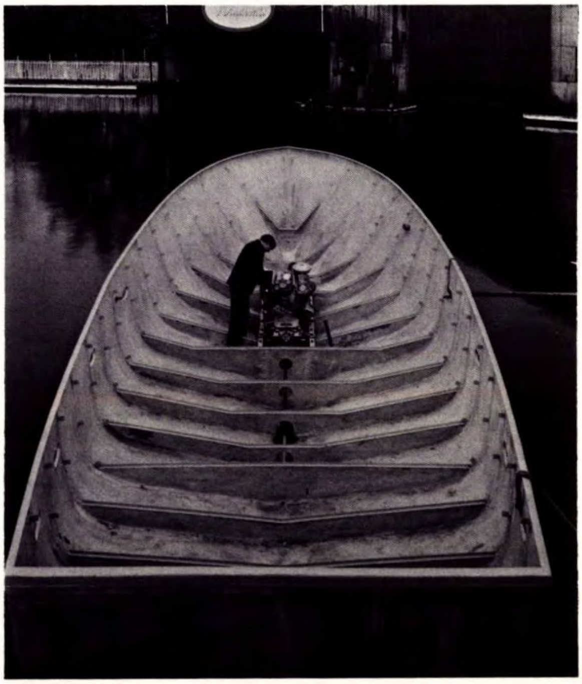
These have been exported to ten countries and have ranged in size from a 20-ft. dumb barge to be used in connection with oyster fishing, thirty-six 26-ft. cruisers for Norfolk Broads charter work, three 30-ft. open fishing boat hulls with a beam of 13 ft. for use in Kenya, nineteen 34-ft. hulls for use in Norfolk Broads charter work, five 35-ft. pilot boat hulls for use in the Arabian or Persian Gulf, thirteen houseboat hulls some 37 ft. in length, one 40-ft. tug for Guiana, one 45-ft. motor launch hull for use in the British Solomon Islands, and three 47-ft. fishing trawlers for use in Aden and Somalia.

Even this extensive experience will be supplemented in the very near future, as licensing agreements for the manufacture locally of "Seacrete" boats have been concluded with firms in the States of California, Maine and Washington in the U.S.A., British Columbia in Canada, Iran, South Africa and Spain, and there will be a complete pooling of knowledge between us and our licensees.

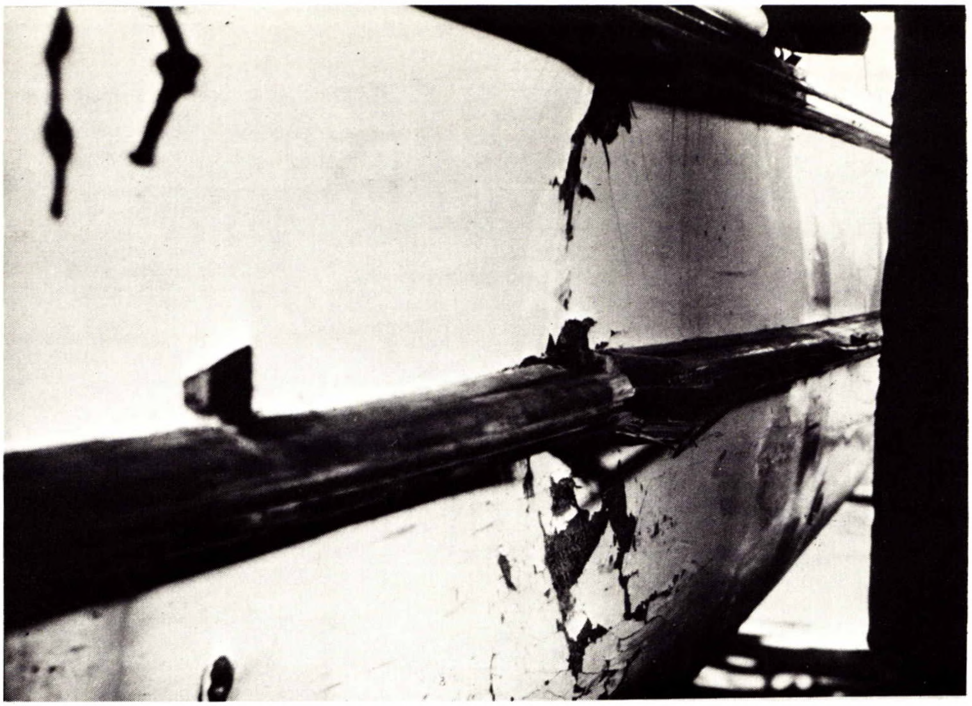
If you are not now convinced of the outstanding advantages of ferrocement for fishing and commercial craft, write me off as a poor advocate, but do not write off ferrocement; the demand will grow and grow world-wide – it is so logically right.



Photograph A. 46-ft. trawler in which the hull, decks, bulkheads, floors and engine bearers, fish tanks and bulwarks are built in one piece of Seacrete ferrocement.

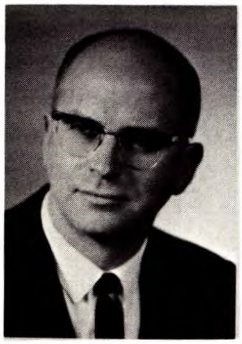


Photograph B. A 30-ft. Seacrete ferrocement hull with engine installed, as supplied to Kenya for completion locally into shrimp trawler. The hull maintains shape without cross bracing.



Photograph C. A 34-ft. Seacrete ferrocement hulled cruiser after she had been struck amidships by a 3½-ton sloop travelling at 10½ knots. The hull is damaged only at the point of impact. The repair, including painting, took 21 man hours.

Reinforced Plastic Fishing Vessels - An Atlantic Provinces Assessment and Future Outlook



Mr. Eisenhauer

by

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Mr. Eisenhauer obtained his degree of Bachelor of Mechanical Engineering in 1945 from the Nova Scotia Technical College. He is a member of the Engineering Institute of Canada and the American Material Handling Society. He is Vice-President of ABCO Limited and its subsidiary companies, which include Atlantic Shipbuilding Company, Limited, builders of wooden trawlers and deck equipment manufacturers; Industrial Shipping Company Limited, manufacturers of fiberglass sailing yachts, and Atlantic Bridge Company Limited, manufacturers of fiberglass lifeboats, motor boats and other marine and industrial equipment.

Mr. Eisenhauer's experience includes seagoing time as engineer on Diesel freighters, sales and service of marine machinery and equipment, production and manufacturing of fish plant equipment, development of pleasure and work boats of Reinforced Plastic, and service as a member of a Canadian Trade Mission observing shipyards and fish plants in Central and South America.

ABSTRACT

This paper deals with reinforced plastic fishing ship development in the region of Canada's Atlantic Coast. The type of fishing ships now owned and operated out of these ports is discussed. The need is emphasized for efficient, low cost shipyards and the effect of shipyard costs is examined.

The region's present facilities for R.P. boat production is outlined and a history of some of the boats that have been built in the area is given. Particular attention is given to "Cape Islander", the prototype fishing boat built for the federal and Nova Scotia Provincial Governments.

Special considerations for the promotion and introduction of small craft are differentiated from those necessary for the introduction of large fishing ships, bearing in mind the particular needs of the region. In setting up to build large R.P. ships, the need is expressed to keep the capital investment in the shipyard low so as to minimize overhead, thereby assuring continued competitive pricing. Some design considerations are given and some Reinforced Plastic applications for onboard ships of basic steel or wood construction are listed.

The paper is written in non-technical terms, dealing with the Canadian Atlantic Region, outlining the present day situation with a look at the future.

INTRODUCTION

There are two main groups of people interested in the application of reinforced plastics (R.P.) to fishing craft construction in the Canadian Atlantic area. One group, the plastic fabricators and designers, tend to approach the problem by pondering the size limitation to which a fishing craft can be built in reinforced plastics—"Is it feasible to construct distant water trawlers or even factory ships from R.P.? " The other group, the fishing industry, are familiar with and have confidence in R.P. pleasure craft, but remain skeptical of its application to commercial craft. The fishery departments of the federal and provincial governments are now acting as the catalyst to bring the two groups together to make R.P. fishing craft an accomplished fact. Proof is now available that R.P. is both entirely feasible and economically viable in all sizes of fishing craft presently in use on Canada's Atlantic Coast.

Because of our proximity to the traditional fishing grounds, the need for larger distant water ships does not exist. Since our fishing industry is oriented to processing and marketing the varieties of fish caught on nearby grounds, it would take a drastic change in the basic thinking of our fishing industry to go to distant waters for other types of fish. Such a move would require changes to processing plants, as well as larger ships. The possibility of such a change is so unlikely that we need not anticipate a requirement in fishing ships larger than the largest stern trawlers presently in use in the Atlantic Provinces. Any study can, therefore, safely be confined to the sizes of ships presently in use.

TYPES OF CRAFT NOW IN USE

The largest craft presently in use are the 145 to 165 foot stern trawlers. The present ships of this size are all built of steel and most of them have been built within the last six years. Since they have so recently been constructed, it is unlikely that there will be any large scale rebuilding program required for several years. A gradual demand for increased fleets can be expected, but not in large volume. Therefore, the Canadian Atlantic area can afford to await the experience of plastic laminators and fishing interests in other parts of the world before looking seriously at the construction in Canada of large stern trawlers for the fishing industry here.

During the last two decades some wood and steel trawlers in the 120 to 130 foot range, have been built. They were mostly side trawlers. Recently, the demand for this size ship has almost disappeared. Since low cost production of R.P. ships requires volume building of any one size, it would presently seem unnecessary to consider building this size of trawler in R.P.

In recent years, there have been more fishing hulls launched in the 90 to 115 foot length than in any of the larger sizes. These hulls have been popular as ground fish draggers, scallop draggers, and recently as herring seiners and crab boats. The larger trawlers referred to in the preceding paragraphs are generally owned as part of the fleets of the major fishing companies. The 90 to 115 foot boats are almost entirely owned by individuals who sail as captains in their own ship, or by small fleet operators. Most of these are built in native wood. Recent meetings between federal and provincial government departments, plastics laminators and designers, have decided that this range of fishing ship should receive first attention for R.P. development in Atlantic Canada.

Under the 100 foot range is found a large variety of sizes of boats designed for many types of fishing. Orginally, it was felt that the 65 footer was the most ideal size for the plastic laminators' early efforts. On further investigation, it was found that although the 65 footer was once popular in most of the Atlantic Provinces, it is now confined largely to Gulf of St. Lawrence fishing. When used for fish trawling or scalloping, its operation on the Atlantic Ocean coastline has largely been an economic disaster.

A quantity of boats in the 50 to 70 foot length are in use principally in the Bay of Fundy area as seiners and scallopers. In Newfoundland, and some mainland areas, another type of hull in the 40 to 50 foot length is in use as longliners, gillnetters, seiners and trap boats.

By far the largest quantity of boats in use are the lobster boats in the 30 to 40 foot range. There are several thousand of these. Each fishing area has its own traditional preference of hull form, although most are simply referred to as Cape Island boats. They were made popular by the fishermen of the Cape Sable Island area of Nova Scotia.

Other than the seven categories of fishing craft just described, there exists a myriad of smaller boats that defy classification. They are used for lobstering, longlining, trap fishing, gillnetting, Irish Moss gathering, and many still are used for handlining.

Is it any wonder that the plastic laminator, when confronted with this conglomerate of boats, trembles at making a decision as to where to begin.

SOME ECONOMIC CONSIDERATIONS

The three basic elements of cost in shipbuilding are materials, labour and overhead. Steel ships are made from materials of low cost, requiring many man hours of high cost labour in shipyards that because of the machinery and equipment necessary, have high overhead factors. Reinforced plastic ships are made from high cost material requiring fewer hours of lower cost labour in lower overhead yards. Wooden ships use low cost material with relatively high man hours of low cost labour in low overhead yards.

Any price differential between steel and reinforced plastic should not be of sufficient proportion to cause a price problem with the introduction of R.P. ships. However, a purchase price comparison between wood and reinforced plastics can be quite a deterrent to the introduction of R.P. ships in the Atlantic Provinces. Durability, long life and low cost maintenance are the factors that will make the R.P. boat a better economic proposition than wooden ships. From a later consideration in this paper, it will be seen that the repair to damaged hulls can be done at much lower cost with less loss of fishing time than to those of other materials of construction. This should allow the insurance companies to develop more favourable rates for R.P. ships, thus creating a further saving factor to the owner.

The wooden shipyards of the Atlantic Provinces obtain their materials from local mills. Some yards buy logs and do their own milling. Labour rates are lower than in other areas. There is an abundance of woodworking skills in most ports for both new construction and maintenance. Many of the individual owners of smaller craft do their own maintenance work.

It is possible to buy a wooden hull of a 40 foot lobster boat for about $2,400. In R.P. the cost would be approximately $2,000 higher. Herein lies the difficulty in introducing R.P. boats in the Atlantic area. This comparison is particularly adverse when considering hull only – however, a fisherman cannot fish with a hull only. When accommodations, diesel engine, fishing gear and electronics are added to complete the boat, the final price is about $10,000 for the wooden hulled boat and $12,000 for the R.P. hulled boat – or a difference of twenty per cent which the owner will recover in three or four years due to lower cost maintenance. With this type of saving to the fisherman and with a hull that will give many times longer life, the economic advantages to the individual, and therefore to the industry and the economy of the area, are substantial. If these advantages are recognized by the various government financing agencies through the granting of lower percentage down-payment loans to the fishermen for R.P. boats, and through longer pay-out terms, then the plastics industry can become a substantial factor in improving the economic return to the fishermen.

Since a favourable economic picture is apparent in the smaller sizes of fishing craft, we can expect that from this and from the experience gained in other parts of the world, it is reasonable to assume that comparable results will be obtained when constructing the larger sizes of fishing boats from reinforced plastic for use on the Atlantic Coast of Canada.

EXISTING ATLANTIC PROVINCES FACILITIES

Before looking into the future, it is worthwhile examining the extent to which the present R.P. laminators have progressed in boat building in the Atlantic area. To the best of our knowledge, there have been six different firms engaged in R.P. boat building in the region. Two of these have gone out of business, one has gone out of the pleasure boat business and is largely active in producing boats under 30 feet of length for various government departments. One company confines its production to outboard type boats and another builds a few small sizes of sailing craft.

The sixth, the ABCO Organization, builds 14 different sizes of pleasure sailing craft up to 32 feet in length, and in the power boat field, several different types are built including a high performance 16 foot despatch boat, developed for the Canadian Navy, using a Cathedral hull. This boat has recently been developed in a commercial version. Several sizes of C.S.I. approved lifeboats and several sizes of motor boats to 40 feet in length are also built.

"CAPE ISLANDER" – THE FIRST R.P. FISHING BOAT TO BE BUILT IN ATLANTIC CANADA

It is most interesting to follow the history of the 38 foot "Cape Islander" built by us in 1962 for the federal Department of Fisheries and the Fisheries Division of the Nova Scotia Department of Trade and Industry (now the Nova Scotia Department of Fisheries). This craft was constructed by these departments in order to gain experience with R.P. and to evaluate its use as a material for building further R.P. fishing craft. Before building it, we sent our engineers, technicians and production people in search of information to the United Kingdom, Germany, the U.S.A. and the West Coast of Canada. We studied articles available to us on boats built in other parts of the world. Our representatives visited R.P. boatbuilders and designers. Almost everywhere they were met with helpful and co-operative people in the industry. Most useful was the information they were given by laminators in the U.S.A., who were working on substantial U.S. Navy orders. As a result of the information compiled, we were able to build "Cape Islander" with confidence.

It is a well-known fact that an owner operating his own boat will be more careful with it, and will carry out better maintenance at lower cost than another individual will when using someone else's boat. This seems to be particularly true when the boat is government property. The "Cape Islander" has been no exception. She has been put in the hands of many different fishermen from Yarmouth to Cape Breton. She has been run at full speed onto reefs. On one occasion, she was being hauled through a town on a wooden cradle for display at the local county fair, when the cradle broke and she fell to the road. During two successive winters in one port, she was loaded with rocks to make her heavy so that she could be used as an ice breaker to keep the harbour clear of ice. During one hurricane, she was tied to a wharf in Lunenburg with a 48 foot wooden hulled boat tied to her seaward side, and a steel hulled boat at the other side. The only damage sustained was to a wood rub rail that needed replacement, but the wooden boat which was lying alongside had to be hauled out for extensive and costly repairs. During all of this usage, the only R.P. hull work that was necessary, other than cleaning and painting, was a $25 repair to the bow, necessitated when she was launched from a beach by placing a bulldozer blade against the bow and shoving her into the water. There has been other money spent on "Cape Islander" during this time, but not on the R.P. parts. She has had many changes in accommodations and fishing gear and a new diesel engine has been installed. At this writing, she is undergoing another change in fishing gear. The most notable feature, however, is that after six years and all this rough usage, the hull and other R.P. parts have required only $25 of repairs. The hull is still as sound and strong as the day she was built. After five years of operating a wooden hulled 38 foot boat, most successful Nova Scotian fishermen try to get rid of the boat and replace it with a new one because of mounting hull maintenance.

A few years ago, we produced some 37 foot boats for the Department of Mines & Technical Surveys for use in the far north. They were required to withstand difficult conditions on shorelines and on coming alongside freighters in rough seas. It was necessary for them to stand up under rugged ice conditions. We recently examined one of these boats, in which, after several years of hard service, there is no visible hull deterioration.

R.P. fishing craft have a proven record in many parts of the world. We feel as a result of the experience with "Cape Islander", that R.P. hulls now have a proven record in the Atlantic Provinces' fishery.

SMALL FISHING CRAFT CONSIDERATIONS

What comes next in R.P. hull developments in this area? What opinions have we formed as a result of existing experience? For answers, we must look in two directions. For the purpose of this paper, we will assume a 50 foot length of hull as a break point when referring to large or small ships. Any boats under 50 feet in length will be considered as a small fishing hull and over that as a large fishing hull.

The owner of a small fishing boat often does his own maintenance work. If he changes from one type of fishing to another, he will make the physical changes himself or he will get help from small local shops. These changes usually require that work be carried out to deck, cockpit or fishing platform, which necessitate drilling, bolting, cutting or other changes. He is accustomed to doing this work with the wood materials of his present boats. Even though R.P. can be worked in much the same manner as wood, yet he does not have the experience with it, and is therefore reticent to attempt to work with it. If structural additions are necessary, he can readily do it in wood, but may not want to attempt it in R.P. Therefore, there will be less resistance to the acceptance of a boat with an R.P. hull and wooden deck and interior, than there will be to one that is entirely built from reinforced plastic. This, then, is the direction in which we should look for early small R.P. fishing boat construction.

Another problem in providing an all R.P. small boat is the various traditions in the different fishing communities. Some areas prefer a wide deck around the working area, some a narrow one; some prefer a long deck aft, some a short one; some want the working platform higher than others. The cost of tooling to produce boats for all these different desires would be prohibitive. Therefore, at least during the early years of small R.P. fishing boat production, the wisest method of marketing would be to produce R.P. hulls and finish the decks and interiors in wood. After fishermen have gained experience with boats built in this manner, it may be possible to introduce small fishing boats built entirely of R.P. However, the early introduction will have to incorporate wood parts in use with R.P. hulls.

Producing R.P. hulls has another very desirable advantage. The hulls will be able to be produced in the plastics plant, and then be shipped to the existing boatbuilders. The boatbuilder will then complete the boat with wood decks and interiors. This will help maintain employment in the small boatyards, and thereby maintain economic stability in the small boatbuilding industry. This method of production is carried out very successfully by two R.P. laminators in the New England states. Over one hundred hulls have been produced in that area, of which approximately fifty per cent has been delivered to commercial fishermen.

There are two main problems adversely affecting the production of R.P. hulls for small fishing boats. The first is the natural reticence of the fishermen to depart from the traditional wooden boat. The second is the additional first cost of the R.P. hull. Last year, our company conducted a survey in Western Nova Scotia of fishermen, fish buyers, (who sometimes help finance boats for fishermen), and boatbuilders. We were pleased to learn that most builders were prepared to accept the advent of R.P. hulls and that they, in turn, were pleased to know our plans to produce hulls only, and to have them finish the hulls into complete boats. We also found the more progressive fishermen were acquainted with the "Cape Islander" and with the developments going on in the New England states. They realized that the day was not far off when they would be operating R.P. hulls themselves. The problem of higher first cost is a substantial one to them. This problem can be overcome if governmental financing boards will make available lower percentage down payments on loans to fishermen contracting for R.P. hulls. This would then allow a fisherman to obtain a more costly R.P. boat without having to put up any higher deposit than he now does for his wooden boat. If he could then be given a longer pay-out term so that his annual loan payments were no greater than for the wooden boat, he would then feel the acquisition of the R.P. boat would be within his means.

There would be justification for this action on the part of lending boards, because of the longer life and lower maintenance of the R.P. hull. Also, because of these facts, the fishermen would be saving more money. Such action on the part of the lending boards would create a better economic climate in that sector of the fishing industry.

LARGE FISHING CRAFT CONSIDERATIONS

Because of its considerable achievement in the development of R.P. fishing craft, South Africa is now leading the world in this field. We cannot say too much in praise of this work, not only because they have compiled substantial knowledge in this field, but also because the recognition that large R.P. fishing boats have been in use and give excellent performance, will make it easier for laminators in other countries to introduce R.P. craft to their own fishing industry.

Several yards are now setting up in the U.S.A. to build 70 foot shrimp boats from R.P. We have visited the largest of these yards, and have received considerable information from them. At least one shrimp boat in Port Brownsville, Texas, has been built in R.P., and is rendering good service to its owner.

With the background knowledge from other countries, the Canadian Atlantic area can look forward with confidence to the future of R.P. fishing craft operating in their industry. When deliberations concerning larger East Coast fishing craft first began, the principal question to settle was that of size. Having practical experience with 40 foot boats, it seemed logical next to attempt construction in the 65 foot class. This idea was abandoned when it was realized that the anticipated demand for this size of ship was diminishing. It has limited use due to winter freezing conditions in the Gulf of St. Lawrence, and it cannot perform in the rough waters of the North Atlantic winters. The smallest size fishing ship that can operate successfully on a full year basis is the 90 footer used largely for scalloping. It was, therefore, assumed that if a satisfactory hull form could be developed for use in scalloping, trawling, seining and crabbing, then one hull mold could serve for the construction of boats for several purposes. By the installation of different deck and fishing gear arrangements, this hull would be suitable for several types of fishing. A 100 foot ship seems to be the optimum size for this particular development.

Acknowledgement has frequently been given to the low cost maintenance resulting from the use of reinforced plastics. It is often difficult to get good comparisons of the extent of this lower cost, because usually the maintenance of machinery, electronics and deck gear is included with hull and super-structure, making it difficult to extract meaningful figures.

There are many other advantages not too frequently recognized. Reinforced plastic ships are usually lighter than ships built of other materials, a fact with which the designer must be familiar, in order to be able to design a seakindly boat. This feature can produce a substantial fuel economy. Insulation can be more readily built into the fish hold than with any other type of construction. A unitized tight hold has less cleaning problems with resultant lower bacterial count than any other. As a result of this insulated hull design, it is possible to achieve larger fish hold volumes, and therefore, carrying capacity for a given size of ship.

