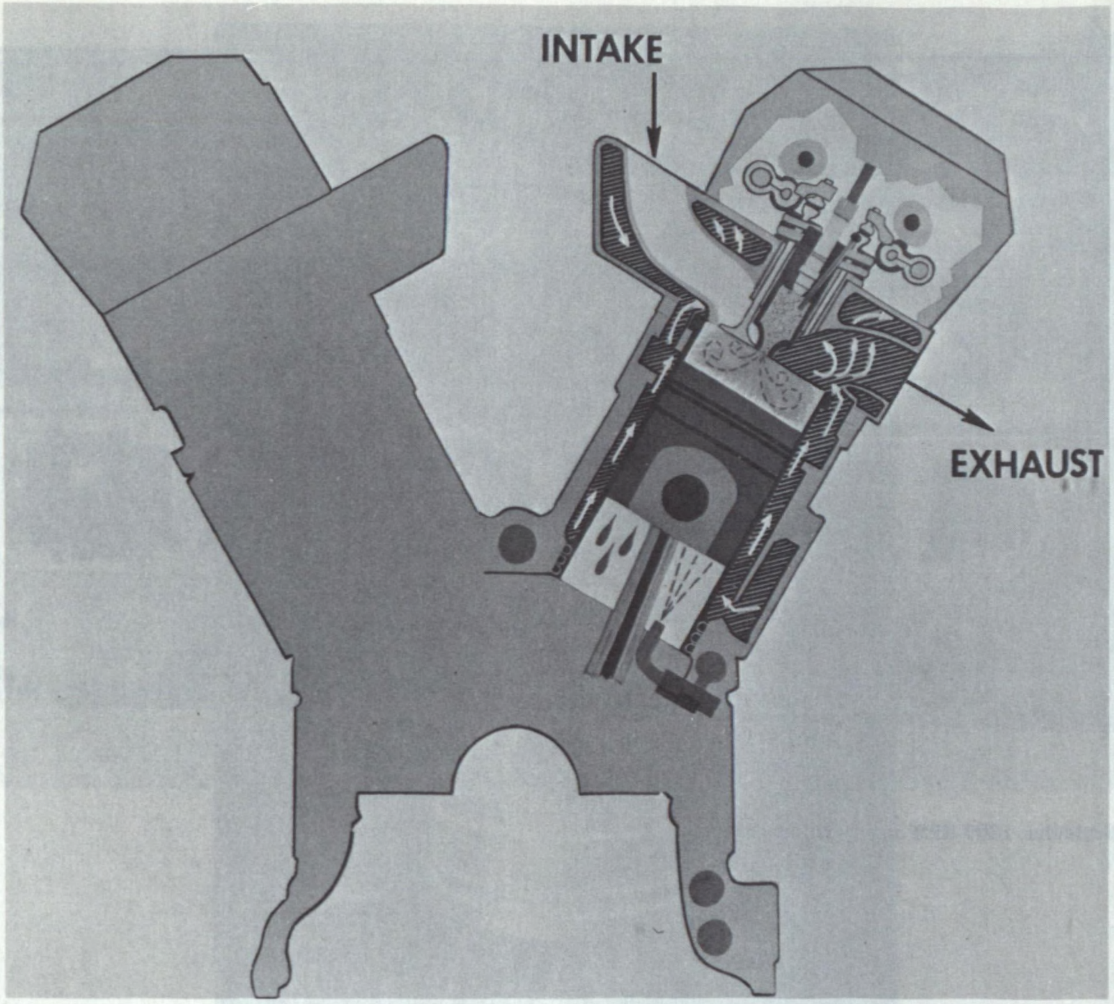

Figure 9. Transverse schematic of 8-, 12- and 16-cylinder 1800 RPM engine.

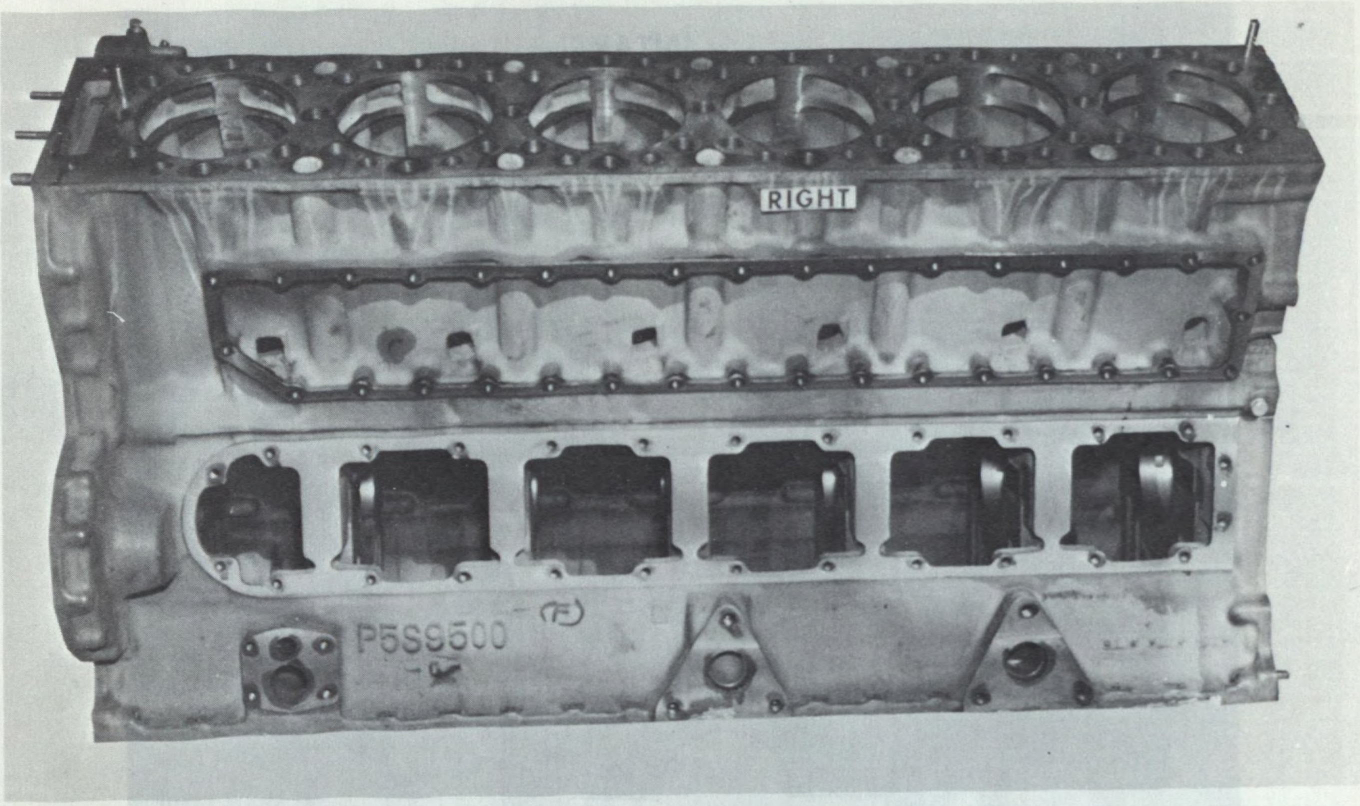

Figure 10. 12-cylinder, 1800 RPM engine cylinder block.

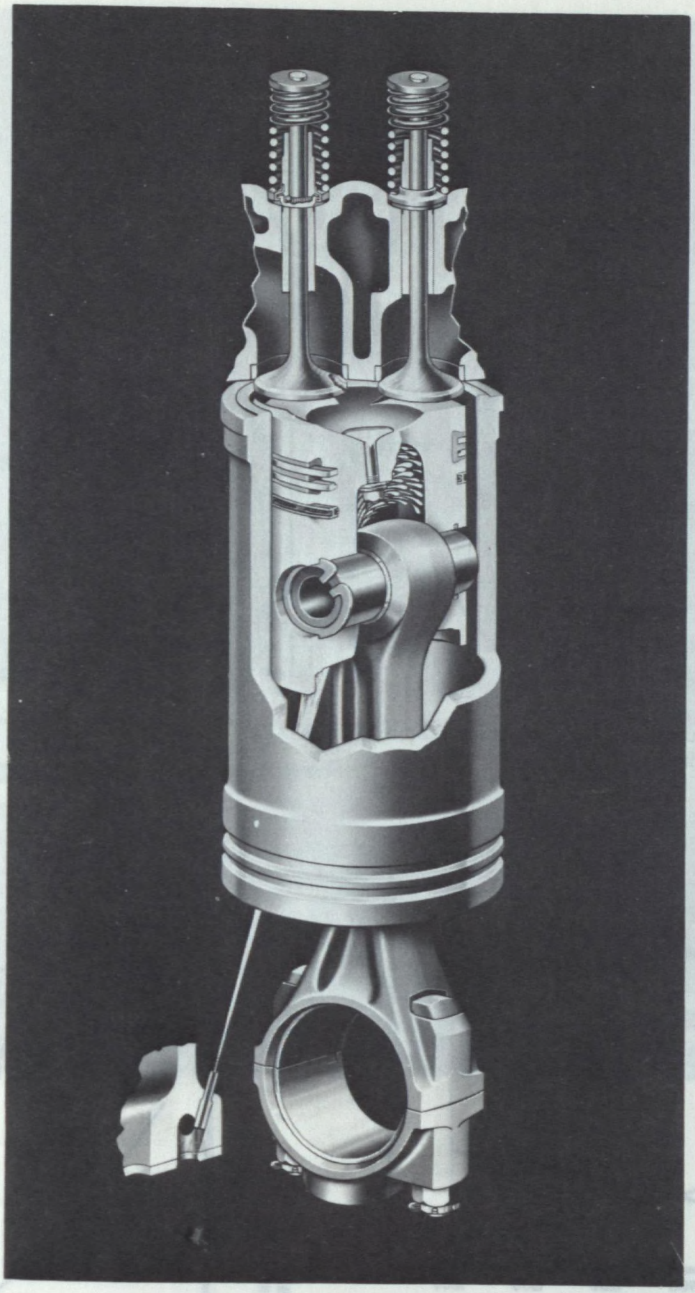

Figure 11. Piston-liner assemblies, 1200 RPM engine.

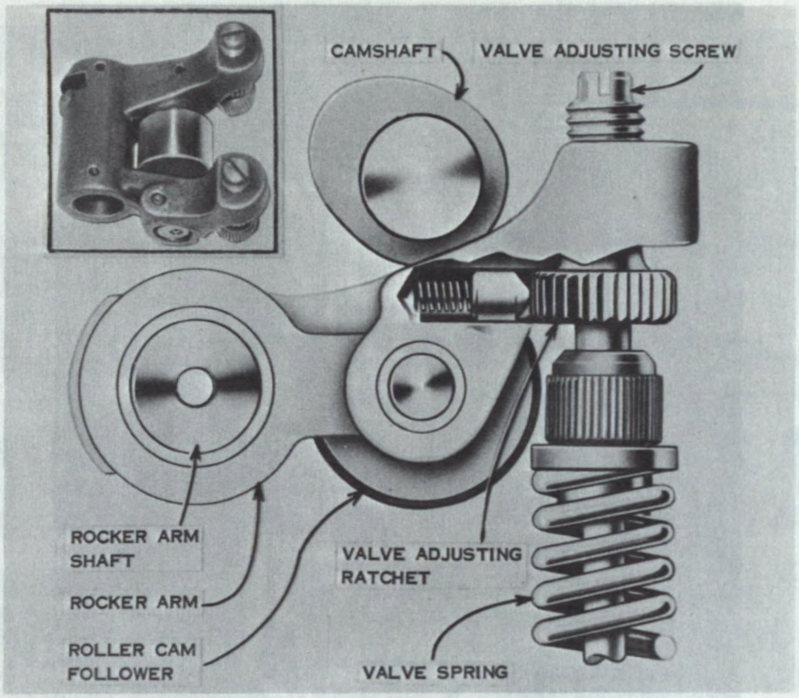

Figure 12. Valve adjusting feature – 1800 RPM engines.

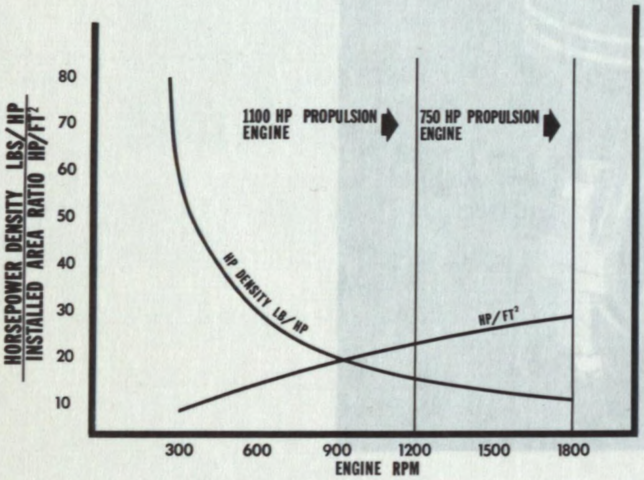

Figure 13. Weight and space curve.

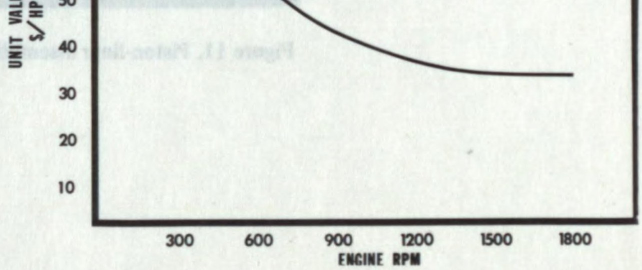

Figure 14. Unit value of representative 750 and 1200 hp propulsion engines.

Figure 15. MV "Mark I".

Figure 16. MV "Lori-J."

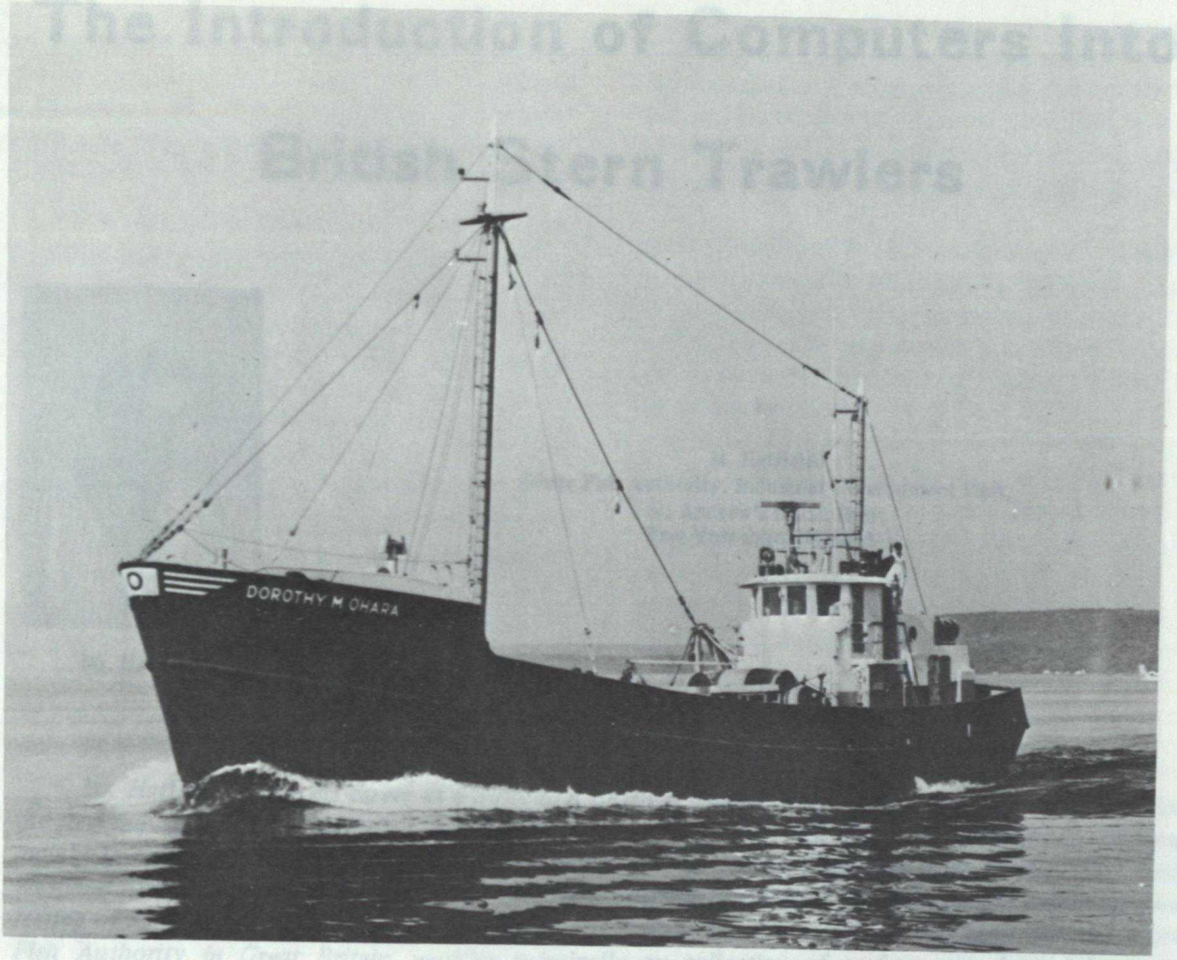

Figure 17. MV "Dorothy M. O'Hara".

The Introduction of Computers Into British Stern Trawlers

Mr. Hatfield

by

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Mr. Hatfield started his career as a Structural Engineer mainly concerned with heavy equipment for the steel industry. In 1954 he took a short service commission in the Royal Electrical Mechanical Engineers, mainly in charge of detachments carrying out field repairs on trucks, tanks and guns. In 1957 he joined Westland Aircraft Limited as Mechanical Development Engineer responsible for development and endurance testing of rotor hubs, gearboxes, etc., for a variety of helicopters. From 1963 he has been with the White Fish Authority in Great Britain, working principally on collection of performance data and on the development of fish working and deck machinery, and mechanization/automation projects in general. He holds the degrees of C. Eng. and M.I. Mech. E.

ABSTRACT

Part I describes a computer-based electronic watch keeper in course of installation on a stern freezer trawler owned by a Hull company. This is a joint project by two Government agencies: the White Fish Authority and the National Research Development Corporation. The intention is to eliminate the engine room watch entirely, all of their duties, including response to emergencies, being carried out by the electronic equipment.

Part II describes how the computer in this equipment will ultimately form a central processing unit for the ship, carrying out other duties such as ship management and navigation on an experimental basis.

Part I

An Unmanned Engine Room Equipment for a Large Stern Trawler

1. THE PROGRESS OF MARINE AUTOMATION

Marine craft of many varieties have been operating with unmanned engine rooms for several decades now; these are of course small vessels with very simple machinery, capable of remote bridge control and with special legal and labour concessions. This includes U.K. inshore fishing vessels up to 80 ft. in overall length.

The running of larger ships with machinery spaces unattended at least part time, using fairly complex electronic and electro-pneumatic scanning and control equipments, is now becoming practicable, such vessels as the "Sealord" class (U.K.) and "Andorra" class (Denmark) being current examples.

There is also a very large number of vessels with alarm scanning and data logging equipment in a central display and control room, this being aimed at staff reduction and increased efficiency rather than total unmanning. The "Zealandic" class (U.K.) could be mentioned as representative.

So far this trend has not spread to fishing vessels, though remote control is almost universal on the larger trawlers, and remote centralized watch keeping stations are emerging on such vessels as "Gadus" (Norway), "Atlantik" class (U.S.S.R.) and "Coriolanus" (U.K.). Total remote control and supervision by the skipper has also been tried on the "Ross Daring" class (U.K.).

Vessels of a length greater than, say, 80 – 100 ft., on which no engineer watch is required at any time, are still rare in the merchant fleets of the world, and non-existent in the fishing fleets. In this context the equipment described in this paper may be said to be an extension of existing techniques into a novel field.

2. INTRODUCTION

The incentive to reduce crew on a large fishing vessel is partly financial and partly sociological.

The wage bill for a British stern freezer trawler is about 30% – 35% of the total running costs excluding depreciation, and therefore the elimination of any man from the crew of 26 has a significant effect on the vessel's profitability, even allowing for any necessary adjustments to the wage structure.

In addition to this, and particularly in the case of engineers, it is becoming increasingly difficult to find adequately skilled personnel, or young men to train for a career in the fishing industry. Thus any technique which decreases crew requirements and at the same time makes the work more attractive for the remainder is highly desirable.

Therefore, in addition to other similar projects related to gear handling and fish working, the White Fish Authority decided to study an automation scheme aimed at the reduction of engine room staff, the increase of responsibility and status of the remainder, and as a parallel aim, increased efficiency and safety in the engine room.

3. THE UNMANNED ENGINE ROOM CONCEPT

The vessel class chosen for study was the most complex and expensive in the fleet, the distant water stern freezer trawler being the class most likely to benefit from, and most in need of, such a system.

These vessels have usually operated with an engineer staff of five, although lately increased to six in most companies by industrial arbitration.

Study of their duties showed that four men are continually employed maintaining a two-man watch in the engine room. The actual labour requirement of the watch is not high, but certain routine duties have to be performed to keep the machinery running, and a continual audio-visual check kept in case of malfunction. Most non-scheduled repair is done by the Chief Engineer with assistance from the duty watch.

Thus it was seen that no significant labour-saving could be achieved unless the watch were eliminated entirely, staff being left on board only for trouble-shooting, cleaning down, and training.

The Unmanned Engine Room Equipment was therefore defined broadly as a system which would:

(1) take the place of the engine room watch by performing all their duties;
(2) impose no extra duties on other members of the ship's crew, who are already fully occupied;
(3) impose no extra hazard on the ship or its machinery when operating unmanned.

Since such an equipment would almost certainly be computer-based electronic equipment, the following additional benefits were also predicted:

(1) increased safety due to faster response to machinery defects;
(2) provision of data to assist maintenance planning;

(3) use of the computer for on-line programs to improve the management of the ship and its catching potential.

4. CHOICE OF CONTRACTOR AND VESSEL

After a preliminary design study for a system based on the above outline, the decision was made to build such a system into a new vessel.

The English Electric Company Limited, Power and Marine Division, were chosen as main contractors on the basis of tenders to the original design study, and because of their previous experience in supplying alarm scanning, data logging and remote control systems in the marine field, and fully automatic control of land-based power and process plant.

Choice of a vessel was governed by questions of machinery layout, timing of vessels on order to be built, and the necessity to find an owner prepared to co-operate.

These considerations narrowed the choice to a single vessel, the "St. Jasper," now built and in service in the fleet of Thos. Hamling and Company Limited of Hull.

The project is being carried out by the White Fish Authority with financial support from the National Research Development Corporation.

5. PROGRESS

The state of progress of the project at the time of writing is:

(1) the system specification is complete;
(2) all special ship's equipment related to the scheme, and all ship modifications to suit it, have been built in to the vessel at the shipbuilding state;
(3) most of the local controls and alarms, external to the electronic equipment, have been installed and tested at sea;
(4) the electronic equipment is in course of manufacture;
(5) final installation and commissioning should take place in about October 1970, followed by three voyages staffed by W.F.A. engineers;
(6) a two-year trial period will follow, during which time the manned watch will be discontinued, and close studies will be made both on the work load of the engine room staff and on the efficiency and reliability of the equipment.

Negotiations with crew and unions regarding staffing requirements will be the responsibility of the owners.

6. DESCRIPTION OF VESSEL

The vessel to receive the Unmanned Engine Room Equipment is the "St. Jasper," owned by Thos. Hamling and Company Limited of Hull. It is the third in a line of three sister vessels made by Ferguson Brothers of Port Glasgow for the same company. Main machinery is by British Polar and refrigeration equipment by L. Sterne and Company Limited.

An outline specification of the vessel appears as Appendix 1 to this paper. An outline of the ship is shown in Fig. 1.

7. THE UNMANNED ENGINE ROOM EQUIPMENT

7.1. Specification and Supply

The detailed specification for the equipment, and for all modifications to the ship's machinery and systems, was drawn up by the English Electric Company Limited, Power and Marine Division (now part of the G.E.C. Group), in consultation with W.F.A. as the purchaser and with all the ship's equipment suppliers where involved.

All the electronic equipment will be supplied by English Electric.

Modifications and additions to the ship commissioned at the building stage include:

(1) changes in system pipework and ship's structure by the builders, Ferguson Brothers;
(2) supply of remote operated electro-pneumatic valves by J. Young and Cunningham (agents for Cupedo);
(3) building-in of wiring and junction boxes, totalling about 10,000 terminations, and supply of remote controlled starters and circuit breakers, by the electrical contractor, J. Charters;
(4) building-in of minor machinery modifications, principally transducer tapping points, by nearly all the ship's machinery suppliers.

These points are mentioned because such a system, although totally dependent on a complex and costly electronic control system, is equally dependent on its extensions into the machinery space, i.e. its transducer points, motor systems and wiring; and these features can form a considerable part of the complexity and cost of the total equipment.

It is also worth noting that when a system of this kind is commissioned at the same time as the ship, great difficulty is experienced in calling-up the necessary ship modifications concurrently with writing the specification; extra cost is necessarily incurred due to duplication of effort both at the yard and in the office, and it is therefore highly desirable to have the specification of any such equipment finalized concurrently with the ship specification and forming an integral part of it.

7.2. Purpose

To relieve the engine room of its watch, the equipment will carry out the following functions:

7.2.1. *Scanning*

All running machinery and working systems on the ship will be scanned continuously to establish their state and detect abnormality.

7.2.2. *Warning*

Warning will be given, by low-priority alarm and typed message, if any parameter in running machinery or systems starts to depart from normal.

7.2.3. *Alarm*

A high priority alarm will be given, and typed diagnosis presented, when any parameter nears a failure condition.

7.2.4. *Routine Automatic Control*

Certain routine functions in the engine room will be carried out automatically by the electronic watch keeper; for example, fuel oil transfer and bilge clearing.

7.2.5. *Emergency Automatic Control*

Certain functions will be carried out by the equipment automatically in response to alarm conditions. For example, start-up of standby machinery on failure of duty sets.

7.2.6. *Remote Manual Control*

All functions subject to automatic control may also be initiated manually from a remote control station.

7.3. Control Room

7.3.1. *General Philosophy and Description*

The bulk of the electronic equipment will be housed in a control room at main deck level, inside the engine room casing and next to the engineers' accommodation.

It is an integral part of the design philosophy that this control room should not be regularly manned.

The engineers remaining on board will have duties in various parts of the vessel. When any machinery abnormality arises, alarm systems at carefully chosen positions in the ship will operate, and the engineer will then go to the control room where a mimic display and typed message will give full details of the condition.

In all cases of hazard to the ship or machinery, corrective action will already have been taken by the equipment, before the arrival of the engineer.

The engineer will then be free to assume remote manual control from the control room, or proceed to the engine room for investigation, where he can assume local manual control.

7.3.2. *Contents*

The control room will house cubicles containing the logical equipment, and a control console containing circuits associated with display and machinery control.

The working surfaces of the control console are shown in Figure 2.

The large vertical panel will comprise a mimic display of all the ship's machinery. Each unit on the mimic will have alarm, auto/manual and other indicator lights as applicable, and certain push-button controls.

The desk panel will comprise:

(1) The control panel for the electronic equipment, allowing setting of alarm tolerances for all parameters, call-up of display of individual

parameters or a complete log, and other controls and indicators;

(2) Control panels for the main engine service pumps, bilge and general service pumps, fuel oil system, and electrical system including alternator sets;

(3) Electric typewriter.

7.4. The Electronic Watch Keeper

7.4.1. *General*

The system construction is based on the English Electric "Datapac" range of silicon semi-conductor logical units. Combinations of certain "Datapacs" are provided as system modules to perform specific functions; the overall control of the modules is effected by means of a central processor (computer).

The "Datapac" units are in the form of cards combined into plug-in units mounted on hinged racks.

7.4.2. *Central Processor*

This is an M.21-12 stores program computer with directly addressable memory of 8000 words of 16 bits length. Its function is to control the electronic watch-keeper system, under the control in turn of a "watch dog" timer system with a crystal oscillator source.

7.4.3. *Analogue System*

Receives and converts to digital form, analogue signals from the plant; reads these by means of an Integrating Digital Voltmeter; and presents them to the Central Processor for storage, and further processing.

Parameters are scanned in groups of 16, each group in 1 milli second; any given parameter being scanned at least once per second.

A total of 150 analogue parameters will be scanned.

7.4.4. *Digital System*

Interrogates all switches such as pressure and temperature switches, relays, micro switches etc., both in the plant and within the electronic equipment, for diagnosis and display.

The rate of scan is the same as in the analogue system and a total of 234 plant switches will be scanned.

7.4.5. *Typewriter*

This is an IBM Model 731, printing 15.5 characters per sec on a line length of 102 characters.

The data printed will be in the form of messages in plain language with standardized abbreviations, and parameter values in engineering units.

Data will be printed as follows:

(1) Trend information (in black) automatically when any parameters depart from the 'normal' limits;

(2) Alarm information (in red) automatically when any parameters enter alarm limits, or when certain other alarm conditions develop;

(3) General information (in black) printed when certain routine functions are performed by the electronic watch-keeper; or in the form of a log at pre-set time intervals; or on demand by the engineer.

7.4.6. *Program Input*

All processor activity is determined by programs input via a paper tape reader and retained in the processor store.

7.4.7. *Watch-Keeper Internal Fault Monitoring*

A general "Equipment Alarm" lamp will be included in the main-control console.

In addition, a group of lamps will indicate the sub-system in which any fault has occurred, and, in all cases except faults in the typewriter or its drive, a diagnostic message will be printed out, followed by that sub-system ceasing to function.

From this point on, fault finding by the engineer will be required, using a standard check schedule. Repair is effected by card or module replacement, if the fault occurs within the equipment.

7.4.8. *Power Supply*

The equipment will operate from 230 v 1 ph 50 Hz, via trickle-charged "floating" batteries and an inverter.

This system enables the electronic equipment to function for a minimum period of 10 minutes after failure of the ship's main supply, allowing automatic start-up of stand-by generators and diagnostic information to be printed.

7.5. Alarm Annunciation

Remote alarm facilities will be provided by display modules situated at points in the ship where engineers are most likely to be working. These positions are:

- Control room;
- Engine room, also visible from workshop;
- Shaft tunnel, aft end;
- Refrigeration machinery room, visible from freezer space;
- Steering flat, visible from fish wash space;
- Standby engineer's cabin (selected from control room);
- Wheelhouse.

The annunciator in the wheelhouse will be a flashing light turning to a steady light when acknowledged by the engineer, from elsewhere, and extinguished when the alarm condition is cleared. The only requirement of the officer on watch is to see that the alarm is acknowledged within a reasonable time, and if not to take appropriate action.

7.6. Control Systems

7.6.1. *General*

Machinery and system automatic control will be effected external to the electronic watch-keeper by dry reed relay sequencing equipment, generally initiated by direct switch contacts within the plant, to provide continued automatic control even on failure of the watch keeper.

Remote manual control will be effected through the same circuits or direct to plant by push-button.

Local manual controls, as provided on the ship prior to the installation of the electronic equipment, will be maintained and can be selected at the appropriate positions in the engine room.

7.6.2. *Automatic Independent Controls*

The sequencing equipment will cater for the automatic execution of the following functions:

Routine Functions

Heavy Oil Transfer Sequence
Diesel Oil Transfer Sequence
Bilge Clearing
Deck Wash/Fire Main Select

Standby Functions

Prepare main engine for re-start
Re-start main engine
Shut down salt water pump after main engine failure
Start standby pumps on failure of duty set:–
- Coolant pump on salt water duty
- Coolant pump on fresh water duty
- Lub oil pump on pressure duty
- Lub oil pump on scavenge duty
- Heavy oil circ. pump
- Heavy oil boost pump
- Injector collant pump

Start standby alternator set on incipient failure of duty set, parallel if duty set still on board, bring standby set onto board, bring duty set off board and stop.

On failure of both alternator sets, start harbour set and bring onto emergency busbars, which provide ship's lighting only.

7.6.3. *Emergency Functions*

In addition to the above, certain functions will be carried out locally and directly by on-plant equipment. These include stopping of main and auxiliary engines due to failure of essential services.

7.6.4. *Miscellaneous Direct Controls*

Certain minor functions, such as topping-up lub. oil sumps, water drainage from air and oil systems etc., will be carried out directly by on-plant equipment.

In all these cases, the electronic watch keeper will check that the function is carried out correctly.

7.6.5. *Watch-keeper Controls*

The watch-keeper can initiate any of the control sequences in 6.2. above either on a time basis or by detection of fault conditions in routine scanning. The watch keeper also checks that these functions are carried out correctly and prints out messages and initiates alarms as appropriate.

7.6.6. *Remote Controls*

All the automatic functions noted in 6.2. above can be initiated by push-button from the control console. In addition, all remote controlled valves, electric starters and circuit breakers can be operated in the same way.

8. MACHINERY OPERATION

The operation of the ship's plant with the Unmanned Engine Room Equipment in operation can only be sketched in very broad outline within the confines of this paper, as follows.

8.1. Prepare Ship for Sea from Cold

Leave Port

Enter Port

Shut Down

It is assumed that duty engineers will always be on watch in the engine room in these circumstances, and the necessary routines have not all been automated.

The ship will be "handed over" to the electronic watchkeeper when running free, with all manually operated valves set to the correct position and all "local/remote" switches on starters, valves and circuit breakers set to "remote".

A check routine within the control room will ensure that all switches and controls are correctly set.

8.2. Main Engine

This engine is already supplied with bridge control of propeller pitch and engine speed.

If the main engine fails due to loss of services from a blackout, or for some other reason, the equipment will stop the salt water pump to reduce the rate of heat loss. All the service pumps will then be restarted automatically, the propeller pitch reduced to zero and the trawl winch clutch de-energized; then, if all parameters are correct, a "Main Engine Ready" signal will be given. The main engine can then be restarted by push-button from either the wheelhouse or the control room, and the propeller pitch will automatically return to its previous setting.

The main engine may be stopped by push-button from the control room or wheelhouse, or automatically by:

Low lub oil pressure;
High piston cooling oil return temperature;
High jacket water return temperature

8.3. Main Engine Cooling

A standby pump will be automatically started, and the necessary valves changed over, if either the duty salt water or duty fresh water pump sets fail.

Thermostatic valves will maintain the engine jacket temperature between required limits, by operating a heat exchanger and steam heater as necessary.

8.4. Main Engine Lubricating Oil

A standby pump will be automatically started, and the necessary valves changed over, if either the duty pressure pump or the duty scavenge pump should fail.

Cylinder lubricator boxes will be topped up automatically.

An oil mist detector system will check for excess concentration at each crank position, the thrust bearing and timing gears.

8.5. Fuel Oil Systems

Topping up settling tanks and service tanks, pre-heating and filtration will all be done automatically by selection of the necessary pumps and valves. These sequences will be initiated on a level detection basis, and in the case of the main engine fuel system, by changing over duty tanks.

It will be left to the engineer to select the bunkers from which fuel is drawn, and to transfer fuel for ballasting. Both of these functions are infrequent.

8.6. Compressed Air

Pressure will be maintained by automatic running of the main compressor as necessary, and water will be drained automatically from the bottles. The compressor sump will be topped up automatically.

8.7. Steam Generation

There are two boilers, one heated by exhaust gas for cruising duties, the other by oil for fishing duties. Much of the oil-fired boiler operation is already automated by Spanner Boilers Limited, the following extras being supplied for the unmanned scheme:

Auto feedwater supply to both boilers;
Auto blow-down and de-scumming;
Auto hotwell topping up.

8.8. Generator Sets

Three sets are provided:
1 – 560 KVA for fishing duties;
1 – 350 KVA for cruising duties;
1 – 55 KVA for harbour duties.

Selection of one of the main generators as duty set will be done by the engineer either in the engine room or from the control room.

The automatic control of these three sets is highly complex, and further complicated by the fact that loss of electrical power from the board for more than a few seconds will stop the main engine due to lack of services.

This system is best illustrated by examining the response of the unmanned engine room equipment to a sequence of failures, as follows:

Ship fishing, 560 KVA set on board;
560 KVA set lub oil pressure falls to "x" lb psi;
Trend print-out, engineer warned, proceeds to control room;
Meantime, lub oil pressure falls to "y" lb psi;
Print out and initiate alarm;
Auto start demand to 350 KVA set –
– start lub oil priming pump
– check lub oil pressure
– energize start solenoid valve, hold off fuel rack
– check engine speed > 150 r.p.m.
– de-energize start solenoid, release fuel rack
– check speed > 600 r.p.m.
– print out "engine started";
Shed refrigeration machinery load;
Synchronize and parallel 350 KVA set to board.

In this case, assume that the duty set has already shut down due to lub oil failure.

Print out each of these events in turn.

350 KVA set comes onto board
Print out
'Prepare main engine for re-start' sequence initiated
Signal 'main engine ready'
Main engine re-started by push-button

Notes

(a) The whole of the above sequence of events would occupy about one minute. The duty engineer would arrive at the control room, acknowledge the alarm signals, and find a series of printed messages to indicate the sequence of events.
(b) If the 350 KVA set failed to start, there would be two further attempts, then the harbour set would be started and put on the bars on lighting duties only.
(c) If the 350 KVA set came on the board before the 560 KVA set failed, it would synchronize and parallel with it, then drop the 560 set off the board and stop it. Main engine failure would be averted.

8.9. Shaft Bearings and Stern Tube

Monitoring duties only.

8.10 Bilge and General Service Systems

On detection of water in any bilge, all bilges will be automatically pumped dry by starting the bilge pump and selecting the necessary valves. The pump will be stopped when all bilges are dry.

If the bilge pump fails to start, the general service pump will be started on bilge duties and the necessary valves actuated.

If both these systems fail, overall high bilge level detectors in the tunnel and in the engine room will sound a priority alarm.

Fire main and deck wash duties will be selected by push-button from a number of alternative stations by the deck crew, this initiating a sequence to start the general service pump and select the correct valve positions.

Fish washing duty will be selected by the crew from the fish handling space.

8.11 Refrigeration System

This machinery, by L. Sterne and Company Limited, is already highly automated, in that the compressors are brought into circuit as required, to a duty sequence selected by the engineer. Refrigerant pressures and temperatures at the various stages are controlled by well-established and self-contained off-loading techniques. The Unmanned Engine Room Equipment will provide a comprehensive monitoring and fault diagnosis facility.

8.12 Steering and C.P. Propeller Systems

These are already supplied with automatic start-up of standby pumps. The unmanned engine room equipment will provide monitoring and remote start facilities.

8.13 Safety

The following external systems will be provided to enhance safety while operating unmanned in addition to the features mentioned above:

(1) Machinery space fire detection by the ionized particle detection system, by Minerva.
(2) Main engine scavenge belt fire detection.
(3) Main engine crank case oil mist detection.
(4) High pressure fuel pipe shrouding.

The ship's existing manually-operated CO_2 extinguishing system has not been altered in any way. Automatic operation of this type of system is not permitted by Board of Trade for obvious reasons.

9. IMPACT OF THE UNMANNED ENGINE ROOM EQUIPMENT ON THE CREW

The equipment described will not eliminate all the duties of the engine room watch. Some of the remaining duties, such as general cleaning down and greasing, would be impractical or very clostly to automate; while some such as routine visual inspections are a matter of common sense and prudence.

By far the greatest remaining task for the engineers will be unscheduled maintenance and repair, and the scheme will not be a success unless the vessel's running machinery is maintained by shore staff in a state of adequate reliability. The data recorded by the automatic watch keeper is expected to assist in this.

Equally, the scheme will not be a success if the equipment itself requires more than minimal maintenance at sea. Study of failure rates on similar equipment now in service indicates that, after an initial period of component failures, and given a good shore maintenance policy, this feature will not cause concern.

The effect of the equipment on the crew is best illustrated by an analysis of the whole of the engineers' duties remaining after commissioning the equipment.

9.1. Extra Duties for Duty Officer in Wheelhouse

9.1.1. Check that alarm signals are acknowledged by engineer after a reasonable time.

9.1.2. Re-start main engine after failure, on receipt of "main engine ready" signal.

9.2. Extra Duties of Deck Crew

9.2.1. Select fire main and deck wash pump supply by push-button.

9.2.2. Start fish wash pump by push-button.

9.3. Duties Remaining for Engineering Staff

A list of the remaining duties appears as Appendix II to this paper.

It is evident that the extra duties in 9.1. and 9.2. are insignificant.

To the duties in 9.3. must be added repair work and a daily inspection of all machinery spaces by the duty engineer.

On these vessels, operating until recently with one Chief Engineer, one Senior Second Engineer, one Junior Second, and two greasers, the Chief is on day watch, principally carrying out repairs and routine inspections, while one engineer and one greaser are on watch on a six-hour basis.

Studies on sister ships, using random activity sampling techniques, which of course took into account all repair work which happened to occur during those voyages, indicated that the unmanned engine room scheme, if operating during those voyages, would have relieved the engineers of 65% of their work and the greasers of 85% of theirs. The disparity is an indication of the amount of repair work carried out, since this is done mainly by the engineers and a large proportion of the total relief is the elimination of the necessity to stand-by on watch.

Thus it seems clear that the equipment should enable the vessel to operate with three engineering staff:

Chief Engineer and Second Engineer on alternate stand-by to carry out the remaining tasks listed, attend the control room as necessary, and carry out a daily inspection.
One greaser or apprentice on day watch for cleaning down, greasing and the remaining tasks listed.

The White Fish Authority expects the two-year trial period to demonstrate this and to indicate where the unmanned engine room equipment falls short of, or exceeds, the minimum requirement.

It is therefore confidently expected that this equipment will be the forerunner of a standard package equipment for the stern freezer trawler class.

Part II

The Extension of the Computer into other Activities

1. INTRODUCTION

The choice of a computer-based system for the unmanned engine room equipment described above was not only due to its considerable advantages for that purpose. The computer, although scanning continuously in effect, can still be programmed for other simultaneous activities if the memory store is adequate.

Therefore the computer has been designed to allow the addition of an extra 4,000 words store in the future.

A number of future developments on large trawlers can use computers to a greater or lesser degree, and some of these are being actively pursued by the W.F.A.

These are as follows.

2. DECISION MAKING

Decision making on a fishing vessel is involved in both long-term fishing strategy and short-term tactics.

The whole process whereby a vessel's operator decides on the fishing grounds, the route out, whether or not to change grounds or stop fishing temporarily, when and by which route to return home, and so on, is a complex series of decisions. These are based on external information and mentally processed, partly by logical processes and partly by experience, intuition and prejudice.

The top skippers of course are the ones whose deductions and information are most often correct, and who do not permit ill-founded prejudice to affect them.

The use of a computer on board ship, if supplied with the correct information, should be able to reproduce or better the logical approach and experience of a top skipper. Its only intuition and prejudice will be whatever is supplied with the information fed in.

Thus a tool would be available to help a mediocre or poor skipper to make administrative decisions as good as his superiors. If all British stern freezers were commanded by top skippers, there would be a dramatic increase in productivity.

Therefore plans are being made to use the unmanned engine room equipment computer for management decisions. It is estimated that an extra 4,000 words memory will be needed for this, and sufficient space is available in the computer rack to cope with this.

Programs are being written by W.F.A. for this purpose, on the following lines.

It is assumed that information will be input by keys and dials, and output in typescript, the address unit and typewriter being panel mounted in the wheelhouse. Other facilities for inputting data may be selected if required.

Programmed Information
Rate of change of catch rates on different grounds, involving the use of short-term forecasting models
Weather forecasting models
Ship speed
Freezer throughput
Gutting rate
Fuel capacity
Running costs
Hold capacity
Catch value per ton

Input Information
Date/time
Position

Catches for last "X" hauls
Amount of fish being processed
Amount of fish stowed so far
Weather conditions in other relevant areas
Present catch rates in other relevant areas

Output Information
Choice of grounds
Outward route
Decision to lay for fish processing
Decision to change grounds
Decision to re-fuel at foreign port
Decision to finish fishing
Route home

Each of these decisions will of course require a separate program. The skipper will select the required program at the address unit, feed in the best available input information, and receive a typed message in reply.

3. FISH COUNTING

W.F.A. are in the course of developing a fish counter which employs a small digital computer. This also could form part of an integrated ship computer system, using the central processor in the unmanned engine room equipment.

The counting device works on the signals generated by the vessel's own fish finder, typically the Kelvin Hughes Humber gear. The counter receives the returned signals from the sea bed and processes them through a Time Varied Gain System which ensures that the signal strength of a fish echo remains at the same level regardless of its depth. Each "standardized" echo is then compared to a signal level representing fish of minimum marketable size, and echoes which are above this minimum and within a predetermined height above the sea bed are fed to a computer.

To convert the total echoes into predicted baskets of fish caught, the echoes per sounder transmission are divided by the square of the depth and multiplied by a conversion factor. The computer arrives at this factor by comparing an estimate fed in by the skipper at the end of each tow of the number of baskets caught, with the totalized echoes for that particular tow.

The computer can be set to obtain the value of the factor from several previous tows, determining the priority on an exponential basis; that is, more recent tows have proportionately more effect on the value of the factor.

This device is in the late development stage, and early indications are that, in predicting catch rate from echoes, it has an accuracy of about ± 1.8 : 1 for 90% of the tows, or about ± 1.5 : 1 accuracy for 75% of the tows. This is higher than a good skipper's own predictions, and enables the decision when to haul to be arrived at with much greater confidence.

The counter output is in the form of digital displays of depth and catch in baskets, and paper traces of depth and catch rate.

The digital computer required for this device is of course relatively small and at present is supplied as a part of the equipment; but this provides one further argument for a centralized, multi-purpose computer.