It will take less time to deliver an R.P. constructed ship to an owner, than one of another type of construction. The present wooden draggers require about six months in the building berth, and another three months after launching for outfitting and readying for fishing. Steel construction requires about the same time as a wooden ship from date of order to date of delivery. The time required to deliver an R.P. ship of comparable size, would be about half that for wood or steel.

Fire retardency is another important factor. On January 20, 1968, fire destroyed the Essex Boat Works Incorporated of Essex, Connecticut. About 98 yachts were lost in the fire. After the embers cooled, an examination was made of the debris. Almost all of the metal fuel tanks, both gasoline and diesel, were either ruptured or badly damaged. It was found, however, that two of the yachts were fitted with R.P. tanks. One tank of 180 gallon capacity was three quarters full of gasoline after the fire and the other, of 80 gallon capacity, still contained a small amount of gasoline. Both yachts in which these tanks were installed, were destroyed. Certain non fire-retardant resins will support combustion, but after the surface resin is burned away, the first layer of glass acts as a retardant to the flame, allowing for relative ease in extinguishing the flame.

Occasionally, a fishing ship may be holed because of grounding, hitting a submerged object, collision or some other misadventure. When this happens, it is usually out of service for quite some time. If it happens to a steel hull, it is necessary to remove plates, straighten framing and refit new plates. If the hull was constructed from wood, it requires planks to be removed, inside ceiling to be removed, broken timbers to be removed and replaced, then the new ceiling and planking must be fitted and the work finally caulked. These operations require a lot of time and this lost time means lost money to the owner. If such misadventure strikes an R.P. hull, it is simply necessary to grind away or otherwise remove fractured laminations and then to relaminate the defective area. The time required is usually a few hours, but at the most, only a few days before the ship can again go back into service.

SHIPYARD CONSIDERATIONS

Facilities presently exist in Eastern Canada for the construction of smaller R. P. fishing boats. The ABCO facilities at Mahone Bay, Nova Scotia, are the most complete and extensive of any in Canada for this purpose. These facilities are capable of producing boats up to 60 feet in length. Since adequate facilities for this size of fishing ship already exist, a consideration for the building of facilities for larger craft then becomes necessary.

An examination of existing shipyards for the construction of both wood and steel ships can reveal problems that should guide us in selecting the location and the design of a yard for the production of R.P. ships.

During the last six years, approximately twelve shipyards in the Atlantic Provinces were engaged in the construction of large wooden ships. Of these eight were actively engaged in building in the 90 to 115 foot range. Competition, and therefore pricing, has been keen. The most important factor in being competitive was in the utilization of labour. However, almost as important a factor was the amount of overhead the yard had to carry. The best prices came from the yards that had small effective management groups, building in low cost premises. As work tapered off, these were the yards that remained active the longest.

During the past few years, there have been three yards established in Eastern Canada which were designed primarily for the construction of steel fishing ships. However, these yards have not produced a very large percentage of the steel trawlers built in recent years. The majority of Canadian built trawlers have been constructed in yards designed primarily for the construction of larger craft, Naval ships, ferries, D.O.T. ships, freighters, tankers and other large ships. Steel shipyards designed to produce larger ships require more extensive facilities and staff than yards designed to produce fishing ships under 200 feet in length, such as are required by our East Coast fishing industry. When our fishing industry first began to purchase steel trawlers, they were built in European shipyards which were largely designed to produce the smaller sizes of steel ships, such as trawlers. It was only after the creation of a substantial federal government subsidy program for the construction of steel trawlers, that the Canadian yards were able to produce at competitive costs to the fishing industry. Some of the yards found it necessary to assign lower overhead rates to that section of the yard engaged in fishing ship production in order to bring costs down.

Our organization has examined many yards engaged in shrimp boat and seiner production in the southern U.S.A., Central and South America. We believe that there is much to be learned from these yards. Shrimp boats are in larger demand and are built in larger quantities than any other type of fishing craft in the world. Observing the shrimp boat yards, it is not always the lowest overhead, lowest labour cost yards that are the busiest. There are some yards in the U.S.A. paying high labour rates. The combination of low overhead and efficient labour utilization does, however, produce the most viable operation. If we hope to build large R.P. fishing ships in Eastern Canada, at prices that will meet competition and thereby obtain orders from the Canadian fishing industry, we must learn these lessons. A suitable location should be chosen, preferably in an area not subject to periods of high humidity, thereby keeping down the cost of dehumidification equipment. Buildings should be utilized that relate to the size of ships required by the Canadian fishing industry. The most efficient applicating and glassing equipment, coupled with simple handling and transportation equipment should be used. Good technical and quality control staffs combined with production management that can effect good labour utilization will have to be brought together. These aspects should all be planned and overheads estimated so that end prices can be established, and thereby allow for an examination of the yard's projected competitive position, before the yard is constructed. If this position is not favourable, then the planners must prepare alternatives until a viable operation can be projected.

Quality control and good plant housekeeping must be effectively established and rigidly enforced. The operation is subject to a considerable amount of dust from cutting and sanding. If allowed to accumulate, this can be harmful to persons and also to the laminate. A build-up of resin drip and chopped fibres can make difficult working conditions. Sloppy premises will make sloppy workmen with resulting poor quality laminates. Carelessness can create a fire hazard during lay-up. Too much emphasis cannot be stressed on efficient quality control and good plant housekeeping.

DESIGN CONSIDERATIONS

It is not the intention of this paper to examine technical design aspects of either the ships or the laminate. We feel, however, that certain basic principles should always guide the designer. It has previously been pointed out that small R.P. fishing craft normally maintained by their owners, are easier for them to look after if the hulls are built of R.P. and the decks and interior are made of wood. In the case of larger ships which are normally maintained and refitted by shipyards, we feel that the entire construction should be of Reinforced Plastic. The history of industrial R.P. laminating has been one of innovation and the use of novel practices and shapes to endeavour to take maximum advantage of the material. The thought of innovation and of the novel must be uppermost in R.P. ship construction, in order to permit future ease of maintenance and change or replacement of machinery and fishing gear. It would be possible to construct in reinforced plastics in such a way as to make it difficult to fit new equipment that may become available as the fishing industry develops. Good sound, simple construction practices are the best for fishing ships.

Many builders of smaller craft have used encapsulated wood as stiffener members. Our experience is that it is best to avoid this practice in favour of solid laminated stiffeners and girders or the use of "top hat" construction. This method avoids any tendency for the designer or builder to depend on a material that may deteriorate with age and lose its value as a strengthener. Mechanical and electrical fittings are easily attached to solid laminates, thus facilitating future maintenance.

OTHER MARINE APPLICATIONS

Reinforced plastics have desirable applications in fishing ships of wood and steel construction. It is an ideal fish hold lining material. We have carried out this work in many of the steel yards and some of the wood yards. Although our organization does a considerable amount of aluminum fabricating, we feel that R.P. is the most desirable material for fish hold lining. When finished with white gel-coat or polyurethane paint, it looks and is sanitary. It is very difficult to puncture and can readily be made watertight.

Sharp crevices can be reduced, therefore, lending to ease of cleaning and low bacterial count. An entire watertight envelope can be achieved by this method of lining.

Deck winch covers and enclosures are installed on many wood and steel ships. The use of R.P. eliminates the high replacement of these items due to corrosion. Accommodations are being lined with flat sheets produced with a smooth gel-coat surface.

Reinforced plastic lifeboats certified for use on fishing ships are an important safety factor. Wooden lifeboats tend to weather and deteriorate. They are often forgotten until needed, at which time a leaky lifeboat can aggravate a disaster. An R.P. lifeboat can be counted on no matter what its age may be or how long it has weathered on an upper deck.

THE FUTURE

Although fishing ship development in reinforced plastic has progressed in other parts of the world, the development is in its early infancy on Canada's Atlantic Coast. It is probable that small fishing craft will now start to appear. We look for several years of slow growth in small fishing craft, followed by a more rapid rate of increase, after fishermen are able to learn at first hand the favourable results that will be obtained by the early users of R.P. craft.

It is encouraging to know that the federal and provincial governments are now working on plans for larger R.P. fishing boats. With the sluggish state of the fishing industry today, we can appreciate the reluctance of any fishing company to proceed alone in the development of large R.P. ships. If governments proceed with this development in consultation with the fishing industry, and put a unit into operation for evaluation, it is our opinion that the results will bear fruit. Such a development, we feel, will result in the recognition that reinforced plastic is the ideal material for construction of 90 to 115 foot fishing ships. Once this is recognized, it is only a matter of time before our larger stern trawlers will also be made of reinforced plastic.

Cored Fiberglass Reinforced Hull Construction

Mr. Spaulding

by

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NOTE: The opinions expressed in this paper are those of the author and should not be construed as reflecting official views of the U.S. Navy, or the Naval Service at Large.

ABSTRACT

This paper contains guidance and background information for the consideration of various core materials and configurations for use in hull construction. Construction experience in several countries is first cited, followed by a general discussion of the applicability of cored construction and a listing of critical characteristics of core systems to be considered in making a selection. Specific materials, configuration, and fabrication methods currently available are then discussed, followed by comments on design methods for cored construction.

INTRODUCTION

Cored FRP construction, for hulls, decks, and superstructures, in a number of materials and configurations, has now been proved in service. At this point it is generally a question of cost effectiveness for a particular application rather than one of basic feasibility. If a material has no characteristics which obviously disqualify it for an application, its cost effectiveness can only be resolved by careful study. It is the intent of this paper to provide guidance and background information for the consideration of various core materials and configurations for use in boat construction. Specifically, only hull construction will be considered, though much of the information will be applicable to superstructures.

Construction experience in several countries is first cited, followed by a general discussion of the applicability of cored construction and a listing of critical characteristics of core systems to be considered in making a selection. Specific materials, configurations and fabrication methods currently available are then discussed, followed by a commentary on design methods for cored construction.

CONSTRUCTION EXPERIENCE

The following are examples of boats with sandwich hulls actually constructed and currently in service. Smaller craft are not covered, and there are undoubtedly larger craft not included because their existence is not known to the author.

CCA – Core Mold U.S. Navy – 33' to 50' Hulls.

Between 1955 and 1962, 32 U.S. Navy boats from 33 to 50 feet in length were fabricated with cellular cellulose acetate (CCA) core by the "core mold" process. This construction system utilizes wooden forms in place of a mold. Foam core boards are planked over the wooden forms just as a wooden boat is planked (fig. 1). Male or female forms may be used but the female forms are favored as they allow installation of structural members before removal of the forms (fig. 2). When the core planking is complete, one skin of the shell is laid up (fig. 3), followed by installation of bulkheads and girders if female forms are used. The entire assembly is then inverted, the forms removed, and the remaining skin laid up. Service experience with these hulls has been generally satisfactory.

PVC – Slat Mold – Royal Netherlands Navy – 20' to 77' Hulls.

The Royal Netherlands Navy has developed a construction system for fiberglass small craft consisting of the forming of polyvinyl chloride (PVC) sheets over wooden slat molds, followed by layup of fiberglass faces. Craft constructed by this system include 20 ft. pilot launches, 25 ft. motor boats, 32 ft. motor scows, 47 ft. landing craft (LCA) and 77 ft. pilot boats (fig. 4).

Wood battens, 1 1/2" in width, are planked over male forms with gaps equal to the batten width (figs. 5 & 6). Areas of single skin, such as that in way of the sheer connection, are filled in solid to form a mold. The core is then applied in sections approximately 3 feet by 6 feet by 1 inch in thickness (thickness may be reduced for smaller craft). These sections are heated to 212°F and then formed by hand over the wooden battens (figs. 7 & 8). Occasional headless nails are used to secure the foam. These are pulled through the core as the forms are removed. Gaps between core sections are troweled with syntactic foam. To prevent styrene attack from the polyester resin, the entire PVC surface is sprayed with a thin film of polyurethane resin. Eighteen-inch wide strips of unidirectional cloth are laid up in alternate diagonal plies by a typical hand layup process. After completion of the outer skin, the hull is removed from the forms and placed in a cradle. The inner skin is then laid up in a similar manner and structure bonded in place.

Service experience with all of these craft has been excellent. This form of construction appears to have achieved an exceptional ruggedness. On one occasion, an LCA on trials was hit amidships by a tanker which rode completely over the capsized landing craft. On recovery of the still floating LCA, it was found that, though there were long cracks in the skin of the sandwich shell, the hull had returned to its original shape and was essentially intact. Two 77 ft. pilot boats have now seen 4 years of exceptionally hard service off the Hook of Holland. Their excellent performance has justified the current construction of two more craft of identical hull construction.

PVC – Male Mold – South Africa – 67' Trawler.

The 67 ft. fiberglass pilchard trawler "Western Dawn" was completed in 1963 by the firm of S.A. Bonded Fiberglass of Cape Town (figs. 9, 10, 11, 12 & 13). Construction was similar to that of the Dutch craft except that a solid male plug was used in lieu of a slat mold. Core material was "Airex" PVC. Service evaluation has been excellent. Periodic surveys, conducted of hull condition, have indicated no deficiencies.

PVC – Slat Mold – Japan – 54' Tuna Catcher.

A 54 ft. fiberglass tuna catcher was delivered in 1965 by Yamaha Hatsudoki Company, Ltd. (figs. 14 & 15). Construction was with PVC core formed over a wood slat mold. It is noted that an actual hull weight of 7.5 tons was achieved compared to 13 tons for a comparable wood craft, 11 for steel, and 8 for aluminum.

A representative of the builder stated in 1966 that, based on the success of this craft, the firm planned to construct larger boats by the same process.

PVC – Slat Mold – U.S.A. – 37' Trimaran.

A 37 ft. cruising trimaran has been constructed in the U.S. employing "Plyfoam" PVC over slat molds.

Flat Grain Balsa – Slat Mold – France – 32' and 60' Hulls.

The firm, Societe Des Chantiers Reunis Loire Normandie constructed, in 1958, a 60 ft. fiberglass passenger launch (fig. 16). The core material, flat grain balsa to a thickness of 4 3/4", was assembled, in the form of transverse planks, over wood male forms and ribbands (figs. 17 & 18). Adjoining balsa pieces were glued with glass and resin. A shear strake of laminated ash was incorporated in the core. After layup of the outer skin the hull was righted, the forms removed, and the inner skin laid up followed by installation of bottom framing. A number of 32 ft. launches were constructed by the same system. Service evaluation has been good. A February, 1966, report indicated that the boat was still in operation and in excellent condition.

End Grain Balsa – Female Mold – U.S.A. – 40′ to 72′ Hulls.

In the U.S. a number of hulls have been fabricated in female molds with end grain balsa cores in the form of "Contourkore" (registered trademark of Balsa Ecuador Lumber Corp.), a matting of square end grain balsa blocks held together by a light scrimm cloth. This core material has been used in various thicknesses from 1/4″ to 1″ in single and multiple layers. Core and laminate are fabricated by conventional hand layup methods. Hulls fabricated by this system include a 72 ft. shrimp trawler by Newport Trawlers of Newport, Florida, the 53 ft. sloop, "Inferno", and 40 ft. sloop, "Red Jacket", by Bruckman, Ltd. of Burlington, Ontario and two 46 ft. crew boats by Pacific Fiberglass Laminates, Inc.

Service experience has reportedly been excellent. In one incident, the 53 ft. "Inferno" was blown onto a rocky shore in the Bahamas where she pounded for three hours in heavy surf. When hauled off by the Coast Guard she was scarred but still watertight.

CCA – Female Mold – U.S. Navy – 40′ Utility Boats.

In 1959 and 60, 24 – 40 ft. Utility Boats were fabricated for the Navy in a female mold. A female mold in two halves hinged on the centerline was constructed. Layup of the outer skin and core then proceeded with the two halves hinged open in order that the layup could be essentially horizontal. CCA core was layed up in strip planks and weighted with fire hoses filled with lead shot during cure. The mold was then closed and a keel laid up joining the two halves. Layup of the inner skin completed the shell.

Although core bond tests indicated that minimum bond requirements were met the condition of the test samples indicated some areas of defective bond. No failures have been reported in service with these craft.

Polyurethane – Female Mold – East Germany – 44′ Power Boat.

In 1961 a 44 ft. fiberglass power boat was constructed by the VEB boatyard in Geroifswald, German Democratic Republic. The hull was fabricated in a wood female mold with a .8″ thick polyurethane core. The face laminates, from .12″ to .16″ in thickness, were a combination of plain weave cloth and an imported French woven roving. The design of this craft was developed by the Institute for Shipbuilding Technology at Wolgast in cooperation with the Institute for Plastics in Berlin. The selection of the sandwich hull was the result of a series of panel tests where deflection was the limiting criteria. An inspection of the hull after three year's service indicated no deterioration.

Honeycomb–Female Mold & Male Mold–U.S. Navy–57′ XMSB-23.

In 1951 a U.S. Navy contract was awarded for development and construction of a 57 ft. fiberglass minesweeping boat. Five years and considerable R & D later the XMSB-23, minus minesweeping gear was delivered to the Mine Defense Laboratory at Panama City, Florida, where it has served to this date as a general purpose workboat. The result of two and one half years devoted to research on materials and construction techniques was the selection of a honeycomb sandwich laminate molded by hand layup and vacuum bag in a female mold. The hull shell was nearing completion when it was destroyed by fire. The second hull was fabricated over a wood female mold (fig. 19).

Service evaluation of this boat has been satisfactory in spite of the complete water absorption of the honeycomb hull core. This craft is, to this date, the latest U.S. Navy boat constructed in fiberglass.

Honeycomb–Slat Mold–U.S. Navy–36′ Landing Craft.

In 1955, 26 36 ft. fiberglass landing craft (LCVP) were constructed with 3 inch thick honeycomb core. The core was assembled in sections over a female steel framework consisting of 1″ wide steel longitudinals on 3″ centres over transverse steel frames on 15″ centres. The inner skin consisted of #1000 cloth against the core and 24 oz. woven roving. Interior shoring was added after cure of the inner skin and the hull removed from the mold and inverted for lamination of the outer skin. Service experience with these craft has not been entirely satisfactory as on several occasions the bottom cores have filled with water.

"Unicor"– Female Mold – U.S.A. – 17′ to 35′ Hulls.

Approximately 500 craft from 17 to 35 feet in length have been constructed by three firms on the west coast of the United States by a vacuum bag, heat cured, female mold process employing a cloth blanket with sewn in foam strips known as "Unicor" (registered trademark of Unicor, Inc., Paramount, California). The majority of these craft were constructed by the firm of Tollycraft whose entire production line of power boats to 34 ft. in length is in Unicor. To date this firm has delivered 431 Unicor hulls. Hull shells are laid up in one operation, outer skin, Unicor, and inner skin, resin being sprayed on each ply as it is laid up in the female mold. On completing the layup the entire shell is vacuum bagged and placed in a hot air oven at 170°F for two hours. The resulting sandwich shell laminate contains 1/2″ thick 4#ft^3 polyurethane core with vertical fiberglass sheer webs on 3″ centres. Resin contents average 38%. Weight savings over single skin of up to 30% are claimed.

Unit Core – Female Mold – Admiralty, United Kingdom – Minesweeper Section.

As the result of an Admiralty contract with J. I. Thornycroft, Ltd. and Bristol Aeroplane Plastics, Ltd., a full scale fiberglass test midship section for a 170 ft. minesweeper was completed in 1967. Fabrication was by mechanized hand layup in a sectional steel female mold. Layup of outer and inner skins was accomplished with a mechanized cloth impregnating and dispensing unit suspended from a gantry system over the hull mold. An adjacent gantry supported movable scaffolding for the laminators. Outer skin thickness was .45″ on the bottom, .35″ on the sides. The inner skin varied from .25″ to .15″ in thickness. The core consisted of 3″ thick premolded fiberglass cellular units bonded to each skin and to adjacent core units. Core density varied from 12.8 lbs./ft^3 to 18 lbs.ft^3. This test section is currently scheduled for structural testing at the Naval Construction Research Establishment, Rosyth.

Polyurethane – Slat Mold – U.S.A. – 52′ and 71′ Hulls.

In 1966, the Martin Weir Co., Inc. of Chula Vista, California, completed construction of a 71 ft. power cruiser (fig. 20). This craft was fabricated by a unique patented core-mold system, using individual core planks wrapped with rovings. This construction system, developed by Mr. Weir in 1953, has been employed in the construction of a number of craft, including 26 Lightening class sailboats and a 52 ft. ketch. A female jig was erected, consisting of 2x4 frames on 4 ft. centers to which small diameter pipe ribbands, on approximately 12 inch centers, were attached. A series of small section wood transverses were then attached to the ribbands. In each wood transverse was imbedded, on the inside face, a laminated strip 5/16″ square. In way of the keel a female mold was incorporated in the jig. For wrapping each individual foam plank, a wrapping machine was employed (fig. 21). This machine simultaneously lays longitudinal roving strands along the inner and outer faces of the plank and applies a double diagonal spiral wrapping which serves as a sheer web in the core. A preimpregnating device was employed which heats the woven roving used for the laminate faces to 100°F immediately prior to immersion in a resin bath.

The keel and garboard area in way of the solid mold was first laminated. Then the keel cavity was filled with ballast. Planks were wrapped, impregnated, and placed in position where they were tied to the jig, working down from the sheer (fig. 22). When the planks were cured the inner surface was faired with syntactic foam. The inner skin, of preimpregnated woven roving, was then layed up. The jig was removed leaving the 5/16″ laminate strips which served as guides for applying the syntactic foam to the outer face. The outer skin was then laminated with preimpregnated woven roving. Decks, bulkheads, and girders were fabricated by the same process.

Foam thickness for the shell was determined by flotation requirements. Fire retardant resin and 2# polyurethane foam were used for shell construction. The cost for the 71 ft. power boat, complete but minus machinery and equipment is estimated at $110,000 of which the jig represents only $5,000.

Polyurethane – Male Mold – U.S.A. – 50 ft. Catamaran.

In 1965, the firm of Glas-Craft of Glendale, California, constructed a 50 ft. polyurethane cored fiberglass catamaran. Twin male molds were constructed of plywood at a cost of $1350. An inner skin of 2 plies of 20 oz. glass cloth was laminated on the molds followed by 2 1/2″ of sprayed 4#/ft^3 polyurethane. The core was then routed to a uniform thickness of 2″ and an outer skin of 2 plies of 20 oz. cloth and 2 plies of 1 1/2 oz. mat. Total hull thickness was 2 3/8″. Total cost of this 15,000 lb. craft was $65,000.

ADVANTAGES AND PROBLEMS–GENERAL

The overriding consideration in material selection for commercial hulls is cost, not simply acquisition costs, but total ownership costs (life cycle costs). On a straight materials cost, dollars per pound, basis sandwich construction is more expensive simply because balsa, and all of the available foam cores, are considerably higher in cost than glass and resin. Hence if the acquisition cost of a sandwich hull is to be equal to or less than one of single skin, savings must be accomplished by reducing weight, labor, or tooling costs.

Weight. – Based on the superior stiffness/weight ratio of a sandwich panel, weight savings are often considered synononous with cored construction. Weight savings are certainly attainable but in practice they may not always result. For example, in smaller craft the minimum outer skin thickness required for abrasion and impact resistance may exceed the requirements of a balanced sandwich structure. With inner skin increased to balance the panel and a core of sufficient density to resist impact and provide an adequate face bond, the hull weight may exceed that of single skin. In the case of larger craft core density may be increased to resist the higher sheer stresses of large unsupported panels. Sandwich construction was considered in the U.S. Navy minesweeper studies (ref. 16). In this case it was determined that hull weights for sandwich construction could be competitive only if 4 inch core thickness was employed (8#/ft^3 polyurethane). In table A (from ref. 5) hull structural weights for sandwich construction of a 110 ft. trawler were determined to be approximately 5% higher than hull weights for single skin (fig. 24). Weight savings are particularly critical as each pound saved may be added to the payload (or speed increase).

Labor – Man hours expended in fabrication of the hull shell alone are expected to be higher in the case of cored construction since more steps are generally required. In the case of the U.S. Navy core-mold hulls labor costs were prohibitive, particularly in finishing the outer surface. An appreciable weight saving should occur with cored construction in fabrication of frames and stringers which, in some cases, may be essentially eliminated. Hence there is definitely a potential for a saving in labor costs with cored construction but achievement of this saving depends on effective structural design.

Tooling – If cored construction is accomplished with simple forms or slat molds a great saving may be realized over the female mold required for single skin construction. This advantage, of course, is inversely proportional to the number of craft constructed.

Each of the numerous advantages and problems associated with cored construction should be considered with respect to possible savings or losses over the vessel's life. For example, the insulating qualities of sandwich construction might justify even a cost increase if the fish holds were to be refrigerated. Certain advantages of sandwich construction such as reserve buoyancy and resistance to hull puncture are safety considerations and might justify an increased cost even though the benefits are intangible.

The following advantages and problems are general in nature and will vary with the particular core material and configuration selected.

Advantages

Minimized Tooling – As discussed above, the adaptability of certain core materials to "core-mold" construction makes them particularly attractive for prototype construction.

Hull Integrity – The resistance of sandwich construction to hull puncture and loss of watertight integrity has been demonstrated on several occasions. Considerable damage can be sustained by the outer skin without puncture of the inner laminate. PVC, in particular, has demonstrated a remarkable impact resistance.

Monocoque Construction – The elimination of framing and its associated stress concentrations has a particular appeal to the engineer. In practice this is really an advantage only if a weight saving can be accomplished with equivalent strength.

Elimination of Framing – Framing may be eliminated, or at least minimized, resulting in clean, unobstructed, interior space which makes for easier housekeeping (i.e. cleaning of fish tanks), more complete utilization of space, and improved fire resistance (elimination of heat pockets).

Reserve Buoyancy – If it is desired to provide reserve buoyancy sufficient to float a completely flooded boat, the additional foam required will be greatly reduced (or eliminated) by the built in buoyancy of the hull core.

Thermal Insulation – Hull sweating is eliminated and efficiency of heating or refrigerating of spaces greatly improved.

Acoustic Insulation – Noise levels should be reduced throughout the boat.

Vibration Damping – Transmission of machinery and propeller vibration should be reduced.

Problems

Deficiencies in available core materials and configurations, though they vary with materials, may be categorized as high cost, deficiencies in core properties, and difficulties in fabrication.

High Cost – Core materials commonly used in hull construction cost between $1.00/lb and $3.50/lb compared to approximately $.25/lb for resin and $.50/lb for woven roving.

Deficiencies in Core Properties – These vary greatly between materials but the following are critical: sheer strength, core bond strength, compressive strength, resistance to water penetration, and resistance to heat deformation and creep.

Difficulties in Fabrication – Again this varies with the core materials and configurations, but the following areas may be expected to give problems: forming of core material, vacuum bagging, joining of core sections, and finishing of outer surface where a mold is not employed. Quality control, in general, is a more serious problem than with single skin.

CRITICAL CHARACTERISTICS

The following items are presented as a form of check list for guidance in selection of a core system. The applicability of each item should first be considered. If the characteristic is critical to the application the core selected must meet some minimum requirements for that characteristic to be acceptable.

1. *Density.*

2. *Cost/lb.* – Core costs are often presented on a square foot basis which is quite adequate for pricing a given area to be covered but misleading in comparing different core materials. In comparing cost/lb figures, however, the basic capability of the material must be considered in relation to its density, i.e. if a lower density in one material will give equivalent strength to a higher density in another material a cost increase for the lower density material on a cost/lb basis is justified.

3. *Compressive Strength.* – This property directly effects impact resistance and resistance to crushing from local loads. The method of testing for compressive strength must be specified or the data may be meaningless. Compressive strengths are often taken at 10% offset.

4. *Sheer Strength.* – This property is critical to panel design. The core may fail in horizontal sheer at the faces or vertical sheer perpendicular to the faces. Materials such as balsa or honeycomb with directional properties require consideration of sheer in two directions.

5. *Unicellularity.* – Experience indicates that where there are voids adjacent to laminate faces, or interconnected voids, water may eventually penetrate. Core samples should be tested for unicellularity (water absorption). Where core configurations leave voids between adjacent core sections, the consequences of possible water penetration must be considered.

6. *Tensile Strength.* – This is related to face bond strength. For example, in U.S. Navy construction it was found that when 6#/ft^3 polyurethane was tested for face bond strength, tensile failures occurred in the core before bond failures took place. When density was increased to about 7#/ft^3 core tensile strength increased and a balance was achieved. A core tensile strength test is now a standard materials quality control measure.

7. *Resiliency.* – Resiliency might be considered a measure of foam recovery from compressive loads. It is one method of achieving impact strength. PVC, in particular, is remarkably resilient. Certain rigid PVC foams can be compressed to one half their thickness and return naturally to full thickness and strength over a period of several hours. A completely non-resilient foam would have essentially no recovery from compressive strain.

8. *Bond Strength.* – This is an extremely critical property. There should be good margin for error here as quality control is most difficult. U.S. Navy boat specifications call for random sampling on finished

parts by cutting a 1″ radius circle through the face and measuring the load required to lift the cut out away from the core. Bond strengths vary from 100 psi for 7#/ft^3 polyurethane to 400 psi for 8#/ft^3 end grain balsa. Compatibility of bonding resins with core materials must be considered. Styrene in polyester resins will attack styrofoam and certain of the PVCs. These foams must be pre-coated.

9. *Impact Resistance.* – The principle concern here is the impact resistance of the finished sandwich panel. This is related to the face laminate, core properties, and to the use of FRP sheer webs. For a given face laminate there are two ways to increase impact resistance through core properties: the core may be extremely resilient or have a very high compressive strength. A resilient core deflects with the face and returns, a high compressive strength core prevents the deflection of the face (up to the ultimate compressive strength of the core).

10. *Durability.* – The core selected must retain its basic properties throughout the life of the hull. It must have proven resistance to deterioration, aging, and fatigue.

11. *Workability.* – Core samples should be tested for sawing, routing, planing, sanding, etc., as required for the particular method of fabrication.

12. *Formability.* – Will the core selected take the shape required, and can it be retained in position during panel cure? Certain of the PVCs, for example, are true thermoplastics and may be easily heat formed.

13. *Brittleness.* – This is, perhaps, the opposite of resilience. It is mentioned because certain low density polyurethanes, for example, in structural applications are extremely brittle and tend to pulverize with panel flexure.

14. *Creep Characteristics.* – This is a particular problem with certain of the PVCs. For a given temperature there is a load at which permanent set may occur. This is not necessarily restrictive but must be accounted for in design.

15. *Self Sealing Characteristics.* – Certain foams are claimed to have self sealing properties. Usefulness of this property may be more appropriate to military applications.

16. *Heat Insulating Properties.* – These would be of particular interest where spaces are to be refrigerated.

17. *Sound Insulation.* – Sandwich construction might be utilized to sound insulate engine compartments.

18. *Availability.* – Certain foam materials and systems are proprietary or imported. Their continued availability should be assured.

19. *Fire Resistance.* – This is clearly of interest with regard to insurance rates and basic safety requirements. Fire retardant resins and foams are available. One theory advanced maintains that a sandwich construction may, in itself, appreciably improve fire resistance since framing, with the resulting heat pockets (particularly overhead), are eliminated.

20. *Repairability.* – This is generally not a problem as cored construction lends itself to easy repair, particularly when the damage is to one skin only. However, in the more sophisticated vacuum bagged laminates, faces are thinner and of high glass content. Repairs will be thicker and of lower glass content, adding weight and possibly introducing weaker sections because of reduced scarf area on the thin face laminate.

21. *Quality Control.* – Ability to visually or non-destructively determine quality of core bond and wet out of sheer webs is critical. When this is impossible and the chance for error high, the core system may be unacceptable.

22. *General Fabricatability of System.* – This is reflected in labor hours, skill levels, and complexity and cost of equipment.

23. *Resistance to Vibration and Fatigue.* – Core panels must be able to resist expected fatigue and vibration loads. This quality is directly related to resilience of core material, strength of core bond and existence of sheer webs.

SPECIFIC MATERIALS, CONFIGURATIONS, AND FABRICATION METHODS

Core Materials.

Polyurethane.—Polyurethane is a unicellular foam core, available in densities from 1-1/2 lbs/ft^3 to 20 lbs/ft^3. Polyurethane resins cost approximately $.65/lb but foam in board form will exceed $1.00/lb. Polyurethane foams may be mixed with a simple bucket and electric mixer system, though a foam metering machine gives better control and its cost is easily amortized where a large volume of foam is used. Spray equipment may be used to apply foam to a surface. Polyurethane, in densities from 1-1/2 lbs/ft^3 to 3 lbs/ft^3 is widely used for foamed-in-place or block flotation material. 6 to 8 lb/ft^3 polyurethane is more suitable for structural applications. This material is used in all girders, bulkheads, and flats below the waterline on U.S. Navy fiberglass craft. Above the waterline end grain balsa is used.

6-8# polyurethane has adequate strength for most structural applications, though compared to end grain balsa, for example, sheer, compressive, and core bond strengths are relatively low. Core bonds in tension give approximately 100 psi for 6-8# polyurethane compared to 400 psi for end grain balsa. Resilience of PVC is far superior to polyurethane which tends to crush under impact loads. Polyurethane does not deteriorate with age and has a very low water pickup. Polyurethane is not normally fire resistant but self extinguishing polyurethanes are available. Polyurethane does not have adverse creep characteristics and is not attacked by styrene.

Any rigid foam which is not a thermoplastic, such as polyurethane, will present certain difficulties in forming to a curved surface. Pressure must be applied and maintained during cure when the foam is applied in a mold. In the case of the core-mold system, where the core is planked over wooden forms, it will hold its shape on the forms when the nails are removed after the glue between the planks is cured.

CCA—Cellular cellulose acetate (CCA) is very similar to polyurethane. It is available in 6-8# density at approximately $1.30/lb. CCA is available only from Aircraft Specialties Co., Inc. of Hicksville, New York, under the trade name "Strux". CCA is somewhat more brittle than polyurethane. Originally CCA was used for all structural applications in Navy fiberglass craft. It has been completely replaced today by polyurethane and end grain balsa.

Balsa. – Balsa has been used in hull construction in flat grain, end grain, and end grain "Contourkore" (registered trade mark of Balsa Ecuador Lumber Corp.). The French river craft described earlier in this paper were constructed with flat grain balsa. Though these applications were successful, flat grain is seldom used because of its poor strength characteristics. Compressive strength, for example, varies between end and flat grain by a factor of 10 to 1.

Balsa is available in three nominal densities: 6, 11, and 15-1/2 lbs/ft^3. In practice (on Navy contracts) end grain balsa is running approximately 8#/ft^3. Cost for end grain panels varies from $1.20 to $1.35/lb for 1/2" and 1" thickness respectively. Contourkore runs from $.86 to $1.07/lb. for the same thicknesses. Compressive strength and face bond strength are exceptionally high. Compressive strength, for example, runs approximately 1500 psi compared to 150 psi for polyurethane of approximately the same density.

Rot resistance of end grain balsa still concerns the Navy to the extent that the material is not used below the waterline. To this author's knowledge, however, there is no known instance of balsa core deterioration to support this limitation.

In designing panels with balsa cores, consideration must be given to the relatively low sheer strength along the grain.

The high compressive strength of end grain balsa contributes to a high impact resistance, though this material lacks the resilience of PVC.

The use of end grain panels glued edge to edge is feasible for flat layups where forming of the core is not required. Even here though, pressure is required to assure good bonding where the core is pressed into a wet laminate. Where the face is laid up on the core, pressure is not required. Experience has indicated that a ply of mat in the core faying surface is vital to a good bond (for all core materials). End grain surfaces should be precoated with resin to prevent excessive absorption of resin by the balsa during layup of the faces. Where curved surfaces are to be cored, Contourkore is most applicable. Contourkore consists of a blanket of small, square, end grain balsa blocks held together by a light scrimm cloth over one face. Contourkore is available in thicknesses of 1/4" to 1" in

1/8″ increments. This material is extremely flexible and will easily conform to compound curvature. Pressure is not required. Gaps between core blocks are generally not filled with resin, resulting in a small reduction in panel strength and introducing the possibility of water penetration. Contourkore has proven to be a relatively inexpensive, high strength, core material which is easily fabricated in areas of complex curvature.

Polyvinyl Chloride. – As noted in the previous section on construction experience, PVC has been extensively used in the construction of craft to 77 ft. in length, though use in larger craft in the U.S. has been limited to one 37 ft. trimaran. PVC is available in the U.S. and Canada from at least three different manufacturers. The following discussion applies to "Airex" rigid PVC foam, a product of the Swiss firm Airex, Ltd. Airex, in the 5#/ft^3 density, was used for all PVC craft constructed for the Royal Netherlands Navy. Other PVC foams available are similar but will differ considerably with respect to certain properties.

Airex is a rigid, unicellular, PVC, available in densities of 3 and 5#/ft^3. Its outstanding advantages are its thermoplastic nature which allows it to be heat formed to areas of complex curvature, and its exceptional resilience, or toughness. It can be compressed to one half its thickness or bent 180° (in 3/4″ thickness) and will return to its original form within a few hours. Disadvantages are its relatively low compressive and sheer strengths and susceptibility to creep at elevated temperatures.

The thermoplastic nature of Airex is not necessarily a handicap. Design must simply account for the material's actual properties. Traditional ship design assumes extreme hydrostatic loads and designs statically for what is, in reality, a dynamic load. With Airex, panels would continually deform to failure under the extreme load were it actually static. As these loads are dynamic, the panel simply deforms and recovers, ultimately giving greater resistance to dynamic loads than less resilient foams which have higher static stress limits. In other words, Airex panels must be designed for an actual static load and an extreme dynamic load. Data is available which shows stress limits for static loading at varying temperatures. For example, 5#/ft^3 Airex, at 68°F, gives a 60 psi compressive yield strength when loaded for 5 minutes, and 47 psi when loaded for 14 days. At 104°F compressive yield is 29 psi for five minutes, 13 psi for 14 days.

Five-pound Airex is available in sheets approximately 48″ x 110″ in thicknesses from 3/8″ to 1″ by 1/8″ increments. Cost is in the order of $3.25/lb depending on the thickness.

Airex sheets are heated to between 112°F and 148°F in an oven for forming. A hot air oven is preferred since exposure to direct heat may decompose the foam. Infrared lamps may be used for thin sheets. Since there is some tendency for styrene to attack Airex a hot coat of polyester is applied and allowed to cure before layup of the faces.

Airex may be cut with hand shears. Mechanical shears tend to compress the edges which must be heated to restore them to full thickness. Plastic type hand and circular saws may be used. Conventional drills are not effective, but rotating tube types may be used.

It is noted that the resiliency of PVC appears to make it particularly suitable to applications where vibration or fatigue are critical.

Honeycomb. – There are many honeycomb type core materials on the market. Materials include paper, cotton cloth, fiberglass, and aluminum. Honeycomb cores have been used very successfully in the aircraft industry. They offer a very high strength weight ratio.

Applications to date, in marine use have been particularly unsuccessful. A major problem is the large cell size. Water penetration is difficult to prevent and it is virtually impossible to remove water from a honeycomb hull core. Reduced face bond area is also critical. Adequate face bonds are achieved in aircraft parts with heat and pressure. Marine work has not justified the cost of these sophisticated methods, and quality of bonding has suffered accordingly. Honeycomb has also proven inadequate for the high local impact loads experienced in marine applications. Local crushing occurs since honeycomb generally has poor resilience.

Fiberglass/Core Combinations.

Consideration of certain basic requirements of a sandwich structure suggests possible improvements over the use of core material alone. There is a need to provide a high strength connection between the two faces. This connection would minimize the tendency of the faces to separate under various loading conditions. It would allow fasteners and connections to one face only and it would carry panel sheer and compressive loads. With sufficiently flexible connections, panel resiliency and impact resistance would be increased. Several core systems have been developed utilizing fiberglass sheer webs between the faces. Cost, weight saving, and possible quality control problems would govern in selection of a system of this type.

Unicor. – Unicor (registered trademark of Unicor, Inc., Paramount, California) is a blanket type core material formed by stitching two layers of glass cloth together over and between strips of polyurethane foam. Several styles are available, the most commonly used in boat construction being designated style 5000. Style 5000 has rectangular foam strips. Style 3000 uses triangular foam strips and is laid up in two sections, one section forming each face of the sandwich and one half the thickness of the sheer webs. Unicor is available in thicknesses from 1/4″ to 2″. Thicknesses up to 6″ are available on special order. Density of polyurethane core strips may be varied or PVC may be used.

Hull fabrication is accomplished in female molds with vacuum bag and heat cure. The entire hull shell is molded in one operation. The outer skin laminate of cloth, mat, or woven roving, is laid up with resin sprayed on each ply. Then the Unicor is applied followed by the inner skin. The layup is then vacuum bagged and heat cured for two hours. A typical cost/ft^2 for Unicor is \$.87 for style 5000 with 1/2″ x 2″ foam strips.

As noted in the construction experience section of this paper, nearly 500 craft up to 35 ft. in length have been fabricated with Unicor. Hull weight savings to 30 per cent are claimed and hulls of this material are proving to be economically competitive with single skin hulls. The requirements of this process for a mold, vacuum system, and curing oven would seem to restrict its use to fairly high production hulls.

Hitcore. – Hitcore (registered trademark of H. I. Thompson Co.) is a material similar to Unicor but manufactured by a different process. The two faces and sheer webs are actually woven integrally by special looms to provide a one piece fabric with two faces and diagonal sheer webs into which triangular foam strips may be inserted. Examples of hull construction with this material are not known to this author.

Wrapped Core. – This method is described in the construction experience section of this paper, as applied to 52′ and 71′ hulls by the Martin Weir Co.

Unit Core. – This system is described under construction experience as applied to a minesweeper midship section in the United Kingdom.

DESIGN

The general approach to design of a sandwich hull is identical to that for a single skin hull. Design criteria are chosen and panel loads determined. Reference 16 outlines this process for U.S. Navy minesweeper designs. Design of the cored panels themselves is a more complicated process than design of single skin panels. For detail methods of sandwich panel design the reader is referred to several sources: Reference 8, pages 6-180 to 6-191 provides a good general discussion of sandwich panel design. References 7 and 12 provide a method of designing for balsa cored panels. Reference 16 provides results of a weight and cost analysis of sandwich vs. single skin construction. Reference 20 provides a comprehensive discussion of sandwich design with particular application to PVC cores.

Careful attention must be given to joint design to eliminate face peeling and core crushing. A common failure in sandwich designs is the application of loads to a single face of a laminate which exceed the strength of the core bond or core.

It is suggested that careful consideration be given to all of the items listed under "Critical Characteristics" in the design process.

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Figure 1. Core-mould system – 40-foot and 33-foot navy personnel boat hulls under construction on male forms.

Figure 2. Core-mould system – 26-foot motor surf boat, female forms.

Figure 3. Core-mould system. Layup of outer skin on 33-foot navy personnel boat constructed over male forms.

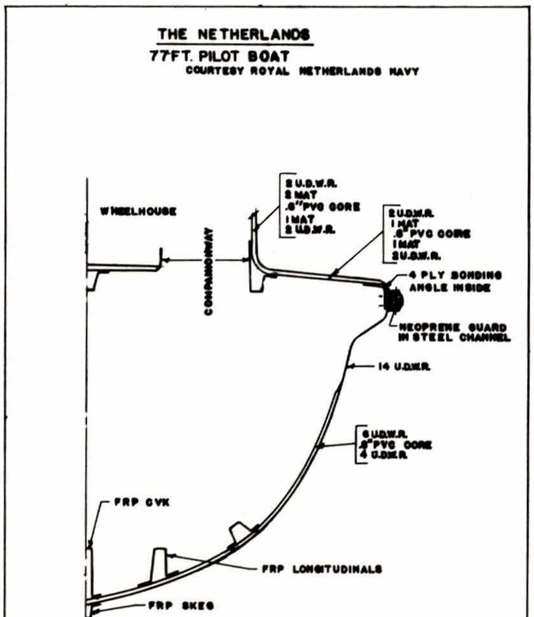


Figure 4.

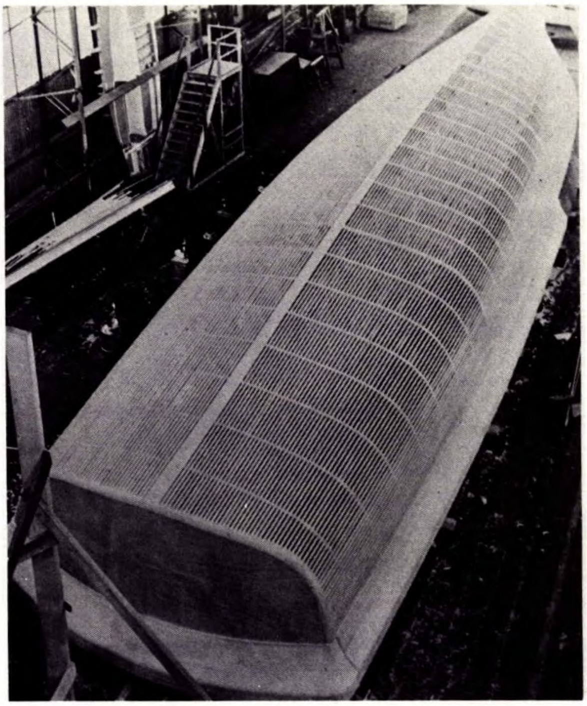


Figure 5. Slat mould for 77-foot pilot boat. Courtesy Royal Netherlands Navy.

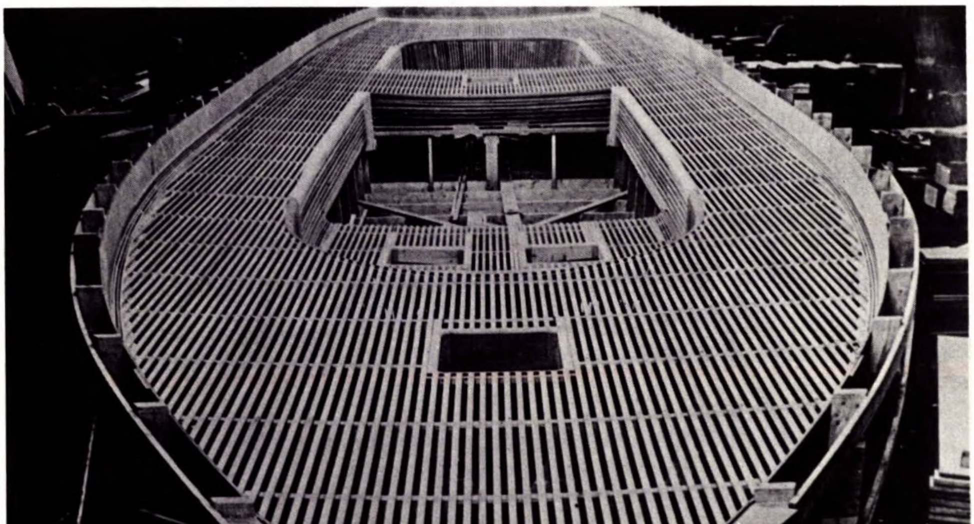


Figure 6. Slat deck mould for 77-foot pilot boat. Courtesy Royal Netherlands Navy.