4. NAVIGATION

Navigational aids of a high degree of accuracy are required by all fishing vessels for a number of purposes:

(1) time saving in accurate location of desired grounds;
(2) accurate plotting of known snags on the sea bed;
(3) precise repetition of previous tows;
(4) reduction of cruising time by more precise course-keeping.

For these purposes, particularly the second and third, position fixing at any time and season to an accuracy of a few hundred metres or less, is highly desirable.

Vessels fishing near the European and parts of the Labrador and Newfoundland coasts generally use Decca for this purpose, achieving position fixing to within about 500 metres, and ability to return to the same spot within very much less.

However, many major fishing grounds are outside Decca coverage, and in addition weather conditions and local masking may mean loss of signal in covered areas.

The commercial exploitation of satellite navigation systems, made possible by release of classified information by the U.S. Government, has started and is likely to accelerate rapidly.

For example, the Navy Navigation Satellite System* has a potential accuracy of about 200 metres and has a global coverage in all weathers. The disadvantage at present is shortage of satellites leading to periodic "blackouts" as the satellites rotate.

On the assumption that, with commercial incentives, sufficient satellites will become available to give 24-hour coverage, it is obviously necessary to be prepared to accept this highly desirable innovation.

The N.N.S. system, like all other satellite-based systems, requires the services of a digital computer to process the information received on the ship. Although a N.N.S.S. package including a computer could be envisaged, this is a further use again for a centralized multi-purpose computer on the ship, and W.F.A. fully intend to use the computer on the "St. Jasper" for this purpose.

5. MAINTENANCE

Most merchant shipping companies with high speed data logging facilities on their vessels have not yet solved the problem of how to get real value from the large quantities of information returned from each trip.

At first sight, it would seem that this problem should have been solved before installing the data loggers; but in fact in most cases logging equipment is merely an inexpensive addition to alarm scanning equipment, itself an essential feature in automation schemes. Therefore the logged data is frequently merely filed at the end of each voyage, and often the Chief Engineer's log sheets are consulted by the Superintendent Engineer in preference to the data logger output, simply because the former are more concise and easier to follow.

Therefore it is clear that computer processing of data logger output is essential for it to realize its true value.

Maintenance of machinery on trawlers is done by the bigger companies to a pre-conceived plan which is however a compromise. Thus, each line on the main engine may be strip examined at a time interval which is dictated by:

(1) voyage length;
(2) insurance requirements;
(3) manufacturer's requirements;
(4) experience of the Superintendent;
(5) availability of shore labour;
(6) breakdowns.

The computer processing of logged data may be able to improve these maintenance policies by:

(1) modifying insurance and manufacturer's requirements, by furnishing evidence of the equipment's state of reliability;
(2) considerably extending the Superintendent's knowledge of the equipment;
(3) detecting wear and incipient failure.

Therefore W.F.A. intend to find out whether the computer on the "St. Jasper" can be programmed to carry out this function, using the data logged on the main engine, and certain other parameters added specifically for this.

Computer facilities for ten maintenance procedures will be allowed for. Each procedure will call up the reading, at suitable intervals, of a master parameter. If this parameter is outside certain limits, it will read and compare certain other parameters. If the relationship of these parameters with the master does not obey a law input by the program, there will be a print-out calling for inspection of certain components.

The first procedures programmed will be:

Procedure 1. Detect faulty fuel injector(s)
2. Detect excess carbon formation
3. Detect wear in rings or liners
4. Detect wear in main bearings
5. Detect deterioration in fresh water system
6. Detect deterioration in salt water system
7. Detect deterioration in lub oil system
8. Detect deterioration in fuel oil system

The parameters used for Procedures 1 and 2 will be:

Shaft torque
Shaft rpm
Propeller pitch
Individual fuel rack settings
Individual exhaust temperatures
Individual cylinder peak pressures

*The Navy Navigation Satellite System Commercial Utilisation Status Report – Chernof, J., International Symposium on Maritime Navigation, The Norwegian Society of Professional Engineers, September 1969.

The inter-relation of these parameters to produce the fault conditions mentioned, will be the subject of study before writing the computer programs.

6. FURTHER ACTION

The four duties mentioned above, when added to the basic watch-keeping duty of the computer being built for the "St. Jasper," would make the computer a central processor for the management of the ship as a whole.

However, unlike the unmanned engine room equipment, they are as yet only concepts and will require considerable experimental work over a two or three-year period, to prove their feasibility.

Other activities on large fishing vessels would profit greatly by automation and mechanization, namely gear handling, winch control and fish processing. It is felt, however, that these functions by their nature would, at the present time, profit more from direct mechanical mechanization techniques rather than by centralized cybernetics; the latest developments by W.F.A. in these fields are reported elsewhere in this Conference*.

Appendix I

Outline Specification of "St. Jasper"

The "St. Jasper" is a single screw refrigerated stern trawler owned by Thos. Hamling and Company Limited of Hull and built by Ferguson Brothers of Port Glasgow, Scotland, to Lloyds Classification + 100 Al stern trawler, strengthened for ice.

Length overall	231 ft	(76 m)
Beam moulded	39 ft	(12.8 m)
Depth moulded	24.5 ft	(8 m)
GRT	1137 tons	
Design service speed	14 kts	
Accommodation capacity	31	
Fishroom capacity	32000 ft^3	(1130 m^3)

Main Propulsion:—

British Polar M66T, 6 cylinder, 2 stroke diesel engine rated at 1920 bhp at 225 rpm. Operates on residual fuel of about 400 sec. Redwood No. 1 viscosity at 100° F. Direct coupled to Liaaen four-bladed controllable pitch propeller.

Main propulsion controls are situated in the engine room and in the wheelhouse.

Alternator sets:

There are three diesel driven sets supplying 440 V 3 phase 50 c/s for power and 220 V 1 phase 50 c/s for lighting.

1 British Polar SF15RS four stroke five cylinder charged cooled engine developing 720 bhp at 750 rpm, driving 560 KVA alternator.

1 as above but SF13RS three cylinder, 450 bhp, 350 KVA.

1 Gardner diesel engine type 6 LX six cylinder, developing 80 bhp at 1000 rpm, driving 55 KVA alternator.

These sets all operate on Marine Distillate.

Steam Generation:

1 Spanner 'Swirlyflo' exhaust gas boiler producing up to 1340 lb/hr at 100 lb/in^2.

1 Spanner 'Swirlyflo' oil fired boiler producing up to 2000 lb/hr at 100 lb/in^2.

Refrigeration Machinery:

By L. Stern and Co. Ltd.

5 Mark 6VPC 60 hp electric motor driven compressors, 1 Mark 1 MAC 25 hp compressor for holding duties.

8 20-station Jackstone vertical plate freezers.

Primary R22 refrigerant, secondary trichlorethylene refrigerant.

Machinery complete with circulating pumps, condensers, cut-outs and warning panels.

Services:

All service pumps and the main air compressor are electric motor driven, except the service pumps for the alternator sets. The pump sets include:

Main Engine Lub Oil	(3)
Main Engine Fresh/Salt Water	(3)
Fuel Valve Cooling	(2)
Heavy Oil Transfer	(1)
Heavy Oil Circulating	(2)

*'Mechanisation of Gear Handling and Fish Working on Board' — Kerr, N.M.

Heavy Oil Boost	(2)
Diesel Oil Transfer	(1)
Oily Bilge	(1)
Bilge	(1)
General Service	(1)
Fish Wash	(1)
Fish Offal Sump	(1)
Boiler feed	(2)
Steering gear	(2)
CP Unit	(2)

Refrigerant circulating and cooling pumps.

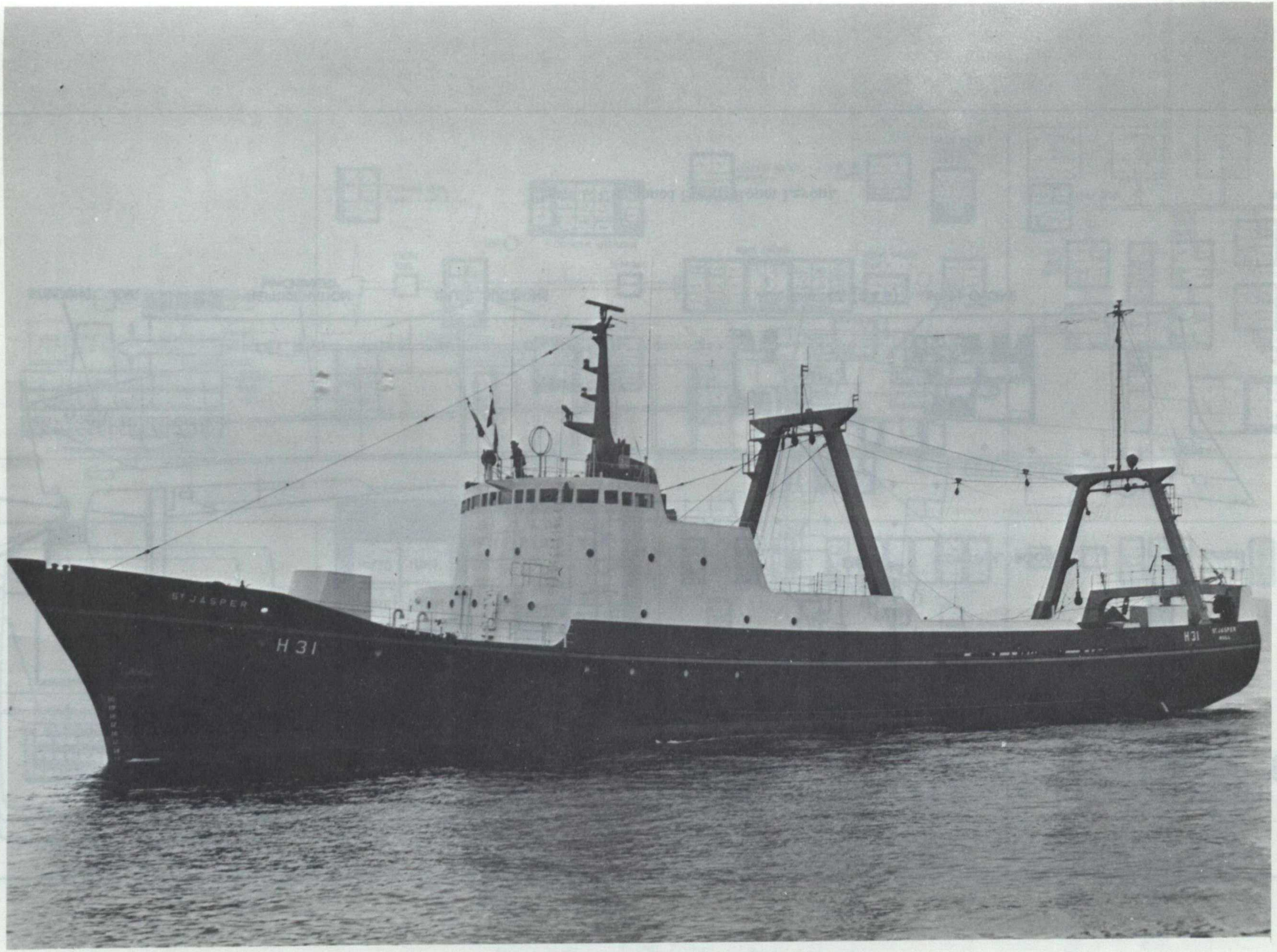
Trawl Winch:
By Hydraulik A/S, Bratvaag.
Driven by 6 hydraulic pumps fitted to a common gearbox and driven from the forward end of the main engine.
Single standby hydraulic pump driven by 80 hp electric motor.

The above is an outline machinery specification only, details being omitted.

Appendix II

Manual Duties Unaffected by U.E.R. Scheme

		Frequency	Duration
1.4.	Checking of bunker tank levels. At present the duty bunker tanks are checked each watch, but with the installation of the U.E.R. scheme this will be carried out daily.	Daily	15 min
1.11.	Pumping out oily bilge.	Daily	1 hour
1.14.	Topping up of steering gear oil cups.	Daily	5 min
2.1.	Testing refrigerating plant for gas leaks.	Daily	1 hour
2.3.	Cleaning of lub oil purifier.	Daily	45 min
2.4.	Addition of boiler water treatment.	Daily	15 min
2.5.	Greasing of main winch and sheaves.	Daily whilst fishing	1 hour
5.2.	Oiling fuel rack lay shaft bearings.	Every two days	5 min
5.4.	Greasing steering gear.	½ weekly	5 min
5.5.	Greasing windlass.	Once per voyage	½ hour
5.6.	Greasing Witchita clutch.	Once per voyage	10 min
5.7.	Greasing auxiliary pumps.	Daily	10 min
5.8.	Greasing rudder post.	Daily	5 min
5.9.	Checking oil level in main hydraulic pump gear box.	Once per voyage	15 min
5.10.	General cleaning and wiping down.	Daily	variable
6.1.	Cleaning bilge filters.	½ weekly	1 hour
6.2.	Cleaning main engine lub oil filters.	3 weekly	1 hour
6.3.	Diesel alternator lub oil filters.	Once per voyage	½ hour
6.4.	Diesel alternator fuel oil filter.	Two weeks	½ hour
6.5.	Boiler fuel filter	Weekly	½ hour
	Dirty oil filter } Winslow filter	Six months	1 hour
	Clean oil filter } Winslow filter	Six months	1 hour
	Diesel oil filter } Winslow filter	Six months	1 hour
3.	All start up and shut down procedure when preparing the vessel for sea or entering port.		



The "St. Jasper".

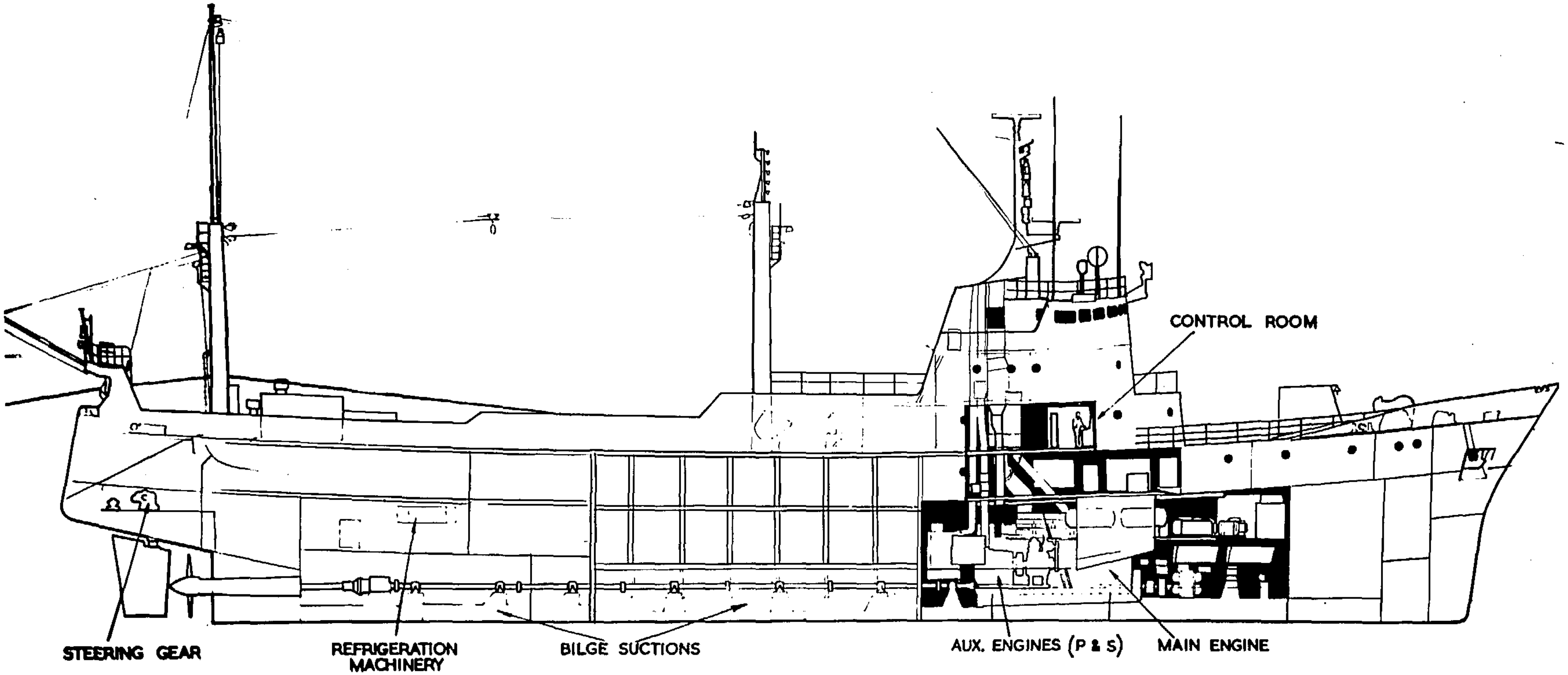


Figure 1. Unmanned Engine Room Layout.

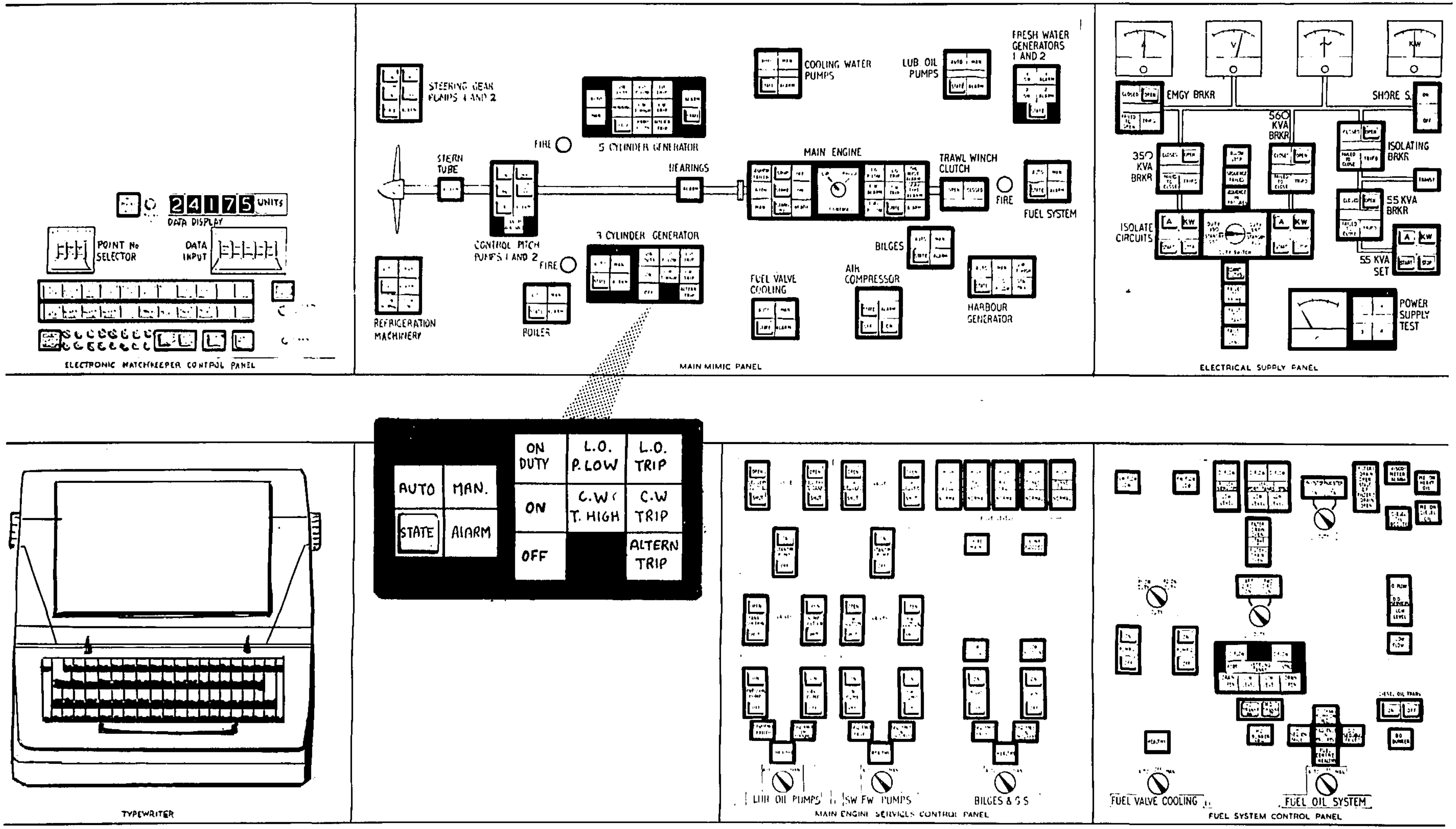


Figure 2. Unmanned Engine Room Control Console.

Canadian Experience Spawns an Advanced New England Stern Trawler

Mr. van Dissel

A Case Study of the Success of the "Old Colony" and Its Influence on Modern Fishing Vessel Design

by

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Gerrit J. van Dissel
and
William Buote,
Potter & McArthur, Inc.,
Naval Architects & Marine Systems Consultants,
Boston, Mass.

and

Caleb Warner,
Bolt Beranek Newman, Inc.,
Boston, Mass.
(Presented by G.J. van Dissel)

Mr. Potter, a graduate of the Drake School (N.Y.) of Marine Drafting and Naval Architecture, was employed from 1936 to 1940 by the Luders Marine Construction Co., Stamford, Conn. In 1940-41 he designed interior components of commercial flying boats for the Vought-Sikorski Branch, United Aircraft Corporation, Stamford, and from 1941 to 1945 was Chief Draughtsman for Luders Marine Construction Co., Stamford, working on design and calculations for navy, army and air sea rescue craft and other vessels of wood, steel, aluminum and molded plywood construction.

From 1945 to 1950 Mr. Potter was Head of Construction and Arrangement Section, Building Supervision, for Sparkman and Stephens, Inc., New York, N.Y., and among other things was in charge of hull design and arrangement for navy 144-foot minesweepers. In 1950-51 he was Head of Arrangement and Construction for John C. Alden, Boston, in building prototype boats for the Army Transportation Corps – dry cargo, tanker, reefer. From 1951 to 1954 he was Naval Architect and Superintendent for the Manchester Marine Construction Co., Manchester, Mass. and from 1954 to the present Director and Senior Naval Architect for Dwight S. Simpson and Associates, which was succeeded by Potter and McArthur, Inc., Boston. He is a member of the Society of Naval Architects and Marine Engineers, and of the Working Group on Stability of Fishing Vessels, IMCO. He presented a paper on design and construction at a meeting of the FAO Fishing Vessels Congress, Gotenburg, in 1965.

Mr. Van Dissel received his I.R. Degree in Naval Architecture at Delft University, Delft, Holland, and his B.A. Degree at Goddard College, Plainfield, Vermont. From 1951 to 1953 he was naval architect and *field supervisor of construction for Phs. Van Ommeren N.V., Rotterdam, and from 1953 to 1954 consulting naval architect and Field Supervisor of construction for Nederlandse Scheepbouw Export Centrale, Rotterdam, working on 100-foot patrol vessels, oil tankers and general cargo vessels.*

After going to the United States in 1954, Mr. Van Dissel was Lubrication Engineer and Staff Consultant for the Farrel Corporation, Ansonia, Conn., and later Marine Superintendent, cargo vessels and supertankers, for Phs. Van Ommeren Shipping (USA) Inc., New York. His field included ships' operation and management, chartering and husbanding, seaworthiness for towing of floating equipment of varied nature, cyrogenics design for carriage of LFG and condensed chemical gases, and handling and storage of liquid chemical cargoes and explosives. From 1966 to the present he has been with Potter and McArthur, Inc., Boston, as general manager in charge of operations, design of fishing vessels, research vessels, tugboats, hydraulics systems, conversions, management consulting, chartering and brokerage. He is a member of the Society of Naval Architects and Marine Engineers and of the Royal Institute of Engineers, The Netherlands.

Mr. Buote is a graduate of the Electrical Engineering Department of Northeastern University, the Webb Institute of Naval Architecture, the Massachusetts Institute of Technology, and the SB Naval Architecture and Marine Engineering.

From 1962 to 1965 he was employed by the Arenberg Ultrasonic Laboratory, Inc., in production testing and alignment of high powered pulsed oscillators and wireband amplifiers, as well as in prototype fabrication. In 1965 he joined the Electric Boat Division of General Dynamics Corporation, and from 1966 to the present has been employed by Potter and McArthur, Inc., Boston, in the design of fishing vessels, research vessels, fireboats, hydraulic systems, marine electrical systems, the conversion of yachts, and sailing yacht research. Mr. Buote is an Associate Member of the Society of Naval Architects and Marine Engineers.

Mr. Warner holds a B.Sc. Degree (Marine Engineering) from the University of Michigan, 1944, and was a member of the Tau Beta Pi Practising Engineering Fellowship to Scandinavia, 1947-48. He was a non-degree "special student" in the graduate program at Harvard University, 1948-49.

His professional experience follows: 1964-1966, Consultant to Edgerton, Germeshausen and Grier, Inc., (systems design and technical marketing); General Manager, small R and D firm, now division of D.N. Baldwin Co., (doing mechanical and electronic development of musical instruments); 1962-1964, E.G.G. Assistant Department Manager; Oceanography Department and Applied Optics Department; 1961-1962, General Manager at Magnion, Inc., (developing large research laboratory electromagnet systems); 1952-1961, Arthur D. Little, Inc., (ASW Systems Studies, Project TRIDENT, Cryogenic systems design, cryogenic systems development); 1950-1952, duPont Co., Departmental Technical Planning Staff; 1949-1950, C.I.A., Technical Studies; 1946-1948, Instructor, Tufts University, School of Engineering; 1944-1946, Machinery Repair Officer, at sea, U.S. Naval Repair Ship.

In his present position at Bolt Beranek and Newman, Inc., Boston, Mr. Warner performs planning and staff functions in the ocean sciences. He is also concerned with staff functions in the development of commercial instruments.

At ADL Mr. Warner's positions included that of Marine Engineer for ASW Studies, as a member of the initial team preparing and performing Project TRIDENT for the Bureau of Ships. At E.G.G., Mr. Warner planned and participated in several large R and D programs concerning oceanographic systems design, geophysical survey services and night aerial photoreconnaissance lighting.

He is a Fellow of American-Scandinavian Foundation (Marine Engineering Studies in Sweden), Tau Beta Pi. He has had one patent granted, two pending re *musical instrument electronics acoustics and mechanical design. One patent in process* re *stable manned floating platforms.*

ABSTRACT

I. *Targets for Progress* – A summary of what the fleet operator really wants from mechanization, automation and from the integrated design services of the naval architect.

II. *Evolution vs. Revolution* – A case history of the design and operating results of the "Old Colony", a highly successful mechanized stern trawler in the Boston groundfishing fleet.

III. *Practical Tools for Planning* – Economic analytical techniques for use in planning next generation vessels based on actual Canadian groundfish fleet experience.

IV. *Format for Action* – A practical approach to be used by owner and naval architect to develop next generation stern trawler designs.

I. TARGETS FOR PROGRESS

What Does the Fleet Operator Really Want from Mechanization and Automation?

While this conference is dedicated to automation and mechanization we would like to suggest that an important descriptor be added to the conference title, namely "integrated design". As naval architects to the fishing industry, our approach here will be to fit the opportunities from automation and mechanization into the whole problem of the fishing system – the resource, the vessel, the man and the shore facility.

The proponents of mechanization and automation must examine the cost/*effectiveness* of their products and techniques. We, as systems designers, must translate their proposals into cost/*benefits* to fleet owners, crew and the national economy.

But first, let us try to agree on some ground rules. In simplest form, the major topic words for the conference might be defined as follows:

Mechanization: mechanical aids for crew labor, controlled by the crew, aimed at reducing the demands on the fisherman of strenuous or labor-intensive tasks.

Automation: mechanized processes replacing crew labor, controlled automatically.

Notice that we have reversed the order used in the conference title. First must come mechanization, then automation, since the latter consists of one machine controlling another without significant human intervention.

For our proposed third descriptor, we propose a cross between a definition and a target, namely:

Integrated Design: Use of modern yet proven elements throughout the fishing system, selected so that they mesh into an optimum combination of hull, propulsion, outfit, gear and shore facility capable of being economically operated by available personnel to produce a highly marketable product.

With these three definitions in mind, it is possible to set forth what the vessel owner is seeking via the naval architect – let's call these goals. It is also essential to alert ourselves to some of the problems that will be encountered in seeking for the owner the advantages of mechanization, automation and integrated design. The following table relates goals and problems in a general way:

BASIC INTERRELATIONSHIPS OF TRAWLER MODERNIZATION

MECHANIZATION

Goals:	*Problems:*
Increased vessel productivity	High initial cost
Higher product quality	Questionable mechanical reliability
Improved personnel safety	Difficulty of maintenance
Better working conditions	High level of operator skill needed

AUTOMATION

Goals:	*Problems:*
Crew reduction Increased individual productivity	High first cost Questionable reliability, maintainability, flexibility

INTEGRATED DESIGN

Goals:	*Problems:*
Optimum initial investment Minimum maintenance and downtime Low at-sea costs Consistent all-weather performance Attraction to desirable crew High returns to owners and crew	Local traditions hindering progress Unpredictability of fishing conditions Short supply of available capital

The "Old Colony" heading out to the fishing grounds.

II. EVOLUTION VERSUS REVOLUTION

The story of development of the "Old Colony", a highly successful New England groundfish trawler.

Today's most successful groundfishing vessels are the product of an evolutionary design process. While progress in many areas of technology has depended on revolutionary approaches, our own fishing industry has stepped forward cautiously, evolving each new vessel design based on proven practice. The design of the most successful vessels of the future may have to follow a new course. To promote progress as fishing vessel designers, we are now faced with some difficult decisions; three tracks are open to us:

1) We can continue the *evolutionary* approach – merely changing our last designs in a minor way, resulting in small and perhaps uncertain improvements in permance.

2) We can approach the new design problem in a *revolutionary* way, casting out proven practices in favor of experimentation.

3) We can use an *integrated systems design* approach, whereby each element of the vessel – hull, propulsion, outfit and gear – is carefully considered anew in each new design in search of improvements, finally to be woven into a truly new and optimized design.

We obviously favor adopting the last design approach. Fishing vessel design is only just reaching the point where we can proceed in this fashion. The industry has finally reached the point where the technology has advanced and the vessel owner's attitudes have developed to a point where integrated systems design can be practised.

To put all this into proper historical perspective, let us see how the "Old Colony" evolved, since she is the most successful vessel in the Boston groundfishing fleet. By understanding this evolutionary experience, it will be possible to see how to take the next step for future vessels using the integrated design approach.

About 10 years ago Dwight Simpson of our firm was engaged by a Canadian maritime fishing enterprise to consult on the selection of a suitable trawler design from several alternatives as offered by a number of Dutch shipyards. A design was chosen and three vessels were then built: the "Nancy J. Fletcher", "Jean H. Fletcher" and the "Barbara B. Fletcher". The vessels were well equipped and have given a satisfactory performance. The hull form was a typical Dutch design of that time; it was somewhat narrow by today's standards, quite shallow and full-ended.

The next generation of vessels for the same Canadian owner were designed by our firm from the keel up. Based on experience with the previous Dutch design, we evolved vessels with more beam and more depth, increased freeboard and reduced overall length. George T. Davie & Sons built this design, resulting in the "Ann C. Spencer", "Rose J. Gordon" and the "Ellen N. Fletcher". This design met all expectations of speed and seakindly behavior, landing consistently large catches in almost all weather conditions. A number of additional vessels of the same design were built, including the "Rupert Brand VI", "VII", and "VIII", and the "George Kentner". The naval architect's role in this stage of evolution concentrated on providing a good hull form of better-than-usual seakindliness, sufficient stability, and with economical but adequate powering. Fishing gear and deck arrangements were copied from established patterns with minor modifications to suit.

As stern trawlers showed promise in Europe, interest grew among the North American groundfish industry. But now the naval architect's function had to take on an entirely new depth of approach. In order to realize the apparent benefits of the new stern trawlers, the naval architect needed to involve himself deeply in areas previously taken for granted, such as fishing techniques, fishing gear handling, rationalization of fish handling by time and motion studies, and considerations of protection of crew against weather and seas. The naval architect now found reason to draw heavily on the findings of the industrial engineer, mechanical engineer and systems analyst. The job of "shoe horning" a new range of equipment into a hull and arriving at an economical, easily operated and safe stern trawler design became the new responsibility of the naval architect. His landborne colleagues practising the other technical disciplines could only suggest components. The naval architect had to integrate them.

At this point in history, the advent of the stern trawler in Europe found the North American fishing industry a bit disjointed in approach to new designs. Owners were over-eager, the naval architects were under-experienced, and national subsidy and advisory programs were not yet in tune regarding the application of the stern trawler to the local scene. As a result, the pioneering stern trawlers on this side of the Atlantic ended up to be of questionable economy compared with the better side trawlers of the earlier decade. The first new stern trawlers were, as it turned out, perhaps too large and certainly too costly at the outset. The results were that initially they landed fewer tons of fish per dollar invested.

Generous construction subsidies and loans, together with strong influence of European designers of long-distance stern trawlers, guided the Canadian owners in most of their new construction decisions. The larger vessels should have allowed ample space to accommodate net hauling and fish processing without difficulty. However, cluttered areas and wasted space remained abundant in many vessels due to inadequate integration of the functions of subsystems.

Much that was good came out of the early Canadian experience, however. Habitability and general improvement in working conditions were noticeable on stern trawlers. It also became evident that there was the seed of a sound idea which could become highly successful in the Canadian environment if the design could be optimized.

Meanwhile, in New England, a watching process was going on. For the New England fleet, financing arrangements for new construction are, and have been, much less favorable than in Canada, putting severe restraints on the ambitions of owners who were following and watching the Canadian stern trawler fleets with great interest and envy.

Early in 1966, the Boston Fishmarket Corporation commissioned our firm to prepare a design for a series of stern trawlers. Targets were set as follows: 1) cost approximately $750,000; 2) vessel to be fully competitive with European and Canadian stern trawlers; 3) fishing limited to Georges Bank, Browns Bank and Grand Manan Bank areas; 4) aimed toward landing capabilities of high-priced fresh groundfish (haddock and cod) during the winter months when many smaller boats are weatherbound and market supply dwindles; 5) powered for and capable of operating in the worst winter weather; 6) speedy enough to be able to play the fluctuating market; and 7) automated and mechanized vessel as so to qualify for the Atlantic Fisherman's Union acceptance of a crew of 13 (instead of 17, as required by contract on all other trawlers operating out of Boston).

Our experience with the design and construction of the 187 ft stern trawler-fishery research vessels "Albatross IV" and the 85 ft "Dan Moore" provided us with background design data for the upper and lower limit of the size range sought. The design concept of the new vessel and many of its subsystems and details evolved in a large part from Canadian experience. We are indebted for the guidance we obtained in discussions and interviews with many Canadian owners, operators and shipbuilders, many of whom are assembled at this conference.

Under the pressure of a tight budget, and based on our own interpretation of the requirements of Georges Bank fisheries, we set out to delineate minimum volumes for the modules or "building blocks" required for engine room, fish hold, fish processing, accommodations, navigation and stretched net area on deck.

A design envelope resulted, in which the following were the critical values: 1) 1500 HP main engine installation, sized for future midwater trawling; 2) fishhold for 400,000 lbs of iced fish; 3) crew accommodations for 14; 4) ample space on deck to bring a Skagen or Yankee 41 trawl on deck in a single haul; and 5) a resulting overall length of about 120 ft.

Experience with the very favorable hull form characteristics of the 129 ft Canadian side trawlers mentioned earlier made us hesitant to limit the length in the preliminary design to 120 ft. An increase of displacement over the side trawler was anticipated due to higher horsepower, larger tankage, heavier winch system, and increased superstructure. The side trawler's basic hull form was therefore adopted, with a modest increase in beam, depth and prismatic coefficient. The stern area above the waterline was widened out and redesigned to accommodate the ramp and the stern gallows. Model tests were then run at the Massachusetts Institute of Technology's towing tank, running free and towing in a simulated seaway up to sea state 7. As a result of the tank tests a minor modification to bulwark flare and wavebreak was made. It appears, however, that the model tank simulation implies a more severe condition than in actual sea conditions, and on the second vessel we have reduced most of the high wavebreak on the forecastle, which had been placed on the first vessel for the peace of mind of the captain. Figures 1 and 2 show the profile and arrangement plans of the finalized "Old Colony" class design.

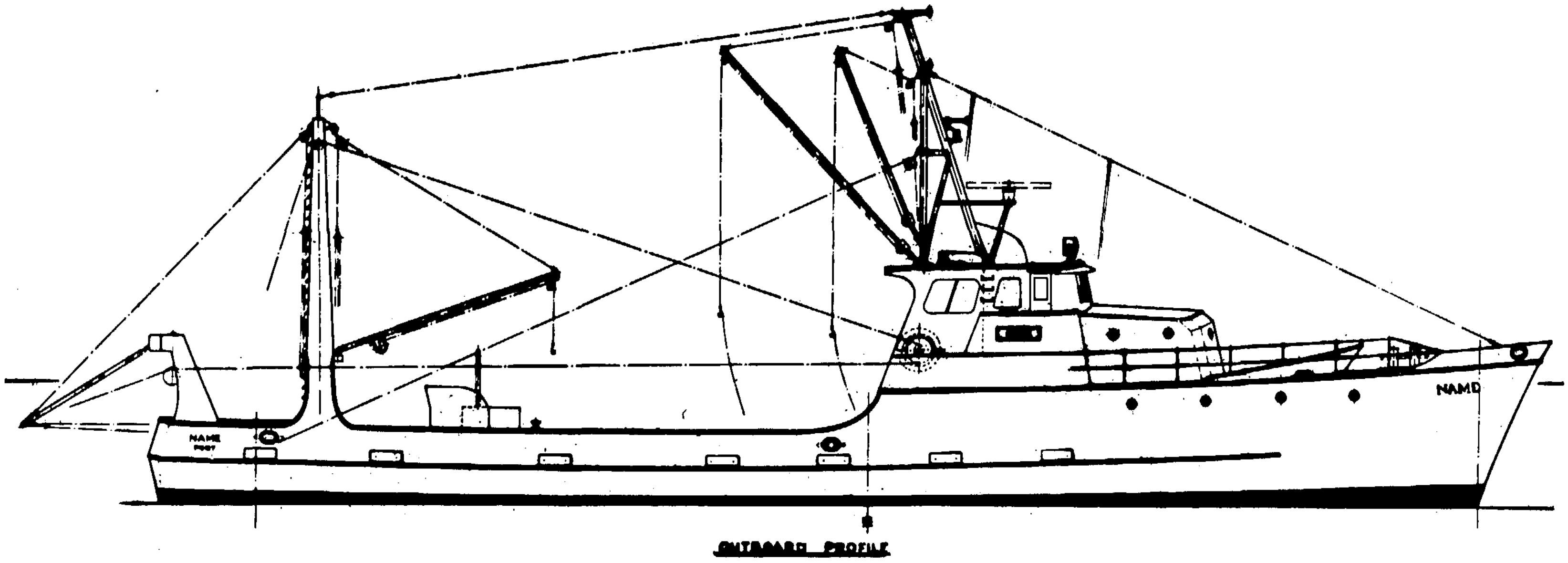


Figure 1. "Old Colony" Class Stern Trawler.

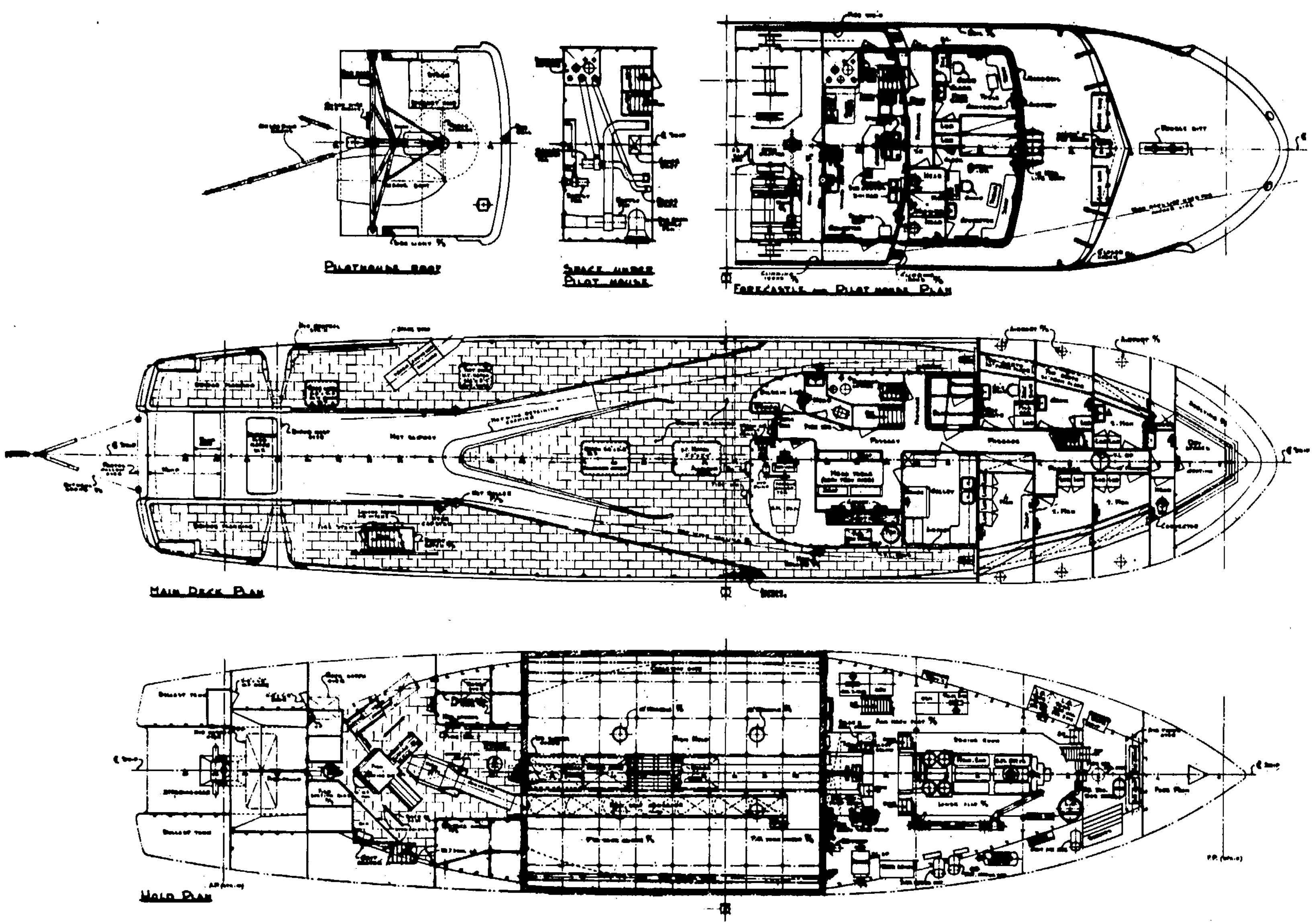


Figure 2. "Old Colony" Class Stern Trawler.

The General Goals of Mechanization in the "Old Colony" Design

Throughout the design of "Old Colony", there was heavy emphasis on mechanization. The intent was several-fold, namely:

1) to raise the general productivity of the vessel

2) to reduce crew size both to better the share of individual crew members, reduce insurance costs, and to eliminate costly accommodation spaces

3) to increase the crew safety through requiring less strenuous and dangerous physical handling of the catch,

4) to improve product quality through lowering the amount of manual re-handling during shipboard processing and storing.

Apparently, the first goal has been achieved. The "Old Colony" has set production and landed value records for the fleet operating out of the Boston Fish Pier.

The second goal has been achieved in that the crew size has been successfully reduced. The Atlantic Fishermen's Union co-operated with the owners in an agreement to allow a manning schedule of 13 as opposed to 17 usually required on the sidetrawlers. The agreement was based on the fact that the workload and working conditions would justify such a reduction without added strain on the fishermen.

The third goal – safety – has been met to date. The general level of strenuous or dangerous physical effort seems to be below that experienced in earlier vessels.

The final goal – product quality – seems to have been achieved. There has been no evidence of degraded product to date, in spite of the minimum crew used and the comparatively large landings.

From the naval architectural systems point of view, we encountered some initial difficulties in dealing with mechanization. The requirements of the U.S. fishing vessel differential construction subsidy law prescribes that U.S.-manufactured equipment shall be used unless proved to be unavailable at any price. We found that traditional U.S. fishing vessel equipment manufacturers could not supply the requested components for mechanized systems. It became the naval architect's responsibility to expend engineering effort to enable some manufacturers to offer designs in sufficient detail to be suitable for inclusion in contract plans. To achieve mechanization progress, therefore, the modern fishing vessel designer must analyse all subsystems in detail, and prepare specifications and plan details on equipment which, on more conventional vessel designs, could be specified as existing, fully engineered units.

The Role of Automation – The Propulsion System

Automation was considered seriously in only one aspect of the "Old Colony" design – namely remote engine room operation. Based on earlier fleet experience, the owners preferred a fixed pitch propeller, without nozzle, driven by a General Motors Electro-Motive Division main engine. The propeller speed and rotation is controlled by a single-lever air-control for both throttle, clutches and reversing gear. This control is placed in the pilot house adjacent to the steering stand.

The pilothouse panel has "alarm" and "emergency stop" buttons, and an additional "call" alarm for the wheelhouse watchstander to alert the engineer when the engineroom is unmanned. With this arrangement, the U.S. Coast Guard waived their requirement for "one licensed engineer in the engine room on every watch". Now, the Coast Guard requires only "one licensed engineer to be on board the vessel".

The engineer's function as merely a watchkeeper on board U.S. and Canadian groundfishing vessels is apparently vulnerable in the face of automation, yet he may become critical as a trouble-shooter and maintenance man as vessels become more highly mechanized and automated. His presence onboard as a routine watchstander may be only prolonged by the actions of regulatory agencies and unions unless he takes on additional functions directed at sophisticated equipment maintenance, highly skilled operation of the fishing gear, or as captain or mate of the vessel.

Mechanization Manifestations – Gear Handling

Gear handling design on the "Old Colony" is based on the premise that the productivity of the vessel will be primarily dependent on the ability of the crew and mechanical aids to handle the net. The hull and propulsion system were selected to provide a platform which should not be limited by weather or sea conditions, hence the total "fishing system" is net limited, and can perform only as well as it can handle its gear. Accordingly, great emphasis was placed on this aspect of the design.

A six-drum winch was selected with 350 HP input driving the hydraulic pump. Drum line speed is 210 ft per minute at 36,000 lbs pull. The winch is placed on the superstructure deck, and the trawl wires pass above the work deck with 9 ft vertical clearance. The winch console is placed just aft of the steering stand inside the pilothouse on the centerline of the aft bulkhead. The failsafe air controls for clutches, the brakes for each drum, and the hydraulic reversing valve give the pilothouse full control over all net hauling gear. The stern ramp gate, fish-pond-hatch and outhaul capstan are controlled at a station on the port leg of the A-frame.

Originally it was planned to take the hydraulic winch power from the front end of the main engine. The engine manufacturer, however, was strongly opposed to running anything but a generator from the main engine for reasons of uncertain effects on the torsional vibration in the propulsion system. An independent diesel thus drives a hydraulic pump. This choice has proved to have unpredicted benefits, since the captain now has completely independent control over both propulsion and winch. Fine speed control of the winch with regulating valves has proved to be less satisfactory than originally claimed, but the addition of independent diesel-driven pump speed control provides an additional 3:1 speed variation giving an ideal degree of flexibility.

Before every haul-back, the winch engine is started with a pushbottom control on the winch console, and is subsequently shutdown remotely when the trawl wires are ready to be released.

The net handling is similar to many well-designed Canadian stern trawlers. The wings are hauled forward on the port and starboard sides till the footrope fits around the horseshoe. A Gillson wire brings the bag up on the ramp and a baglift dumps the catch against the fishpond hatch, which has meanwhile swung upwards. The sweepline and the pendant or messenger wire are 5/8" diam, which is more than adequate for strength, while it is also light and flexible enough to be handled by one man. A carefully placed set of hooks is installed on the trawl door brackets and a pendant is fastened at half-height to the A-frame legs. This layout allows the link between messenger and sweepline to swing upwards to the door bracket level, allowing the crew to disconnect and fasten the messenger to the door bracket without strain.

Although quite often a four-man fishing crew happens to be on deck during hauling and setting, only two men are actually required to handle the gear.

During the last eight months, the captain of the "Old Colony" has evolved an interesting and productive operating philosophy which is new to the Boston fleet, and is a direct reflection on the degree of mechanization of his gear handling subsystem. Specifically, "Old Colony" hauls back their gear about every 30 minutes, as opposed to the 1 1/2- to 2 1/2-hour period practised by other local side trawlers. The rationale is as follows:

1) the time and effort required to shoot and haul back is much less than heretofore (thanks to deck layout and mechanization), hence little time is thus lost.

2) the net can be checked for tears and rips more frequently, hence there is less unproductive time on the bottom.

3) the species can be frequently checked, hence fewer hauls result in low-market-value fish.

4) the hauls can be handled in smaller quantities with less attendant physical damage and a smoother flow through processing into icing, resulting in a higher quality product.

Fish Handling and Processing

The underdeck sorting, ripping and handgutting of the catch is similar in principle to that practised by many Canadian trawlers. A lot of effort has gone into layout for efficiency and product quality. The bulk of the fish is retained in a fish pond, and admitted as needed into the processing room by controlling the height of vertical bulkhead hatches.

The whole fish enter two sorting and ripping bins, about 2000 lbs capacity each, elevated 18" from the workdeck. Trashfish are discharged over the rail of the weather deck by a scraper-type conveyer. Ripped market-grade fish are placed in an adjacent 600-pound holding bin. From here, the fish flume into two gutting tables with a V-shaped bottom, placed adjacent to the washbox. The washed fish flume out of the washbox onto a conveyor system and into the fishhold. Pre-set plows dump the fish into allocated bins. The ice handler periodically spreads out the fish and adds ice on top from an adjacent icepen. The ice is stowed in a checkerboard pattern throughout the fishhold when the vessel is initially loaded.

Some Trends Away From Mechanization

In at least two subsystems – ice handling and eviscerating – we found reasons against mechanization. We firmly believe that mechanization can eventually help in these areas.

All efforts to devise a mechanical ice handling system that is more practical and efficient were defeated by inherent difficulties in handling ice of varying quality mechanically, and the ease and efficiency with which the fishermen can shovel ice.

In the design stage of "Old Colony", we considered using a vacuum eviscerator, similar to that used in the poultry industry, and as presently developed to pilot operation stage by the U.S. Bureau of Commercial Fisheries. Analysis of gutting rates indicated that such a system would be desirable with consistently large catches of one species. For fishing on Georges Bank, where we experience a mixture of species in erratic quantities, the advantages of mechanized eviscerating did not seem to be apparent. Hence, there has been a trend away from mechanization in this particular area.

Maintenance and Repairs

The vessel has not been hauled for refit yet, although it has been in the water for over 18 months. Diver inspection confirmed the excellent condition of underwater hull, rudder, propeller, zinc anodes, etc. Repairs carried out during the layover time in port have been limited to incidental items such as refitting larger pins and bushings in the trawl blocks, replacing bearings on the trash fish conveyor, which occasionally jams due to oversized skates, dogfish or rocks.

During the first eight months, two hydraulic failures and one bearing failure occurred in the winch system, due to over optimistic predictions by the manufacturer concerning ability of the equipment to survive intermittent loads of 30% in excess of design loads. The failures were traced to pump cavitation and subsequent mechanical damage to both pump and motor. Installation of filters between pumps and motors and re-setting of governors and relief valves to limit the system to design pressures and flows have provided satisfactory operation of the winch.

We would like to inject a few comments on the application of individual systems, such as a hydraulic winch system. In development of new gear aimed at automation and mechanization of the fishing operation, many component suppliers are eager to become established in this new market, and promote their components without a full understanding of the rugged duty requirements of the fishing vessel. At the same time, many manufacturers may not have sufficient performance data about their components to offer them for fishing service. When a number of components from different and independent manufacturers are to be assembled into fully reliable fishing subsystems, evaluation of the suitability of the system components requires a thorough engineering background and approach. Neither the shipyard nor the owner's superintendent nor the traditional naval architect is equipped to guarantee the reliability of such a design and its components. A new type of systems engineering skill must now be applied, and the responsibility must be increasingly born by the naval architect. By way of example, during consturction and shakedown of the "Old Colony" system, troubleshooting was directed by our own engineers in a concerted effort with component suppliers. Design modifications and installation supervision was delegated by the owners to us, as the usual maintenance and repair staff had no experience with hydraulic installations.

It may be interesting to note that although the owners are now satisfied with the original hydraulic system of the "Old Colony" as now re-worked, the next vessel will be fitted with a modified torque converter drive for the winch, similar to those used on many oil drill rigs and earthmoving equipment. The basic reason for shifting to torque converter is a sizeable cost reduction and substitution of a single pre-engineered system package, eliminating shipyard installation of piping and components selected from many different manufacturers. As the torque converter performance characteristics are similar to those of the long-favored DC electric drive (slowing down as the load increases above average), we believe this system will find favorable acceptance from captains as well as shore maintenance personnel and owners.

Overall Performance of the "Old Colony"

In the currently depressed New England fisheries, the "Old Colony" has given new direction and encouragement.

The vessel broke all existing records for the Boston fleet. It received the highest unit price ever paid for haddock on its first trip, when due to stormy weather all other vessels were weatherbound. Its largest trip grossed over $43,500 – 30% more than the previous record catch dating back to the late 1940s.

The small crew has been able to handle the workload on board without undue strain and effort. At no time has there been a demand for more men.

Among non-unionized, family-operated boats the concensus is that they would operate a similar boat with an 8- or 9-man crew without difficulty.

The effect of the small crew and the excellent fishing record on crew earnings and crew morale have been dramatic. In 1969 the crew share amounted to approximately $16,000, considerably above the average earnings of the Boston fishermen. The vessel has never been delayed because of reluctance of crew members to sail.

Perhaps the most significant tribute has been paid by the owner. A sistership is under construction for 1970 delivery, and two more vessels are awaiting funding from federal subsidy funds, all for the owner of the "Old Colony".

III. PRACTICAL TOOLS FOR PLANNING

Modem analytical techniques show great promise when applied to the fishing industry. System Analysis has proved to be a powerful tool for investigating the overall effects of varying parts of an economic entity. Briefly, there are five pieces to the economic "puzzle" of the next trawlers. In plain terms (followed by the more up-to-date systems analyst's terms in parenthesis,) these become:

1. the needs and conditions of the owner.
(model inputs)

2. expectations from advanced technology.
(cost/effectiveness model)

3. method for measuring profitability.
(cost/benefit model)

4. comparison of altemate ways of improving the business.
(sensitivity analysis)

5. a plan for action.
(optimization and decision-making by exercising the models)

Providing the cost/effectiveness and cost/benefit models requires as much data as is possible to gather. The value of the results derived from exercising the models is only as good as the quality and quantity of the data used.

Few owners can afford to provide the data-gathering personnel and equipment required to construct extensive models and to provide the detailed system analysis which is theoretically possible. A streamlined approach to the problem is called for, which is tailored to the type of data normally available from the bookkeeping department of any fishing operation.

Such an approach is outlined as follows:

(a) *Study present fleet operating data* to evaluate real costs and performance, as well as to identify present trouble spots that could be overcome by new designs or new techniques.

(b) *Project a series of "standardized" costs and performance* which combine real experience with conservative forecasts for new vessels.

(c) *Analyse various alternative fleet and vessel combinations,* thus gaining an indication of how future fleet configurations might perform as to catch rate and landed costs.

(d) *Work with the owner to determine his requirements,* thus taking advantage of his experience and specialized knowledge.

(e) *Establish design factors* from naval architectural considerations to bring to bear the best judgement on the problem of producing an optimum vessel design.

(f) *Enumerate and evaluate* alternative design features so that the owner can determine which extra-cost options are cost-effective for his proposed fleet.

(g) *Evolve a design envelope* describing the optimum vessel (or range of vessels).

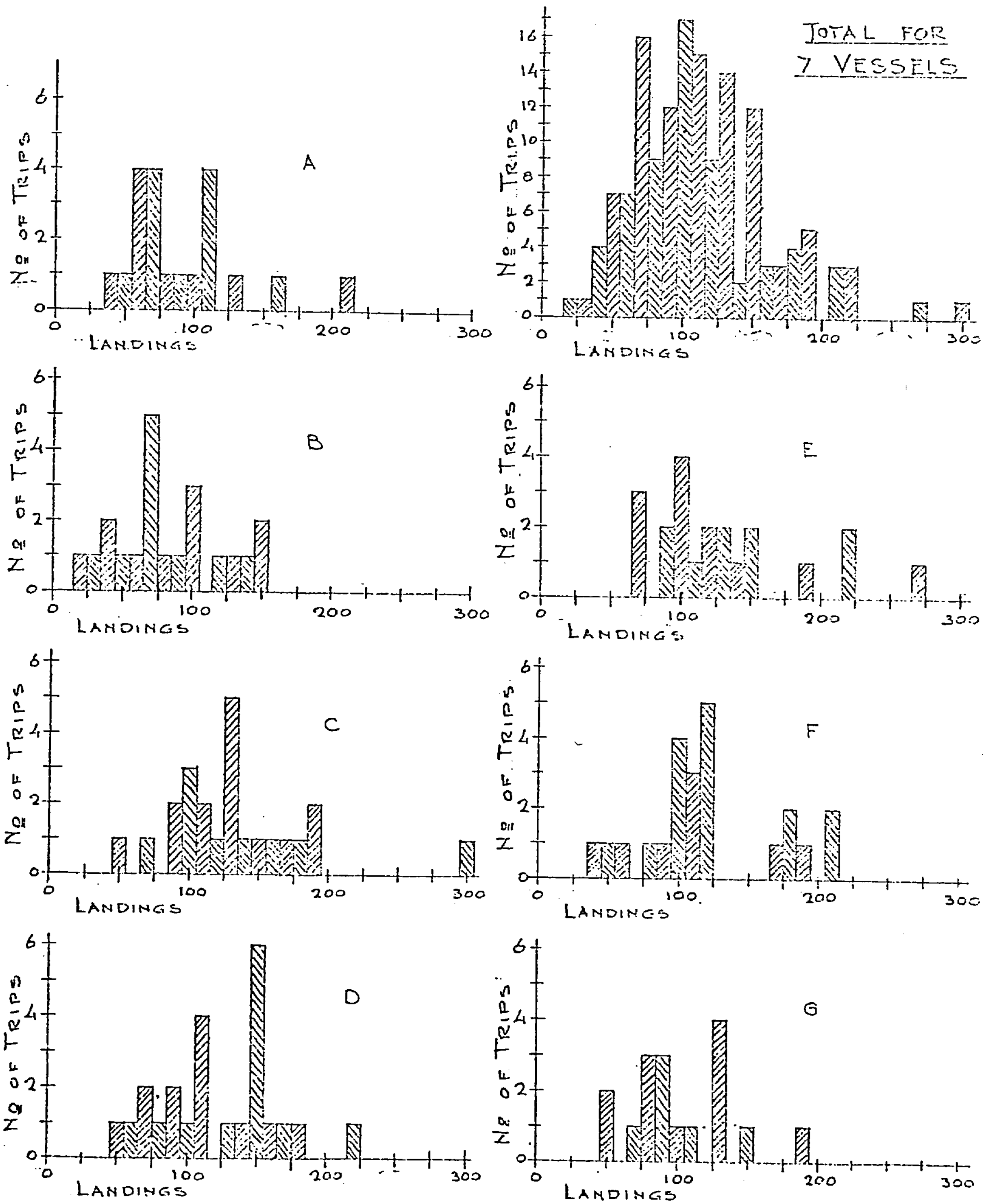
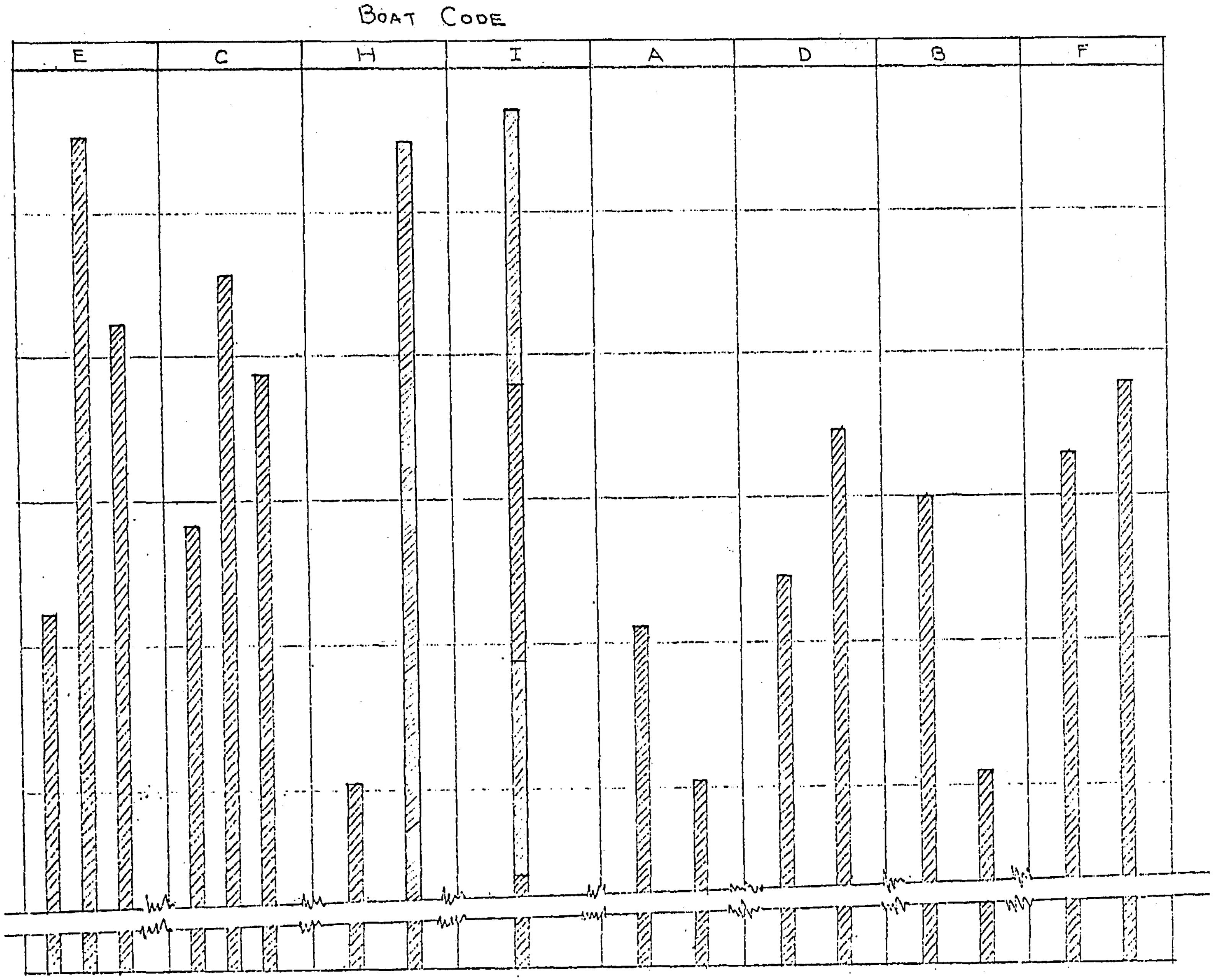


FIG. 3 FREQUENCY DISTRIBUTION. QUANTITY OF FISH LANDED PER TRIP



TYPICAL DISTRIBUTION OF ANNUAL CATCH
FOR VARIOUS VESSELS AND YEARS
FIG. 4

Projecting "standardized" costs and performance begins with the specific fleet operating data. The available data usually consist of trip catch records and operating cost records for the various vessels in the fleet. The catch records are analysed by statistical methods to obtain average catching levels of the whole fleet and its component breakdown. Operating costs are subdivided into two convenient parts: crew wages and non-capital vessel costs.

Figures 3 through 10 show typical charts and graphs resulting from analysis of available data.

Fig. 3 shows an example of the spread in the quantity of fish landed from trip to trip by seven typical vessels. Notice the variation in general performance level between vessels. Notice also the lack of consistency in landings in some vessels, while other vessels have a consistent record.

Fig. 4 shows the total annual landings for various years and various individual vessels. Notice again, the lack of consistent performance on the part of some vessels from year to year, as well as the substantial difference in annual performance between vessels.

Figure 5 shows typical curves of crew wages per pound landed and non-capital operating cost per pound landed; the relative positions of these curves may vary from one fleet to another, but the shapes generally hold true. The cost figures will hold only for one type and style of fishing boat (such as a stern ramp trawler) which may be under consideration for new construction. Different figures may be obtained if alternative vessel types (such as scallopers or purse seiners) are being considered.

Capital costs are readily figured by the required Return and Investment for the initial investment and period of amortization. The overall cost picture ends up looking like Figure 6, where the total cost per pound of fish can be taken off as a function of the initial total investment and the annual catch of the vessel.

Initial cost of trawlers in the size range under consideration can be estimated from a standardized formula in the following form:

$$\text{"Standard vessel cost"} = k_1 (L) + k_2 (L \times B \times D \times C_b) + k_3 (bhp)^{2/3} - k_4$$

Where:
- L = Length
- B = Beam
- D = Depth
- C_b = Block coefficient
- bhp = Brake horsepower
- k_1, k_2, k_3, k_4 = constants

The value of the formula lies in the determination of relative cost of individual vessels compared to others with variations in size and installed bhp.

The actual catch data as gathered at the beginning and shown in Figures 3 and 4 is rationalized on the basis of "standard vessel cost" and shown in Figure 7. Also shown in Figure 7 is a curve taken from published data by John Proskie,[1] which were factored upwards to reflect current vessel costs.

Combination of the catch and cost data results in an optimizing curve for a single vessel as is shown in Figure 8. From this curve or curves, the catch and cost expectations can be taken off for any initial investment in a single vessel.

Whereas data analysed so far has focused on single vessel operations, the picture might change when a fleet of vessels is considered. Figure 9 shows estimates of reduction in the "standard vessel cost" of a group of sisterships if procured simultaneously from a single yard. Significant savings (5 - 10%) on vessel costs can be obtained from group vessel procurement.

It is now possible to examine a fleet of vessels to determine the combination of individual vessels that will maximize annual fleet landings as well as call out total fleet costs of the fish thus landed.

Accordingly, Figure 10 shows the comparative performance of sample fleets of new vessels. Annual total fleet landings are related to fish cost indices for three levels of new fleet investment. For a given fleet investment, we show the effect on landings and cost as we buy vessels of different prices–i.e., when we hold the total investment target fixed and buy a larger number of small vessels vs. a smaller group of bigger vessels.

Notice that vessels in the $900,000 to $1,000,000 price class show economy of fish costs while achieving high

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1. Proskie, J., "Some Economic Considerations Relating to Canadian Atlantic Offshore Fishing Vessels", *Proceedings, Canadian Atlantic Fishing Vessel Conference, 1966*. Ottawa, 1967.

annual productivity. Going outside of this price class seems to invite disadvantages to the sample fleet owner, in that *both* fish costs and fleet productivity become less favorable.

The key to successful analysis is in the existence of optimum points on the curves shown in Figure 10. The optimum investment and the consequences of deviating from optimum are shown, to be subsequently used by the owner as guidance in making his decisions.

When applied recently to an actual fleet operation, this form of economic analysis allowed us to quantize some facts about vessel selection which had long been the subject of "hunches" of some of the better operators. Specifically, we found numbers to indicate:

(1) There was a size above which groundfish trawlers become uneconomical, since the annual landings do not increase proportionately with vessel size beyond a certain overall length.

(2) Conversely, there is a size below which vessels are uneconomic because they cannot produce in unfavorable weather.

These findings allowed us to bracket the size and general specifications for trawlers suited to the type and size of nets to be used, and the operating practices in the particular fisheries.

IV. A PLAN FOR ACTION

The role of the Owner and His Naval Architect In The Development of a Successful New Vessel

To arrive at the successful vessel of the future, the owner and architect must agree to embark on an intensive program of co-operative effort. Too often in the past, new vessel design was unduly influenced by one or the other of the two parties involved.

The naval architect has the economic and technical tools plus the design experience, but he needs continuing guidance from the owner who has the important practical experience and knowledge of the conditions under which the boat must operate. Conversely, the owner may have a set of general goals or even rigid requirements, but the naval architect has a dispassionate viewpoint on the cost benefits of the features desired by the owner. As a result, the best design can only emerge through continuous interplay between owner and designer.

Fig. 11 shows some of the typical inputs by owner as well as the role played by the naval architect. The steps seem numerous and the process inevitably is lengthy and time consuming for both sides involved. The guidelines cited in this figure sould, however, be given serious consideration and not skipped over lightly in the process of evolving a new design.

The technology is most certainly here to produce a successful next generation of vessels. We now must learn to apply various disciplines in a systematic fashion to produce significant progress in the design of future vessels.

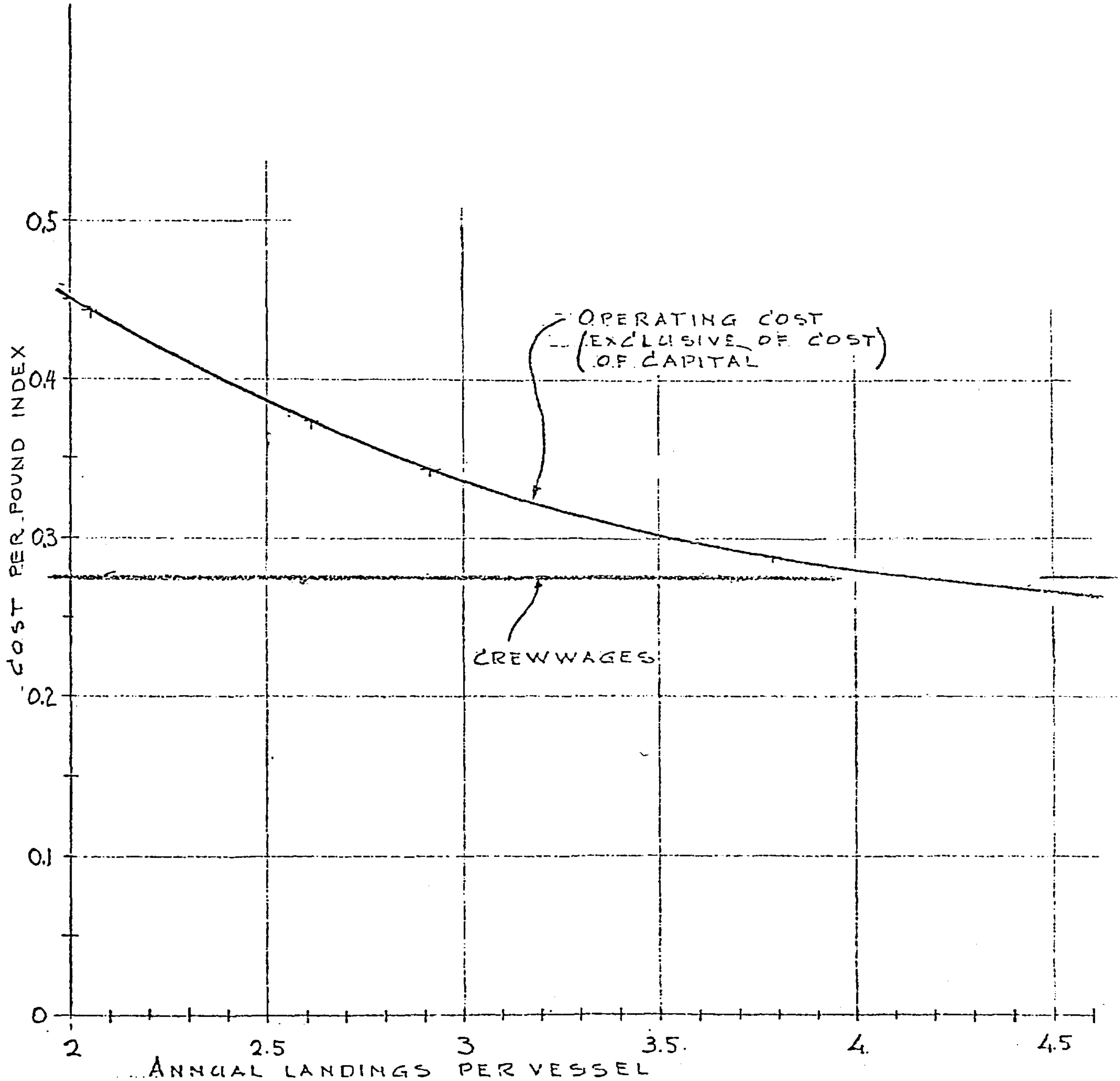

FIG. 5 CREWWAGES & OPERATINGCOST (EXCLUSIVE OF COST OF CAPITAL) VERSUS LANDINGS

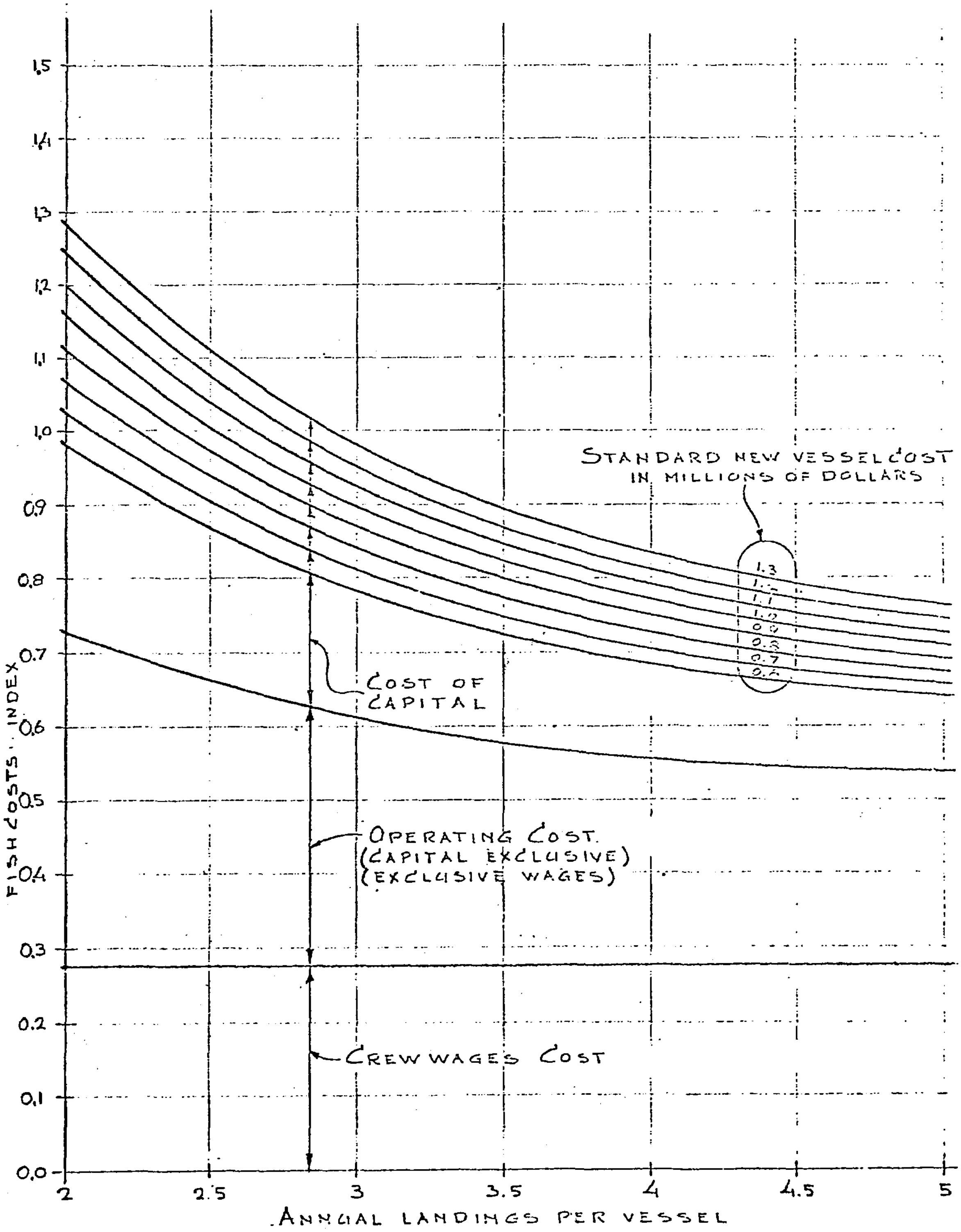

FIG. 6 TOTAL COSTS OF LANDED FISH VERSUS ANNUAL LANDINGS (SINGLE VESSEL OPERATION)

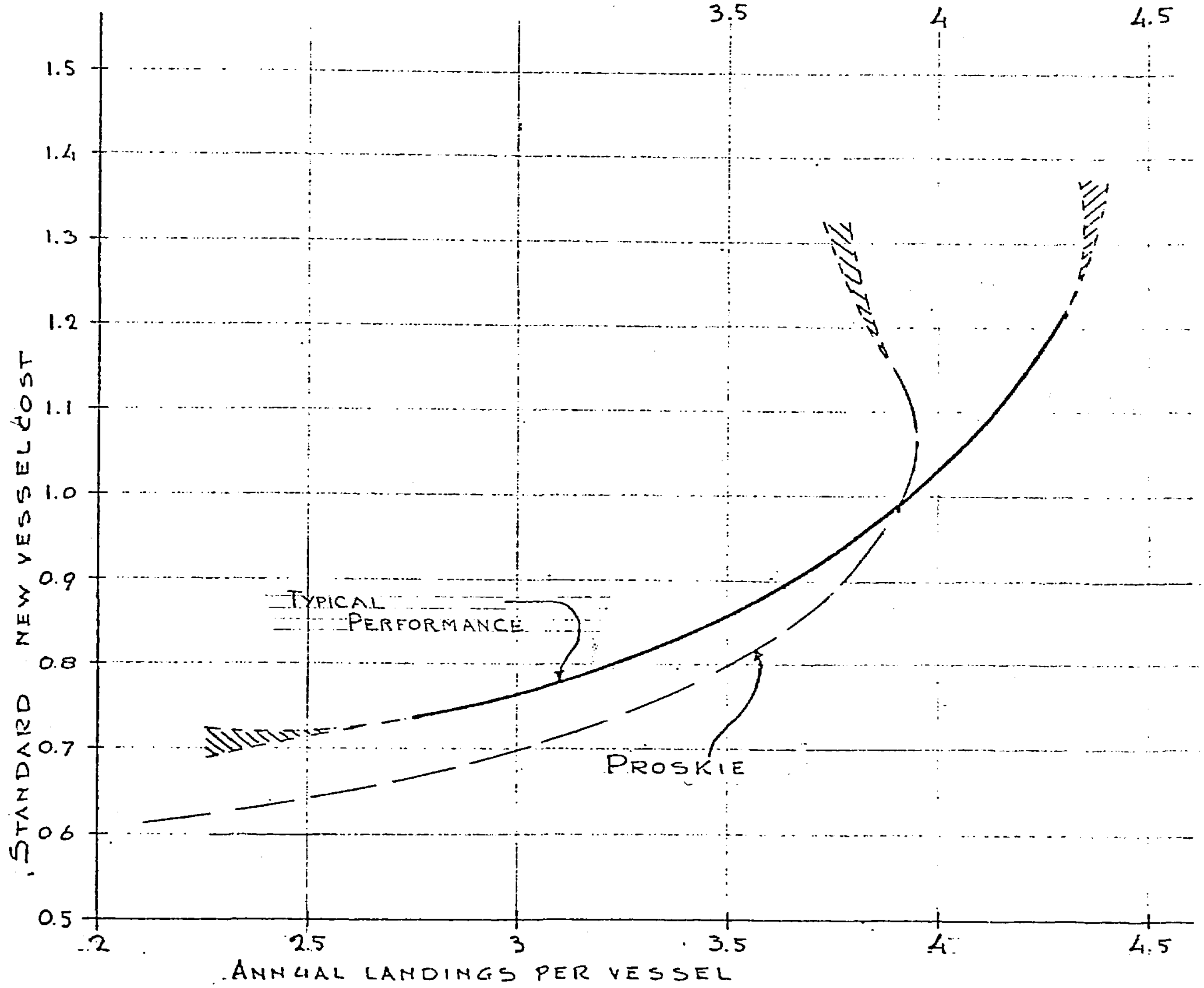

FIG. 7 STANDARD NEW VESSEL COST VERSUS ANNUAL LANDINGS (SINGLE VESSEL OPERATION)

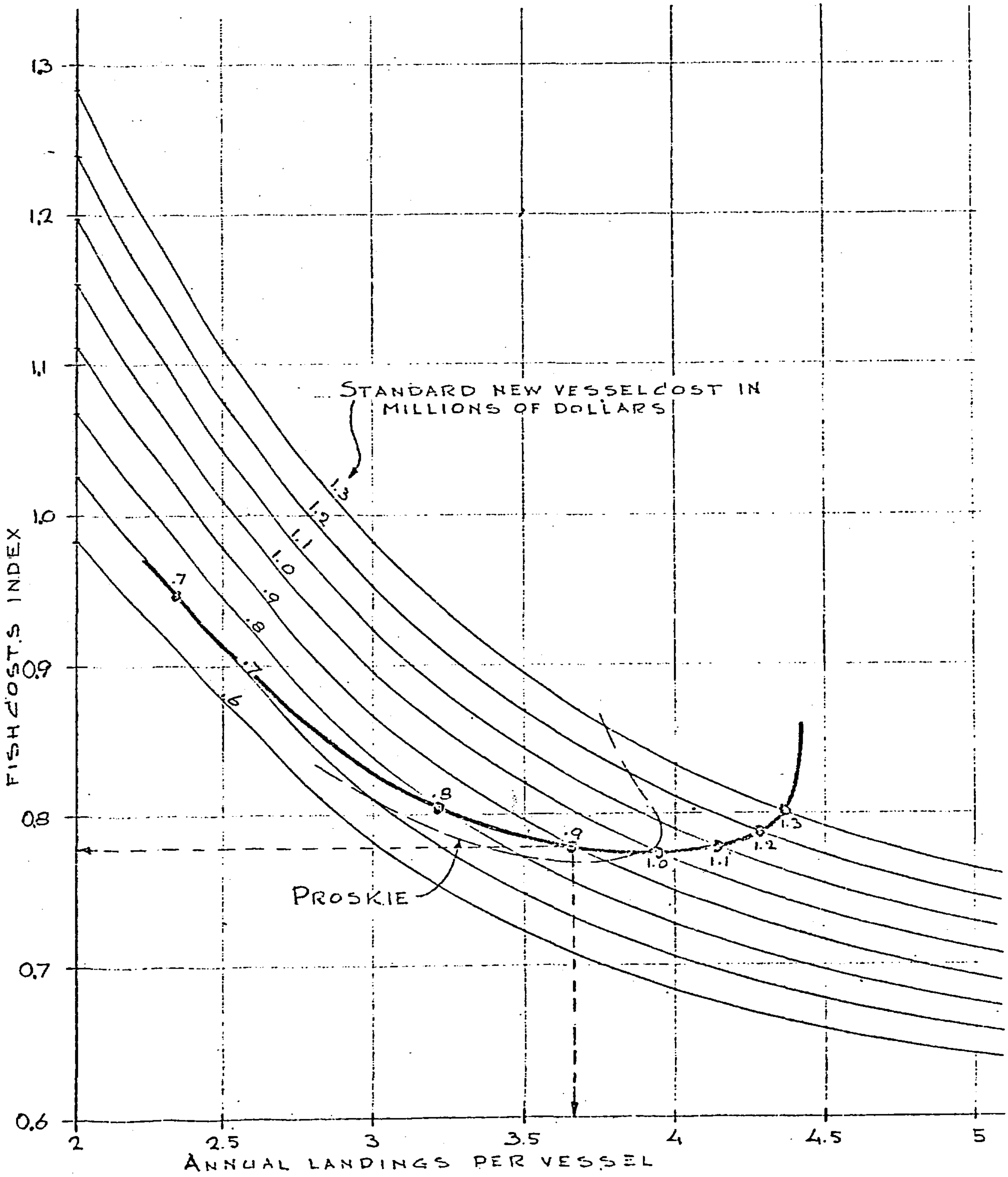

FIG. 8. RELATIONSHIP BETWEEN PRODUCTION, COST AND INVESTMENT

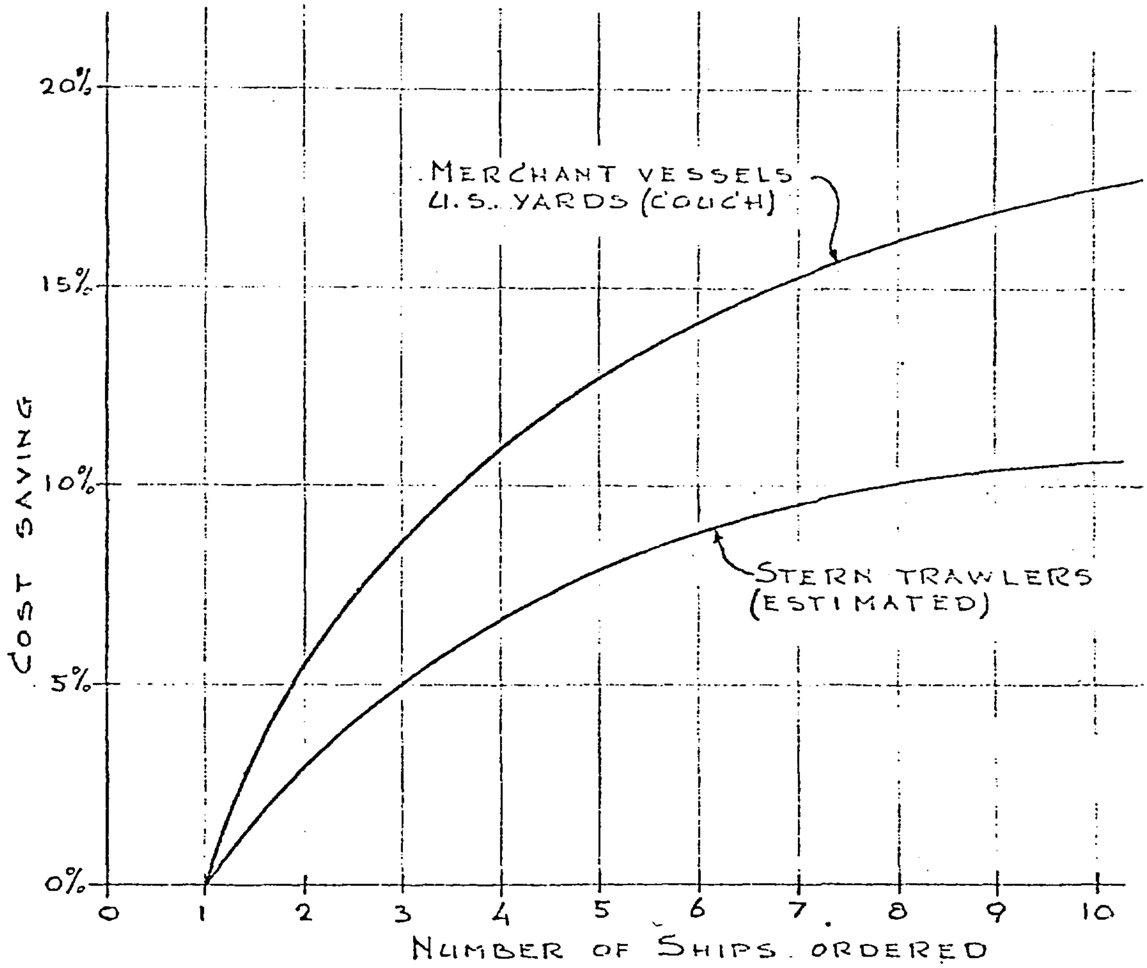

FIG. 9 COST SAVINGS FOR MULTIPLE SHIPORDERS

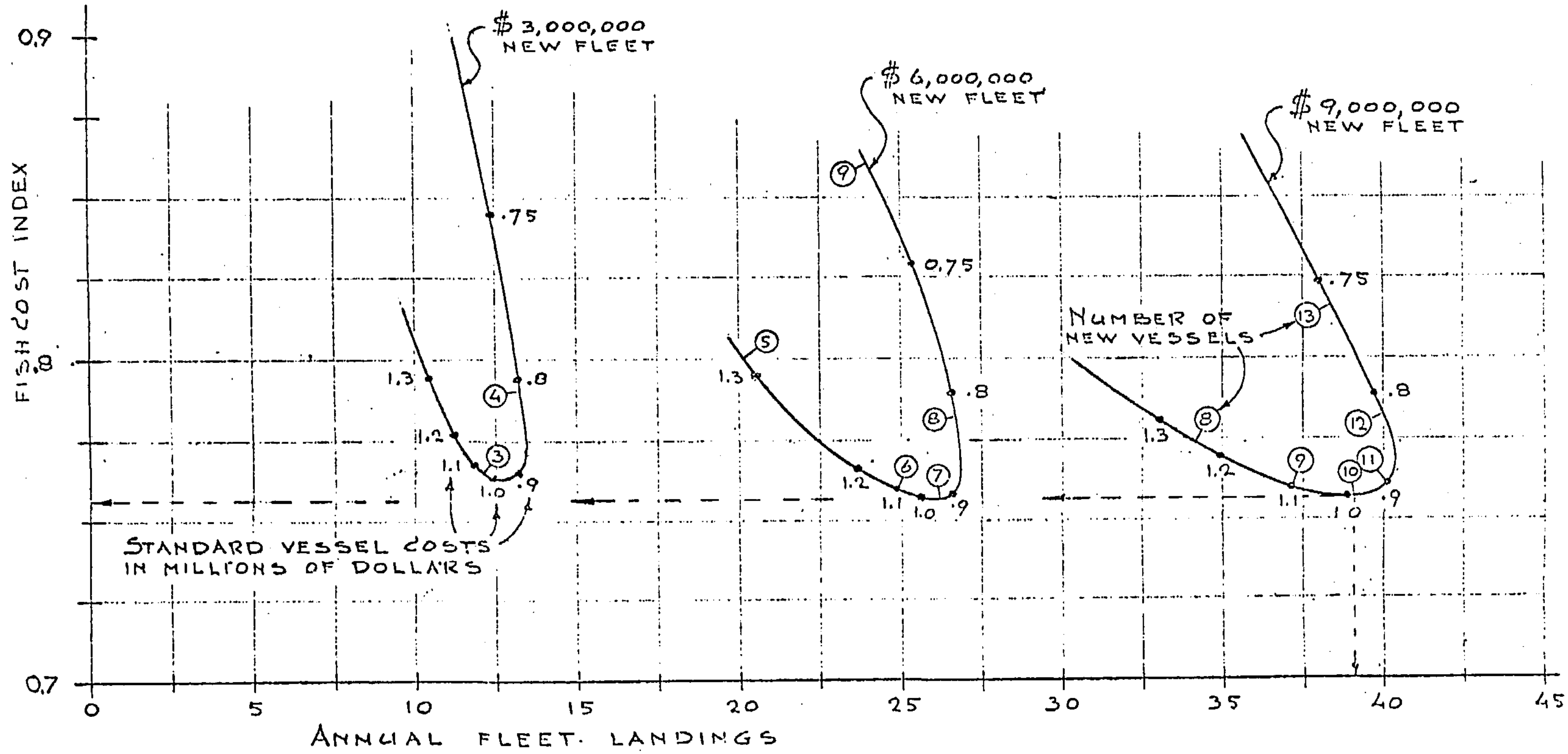

FIG. 10 COMPARATIVE PERFORMANCE OF VARIOUS PROPOSED FLEETS

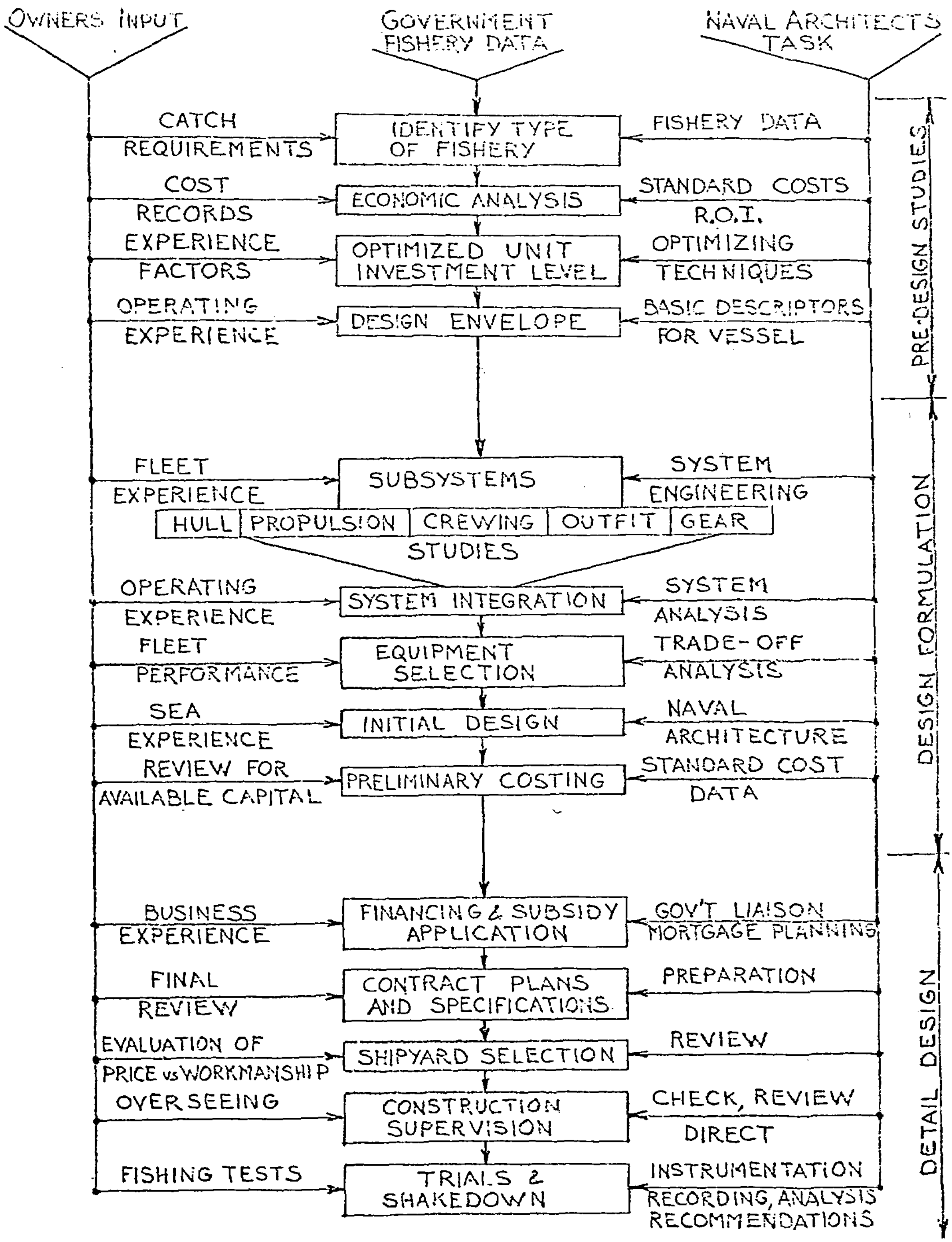

FIGURE II

COOPERATIVE ROLES OF OWNER AND ARCHITECT IN MODERN DESIGN

Discussion

Jan.-Olof Traung, of the Food and Agriculture Organization of the United Nations, Rome, said his question was rather involved. "First, is the 'Experiment', as reported in Kadilnikov's paper, to make 9 knots in quiet waters with two times 300 horsepower? Do you consider this better or worse than is possible for a single hulled ship? Is the speed length ratio acceptable for a Canadian fishing vessel? Secondly, do you realize when advocating catamarans for fast inshore work, that power catamarans must be very light to make speed and thus cannot carry a load? Thirdly, do you know of the papers by the British National Physical Laboratory, Corlett's, and others which show that catamarans require more power than normal well-designed single hulls? Fourthly, do you know that houseboats at the New York Boat Show indicated far better speed and capability than catamarans? "

Walter Scott: "That's a rather involved question. and I think that comment on the nature of the Russian catamaran is perhaps their privilege and not mine. But, referring to a Canadian ship, not having a slide rule at nand. I would say that the $\frac{V}{\sqrt{L}}$ as achieved by the Russians on trial is perhaps a little bit less than we would normally go for. Personally, I would like to think that to go up to $\frac{V}{\sqrt{L}}$ 1.1 is common sense; after that you are just pushing dollars up the funnel.