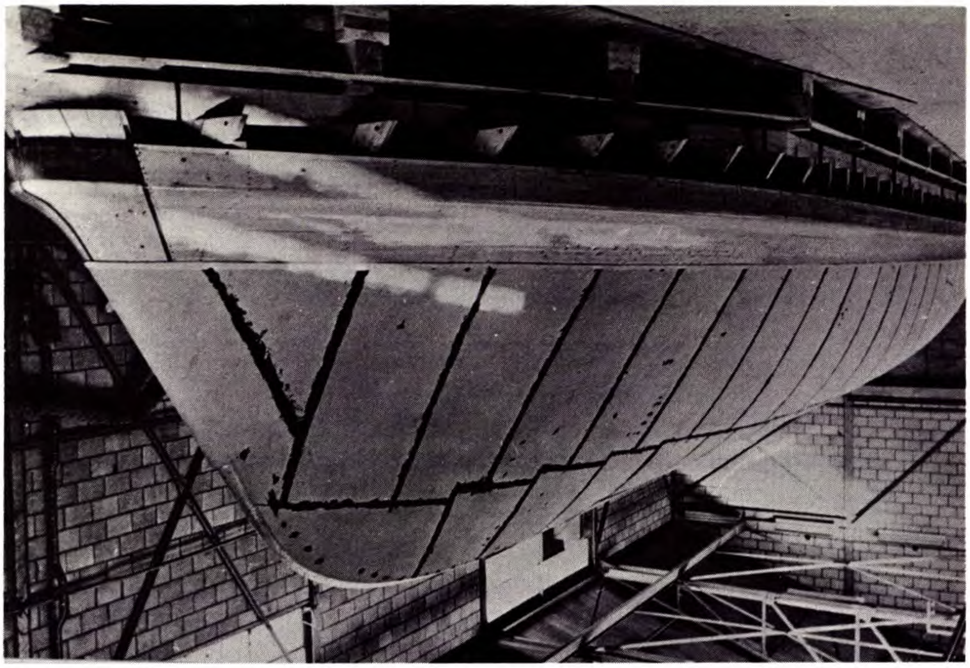


Figure 7. Completed hull core on slat mould, 77-foot pilot boat. Courtesy Royal Netherlands Navy.

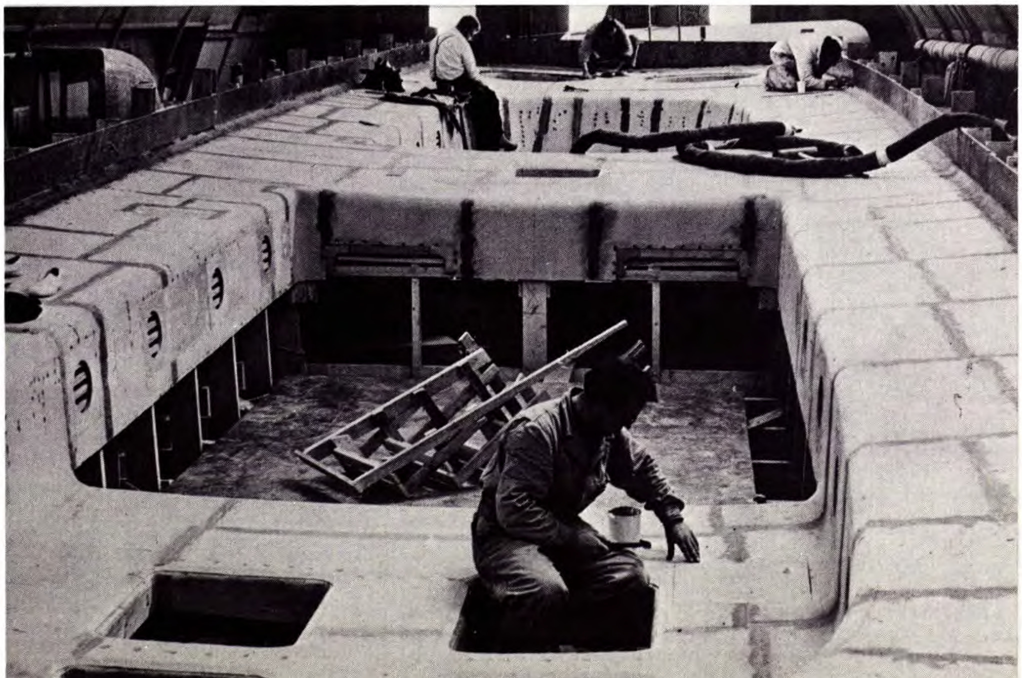


Figure 8. Completed deck core – 77-foot pilot boat. Courtesy Royal Netherlands Navy.

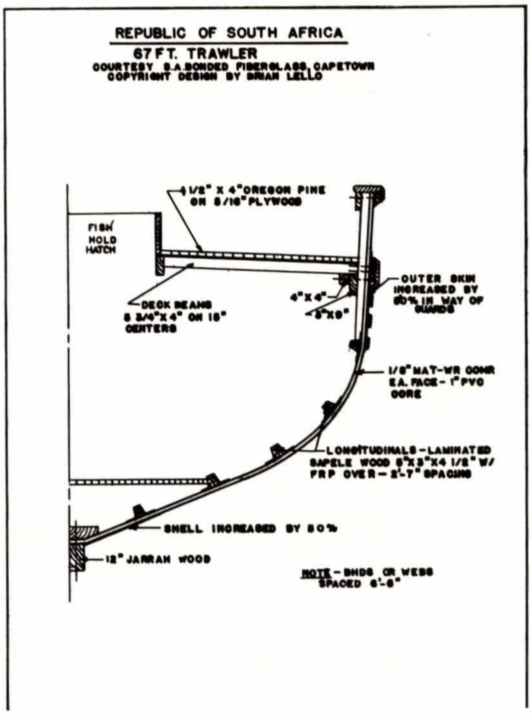


Figure 9.

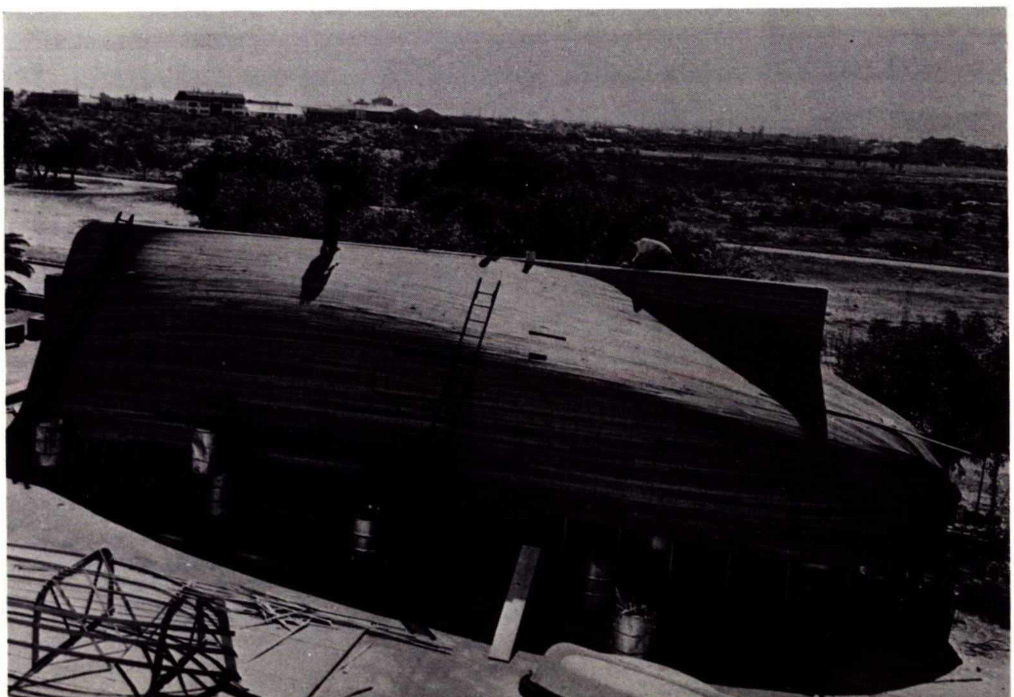


Figure 10. Male mould for 67-foot trawler. Courtesy S.A. Bonded Fiberglass, Cape Town.

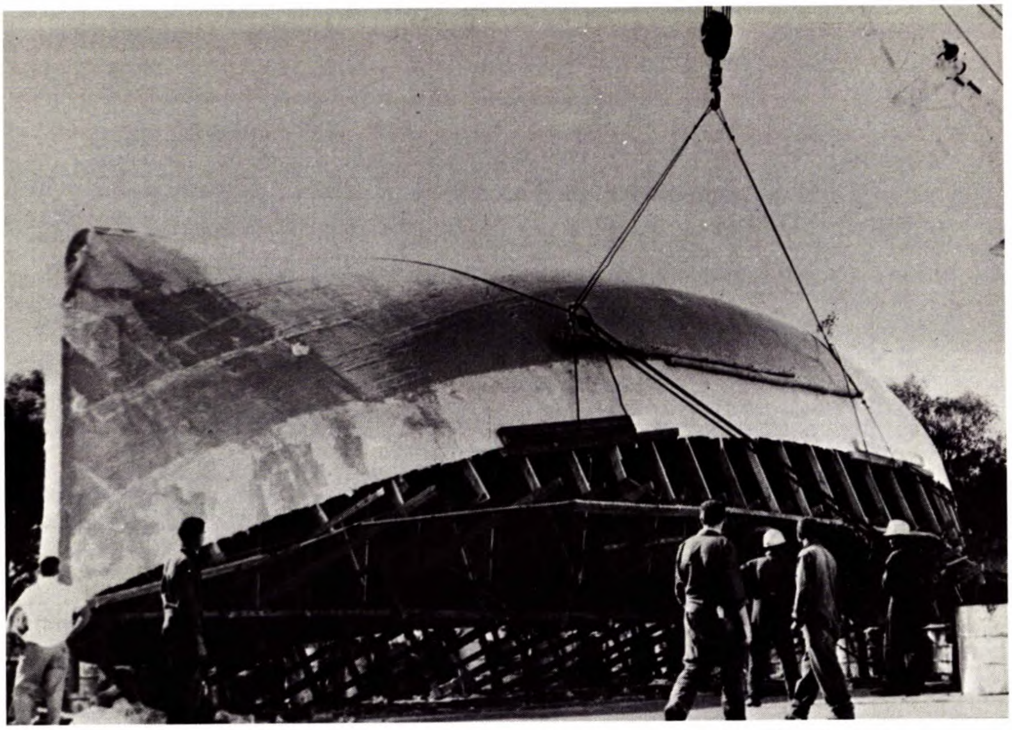


Figure 11. Inversion of 67-foot trawler hull. Courtesy S.A. Bonded Fiberglass, Cape Town.

Figure 12. Layup of inner skin – 67-foot trawler. Courtesy S.A. Bonded Fiberglass, Cape Town.

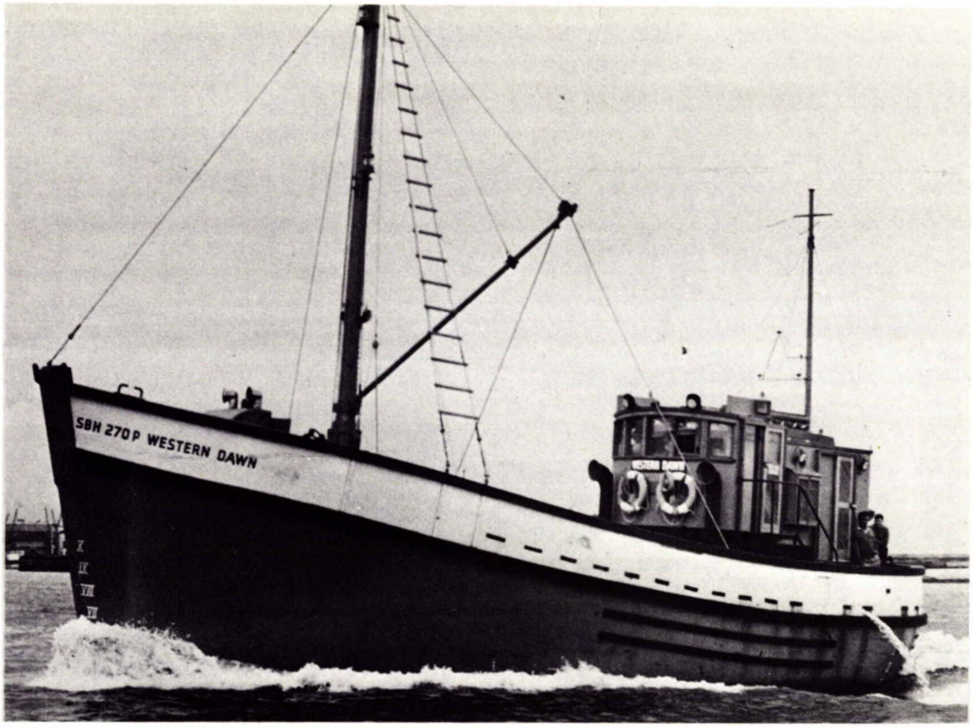


Figure 13. 67-foot PVC cored trawler. Courtesy S.A. Bonded Fiberglass, Cape Town.

Figure 14.

Figure 15. 54-foot tuna catcher. Courtesy Yamaha Hatsudoki Co. Japan.

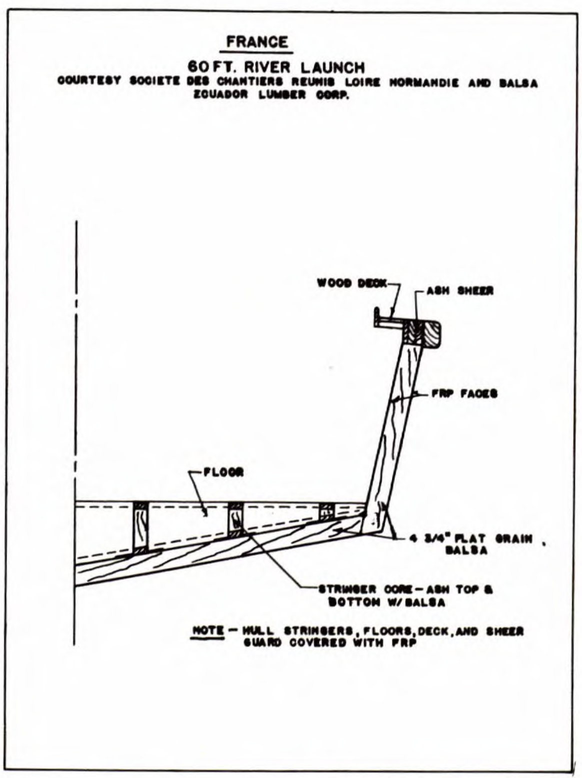


Figure 16.

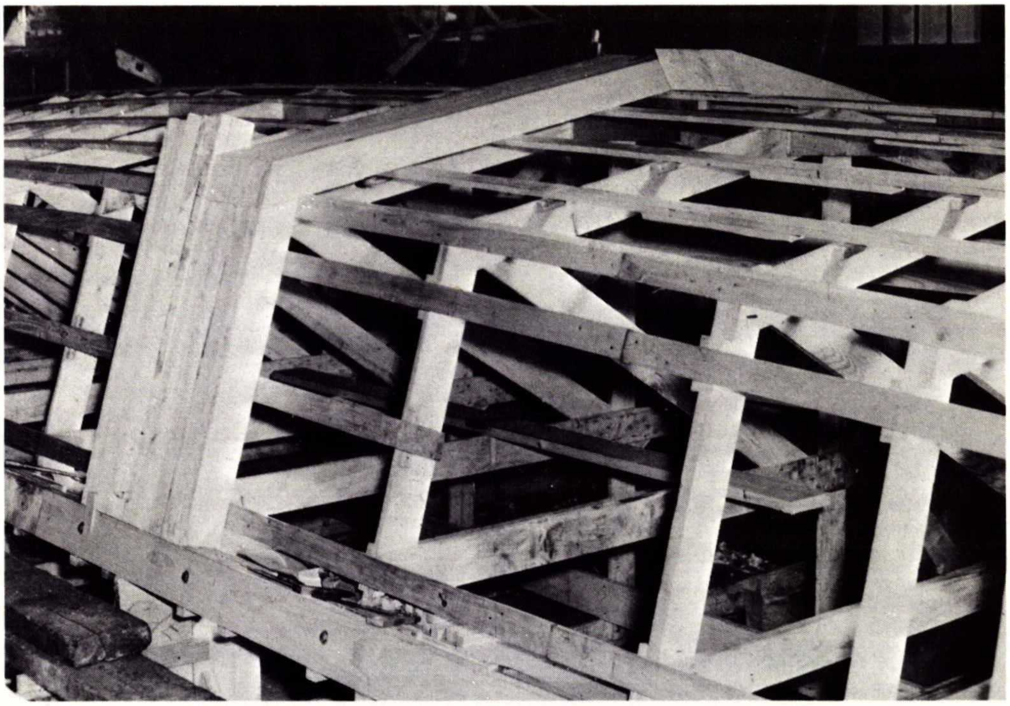


Figure 17. 60-foot river launch – core fabrication. Courtesy Societe Des Chantiers Reunis Loire Normandie, France, and Balsa Ecuador Lumber Corp., N.Y.

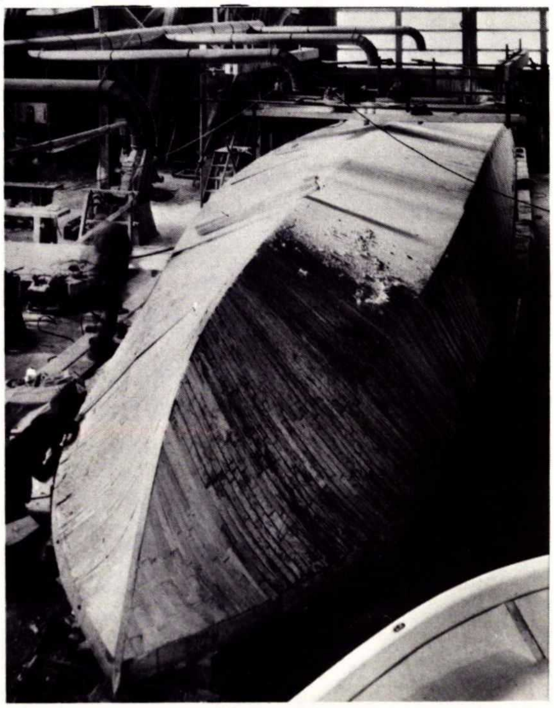


Figure 18. River launch, France – completed hull core. Courtesy Societe Des Chantiers Reunis Loire Normandie, France, and Balsa Ecuador Lumber Corp., N.Y.

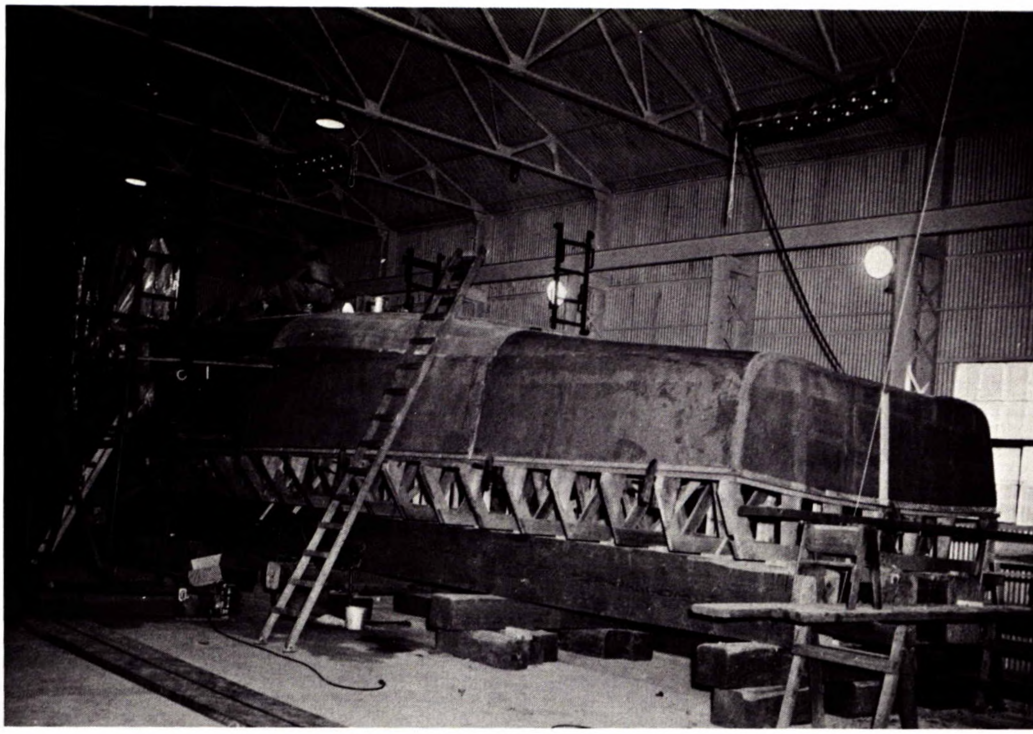


Figure 19. 57-foot XMSB-23. Honeycomb core on male mould.

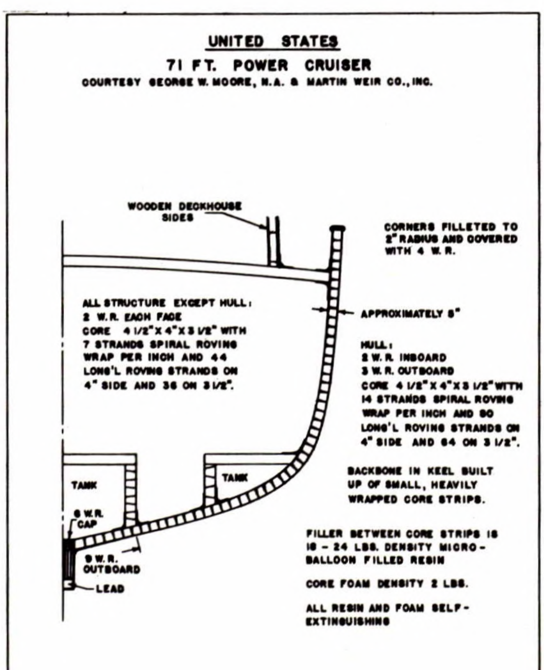


Figure 20.

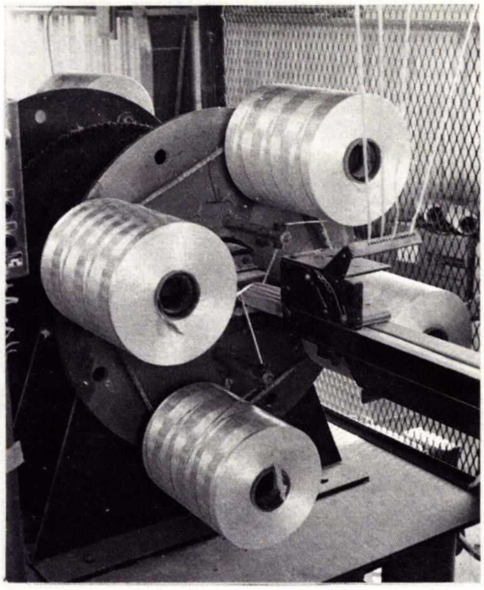


Figure 21. 71-foot power cruiser – United States – wrapping machine. Courtesy Martin Weir Co., Inc., Chula Vista,

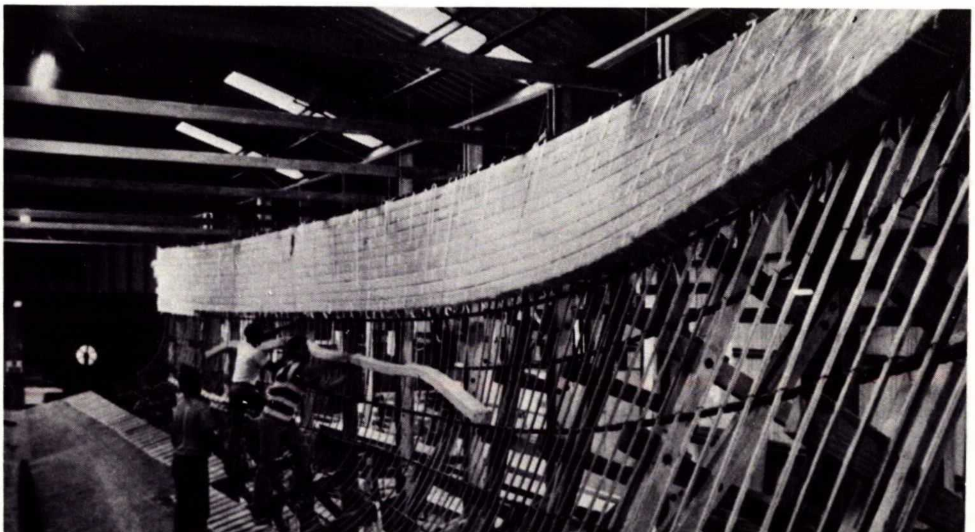


Figure 22. 71-foot power cruiser – United States – core fabrication. Courtesy Martin Weir Co., Inc., Chula Vista, Cal.

TABLE A

110 FT. TRAWLER DESIGNS – COMPARATIVE DATA
COURTESY R.J.DELLA ROCCA, GIBBS & COX, INC.
FROM REFERENCE NO. 13

	WOOD	STEEL	FRP SINGLE SKIN	FRP SANDWICH
WT./FT. AMIDSHIPS – LBS.	1500	1510	700	770
HOLD AREA INSIDE SHEATHING – FT²	200	220	230	234
MAX. HULL STRESS-LBS/IN²	170	2190	800	810
SAFETY FACTOR ON ULTIMATE STRENGTH	38	27	21	21
HULL STRUCTURAL WT.-TON.	120	130	71	75
LIGHT SHIP WT. – TONS	232	233	168	173
MATERIAL COST/TON- $	250	200	880	1240
HULL MATERIAL COST- $	38,300	32,960	79,100	117,700
HULL.LABOR COST – $	58,500	62,800	30,800	44,800
MOLD COST- $			85,000	60,000
TOTAL COST–ONE BOAT	319,700	322,200	394,700	439,800
TOTAL COST–EACH BOAT IN LOT OF 5	290,500	289,300	304,500	365,500

Figure 23.

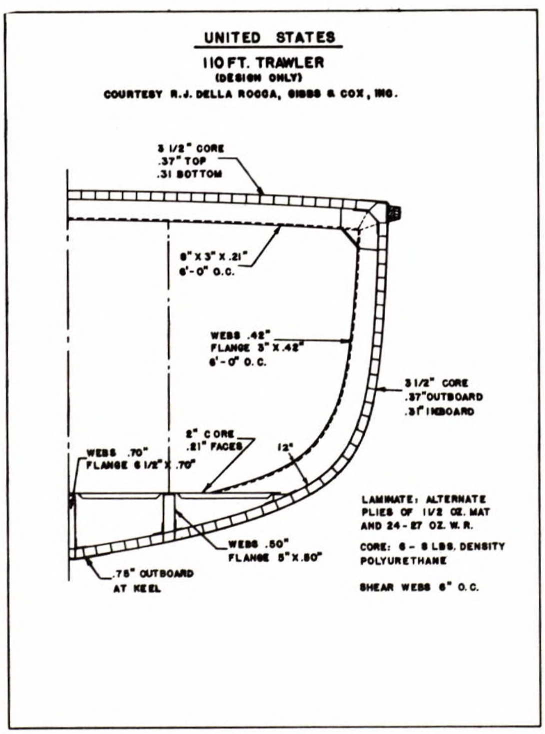


Figure 24.

Session 5

SYMPOSIUM DISCUSSION

Professor Benford: "To get the ball rolling, I think I will ask each of you gentlemen if you would be frank enough to admit to the weak points in the material that you advocate. I realize that some of you do not pretend to be advocates of any given material, but if Mr. Brandlmayr for example would represent plywood, and so forth, I would appreciate it. Let's go down the line and admit what shortcomings may be in your material and what particular combination of circumstances you would recommend against using it. I hope none of you will get fired as a result of this. Mr. Elder, do you want to start? "

Mr. Elder: "First of all, I am very hot under the collar at your questions. I think steel perhaps is the established material in the larger vessels at least." Professor Benford: "Would you admit it corrodes? " Mr. Elder: "Yes, there is a corrosion problem. However, with sandblasting techniques and inorganic zinc silicates, I don't think the problem exists to the extent that it did previously. The steel companies might well supply the shipbuilder with a pre-blasted steel complete with primer coat. This would cut the cost to the shipbuilder and the customer." Professor Benford then asked Mr. Elder if he would buy a steel rowboat. Mr. Elder said he did not think so. Professor Benford: "I think there is a lower limit on where you build a steel boat, eh? " Mr. Edler: "I think perhaps below 65 feet as some papers indicate; I think below that it's a big ball game: fiberglass, plywood, wood, and ferro-cement, which seems to have caught the imagination of many. However, over 65 feet I think steel will still offer a very competitive medium for fishing vessel construction."

Professor Benford: "Mr. Hines, are you willing to admit to any shortcomings in wood as a fishing boat material? " Mr. Hines: "The only limitation that I can see in respect to wood is that when you get beyond 100 feet it does become difficult to cope with certain problems. They can be handled, but in our particular area, up to 100 feet over-all, only the very new building materials, I think, will compete with what we have."

Professor Benford: "Let's move on to Mr. Brandlmayr. What about plywood? Any flies in the ointment there? " Mr. Brandlmayr: "Well, plywood requires protection from abrasion first. It has to be handled carefully, so as to avoid rot, and you might still be faced with this. It is used in a secondary sense in most boats. I just checked with Mr. Hagenbach, who tells me that even his concrete boats have some plywood in them in the door fronts or similar uses. I think the secondary uses are going to be most important, rather than for the hulls themselves."

Professor Benford: "Thank you. Mr. Campbell" Mr. Campbell: "The main thing I think that aluminum has been lacking over the last few years has been an economics professor to explain the financial aspects, because you are dealing with a premium product here. You have one-third the weight of most steels and it is very durable. You put on some bi-metallic fittings, and aluminum, as you know, may appear to be inert; the surface of it is. It is, however, an extremely active metal and when you do make the wrong type of joint, such as with bi-metallic fittings, you can get galvanic corrosion and you've got a real hell-cat on your hands. You have to watch that very carefully.

"Aluminum is strong and we get good welded strengths. You do have to watch fatigue in your engine seatings and at your shaft log. But from a fatigue point of view it's not too bad." Professor Benford: "Mr. Hagenbach's opening statement was a euphemism for the fact that aluminum is expensive. He feels the need of rational economic analysis to convince owners that the future savings more than offset high material costs."

Professor Benford then asked Mr. Hagenbach if he was willing to admit to any possible shortcomings in ferro-cement as a fishing boat material. Mr. Hagenbach: "I think, with regard to ferro-cement, we have so far not produced a dud, but at this stage we would not build above 70 feet. We have gone ahead very slowly. I would say the material is not suitable for any craft that are not displacement craft. I think we score on all other things – durability, maintenance, ease of fabrication, ease of joining, etc. With regard to operational conditions, we have had two craft locked in 18 inches of ice; I see ice especially mentioned here, and a man talked to me yesterday about blue ice, which completely terrified me, but we don't have it in England, so I can't speak on that.

"With regard to production circumstances, of course we don't need skilled labour, and we don't need sophisticated plants. In overseas plants we must have protection from direct sun and we must have an ample supply of water. I can't say much about capital facilities. With regard to owners' prejudices, when we made the first vessels we couldn't give them away. So we have had any amount of skepticism and prejudice, but this Convention has done much to break that down. Not much cost and technical data are available. I am afraid all builders are a bit cagey and everyone disagrees with everyone else. With regard to appearance, if you don't paint them they look revolting."

Professor Benford: "Thank you very much. That was straightforward and to the point. Mr. Eisenhauer, do you see any possible shortcomings in single skin plastics?" Mr. Eisenhauer: "Well, we can even do planing boats. The material cost is a factor, so that the use of it has to be justified in lower operating and maintenance costs. If I were to be an investor having a fishing ship built I wouldn't buy a factory ship built of single skin plastic, because the state of the art hasn't progressed into larger ships yet. I think we need to go step by step. The chopping of ice was mentioned here earlier this week. Perhaps on the lighter sections this might be a factor to consider. I am not even prepared to say it is, but certainly on the heavier sections it would be. Yes, you have to take some preventive measures against ice and abrasion. I suppose those are the major negative points I can think of."

Professor Benford: "Mr. Spaulding, how about cored plastics?" Mr. Spaulding: "Well, I think I would group the disadvantages of core into three areas – cost, core property deficiencies, and fabrication problems. The cost is three to ten times higher than a glass resin combination. Balsa will run 80¢ to $1.20 per pound. PVC averages $3.25 per pound in either a three- or a five-pound density. Polyurethane in liquid form goes for about 65¢, but in board form, say 6 to 8 pounds structural quality, about $1.00 per pound. There is no apparent reduction in these costs in the future.

"As for core property deficiencies, we have found that the greatest deficiency is shear strength, that if we went to a larger craft we simply couldn't achieve the proper panel shear strength without going to some type of shear web. We did a design study on an 86-foot boat, and found that we either had to go to 20-pound polyurethane or use 6-8-pound polyurethane with shear webs. There is a core bond problem; it is probably worse in honeycomb. Its core bonds are good in balsa wood; this is the problem with polyurethane. Polyurethane has a tendency to be somewhat brittle, which aggravates the core bond problem. Compressive strength can be a problem in the area of bolted connections or highly loaded connections. Water penetration, as I mentioned in the case of the honeycombed cored hull, is definitely a problem. Any place where you have voids we have pretty well determined you have got a good chance of getting water, unless the voids are of the type found in unicellular foam.

"Heat distortion is a problem. PVC, which has this tremendous advantage of being formable by heating, also gets formed sort of unexpectedly. If you have very high operating temperatures – deck temperatures have been recorded up to 158° – PVC deforms. You simply have to design for it; you have to provide sufficient stiffening.

"The other area is the fabrication problem. There is difficulty in joining the edges of core material to give continuity, and that is a real forming problem. PVC is the easiest, you just heat it and shape it. With the others you've got to hold them in place while you cure it, and this is not easy. It often results in core bond deficiencies. Finishing can be something of a problem, mainly in man hours. I think that pretty well covers it."

Professor Benford: "For the next part I am going to ask each of the panel members to ask any of the others an embarrassing question. I would ask you before you ask it, however, to make sure that you identify yourself so that we will have a record of who asked the dirty underhanded questions.

"Let me ask Mr. Hagenbach one. I am curious to know exactly what the difference is between Seacrete and ordinary cement construction. Is it in the method or the materials, or what?" Mr. Hagenbach: "Seacrete is ferro-cement, but not knowing what other people do with their ferro-cement I am perfectly confident, particularly from all that I have read, that there is no other ferro-cement that is Seacrete. We use seven different types of reinforcement, all of which are made to our own specifications and requirements. There was a question asked yesterday – yes, we do use additives. It is quite crazy to build a boat on a dry and hot day using the same mix as on a wet and humid day. Remember that we are setting up licensees in various climatic conditions, and the mix must be varied if you are going to get a proper result in different climatic conditions."

Mr. Eisenhauer: "I would like to toss one back to you, Mr. Chairman, if I may. I notice that all through the last two and a half days reference to the fishing industry part in this has been noticeably lacking. All this new technology has got to be paid for somehow or another, and it's the fish that swims in the water that's going to do it. We are dealing with a low profit industry that makes its return on investment by volume of sales. You, sir, have a very fine paper with a return on investment based on a discounted cash flow, which to most people who are not economists is a lot of hocus pocus, and very difficult to understand. Isn't there a simpler form of return on investment that can be relied on as much as the discounted cash flow method?"

Professor Benford: "I only advocate people taking short cuts after they have fully understood the complicated way of doing it. To try to teach people short cuts before they fully understand the fundamentals behind the thing is pretty dangerous."

EDITOR'S NOTE: *Professor Benford subsequently provided the following written response to Mr. Eisenhauer's request:*

"Pay-out period is a rough measure of merit that is often used by business men for quick judgments about investment proposals. Like any other shortcut procedure, it is often valid but not always. There are several variations applied to this criterion. The most vigorous is shown in Figure 2 of my paper. The simplified version proposed here assumes the following to be true, or nearly true:

1) All alternatives have equal lives.

2) Resale values at the end of the useful lives are relatively unimportant, being neither very large nor greatly different between the alternatives.

3) The patterns of incomes and expenses, while not necessarily uniform, are at least reasonably similar for all alternatives.

4) The best alternative before-tax will also be the best alternative after-tax.

5) The project is still in the design stage.

Given the above, our variation of the pay-out period becomes simply P ÷ A, in which P is the initial investment and A is the average annual return before tax. The latter amount is the difference between the average annual gross income and the average annual direct costs of operation including any overhead. Depreciation is not *considered as a cost in this calculation.*

"In applying the pay-out period criterion, we seek that alternative promising the quickest return of the investment, that is, the minimum pay-out period."

"If we make the additional assumption that the boat will last for 15 years, then the pay-out period–as defined here–should be no more than 7 years if the owner is within the 21 percent tax bracket, and no more than 5 years if he is within the 50 percent bracket. Those are the approximate times corresponding to a 10 percent yield on total investment. If the owner wants a 15 percent yield, and is in the 50 percent tax bracket, the corresponding pay-out period becomes roughly 3.5 years."

Continuing the discussion, Professor Benford said: "I would like to encourage those of you who know about boat building costs to emulate Mr. Fraser and publish them. I think that keeping costs as little black book secrets is something we should abolish. There is nothing to be ashamed of in a good cost estimate. Why keep it secret? If you are an experienced shipyard, and you really know how much it costs to build a boat, why not let people know? You are protecting yourself against another boatyard's underbidding you through ignorance; you are protecting the ignorant boatyard from losing money on a contract; you are protecting the owner from having a boat built at a yard that's losing money. Finally, you are benefiting researchers like myself. I would like to encourage the support of research in this area. Again, this benefits everybody. You benefit the owner by giving him a more competitive fish boat. You benefit the shipyard because by accelerating technological innovations, existing boats become obsolete sooner and have to be replaced sooner, so you get to build more boats. If you do this research at educational institutions you have an important secondary benefit in attracting and supporting graduate students, who usually help the professors in that kind of research. I think everyone will agree that the fishing industry does need more bright-eyed people.

"For those of you who are interested in furthering your knowledge in this area of ship economics, we have a lot of literature available at the University of Michigan. I think it's pretty good literature. We do sell it, and I hate to get so commercial here but if you will write to me at the University of Michigan at Ann Arbor, I can send you a list of the available literature.

"I want to thank all the panel members for their very good work. They are going to stay up here incidentally and field questions from the floor. I also cannot resist the opportunity to compliment and thank the Secretariat who, I think, put on a very splendidly run show, very carefully thought out and very carefully planned. As a token of thanks, gentlemen, I would like to suggest a title for your Proceedings. I saw a book the other day with a title that could be modified to suit your purposes. The name of it would then be 'The Truth about Fish Boat Materials and Other Lies'."

Mr. Pierre Guay, Fisheries Division, Department of Industry and Commerce, Quebec, asked Mr. Brandlmayr to comment on nylon sheeting as a covering material for plywood. Mr. Brandlmayr replied: "We have not had enough experience with this on the west coast. Nylon is more flexible and may have some advantages, but currently we are using fiberglass."

Mr. Saethre, D.N.V., asked Mr. Hagenbach: "On Norwegian road bridges built in concrete it is found that the combination of temperatures below zero, and salt used to remove ice, has resulted in serious *erosion of the concrete. Might similar problems arise for ferro-cement boats in a marine atmosphere?" Mr. Hagenbach: "Positively no, sir! We have been doing research in the cyrogenics field, and we have containers that have withstood temperatures of -160° Centigrade."*

Mr. L.L. Watson, of West Sacramento, California, said that in the interest of a more complete understanding of the ferro-cement field, he felt obligated to report that five affiliated companies in the United States were producing ferro-cement boats, barges and marine floats by a method quite different from those presented so far. This method, he said, was especially adapted to mass production and utilizes a single surface mould and a modified gunnite system. "No welding of steel is required, and a greater steel content is possible without the attendant penetration problems. Single skin or double skin cored hulls may be produced. For example, four men working an eight-hour day have fabricated and launched a pair of 6' X 60' X 3' floats each day, a total production of 36 tons per day. We believe that these techniques will be of significant value to fishing industries of Canada and the world."

Professor Benford made the following statement to the assembly: "Looking to the future, what new materials or processes do you see? For example, steel fibres in plastic or concrete, aluminum - explosion bonded to steel? We have been talking here about technologies that are with us today. I think we ought to be looking to the future too, and considering what possibilities exist."

Mr. Sutherland: "My interest in this is as a civil engineer, and associated with the concrete industry. I think some of the points that have been raised here today and in the last two or three days have been very interesting indeed. Sitting down listening this morning I can't help feeling that there is a far greater wealth of knowledge in this room now than I have seen ever before put together for the particular problems that are in mind. Professor Benford asks about the explosive problems, one of which was raised yesterday in the use of wire in plastics. Strange as it may seem, and quite by chance, I have been dealing with the effects of earthquakes on multi-storey concrete buildings and bridges, and I have been intrigued by some of the questions such as one from Det norske Veritas. This has been dealt with fairly well, and I am sure it has been very fully covered in standard concreting techniques through the concrete institutes.

"On the question of explosives, I could just mention that I can provide quite a lot of information if anyone would like it, or I can put you in contact with the people who have been doing research on it. I have been associated with a person who has been exploding various steel shapes, mainly because we haven't got any presses in New Zealand that will bend, or equipment that can produce domed ends for pressure tanks, so that has set a problem, and there is information there." Mr. Sutherland also mentioned the introduction of wire fibres in cement and plastics, which he said could be done and would probably be applied before long. He continued: "The most interesting thing, I think, which has come out of this, is that every one of us, or most of us, and the industries, are trying to sell or promote their own material. I have a concrete boat, and I think I explained that it has wooden cabin tops, with fiberglass on those; it has an aluminum mast, and my particular interest is to try to see how you can take all of the techniques that you have got here now, and combine them into one common interest, and I think that if nothing else comes out of this conference it will probably be a getting together, but not as a concrete or a fiberglass institute." He spoke of combining all of the materials and using them where they were most applicable, if possible combining them into one form. "Maybe concrete is the proper solution as the ideal core material, with fiberglass."

Professor Benford said there apparently had been a slight misunderstanding. He appreciated what Mr. Sutherland had said about explosion forming, but said he himself was talking about a recent Dupont development in which explosions had been used to force aluminum to bond to steel. A thin layer of aluminum over steel was forced into molecular contact with the steel by explosive techniques.

Mr. Benford also referred to an experiment in which concrete was poured over a rubber diaphragm, the edges of which were held to the ground. While the concrete was still wet, the diaphragm was inflated to make a beautiful concrete igloo. "I couldn't believe the way the cement stayed on – it didn't slide off. There might conceivably be an application of this to boat forming."

Referring to the Dupont product (an aluminum steel sandwich), Professor Benford said the main application envisaged was to join aluminum deck houses to steel ships.

Mr. J. Rycroft, Department of Fisheries, Ottawa said, "While we are on the subject of new materials, there are panels composed of compacted wood chips now on the market in Canada under various trade names. Would any of the gentlemen on the panel care to comment on the possibilities of this type of material in fishing boat construction?"

Mr. Brandlmayr said he was familiar with such a product, a material produced in Saskatchewan, called aspenite. He said it was stable, lighter than plywood, somewhere in the 20-25 pounds per cubic foot range, and could be used as a core material.

Mr. T. Johannsen, Chemacryl Plastics Ltd., Toronto, asked Mr. Eisenhauer if there was any influence on the taste of fish resulting from an FRP laminate which was not completely cured.

Mr. Eisenhauer: "We have not had any experience with that because any time we line a fish hold it is completely cured before the fish go into it. I know the brewing industry is very conscious of this, and temper their desire for reinforced plastic tanks because they are afraid that perhaps they will not be completely cured out, but I think that reliable laminators with good quality control measures should not line a fish hold that will contain uncured resin."

Mr. D.J. Fraser addressed the following question to Professor Benford and Mr. Eisenhauer: "Steel fishing vessels up to about 120 feet LOA are limited by displacement weight, therefore it is difficult to maintain constant capacity by change of dimension. How would you attempt it in view of the radical changes in the main dimension that would be required to meet both stability and free board requirements?"

Professor Benford: "When you can save weight in hull material, you can re-design the boat. You do not need as much displacement as you did before in order to carry the same amount of fish. You start out by making the hull somewhat shorter. That is always the best way to save money. You want to hold the volume for the fish, of course, so you probably have to increase the freeboard. This leads to stability problems, so you increase the beam. A shorter, deeper, wider ship is usually much cheaper to build than one of more normal proportions. You do run into certain things that get perhaps into an intangible area in that the new boat is perhaps less able to maintain speed in a seaway, and here you get into a grey area that is not well defined. However, my main contention is that any time you can save weight in building a boat you can indeed convert it into a smaller boat that will, in essence, do the same job. For such vessels as ore carriers and tankers you just take on the saving in weight by adding to your deadweight capacity, that is, your cargo carrying capacity, but in a fishboat or any other where the availability of what you are to bring back is limited, it is better to redesign the boat to train the functional capability."

Mr. Ullman Kilgore, Research Engineer, Department of Naval Architecture and Marine Engineering, University of Michigan, provided, in written form, the following addition to the discussion of Professor Benford's remarks on economic criteria in fish boat design:

"These comments pertain to the NPV criterion and to the question of working capital.