"Now for the second part of your question. I am well aware of the problem catamarans will have in carrying any significant amount of deadweight. However we, in our outline requirements for the very very small scale activity we did, have tried to concentrate on the higher priced fisheries, allowing us to take less weight, with more dollars for the effort we are talking about. Shellfish, crabs, lobsters, salmon and the like. I think I have given a list of our requirements in my paper.

"I am also aware of the work done by N.P.L. on catamarans. In fact, I consider Dr. Lewison there as a personal friend although I haven't seen him for some time. But I do have a couple of papers he has written. I also know of the work which Dr. Corlett did, I believe at I.M.A.S., which made very interesting reading.

"Referring to the comments that were made at the New York boat show, I think that there are many many new types of marine craft which could have an application in fisheries. In the matter of houseboats, I would not like to give a definite answer because these are not usually developed for open water operation, although they are perhaps a barge-like form, and I have referred in my own paper to one barge design which I believe is in operation now in Canada. This is something that I am looking to with some interest. We have not had any feedback from it as far as its performance is concerned, but certainly on paper the idea looks possible. However, if you have any information on these houseboats in the form of any data, I would be very pleased to have a look at it. I hope I have answered your question."

O. Egilsson, of the Nova Scotia Department of Fisheries, Pictou. asked Mr. Kadilnikov: "How does the catamaran type vessel react when steaming into heavy seas at a speed of 10-12 knots, compared to a uni-hulled vessel? "

Mr. Kadilnikov: "The catamaran type vessel speed in calm seas was only 9 knots; that is why, with reference to the conditions incorporated into the question, I can give the answer only in the case of steaming with a following wind. With wind astern, the catamaran could achieve a speed of 10 knots, and side rolling was insignificant. Also, stability was rather high, which gave an opportunity to keep the course when, for example, a single 1-hulled vessel could do this as effectively."

Michael Pym, of Contrary Holdings Limited, Montreal, asked: "What is the lower limit in size of catamaran fishing vessels – is it a relationship between bridge deck height and anticipated wave size? "

Mr. Kadilnikov: "I presume there is no lower limit in size of the catamaran. Of course with regard to small size catamarans, the height of bridge (wing) above the water will be less than the same measurement on a larger vessel, but the smaller size vessel can stand the waves more easily. Of course, research should be carried out which would determine the relationship between the size of a catamaran and the length and height of waves, but it seems that for catamaran vessels having lengths less than wave lengths, the height of bridge deck might be smaller."

E.S. Wagner, of the Department of Fisheries and Forestry, Halifax, asked: "Is the overall structural strength of the catamaran equal to the conventional vessel of similar size? "

Mr. Kadilnikov: "A question such as this cannot be answered briefly, and it is a very important area for discussion. On 'Experiment', we have found no problems with the structural design, which suggests that vessels of this size, if properly designed and built, will be successful in the open sea."

Mr. Engvall, of FAO, Rome, asked: "What kind of further research or commercial application has been initiated as a result of the 'Experiment' tests? "

Mr. Kadilnikov: "At the present time at Kaliningrad we are making designs of the next catamaran type vessel which is to serve as a freezer trawler. Aboard that vessel, which is about the same size as the first one, a freezer will be installed with a daily productivity of 20 tons."

W.E. Currie, of Honeywell Marine Systems, asked Mr. Kadilnikov to restate the ratio of catamaran capability to increase in original cost as compared to single hull vessels.

Mr. Kadilnikov: "The ratio of catamaran capability to increase in the original cost compared with single hull vessels will be approximately equal or even less. I can illustrate it. First, with regard to catamaran type vessels we have purely constructive problems, such as the problem of stability. For example if, as a result of trials, it appears that it is necessary to install heavier fishing equipment aboard a catamaran type vessel, we would simply do that by decreasing only the cargo capacity, but not recalculating the stability of the vessel and not making estimates related to it. From this viewpoint, catamaran type vessels seem to be most convenient for continuous modernization."

A.G. Hopper, of the White Fish Authority, London, put the following question to Mr. Kadilnikov: "The handling times in table N3 are obviously good but so much time seems to be lost in transferring the carriage each time. The board handling times too seem rather high, and these two items are tending to reduce the advantage of the dual facility. My first question is would it have been better to provide the vessel with separate winches and doors for each ramp, so that each set of gear could be shot away from each ramp in turn and probably towed from the quarter as a side trawler does at present? If this was not practicable from a steering point of view it would be easier to transfer the warps to a symmetrical position after shooting than transfer the doors over each time."

"Secondly, we too have studied dual facilities for large stern trawlers involving a single ramp and one set of doors. The proposal is to split the deck down the middle with one cod end to be hauled up say the port side, while the starboard set of gear is laid away. Our estimated time gains are slightly at variance with those given in the paper. Our estimates from logged observations are: time saved by shooting one cod end before emptying the other, 4 min. per haul, and gain in fishing time due to elimination of mending time and the time saved with the cod end, 10% on bad ground, 6% on good ground."

Mr. Kadilnikov: "With a working scheme as proposed by Mr. Hopper, by having propellers set wide apart we would lose a lot of power to maintain course. Furthermore, transference of the boards into the middle position will also cause a waste of time, although this scheme of catamaran work also provides for towing in the middle position. When hauling the trawl we are able to transfer the carriages each time taking only slightly above one minute, and in the future this time can be considerably shortened due to the installation of more modern equipment.

"With regard to the second question such proposals are known in relation to the 1-hull vessel, and they have been executed to a certain extent, but their implementation is possible for comparatively wide vessels and for comparatively large vessels. In order to split the deck into two parts, reserve room and space is required. In order to install the second set of fishing gear and related mechanical devices on the upper deck, we have to consider putting additional ballast into the vessel. With regard to catamaran vessels, the dual scheme is implemented in a more effective and simple way, as is shown in the report. The time spent for emptying the catch is directly related to the size of catch, thus the more powerful and the larger the vessel is, the more time is spent for emptying its catch."

Gerald L. Schroeder, of Ocean Technology Inc., Cambridge, Mass., asked if the sea-keeping characteristic of the catamaran permitted seining in weather normally too rough for a conventional stern seiner. That is, were there more fishable days in a catamaran than in a single hulled vessel?

Mr. Kadilnikov: "That is quite right. The catamaran can operate in rougher weather than a conventional stern seiner, using, as is the practice in the Soviet Union, the purse seining scheme without use of skiff."

Brian Meagher, Deputy Minister of Fisheries for Nova Scotia, said: "Do the Russians agree that 30,000,000 pounds annually is realistic even in 10 years' time? "

Mr. Kadilnikov: "I don't know the origin of that figure but, for the catamaran of the 'Experiment' type, if it is the catamaran in question, the realistic figure will be about 1400 tons; with certain modifications, 2000 tons annually. But this is under the provision that we would manage to keep it in the condition provable for fishing operations. The arrangement aboard the vessel both for trawls and pursing makes it much easier for the catamaran to achieve the goal than for any other one-trawl vessel of special designation."

Dr. N.M. Kerr, of the White Fish Authority, Hull, England, put the following question to Mr. Kristinsson: "Containerization is an important subject, with many implications in fishing. It thus requires discussion in greater depth than the author has been able to achieve. I cannot accept his conclusion that the proposed vessel could be economic and would therefore ask the source of his information on catch rates. He uses 60 tons per day as the basis of his calculations, when to my knowledge 25 tons is the maximum realistic rate. Recalculating on this lower figure leads me to expect an annual loss of $400,000. Would the author please state his catch rate information more fully and comment on his costings? "

Mr. Kristinsson: "With regard to the catch rate, I have no actual records of a vessel catching average of 60 tons/day, but on the other hand many vessels have got up to 80 tons per haul day after day over certain periods. My catch figures are predictions only. The vessel will be a high powered fishing vessel, 3000 BHP or more. It will haul much larger nets than presently used and be capable of seining as well as bottom and mid-water trawling. The system of crew changes will be used. Unloading time of the containers is a matter of only a few minutes and you can allow for a turn-around time of six hours as a generous figure."

Dr. Kerr, to Mr. Kristinsson: "The vessel is designed to carry 375 tons of frozen fish when three-quarters full. This is equivalent to 500 tons when full. With 500 tons of fish in 20 standard containers there is no allowance made for loss of volume due to insulating the containers, and without insulation there will be dehydration once the containers are removed from the fishroom. Would the author clarify the position regarding container insulation? "

Mr. Kristinsson: "About 20 tons of fish can be loaded in each container. The containers are insulated with 6" – 8" of polyurethene and kept at −20°F. The container has its own refrigeration unit installed and will maintain the temperature whether the container is in the hold or at the dock side. The 500-ton capacity includes the fish meal."

Henri Legaré, of the New Brunswick Department of Fisheries, asked Mr. Kristinsson to comment on the possibility of using refrigerated containers on board shrimp vessels having a length of less than 80 feet.

Mr. Kristinsson: "I have done some preliminary design studies on adapting containers for shrimp trawlers. The containers would be of the 8′ x 8′ x 10′ dimension refrigerated containers as this size would be more suitable for vessels less than 80 ft. length."

Mr. Hopper submitted the following to Mr. Kristinsson: "From a naval architect's point of view I find the drawings lacking in detail and I feel that when certain functions are examined in depth the spaces allocated for them may increase in size, leading to a larger ship. I am particularly concerned about the space allocated for net handling, and the proposal to handle 80-ton cod ends. I agree with the author that conventional methods of handling cod ends must be questioned, but the details given in the paper do not really offer anything new.

"There are several points to bear in mind here: (1) we at the IDU have found the line pull to haul a cod end up a 24 deg. ramp is 0.7 times the weight of the cod end in air; (2) transient loads equal to the weight of the load in air will be experienced by the gilsons if the vessel is pitching with the wide ramp proposed. I suggest these loads could momentarily come on to one gilson with disastrous results, and (3) taking aboard an 80-ton cod end at the stern could change the trim by about 70 in upsetting the stability pattern. Would Mr. Kristinsson like to comment on these points? "

Mr. Kristinsson: "The drawings in the paper are sketches only, and are referred to as such in the paper. Your comment in general seems to be quite reasonable. It should be borne in mind that my paper is based on a study conducted to develop a containerized fishing vessel concept. Therefore, various details and established systems which will be adopted in the vessel are not detailed in the paper. However, with regard to space allocation for the various systems, this has been studied and found adequate for the type of components selected.

"Referring to sketch 'D' in the paper, you will note that double drum with belt is adopted for storing the net, and the cod end is taken up on the port side of the ramp. With regard to the handling of an 80-ton cod end, I do not see any problems for a vessel of this size; we are talking about a 200 ft. vessel with a beam of 44.5 ft. and well laid out for stability. I know of some cases where 136 ft. have landed an 80-ton cod end over the stern without any disastrous results. Thank you for showing interest in my paper, and should you have some other specific questions, I should be pleased to reply to them in detail."

T. Gunn, of UNIVAC of Canada, Ottawa, asked if the scheduling of container distribution was the responsibility of the fishing company, the government or the transportation industry.

Mr. Kristinsson: "The scheduling of containers is done by the shipper, be it a fishing company or a private shipping company. The containers would be rented from a container consortium and shipping can be effected by rail, road, ships and in some cases, by aircraft."

Dr. Kerr to Mr. Kristinsson: "The author suggests that the vessel's payload could be increased by stowing pallets between the containers. Would he describe how pallets are to be offloaded at a container port? "

Mr. Kristinsson: "Pallets would be discharged by vertical lift in the same way as the containers."

Dr. Kerr: "In U.K. vessels, the crew share of the grossings is about 30%. This reduces the owner's profit by approximately $500,000 a year. Would the author state the number of men on board and how they are to be paid? "

Mr. Kristinsson: "We are planning for this vessel to operate with a total of 17. Of course it is going to be very highly automated and the catch will be partly processed aboard the vessel, gutted, possibly filleted and then frozen aboard the vessel and stored into containers which are refrigerated."

John Barker, of National Sea Products, Limited, Halifax, put the following to Mr. Kristinsson: "Will the author kindly justify his yearly catch figure of 31,920,000 lbs. at 6-1/2 cents per pound? This apparently refers to groundfish procurement and is far in excess of current catch figures by Canada's largest stern trawlers, about 5 to 6 times greater."

Mr. Kristinsson: "Actually, this total concept is in a preliminary state. As I mentioned in my paper, it will most likely be ten years before this type of vessel will be fully realized in the industry. But the catch figure I have given here in my paper is based on the assumption that the vessel is going to go all the time. It is not tied up at the wharf. You have an exchange crew (you are operating with two sets of crews). The vessel is never going to be more than, say, six hours at the wharf. Of course you have to allow for maintenance time, and you would figure it something like 15 to 20 days per year. This is a highly automated vessel, highly mechanized, and it has much greater catching power than any vessel built today. It has 3000 horsepower installed which could be used when you are towing. Therefore, you can tow a much bigger net than you are doing now. Any vessel of this nature has to have a much bigger catching potential than the present day trawlers. If you talk in terms of herring, it's available now and it will probably continue to be available in ten years' time. The fish is semi-processed aboard the vessel. It is stored and frozen, stored direct into containers. You are showing a much higher grade of fish, much better quality fish than ever landed before. Therefore, I feel that six cents per pound is a conservative figure."

Commander M.B.F. Ranken, of Aquamarine International (Fisheries and Ocean Development) Limited, London, to Mr. Kristinsson: "Many of the fishing aspects of this paper are so far from reality that they would detract from the high value of material on containers and containerization. For example, propulsion and refrigeration systems. The latter were dealt with fully at the FAO meeting in Madrid in 1967. In particular, where does the author expect to average 80 tons a day catching rate consistently all year round? "

Mr. Kristinsson: "If you are dealing with herring you can easily catch, even today, over 100 tons of herring a day, in Canada. I know of a case where they caught 60 tons of herring in one net."

Richard McNeely, of the U.S. Bureau of Commercial Fisheries, Washington, D.C., asked Mr. Hatfield: "How do you distinguish fish echoes from none-fish echo soundings to get a reliable count of fish into the computer? "

Mr. Hatfield: "Principally by study of the size of the signal, in terms of amplitude and straight micro-volts. This needs processing, as I said, to relate it to a known micro-voltage of a size of fish of the minimum marketable size. At a constant depth, and this is then taken as a norm, any signal that size is taken as a fish. Now, a signal of that size might not be a fish and this is precisely why fish counters, basically, are not highly accurate. But the technique which I described of calibrating instruments by feeding in data from each past tow is intended, of course, to progressively run up the accuracy of the machine, for a particular region at a particular time. The calibration of the machine, which is achieved in these circumstances, might be wildly inaccurate compared with some other time or in another location; in fact all this machine is trying to do is precisely what a good skipper does; namely, to look at the return fish echoes and say 'in this place that's not a fish, but that is a fish' ".

A.G. Hopper asked Mr. van Dissel: "Have you considered a net-reel for this size of vessel in order to try and shorten the trawl deck? "

Mr. van Dissel: "Yes and no. I think I have found in a vessel over 115 feet it is quite possible that the deck is long enough to accommodate stretched wings and foot ropes of most standard trawls." He went on to say that with a smaller vessel, there was no choice; it was necessary to have a net-reel in order to haul and shoot rapidly. "On this particular vessel we did look at the net-reel but did not give it serious consideration. One of the objections was the captain's opinion concerning handling the big rollers of the net when fishing on rough ground. How do you keep the net from tangling in its hardware as it winds to a diameter of 70-74 inches? If you are only going to wind the wings of the Yankee 41 trawl used around our area, on a ship such as ours, as shown in the drawings included in our paper, there's little point in using the net drum as the length of the deck is sufficient to accommodate the stretched length of the wings and footrope of the trawl."

Walter Loevinsohn, of Deutz Diesel (Canada) Ltd., Montreal, congratulated Mr. Palmer on the effective presentation on engines by his company. He said: "It should be remembered that they cover only a narrow range of speeds and outputs. To obtain a more balanced picture, I wonder whether Mr. Palmer would answer the following: the internationally recognized speed ranges are 720-1200 RPM for medium and 1200-1400 RPM for high speed engines. What was the reason why no medium speed engines below 1200 and no high speed engines above 1800 RPM were discussed? "

Mr. Palmer: "I fully recognize the speed ranges involved. I limited my discussion to 1200 RPM and up from basically the economic trade-off of weight and space relationship. There seems as if there is a definite break-in; if you would like to plot lbs./HP or space cubic foot for horsepower occupied by a propulsor, there is a definite break in that curve. Admittedly, for selfish reasons, my company does not build anything slower than 1200 RPM. We like to think that we are in a sense in a very durable medium speed range. And we do wish to point out that the 1200 RPM engine is where we feel is a very excellent position. To begin to look at some of the considerations you can get into by optimizing the engine room compartment, you are compromising the durability, the operating costs in general, by looking at this power range. To optimize, let's say the fish hold capacity vs. the propulsion rate, as far as up to 4000 RPM; my company does build them up to 3200 RPM, but from 2200 on we limit the application pretty well to highway trucks. We have examined the marine market in depth. We find basically that much of the dollar volume that we engine builders can compete for is in the 1800 RPM range and below. I think we find that a substantial volume is in that end of the business."

Mr. Loevinsohn: "The paper states that specific fuel consumption values of .36 lbs. per horse per hour can be achieved with high speed engines. That is, of course, a value which many modern, high speed, medium speed and low speed engines achieve and better. It would be interesting to hear from Mr. Palmer whether the engines he discusses, which are the ones mostly installed in fishing vessels do not actually have at least 10-25% higher fuel consumption as stated in the authoritative British reference book 'The Motor Ship! "

Mr. Palmer: "As the statement appears to tally with the Canadian operating experience and its field costs are one of the major factors affecting profitability of a vessel, this point should be an important consideration. With regard to the fuel consumption data I had in the paper, I tried to be international in context, and I find from readily observable trade data technical specification sheets that .36 is achievable by many of the world's engines. I would also caution, when looking at specific fuel consumption, to be sure that the apples and oranges are really separate. We try to give our fuel consumption when we put an engine on the market with a propulsion system in mind. We have marine gears in it, and you all realize that there are more gear losses. So we would present our fuel consumption in terms of shaft horsepower. Admittedly they are 1½ or 2% but they are there. Another feature of our fuel consumption is the fact that we do use a prechamber function; fuel consumption tends to be higher but we also attempt to trade a bit higher, more in terms of 5-7% in terms of durability."

Mr. Loevinsohn: "While neither the medium nor the high speed marine engine have made any significant impact on the higher horsepower range in the case of money-making as opposed to military applications, the paper suggests that multiple engine installations could escalate high speed engines into that range as well. How could such multiplication of pistons, cylinders, bearings and other moving parts subject to wear be justified on a rational economic basis at a time when Canadian owners on both coasts are having second thoughts concerning fuel and maintenance costs of higher speed engines, as opposed to those in the 320-900 rpm range? "

Mr. Palmer: "Multiple or compound engines of the higher speed types should be considered as alternate solutions to high horsepower requirements and it is not suggested they be anything else. We have seen no reason to apologize for 'higher' maintenance and operating costs of higher speed engines. The wear out items are basically a function of piston speed, cylinder pressure and temperature. The high speed engines are operating at the same piston speed as the low speed competitors – cylinder pressures and temperatures are also in the same order of magnitude. The challenge of the higher speed engines, compounded, is in the area of reduced operating costs, reduced weight of propulsion unit and hopefully, less first cost."

E.C. Snead, Jr., Washington, D.C., asked Mr. Palmer: "Has there been or is there now any effort in developing engines (with reasonable costs) that have the capability to produce, by turbo-charging or other means, a very high continuous horsepower output to travel to and from fishing grounds?"

Mr. Palmer: "I presume the question refers to the capability of having a turbo-charger or other means available to boost the engines as desired when needing additional power. There is, to my knowledge, little or no commercial development to this end. Hull considerations pretty well determine how much horsepower is economical to drive the hull to and from the fish grounds. $\frac{V}{\sqrt{L}} = 1.1$ appears to be the economic hull speed rationale (refer to Mr. Scott's earlier paper of Session 1), thus the horsepower for the hull becomes determined on this basis. The power required to operate the vessel during fishing operations is substantially less than that which is required to drive the vessel free and loaded. It would seem to me more practical if the economics of the operation could allow it to put an oversize engine in the hull to meet unique requirements."

Commander Ranken: "With regard to the use of catamarans in the fishing industry, the main drawback is the difficulty of providing adequate cargo-carrying capacity without increasing the individual hull dimensions to such an extent that costs are very high. This must be the case with the "Experiment," which in other respects is such an interesting conception.

"An economical catamaran design should include the use of containers on deck, dimensioned to suit average catching rates and ease of handling on board and when discharging in port. There is no question whatever of adopting standard I.S.O. containers in anything less than a full-scale mother ship, but smaller boxes or containers could certainly be sized to facilitate close stowage in ISO containers, if this will assist handling during distribution.

"The great advantages of catamarans are their extremely high stability and the very large working area available for gear and fish handling and stowage. The Netherlands Offshore Company N.V.'s motor vessel "Duplus" was the brain child of Ir. Jacob Stenger, the Dutch naval architect, whose company Trident Offshore Netherlands N.V. is now offering many variations of the 'Duplus' design to suit other applications besides that of an offshore work-base.

"The 'Duplus' comprises two submerged submarine hulls each 40 m. (131 ft.) long supporting through thin vertical vanes a work platform 41 x 17 m. (134 x 56 ft.) in size. Two hydrofoils connect the submarines underwater. Two 850 H.P. electric propulsion motors and conventional propellers in Kort nozzles are fitted, one at the after end of each submerged hull, to give a passage speed of 9 knots; there are also four 220 H.P. Voith Schneider units, two in each hydrofoil, for use at the work site in conjunction with the dynamic positioning inclinometer and equipment. Two 1500 H.P. main and one 190 H.P. auxiliary diesel-generators are situated in an engine room above the port submarine, and the bridge and most of the accommodation above the starboard one.

"A central working well 7 m. (23 ft.) in diameter is provided in the upper deck, and a 75-ton gantry, a 20-ton revolving crane and various winches are available for handling heavy equipment for drilling, diving, coring, etc.

"The secret of the vessel's great stability lies in the submerged hulls, which are little affected by wave action up to 25 ft. in height. The ship is not a catamaran except in her configuration. A film taken during trials showed a coaster of about the same length really pounding in a 20 ft. swell, while the 'Duplus' remained almost motionless in the foreground. She was recently at sea in the Force 8 gale during which the drilling rig 'Constellation' was lost and the 'North Star' was in danger. It is also of interest that the water between the two hydrofoils and below the working well remains very calm while the ship is on station.

"Whether the 'Duplus' design is, or could be cheap enough for fishing operations needs further study, but she certainly has characteristics very desirable for larger vessels normally operating in bad weather conditions.

"Small catamarans of really low draft have great potential for beach landing, especially on coasts where littoral drift is a problem and the cost of maintaining a fishing harbour prohibitive. Such conditions exist on the coasts of many developing countries and at present prevent the use of anything larger than quite small boats which can be manhandled up the beach to above the high water line. The result is that few if any of these boats can operate in deep water to trawl for known fish resources near the edge of the continental shelf.

"For these regions, carefully designed catamarans offer a solution, especially if they are provided with adequate engine and winch power, the latter being available for hauling the boat up the beach using suitable bollards on land. Care needs to be taken, however, in selecting the length to beam ratio of these vessels in relation to the form of the two hulls, and to prevailing sea conditions. Work and tank tests are in hand on such a catamaran beach-landing system in the United Kingdom."

SESSION 3

Moderator – Eugene Gorman,
Deputy Minister of Fisheries, Prince Edward Island.

Study on the Ultrasonic Fish Counter*

Dr. Nishimura

by

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Dr. Nishimura, with a degree in engineering, is Professor of Underwater Acoustics at the College of Marine Science and Technology, Tokai University, Shimizu City, Japan. Born in 1923 in Tokyo, he graduated from Tohoku Imperial University in 1947, and has been engaged mainly in the study of underwater acoustics and development of acoustic devices for ocean application. Until April 1968, when he accepted his present post at Tokai University, Dr. Nishimura worked in the Fishing Boat Laboratory of the Fisheries Agency, Japanese Ministry of Agriculture and Forestry.

Dr. Yamanaka, who obtained his degree in agriculture, is Chief of the Oceanography Division of the Far Seas Fisheries Research Laboratory, Japanese Fisheries Agency, Shimizu City, Japan. He was born in 1922 in Tokyo, and following his graduation from Tokyo Imperial University, he was engaged mainly in the research of fish population dynamics and fishery oceanography at the Japan Sea Regional Fisheries Research Laboratory, Niigata, the Nankai Fisheries Research Laboratory, Kochi, and at his present duty station. He studied at the Scripps Institution of Oceanography in the United States as a Junior Research Biologist in 1957 and 1958, and from 1966 to 1968 was Chief of the Marine Environment Section of the Fisheries Department of FAO.

ABSTRACT

The estimation of the size of a fish school by means of ultrasonic detectors is examined for accuracy. Two forms are investigated, the individual fish counter and fish school counter. The individual fish counter is for use where fish are sparse in relation to the sound cone coverage and the school counter calculates the mass, relative to school size, of a densely packed fish school. A number of experiments have been carried out to determine the accuracy of the counters, with good results. Further experiments are necessary to determine the factors for conversion of relative numbers to absolute numbers of fish in a school and to confirm the counting accuracy. These experiments are now in hand.

1. INTRODUCTION

The ultrasonic fish-detector is now being used to observe the behaviour of fish schools. One of the authors, M. Nishimura, developed in 1966 an ultrasonic fish counter and made several fundamental experiments at the Fishing Boat Laboratory of the Japanese Fisheries Agency, where he served until March 1968. In Japan, there are three kinds of fish counting systems for estimating fish abundance by

*This study is one of the items of the national project "Development of new technique in the research of fish abundance", sponsored by the Japanese Fisheries Agency, and is undertaken in co-operation with members of the Fishing Boat Laboratory, Tokai, Seikai and Nanseikai Regional Fisheries Research Laboratory, Far Seas Fisheries Research Laboratory, University of Nagasaki and College of Fisheries.

means of ultrasound, namely, direct counting method which is mentioned in this paper, "pattern analysis" (T. Ishii and S. Tanaka, 1969) and "optical integrating system" (K. Shibata and T. Aoyama, 1969).

On the basis of the results obtained by the first devices for the direct method, two types of fish counter were designed and manufactured with financial support from the Fisheries Agency. One of them has been designed to calculate numbers of fish such as tuna, of which school density is sparse in relation to the width of the sound cone. This was named an "individual fish counter". The other has been designed to calculate the mass of the area of a cross section of a dense fish school, such as of sardine or mackerel, and was named a "school counter". After the fundamental tests were carried out in a tank, several field experiments using fish models were made since May 1969, in order to investigate the accuracy of the counting system and to clarify problems involved in the application of these devices to the estimation of fish abundance.

This paper describes the outline of newly manufactured fish counters and some results of field experiments recently carried out. Since only a few observations have been made, the complete result would be obtained following experiments to be made in the near future.

2. ULTRASONIC DIRECT COUNTING METHOD.

An echo-trace of fish such as the tuna generally appears in an inversed "V" shape on recording paper of a fish-detector when the density of fish is sparse compared with the width of the sound beam. As was reported by Nishimura and Shibata (1966), the density of fish schools could be obtained by the ratio of the numbers of echo-traces to the water volume searched by sound beams for a given time. The number of fish is obtained by the number of echo signals from fish and the searched water volume obtained from the beam angle of the sound cone, the depth of fish school and the speed of the boat, so that the density of the fish school is automatically computed from this information by electronic computer. This method was applied to the "individual fish counter".

Now let us consider the case of a dense fish school such as of sardine or mackerel, where numerous fish enter a sound beam. In this case, numerous echoes are received by transducer from a single transmission of ultrasonic pulse. Total echoes can be computed for a fish school by summing up echoes electronically in vertical direction received from consecutive transmission of pulse while cruising over the fish school. The total number does not indicate the absolute number of fish in a school but gives some index for estimating fish abundance. This method is applied for "school counter".

3. MAIN FEATURE OF FISH COUNTER.

3.1 *Individual fish counter*

The block diagram of the individual fish counter is shown in Fig. 1. The system is composed of ultrasonic power transmitter, ultrasonic transducer, logarithmic amplifier, main amplifier, recorder, binary circuit, signal generator for counting depth range, computer system, digital indicator and printer. The numbers of echoes are calculated in the computer system on the basis of three factors, namely, the ship speed, the thickness of the fish school and the volume of water searched by a sound beam. The calculated values are shown in the term of the number of fish per searched water volume by a sound cone. Main features of this counter are as follows:

1) ultrasonic frequency: 28 kHz;

2) Maximum depth of fish to be counted: 300 m for the middle size tuna;

3) counting range (Fig. 2)
   a) depth when counting compences H_0: 10 - 100, 100 - 200, 200 - 400 m.
   b) width of counting h : 10, 20 and 50 m.;

4) echo recorder: Linear indication on wet paper (Furuno F.N.V. type 3,000);

5) digital counter: 3 digits; unit in number of fish/N m^3 (N: 10^4, 10^5, 10^6, 10^7 and 10^8);

6) printer: numerals thus obtained are typewritten in 12 digits including 4 for times, 3 for fish density, 1 for water volume, 4 for spare;

7) output power of electric transmitter: 2 kW;

8) directivity of transducers: 9.7° (half power beam angle);

9) pulse frequency: 90 pulses per minute;

10) changeable factor: Ship speed: 2, 3, 4, 5, 6, 7, 8, 9 and 10 kt. Volume of water searched by sound; 10^4 - 10^8 m^3;

The photograph of an individual fish counter is shown in Fig. 3.

3.2 *School counter*

The block diagram of the school counter is shown in Fig. 4. The system is composed of power transmitter, three ultrasonic transducers, logarithmic amplifier, echo-recorder, Schmit circuit and gate circuit, computer system and digital counter and printer. The counter indicates "1" when an echo is reflected from a target of 1 meter in thickness. For example, when an echo is reflected from a fish school with thickness of 10 meters by a single pulse transmission, the counter must show "10". If echoes from a fish school of 10 meters thickness are received during a hundred transmissions, the counter indicates "1000". The duration of counting is controlled in three ways, i.e. by manual operation, by a clock switch, and an automatic switch which works only when reflections are received, as is shown in Fig. 5. In the last case, the echo number printed represents that for a single fish school and the counter starts over again for another school. Main features of the school counter are as follows:

1) ultrasonic frequency: 50 kHz;

2) maximum depth of fish school to be counted: 200 m.;

3) counting range (Fig. 5)
   a) Depth when counting commences H_O : 10 - 200 m.
   b) Width of counting h : 10 - 200 m;

4) echo recorder: linear indication on dry paper (Sanken S.L. type 16);

5) digital counter: values in five digits represent the area of cross section of fish school;

6) printer: numerals thus obtained are typewritten on the paper in 14 digits, including 5 for fish school index, 5 for each variable factor i.e., ship speed, directivity of transducers, duration of counting, pulse frequency and operation of counting, 4 for spare;

7) output power of electric transmitter: 2 kW;

8) directivity of the transducers: 25° and 10°, angle along the ship's course and right angle to it. Three transducers are used, vertical, two aslant each for left and right;

9) pulse frequency: 225 pulses per minute (shallow range), 112 (middle range 1), 56 (middle range 2), 28 (deep range);

10) changeable factor: Ship speed: 2.5, 5.0 and 10 kt.

The photograph of school counter is shown in Fig. 6.

3.3 *Results of fundamental experiments*

In order to test the operational characteristics of devices and to investigate their application to the research of fish abundance, several fundamental tank tests and field experiments have been carried out since April 1969.

1) Individual fish counter

The device was installed on the research boat of Tokai University "Minami-juji", 20 G.T. The experiment was carried out at St. 1 and St. 2 in Suruga Bay as is shown in Fig. 7.

a) Counting accuracy for a fixed target

The following experiment was made to check the accuracy of the fish counter. The boat with the fish counter installed was anchored in waters with a depth of 25 meters (St. 1), and the number of echoes per unit time was counted for the sea bed and also for a vinyl plate (58 cm x 109 cm x 1 cm in size). Results of experiments are shown in Fig. 8, in which both the abscissa and the ordinates are the order of measurement and number of echoes counted, respectively. In both cases, the number of counted echoes hardly varied and agreed very well with only a few per cent deviation.

b) Counting accuracy for multiple targets

The experiment was made on the St. 3 shown on the map of Fig. 7. Targets, glass floats, were fixed under water as shown in Fig. 9. The boat installed with the fish counter moved above these three targets with a constant speed of about 4 knots. Results of this experiment are shown in Fig. 9, in which both the abscissa and the ordinate are the order of measurement and numbers of echoes counted, respectively. In this case it can say that numbers of echoes were almost proportional to those of targets. A similar experiment was carried out by using small tuna in the successive field experiments. Fig. 10 shows the echo-chart and the printed paper obtained when the boat passed above the tuna. The tuna were recorded clearly and the printer recorded the number of echoes.

c) Experiment on fishing grounds

As the first step to examine the applicability of a fish counter to fisheries research, the following experiment was carried out for three days in the summer and autumn of 1969, in Suruga Bay. The fish counter was installed on the research boat "Hokuto", 20 G.T., 12 kt, and the total distance cruised was about 120 nautical miles. Fig. 11 shows the echo-chart and the printed paper obtained from these experiments. As is shown in the figure, the number of fish were counted when the fish-detector recorded the echo from fish school. In addition there were no mistakes in printing caused by the reception of ultrasonic noise generated by under-water bubbles passing below the hull of this boat. In this year, experiments on the fishing grounds will be repeated until good results are obtained.

2) School fish counter

The devices were installed on the research boat "Minami-juji", and the experiment was carried out at St. 1 and St. 3 shown in Fig. 7.

a) Counting accuracy for a fixed target

The following experiments were made to examine the counting accuracy of the school counter. The experimental boat installed with the fish counter was anchored at St. 1 with a depth of 25 meters. First, the number of echoes per unit time was counted for the sea bed and also for a glass ball of 10 cm in diameter. Results are shown in Fig. 12, in which the abscissa and the ordinate are the order of measurement and the accumulated numbers of counted echoes, respectively. In the case of the sea bed, few fluctuations were observed in the numbers of counted echoes. In the case of target, the measured value fluctuated as is shown in Fig. 12 and the accuracy was slightly less. The reason why the error was larger in the counting of the glass ball target may be that the target has drifted in the sea water. The resolving distance between the sea bed and the vinyl target was estimated to be about 2 meters on the basis of an abrupt change in the number of counted echoes observed in response to changing the distance between two targets.

b) Accuracy of counting for multiple model of fish school

The experiment was made on St. 3 in Fig. 7. The target was constructed of bamboo, steel wire and 330 ping pong balls (six balls tied to each steel wire branch as is shown in Fig. 13). This model was designed to simulate a dense fish school such as of sardine. The size of the model was about 5 meters in length, about 2 meters in width, and about 5 meters in depth. In the experiment, the bamboo frame was set at the depth of 35 meters by nylon rope at four corners of the frame hanging down from floats on the surface. These floats are also used as surface marks. The research boat installed with a school counter moved above the model target in parallel to its longest and shortest axes in turn.

Fig. 14 shows the echo-chart and the printed paper. In this figure, the number of echoes are sometimes divided into two or three parts because, as the counting of echoes conforms to a "school unit", the counter prints out when the continuity of echoes breaks. The total number of echoes, therefore, is obtained by summing up each printed number on the paper. In this experiment, whole echoes received were printed on the printer throughout the actual operation. These numbers should be recalculated later by the factors such as the ship speed, and the thickness of the fish school.

Judging from the results obtained, it can be said that the fish counter is now being continued by Dr. T. Aoyama of Seikai Regional Fisheries Research Laboratory and by Dr. K. Shibata of Nagasaki University.

4. DISCUSSION.

The authors report in this paper some results of the fundamental experiments conducted for several months on the sea, and complete results will be reported in the future. The results obtained this time indicate that the following points must be considered for any future experiment in applying the fish counter in the field of fisheries research.

1) *Stabilization of electric power supply.*

There were some errors in counting caused by the fluctuation of voltage of electric source. To increase the accuracy of the fish counter, it is necessary to use an electric source with constant voltage and frequency.

2) *Elimination of error caused by cruising of boat.*

There are mainly three types of errors in the fish counting caused by cruising of boat installed with fish counter. Namely, the swing of the sound cone induced from rolling and pitching of boat, and the generation of bubble below the bottom hull of the boat, which induces attenuation of ultrasound and generation of acoustic noises. In the current experiment, these effects were not observed because of the calm sea. To eliminate such effects the authors are planning a towed vane in which transducers are mounted. It will be accomplished in the next year.

3) *Determination of counting unit in school counter.*

In the case of the individual fish counter, the figures recorded on the paper may indicate the number of fish either in absolute or in relative values. In the case of the school counter, the number of echoes indicated is relative to the depth and the length of fish school. To estimate the abundance of fish, it is necessary to find factors to convert from relative values to absolute ones. This needs further study.

5. CONCLUSION.

By the results of the preliminary fundamental experiments at sea, the authors believe that the two types of fish counters should be used in the actual estimation of fish abundance on the fishing grounds. The authors hope that success will be obtained through consecutive experiments which will be held in the next two or three years.

The authors wish to express many thanks to the collaborators on this study, Mr. H. Yamanaka; Mr. M. Yukinawa of Far Seas Fisheries Research Laboratory; Dr. K. Shibata of Nagasaki University; Mr. M. Kato and Mr. S. Sekikawa, design staff of Furuno Electric Co. Ltd., and Mr. M. Hirano, Mr. T. Noda and Mr. Takeshi Inamura, design staff of Sanken Electronics Co., Ltd. The authors also thank Prof. M. Iwashita of Tokai University for his valuable advice and encouragement, the crew of the research boat of Tokai University and seven students for their capable assistance.

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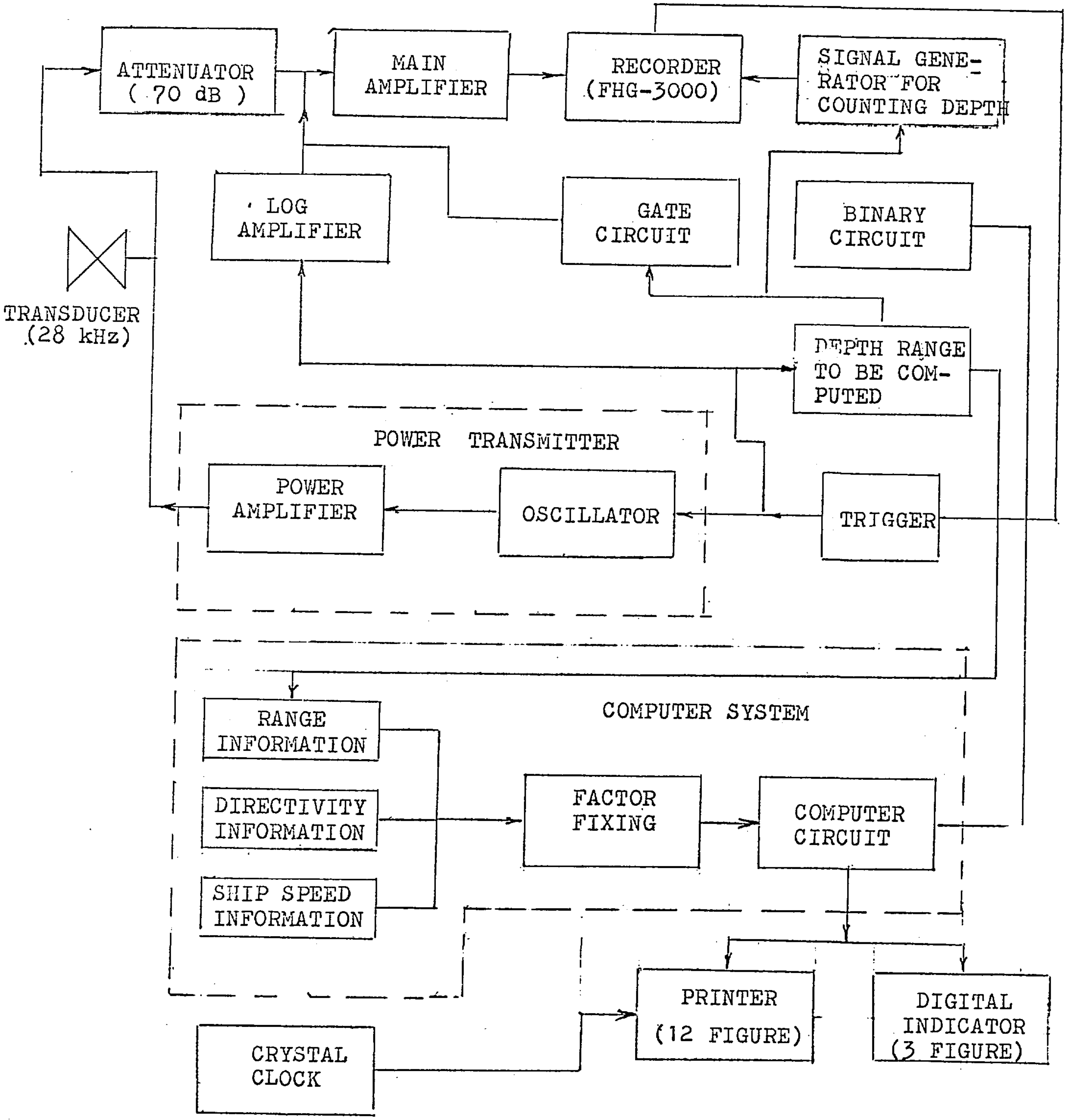

Figure 1. Block diagram of individual fish counter.

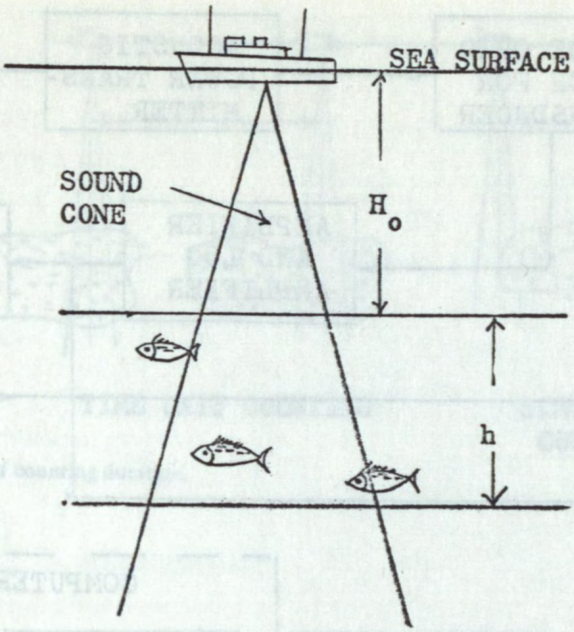

Figure 2. Explanation of counting range.

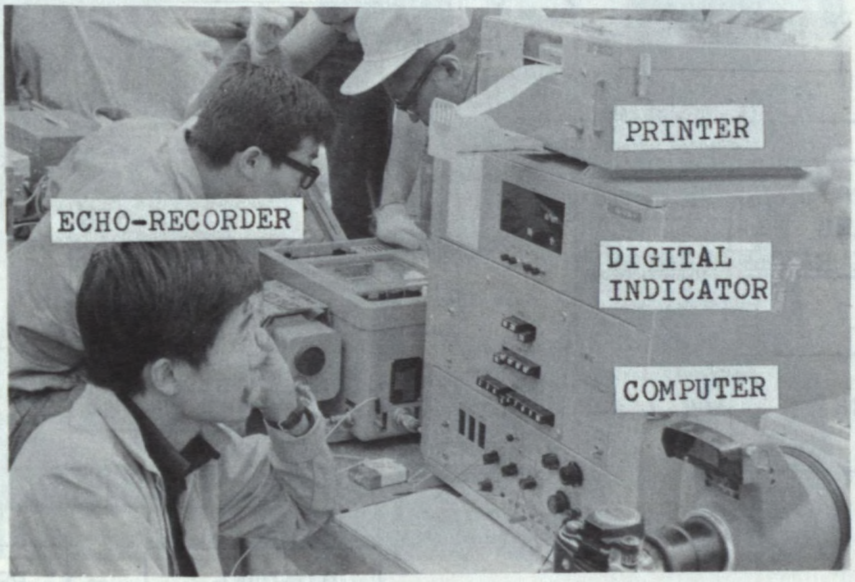

Figure 3. Photograph of individual fish counter

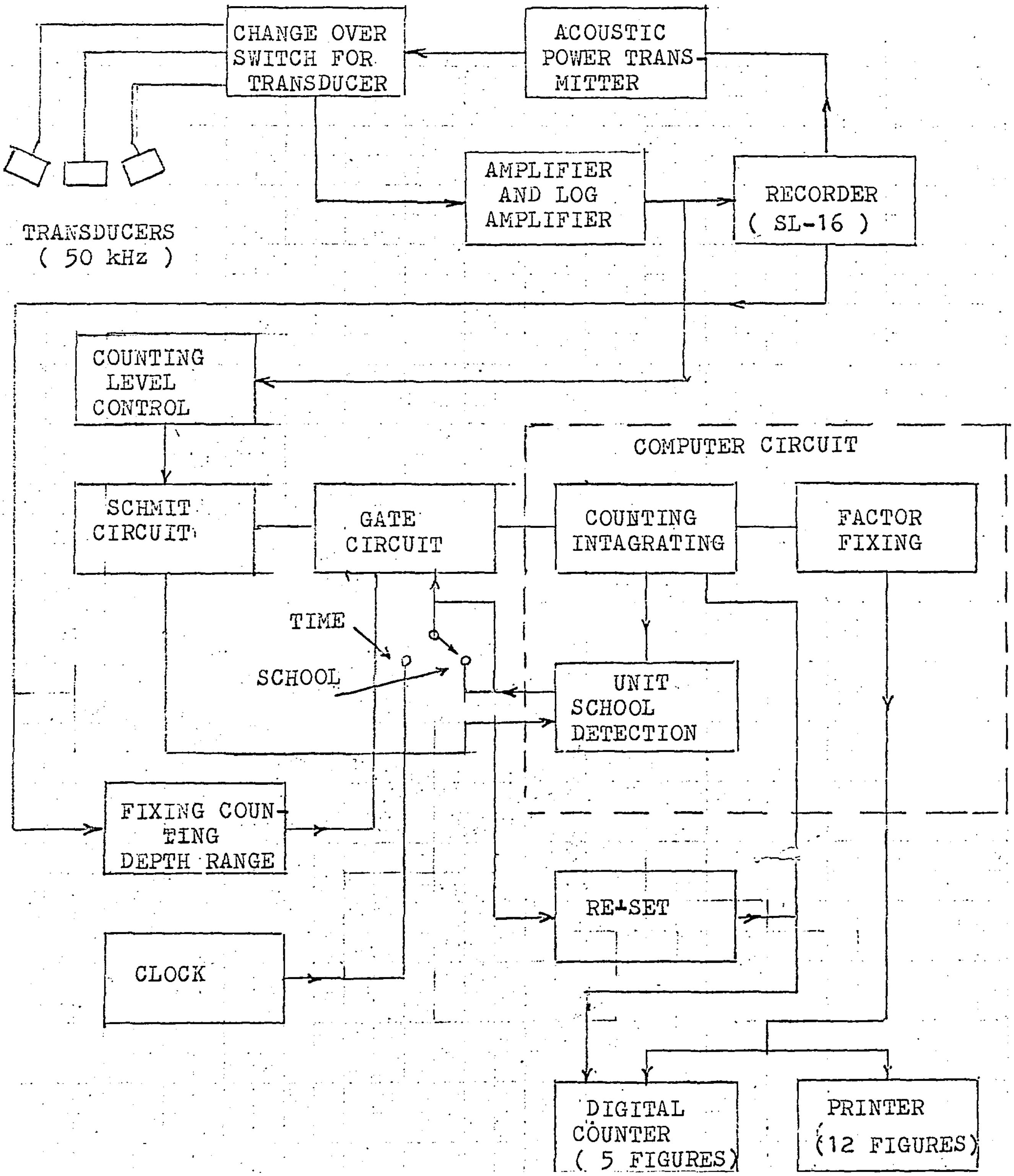

Figure 4. Block diagram of school counter.

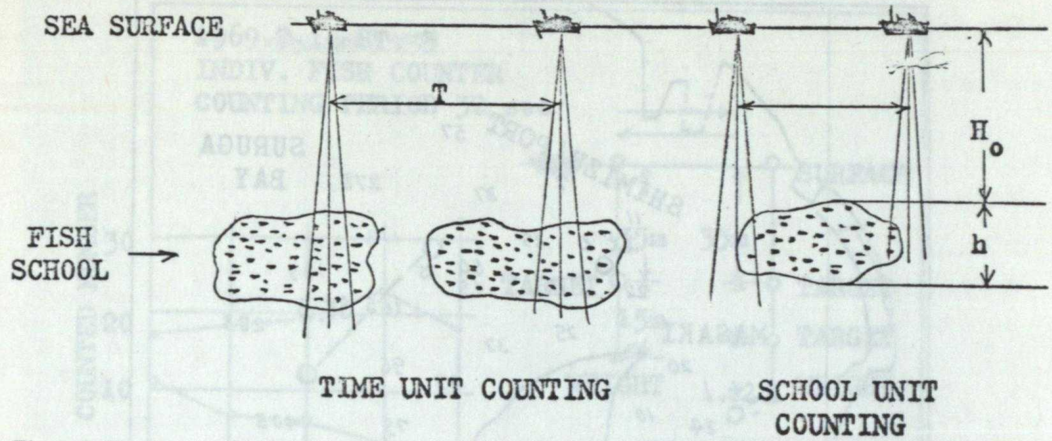

Figure 5. Explanation of counting duration.

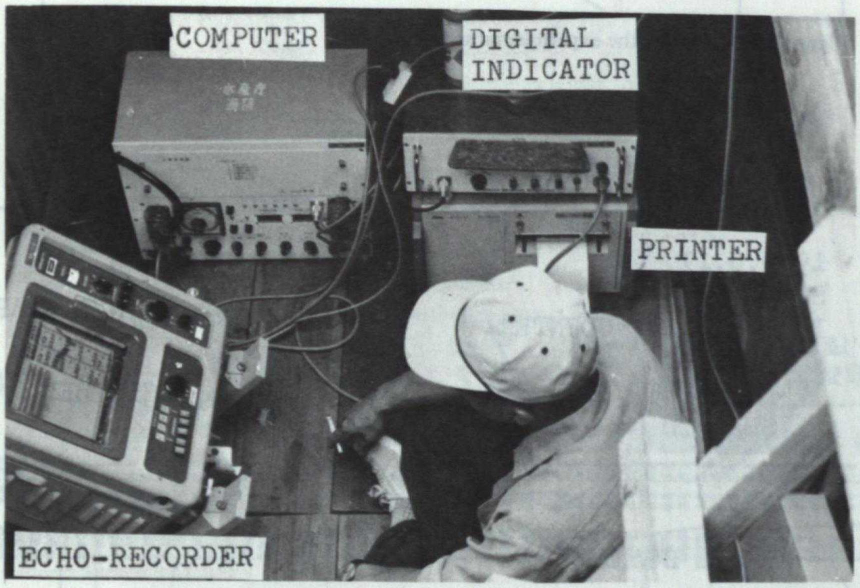

Figure 6. Photograph of school counter.

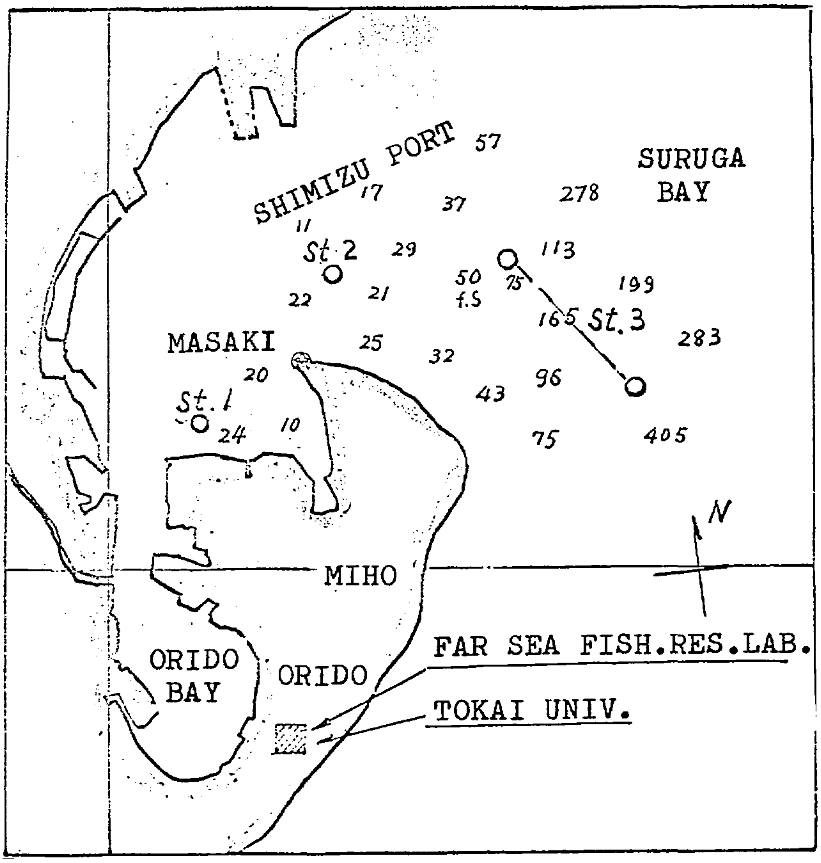

Figure 7. Location of the experimental station.

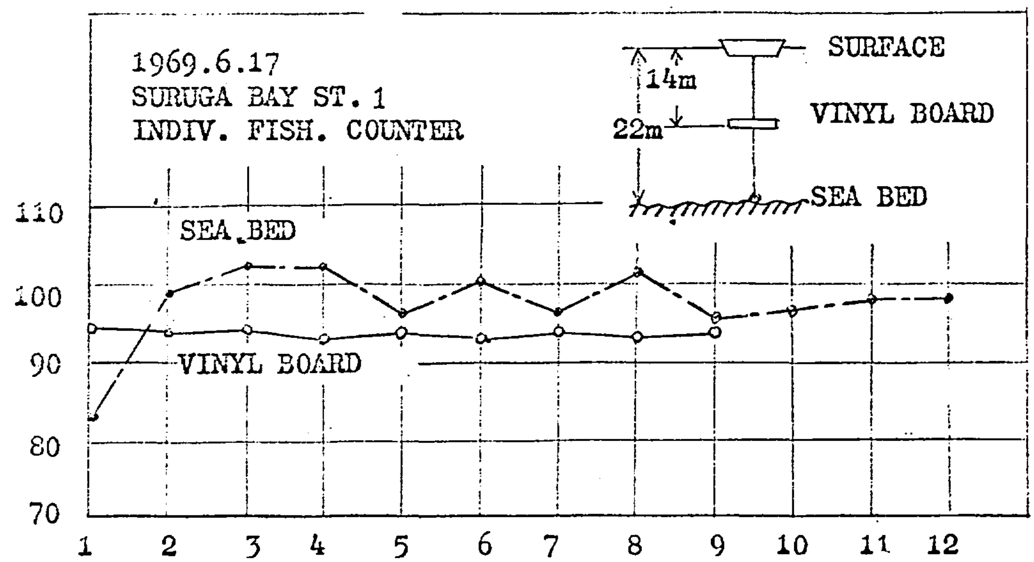

Figure 8. Measured counting accuracy for sea bed and for vinyl board.

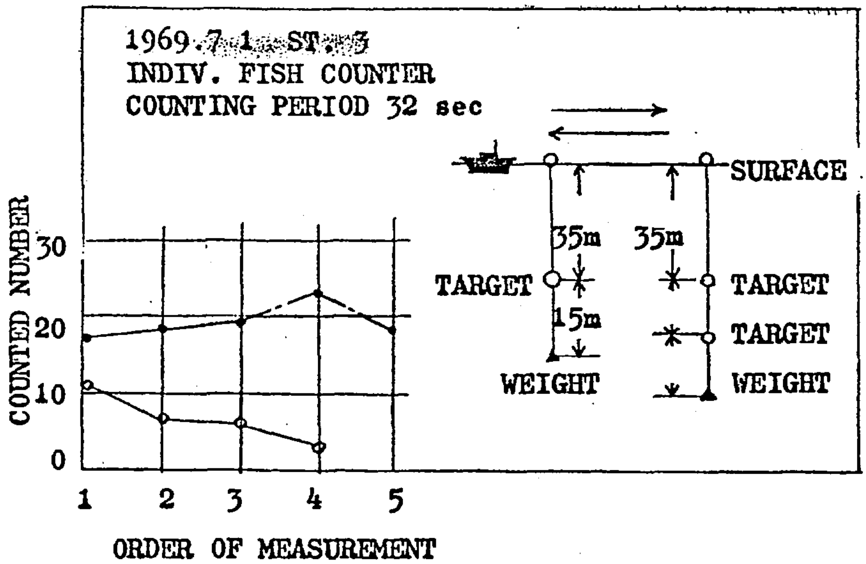

Figure 9. Numbers of counted echoes for single and double float.

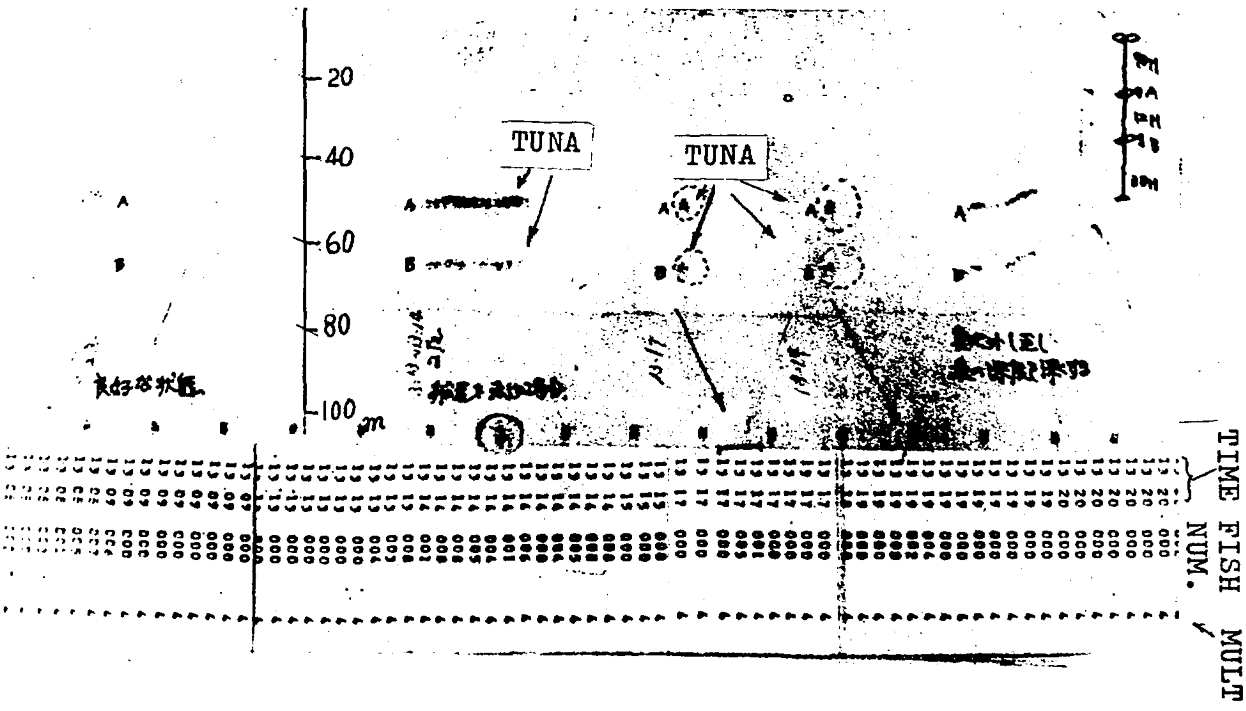

Figure 10. Echo-chart of tuna and printed paper of counted echoes.

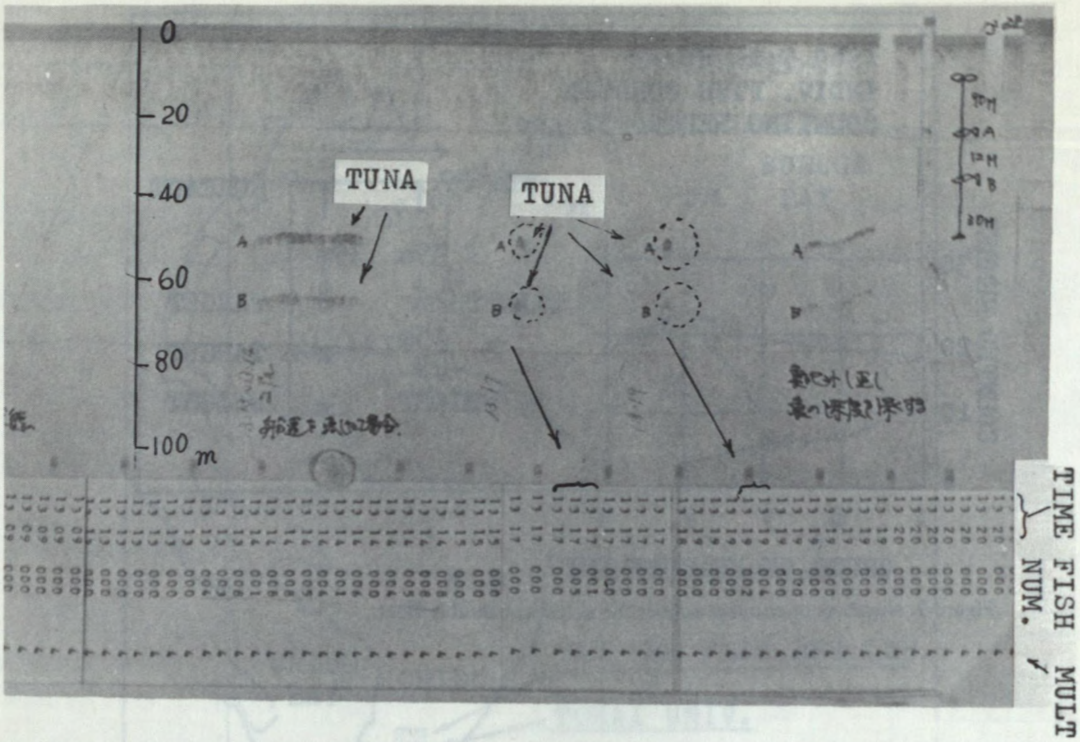

Figure 11. Echo-chart and printed paper obtained on the experiment at the fishing ground.

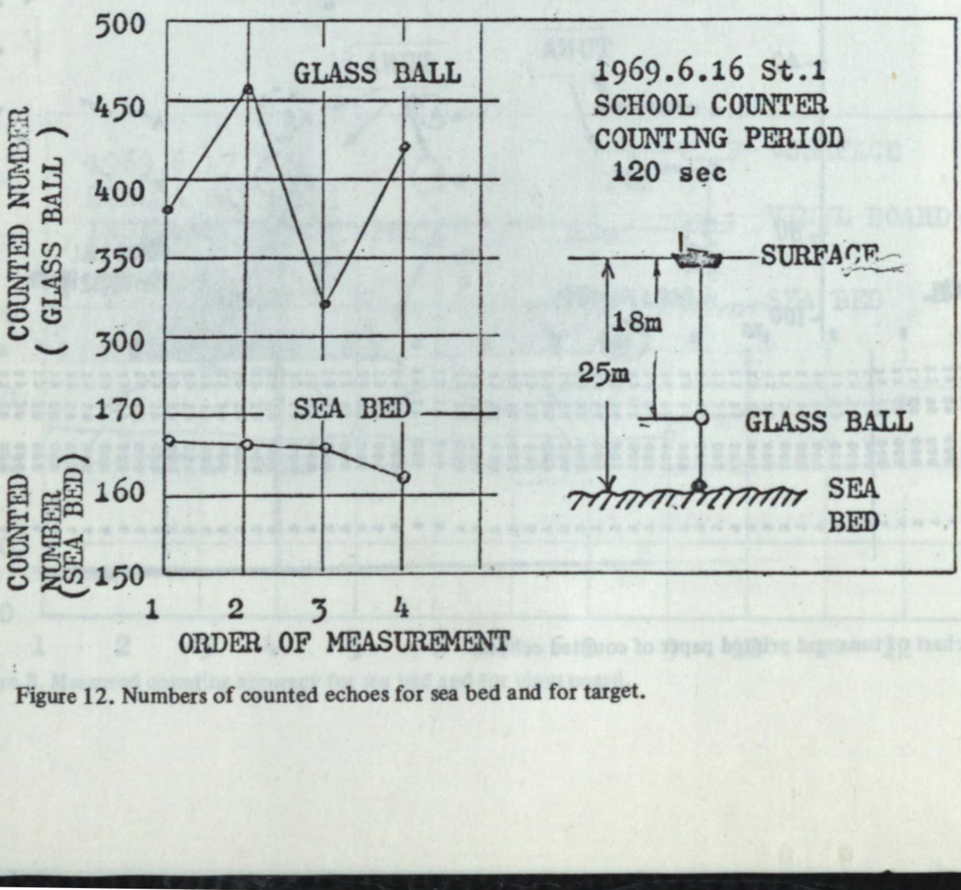

Figure 12. Numbers of counted echoes for sea bed and for target.

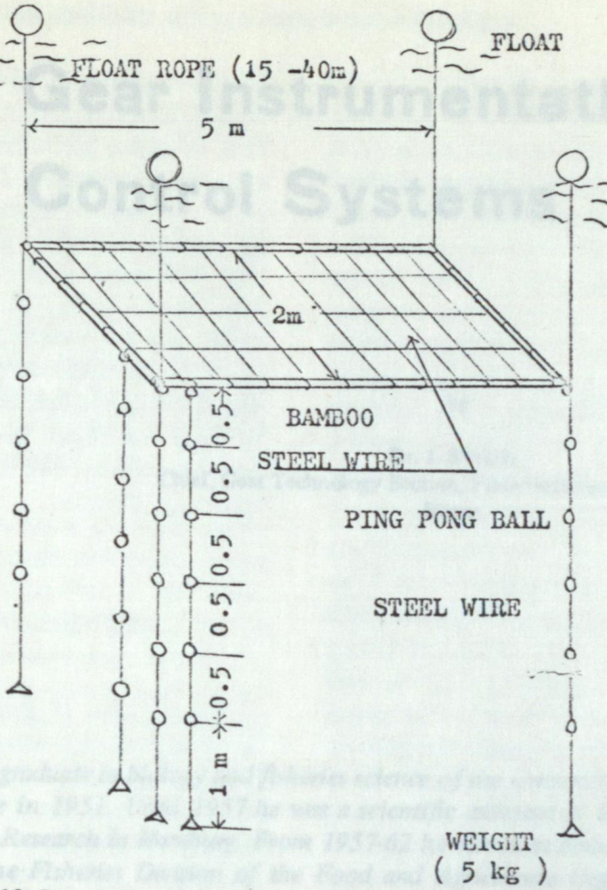

Figure 13. Construction of artificial fish school made of bamboos, steel wires and ping pong balls.

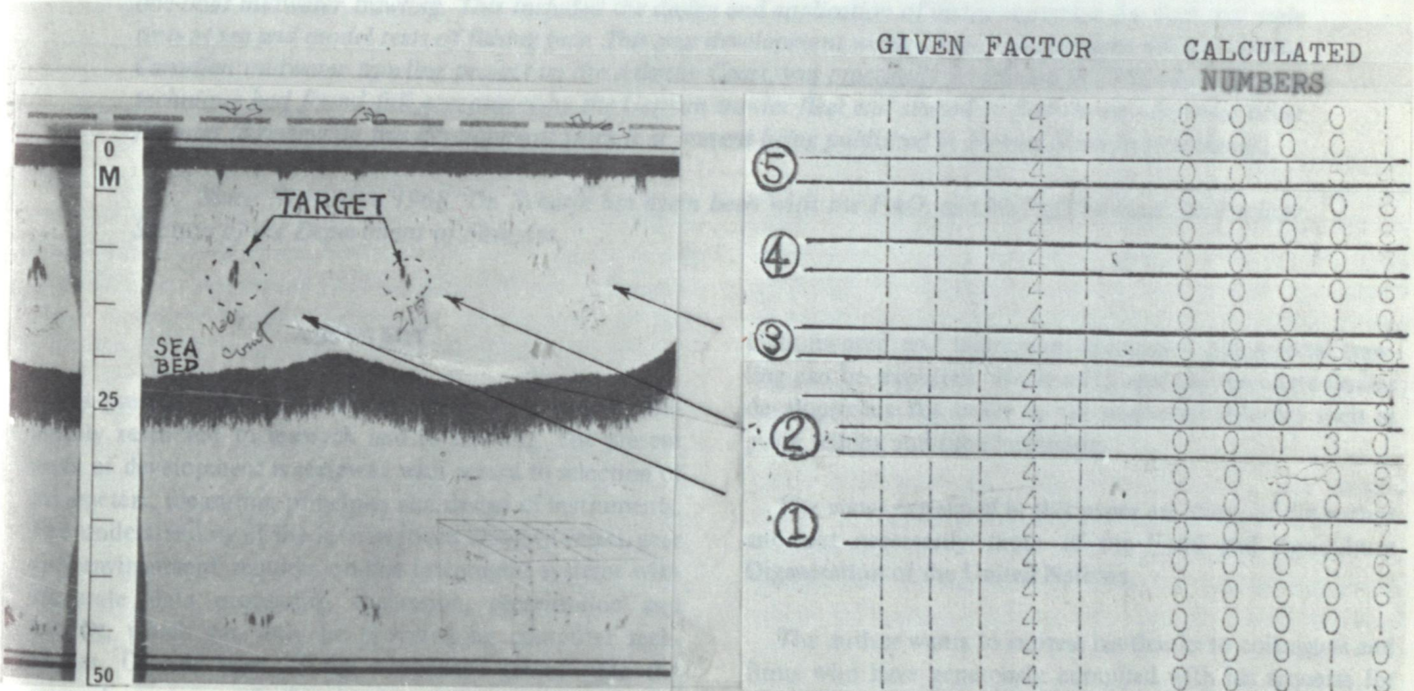

Figure 14. Echo-chart and printed paper of the artificial fish school.

Fishing Gear Instrumentation and Control Systems

Dr. Schärfe

by

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Rome.

Dr. Schärfe, 51, is a graduate in biology and fisheries science of the University of Hamburg, where he obtained a Doctor's degree in 1951. Until 1957 he was a scientific assistant at the German Institute for Fishing Methods and Gear Research in Hamburg. From 1957-62 he served as Fisheries Technologist in the Fishing Gear Section of the Fisheries Division of the Food and Agriculture Organization of the United Nations at Headquarters in Rome. From 1962 to 1968, after his return to the Institute for Fishing Methods and Gear Research in Hamburg, he was responsible for most of the development work done in Germany on one-boat midwater trawling. This included the design and application of instrumentation for both full scale tests at sea and model tests of fishing gear. This gear development work, which has also been utilized for the Canadian midwater trawling project on the Atlantic Coast, was practically concluded in 1968 when his new technique had found full acceptance by the German trawler fleet and started to find its way also into other fisheries (a review on this development work is at present being published in Fishing News International).

Since November 1968, Dr. Schärfe has again been with the FAO, as Chief of the Gear Technology Section of the Department of Fisheries.

ABSTRACT

At present fishing gear instrumentation is almost completely restricted to research and to trawling. The present state of development is reviewed with regard to selection of parameters, measuring principles and design of instruments. The understanding of the interrelations between vessel, gear and environment requires on-line instrument systems with adequate data processing, evaluation, presentation and logging, which can only be provided by computer techniques. On the basis of the experience gained with the research systems of this kind, substantial progress for instrumented and instrument controlled commercial trawling can be expected, which will hopefully stimulate similar developments for other so far neglected fisheries such as purse seining and tuna longlining.

The views expressed in this paper are those of the author and not necessarily those of the Food and Agriculture Organization of the United Nations.

The author wants to express his thanks to colleagues and firms who have generously complied with his requests for illustration material.

INTRODUCTION

Instrumentation and control systems are the natural tools and partly the aim and outcome of the rational engineering approach to fishing methods and gear problems. The principles of measuring, display and communication are taken over from general engineering and are mostly simple. The particular conditions of fishing, such as hydrostatic pressure, distance between instrument and observer, interference by weather, sea conditions, movements of the vessel and the difficulties or impossibility of direct access to the object to be measured, require a respective adaptation of the instruments and – together with the objectives – govern the setup of combined systems.

From the beginning, about 20 years ago until now, the rational study and the related instrumentation of fishing gear were predominantly concentrated on trawls and trawling. The few exceptions, mainly recently, are rather limited studies of purse seines, tuna longlines and gillnets. This is not only due to the importance of trawling for many developed fisheries, but also to the complexity of trawls in action as a mechanical system, the physical performance of which is much more difficult to comprehend and to judge than for other simpler fishing gear. Trawling was therefore in particular need of rational investigation for further development. At the same time it is also the most interesting and challenging fishing gear for engineers, physicists, mathematicians and also behaviourists.

Fishing gear instrumentation naturally developed in industrialized countries. The application of most of the present instrumentation is still for research and development work, which is predominantly conducted by governmental or semi-governmental institutions on research vessels. There is, however, an increasing tendency towards practical application which is supported by the introduction of midwater trawling. Under the increasing economic pressure the demand for optimum efficiency will doubtless strengthen this tendency towards instrument controlled fishing, not only to provide essential information (e.g. depth of midwater trawls) but also to improve the accuracy, the presentation, the evaluation and the co-ordination of fishing parameters, including the vessel and its motion, and the environment.

Since, particularly in trawling, the vessel and the gear operate as a unit and the environment (wind, sea, currents, bottom conditions) often has decisive influence, comprehensive instrument systems have to include certain parameters of engine performance, navigation and also meteorology and hydrography. The relevant instrumentation which could therefore be included in the definition of fishing gear instrumentation in a wider sense will not be discussed here. The following review of the remaining fishing gear instrumentation "proper" also cannot go into the technical detail and the reasoning behind it. For this reference is made to the relevant publications cited. The brevity of descriptions, discussions and comments appeared necessary to keep the paper within a reasonable total size. The selection of examples should not be taken for a rate as to value or preference.

METHODOLOGY AND INSTRUMENTS

The selection of the parameters to be measured and of the measuring techniques obviously are both ruled not only by the purpose, but also by the skill, the facilities and, last but not least, the funds available. Consequently, the existing variety in instrumentation standards is not incidental and at least some of it will remain. This refers, in particular, to commercial application for which economic considerations are decisive. Warp divergence is still measured with a broomstick and depth control of midwater trawls is in some cutter fisheries still based on warp declination and empiric tables, although one may wonder if this is really always a financially sound solution.

A number of variables such as speed, load, angles and distances are clearly definable and can be measured more or less accurately. The choice of parameters and the extent to which they can be measured with the present instrumentation as well as the present evaluation techniques are, however, not sufficient for a comprehensive deduction of actual fishing gear configuration and performance. For complementation regarding, also, certain still not measurable features and for certain aspects of fish distribution and behaviour, direct or indirect observation techniques are employed which have to be considered here. In this context model experiments in large scale should at least be mentioned in so far as – apart from diver observation – in some cases very similar instrumentation and measuring techniques are being used, as discussed below for full scale tests and commercial operation (e.g. Dickson, 1959; Schärfe, 1966).

Speed

Since speed is a vector, the direction also must be considered.

Water currents may have an effect on most fishing gear and are a great nuisance for trawl investigations, particularly since velocity and direction can be different at different depths. For their determination a great variety of instruments is available from hydrographic research. They are mostly of the propeller type and some of these, eventually with slight modifications, are used for more accurate speed through water measurements of vessels and gear.

In trawling speed measurements are quite problematic (Carrothers, 1968). The speed through the water of the vessel is almost always different from that of the trawl. Because of their frictional resistance, for bottom trawls also the speed over the ground must be taken into account. In commercial trawling this complexity cannot possibly be dealt with accurately. The skill and practical experience of the skipper have to make up for the lacking completeness of information which mostly consists of the speed of the trawler through water only. On some grounds the speed over the ground may be roughly determined by Radar, Decca Navigator or echo sounding. In spite of these limitations skilled comparative evaluation of the rather rough speed measurements are of great practical significance for judging the performance of trawls and for recognizing damage.

Engineering studies require more accuracy, particularly since the towing or current resistance is usually one of the main objectives. The requirements for instrumentation, collection and evaluation of measured data are considerable. Probably the most complete scheme is employed by Carrothers (1968) who determines the water currents at the surface and near the bottom, the speed of the trawler through water (Ott propeller current meter), the speed of the trawler and trawl over ground (Radar, Decca) and the hydro-dynamic pressure in the net opening (recording pitometer). The pitometer was specially designed for this purpose (Fig. 1).

Even modern trawl logs are considered not accurate enough, so that for trawl studies specific logs are usually employed for measuring the trawler's speed through water. These are normally towed from outriggers in sufficient distance from the vessel to avoid interference and are mostly propeller type current meters (e.g. Carrothers, 1968; Nicholls, 1964; Hamuro and Ishii, 1964). The accuracy of these logs may be affected by rolling of the vessel. Another type, the resistance log (designed by Kempff) which was used in German investigations, does not suffer from this effect, but is rather time consuming in operation (Schärfe, 1959). The latest development is the electro-magnetic log which measures two speed components, i.e. in ship's direction and normal to it (MacLennan, 1968). Acoustic Dobbler measurements, eventually utilizing existing Sonar equipment, have been considered, but do not seem to be used yet. Even today the old rail log method is employed when only a measuring tape and a watch are available.

The speed over the ground is generally determined by navigational aids, i.e. bearings of terrestrial targets by sight or Radar, radio direction finding, Decca Navigator and, for particular accuracy, also with buoy marked distances (Carrothers, 1968). A more direct method can be proposed from own multi-netsonde observations. Attached to the headline bosom of a bottom trawl the forward directed transducer inevitably picks up echoes from stones and other small bottom irregularities. When displayed on a storage oscilloscope in suitable scale the speed of advance can conveniently be determined and the regularity of distance variation from sounding to sounding would allow the selection of targets in correct forward position and the exclusion of fish targets which would be undesirable because of their own movements. Also Dobbler measurements of bottom reverberation eventually with an additional backward directed transducer would appear feasible.

For midwater trawling in general and also for certain aspects of bottom trawling, including fish reaction and catching efficiency, the speed of the trawl through water is decisive and the speed of the vessel and over ground can be neglected. The measurement requires underwater instrumentation which may be recording or telemetering. The position of the meters depends on the objective and may be some distance ahead of the trawl on, above or below the headline bosom, in the net opening or even farther aft in or outside the net. Usually hydrographic current meters are modified for this purpose (Nicholls, 1964; Schärfe, 1969). The pitometer in the net opening (Carrothers, 1968) was already mentioned. From the hydrostatic pressure the speed can be deduced. Also resistance logs are used with which the towing resistance of a defined body is recorded (Hamuro, 1967) or the resultant tilt of the body retained by the set surface of a jelly filling (Petrov, 1967). In general the measurement of trawl speed through water appears to be rather neglected and would deserve more attention. Similar to that for the vessel, a two component measurement would be desirable for the correct assessment of trawl speed and direction for which – also in regard to accuracy – the magnetic-electric principle should be well suited.

Loads

The loads on warps and other lines or the netting are the result of the various forces acting on the gear and therefore one of the main subjects of most studies. In commercial fishing they provide important indications for the judgment of the gear performance under normal conditions and in case of damage. For the analysis and isolation of the various forces (e.g. drag, shear, lift, weight) their direction must be known, which requires the determination of certain angles. The significance of the speed for hydrodynamic forces (shear, drag) has only to be mentioned (square law).

Loads on warps and lines are measured mechanically (spring), hydraulically (bellows, Boardon tube) or electrically (strain gauge). The measurements are continuous and usually recorded. For routine warp load measurements on commercial vessels visual display on a calibrated scale is also used, eventually in combination with recording and an overload alarm (visual or acoustic). Most underwater instruments are self contained recorders, but there is a clear tendency towards telemetry. Loads on netting yarns require specific means.

In trawling and Danish seining, factors like current, wind and ship's course influence the distribution of forces to such an extent that symmetry cannot be taken for granted. Consequently, the loads on both sides (warps, bridles, legs, etc.) have to be measured simultaneously. With lines of fixed length or rig (bridles, legs, otter board end of warps) the load meters are inserted and carry the whole load (Fig. 2). For measurements on the uninterrupted warp on board the same setup may also be used, particularly for smaller gear (Fig. 3). This has, however, the obvious disadvantage of interfering with the modification of warp length and, in case of a hook-up, the instrument may be damaged. With larger loads the attachment of the warp with clamps or stopper chains also becomes problematic. These drawbacks lead to the introduction of the deflection-type warp tension meters (e.g. Carrothers, 1968; Nicholls, 1964) which measure only a well defined component of the total load (Fig. 4.). The most advanced versions of this type allow measurements even on the moving warps, and well designed sets are available for routine operation on commercial trawlers (Fig. 5) and Danish seiners (Fig. 6) (White Fish Authority, 1964; 1965; 1968; Drever and Ellis, 1968).

Another principle also designed for commercial trawlers uses the load on the winch brakes as a measure for the warp tension. Since the measured values depend also on the filling of the winch drums, no absolute accuracy can be expected from this method. In spite of this shortcoming the possibility of comparative judgment of the load distribution and the approximate estimation of the actual loads from the biased measurements is considered advantage enough to justify the installation.

Regarding the load on single yarns in the netting of trawls and stow nets, so far only maximum load measurements can be obtained. One method based on the Brinell hardness test uses the depth of the indentation created by a steel ball in a metal plate of defined hardness as a measure for the maximum load (Nicholls, 1964). This method, for which a number of bars in a row of netting are replaced by the twine load cells, has the disadvantage that it does not allow for elastic stretch which is a feature of most modern synthetics. The same applies for another method for which bars are replaced by wires of known strength and the maximum loads are deduced from those which are broken. In both cases more than the normal maximum load in undisturbed netting will be found. A third method avoids this bias by utilizing the elastic property of the netting yarns themselves as a measuring element (Schärfe, 1954). The maximum elastic stretch of the netting yarn is retained by the elongation of a thin copper wire, the ends of which are attached close to the knots of the bar. The respective maximum load is determined after the trial by restretching the bar to the same extent in a simple apparatus with a spring dynamometer.

Angles

The angle or divergence between the two trawl warps has always been used in commercial trawling as a means for judging the gear performance. Usually not the angle is measured, but the increase in distance between the warps for a convenient unit of length (e.g. 1 meter, 1 fathom) close aft of the towing block or the gallows rollers. From this value a rough indication of the distance between the otter boards can be obtained by simple triangulation. In spite of its limited accuracy (curvature of the warps) this method is very useful for ascertaining proper gear performance and for identifying certain irregularities such as over-tilting of an otter board, serious damage to the net or excessive net drag which may be due to mud or an exceptionally large catch. The simple "broomstick" and measuring tape devices which are employed also for comparative trawl studies need only to be mentioned.

The angles of the trawl warps with the horizontal (declination) are still used in some midwater-trawl fisheries for the depth control of the net. The simple measuring devices employ either a water level or a pendulum as reference. Difference in these angles between the two warps indicate irregular trawl performance and may also allow identification of the cause, such as an overtilted otter board or unequal warp length. During sharp turns this "warp heel" indicates the state of oblique uplift of the trawl and is observed to avoid "putting a turn" in the gear.

For gear investigation certain additional warp angles are required for the vectorial isolation and more accurate determination of the main forces of which the total measured loads consist.

The presently most common warp angle meter for such purposes (Nicholls, 1964) measures the angle of divergence between the warps directly and uses pendulums as reference for the angles of declination and heel (Fig. 7). The continuous real time measurements are either recorded separately (Nicholls, 1964; Carrothers, 1968) or fed into a computer (MacLennan, 1968).

An even more sophisticated instrument allowing for independant warp angle recordings under water at any depth down to the otter boards measures the true angle of incidence to the direction of motion with reference to the "stream" and the angle of roll with reference to gravity (Carrothers, 1968). As compared with the former one, this instrument is not restricted to side trawlers and the different choice of angles measured is expected to improve the accuracy of drag estimations.

In view of the inconvenience of the present instrumentation, warp angles are just neglected for the "towing resistance" measurements in commercial trawling. To date technical know-how would certainly enable the design of a much more satisfactory measuring system for trawlers – for instance with strain gauges in special gallow posts. It is, however, not certain whether the improvement of information would justify the probably considerable expenses.

The position of otter boards and other sheering devices which is decisive for their performance is usually characterized by three angles, i.e. of attack (to the direction of motion), of heel (to the vertical sideways) and of tilt (to the vertical lengthwise).

In commercial bottom trawling the working position of the otter boards is judged and corrected according to the abrasion marks on the shoe plates. The direction of the scratches on the soles gives a good indication of the average angle of attack while the tilt and the heel can only very roughly be guessed from the extension of abrasion marks ("shine") on both sides and along the length of shoe plates.

For gear investigations average values are naturally not sufficient and considerably more accuracy is required as well. The instrumentation which consequently had to be developed is mostly recording. Only recently telemetering was introduced (SI, 1965; MacLennan, 1968).

The angle of attack is obviously the most difficult to measure. The reference to the direction of motion is mostly attempted by means of a trailing rod (on the sea bottom) or a trailing resistance body or a vane in the water stream (de Boer, 1954; SI, 1965, Nicholls, 1964). Both are inconvenient to handle and susceptible to mechanical damage. The principle furthermore is affected by the angle of heel. As an alternative bridles (Nicholls, 1964) or warps (Schärfe, unpublished) have been used as directional reference. Here the accuracy is obviously dependent on the accuracy with which the position of these lines to the direction of motion can be measured or deduced and this will mostly be rather poor. The angle of attack measurement does not seem to be satisfactorily solved yet. The gyro principle which could at the same time serve for heel and tilt measurements would appear to be suitable, and may be considered for more appropriate instrumentation.