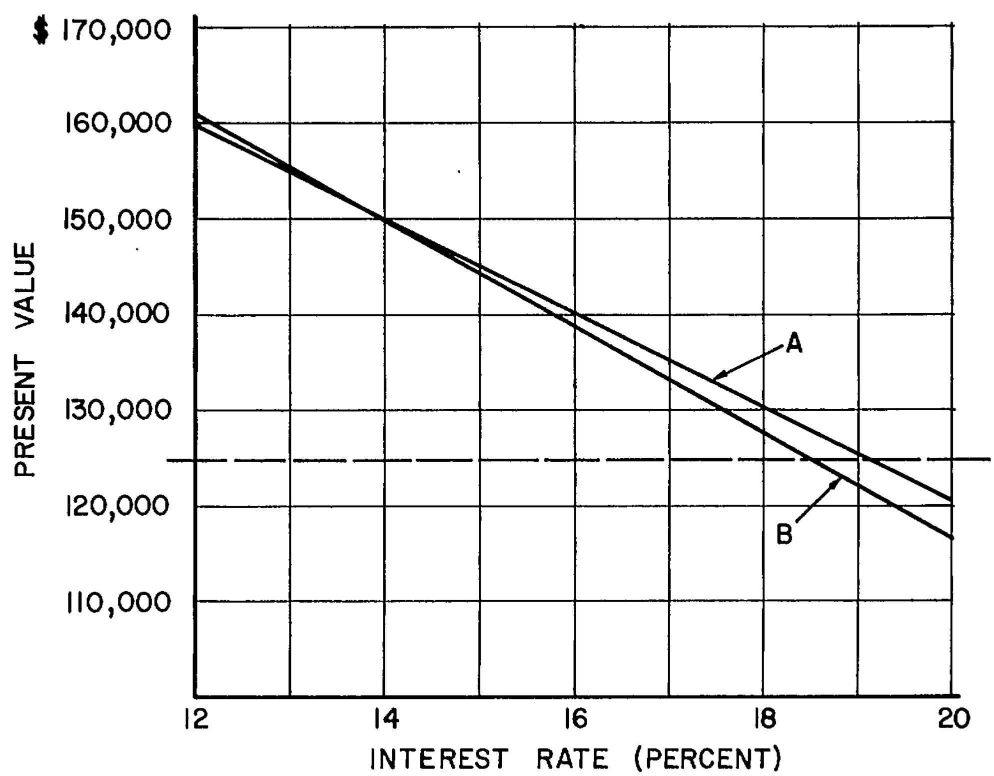
"NPV – Its proponents grant that NPV favors the most expensive investments but claim that in case of ample capital and limited opportunities it will lead to the wisest choice. Any such general assertion becomes doubtful at large if shown invalid in a single instance.

"Consider the investor who has $125,000 in ready cash. He is to be allowed one boat, and one only. The life of each investment is to be 10 years. Of course, he will invest his entire capital in some combination of productive ventures. He thinks 'cost of capital' is 12 percent.

"Under alternative A, he may purchase Boat A for $100,000 and invest $25,000 in 6-percent, 10-year bonds. Boat A is generously large, but not new, has a second-hand engine, and will start requiring repairs in its second year. A $15,000 overhaul will be necessary in the fifth year. Resale value will be $15,000 in the tenth year. Due to frequent repairs and lost fishing time, operating profit will fluctuate as shown in Table I, where present value is calculated. (The purpose of calculating PV at 20% is to obtain the actual yield by interpolation.)

"Boat B is smaller but of top quality. Her cost new is $125,000, but thereafter the owner will be free from repair bills and will never lose a day of fishing. Net operating profit will be steadily $26,500 each year, and at the end of 10 years Boat B will have a resale value of $35,000. Her present values (at 12% and 20%) are shown in Table II.

"At 12 percent, Investment Plan B has a NPV of $35,988, while A is worth only $34,844, so that if the investor has faith in the NPV criterion he will choose B – and thereby make 18.5 percent on his $125,000 when he could have made 19.1 percent by Investment Plan A.



"Working Capital – Whether or not required working capital can be or should be ignored by engineering analysts, they in fact do usually ignore it. Leaving this consideration up to the final decision-maker may be proper, but I believe the professional obligation of the engineering economist is to call attention to the effect of required working capital where it clearly is a decisive factor. Instances are hard to find in comparison of fishing boats, where usually no inventory, no accounts receivable, and very little cash are required. Any lag between time of recurring outgo for labor, materials, or maintenance and of income from catch produces a need for working capital. For example, evaluation of a factory ship operation, where the pack must be sold after landing and after payment of all trip expenses would not be complete until required working capital had been accounted for.

Table I

Present value of Investment A where boat costs $100,000 and $25,000 is invested in 6-percent, 10-year bonds. Major overhaul in 5th year. Boat sold for $15,000, and bonds cashed, in 10th year.

Dollar figures are in thousands.

Note: Gross in year 10 includes catch plus proceeds of boat and bonds.

Yr	Gross.	Exp.	Op. Net	Bond Int.	Tot. Inc.	PWF_{12}	PV_{12}	PWF_{20}	PV_{20}
1	$ 50	$ 20	$ 30	$ 1.5	$ 31.5	.8929	$ 28.126	.8333	$ 26.249
2	50	21	29	1.5	30.5	.7972	24.315	.6944	21.179
3	48	24	24	1.5	25.5	.7118	18.151	.5787	17.757
4	48	25	23	1.5	24.5	.6355	15.570	.4823	11.816
5	46	37	9	1.5	10.5	.5674	5.958	.4019	4.220
6	50	20	30	1.5	31.5	.5066	15.958	.3349	10.549
7	50	21	29	1.5	30.5	.4523	13.795	.2791	8.513
8	48	24	24	1.5	25.5	.4039	10.299	.2326	5.931
9	48	25	23	1.5	24.5	.3606	8.835	.1938	4.748
10	85	28	57	1.5	58.5	.3220	18.837	.1615	9.448
	Present Value (12%)						$159.844		

Present Value (20%) $ 120.410

By interpolation, actual yield on investment is 19.1 percent.

Table II

Present value of Investment B. Boat costs $125,000, resale for $35,000 in 10 years. Operating net profit steady at $26,500 per year.

12% : CR = .1770 ; PW = .3220
20% : CR = .2385 ; PW = .1615

PV at 12% = 26,500/.1770 + (35,000) (.3220) = $160.988 (Thousands of $)
PV at 20% = 25,500/.2385 + (35,000) (.1615) = $116.764

Interpolated yield: 18.5%

Mr. Hans F. Muhlert, student in the Department of Naval Architecture and Marine Engineering at the University of Michigan, provided the following written comments on Mr. Hagenbach's paper on ferro-cement boats:

My principal criticism of this paper, indeed of most papers on ferro-cement that I have encountered, is the lack of quantitative information. I cannot help but believe that, until the properties of ferro-cement are accurately determined, and until rational analysis and synthesis methods are discovered or devised, the *design of ferro-cement structures will be a haphazard and approximate undertaking. We must begin to express our knowledge in terms of numbers.*

The results of a lack of understanding of this particular material are clear. Structures designed by "experience" or "eyeball" are in danger of being either underdesigned and unsafe, or overdesigned and wasteful of manpower and materials. In either case, a poor investment is the result. Therefore, I suggest the following approach (figure 1):

First, the material properties of the components are to be determined. In this case these would be the mortar, the wire mesh, the rods, etc.

Then a rational method of synthesizing these components and of analysing any given composition should be either adapted from existing technology or devised from scratch.

Having done the foregoing, one is in a position to design the structure. Then a feasibility study can be conducted and ultimately the structure can be fabricated.

It is my belief that all too often the foregoing flow diagram (figure 1) is, in effect, entered somewhere in the middle rather than at the top, or that the steps are not taken in order.

For the first step, the following values were obtained from tests at The University of Michigan by N. Jergovich, J. Coleman, and myself:

The second step involves a rational analysis and synthesis technique of the composition. The following technique is one that I am currently investigating:

Two basic assumptions are made:

1) *ferro-cement is a non-homogeneous material*
2) *standard reinforced concrete techniques are applicable*

"Proceeding on these assumptions the cross section of ferro-cement member is studied in detail. The neutral axis is found by assuming that the mortar is only effective in compression and by taking into account the exact location and amount of steel. Then, assuming strains are equal in the mortar and steel at a given distance from the neutral axis, the stress can be found at any distance from the neutral axis both in the mortar and in the steel.

"Using this method, I predicted the stress for failure for a number of ferro-cement specimens to be that stress at which the outer steel fibers would fail in tension. Keeping in mind that the ultimate tensile stress of the wire mesh is 107,000 psi please observe figure 3 showing the results of three bending tests.

"With this technique the structural design can be approached. I feel that in this area much can be learned from fiberglass construction techniques, for ferro-cement is very similar to fiberglass. Both consist of a network of fibers held together and made impervious to water with an adhesive.

"The last two steps follow in order, and there is no need to elaborate on them except to emphasize, as Mr. Hagenbach has, that **all** *costs, including labor and overhead, should be accounted for in the feasibility study. Also the study should encompass the life of the vessel, not just its construction.*

"In conclusion, I want to say that I respect the time and effort that Mr. Hagenbach has put into this interesting paper, and that I acknowledge his authority on this subject, stemming from his extensive practical experience, which I, unfortunately, cannot claim to have."

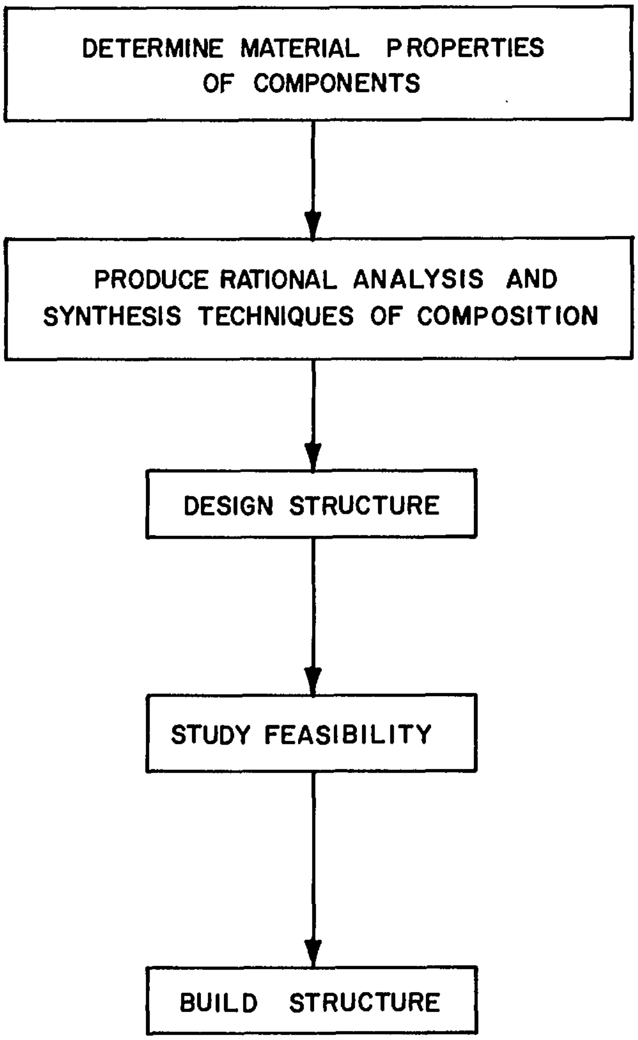


FIGURE I

MATERIAL PROPERTIES OF COMPONENTS

Mortar

Composition used:

cement	*16.5 lbs*
pozzolan	*4.5 lbs*
sand	*30.0 lbs*
water	*3500.0 cc*

Ultimate compressive stress:

$\sigma_{\mu} = 4{,}760$ *psi (after 7 days)*

Steel Rod Reinforcing

1/4 in. hot rolled steel rods (no deformations):

Yield stress:

$\sigma_{\mu \bar{y}} = 39{,}800$ *psi*

Ultimate tensile stress:

$\sigma_{\mu} = 62{,}600$ *psi*

3/16 in. cold rolled steel rods (no deformations):

Ultimate tensile stress:

$\sigma_{\mu} = 90{,}800$ *psi*

Wire Mesh

19 gage 1/2 in. x 1/2 in. galvanized hardware cloth:

Yield stress:

$\sigma_{\mu} = 91{,}800$ *psi*

Ultimate tensile stress:

$\sigma_{\mu} = 107{,}000$ *psi*

Figure 2

SEPTEMBER 26, 1968
HANS F. MUHLERT

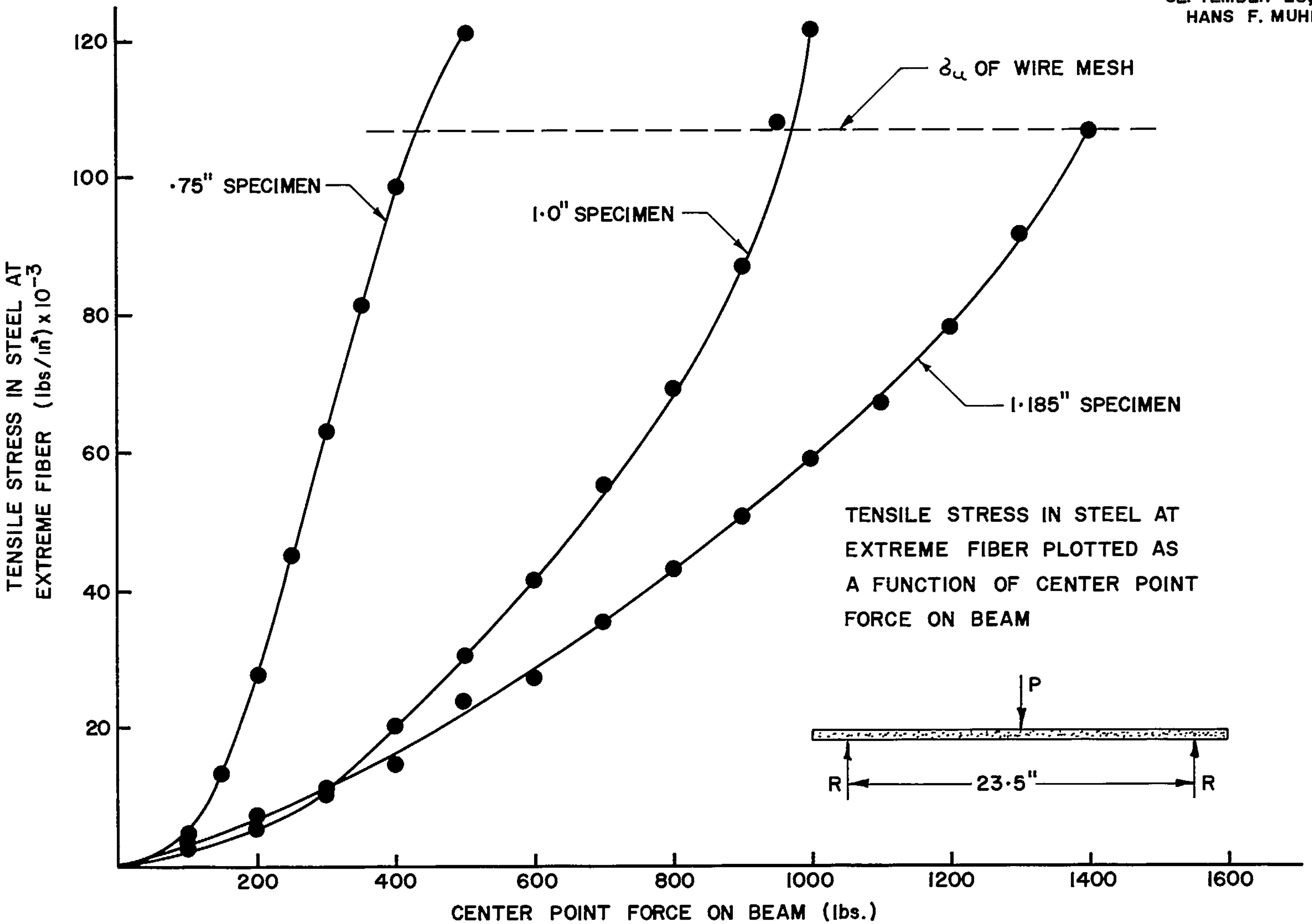


FIGURE 3

General Remarks on Conference

by

Jan-Olof Traung

Mr. Traung: "I had the first word, and I almost think it's a shame that I should have the last word. What we are all aiming at is what Professor Benford called 'profitability', or what I try to call 'effectiveness'. Both words mean naturally that the fishing vessels would make more money and that the crews would also make more money.

"One of the problems with the industry now is that not too much money is being made, at least not by the fishing vessel owners, because the problem which we faced when we tried to prove, Mr. Gulbrandsen and I, that the great influence of the cost of material was how little profit really was made on these fishing vessels.

"We have made an average of statistics given by Mr. John Proskie, of the Department of Fisheries of Canada, and we found that out of 102 vessels the amount paid for taxes and interest was only three per cent of the total expenditure for those vessels. In other words, if they first paid interest and then on top of that paid taxes and the total was three per cent, there is really no tax problem in the fishing industry.

"The whole problem of the economy in the fishing industry is no doubt extremely important, and I do realize that the economic language we used in our paper was perhaps not the proper one. I must also admit that I did not submit the paper for screening by the FAO Economics and Products Division, which might have had several things to add both with regard to the economics of the paper and my lack of favouring one or the other material for the lining of the fish hold. The point I am trying to make, however, is that FAO is contemplating next year, or the year after next, a rather large Conference on the whole problem of investment in the fishing industry, and you can take my word for it, that one man who is going to be approached to try to put across the naval architects' views on economics will be Professor Benford.

"I think another thing has gone through this meeting which has gone through meetings before concerning fishing vessels, and that is that they all talk about how strong vessels we want to have but nobody knows really how strong. When somebody was complaining about the fact that nobody had been talking during this meeting about the use of hides over wooden frames like the Eskimo uses, I came to think about one very simple way of finding out local stresses, at least on a model scale, in a fishing boat. I think about a method which was used by a colleague of mine, Dr. Schärfe, one of the world's best experts on how to design an efficient trawl. He took in various places of the trawl and made small loops of very soft copper threads, and when that trawl had been working in the water he studied the elongation of the copper wire and he found that the stresses in the trawl were at completely different places than the trawl makers had thought.

"Perhaps if somebody made a small kyak, not covered with hides but with, say, some elastic nylon sheets, and put up similar small loops of copper wire, he could make a first attempt to see where the stresses were in a boat working in a seaway.

"That brings me to the point and the suggestion I want to make, which is why I am really standing here, that it is time that somebody sponsored the instrumentation of a couple of fishing vessels by strain gauges so we really could see if the stresses are where we think. I would suggest, for example, a high liner on the west coast and another high liner on the east coast. It would carry out tests for a year or so. I understand this doesn't have to be too complicated if it is organized the right way. The captain could switch on the system when he is meeting severe weather and he could then measure both what is happening in the shell plating and measure the waves themselves, and it could then all be analysed by the help of tape readers, computers, etc., at some Department of Naval Architecture. I guess such a test has to be done with a vessel built of material like steel, and it should be done by a hard driving skipper so that you are really seeing the forces which are happening.

"We have heard a lot about ferro-concrete during this meeting, and it is obvious that the ferro-concrete builders today, in order to be on the safe side, are perhaps building heavier than necessary. I think those people, even if the other tests were made on steel vessels, could learn quite a lot from such tests. Also, classification societies like Det norske Veritas could learn a lot, because as far as I understand the present investigations they are doing are just in static conditions, and not even considering the pressures – the over-pressures and the under-pressures which do happen when a fishing vessel travels along at a speed length ratio of 1.0 and more, and where rather large stresses are happening along the hull.

"I hate to come to back to profitability, but I still think crew costs are very high in the fishing operations carried out not only in Canada but in most countries. The average expenditure for the crew cost of the 102 Proskie vessels was not less than 38 per cent. I believe the average crew of these vessels was something like 3.8. You do realize that if you can cut out one phase of four you can cut out one crew member, and you would reduce the total expenditure by nine per cent. That speaks very highly for those men in Canada who conceived the idea of organizing a Conference on Automation and Mechanization in the fishing industry. I think we can expect very important results from such a Congress.

"Some people here have spoken about the future. May I say a few words about the future as we see it from FAO in the choice of materials. We naturally deal with developing countries, and there is a reason why we, for example, are now building a ferro-concrete fishing boat in Thailand and are trying to interest the government of Thailand to take up such construction. In a country where they have the best boat building material in wood in the whole world, Bangkok teak, it is natural that Bangkok teak is hard currency and sand is not. That goes for all those countries where we are working; in India, in Thailand, and all those places. There is plenty of excellent wood, much better wood than you've got in Canada. But it can be exported and it can bring in foreign currency, and if you can introduce ferro-concrete, it is one way of helping these people a bit more quickly.

"The reason why we are not interested in polyester is the difficulty in curing it and keeping it under hot conditions, and keeping temperatures during manufacture within the prescribed limits.

"A last word. People talk a lot here about mass production. We are a couple of old fashioned naval architects here who have seen such tremendous developments in the fishing industry during the last ten or twenty years that we cannot imagine that we can stop here and standardize and start thinking of building 25 or 50 from the same mould. We still believe there is lots of room for improvement, and therefore the argument that a certain material is better from the mass production point of view, I don't think is an argument in favour of that material in the fishing vessel field. It might be in the pleasure boat field where the consumption of units build it much larger.

"The Canadian government has been too good to the world in organizing this Congress. Being a kind of Robin Hood trying to pick the brains of several people in order to tell it to poor people in developing countries, I have one plea. Could the Canadian government please try to sponsor some full scale measurement of hard working fishing vessels, that would be of interest to the whole world? Could the Canadian government also help Mr. Gosse to build that concrete boat to run up in Labrador? Then they would also provide the world with another big service.

"Without having been asked, and on behalf of all the participants, to those who organized this very well run meeting which I have enjoyed so much, I should like to say, 'Thank you'."

Chairman's Concluding Remarks

Dr. A.W.H. Needler: "Thank you Mr. Traung. As an old FAO hand myself, I fully appreciate your world-wide view and its value. I think we have had an interesting Conference. Far be it from me to try to attempt any summary of this. I am not a naval architect, I am not even an economist, I am only a biologist turned by circumstances into an administrator, more or less against his will. So I can make no summary. I would like, however, to indulge the privilege of having the last word and make one or two remarks. One of the things that has really impressed me about this conference has been the breadth of the discussion. We have discussed many materials, we have discussed impact of materials on many designs. We have been interested not only in large but in small vessels, and it has been a very good discussion, I think, which has been stimulating, and has brought out the complexity of these problems. It should lead to some additional or faster progress as a result of the exchange of ideas.

"I have one remark I would like to make, especially in the field of economics. Being only a biologist and not an economist, I can say almost anything I please about economics. One of the things that is very obvious to anybody who looks at the whole Canadian problem and, I suggest, who looks at the whole world problem, is that there seems to have been quite a pre-occupation among people with the large long distance fishing vessels. It is very dramatic. It is very annoying sometimes for those of us who don't have too many of them. It is also very expensive, and I think that it is a long way from paying very well. I don't think that there are any of these really large trawler operations; there may be a very few, but not very many that are making money without very heavy government support. This extends all the way from government ownership down to various levels of financial assistance, even to such things as tax privileges and so forth. I think that under these circumstances it is extremely difficult to make any sound economic appraisal of the performance of the long distance large high seas fishing vessels.