The angles of heel and tilt are determined with reference to gravity by means of pendulums (de Boer, 1954: Nicholls, 1964. SI, 1965).

Regarding investigations on the curvature of warps one instrument was already mentioned (Carrothers, 1968). Another warp declination meter which can also be attached anywhere on the warp under water is described by Nicholls (1964).

For the determination of the curvature of the groundrope of bottom trawls the trailing rod or plough principle is employed. One instrument (Hamuro and Ishii, 1964b, Fig. 8) is paper recording. Another one, which is meant also for commercial application, has a very peculiar recording system; small steel balls are released from the pointer representing the direction of motion in short time intervals towards a semi-circular arrangement of 19 magnets. From the quantitative distribution of the balls over the magnets of which each represents a sector, the average position of the respective groundrope section and its variations can be deduced (Grouselle, 1967). Naturally several such instruments distributed over the groundrope are needed simultaneously to determine the curvature. The results are also utilized to estimate the opening width of the net, and to identify causes for irregularities such as unequal warps. Under respective conditions these instruments can also be used to measure the angle of attack of bridles and otter boards.

Apart from direct diver observation the position of kites seems to have been studied so far only by the jelly-bottle technique (Schärfe, unpublished). Plastic bottles with rectangular cross section are well suited to show angles of attack and heel at the time the jelly has become solid. This technique is of course far from satisfactory. In view of the small size of kites and similar shearing devices and the respective difficulties in avoiding interference the measuring devices would have to be smaller and lighter than are acceptable for otter boards. This requirement, together with the obviously limited interest in the performance of such shearing devices under fishing conditions are probably the main reasons why better instrumentation has not been developed so far.

Distances

Under this heading trawl warp length may also be discussed. Correct trawl performance requires not only adequate but also equal warp lengths. The unequal stress during normal trawling inevitably leads to unequal stretching and the relative correctness of the common warp marks consequently must be checked in certain intervals. This requires a considerable amount of work and time, particularly at sea. To avoid this, wheel type cable meters have been introduced (e.g. Crecelius, 1959) with which the warp lengths are measured each tow. Recently a quite sophisticated magnetic marking technique has been adopted (Foster and MacLennan, 1969) for the same purpose. Both do not determine length changes which may occur during shooting and towing and which may not be negligible with long warps in regard to equality. Because of the surprisingly high sensitivity comparative warp load measurements have been proposed for securing equal warp length (Schärfe, 1953) and in view of the much better warp tension meters available now this old suggestion may be repeated here.

Vertical distances under water such as the depth of a midwater trawl, of the leadline of a purse seine, a floating longline and also the vertical distances of various gear components from each other can conveniently be measured with reference to the respective hydrostatic pressure. Consequently a great number of instruments, mostly recording, are based on this principle.

An example for hydrostatic depth recorders of which several have been developed is the "Bathykymograph" (Hester, Aasted and Gilkey, 1963) for investigating the sinking speed and depth of tuna purse seines (Fig. 9). A telemeter of this principle was designed for midwater trawling (McNeely, 1959) using a special warp with electric conductors for the transmission from the measuring point (otter board) to the vessel. Wireless hydrostatic depth telemeters with acoustic communication are known from Japan (Hamuro and Ishii, 1964a) where they were also introduced for commercial midwater trawling. This instrument has also been used on other gear such as floating longlines and purse seines.

Because of their considerably higher accuracy differential manometers are preferable to separate depth meters for the determination of vertical distances between gear components. The first useful opening height meter for bottom trawls was of this type (de Boer, 1954). Several similar instruments have been designed later for the same purpose (e.g. Dickson, 1959; Hamuro and Ishii, 1959). Subsequently differential manometers for two (Nicholls, 1964) and up to four (Hamuro and Ishii, 1964b) measuring points were developed which, apart from trawls, have also been used on gillnets. The main drawback of the differential manometers is the need for tube connections between the measuring points and the central unit.

For more or less horizontal distances other principles have to be employed. The estimation of the distance between otter boards from the divergence of the warps was already mentioned. Another simple technique for this purpose employs surface floats attached to the submerged otter boards, the distance of which can, for instance, be measured by triangulation with a sextant or by a measuring line (McNeely, 1964). In the first recording instrument a measuring wire between the otter boards was used (de Boer, 1954).

The best solution so far for determining most underwater distances came with the introduction of the acoustic measuring principle, i.e. the application of echo sounder transducers or complete acoustic measuring units to the fishing gear under water. At present practically all underwater distances such as from the bottom or surface, between headline and groundrope, between the otter boards, the wingtips, and certain sections of the net are measured acoustically for gear investigations as well as in commercial fishing. Mostly normal echo sounders are used in the well known netsonde technique. For more recent research measuring systems also specific acoustic distance meters have been developed (Nicholls, 1964; Carrothers, 1968; Burczynski and Szatybelko, 1968; SI, 1965; Hearn, 1969). Some acoustic distance meters are self-contained recorders (e.g. Nicholls, 1964; Carrothers, 1968), but most of them are telemeters with wire connection or acoustic transmission between the gear and the vessel. The display of the measured data is usually echo sounder like, i.e. recording or by cathode ray tube (CRT). Recently also digital (Burczynski and Szatybelko, 1968) and special electric indications (SI, 1965; MacLennan, 1968; Hearn, 1969) have come in, partly in connection with computer application.

The advantages of acoustic distance measurements over other principles are considered to be well enough known so that they do not need to be elaborated here in detail. The commercial application will be further discussed below.

Configuration and performance

As already mentioned, for certain aspects of fishing gear configuration and performance, measurements alone are not sufficient and have to be completed by direct (submarine, diver) or indirect (remote photography, television) observations. Consequently many gear investigations with models (e.g. Dickson, 1959; Schärfe, 1966) and in full scale, include such techniques and some rely on them predominantly (e.g. Sand, 1959). The equipment such as diving apparatus, photo and film cameras is mostly standard but special devices and instrument systems have been designed as well (Fig. 10,11).

Underwater television is unique in so far as it allows real time observations of the gear and its environment on board the vessel. Consequently such equipment can be found in almost all gear research institutes. The extent to which it is actually used on fishing gear is, however, relatively small, which is probably due to the considerable problems regarding the attachment to the gear and the operation of the whole setup, including the cable, under sea conditions. An example of television installation for trawl investigations is shown in Fig. 12.

Similar operational advantage, but with considerably wider range, is provided by electronic sector scanning (Tucker and Welsby, 1964) which has only recently been introduced into fishery research. Apart from fish observations for which the technique is primarily intended, surprisingly clear images of fishing gear, together with fish, have been obtained (Fig.13). Assuming further technical progress this panoramic sonar technique appears quite promising for research and also fishing. At present the complexity of the equipment and the high costs are rather prohibitive.

Typical objectives for visual observation are the shape of the whole gear and its components, such as lines, netting, meshes under various operational conditions. The most obvious advantage over deductions from measurements is naturally the vividness and the comprehensiveness of the impression which enables the experienced observer to draw quick conclusions and favours his imaginative intuition for the solution of practical problems.

Fish

The distribution and density of fish as well as their reactions in relation to fishing gear are, of course, of greatest importance for both gear development and commercial fishing. At present netsonde – echo sounding – is the most common means for the apprehension of this major aspect. In addition and for specific purposes some of the observation techniques just mentioned can provide more detailed information regarding fish species, size, orientation and motion. Their application in commercial fishing would, however, appear hardly practicable, perhaps with the exception of television. If, in the course of further technical development the costs should be sufficiently reduced and the operability facilitated, television could contribute significantly to improved trawling efficiency through reliable species and size determination and more accurate catch estimates. Until then the value of netsonde – echo sounding – alone in regard to fish observation, can hardly be overestimated.

Environment

Water currents which are the main environmental factor influencing fishing gear have been dealt with above. Others such as temperature and salinity hardly influence the gear, but may be decisive for the distribution and abundance of the fish and can therefore be of considerable interest for the selection of fishing grounds and for fishing tactics, particularly in trawling. Basically hydrographic equipment such as reversing thermometers and bathythermographs, which belong to the standard tools of tuna longlining, need only to be mentioned here. In compliance with a request from North Atlantic trawl fisheries thermometers have been incorporated in instrument systems (Hearn, 1969), and also in commercial multi-netsonde equipment (Elac and Atlas, see Fig. 14). The indication is either separate or together with the soundings on the netsonde recorder. The present state of hydrographic instrumentation and of telemetry, including multi-netsonde, would allow for the monitoring of additional environmental factors, such as salinity, transparency, light intensity which, however, do not seem to be required yet.

For bottom and near bottom trawling the kind and configuration of the ground are naturally of great importance and can, to a certain extent, be identified by the ship's echo sounder and sonar. This information can be considerably improved by netsonde-echo sounding. Because of the closer distance of the transducer to the bottom the resolution of details is much better and from the amount of noise created by a bobbin groundrope and recorded by the netsonde the hardness of the ground can be estimated. Of even greater value is the netsonde information, of course, in regard to the position of the trawl relative to the ground, which enables precise depth control, including the avoidance of obstacles.

INSTRUMENT SYSTEMS

In view of the complexity of most fishing gear as mechanical systems and the need for the simultaneous consideration of certain environmental factors as well as fish distribution and reactions, the control of one or a few parameters is satisfactory only in a minority of specific cases. In general measuring and observation systems are required, the comprehensiveness of which is not limited by the requirements but by the technical, operational and financial facilities which fortunately show an accelerating growth rate. Apart from the instrumentation the setup of systems involves naturally the consideration of compatibility, data transmission and co-ordinated evaluation.

The early systems (e.g. de Boer, 1954) consisted of a number of separate, onboard and underwater instruments, mostly self-contained and recording. The measurements of the underwater set became available only after retrieval. Although the vast superiority of telemetering was, of course, quite obvious to all concerned, this unsatisfactory type of setup was maintained until now in otherwise considerably advanced systems (e.g. Nicholls, 1964; Hamuro and Ishii, 1964b). The reason was either the lack of satisfactory means for data transmission from gear to vessel, or specific demands, such as the need for frequent change of vessels (Carrothers, 1968).

The main drawback of such single instrument systems is the impossibility of continuous and simultaneous real time data acquisition, which is a serious operational disadvantage for research and even more so for practical application. It leads furthermore to a laborious and time-consuming evaluation process which, in return, becomes a limiting factor for the amount of data that can be handled practically and for the accuracy of data co-ordination.

For the transmission of data from the gear to the vessel, cable connection or wireless sounder are the obvious means employed so far. There is still no uniformity of opinion regarding the comparative virtues of these two, so that in the most advanced system even both are used side by side (MacLennan, 1968).

In regard to cable connection, some prefer special warps with incorporated conductors to a separate cable. Here also the arguments are still going on. For practical reasons of durability, reliability, ease of repair and resultant overall economy, at least for commercial application, the separate cable will probably win in the long run. A well known example for conductorized warps is the Net Depth Telemeter System developed in Seattle (Standard Controls Inc. Model 1500-4) for gear investigations (Lusz, 1969) and commercial midwater trawling (McNeely, 1959; Lusz, 1967). A more sophisticated modification which avoids the need for direct cable connection at the gear end has recently been successfully tested (MacLennan, 1968; Foster and MacLennan, 1969). Similar "electrified" warps are also used in some electro-fishing devices for trawls. The most common use of a separate cable so far is for the wire type netsonde. There are different constructions with one to six conductors, of which the coaxial two-conductor type with the load bearing multi-layer steel cable as one conductor in the centre is considered the most satisfactory. Separate cables are mostly operated by special semi-automatic winches with electric or hydraulic drive (Fig. 15).

Because of the operational implications of a separate cable (which have been satisfactorily overcome by now), work on wireless acoustic transmission was started already at an early state of fishing gear instrumentation (e.g. Schärfe, 1956). The first instrument of this type which found considerable commercial application in Japan was a wireless net depth telemeter for midwater trawling (Hamuro and Ishii, 1964a), which was subsequently developed to real acoustic wireless netsonde equipment (Hamuro, 1967; see also leaflets of Furuno, Sanken and Koden, all Japan). The acoustic link is also employed for more complex instrumentation systems (e.g. SI, 1965; Foster and MacLennan, 1969; Hearn, 1969). An acoustic link consists of a coding and transmitting unit at the gear and a receiving, decoding and display unit at the vessel (Fig. 16). The main difficulty for acoustic communication is the interference with the propeller wake and other noise of the vessel. To overcome this, the receiving transducer is usually trailed at a short cable slightly aside and below the propeller wake, either installed in a hydrofoil or sliding on the warp. Recently ship's bottom installation of the receiving transducer was found quite satisfactory (Hearn, 1969). Also the turnable transducer of normal sonar equipment has been used for receiving signals from the trawl and for echo ranging backwards to determine the position of the gear in relation to the trawler (Schärfe, 1969). In view of these developments the future aspects for the extended application of acoustic links appear to be quite promising.

The variety of coding and transmission techniques presently employed for both wire connection and acoustic link, cannot possibly be discussed here in detail.

With increasing complexity of the measuring systems the timely evaluation and analysis of the data regarding the interrelation of the numerous parameters becomes increasingly problematic. The obvious solution is the application of computer techniques and the first computerized instrument system for fishing gear research was recently tested successfully on the Scottish FRV 'Explorer' (Foster and MacLennan, 1969). This development sets the pace for a new phase in fishing gear research and has already strongly stimulated the efforts towards instrument controlled trawling. The second similar system will be installed on the new Polish FRV under a UNDP/Special Fund Project for which FAO is the executing agency.

The development of the Scottish computerized system involved the adaptation and partly new designing of the instrumentation and the working out of the required special programs. The impressive number and variety of instruments employed, which include the SI instrument set (SI, 1965), and the respective range of parameters which are monitored quasi-simultaneously on line (Fig. 17) by this system demonstrate clearly the extent of progress obtainable from computerization, which is by far not fully exploited yet.

COMMERCIAL APPLICATION

As will have become clear from the above, most of the fishing gear instrumentation so far is designed for and employed in research and development work. The rather small extent to which experience from research has led to instrument controlled fishing is probably mainly due to technical and economic reasons.

The best known and widest spread new instrument for commercial fishing is doubtless the acoustic netsonde. Originally developed for the depth control of midwater trawls, it has meanwhile become a most efficient tool for controlling trawl performance, fish distribution and reactions, and for catch estimates, also for near bottom and bottom trawling. This widening of the scope, which enables the skilled skipper to considerably increase his efficiency in operation and tactics, is furthered by the technical development of the simple one-transducer netsonde to multi-netsonde systems. The first commercial generation employing two transducers sounding vertically down and up is already available in a number of different designs, both with wire connection and acoustic link. The next step incorporating also forward directed transducers is just coming out (Fig. 18). These commercial multi-netsonde sets were at least partly induced by previous experience gained with considerably more comprehensive research systems employing up to eight transducers and additional devices such as trawl speed meter and sound beacon (e.g. Schärfe, 1969). The telemeter link provided by the netsonde naturally invites additional multiple utilization and this possibility will doubtless be further exploited.

The warp load meters for commercial fishing vessels have already been mentioned (W.F.A. 1964, 1965, 1968; Drever and Ellis, 1968; see also Figs. 5 and 6). The value of the information on warp load is considerably increased by co-ordination with the speed. An early instrument system of this kind, which was patented in Germany as early as

1950, records the propeller thrust or the propeller r.p.m. against ship's speed (Hoppe, 1951). It was claimed that from variations in the propeller slip or between thrust and speed the trawl performance can be judged, net damage be recognized and identified and also the amount of catch estimated. This system has found limited application, particularly on French trawlers.

The more recent White Fish Authority underwater acoustic telemeter combines netsonde features with a thermometer (Hearn, 1969; Fig. 19). The net depth is measured by a manometer, whilst the opening height of the net and its distance from the bottom is determined by a special echo sounder (range 30 m), which, however, does not show fish. An additional set of three echo sounder transducers distributed along the length of the codend is intended for more accurate estimation of the amount of catch. The system, which is meant for both bottom and midwater trawling, has just been put on the market.

With the addition of the non-netsonde type net depth meters for mid-water trawling (e.g. McNeely, 1959; Hamuro and Ishii, 1964a) these examples cover the present state of fishing gear instrumentation in commercial fishing, which is actually restricted to trawling only. In view of the technical facilities available there is certainly considerable scope for the improvement of this – in comparison with other industries – rather unsatisfactory situation and more emphasis on applied research towards this aim would seem to be indicated.

Taking trawling as an example a computerized instrument system of the following general setup could be envisaged:

Item	*Instruments*
On board:	
Vessel, position and movements	gyro compass, Decca, Loran, Radar etc. electro-magnetic log, Doppler log
Performance	propeller thrust and rpm meters
Fish around the vessel: occurrence, distribution, movements, amount	sonar, echo sounder; partly in combination with above
Warp load and angles of divergence, to ship's direction and to horizontal (separate for starboard and port)	strain gauge systems in special gallows ports or conventional deviation type warp tension meters and angle meters
Warp length and length relation	magnetic marking, comparison of warp loads
trawl position relative to vessel	sonar, eventually with sound beacon on trawl, warp angles.
Under water: (all telemetering)	
Trawl depth, distance from bottom, opening height, opening width (wingtips, eventually also otter boards)	multi-netsonde
Loads on bridles or wingtips (both sides)	load cells
Net speed through water	propeller – or preferably electro magnetic log
Fish around and in the trawl (see above)	multi-netsonde
Amount of catch	e.g. multi-netsonde transducers along codend; load/speed relation
Water temperature at the net	thermoelement

Of the listed instrumentation a good deal is actually standard equipment and the rest is available from research systems. The necessary improvements and modifications in regard to accuracy, compatibility and operational reliability would therefore be a realistic engineering task. The same applies to the communication (both ways) between the gear and the vessel, which would require a considerable amount of multiplexing and would therefore probably be by cable. The crucial part would be the central computer unit with peripherals and the software for the co-ordinated evaluation and the presentation of the final data, some of which will be the result of calculations (correction, interrelation of several measured data) which only a computer can perform fast enough. This will lead to considerably improved information regarding vessel and gear performance, technically and in relation to the fish, on which the skipper can base his decisions.

As a second step the computer can take over part of the skipper's tasks, e.g. the decision of the course to be steered to tow the trawl along a chosen path or to hit a selected fish school. This important trawling problem has actually been taken up already and an example for the selection of parameters, the required instrumentation and the computer processed results is shown in Fig. 20.

The third step would be the real automation of suitable sectors of trawling over which the computer system could keep complete control, such as the above steering problem or the depth regulation of midwater trawls in regard to fish, including prompt reaction in case of serious irregularities in gear performance, hook up or damage. Also this step is already under consideration (e.g. Japan, Germany).

The development of gear instrumentation and control in trawling is obviously entering a new phase and substantial progress can be expected for the foreseeable future. It is to be hoped that this will have a stimulating effect on similar developments for other important industrial fisheries such as purse seining and tuna longlining, which have been neglected so far.

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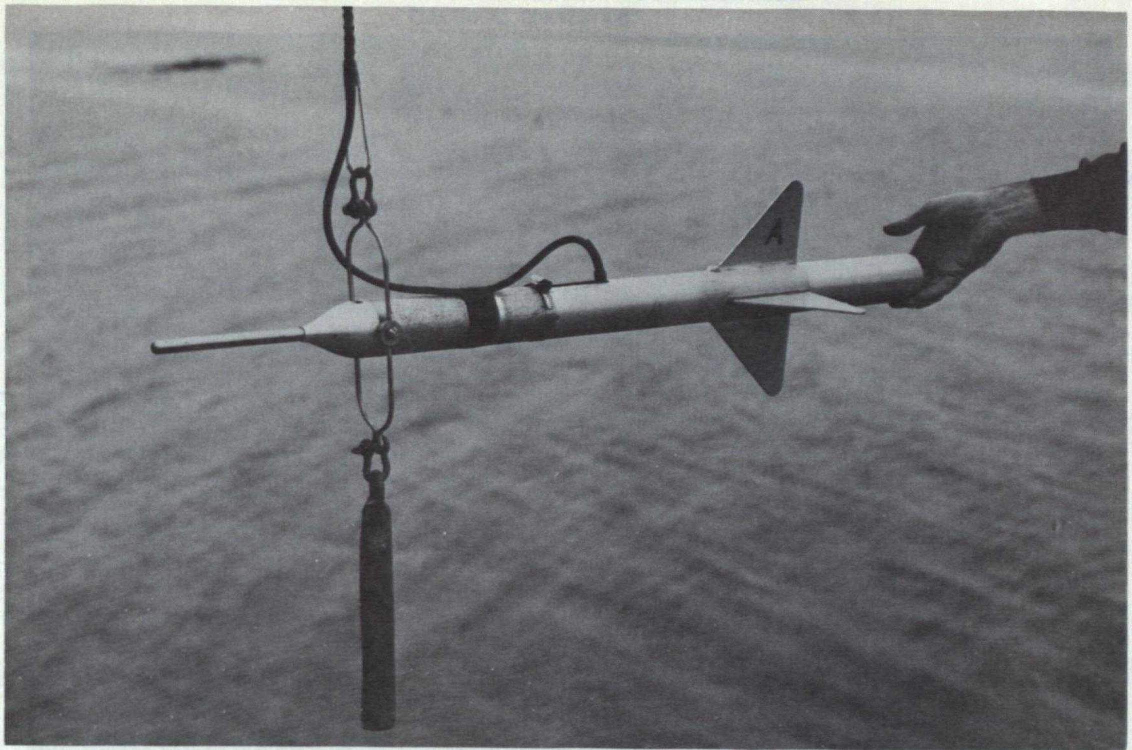


Figure 1 Recording pitometer for measuring the hydrodynamic pressure in the opening of trawls. (Carrothers, 1968).

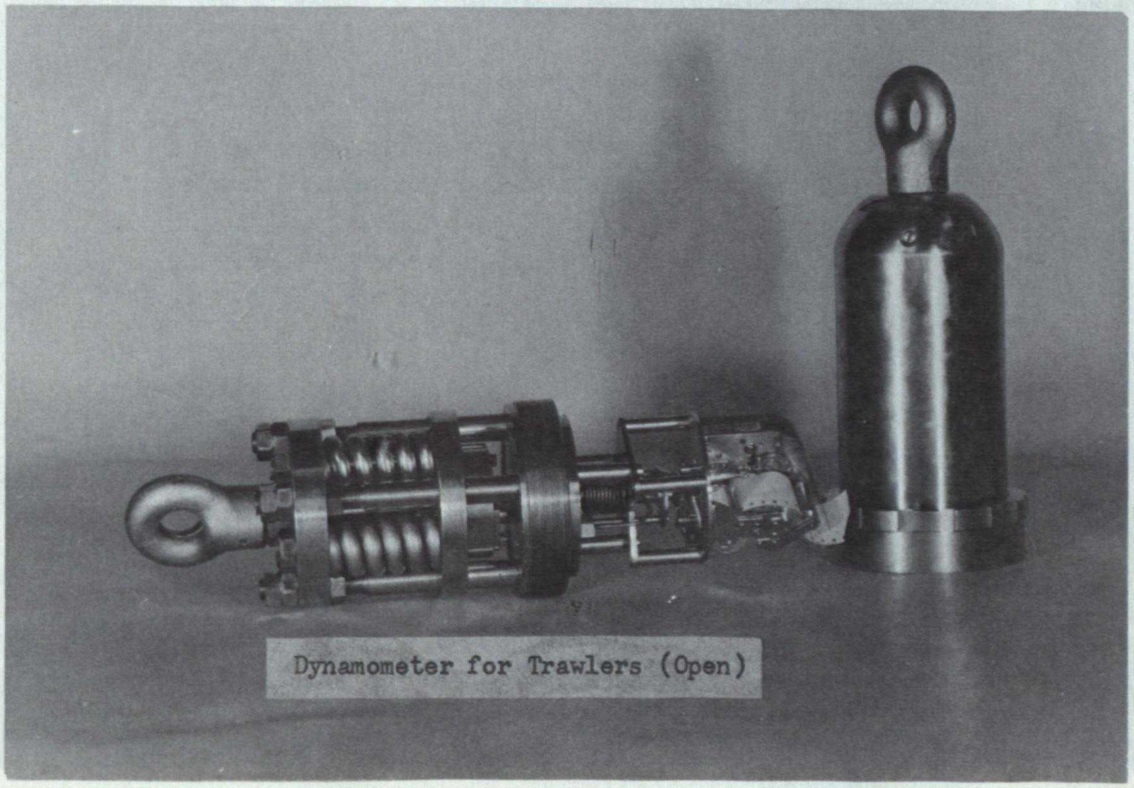


Figure 2 Recording underwater load cell. (Hamuro, 1967)

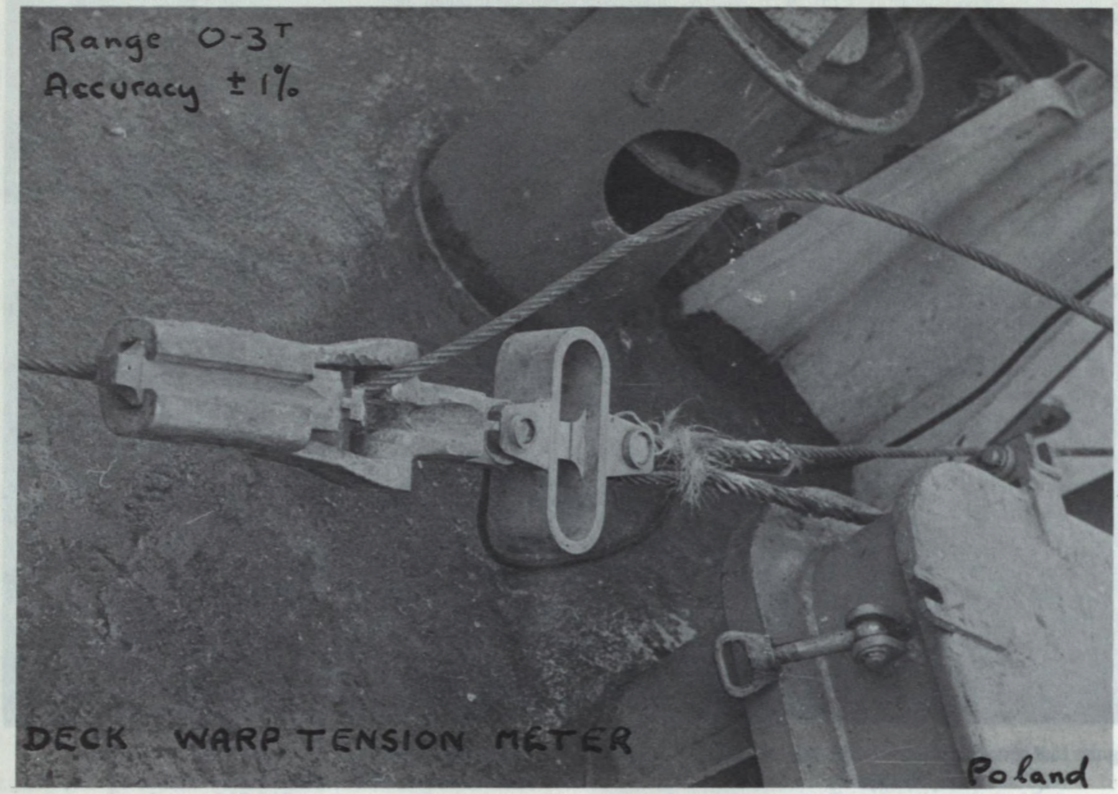
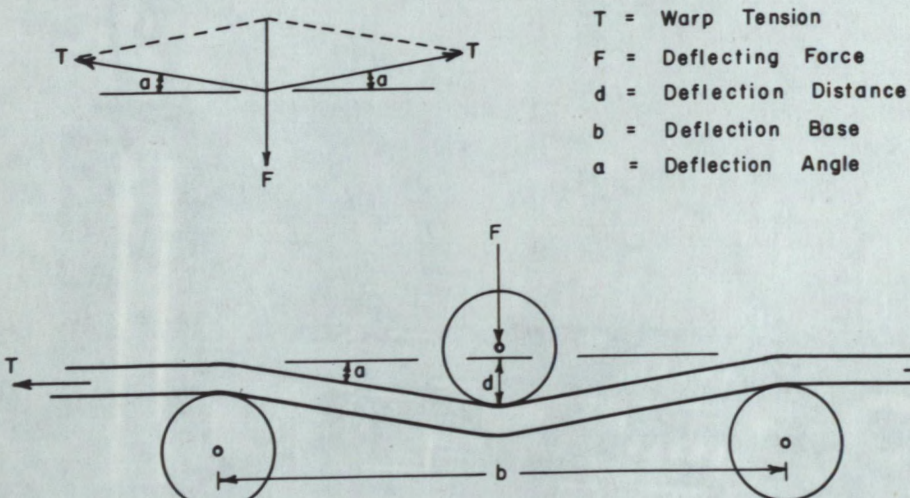


Figure 3 Deck warp tension meter of the full load type. (Morskim Instytucie Rybackim, Gdynia)



$$T = 0.5 \; F \csc a$$

$$\approx \frac{F}{2}\left[\left(\frac{b}{2d}\right)^2 + 1\right]^{\frac{1}{2}}$$

Figure 4 Principle of the deflection-type warp tension meter. (Carrothers, 1968)

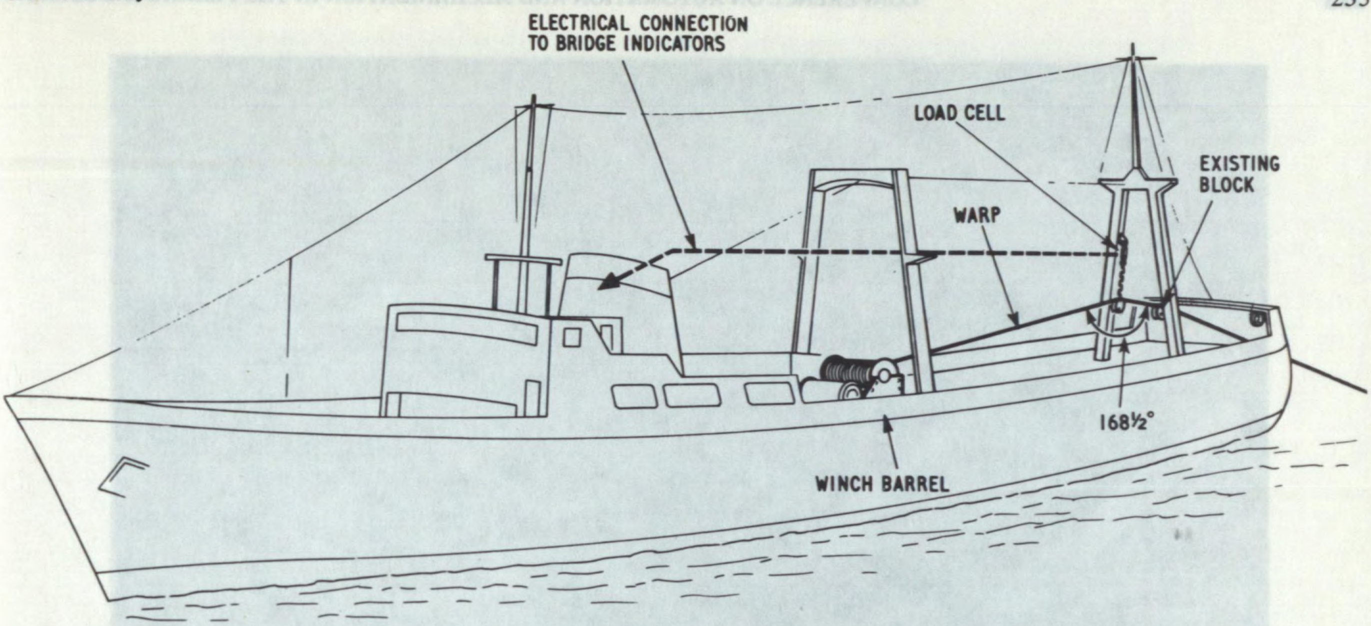


Figure 5 Typical layout of a deflection-type warp tension meter on stern trawler. (Kelvin Hughes, London)

Figure 6 Deflection-type warp tension meter for Danish seining. (Kelvin Hughes, London)

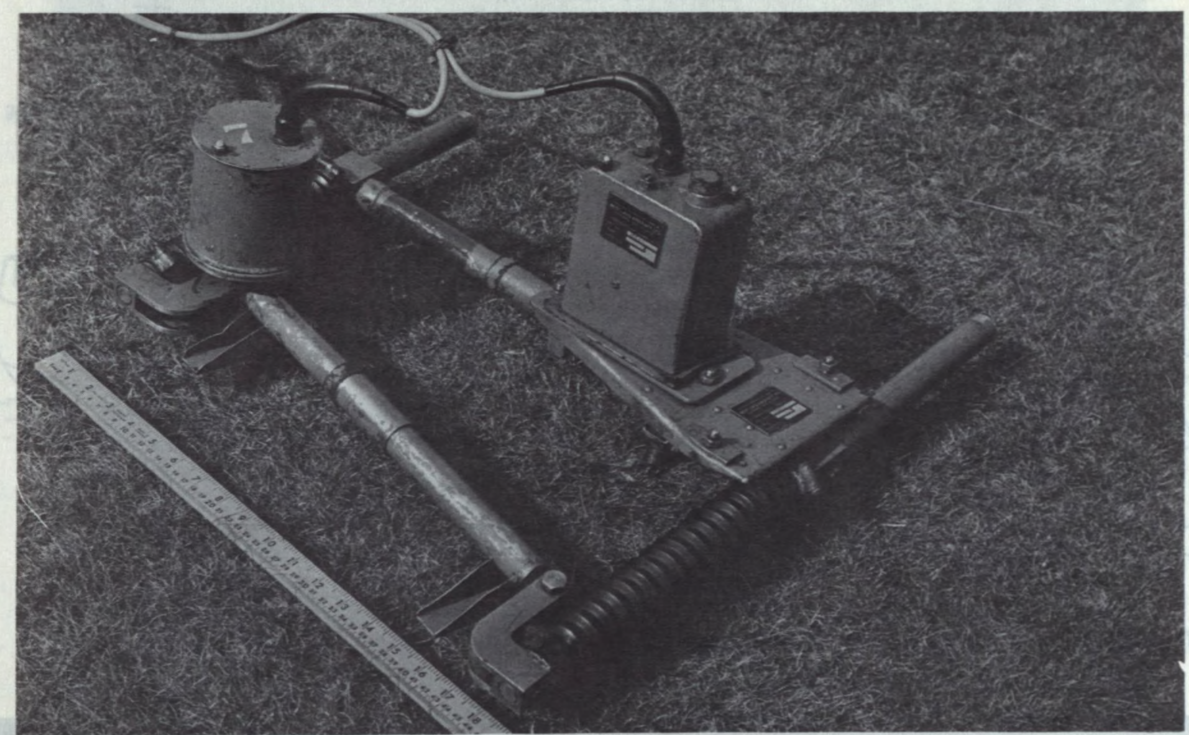


Figure 7 Warp angle meter (Nicholls, 1964) slightly modified for application in a computerized measuring system. (Marine Laboratory, Aberdeen)

Figure 8 Recording groundrope indicator. (Hamuro and Ishii, 1964b)

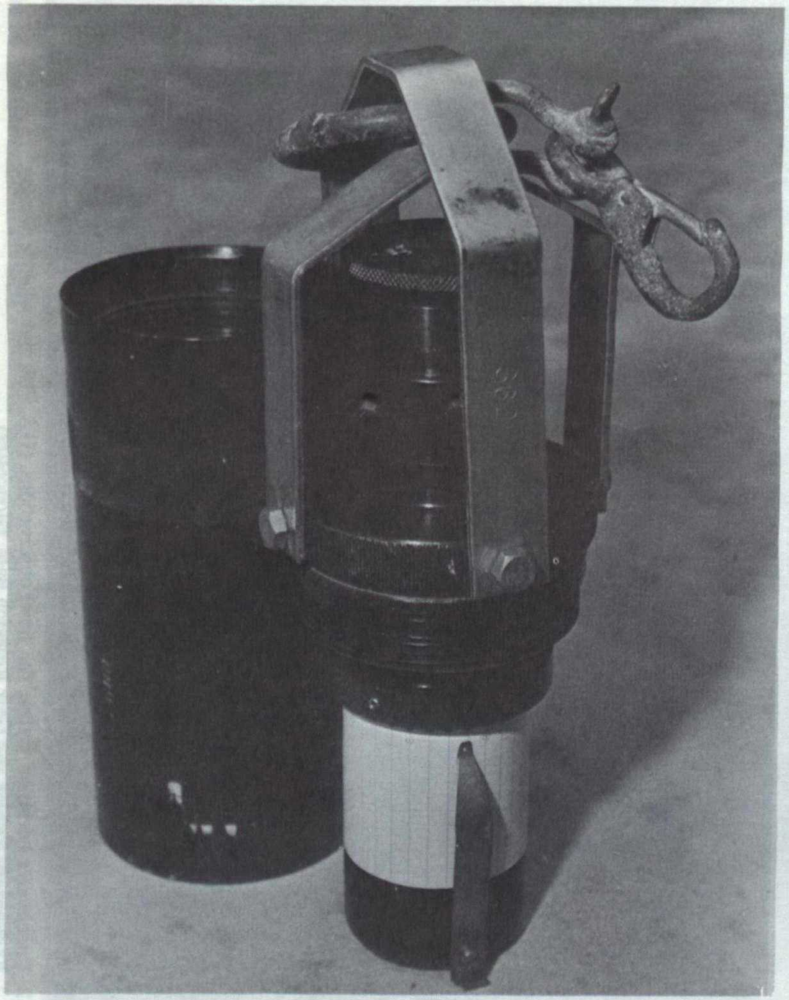


Figure 9 The hydrostatic depth recorder "Bathykymograph". (Hester, Aasted and Gilkey, 1963)

Figure 10 Two men diver's sled for trawl observations. (U.S. Fish and Wildlife Service, Pascagoula Fishery Station)

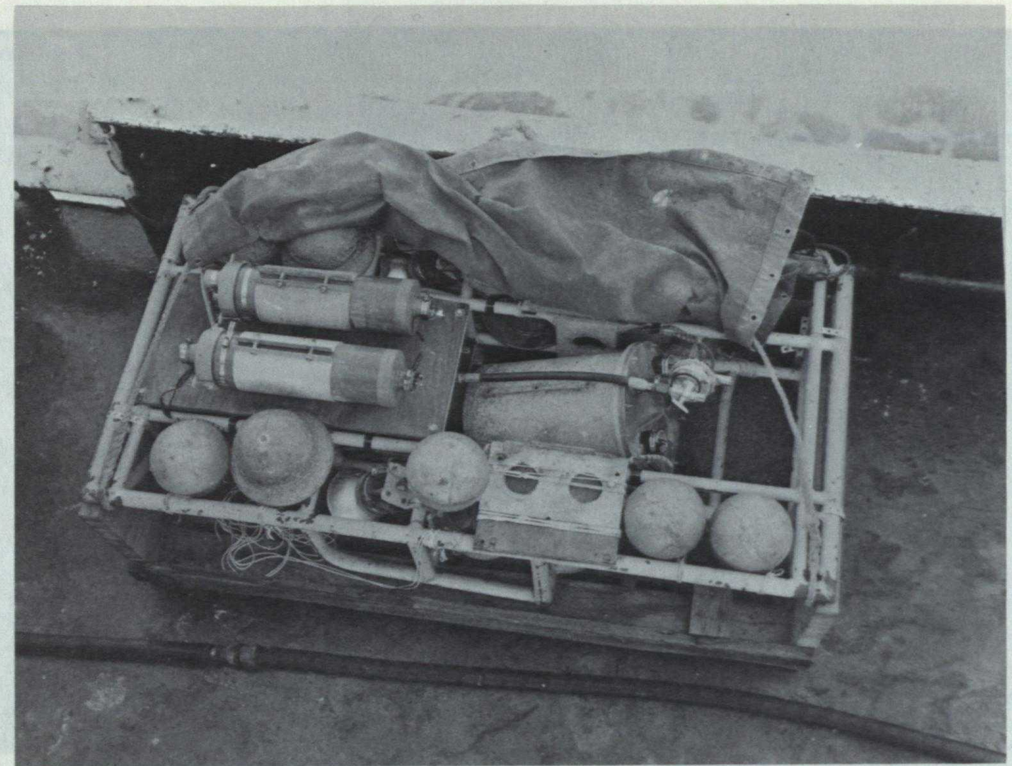


Figure 11 Underwater motion picture camera system for installation in trawls. (U.S. Fish and Wildlife Service, Pascagoula Fishing Station)

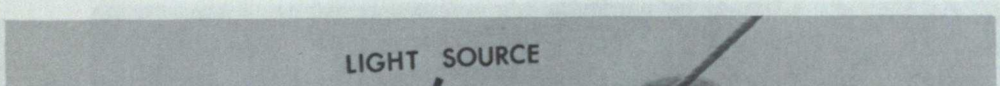


Figure 12 Underwater television system for trawl observations. (U.S. Fish and Wildlife Service, Exploratory Fishing and Gear Research Base. Gloucester)

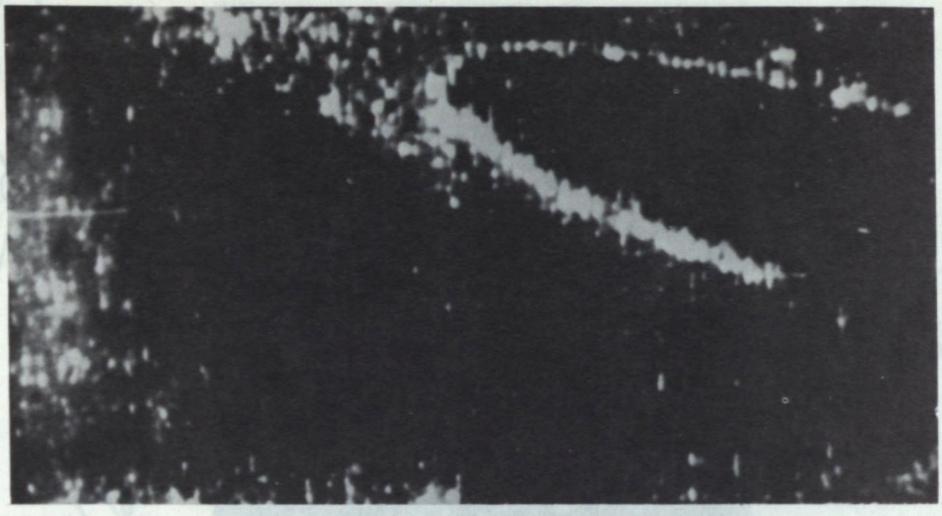


Figure 13 Electronic sector scanning image of a midwater trawl in action. (Fisheries Laboratory, Lowestoft)

Figure 14 Multi-netsonde transducer board with temperature sensor. (Fried. Krupp GmbH. Atlas Electronic, Bremen)

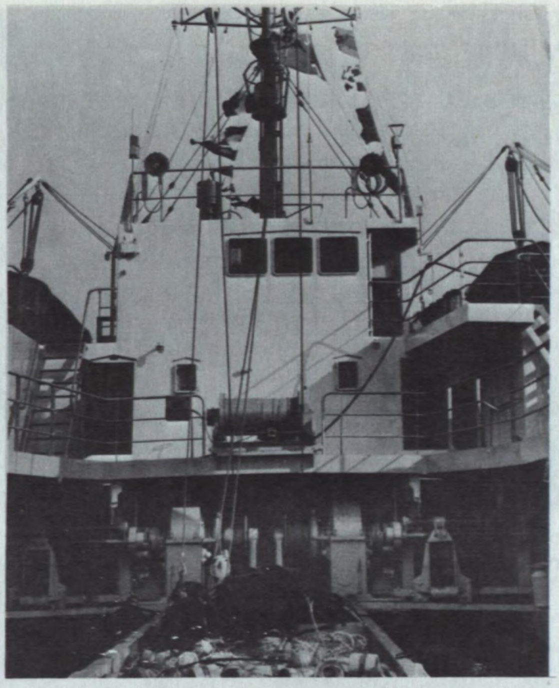


Figure 15 Semi-automatic electric netsonde cable winch on a modern stern trawler. (Fried. Krupp GmbH. Atlas Electronic, Bremen)

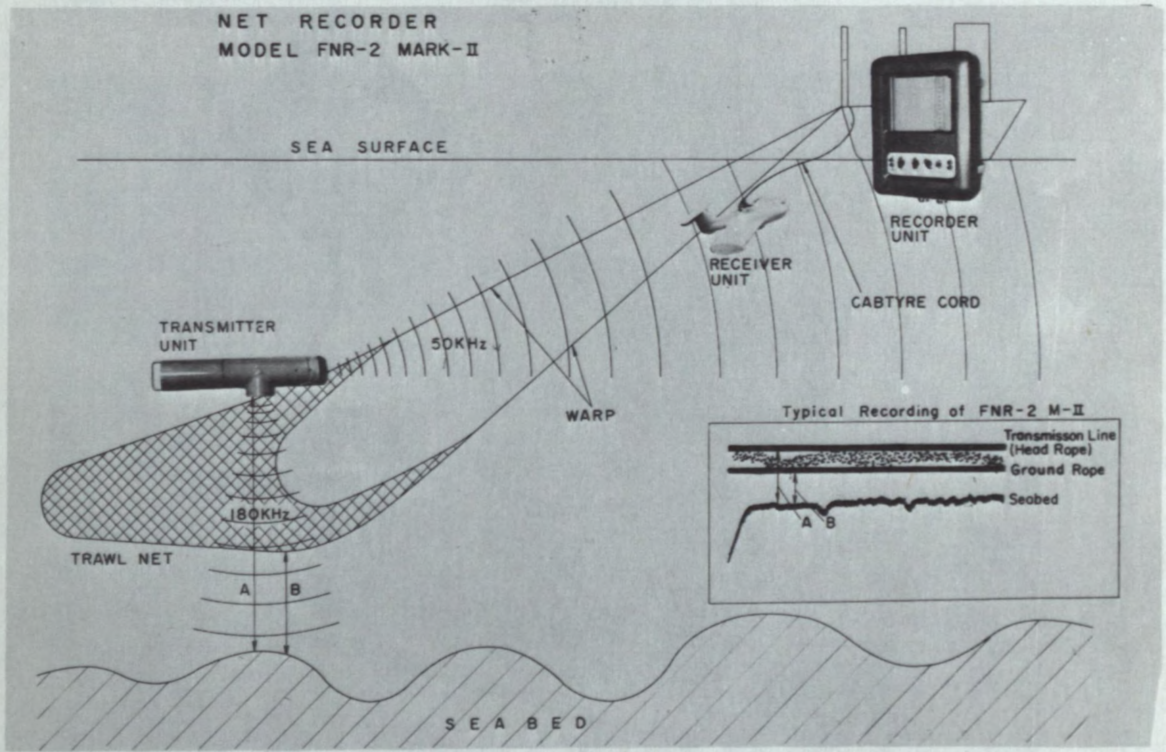


Figure 16 Scheme of a typical wireless netsonde with ultrasonic link. (Furuno Electric Co. Ltd., Nishinomiya-City)

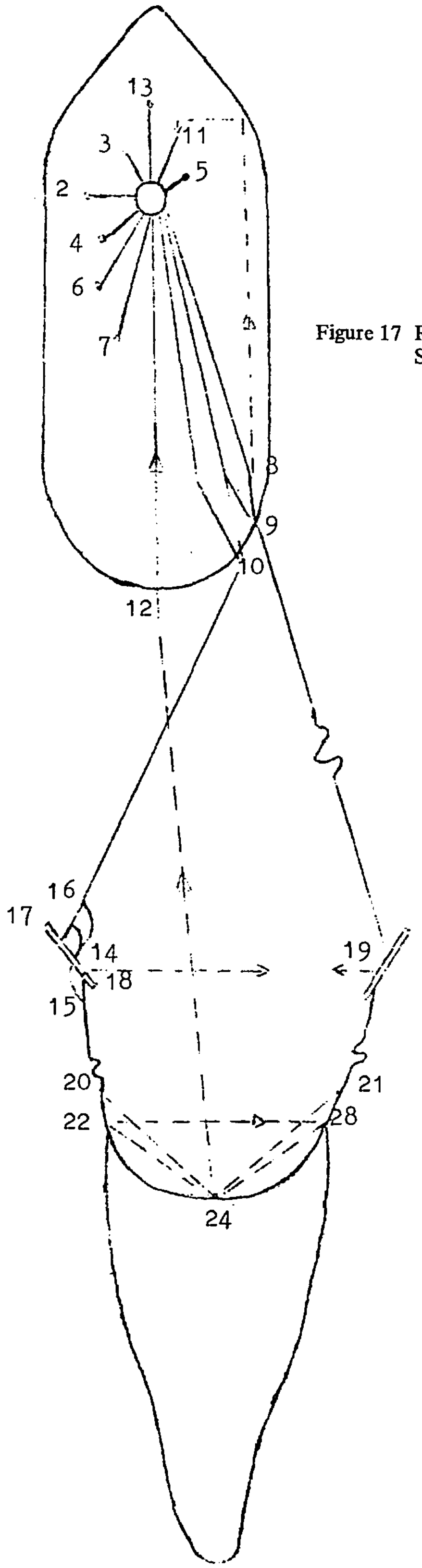


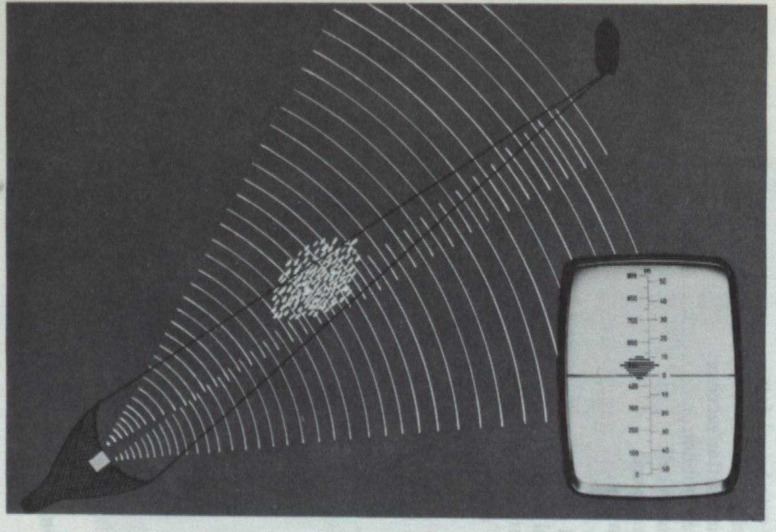
Figure 17 Range of instruments and their distribution on the vessel and the gear of the Scottish computerized instrument system for trawl research. (MacLennan, 1969)

Key

1. Central processor and interface.
2. Electro-magnetic speed log.
3. Decca Navigator.
4. Echosounder.
5. Gyrocompass.
6. Engine RPM meter.
7. Propellor thrust meter.
8. Warp tension cells.
9. Block accelerometer.
10. Divergence/declination meter.
11. Terminal for otterboard data.
12. Terminal for net data.
13. Wind vane/anemometer.
14. Otterboard angle and depth sensors.
15. Sweep tension cell.
16. Transmitter for otterboard data.
17. Warp tension cell.
18. Board spread transmitter/receiver.
19. Board spread transponder.
20. After sweep tension cell.
21. Four sweep tension cell.
22. Netwidth transmitter.
23. Netwidth receiver.
24. Headline height sensor.