"One cannot also help observing that those who have been in the long distance fishing the longest among the really great fishing nations, the Japanese, have apparently been trending away from it and I think this probably has been because their long distance operations don't pay. They have been trending towards setting up regional centers from which they can use less expensive equipment. I think that the same thing will happen in the long run in almost all the other cases. This is just an opinion. Now' this pre-occupation with these large vessels, and even with what we call a large vessel in Canada, has obscured the fact in a lot of people's minds, that far more than half of the dollars from the fishing industry in Canada come from what might be called small boats. If you add our west coast salmon fishery to our east coast lobster fishery and to the inshore cod fishery in Newfoundland, which produces the cheapest cod landed in North America, and many other inshore fisheries, without even going to medium sized vessels, these produce far more than half of the dollars for the Canadian fishing industry. If you go to medium sized vessels which are used now in scallop fishing and long lining for swordfish and a whole lot of other things including herring seining, I call these medium sized. Somebody said that 90-feet was a good vessel size and the same speaker a minute later said 100-feet; with this sort of size, you have a still greater proportion of the take.

"Thus from the biological point of view, from the sociological point of view, from the need to support these fishing populations which certainly influences the direction of government support, but mainly from the resource itself and how it can be harvested in the long run, I would hate to predict any time in which the large vessels would in total be as important to the Canadian fishing industry as the combined small and medium sized vessels. I know that a number of my own people disagree with me, but I would advise them to look at the facts. The most valuable industry in the United States is the shrimp industry, and it is not a large fishing vessel industry, it is a medium sized vessel industry.

"There has been, actually, no trend away from this in the world as a whole, and I don't expect it in the future. I personally expect that after some cream skimming has been done by the mother-ship type of operation, such ships will be found unable to compete with the well organized short systems operation. So I was very glad to see in this conference people thinking of all sizes of fishing vessels, from 35 to 40 feet up. I don't want it to be understood that I think that people shouldn't be considering the problems of the large vessels as well. I was very glad to see that there was a very broad spectrum considered here.

"Maybe I have usurped my privileges already. I found it a most interesting conference myself. I would like to thank particularly the speakers who have contributed the papers. They are always the major factors in the success of a conference, and I particularly want to thank those who came from a distance and allowed us to pick their brains. I think that they have been generous, and I hope that they have got something in return. We shall certainly try to make a broad return by facilitating as much as we can a broad distribution of the proceedings.

"I think we need to thank the people responsible for the mechanics, the translators; this is a really tough job, and I think it has been done well; the press and the radio who have been co-operative and as far as I know patient. Finally the federal and provincial officers and staff who actually organized the conference, who have done the pedestrian work, taking care of the details. We have the Coordinating Committee, but I include also all of the staff; those who have really been an essential part of the success. I would like to thank all of these very sincerely.

"Now, ladies and gentlemen, I think that we can close this conference, and I hope that some of you will come to our next one, which is being tentatively planned for early 1970 on Automation and Mechanization in the Fishing Industry. Thank you very much."

Addenda

The two papers which follow were not presented at the Conference but were made available later for publication in the Conference Proceedings.

GRP Fishing Boat Hull Suitable for Arrangement for Multiple Fishing Methods

by

P. Korner and C. Birkhoff

Naval Architects, Hamburg, West Germany

1. *General Considerations*

Due to their favourable characteristics, such as high resistance against corrosion, light weight, and good workability, plastic materials have secured a firm position in naval constructions.

Unfortunately, the strength of the original plastic material as PVC, Polyethylene, Nylon, or Polyester, is insufficient. It has therefore been considered how to give them higher strength by including fibres into these plastics. Glass has proved to be an efficient fibre material for such purpose. A glass fibre approx. 1/100 mm thickness has a tensile strength superior to that of steel. If it is embedded in plastic, the building material "glass reinforced plastic" results. This combination reaches the strength of aluminium alloys.

In boat and ship construction, glass reinforced plastic has proved very efficient for many years as a material for boat hulls, superstructures, doors and stairs of ships, hatch covers, window cases, etc.

Boat hulls up to 35 feet in length, when produced in series, are nowadays almost exclusively built of glass reinforced plastic. For boats over that length, however, it often is difficult to get so large a series together that the comparatively high cost for the mould is not felt too much in the price for the single boat.

From a technical point of view there is no difficulty in building boats up to 100 feet in length of glass reinforced plastic. In some countries, efforts have been made in this direction, which, however, mostly resulted in a very expensive ship, at any rate more expensive than steel or wood construction.

So the task is, by means of adequate standardization of proper designs, to make glass reinforced plastic vessels economically acceptable to as many interested persons as possible, even to make these vessels comparatively cheaper by building them in large numbers.

The production of the boats is done on a negative mould. The glass fibres, which for better handling have been worked into webs or mats, are laid onto this mould and are soaked with liquid plastic. This plastic is hardened after some hours and becomes a solid compact mass which then can be taken off the mould. Different thicknesses can be obtained by using a different amount of glass fiber matting.

This procedure, unlike timber or steel construction, is rather simple and requires no skilled labour. Unfortunately, as already stated, the cost of the mould is rather high, so that only the construction of a large number of boats can be justified from an economic point of view.

2. *Details of Use in Fishing Vessel Construction*

Fishing vessels made of GRP have the following advantages against steel or wooden ships: almost no maintenance work on hull and deck, no yearly overhauling of the hull, no problems in tropical waters; hull and deck are absolutely waterproof, no leakage problems by drying or aging; repair work can be done by semi-skilled workers, such work is easily done even in developing countries as no special machinery is needed.

In case of a serial production the price does not exceed that of a comparable wooden hull, and can even be lower in a larger series. For instance, of the vessel shown in fig. 1 – a trawler for different trawling methods, of 52 ft in length –

about a hundred would have to be built in order to reach the price of a wooden hull. With a greater number, an interesting advantage in price can be achieved.

It is, however, unnecessary to have all vessels completely alike. Only the hull lines must be maintained. Bulkheads, fishhold, superstructures and internal structures can be arranged individually.

But it is recommended to leave the fishhold or fishtank unchanged in size and position, since it is then possible to build even this fishhold of GRP. (As a maximum, two alternative standard versions could be made available.) The hold could be made, like the hull, in one piece, completely waterproof and with a smooth inside surface on top of the insulation. This insulation is effected by the arrangement of foam plastic between adjacent bulkheads and between shell and lining. All other details can be arranged individually, as already stated.

3. *The 53′ Standard Fishing Boat*

From an investigation into the world requirements of fishing vessels, the boat of 53 ft. L.O.A. resulted as the most frequent type. In this investigation, vessels with widely varying catch equipment were considered (see fig. 2).

From such a basic hull, for instance, the following entirely different types of fishing vessels, with only slight alterations in hull and superstructure, can be developed:

1) Multi-purpose sterntrawler,
2) Sterntrawler with net drum,
3) Double rig shrimp trawler,
4) Gill netter with net drum,
5) Purse seiner,
6) Longliner,
7) Troller,
8) Queen crabber.

Furthermore, variations are possible in the stowage of the catch in the hold, such as bulk stowage, shelf stowage with ice, RSW tanks, etc.

Of course, in such an approach optimum characteristics are impossible to obtain, but this disadvantage is more than compensated for by the reduced building costs and the advantages of the construction material.

Figure 3 shows a selection of the different outfits as listed above, all for the same hull of glass reinforced plastic in serial construction. Hull and deck as well as bulkheads are in any case made of that material. Moulded into the deck are engine-room – and fishhold-hatch coamings as well as the breakwater. An anti-slip covering is cast onto the deck. Spots exposed to damage must be provided with exchangeable wooden gratings. Fuel oil tanks are also made of GRP, laminated into the hull.

The hull presented here can, of course, be adapted to other uses too, such as work boat, tender, hospital boat, or small coaster. What counts is the further price reduction due to the larger number of vessels built from the same mould. For instance, the price for one hull including decks, insulated and sheathed fishhold as well as tank bulkheads, follow the diagram of fig. 4. This makes it clear which number is needed to begin with, so that the producer can offer a reasonable price.

This price tendency shows how a proven design built in mass production meets the requirements, e.g. of developing countries, since the hull can be adapted to many varied purposes. The antimagnetic characteristics of the hull may also be of advantage, for instance for military purposes.

The proposed production of glass reinforced plastic hulls is now far from being intended to deprive smaller shipyards of their job. The hull can be delivered to them at a fixed price, e.g., like the main engine, and the low production cost of the large series can be used to achieve a lower price of the complete vessel, thus enabling the shipyard to make a more favourable offer, and at the same time facilitating the construction projects of shipowners.

This chance should be given special attention in view of the present tendency which forces shipyards specialised in wooden designs to change to steel construction. The GRP hull is an ideal base for further outfitting in shipyards specialised in wooden ships. But it must be repeated that a large number of hulls are necessary in order to arrive at a concentrated production.

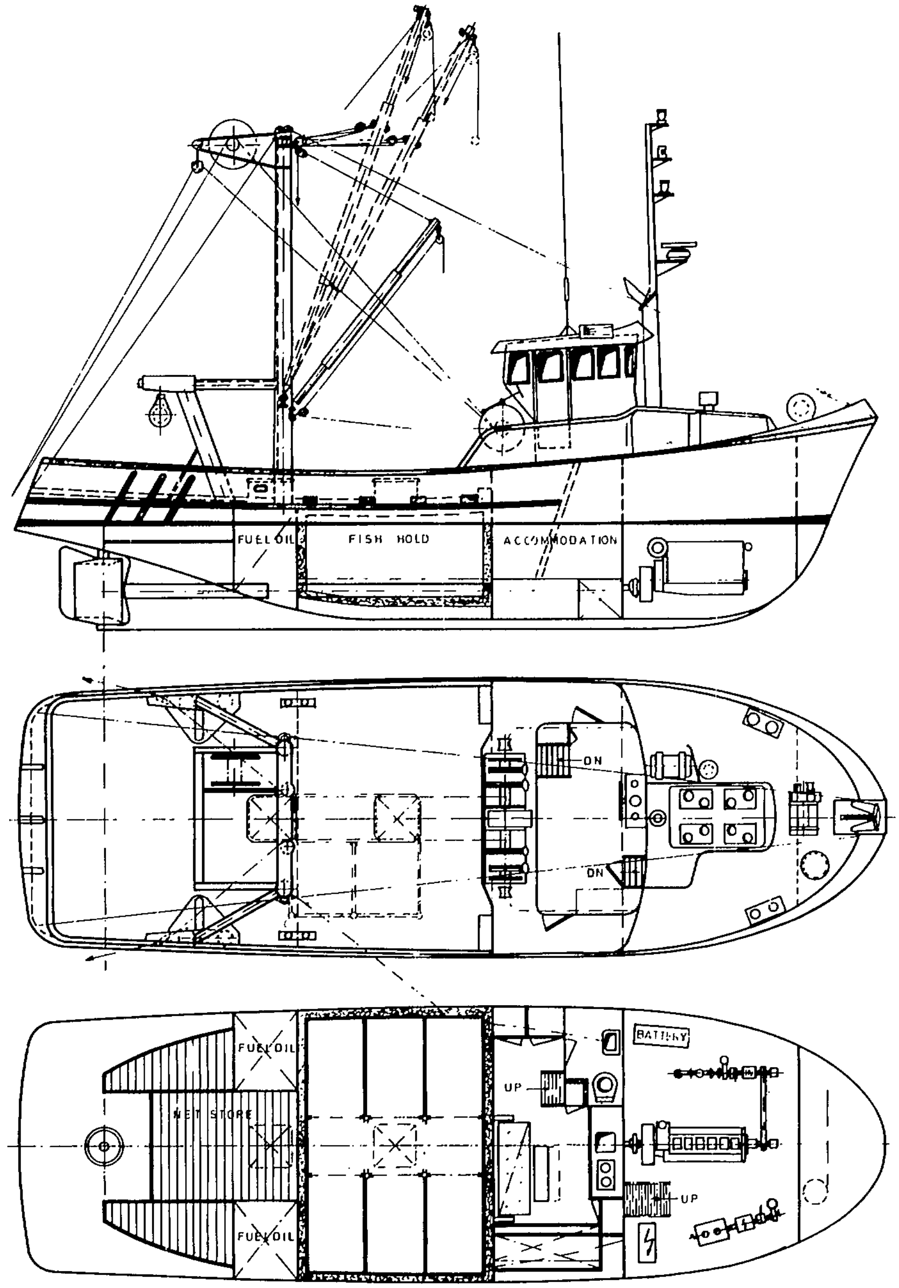


FIG 1 : 52' MULTIPURPOSE TRAWLER

LENGTH O.A	16.00 m	52'-6"	FISH HOLD	21 m³ net 740 CBF
BEAM	5.00 m	16'-5"	FUEL OIL	4.0 t
DEPTH	2.06 m	6'-9"	FRESH WATER	1.2 t
DRAUGHT AB. B.	1.70 m	5'-7"	MAIN ENGINE	150 TO 300 BHP.

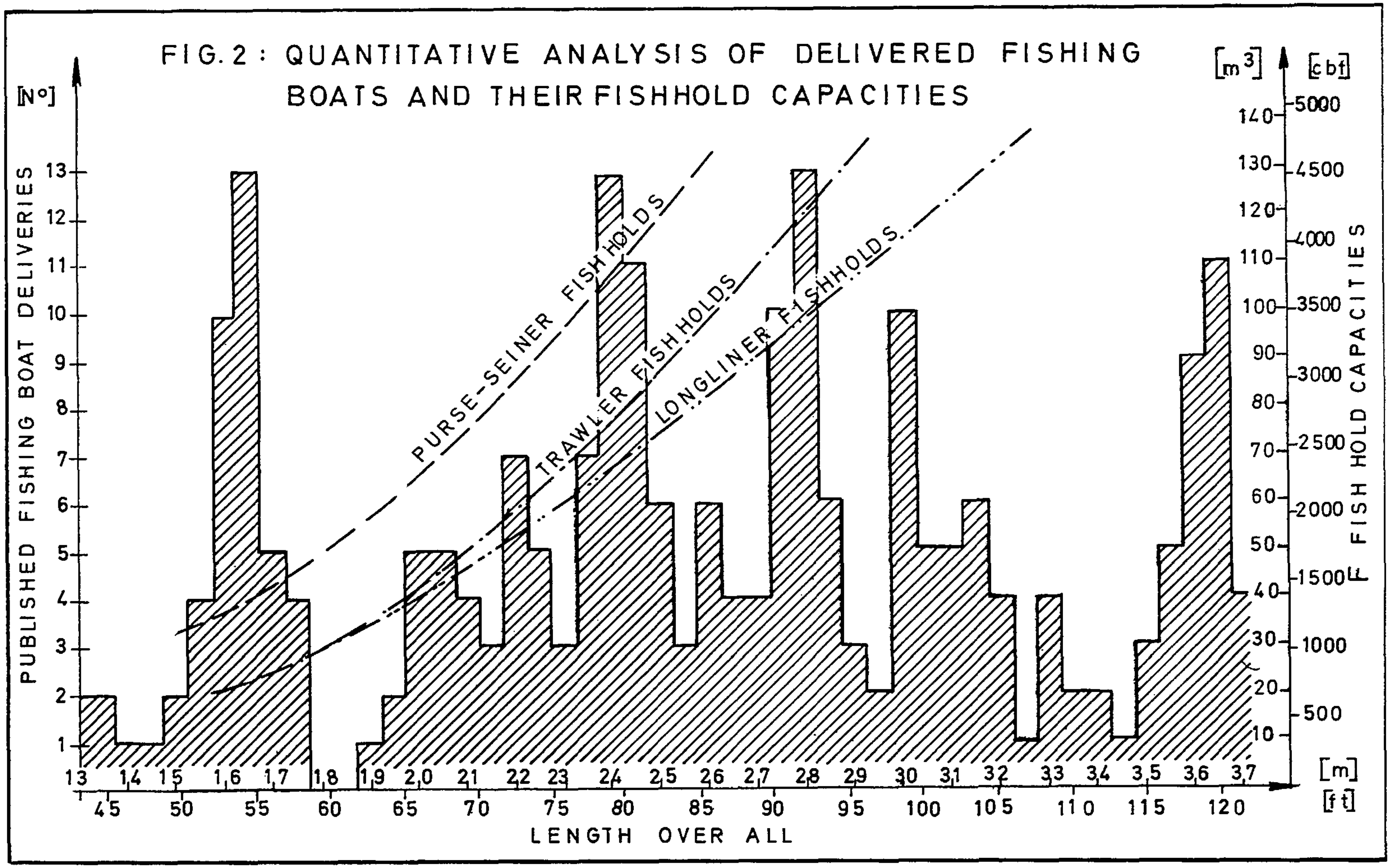


FIG. 2: QUANTITATIVE ANALYSIS OF DELIVERED FISHING BOATS AND THEIR FISHHOLD CAPACITIES

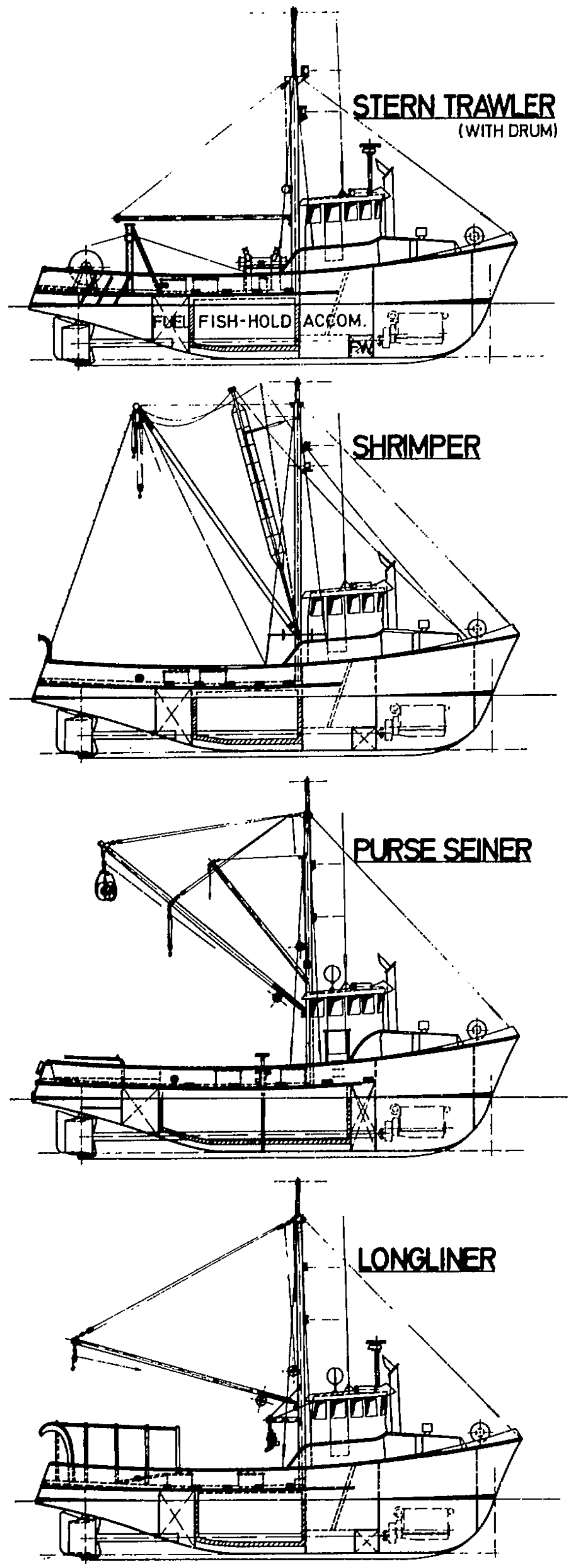


FIG. 3
OUTFIT SELECTION
FOR DIFFERENT
FISHING METHODS

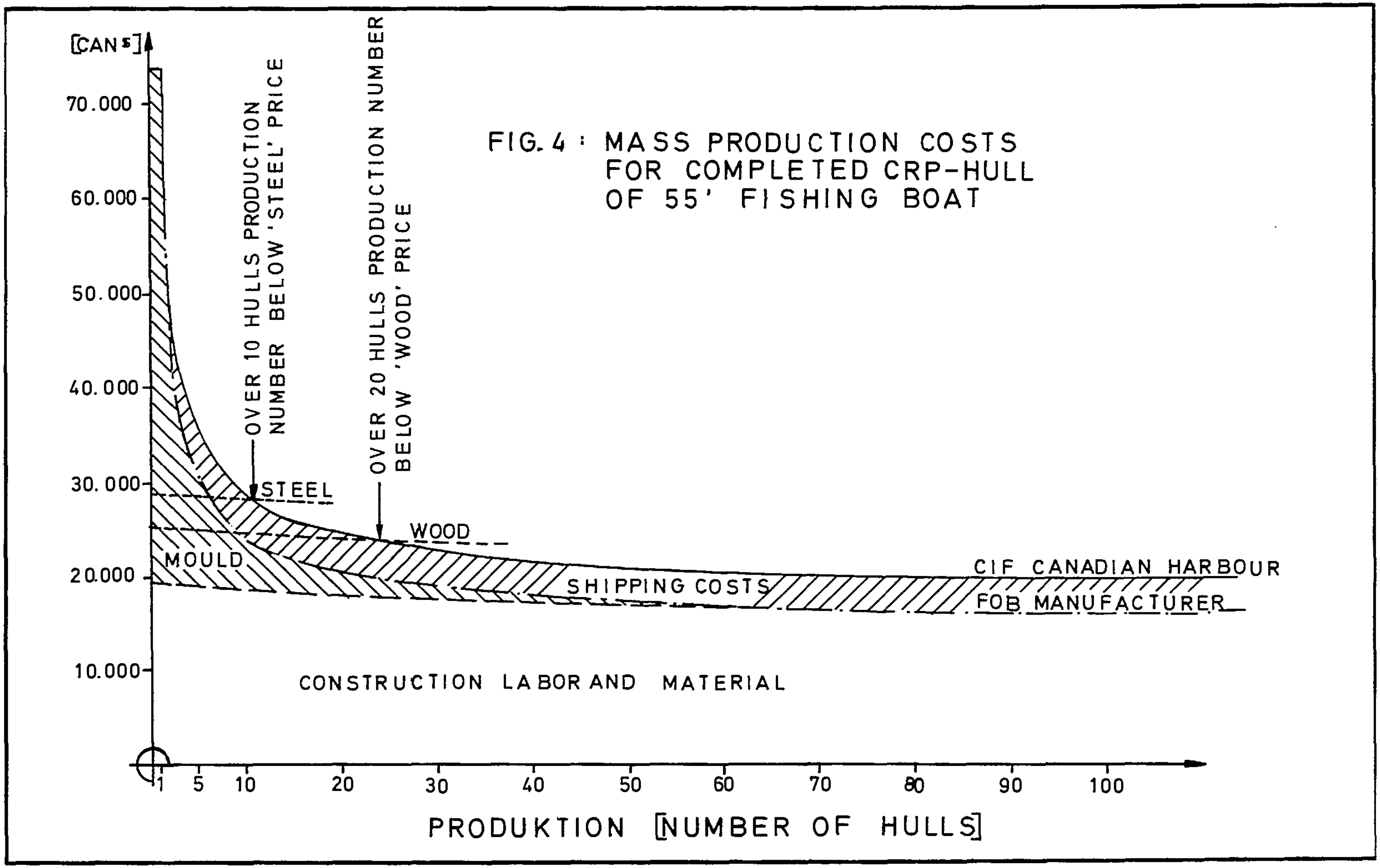


FIG. 4 : MASS PRODUCTION COSTS FOR COMPLETED CRP-HULL OF 55' FISHING BOAT

Ferro-Cement Fishing Vessels

by

Leonard Hedges and Edwin Perry,
Naval Architects and Civil Engineers,
Caringbah, N.S.W., Australia.