Δ Telemeter signal paths.

> Acoustic measurement pulses.



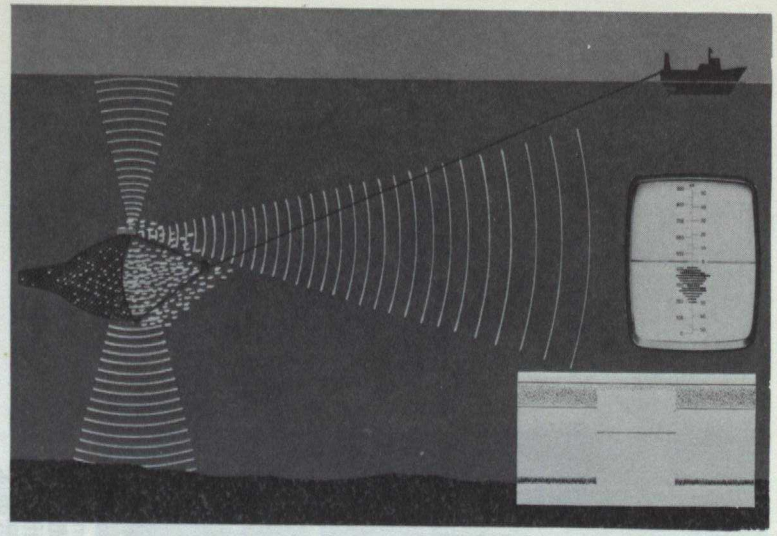


Figure 18 Schematic view from the side (left) and from above (right) of a multi-netsonde system with four transducers on the headline bosom. The two forward directed transducers show the relative horizontal position of a fish school and net mouth to each other. (Electoacustic GmbH, Kiel)

Figure 19 The underwater unit of the White Fish Authority acoustic telemeter attached to the headline bosom of a trawl. (Hearn, 1969)

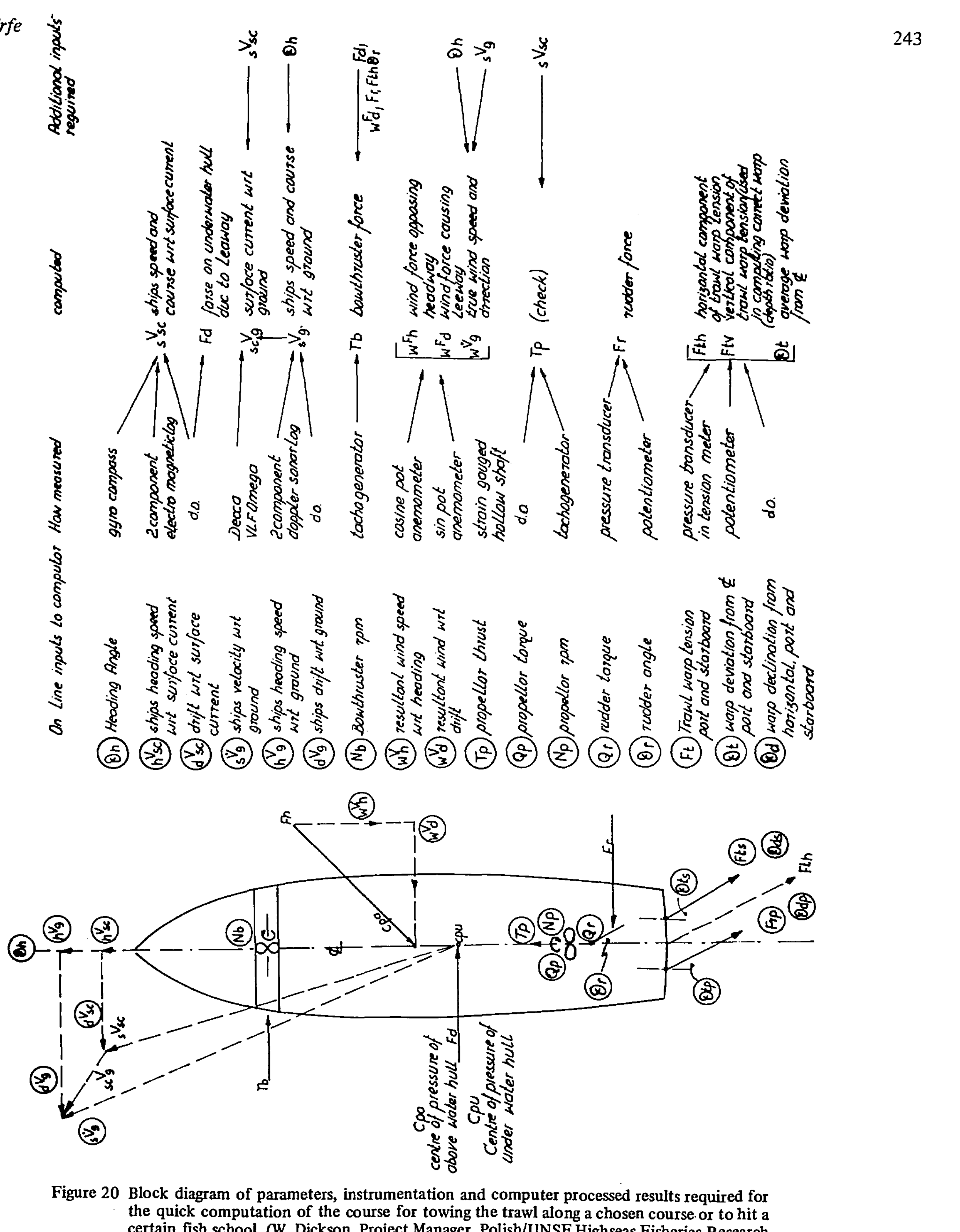


Figure 20 Block diagram of parameters, instrumentation and computer processed results required for the quick computation of the course for towing the trawl along a chosen course or to hit a certain fish school. (W. Dickson, Project Manager, Polish/UNSF Highseas Fisheries Research Project, Gdynia).

Mechanization of Fishing Systems on Polish-Built Trawlers and Automation of Power Plants on Fishing Vessels Built in Poland

Mr. Piltz

by

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Mr. Piltz, born in 1921, attended the Faculty of Naval Architecture of the Polytechnic Institute at Gdańsk, Poland, obtaining his Bachelor of Science degree in 1950. He was employed at the Ship Design and Research Centre at Gdańsk. Since 1956, he has been a Chief Designer of factory trawlers built in series for Polish and foreign owners at the Shipyard of Gdańsk: B.15 type – 2700 GRT; B.26 type – 2900 GRT; B.22 – 3000 GRT. At present, he is Chief Designer for an ocean-going fishing research vessel B.424/abt. 3000 GRT/, now under construction for Polish owners at the Shipyard of Gdańsk.

Part I

MECHANIZATION OF FISHING SYSTEMS ON POLISH-BUILT TRAWLERS

ABSTRACT

After a short review of the growth and actual situation of the Polish fisheries and their share in the development of the Polish shipbuilding industry, this paper gives some examples of solutions applied in the fishing systems used on trawlers built in Poland. The examples pertain to stern trawlers and give a review of the fishing systems, for those applied on big factory trawlers of more than 80 m in length to others provided on small near water craft. The representation of the fishing systems contains the extent of mechanization in operations connected with getting the catch on board the fishing vessels and shows the trends of development in that field. A table enclosed contains characteristics of most of the up-to-date fishing vessels built in Poland both for the Polish owners and for export.

INTRODUCTION

During the past ten years, we have witnessed a rapid development of fisheries necessitated by a steadily increasing demand for fish protein. This development, particularly in socialist countries, was due to the introduction, on a grand scale, of new industrial techniques to stern fishing, to the increasing extent of mechanization in fish preparing and processing operations, and to the initiation of new fish preserving methods.

The evolution of the rapidly developing Polish fishing fleet was a result of the introduction of modern factory-trawlers and freezer-trawlers which could be operated on an industrial scale.

In the early post-war period, the expansion of Polish fisheries was limited to the Baltic and North Sea fishing grounds. An increasing demand for fish on the Polish market and the diminishing fish crop in these areas made the Polish fisheries move to new fishing grounds. Thus, the Polish fishing fleet, with newly acquired industrialized fishing trawlers, began, in 1960, to operate on new distant fishing grounds.

The rapid expansion of the Polish fishing fleet in the past ten years may best be illustrated by its acquisition of more than 50 big stern factory-trawlers and freezer-trawlers which are now the core of the Polish distant water fleet. The overall gross register tonnage of the Polish fishing fleet now exceeds 160,000 tons, with a corresponding propelling engines output of more than 170,000 B.H.P. It is worth mentioning that the whole of the Polish fishing fleet comes from Polish shipyards.

The development of the Polish fisheries further follows the same course of introducing ever more modern fishing vessels to operate on ever more distant fishing grounds, provided with new efficient fishing gear and operated by modern methods.

The rapid expansion of the Polish Fisheries, particularly of the distant water fishing fleet, and a big export production, have promoted the Polish shipbuilding industry to the rank of one of the more important world producers of fishing vessels. A characteristic trait of the Polish shipbuilding industry is that it builds vessels which require much labour and which are fitted with a great amount of equipment and machinery, such as factory-trawlers, freezer-trawlers, mother factory ships, etc., the share of which in the production of Polish shipyards exceeds 25 per cent.

Another characteristic trait of Polish shipyards is that they construct ships, especially fishing vessels, in long series which allows, on the one hand, a considerable reduction of the production costs of the shipyards and, on the other hand, facilitates the operation of the ships by the owners due to the application of typical design solutions.

The extent of production of fishing vessels has placed Poland among the most important world producers of vessels of that type. A list of recently built typical fishing vessels is contained in a table enclosed.

EXAMPLES OF FISHING SYSTEMS APPLIED

One of the factors giving rise to the rapid development of stern trawlers was the facility with which fishing operations could be mechanized.

Among various solutions worked out in close co-operation between the designers of new fishing gear and the ship designers, for mechanized fishing systems applied to fishing vessels constructed in Poland, typical ones are commonly used on the following types of vessels, depending on their designation and sizes:

(a) distant water factory-trawlers;
(b) distant water freezer-trawlers:
(c) middle water trawlers;
(d) near water trawlers.

Examples of such solutions are given below.

FISHING SYSTEM OF B22 TYPE STERN FACTORY TRAWLER.

The fishing appliances (see Fig. 1) comprise the following basic machinery and equipment:

- Electrically-driven double-drum trawl winch with a pull of 12.5 tons on a middle rope turn at the rope hauling speed of about 110 m/min. The line drums have a capacity of 2,600 m steel rope, 26 mm in diameter, each. The winch motor of 290 kw is coupled in a Ward-Leonard system to a shaft generator attached to the propelling engine reduction gear.
- Fishing gantry with sliding trawling rollers.
- Two auxiliary winches installed on the deck above the trawling winch and used for hauling the trawl on deck.

– Gate mast with line sheaves for cod-end emptying by means of two cargo winches.
– Fishing control console in the wheelhouse.
– Working deck, about 23 m in length, extending from the stern ramp edge to the trawl winch.

At hauling the trawl warp, the doors are hove up to the stern ramp. After the warps from the sheaves to the stern ramp are mechanically dropped, the trawl is hauled on deck in such a way that its wings reach as far as the trawl winch.

The cod-end is hauled on deck by means of two auxiliary winches installed above the trawl winch. Only in the case of an exceptionally abundant catch are the trawl winch side ends used in hauling the cod-end.

The cod-end is emptied of fish by being pulled up under the aft gate mast. It is also possible to discharge the fish directly under the deck through special chute hatches, provided with a remote control hydraulic system.

The fishing gear may be remotely controlled from the wheelhouse or locally controlled.

A control console installed in the wheelhouse aft allows remote control of the following fishing appliances:
– Trawl winch, with hydraulic clutch connecting, brake tightening and regulation of the brake tightening.
– Trawling rollers sliding on the stern ramp.
– Chute hatches opening.
– Two auxiliary winches used for hauling the cod-end on deck.

Moreover, the fishing control console is provided with ship control devices.

If the trawl catches against some bottom obstacle in the course of trawling, the trawl winch automatically pays out the trawl warp and in a few seconds the propeller pitch is reduced to zero.

The trawl winch is provided with automatic protection in case of overload by the moment or by over-speed.

Among the instruments to monitor and control the operation of the fishing appliances, the following may be worth mentioning:
– Trawl warps tension meters, to the readings of which the length of the trawl warps may be regulated.
– Trawl warps length meters, to allow determination of the lengths of the paid out trawl warps.
– Overload indicators, to monitor the overload of four cargo winches in hauling the trawl on board ship and in discharging the fish from the cod-end.
– Regulators of the trawl winch brakes tightening, making it possible to obtain the required brakes slip in case of overload occurring in the course of trawling.

FISHING SYSTEM OF B418 TYPE
FACTORY – TRAWLER.

The fishing appliances arranged as shown in Sketch 2 comprise:
– Two electrically-driven single-drum trawl winches with a pull of 8 tons each, on a middle rope turn at the rope hauling speed of about 120 m/min. The line drums have a capacity of 3,000 m trawl warp, 26 mm in diameter. The trawl winch motors of 185 kw each are coupled in a Ward-Leonard system to a shaft generator attached to the propelling engine reduction gear.
– Electrically-driven four-drum auxiliary trawl net winch with a pull of 2 X 8 tons on the inside drums at the rope hauling speed of 20 m/min., the drum capacity being of 80 m rope, 36 mm in diameter. The winch pull on the outside drums, with a capacity of 4 X 250 m rope, 26 mm in diameter, will be of 2 X 4 tons at the rope hauling speed of 40 m/min.
– Stern ramp provided with sliding trawling rollers.
– Gate mast with attached line sheaves for fish emptying from the cod-end by means of two auxiliary winches.

After being hove up to the stern ramp, the trawl doors are held by means of the trawl warps, which are not unclipped from the doors; only the winch drive is automatically disconnected. The bridles used, together with the auxiliary ropes, to haul the trawl on deck, are the only ones to be unclipped. This is done by means of the auxiliary trawl net winch side drums in such a way that the trawl wings come as far as the winch. The cod-end with the fish is hauled by means of the middle drums of the auxiliary winch, the pull of which may be up to 33 tons.

Ths fish is discharged from the cod-end by heaving same up to the sheaves attached under the gate mast by means of the auxiliary winches. The fish may also be discharged directly to the chute hatches.

In principle, the fishing appliances are remotely controlled but they may also be locally controlled.

The fishing control compartment of the wheelhouse is provided with a control console for the ship and for the fishing appliances, to service:

- Trawl winches, with brake connecting, regulation of the brakes slip and clutch connecting.
- Auxiliary trawl net winch, with brake and clutch connecting.
- Trawling roller sliding.
- Chute hatches opening.

Apart from the above, there is a local manoeuvring post beside each particular machine.

As in the preceding solution, if during trawling the trawl becomes entangled in some bottom obstacle, the auxiliary trawl net winch line drums automatically slip and in a few seconds the propeller pitch is reduced. At paying out and hauling the trawl warp, the auxiliary trawl net winch speed controller is also automatically regulated when overload by the moment or by overspeed occurs.

The monitoring and control system in the wheelhouse covers the following:

- Trawl warp tension during trawling.
- Parallel operation of both auxiliary net winches hauling drums.
- Length of paid out trawl warps, with a tolerance of up to 2 per cent.
- Brakes slipping.
- Overload of the trawl warp stacking arrangement.
- Device preventing paying out of the trawl warp whole length.
- Auxiliary trawl net winch rotating speed.

A characteristic trait of this fishing system is the possibility of alternative work with two trawls in turn, enabled by the spacious working deck and by the application of a special type auxiliary trawl net winch.

FISHING SYSTEM OF B427 TYPE TRAWLER

The basic fishing appliances (see Sketch 3) include:

- Electrically-driven auxiliary trawl net winch, with a pull of 12.5 tons on a middle trawl warp turn at the hauling speed of 110 m/min. On each drum 3,000 m line, 26 mm in diameter, may be reeled. The auxiliary trawl net winch motor is coupled in a Ward-Leonard system to a shaft generator attached to the ship's propelling engine reduction gear. The auxiliary trawl net winch is fitted with an attachment provided with a line drum having a pull of eight tons at the hauling speed of 18 m/min., to be used at cod-end hauling on deck.
- Stem ramp, with hydraulically sliding trawling rollers.
- Two aft gate masts used to move the fish inside the cod-end and to discharge the fish from same by means of two auxiliary winches.
- The fishing deck, about 25 m in length.

At hauling the trawl, the trawl doors are clipped to the fishing gantry, the trawl warps are dropped from the sheaves, and the trawl wings are hove up to the working deck as far as the auxiliary trawl net winch. The cod-end is hauled on deck by means of the line drum fitted on the auxiliary trawl net winch attachment.

Emptying the fish out of the cod-end is done by heaving the cod-end up to the aft gate mast by means of two auxiliary winches. To move the fish to the cod-end extreme part, the second aft gate mast is used.

The fishing appliances are locally controlled by means of controllers fitted by each particular machine.

The auxiliary trawl net winch is provided with automatic protection to operate in case of overload by the moment and by the propelling engine overspeed.

The hydraulically controlled auxiliary net winch brakes may be set to a required braking moment. If the moment is exceeded, the slipping brakes pay out the trawl warp and then they reduce the propeller pitch.

FISHING APPLIANCES OF TR27 TYPE TRAWLERS (CUTTERS)

The fishing appliances (see Sketch 4) consist of

- Two hydraulically-driven single-drum auxiliary trawl net winches, with a pull of 3 tons at the hauling speed of 90 m/min., the hydraulic winch motors being driven by the pumps attached to the main engine. The drum capacity is of 1200 m line, 16 mm in diameter.
- Stern ramp, with sliding trawling rollers.
- Two auxiliary hydraulic winches.
- Fishing deck, about 11 m in length.

After being hove up to the stern ramp, the trawl doors are unclipped and the trawl wings hauled on deck. Hauling the trawl on deck is done by the auxiliary trawl net winch, by means of the auxiliary trawl net winch side ends. Emptying the fish from the cod-end is carried out by use of a derrick fitted on the stem ramp.

The auxiliary trawl net winch and the auxiliary winches are remotely controlled from the ship's wheelhouse.

Trawl warp tension meters are provided in the wheelhouse.

FISHING APPLIANCES OF TRT18 TYPE TRAWLERS (CUTTERS)

The fishing appliances of the TRT18 trawler (see Sketch 5) include:

- Three-drum auxiliary trawl net winch with two drums of a capacity of 2 X 600 m line, 14 mm in diameter, with a pull of about 2.5 tons at a hauling speed of 80 m/min. The auxiliary trawl net winch is mechanically driven by the ship's propelling engine.
- Trawl net drum driven by the auxiliary trawl net which by means of a line reeled on that winch's third drum.
- Aft gate mast with attached line sheaves, purse, seine block, and, eventually, side derricks.
- Roller provided on the bulwark aft, in place of stem ramp.

The trawl warp is hauled through the trawling sheaves mounted on the gate mast posts' extemal sides. After heaving the trawl doors up to the mast posts and clipping them to same, further operations in hauling the trawl are carried on by the trawl net drum on which the hauled trawl is reeled through a roller horizontally mounted on the deck transom edge.

The cod-end with the catch is hauled on deck from aft by means of the sheaves attached to the aft gate mast. After being brought over the trawl net drum, the fish is discharged on the deck.

The auxiliary trawl net winch is either remotely controlled from the wheelhouse or locally controlled.

FUTURE DEVELOPMENT TRENDS

A characteristic trait of the fishing systems described in this paper is the great extent of mechanization, due to which the numbers of fishing crews have been considerably reduced.

New designs of fishing vessels actually worked out in Polish ship design centres clearly show a tendency to further mechanization, or even part automation, of work in the fishing systems.

There are great expectations from special studies being carried out on fishing systems, and also from the co-operation between the ship and the fishing gear to be used on a fishing research vessel built in a Polish shipyard to serve as a floating laboratory doing research work on fishing systems.

The principal aims, the attainment of which is a condition of further introduction of mechanization on fishing vessels built in Poland, are as follows:

(a) to limit the numbers of fishing crews;
(b) to improve the degree of safety of the working conditions;
(c) to increase the ships' fishing capacity;
(d) to reduce the time used for non-productive operations, such as getting the catch on deck, and
(e) to obtain further concrete economic gains.

Main Technical Parameters of Some of The Fishing Trawlers Actually Built in Poland.

Item No.	Description	Type	GRT	Length m/ft/	Holds capacities m^3/ft^3/	Engine out-put BHP	Speed knots	Crew per-sons	Endu-rance, days	Notes
1.	Factory-Trawler	B15	2900	83 /272-3/	1850 /65300/	2400	13,2	100	70	
2.	-"-	B22	2700	88,0 /288-8/	2004 /71500/	2500	13,8	103	90	
3.	-"-	B418	2800	89,0 /292-0	2064 /73500/	2700	14,6	70	80	
4.	Freezer-Trawler	B29	1600	75,5 /247-8/	1057 /37600/	2500	14,5	58	60	
5.	-"-	B23	1370	69,25 /227-0/	650 /23000/	1600	13,8	41	50	
6.	Trawler	B427	847	60,4 /212,0/	600 /21200/	2500	14,5	28	60	
7.	"	B411		59,0 /193-0/	500 /17800/	1700	14,0	21	25	
8.	"	B28	1050	59,5 /194-5/	400 /17305/	2080	14,0	28	30	
9.	"	B429	500	54,0 /177-2/	430 /15200/	1800	14,0	21.	30	
10.	"	TR27		29,15 /95-6/	140 /4950/	450	10,5	9	14	
11.	Trawler-Seiner	TRT18	70	19,6 /65-0/	48 /2000/	230	9,5	5	10	hull of plastic materials
12.	Trawler	Storem 7	60	18,3 /60-0/	36 /1270/	210	8,9	5	4	

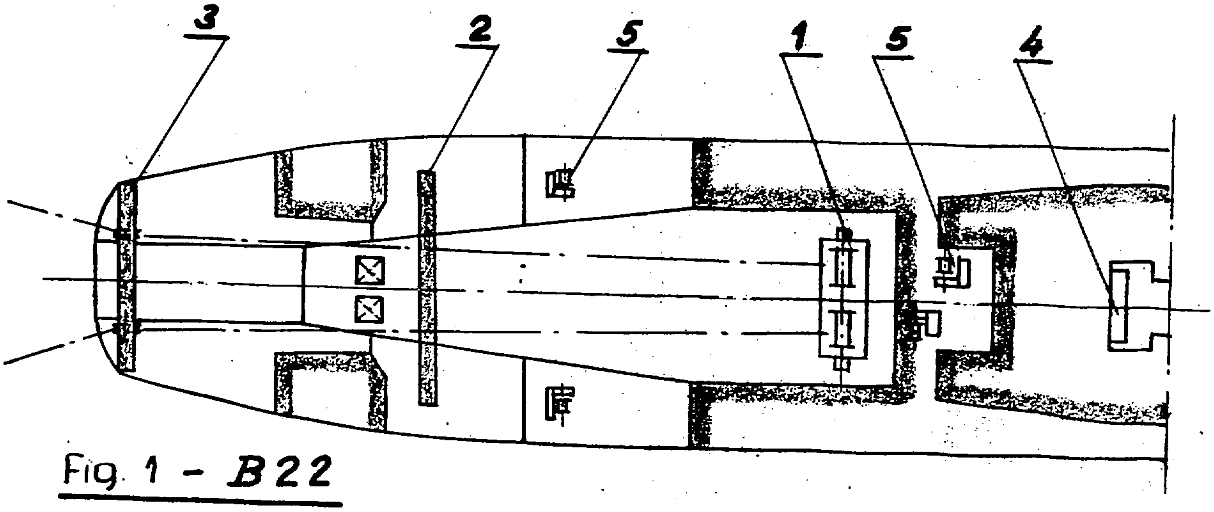


Fig. 1 - B22

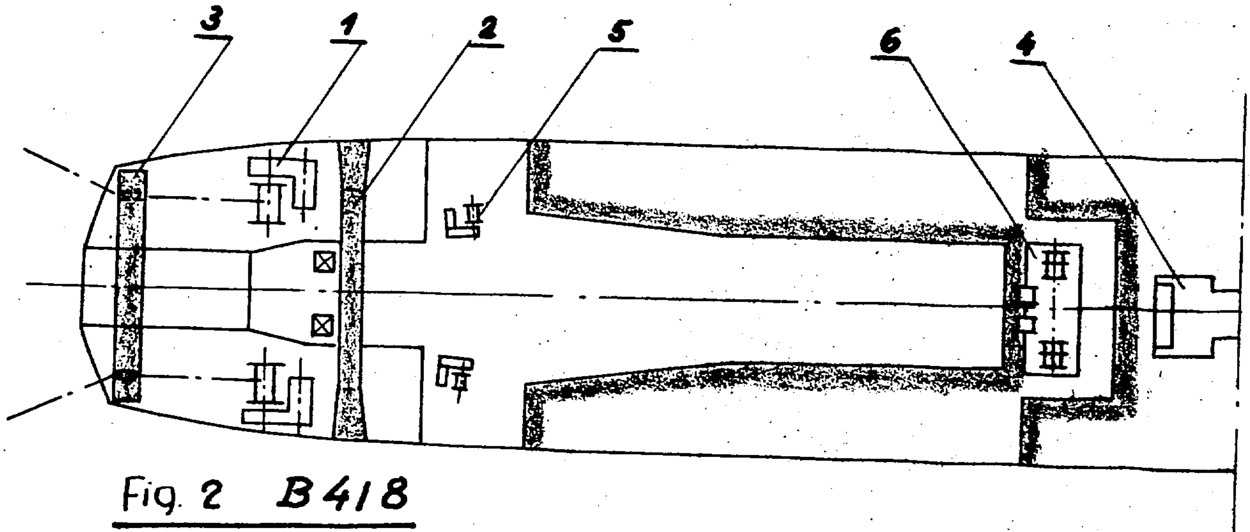


Fig. 2 B418

Key: 1, trawl winch; 2, gate mast; 3, fishing gantry; 4, wheelhouse; 5, auxiliary winches; 6, auxiliary trawl net winch.

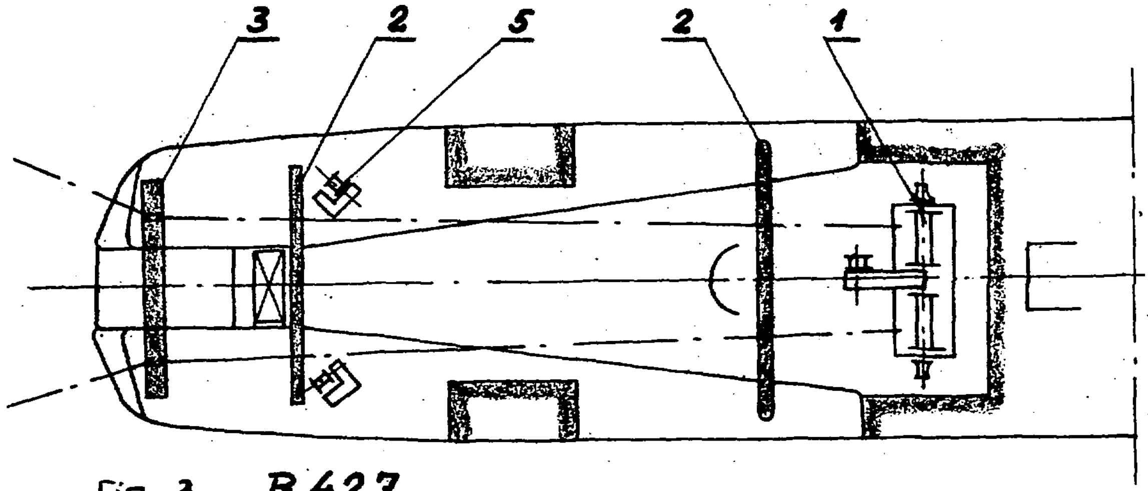


Fig. 3 B 427

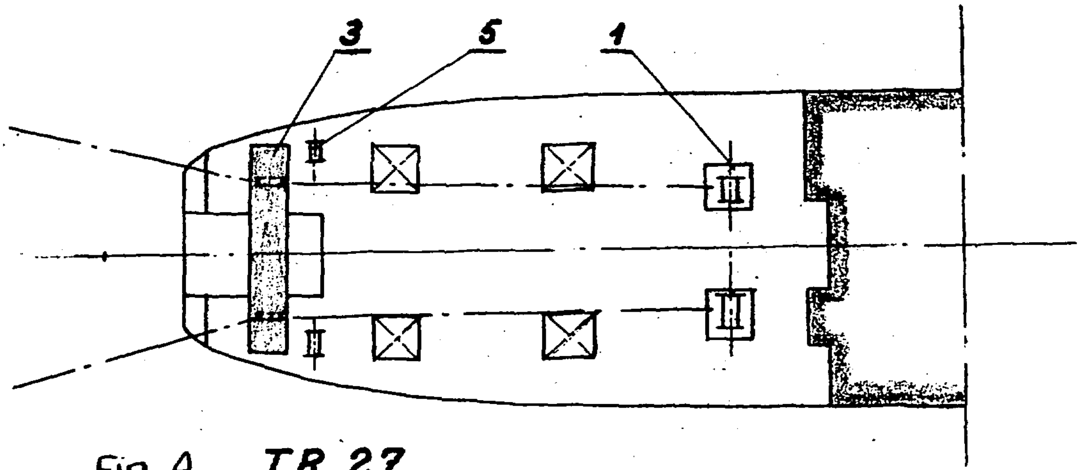


Fig. 4 TR 27

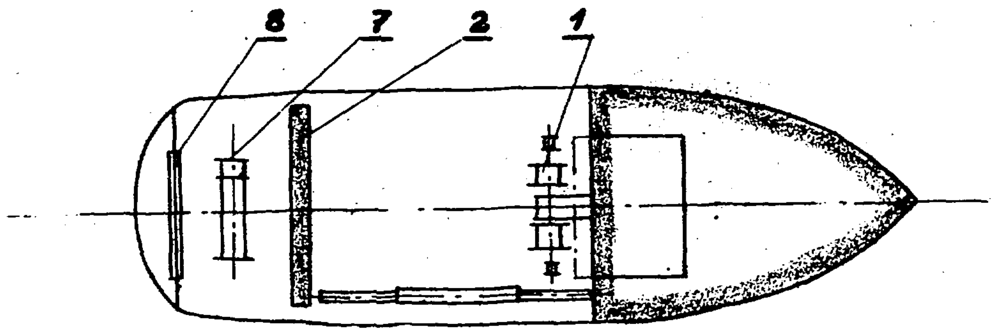


Fig. 5 TRT 18

Key: 1, trawl winch; 2, gate mast; 3, fishing gantry; 4, wheelhouse; 5, auxiliary winches; 6, auxiliary trawl net winch; 7, trawl net drum; 8, net roller.

Dr. W. Piltz

Part II

AUTOMATION OF POWER PLANTS ON FISHING VESSELS BUILT IN POLAND

ABSTRACT

This part completes the paper entitled the "Mechanization of Fishing Systems on Polish-Built Trawlers" with regard to the automation of the power plants on the fishing trawlers built in Polish shipyards.

A short presentation of the reasons justifying the need for automation and the methods by which it has been introduced into the fishing vessels' power plants are followed by examples of solutions of the problem of automation in various ships' power plants, from big factory trawlers to comparatively small craft. The extent of automation varies in the presented examples, from the power plants with a comparatively small degree of automation to the unmanned power plants which have obtained a corresponding class notation.

Further, the future development trends of automation of the power plants on Polish-built fishing vessels are given and the author's suggestions for the successful realization of the problem of automation are stated.

INTRODUCTION

Automation of power plants in ships is not an aim in itself. The purpose of automation is to increase the productivity, to reduce the toil, to spare the human labour, and to limit in this way the numbers of the engine room crews, to make their work easier, to create still safer working conditions in the machinery spaces and, consequently, on board the ships.

Automation allows the best adaptation of the power plant operating parameters to the varying requirements of the fishing vessels on the fishing grounds.

The direct advantageous consequences of automation of the power plants on board the ships, such as prolongation of intervals between the repairs of ships and better use made of the equipment installed, accompanied by a reduction of the numbers of crews, bring definite economic gains.

Another aspect of automation which, however, brings no spectacular economic effects, is the provision of better, safer and more hygienic working conditions for the ships' crews, a matter of primary importance in socialist countries.

Yet a basic condition for the introduction of automation is to provide the equipment and machinery which is reliable in operation and makes possible faultless work of all component parts covered by the automation system.

The problem of automation of the power plants becomes very important, particularly on factory-trawlers and freezer-trawlers requiring a great number of highly qualified specialists among their crews, the fact which, in view of rather long trips of such ships, may make the task of completing the crews difficult.

Apart from securing reliable operation of component parts of the automation system, a decision has been taken in the Polish shipbuilding industry to automate the power plants of ships gradually by introducing automation to them in the following order:

(a) Centralization of monitoring of the engine room machinery operation by grouping, in one compartment with soundproof insulation, all principal monitoring instruments, to be fitted, if practicable, on a control console. The engine room crew could then be divided into the surveying staff in the control room, and the executive staff, to perform the necessary manoeuvres in the engine room.

(b) Centralization of monitoring and remote control of the engine room machinery by supplementing the already introduced solutions with remote controls of the auxiliaries. This solution will also comprise the automation of some of the ship's systems.

(c) At this stage, there will be provided full monitoring and centralization of all engine room arrangements, including the ship's propelling system, the operation of which may be remotely controlled. The engine room arrangements will already be automated to a great extent, and some operations will follow definite programs.

(d) All engine room arrangements will be automatically monitored and controlled, which means the proper operation of all equipment in an unmanned engine room, the duties of the crew being limited to giving orders.

The first step to automation was the application on the recently built freezer- and factory-trawlers of a propelling system comprising a middle-speed propelling engine and reduction gear with shaft generators. This system is an example of a simplified engine room layout designed to facilitate the introduction of automation.

To illustrate the above described stages of automation of the power plants on board ships, some examples are given of solutions of the power plants on the fishing vessels built in Polish shipyards pertaining to the stages from (a) to (c).

The basic technical parameters of the ships described in the present paper are given in Part I of this paper, "Mechanization of Fishing systems on Polish-Built Trawlers".

ENGINE ROOM OF B22 FACTORY-TRAWLER

This is an example of a partly automated engine room belonging to a successive step in the development of automation.

The machinery consists of a diesel engine of 2500 BHP at 500 revs./min. driving, through a reduction gear, a controllable-pitch propeller. Two generators, one of 800 kVA to supply the ship's network, and of 320 kW to supply the trawl winch, are attached to the reduction gear. Two independent diesel-driven stand-by generating sets of 320 kVA each are used when the whole of the propelling engine output goes to the ship's drive.

In a separate soundproof engine room compartment, the so-called "Manoeuvring and Control Central", besides the main switchboard, are grouped all the monitoring and signalling instruments as well as all the remote controls of the main engine room and the refrigerating machinery room remote controls.

Moreover, for experimental purposes, in the same compartment on one of the ships belonging to the same series, a central data logger has been installed.

In addition to the above, the ship is provided with control arrangements and systems to enable the control of the main propelling system, also from the navigating and trawl winch control consoles erected in the ship's wheelhouse.

At the control console provided in the Manoeuvring and Control Central, the following operations may be performed:

(a) remote control, remote monitoring of parameters of operation and signalling of

- main engine coupled with controllable-pitch propeller and co-operating machinery,
- steam boiler,
- vacuum evaporator,
- ship's electric power plant,
- refrigerating machinery room,
- bilge pump,
- air compressors,
- fuel oil separators, and
- ship's anti-corrosive cathodic protection;

(b) automatic recording, survey of faultless operation and indicating of basic parameters of the main engine and the engine room's more important auxiliaries, refrigerated holds, refrigeration machinery and freezing tunnels in the factory, by means of the central data logger. The system covers 162 measurement-taking points of the parameters of temperature, pressure, liquid flow, liquid level in tanks, revolutions, etc.

The central data logger measures, at definite time intervals, the above mentioned parameters, thus making the engineer's log-book unnecessary.

Apart from the above, the systems monitor the overrun limit values and allow reading of the parameters at any measurement-taking point.

Moreover, together with the central data logger, an automatic controllable-pitch propeller manoeuvring recorder is installed.

It is expected that by the adaption of the central data logger the following will be gained:

- More accurate prediction of possible failures, rapid detection of the monitored machinery malfunctions, with resulting improvement of the safety of work and extension of the intervals of time between the repairs.
- Reduction of the ship's operating costs, by obtaining the best operating conditions for each particular machine in changing operating conditions.
- Improvement in the working conditions of crews and easier servicing of the engine room.

- Increase in the operation's safety standards by automatic disclosure of malfunctions.
- Accurate information on the reliability of the machinery in operation.

(c) The following engine room systems are automated:

main engine coupling with controllable-pitch propeller;
main engine stopping in case of malfunction of the co-operating systems;
compressed air system;
fuel oil separating and booster systems;
engine room bilge system;
boiler arrangement, including boiler oil system, feed system, etc.;
change-over from main to stand-by pumps in the main engine, reduction gear and controllable-pitch propeller lubricating oil systems;
change-over from main to stand-by fuel oil supply pumps;
sanitary water system;
remote starting of independent generating sets.

ENGINE ROOM OF B29 FREEZER-TRAWLER

On the B29 freezer-trawlers, the main engine room layout is similar to that provided on the B22 ships. It comprises a diesel engine of 2500 BHP at 500 revs./min. to drive a controllable-pitch propeller through a reduction gear with, attached, an 800-kVA generator to supply the ship's network and a 320-kW shaft generator. One generating set of 400 kVA is a stand-by.

The main switchboard and the Manoeuvring and Control Central are also situated in a separate soundproof compartment. On a control console provided in this compartment the main engine room monitoring/measuring and signalling systems are grouped.

The engine room automation covers:

controllable-pitch propeller coupling to the main engine;
main engine stopping at malfunction of co-operating systems;
air compressors starting;
change-over from main to stand-by fuel oil pumps;
boiler arrangement with fuel oil and water systems;
engine room bilge system;
sanitary water system;
change-over of the controllable-pitch propeller system oil pumps.

The remote control from the Manoeuvring and Control Central and from the wheelhouse covers:

Operation of the controllable-pitch propeller and automatically connected main engine operation;
fuel oil transfer pump;
fuel oil booster pumps;
fuel oil separator.

The remote control and malfunction signalling covers all more important engine room machinery.

ENGINE ROOM OF B411 TYPE STERN TRAWLER

The B411 type stern trawlers have the engine room layout comprising a main engine of 1700 BHP at 500 revs./min. to drive a fixed propeller through a reduction gear with a variable transmission ratio.

The trawl winch driving generating set is of 290 kW, while two generating sets of 150 kVA each are used to supply the ship's network.

The engine room is fully automated and does not require continuous manning in operation.

Several auxiliaries, such as cooling water and lubricating oil pumps, etc., are attached to the main engine as a result of which the amount of machinery designed for independent operation has been considerably reduced.

The remote control from the wheelhouse control console covers:

main engine control and stopping;
trawl winch driving generating set starting and stopping;
trawl winch electrical system control;
reduction gear transmission control;
fire pump starting.

The remote control from the Engine Room control console covers:

main engine starting, control and stopping;
reduction gear transmission control.

The automation system covers:

main engine stopping in case of malfunction of co-operating systems;
reduction gear disconnecting following the main engine stopping and oil pressure drop in the system;
change-over from the main engine and reduction gear main oil pumps to stand-by pumps;
auxiliaries stopping at the Main Engine stopping;
compressed air refilling for the automation system control;
factory bilge well emptying.

Apart from the monitoring and measuring instruments fitted direct by the engine room machinery, on the engine room control console will be installed the instruments to monitor the operation of the main engine, reduction gear and auxiliary generating sets. Some of the measuring instruments are installed on the wheelhouse control console.

Due to automation, the engine room of this ship has obtained the class notation authorizing the ship's operation with the engine room unmanned.

ENGINE ROOM OF TR27 STERN TRAWLER

The engine room of the TR27 vessel is typical of a small stern trawler.