ABSTRACT

The authors discussed the problems associated with the construction of refrigerated fish holds. Mention is made of using ferro-cement for fish hold construction in steel vessels. The temperature range – stress relationship is examined – bonded foam insulation cores are suggested. The need for high quality finish is indicated.

Ferro-cement is being used more and more for construction of fishing vessels, as is discussed in other papers presented to the Conference. Mr. Hagenbach has discussed vessels which Seacrete have produced, but ferro-cement vessels are being constructed in other countries of the world, including Australia.

One of the advantages of ferro-cement is that bulkheads, floors, decks and bulwarks can be built integrally with the hull of the vessel, producing an extremely strong hull structure. Fish tanks within the vessel may also be constructed using ferro-cement techniques.

However, insulated holds or brine tanks do present particular design problems, and the authors put forward the following brief notes to illustrate how these may be dealt with.

For a steel hull, it is very often required that access space be left between the external hull and the internal hold, or that holds be removable, to permit survey and repair. Where the hull is constructed of ferro-cement (with extremely high corrosion resistance) it is considered that these provisions need not apply, and that the insulating material may be fixed directly to the hull surface, with a ferro-cement hold lining built against the inner face of the insulation.

The design criteria for such a hold will be: (a) strength of hold lining; (b) waterproofness of hold lining; (c) ability to permit temperature movements; (d) resistance to chemical deterioration due to fish fluids; (e) resistance to abrasion; (f) cleanliness; (g) considerations of damage to outer hull.

The first three of these items are, to a large extent, interdependent, and the choice of method to cope with temperature movements will dictate the strength requirements.

Because of the wide range of temperature which can exist in a refrigerated hold, high stresses can be exerted on the hold lining if it is rigidly connected to the hull. The authors have therefore preferred to separate the hold lining from the hull structure, except at the hatchway, where continuous construction provides little restriction to the movement with temperature, but ensures complete watertightness.

The hold lining is then designed as a separate box, where the loading of fish or brine is partly transferred through the insulating material to the external hull, and partly taken up within the lining medium, in proportion to the relative stiffness of the two materials.

Should the hull around the hold be damaged at any time, water migration through the insulating material could result in difficult repair problems associated with reinstating the insulation. The insulating material should not, therefore, have continuous air passages or joints, along which water penetration could occur, and should be bonded to the hull and hold lining, sufficient to prevent water passage along the interface.

The insulating material preferred is the closed-cell polyurethane foam, cast in position against the hull prior to building the hold lining. The foam is then trimmed to the required shape of the hold, coated with a suitable adhesive and the ferro-cement lining cast against it.

The remaining three properties (d, e and f) required of the lining are of particular importance in obtaining a lining of long life.

The resistance to abrasion of concrete generally is very good and the ferro-cement lining, because of its high cement content and strength, will perform well in this respect, provided that the initial surface is trowelled to a smooth, high quality finish.

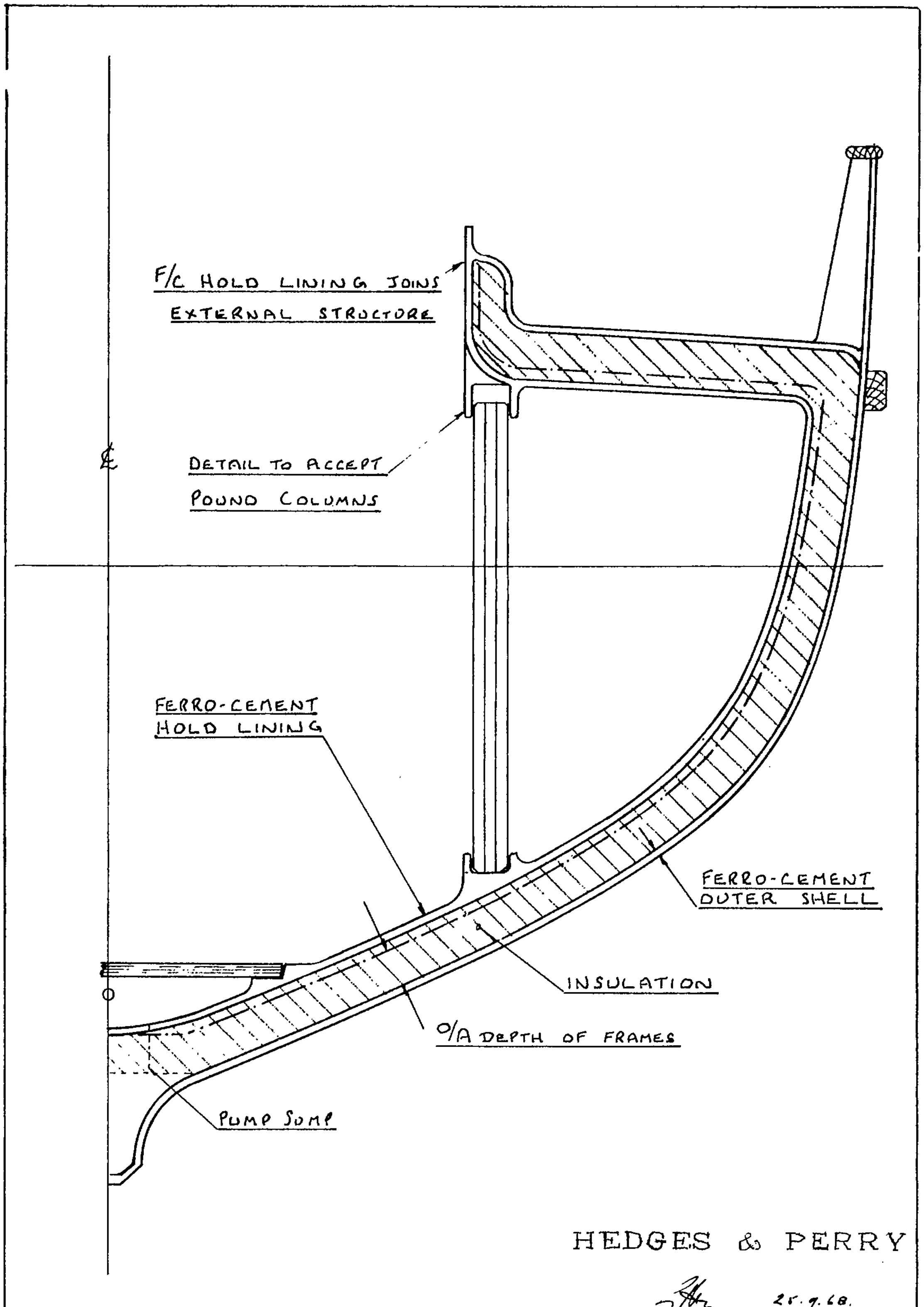
This high quality finish is also necessary to ensure the cleanliness of the hold. Ferro-cement, being a non-porous material, will resist impregnation by fish fluids, provided that particular attention is put to obtaining a uniform and smooth surface.

The above design criteria were originally considered in the design of fish holds in ferro-cement vessels. However, more recently, proposals have been prepared for installing ferro-cement tanks and lining in existing timber and steel fishing boats. The alternative materials commonly used are fibre-glass, which does not have particularly good abrasive resistance, or stainless steel, which is expensive.

The installation of tanks in steel or timber boats does require consideration of ventilation and inspection of the hull, but these particular problems must be catered for whatever lining material is used.

In most cases, the properties of ferro-cement can be used to advantage.

The accompanying sketch shows a cross-section through a typical trawler refrigerated fish hold, showing the arrangement of the construction elements proposed by the authors.


F/C HOLD LINING JOINS
EXTERNAL STRUCTURE
DETAIL TO ACCEPT
POUND COLUMNS
FERRO-CEMENT
HOLD LINING
FERRO-CEMENT
OUTER SHELL
INSULATION
O/A DEPTH OF FRAMES
PUMP SUMP
HEDGES & PERRY
25.9.68.

Address to Delegates at Conference Banquet, October 2, 1968

Mr. Pickersgill (right, at microphone) and Dr. A.W.H.Needler, Conference Chairman

by

Hon. J. W. Pickersgill,
President, Canadian Transport Commission,
Ottawa

Mr. Chairman, Mr. Minister, Deputy Ministers, ladies and gentlemen:

C'est pour moi à la fois un plaisir et un honneur de me trouver ici ce soir pour parler à cette assemblée si distinguée et si instruite dans un sujet dont je n'ai aucune connaissance du tout.

Mr. Chairman, having demonstrated that I can speak French better than I can build boats, I will now continue in what I think is still the other official language even in this province and I hasten to go into English because I am not very good at arithmetic in French and I was very troubled about this eighty per cent you were talking about, and I really sincerely hope that one hundred per cent of my meal is being paid for by somebody else; otherwise I might emulate the vendors of liquor in this province and I would hate to have to do that with all the pain attendant thereon.

It's obvious that I wasn't invided to come here as an expert. I am neither an engineer, an architect, a scientist nor shipbuilder nor even a carpenter. It's true I was once a ship owner and that stood me in very good stead for a little while, until I lost my ship off Cape Race. My ship was built not of any of these new materials like ferro-concrete and aluminum and so on that you have been talking about, it was built of oak in New England about the same time I was born, but it didn't last as long. However, I followed the tradition which was not the tradition of the province where I was born or the province where I was raised, Manitoba. In fact, I remember when some of my friends first heard that I had bought a schooner, they said, "what is it, a Prairie schooner? " But I think I can fairly say that I emulated many examples on the Atlantic coast – I collected. My ship was a total wreck; if you're going to have a wreck it's better, I'm told, to have a total wreck from the point of view of insurance, and like many other residents of the Atlantic coast I used the money to build a house. I no longer have a seat in Newfoundland. I still have a house there.

I cannot assume that I was invited here for any other reason than because the Deputy Minister of Fisheries either thought I was the easiest fish to catch or, and I prefer to believe this, because of the interest I had shown, sometimes I think rather to his irritation, in commercial fisheries over the past fifteen years, during fourteen of which I represented the greatest fishing constituency in Canada, and that he considered that my interest was sincere and not just electoral. Perhaps at this point I should make a clean breast of it and say that I am not in the slightest degree interested in fishing myself and never have been. When people used to ask me if I had been fishing in Newfoundland I always said yes, for votes. But I must say that I have spent many a weary hour pushing my way through the alders along streams in Newfoundland so that my young sons could try to catch trout. They sometimes did but I never tried.

However, my interest in the fishery was in the commercial fishery and my interest in the commercial fishery was because if I hadn't known it before I went there, I soon discovered by actual experience that at least half the people in the part of Canada I represented in Parliament for fourteen years depended upon the fishery for their livelihood and I felt that at the start, it was my duty; but at the end it almost became a form of fanaticism with me that I should try to do anything I could to improve the prospects for the commercial fisheries and the lot of the people who followed the fisheries. In doing so, I think I was a lot of trouble to a succession of Ministers of Fisheries.

I had an advantage over Mr. Sinclair, who was the first Minister of Fisheries with whom I had to deal. It's true he was senior to me in the Cabinet but he was several years younger than I was and he came up to Oxford one year after I did, and in one way or another I could assert a certain amount of seniority. Then owing to a change in the wheel of fortune which, now that I have abandoned politics, I can make no comment about but I'm sure you will all understand what I mean, Mr. MacLean from Prince Edward Island became Minister of Fisheries. I think I hurt Mr. MacLean's feelings slightly once by saying that he was the best farmer who had ever been Minister of Fisheries, but in fact, notwithstanding one or two exchanges we had across the floor of the House of Commons, I always found Mr. MacLean very sympathetic to my constituents. I never knew whether it was his admiration for my beautiful blue eyes or something less than admiration for my tongue, but in any event I always felt about Mr. MacLean that whatever our political differences there was no question about his genuine desire to do a good job. And then, of course, I had my colleague and friend, Mr. Robichaud, now a senator, who I think was the most knowledgeable Minister of Fisheries we have ever had in Canada. He knew the fishery from having been a fisherman and it was a little difficult for me at times to try to convince him that I knew more about the subject than he did.

Well, I wondered what on earth I should talk about this evening because after you have been listening to experts talking about a highly specialized subject about which I have admitted at once I know nothing, I thought I ought to turn to the experts in the Canadian Transport Commission of which I am now the head and, of course, I have a certain number of experts that I can turn to who are supposed to have all the wisdom that I don't have, and I said to the Commissioner in charge of research, what on earth am I going to say? I was caught at a very weak moment on a Monday morning after I had come back from Greece, and felt more than usually conscientious after two week's holiday, and I agreed without really understanding what I was doing to come here this evening. I said, what am I going to say, what can I say that will be worthy of the audience? He's a British Columbian and, therefore, of course, might be expected to have a bias, a bias that I might not necessarily share and I am sure none of you or practically none of you would; he said well, you might tell them that the Pacific salmon is superior to the Atlantic salmon. I must say all this did was to weaken my confidence in his capacity as an expert and totally destroy my confidence in his taste, because every person with an educated palate knows that that is incorrect.

I must say, however, that after he had had his fun he did make one useful observation to me to pass on and it is this, that just as in the Canadian Transport Commission we consider research and the developments that can flow from research as important as our functions in regulating transport and perhaps in the long run even more important, so I think it is in any industry that is going to survive in the tough competition of the kind of world we live in now, and I do believe that over the several years now of its rather unusual, almost unique experience, the Federal-Provincial Atlantic Fisheries Committee, which only includes, of course, those provinces east of the Ottawa River which after all may lack something in wealth but more than make up for it in beauty, has found that in this area perhaps more even than in the richer parts of Canada, if we are to have anything like a comparable standard of living and a comparable future, research and the developments flowing from research are even more important.

You know I am not, having said that, going to follow that theme at all, because you have been exposed to it for two days and you're going to be exposed to it for another day, from experts who I presume know what they are talking about. I don't think you want to hear it from someone who knows nothing about what he's talking about, but I thought instead, I would say something about my conception of the character and of the potential future of the people all of you are trying at this Conference and in your ordinary lives to serve, that is to say the fishermen, and I am not referring to all of the fishermen of Canada. I know nothing about the Pacific fisheries. I know they do catch a lot of fish. I understand that practically all the fishermen earn more every year than Cabinet Ministers do out there, but I don't know how they do it. I am not going to speak about the Prairie fisheries because my knowledge of the Prairie fisheries is half a century old and therefore probably not very relevant.

When I was a small boy my father homesteaded a place in Northern Manitoba in the year 1911. It was near Lake Manitoba and he had a small country store, and there was a quite considerable winter fishery through the ice in Lake Manitoba. My father was a fish buyer and in those days of course Lake Manitoba had good fish in it; I understand they are not so good nowadays. There were three kinds of fish, whitefish and jackfish and pickerel. I don't think any of those are the right names according to modern nomenclature, but I knew I could distinguish between those three long before I was ten years old. I don't pretend to know anything about the Prairie fisheries or the inland fisheries as they exist today. I believe they have a lot of problems, but I think I can say that I do know something about the fisheries of Eastern Canada, and particularly about what they mean and what their importance is for the five provinces that are co-operating with the Government of Canada in this Conference.

The inshore fishery – I shall never forget my first real experience, and I think maybe some of you will find it rather laughable. I started out from Lewisporte on the old "Glencoe", of which nothing is left except the wheel, which is in my house in Newfoundland. The C.N.R. was very helpful. They stopped long enough in every port to enable Joe Smallwood to introduce me for an hour and me to speak for five minutes. I suggest that was a pretty fair division of labour.

The second day we arrived in Herring Neck, which in many ways, of course, I suppose is the most famous fishing settlement in Canada because it was in Herring Neck that Sir William Coaker started the F.P.U. many years ago and it was, I think, the only political movement in Canada that was founded entirely on the fishery. It is also quite important because it was there that I got my first real lesson in the politics of the fishery, because while Mr. Smallwood was introducing me one of the fishermen came up to me – I was sort of at the edge of the crowd – and he said Mr. Pickersgill, it was a nice thing for you to come down here and let us see what you look like but, he said, you know you would have been elected just the same if you had stayed in Ottawa so long as we knew you were Joey Smallwood's man. Then he said something else; he pointed over to Joe White's premises – he was the leading fish merchant in the place – and he said, you know everybody that works over there gets unemployment insurance, and they wouldn't have a job, much less unemployment insurance, if it wasn't for us fishermen and we don't get it. I tried to give him the kind of explanation I would have given Mackenzie King or Mr. St. Laurent of why it wasn't possible for fishermen to get unemployment insurance, but with every word I uttered I became less convinced myself. I made up my mind that morning that I'd never go back and ask for the votes of the fishermen of Notre Dame Bay and Bonavista Bay unless they had unemployment insurance for fishermen, and when I went back in 1957 they had unemployment insurance. I know that there are a lot of people in the fish trade who think that it was a very retrograde step, a terrible waste of the taxpayers' money and so on, but I never had any apologies to make for it, nor for anything else that has been done by any government since I first joined the government in 1953 to maintain the inshore fisheries of the Atlantic coast.

Now when I say that, I'm not at all sure that except in a very specialized and restricted kind of way the inshore fishery has a long term future but I know that it will be a terrible tragedy in Newfoundland, and I suspect it would be in Gaspe and Prince Edward Island and Nova Scotia and New Brunswick, if the inshore fishery was allowed to be scrapped hastily because it didn't accord with modern trends. I'll tell you why I say that. It is because while maybe an economist could prove that the net contribution to the total economy of Canada of the inshore fishery was not very great, I know from the experience of the people I know well on the northeast coast of Newfoundland, that there is all the difference in the world between a family – the family of a fisherman who is actively engaged in the fishery, and the family of a man who has given it all up and had to go on welfare. I don't care whether it costs a few dollars more to keep the inshore fishery going for another ten or fifteen years or it doesn't. I say that for the next generation and for the generation after that, to maintain these people in self respect is going to mean a good generation to follow, and if we don't do this we'll pay an awful price for it.

Therefore, I think that all of us who have some knowledge of the fishery, should also have some knowledge of these older men who really can't be expected at their age, and with the lack of advantage they had when they were young, to adapt themselves to some kind of new occupation. I think it is of crucial importance nationally, not just locally, to continue to nourish this inshore fishery for some years yet. At the same time I am realistic enough to know that there are very few young men going to go into the traditional inshore fishery, and that's what your Conference is primarily concerned about.

We all know that on the East Coast of Canada we have the richest fishery and the most abundant fishery in the world. It, after all, is what brought the Europeans to North America in the first place, and it is very difficult for me to believe, and I am sure it is very difficult for this audience which I am sure on this point at any rate will be entirely sympathetic, to believe that people can come two and three thousand miles to participate in that fishery and do so with financial success, and that our own people who live right on it can't do so. I also know they can't do so unless the fishery is modern. I don't think you can expect young men in Newfoundland or Nova Scotia or Prince Edward Island or the lower part of Quebec or New Brunswick to go into the fishery unless they can have a career and a standard of living and a status in life roughly comparable to what they could hope to get by going into something else, and we all know they can't have it unless the industry is modernized, unless it is perhaps modernized a little beyond what the Russians or the Portuguese or the Spaniards or the Germans or even the French and the Spaniards may do, because our people live in a country which, notwithstanding this debate about Sweden, is certainly one of the countries that has the second highest standard of living in the world, and we can't reasonably expect young men to go into the fisheries, educated young men, and there is no use having them unless they have some education, to go into the fishery and bring up their families in fishing settlements unless the fishery is modern and up-to-date and unless they can have what the late Premier of Quebec would have called a North American standard of living. Now this is a fact. I think it can be done. I think, if we apply to the problem enough research, enough initiative, a reasonable amount of capital and a lot of enthusiasm, that we can have a Canadian fishery that will be as good as any in the world, even as good as the Japanese. But it's not going to be easy, and one of the ways in which it's going to be done is by doing the kind of thing you have been doing for these last two days and are going to go on doing tomorrow – that is, trying to find efficient and economical means of applying modern technology to this most ancient of all the industries of North America.

We have also, of course, got to do a lot of other things. I don't know so much about the other parts of Eastern Canada as I do about Newfoundland, but the reason there were 1,300 settlements in Newfoundland as recently as 20 years ago is that when you had to row a boat out to the place where the fish were, you wanted to be as near that place as possible. When I first became a Member of Parliament, there were, I would guess, seventeen or eighteen islands on which fishermen lived. There are about 5 left today in the same area. There were fishermen perched on all sorts of little capes and outcroppings of rock because they were near the fish, not because there was any other reason for living there. Today no fisherman rows to the fishery. They all have motive power, and if they are going to have any kind of decent lives for their children and for their wives, they have got to be centralized in settlements that are large enough to have decent schools, large enough to have medical services and large enough to have the kind of social life which will keep people there when they have a choice. Moreover, the notion that a fisherman today can really make a good living in the modern way of fishing without education is patently ridiculous. Moreover, of course, they also have to have a vocation. It isn't every fisherman's son, it isn't everyone living in these settlements, who wants to be or has the capacity to be a fisherman himself. Perhaps that's just as well, considering that we still have a pretty high birth rate in a lot of these settlements, but there are some who really still have the vocation if they also have the opportunity. Now I don't think that this modernization of the fishery necessarily needs to mean that all the capital and all the enterprise and all the initiative will have to be provided by the fish plants and their owners. I know that a lot of them have done very praiseworthy things in providing modern fishing vessels, and in providing opportunities for young men and middle aged men to pursue the fishery under modern conditions, but I also know that there are a lot of bright and enterprising men. There are a few of them in their fifties, there are one or two I know in their sixties, there are quite a lot in their forties and there are more in their thirties who, given half a chance, would be able to operate on their own under modern conditions, operate modern vessels. I have known quite a few of them in Newfoundland. There are one or two of them here tonight and I would not like to see the fishery just become a kind of dependency of the fish plants. The fish plants are very necessary, and I am not one of those who disparage the enterprise or the skill that they have shown in building up their businesses, but I like to think there is a place too for the independent modern up-to-date fisherman operating a vessel he owns himself. I also have a very strong conviction, I suppose it's born of the fact that I was brought up on the Prairies where at two or three crucial periods in my life time the food that was produced that may have saved freedom in the world; I have the distinct impression that a tremendous lot of the food of the future, whatever the effect of the Pill may be, has got to come from the sea. A great deal of it is going to come–I don't care who it is who catches it–from the waters off the Atlantic coast of Canada. Well, I hope a lot of it is going to be produced by Canadians, but it won't be unless we are just one jump ahead of everybody else. We can't just rely on the geographical advantage of being a little nearer the fish than the Russians or the Germans or the Portuguese; we've got to be at least as good technologically and maybe a little bit better, and that's why though I have nothing to contribute in a technical sense to this Conference I did feel that perhaps it would not be altogether presumptuous for me, because of my fourteen years' experience trying to be a spokesman for the fishermen of the Atlantic coast, if I came here tonight to say that I believe in this Conference and in the other things you're doing in this federal-provincial co-operation in the five Atlantic provinces of Canada, you are really making a significant contribution to the future of Canada and the future of humanity.

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