The propelling engine is a diesel, developing 680 BHP at 1200 revs./min. and driving a controllable-pitch propeller through a hydraulic reduction gear. A 90-kVA shaft generator is attached to the reduction gear. An independent generating set of 94 kW is used to supply the ship's network.

The main engine and the controllable-pitch propeller are controlled from the wheelhouse. The panels of the main engine and auxiliaries monitoring and measuring instruments are situated in the wheelhouse and in the engine room.

An engine room of this type does not require continuous manning and needs servicing by the crew only when this is indicated by readings of the instruments.

FURTHER PROGRESS IN AUTOMATION

The examples of the power plants on board the fishing vessels pertain to those already built and operating for from one to three years.

Apart from this, research work is done on the automation of ship power plants, with special importance attached to the expected economic effects of automated operation.

New designs of fishing vessels actually worked out both for Polish and foreign owners show a definite tendency to enlarge the extent of automation, not only with regard to the power plants, but also to other ship systems.

Simultaneously, further research work and studies are performed with a view to ensuring faultless operation of the automated machinery and equipment.

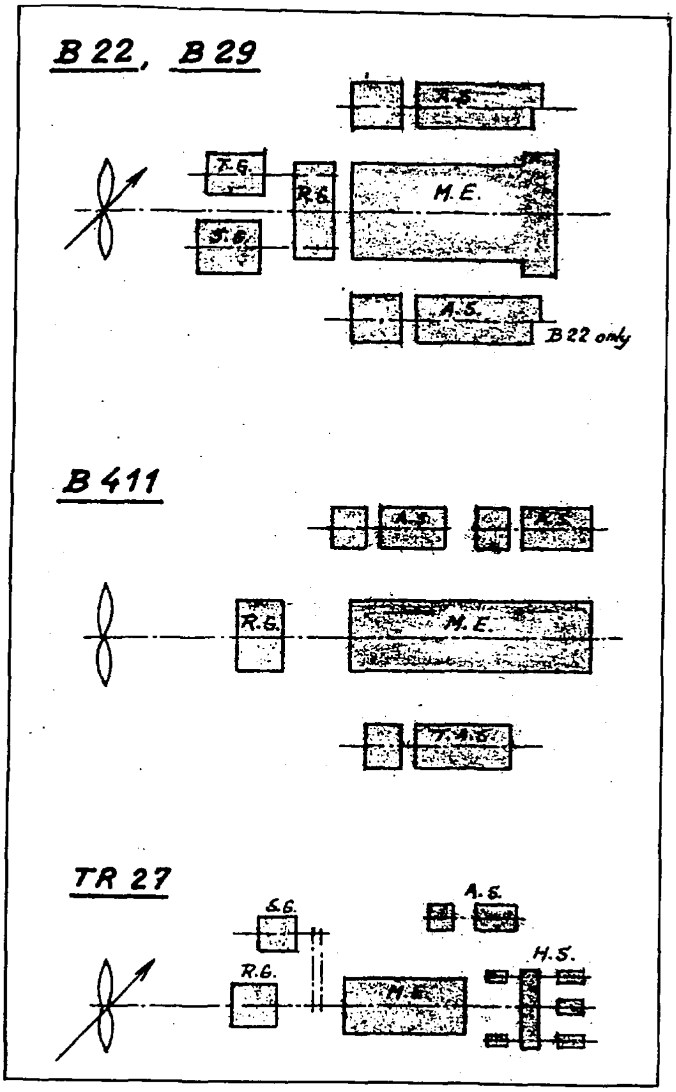
It is worth mentioning that the amount of automated machinery to be installed on board fishing vessels will be the subject of special research work to be performed on a Polish fishing research vessel built in the shipyard of Gdańsk. The development of automation on fishing vessels constructed in Poland depends, to a great extent, on the positive results of the research work to be done on board this ship, which will also become a floating laboratory of the Polish shipbuilding industry.

At the same time, the need for training suitable staff to service the automated equipment is to be stressed. Following the elimination, to a considerable degree, of manual work, it is possible to provide such ships with crews having high technical standards. The demand for highly qualified staff to service the automated equipment is understood and appreciated by the school authorities, who took into account the requirements of automation when working out the programs for the nautical schools in Poland, where crews for the fishing fleet are trained.

When summing up the above, it is to be stressed that the future successful progress of automation on board the fishing vessels still depends on many factors, such as:

the choice of a suitable propelling arrangement;
the reliable operation of machinery and equipment;
training of highly qualified crews;
the achievement of concrete economic effects in the operation of ships;
increasing the degree of safety on board ships;
improving the working conditions of the crews.

The trends in the development of automation assumed in the Polish shipbuilding industry allow expectation that the progress in this field of technique on board the fishing vessels will enable this industry to keep its present position among the world shipyards.



Key: M.E., main engine; R.G., Reduction gear; S.G., shaft generator; T.G., trawl winch generator; A.S., auxiliary set; T.A.S., trawl winch generator set; H.S., hydraulic set.

Fish Processing - Five Years Hence

Mr. Drews

by

Jürgen Drews
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Lübeck, Germany

Mr. Drews, Mechanical Engineer, was born in 1928 in Lübeck, Germany. He has had over 20 years of experience in designing, building, testing and servicing fish processing machines. He spent several years as a service engineer in the fishing industry of the U.S.A. and Canada, and has been a consultant on mechanized fish processing in many countries. At the present time he is Product Manager for Fish Processing Machines, Nordischer Maschinenbau Rud. Baader, Lübeck, West Germany.

ABSTRACT

This paper deals with the processing of fish for food and the development of mechanized processing methods in the future. In a fish processing line cutting operations like gutting, deheading, filleting, skinning and boning are the most time and labor consuming operations. Further mechanization of the cutting operations will be necessary in the future, since savings in labor and a more economical utilization of the raw material will have to compensate for the rising costs of labour and raw material.

New equipment and techniques which will possibly be available in five years, for mechanized processing of the important fish species of the North Atlantic, are introduced.

To derive full benefits from mechanization, processing lines will have to be specialized for certain groups of fish species.

FACTORS INFLUENCING FUTURE FISH PROCESSING

The Food and Agriculture Organization of the United Nations projects an increase in demand for food fish for the developed countries from 14.9 million tons in 1965 to 18.3 million tons in 1975, that is 23% within 10 years. This projection, based on the assumption of a steady growth of income per head, will depend on the prices of fish products. An increase in price will lower the level of consumption. Present processing methods will have to be improved if the predicted growth of the market should not be slowed down by increasing prices.

The rapid expansion of the groundfish filleting industry in the mid-1960s in various countries led to an overproduction of frozen fillets. The consequences are still felt today and it will be the main problem for the fish processors in the future five years to find new ways to produce more economically to meet present product prices and furthermore to compensate for increasing costs of labor and material.

If the overall demand for food fish should not increase due to rising prices for fish products there will be, however, an increase in the consumption of some fish products compensated by a decline in consumption for other fish products. This could be caused by a decline in landings of certain species or by a change in consumer habits. New processing methods could open up possibilities for new products, just as the creation of new products might call for the development of special equipment.

There is a noticeable trend towards more ready prepared convenient fish products. The consumption of fish sticks and fish portions in the U.S.A. rose in the five years from 1963 to 1968 from 78,000 metric tons to 119,000 metric tons per year. The per capita consumption of these products increased by 43% over the 1963 consumption.

More economical processing methods must help in the future to keep the costs of production from rising and thus further expand the market for these products.

Processing costs mainly depend on the amount of labor involved and on the yield of finished product in comparison to the raw material used. Depending on the costs of labor, the availability of labor and the costs of raw material, one factor may be more important than the other. Future fish processing methods will therefore concentrate on a reduction in labor and on an increase in yield. In manual operations there is very little room left for improvement. Most plants are already equipped with conveyorized cutting tables to reduce manual handling of the fish to the cutting, trimming, boning and packing operations.

Time and motion studies could lead to some, but not a significant, increase of the production rate per man hour.

In some cases incentive systems allowing the worker to participate in production and yield gains could be a step towards reduced production costs. However, the more sophisticated the system the less versatile it gets in handling a variety of different fish species and end products.

Mechanization of fish cutting operations during the past ten years went ahead at a rapid pace in many countries fishing in the North Atlantic and competing with their products in the world market.

For mechanized fish cutting operations it is necessary to specialize and concentrate on certain species of fish. A fish filleting machine has to perform the filleting cuts close to the bone of the fish in order to achieve a high yield. This can only be done by presenting the fish in proper position to the cutting tools, so that the knife enters the fish at the correct spot. Bone structure and the outer shape of the fish are the characteristics for the design of the guides which hold the fish in its place.

Variations in size have to be compensated for by a flexibility of the guides and by automatic controls and self-adjustment of the cutters. Furthermore the same components have to be suitable or adjustable for differences in texture. A machine should process both firm and soft fish. The sequence of cuts for the removal of the fillets from the bone depends on the bone structure.

Therefore the design of a universal fish filleting machine, which will handle any species of fish with equally good results, is impossible.

After the fillets have been removed from the bone the differentiating characteristics of shape and bone structure disappear and the removal of the skin is not affected by these problems. Skinning machines are therefore much more versatile.

For mechanized processing the commercially used fish species of the North Atlantic could be divided into four groups of species with similar characteristics:

1) *white fish* like cod, haddock, pollock, hake, whiting;

2) *red fish* like ocean perch, sea bream, rockfish;

3) *flat fish* like flounder, plaice, sole;

4) *herring,* also sardines, pilchards, sprats.

To make full use of the labor-saving advantages of mechanization, equipment to handle all the species that have to be processed in one plant has to be installed.

Canadian plants handling both white fish and flat fish were handicapped in the past by the lack of filleting machines which could handle the flat fish species, landed in increasing quantity and alternately with white fish. In many plants the skinning operation is the only mechanized operation in the production line. This way it is hard to compete with European processors operating specialized processing lines mechanized as far as possible for handling one type of fish only.

To achieve more economical mechanized processing in the future, a change in fishing operations would be necessary to provide a steadier supply of both white fish and flat fish to the processing plants simultaneously. Then separate specialized processing lines, with a lower capacity each, for white fish and flat fish, could be installed and used more economically; as, if plant operations had to change the plant's full capacity operations from white fish one day to flat fish the next, half of the equipment would be idle half the time. Either changes in fishing operations or a change to specialized plants, handling one group of species only, will be necessary in the future even if flat fish filleting machines become available within the next few years, since there will be no filleting equipment which could individually handle both white fish and flat fish.

Automation and mechanization of fish processing operations in the future will be possible to a greater extent with processing lines specialized on certain groups of fish species.

PROCESSING OF WHITE FISH

The unpleasant task of gutting the fish onboard the fishing vessel will be mechanized within the next five years. There are some gutting machines in operation already. The wide range of sizes on cod from 30 cm (12″) to 120 cm (47″) cannot be covered by a single machine. There will be two types of machines with sufficient overlapping in range.

One for the smaller fish from 30 cm (12″) up to 70 cm (28″) and the other for larger fish from 50 cm (20″) up to 120 cm (47″). The speed of the gutting machines with 40 fish/min. for the smaller fish and 25 fish/min. for the larger fish will be sufficient to handle as much fish as a crew of five or six men could gut by hand.

The gutting machines will bring several advantages. Working conditions on board will be improved. The crew will have more time for proper fish handling to improve the quality by bleeding prior to gutting and more careful icing and stowing. The crew could be reduced.

The gutting machines will perform the slitting of the belly and the removal of entrails as done manually today. The head will be left on the fish but a head cutter could be attached to remove the head leaving the lug bones on the fish.

This way the gills will be removed together with the head. The removal of the gills is an advantage for the retention of quality in storage, and quality will be of growing importance. It is not likely that a mechanized operation will remove the gills from a fish with head on, because of the complex problems for such a mechanized cut.

It is likely that in 1975 fish will be landed at the shore plant without heads.

For mechanized filleting there will be a selection of different types of filleting machines for the same type and size range of fish. For the shore plant, yield will be the most important consideration, whereas on board factory trawlers the throughput per operator will be more significant.

New cutting methods recently developed will be used in the filleting machines of the future. These machines will be less complex and will produce clean full nape fillets with a higher yield.

It will not be possible to cover the entire size range of white fish in one machine. There will be machines with overlapping ranges, for instance from 30 cm (12″) to 55 cm (22″) and 45 cm (18″) to 80 cm (32″). These machines will take fish which has been gutted and perhaps already deheaded on board. These processing machines for shore plants will concentrate on product yield, which is the most important factor for the production costs ashore.

Other processing machines for factory trawlers will combine more operations in one machine to reduce the number of operators for the entire production line. In some cases such combinations can be accomplished only by employing cutting methods which do not give the maximum product yield. A reduction in crew will bring more savings for a factory trawler than a slight difference in yield. Therefore mechanized fish processing lines of the future will be different for shore plants and factory trawlers.

For the production of completely boneless fillets there will be attachments to the filleting machines for the automatic removal of the pinbone section. It will not be possible to remove the pinbones without some meat from the fillets. For a high yield in boneless fillet the cut should be close to the pinbones, but for a mechanized operation such close cut would lead to a higher percentage of pinbones left in the fillet than the requirements for boneless fillets could allow.

In the future the pinbones will be removed with sufficient meat around them for a safe cut. The meat will be reclaimed by a meat separator.

Meat separators allow the separation of bones and meat. There are types of meat separators which allow a recovery of 95% boneless meat from normal pinbone V-cuts and which produce a coarse fibrous minced meat.

This minced meat can be added to the fillet blocks for the production of fish sticks and breaded portions. If pinbone V-cuts from cod are utilized this way, the amount of minced meat in the final product will be about 12% of the fillet weight. The overall yield will be increased by about 5%.

If fillets and minced meat are mixed properly and the fillets are partly shredded to increase the surface for a more even distribution of minced meat throughout the block, the amount of minced meat could be increased to 30% of the total, without changing the character or quality of the fish sticks or portions.

This will open new ways in fillet production. More boneless products could be produced. Parts of the fillets like the boneless tail ends or the back loins of larger fillets could be used for IQF products, while the remaining flaps and smaller fillets could be mixed with the minced meat from the pinbone V-cuts. Other products like fish cakes, fish balls, fish sausages etc. can be produced from minced meat alone.

There will be a variety of different products made from fish. Instead of the usual fillets, sections of the fillets will be used for the type of product they are most suited for, and where they will give the best returns.

The packing of fillets in blocks and consumer packs is still a time-consuming manual operation. As long as both individual fillets and a certain weight are required for a pack such an operation could probably not be mechanized. The packing of individual fillets with varying weights or fillet blocks with constant weight could be mechanized.

For fish blocks as raw material for portions and sticks there is a new method to produce an absolutely straight, smooth and voidless block with accurate measurements. First a rough block is frozen, which does not have to be carefully packed. Then this block is inserted into a chamber of the correct block measurements and is pressed under high pressure into this chamber, where the frozen fillets within the block slowly arrange themselves to completely fill the chamber. Just one dimension will vary depending on the weight of the rough block. This dimension is trimmed by a saw cut. This method allows the production of voidless blocks onboard where, through the difficulties of getting correct weights, the production of voidless blocks has been impossible.

The production of portions and sticks from blocks calls for more savings in labour and cutting waste. The development will eventually lead to an automatic production of portions from fresh fillets with a portion forming machine and subsequent freezing and breading eliminating the intermediate stage of the block entirely.

For the blocks as export commodity further rationalization could be achieved by producing slabs instead of blocks. Slabs could be formed and portioned from fresh fillets and filled into cartons automatically.

For the inshore cod fishery producing salt cod, mechanization would be possible only by establishing processing centers where splitting and drying operations could be carried out on a larger scale, using splitting machines and drying plants. This way the individual fisherman could be relieved of the time-consuming task of splitting and salting the catch, and more first grade and higher priced light dry salted cod could be produced.

PROCESSING OF RED FISH

For the production of fillets from redfish, or ocean perch, there are machines available which already bring a high degree of mechanization. There is one type of machine for smaller redfish from 7 to 14 inches and another type of machine for the larger fish from 12 to 22 inches. These machines automatically perform heading, gutting, filleting and skinning operations; the only manual labor left is feeding the raw fish to the machine. Automatic feeding of these machines would not bring any further rationalization since it would just change the job of the operator from feeding to observing.

Apart from the changes in fillet use for final products, which will be the same as for white fish, there will be no significant changes in redfish filleting operations in the future.

PROCESSING OF FLAT FISH

Flat fish filleting machines have been in use for several years already in Europe for filleting the European plaice. The flat fish species of the Northwest Atlantic like the flounder, grey sole and yellowtail are different, and the machine designer is faced with the problem of handling different types of fish in different size ranges and redesigning the machine for easy adjustments for a change from one species to the other.

Within the next five years flat fish filleting machines for the flat fish species of the Northwest Atlantic will be available. For the entire range of sizes from 12" up to 24", there will be two different types of machine, one for the smaller fish from 12" to 16" and one for the larger, from 13" to 24". These machines will dehead and fillet the fish, processing 32 to 40 fish per minute with one operator. The fish can be gutted or ungutted and with or without a bleeding cut in the belly. The fillets produced by the machine will be the same as hand cut fillets with skin on. It is not likely that an automatic transfer of the fillets from the filleting machine to the skinning machine could be developed in the near future, so the flat fish fillets will have to be placed on to the skinning machine by hand.

For the skinning operation the future will bring an improvement for the problem of splitting tail ends of flat fish fillets. This will improve the appearance of the fillets and will make them more suitable for IQF products.

PROCESSING OF HERRING

In Europe herring is a very popular food fish and many cured, marinated and canned herring products are being produced. The European countries are catching an increasing part of their herring, needed as raw material for these products, in the Northwest Atlantic. In recent years the herring fishery in Canada developed rapidly. Most of this herring is turned into fishmeal. In the future the use of herring for food will be an important new branch of the industry to be developed.

In Germany the per capita consumption of marinated and canned herring is about 1.8 kg per year. These products, which are consumed as snacks or sandwich spread, are even more popular in Scandinavian countries. It should be possible to develop a market for herring products in North America, and if the market could be developed to the European level this would mean about 360,000 tons of herring products per year.

Mechanization of herring processing has been brought to a high degree. Well proven processing methods and equipment for the different products are available.

There are filleting machines for all sizes of herring, from 5 1/2" to 15 1/2", which will handle 200 to 300 herrings per minute with just two or three operators. These machines are very versatile and can be adjusted to produce single fillets, butterfly fillets or dressed herrings without heads.

Nobbing machines operating at the same speed can dehead and eviscerate the herring for canning or salt curing. Pre-cooking and canfilling can be performed by one mechanized unit.

A processing line for canned herring fillets, for instance, requires very little labour. There are two persons for the filleting machine. Washing and brining of the fillets is done automatically and continuously. Four operators are needed for the precooking and canfilling unit.

Automatic feeding of the herring filleting machine will bring savings only if the herring is of top quality all the time. With poorer quality, including broken herrings or herrings distorted in storage, any automatic feeding system will make mistakes leading to faulty cuts in the filleting operation. At a speed of 300 herrings per minute a person watching the operation cannot intervene and correct a mistake made by the automatic feeder because the herring is moving by too fast. So an inspection of the fillets will become necessary, which requires one or two persons, which is just the same as an automatic feeder would save. The high speed herring filleting machines of the future are designed to make manual feeding as simple as possible to increase the efficiency of the operators. A new heading device in the herring filleting machine allows a correct head cut independent on variations in sizes at the speed of 300/min. This is important for a high yield in finished product.

For canned herring products lightweight aluminium foil cans will be the new type of can in the future. These cans are made of plastic laminated aluminium foil with a welded cover of the same material. They have the advantage of easy opening without a can opener, easy disposal, being completely neutral in taste and resistant to aggressive contents. They are equally suitable for semi-preserved and fully sterilized products. The cans can be produced by a deep drawing press placed at the side of the canning line, so the cans can be formed, filled and sealed without handling and storing of empty cans. The special sales appeal of these new cans for the consumer might help to open the market for herring products.

CONCLUDING REMARKS

In this paper the author has attempted to predict how far mechanization and automation could advance within the next five years. Some of the equipment has already been developed and will be available soon, while other equipment mentioned will take more time to complete.

The market for fish products and the development of new fish processing machines depend upon each other. New machines facilitate the economical production of new products and the development of new fish products often requires new processing equipment. Research and development work determines whether an idea could be developed into reliable and economically working processing equipment.

There is no doubt that the processing plants of the future will be mechanized to a greater extent than today. The plant engineer and trained maintenance personnel will be of growing importance in the future. Correct adjustments and preventive maintenance to keep up the good performance of all processing equipment will reduce time and will increase the throughput and the product yield.

Complete automation of all operations from receiving the raw material to packing the finished product is not within reach in the near future. Automation will be limited to several steps of operation like gutting, deheading, filleting and skinning, which could be performed by one automatic unit, but manual handling before and after such a unit could not be avoided because of the difficult and the always changing properties of the raw material, fish.

Processing of Herring for Food

Mr. Thomsen

by

Volker Thomsen,
President,
IMO Foods Limited,
Yarmouth, Nova Scotia, Canada

Mr. Thomsen, 26, was born in Flensburg, Germany, and is the son of a policeman.

He is president of: Internationale Marketing Organisation, Germany; Dr. Münch GmbH, Germany, and IMO Foods Limited, Canada. He is also vice-president of Euro-Canadian Shipping Limited, and a member of various institutes.

He finished high school at the age of 17, and served three years' apprenticeship with Import-Export-Marketing, attending night university during the same period (Trade-Commerce-Marketing).

Mr. Thomsen started his own business at the age of 20, and is founder of all the above-named companies.

INTRODUCTION

IMO Foods Limited was established in June 1969 in Yarmouth, Nova Scotia.

In co-operation with the Canadian Government, the Nova Scotia Government, Canadian engineers, German, Danish, and Canadian specialists, this industry was developed to meet the demands of a modern and competitive consumer market. The subject is dealt with under the following headings.

1. World Market for Herring Products.
2. Fishing Areas.
3. Canada in the Centre.
4. Canada's Position and Duty.
5. Concept of a Modern Plant
6. Raw Material.
7. Equipment.
8. Processing.
9. Products.
10. Quality Control and Inspection.
11. Solution.

WORLD MARKET FOR HERRING PRODUCTS

The European markets such as Germany, Holland, East Europe and Scandinavia are far ahead in the world's production and consumption of herring products. Many years ago these countries found that herring not only can be used for ordinary food purposes, but that it is one of the better fish, which can be used for a very diversified range of delicious products. Germany alone produces more than 210,000 tons of herring and has developed, in addition to a big home market, many other markets around the world.

FISHING AREAS

The traditional fishing grounds in the European North Atlantic are now unable to deliver sufficient raw material.

CANADA IN THE CENTRE

Today, Canada's East Coast is the centre of one of the largest herring reservoirs of the world.

CANADA'S POSITION AND DUTY

Canada's position in this picture is both rich and poor. Rich because of the possibilities – poor because of the nonexisting industry which should take advantage of the ideal location. More than 90% of the landed quantity of herring in Canada is used for fish meal. This gives an excellent opportunity for a future development of food herring.

CONCEPT OF A MODERN PLANT

Based on this idea, we tried to take the first step when we built our plant. It was necessary to have a maximum of automation, which ensures that the fish will be handled when fresh and as quickly as possible, with a minimum of manual labour involved. Basically, we wanted to build the plant in a way that the fish goes into the feeding section, runs through the different stations and leaves the plant to go directly into the rail car, truck or storage without any delays or unnecessary handling.

With the help of specialists from different countries and a common source, we fulfilled, in general, the given conception.

RAW MATERIAL AND ITS FAT CONTENT

In order to operate a food herring plant in Canada, it is necessary to have a first class raw material, which has to be handled with much care. The summer temperatures are much higher than in North Europe, and even on short distance hauls, ice-boxing or refrigeration in seawater containers is needed.

The low fat content in the Canadian caught herring represents the biggest problem for a continually economic production. Even in the summer months, we noticed that the fat content differs from catch to catch and from day to day from between 8% and 13% and sometimes up to 15%, resulting in production times and speeds having to be changed very often.

THE PROCESSING EQUIPMENT

Part of the equipment was bought in Germany from Baader and Lubeca; the rest was, more or less, our own construction produced in Canada.

The production line contains the following sections:

1. Automatic washing and scaling
2. Automatic feed into the filleting machine
3. Automatic filleting
4. Automatic washing of the fillets
5. Automatic brining of the fillets
6. Hand feeding of fillets
7. Automatic precooking
8. Automatic sauce filling (1)
9. Hand packing the fillets
10. Automatic sauce filling (2) – check weight
11. Automatic clinching
12. Automatic coding
13. Automatic can closing
14. Automatic can washing
15. Automatic sterilization
16. Automatic can washing
17. Automatic can drying
18. Automatic can packing
19. Automatic master carton coding
20. Automatic transportation of the finished product

Separated from the general processing area is the sauce division, the production of which is the key for the whole operation. In our plant this area is almost as voluminous as the main production hall. It contains the following equipment which was designed for us and was built-in: kettles with a capacity of 600 gallons of sauce per hour, ranges, scale, mixing equipment, automatic pipes, tanks for vinegar and oil, refrigerator.

Up to 100 different ingredients are used and a good dry storage for spices, etc. is needed.

PROCESSING

The processing equipment gives you a guideline for the general process. The precooking tunnel, the autoclaves, the washing machines and the sauce kitchen are operated with steam. A high capacity boiler is needed.

As mentioned before, the following facts are most important:

The herring has to be chilled to 33°F. The fat content will determine the precooking time and should be as high as possible. The average processing time from the raw product to the finished pack is two to three hours.

PRODUCTS

Herring can be processed in many different ways, including whole herring frozen or salted, herring fillets, frozen, herring fillets frozen, marinated, herring fillets marinated in glass or plastic containers, herring fillets in different creams in glass containers and herring fillets in different creams or sauces in sterilized cans. More than 1,000 different products are produced all over the world and there are still possibilities to create new, exciting varieties.

Our assortment includes such products as herring fillets in: tomato cream, paprika cream, sweet pepper sauce, french onion sauce/cream, mushroom cream, curry cream, cheese cream, and bacon cream; which shows how many possibilities the herring gives us.

QUALITY CONTROL AND INSPECTION

It is most important to think only of first qualities. There has to be continuous inspection. As the processing of food herring is relatively new in Canada, it will be necessary to formulate new and specific regulations.

SOLUTION

Canada is in the centre of this big natural resource. With the help of modern techniques and common sense there should be a big future for the Canadian herring food industry.

The Future of Fish Protein Concentrate

Mr. Carsten

by

A. Carsten,
Surveyer, Nenniger & Chênevert Inc.,
Montreal.

Mr. Carsten graduated in Chemistry from the University of Liverpool, England. After a period of research, he joined the U.K.-based Davy-Ashmore Group of engineering companies and eventually managed its Canadian subsidiary. He was mainly concerned with the design and construction of chemical and food processing plants, particularly for oilseed extraction and fish meal production. Mr. Carsten is now with Surveyer, Nenniger and Chênevert Inc., a large Montreal firm of engineering consultants, where he is getting increasingly involved in fish protein concentrate and has become an authority on the subject.

ABSTRACT

This paper considers some of the more important questions in the evolution of a fish protein concentrate industry. Major developments which have taken place since the Conference on FPC in Ottawa in 1967 are reviewed first, followed by a brief discussion of anticipated technical features and requirements of commercial plants.

Most of you will be familiar with fish protein concentrate – FPC for short. It is a highly purified protein, generally bland and odourless, derived from fish by solvent extraction or other means. The product may eventually take a number of forms, all of which will be comparatively inexpensive and will show long-term stability under all climatic conditions. It will be highly nutritious and suitable for diverse applications as ingredient in staple diets and manufactured foods. To the fishing industry, the advent of FPC promises to open up a steady and profitable outlet for vast hitherto unutilized resources.

The 1967 Conference on FPC, held under the same auspices as the present Conference, focused a great deal of attention on the subject and brought out the need for further advancement in several major areas, such as the development of functional properties and formulations, consumer acceptance, market development, harvesting of resources and economic production.

The intervening two and a half years saw some significant strides in the right directions, in particular the following:–

The concept of a defatted fish meal continues to give way to quality consciousness. Principal criteria of quality are wholesomeness, safety and nutritive value, all of which can be determined and controlled by chemical and biological means. Previous futile attempts to manufacture inferior products retarded the development of what we now call FPC.

A number of interesting processes and products are emerging through research and development along different lines of approach, pursued by government institutions and industry in several countries.

An inter-departmental committee was recently set up in Ottawa to assist industry in solving some of its problems and to ensure sound economic development. This committee operates through a number of subcommittees which keep in close touch with industry and scientists in Canada and the U.S.A. One of the main tasks the committee has set itself involves the promotion of research and development pertaining to functional properties to achieve maximum versatility of FPC.

In-house studies by industry have thrown more light on practicable foodstuff formulations, a few of which have already been distributed to the public on a trial basis. A significant step in this connection was taken only a few days ago, when Nabisco and Astra, two large international corporations, announced a joint nutrition development venture for FPC, now leaving the first commercial production unit.

The Agriculture, Fisheries and Food Products Branch of the Department of Industry, Trade and Commerce, in cooperation with the Halifax Laboratory of the Fisheries Research Board of Canada, has applied to the Food and Drug Directorate for approval of FPC from a wide range of species. The Bureau of Commercial Fisheries, which has already obtained Food and Drug Administration approval of FPC from hake-like species, is now seeking approval of fatty fish as raw material for FPC. Industrial concerns have filed similar petitions, both in Canada and the U.S.A.

Four plants based on isopropyl alcohol extraction and intended to produce FPC of the highest quality are in various stages of design, construction and commissioning. Thus, a plant with an annual output of about 2,000 tons started up in Sweden this week. The U.S. Bureau of Commercial Fisheries expects to have its demonstration plant on the U.S. West Coast in operation by August. My own company has completed the basic process design and major equipment selection for the first large-scale plant of this type. This plant, scheduled for completion in May, is to produce up to some 8,000 tons of FPC per year, in Canso, Nova Scotia. Next year, a factory ship will go into service to produce as much as 25,000 tons annually.

Although we will not, of course, be able to refer to any market statistics until FPC is produced commercially by a number of manufacturers, one already notices less concern about the potential demand. The protein requirements of food manufacturers indicate promising applications as long as there is no compromise in respect of product quality.

More and more developing countries are taking an interest in producing and distributing FPC to combat malnutrition. The U.S. Agency for International Development is about to conduct a consumer acceptance study in Chile. Two months ago, the United Nations Industrial Development Organization and the Food and Agriculture Organization convened an Expert Group Meeting on FPC. The meeting came up with recommendations for the development of a commercial FPC enterprise in Morocco, and for the production and distribution of FPC in developing countries generally. Steps are already being taken to put these recommendations into effect.

What, now, can we expect to see in the future?

I believe the Fisheries Research Board of Canada and the Bureau of Commercial Fisheries will continue to take a leading interest in FPC and help to bring about sufficiently broad Food and Drug approval to permit utilization of all suitable major resources and species that are under-utilized or not exploited at all. The petitions now before the Food and Drug Directorate already cover three entire families of species, namely cod, herring and smelt. At the same time, it is hoped that harvesting techniques will be developed to exploit these resources economically and land the fish in fresh condition. One approach to large-scale fish farming for FPC production, now being piloted in the Virgin Islands, involves the artificial upwelling of nutrient rich water. In this manner, a high yield of plankton may be induced, which may well sustain anchoveta and other useful species.

This isopropanol extraction process in some form or other seems to have come to stay, in which case more thought will no doubt be devoted to ways and means of storing the fish in the solvent aboard ship. In this manner, the raw material can be preserved the moment it leaves the sea, transported in tanks and pumped without detriment. We can even expect pre-treatment at sea to go further. For example, the partial removal of bone, moisture and oil could be carried out on board, leading to an intermediate product that can be stored without spoilage for long periods and that can be shipped long distances to centrally located extraction plants.

Such pre-treatment facilities might be installed on a large fishing vessel, or on a factory ship served by a number of catchers. There is, in fact, no technical reason why FPC should not be produced in its final form at sea. The recent announcement by the Swedish firm Astra, concerning the conversion of Scandinavia's largest whale factory ship for this purpose, indicates that these ideas are about to be put into practice.

I do not believe that FPC production will mushroom overnight. Rather, it will evolve gradually, but surely, along with special products for animal feed. Such products have properties which fish meal does not offer, for example, solubility and a low content of lipids. The reason is that the growth of FPC production will depend on progress in developing suitable fishing techniques, on the formulation of products and their acceptance by consumers, particularly those suffering from protein deficiencies, and on the continuing evolution of suitable manufacturing processes. These developments will take time and depend on one another.

By far the most advanced process is that based on extraction with isopropyl alcohol; which can already be applied to commercial production in several alternative forms. A number of other exciting processes are in the course of development. These aim to produce materials with widely differing functional properties, not necessarily competitive. Of particular interest are those which give us at least some degree of heat coagulating ability and solubility, and which promise substantial reductions in production cost. We will therefore have an increasing range of manufacturing techniques at our disposal for selection according to the proposed use of the product and other specific requirements of an FPC project. Even textured products may be developed, analogous with soybean protein.

Procedures based on enzymatic and chemical hydrolysis to produce soluble fish protein concentrates for food and feed applications are being developed. Some of these have already advanced to the point of commercial exploitation. Such products can be expected to find their way into various kinds of beverages.

Heat treatment as well as alcoholic solvents tend to denature proteins, with the result that they lose their coagulating and water binding properties. Instead of extracting the unstable fats, therefore, they may be stabilized by powerful antioxidants or even utilized for conversion by lipolytic microorganisms into additional protein.

To achieve full utilization of protein contained in the raw fish and meet market requirements with some degree of flexibility, more than one protein concentrate may be produced in the same plant. Indeed, some processes yield two or more products in any case. For example, the isopropanol extraction process leads to an insoluble FPC, which can be solubilized by subsequent hydrolysis. From the by-products of the same process, at least a feed grade of soluble protein may be recovered.

The relatively expensive equipment used for stagewise extraction of fish with isopropanol may give way to countercurrent reactors with significant savings in capital and production costs, and simpler process control.

Whatever the process route chosen for a particular project, FPC plants will have certain characteristics in common. Thus, solvent extraction processes, and probably also others still in the development stage, will not lend themselves very well to intermittent operation as is often the practice in the fish processing industry. The magnitude of the investment involved, the nature of the unit operations, the operating and personnel requirements, product control and sanitation measures all demand fully continuous operation, preferably on a year-round basis, interrupted only by regular cleaning routines. Yet the primary fishing activity will remain spasmodic for reasons beyond our control. It is therefore of utmost importance that an FPC plant be supported by an effective fishing and fish handling operation, the task of which will be to ensure that the plant receives acceptable species of fresh fish on a realistic schedule in accord with the capacity and process facilities of the plant. The problem of arriving at a harmonious relation between harvesting the fish and processing it into FPC and various by-products is so complex and so vital to the success of the operation as a whole, that a systems analysis approach leading to a versatile model would not seem amiss.

FPC production will generally lend itself to a high degree of mechanization and automation, with little manual attention. The operation of the plant will be governed largely by quality control to maintain the stringent demands of Food and Drug Directorate regulations and of trade specifications, which remain to be developed. For this purpose, it will be necessary to develop and apply suitable techniques of recording and controlling analytical data, such as bacteria counts, amino acid compositions, residual lipids and solvent content, trace elements, etc., to permit rapid response to changes in raw material characteristics and rapid detection of any malfunctions.

Summing up, an FPC plant differs from conventional fish processing facilities in that it represents a continuous sophisticated operation, more akin to a biochemical plant, with a high standard of sanitation. It calls for specialized knowledge in food technology and for new approaches in respect of fish harvesting. The investment is relatively high, but so are the potential rewards in terms of diversification of fishing activities, of product values, and markets.

Discussion

W.H. Klyn, of Atlantic Aero-Marine Electronics, Tantallon, N.S., put the following question to Dr. Scharfe: "Since the forward working netsonde (in effect sonar) suffers from sea bottom reverberation like any sonar, it appears to be mainly used in deep water operations. What has been your experience? Much of our fishing is done in relatively shallow water, with often a very rough rocky bottom."

Dr. Schärfe: "Like any sonar, when the netsonde is close to the bottom it will pick up echos from bottom traces, and then it will be difficult to distinguish between bottom traces and fish. Actually, Mr. Klyn has stated the case correctly, the main advantage of this forward net sonar is in deep water and under conditions to deal with dense schools, which show active reaction towards the net."

M.J. Hatfield, of the White Fish Authority, London, England, asked Mr. Piltz: "Has the engine room automation, described in part 2 of your paper, actually reduced engineer crew, and if so by how many? In particular I refer to the B29 freezer."

Mr. Piltz: "It is true that you still maintain the same crew. We hope that in the future, regulations will be adopted to permit a reduction in crew. As it is now the regulations do not permit any reduction in the number of the crew. Next year we hope there there may be some change, and if so it will mean a reduction of three or four men."

A.F. Morris, National Sea Products Ltd., Halifax, asked: "Have the forward looking tranducers mounted on the trawl actually been successful in detecting fish ahead of the trawl, despite noise interference from the ship's propellers and machinery? "

Dr. Schärfe: "As you have seen from the White Fish Authority telemeter, the sound from the net can be received by a transducer, in spite of propeller wake and propeller disturbance. It is surprising also to me. Echo sounding apparatus used for this equipment is so powerful that you can get over a quite considerable noise level and receive your echoes."

Jean Frechet, of the Department of Fisheries and Forestry, asked Dr. Schärfe his views on the advantages or disadvantages of the use of very large or extra large mesh sizes in the wings and lengthening pieces of otter trawl nets.

Dr. Schärfe: "I am very much for it. We were able to increase the size of mid-water trawls to a 2000 square meter opening area, for 200 hp trawlers, by using 50-70 cm. streched mesh to make the front part of the net. You may know that larger meshes are being used by herring mid-water trawlers. I have no doubt that this system in connection with what I call the outfitting technique, can be applied also to other types of fish, under certain conditions."

Dr. N.M. Kerr, of the White Fish Authority, Hull, England, asked: "In pelagic trawling it is frequently necessary to fish close to the seabed. How close can the ground rope be brought to the ground, and is this distance affected by the accuracy of the downward facing sounder? In this context are the forward facing transducers able to assist trawl manoeuvers when the ground is uneven? "

Dr. Schärfe: "In answer to the first question, over flat ground as close as one to two meters. The echo sounder, netsonde accuracy is sufficient. The answer to the second question is no, with regard to small hills, stones, etc., but yes for larger obstacles. There is hardly any experience with this. Usually sonar and echosounders are utilized to avoid net collision with obstacles."

Ian M. Bayly, naval architect, of Halifax, put the following question to Dr. Schärfe: "What effect does rough water have on the usefulness of warp tension readings, and what increase in maximum values have been recorded (a) in moderate sea conditions, (b) in extreme conditions such as might cause fishing to be suspended? Would you please comment on the accuracy of the instruments you discuss, when measuring transient tensions? "

Dr. Schärfe: "Rough weather naturally leads to variations in load due to vessel movements. Maximum load values increase, depending on size of vessel and gear, by (a) about 50%, (b) about 100%. As to your second question, please refer to the bibliography cited in my paper."

G.E. Kristinsson, Commercial Marine Services, Montreal, asked Mr. Thomsen: "In what condition is the herring when received in your plant? One, fresh, is it iced and how many days old? and two, frozen?

Mr. Thomsen: "It depends upon the season. In the summer operation we get fresh herring twice daily, landed a few hours after they are caught. These fish should be iced on board, or put into refrigeration on board, right after they are caught, because the temperature in the summer time is quite high, and you can spoil the fish within a few hours, especially when you are handling herring. You have to make sure right away that the temperature goes down to around 32–33 degrees. If you do that, you will have no problem during the summer time. The herring can last, if you keep it well iced, well controlled, up to, I would say, two or three days during the summer time, and during the winter time you will able to handle it up to three or four days. If you handle the herring frozen the problem is one of getting it unsorted, because the quantities you are using are quite big. You need some kind of unit for unsorting. We installed different sinks, and found ways of unsorting them within three or four hours."

A.A. Etchegary, Fishery Products Limited, St. John's, asked Mr. Drews: "How would yields from different flat fish species be influenced by differences in bone structures, when one machine is used for these different species? Will the differences be significant? "

Mr. Drews: "No, I don't think there would be any significant difference in yield on the various species. A filleting machine for flat fish, as it is designed, will cut close to the bone no matter what the shape of the bone structure of the flat fish species is. There are, of course, differences in yield from the differences in the fish species; from the narrower fillet, from the grey sort, compared with the wider fillet from the flounder."

Thomas Pross, of the U.S. Marine Administration, Washington, D.C., said to Mr. Carsten: "Did I understand you to indicate that an FPC factory vessel is under construction? If this is so, please give some details on the vessel, as to size, operator, fish to be processed, etc."

Mr. Carsten: "I believe it is a 25,000-ton vessel and ex-whaling factory ship. It is now being equipped with an FPC plant. It will be operated by a subsidiary of the Swedish firm Astra. It will produce fish meal this year, and FPC next year."

H.W. Nickerson, Seafood Dealers Association, Inc., New Bedford, Mass., asked Mr. Drews when delivery of flat fish automated filleting machines would be available to processors, in sufficient numbers to be practical to warrant investment and eliminate hand cutting.

Mr. Drews said that a machine to handle American plaice, salt cod, grey sole and yellowtail would take a few more years for development but should be available for delivery in from four to five years. Machines are now available for the smaller yellowtail flounder; the first of these have been delivered to the United States.

Mr. Kristinsson asked Mr. Drews: "In five years time will it be possible to cut and fillet 100 tons of round ground fish or herring on board a vessel using fully automatic equipment, and how many men will be required to operate such a filleting line?"

Mr. Drews: "If 'fully' automatic means that no manual handling should be involved from emptying the net to stowing the finished product, then I must say that this will not be possible in five years' time. If the term 'fully automatic' refers only to the cutting operations for the production of fillets then this is already possible for 100 tons a day. One hundred tons per day would be five tons per hour. For large cod of four to five kg each, one filleting line with a speed of 24 fish/min served by three operators could produce skinless fillets of five tons of fish per hour. For herring of 0.2 kg each, two filleting machines with a speed of 250 fish/min each and served by two operators each could handle five tons of herring per hour."

Mr. Hatfield asked Mr. Drews if the compression of frozen blocks damaged the fillets, if the fillets could be retrieved whole, and was it suitable for whole round fish.

Mr. Drews replied: "The compression of a frozen block of fillets does not damage the fillets and after thawing, the individual fillets could be retrieved whole. There are no visible changes in texture and appearance. This method has not been tried on blocks of whole round fish."

L. van Pel, of the Netherlands Institute for Fishery Products, said to Mr. Drews: "In order to keep filleting machines continuously in operation it is important to have a stock of fish. This is possible with frozen fish, that has to be defrosted afterwards. Is it possible to fillet fish that has been frozen and defrosted? Are there limitations and if so what are they?"

Mr. Drews: "It is possible to fillet defrosted fish by machine and this is being done in several countries. Limitations are set by the texture of the fish. Freezing and defrosting make the fish softer and if the fish is soft already before freezing, such as, for instance, the South African hake, the defrosted fish may become too soft to produce fillets of satisfying appearance."

Richard Nelson, of the U.S. Bureau of Commercial Fisheries, Seattle, Wash., to Mr. Drews: "In the Baader fish flesh separator is it necessary to split large fish before passing them through the separator (assuming fillets are not removed first)?"

Mr. Drews: "Before running a whole fish through a bone separator it would be advisable to remove head, entrails, the main bone (blood ducts) and the black belly skin if a white minced meat is required. Blood from the main bone and the black belly skin will cause discolourations. The outer skin of the fish could cause bacteria contamination problems in the minced meat, so for good quality minced meat it would be necessary to produce a kind of rough fillet first. The main application for a bone separator therefore is the recovery of meat from fillet trimming like the pinbone V-cuts."

E.A. Dahle, of the Technical University of Norway, Trondheim, asked if it was possible to sort out the liver in using a Baader gutting machine.

Mr. Drews: "In the gutting machine BAADER 165 for fish from 50-120 cm, the entrails are removed from the belly cavity by a scoop after the belly has been opened. This way the liver is not destroyed and could be saved if picked manually from the waste conveyor. It is not possible to separate guts and liver mechanically because of irregular skin connections."

A.E. Walker, of Hull, England, asked: "Will there be developed within the next five years a machine that will present cod or haddock to the operator with their heads or tails directed the same way, as can be done with herring? "

Mr. Drews: "No, because such an orientating machine cannot replace the operator of a processing machine who will be needed then for supervising the operation. Since the speed of a processing machine is not limited by the ability of the operator but more by the texture of the fish, no increase of speed could be achieved in most cases. Therefore there will be no advantage in labour saving or in an increased throughput. There are no cod processing machines requiring more than one operator as compared with herring machines where the herring allows higher speeds."

John Jay, Canadian Plant and Process Engineering Ltd., Halifax, asked if research work was being done on machines for processing dogfish and other underutilized species which would be harvested in greater abundance in the next five years.

Mr. Drews: "Research work is being done, not so much concentrated on dogfish but to find a way to process the wide variety of perch like species of the South Atlantic or Indian Oceans."

P.J. Amaria, Memorial University of Newfoundland, St. John's, asked Mr. Drews if he envisaged equipment for the separation of various species.

Mr. Drews: "No, not for a wide variety of different species. Separation of species is possible if just two species, being different in size, have to be separated, as for instance small anchovy from larger pilchards. For separation of several species with similar shape and dimensions automatic equipment would become too complex for reliable use on board a trawler."

Commander M.B.F. Ranken, of Aquamarine International, Ltd., London, England, made the following comment on Mr. Drews' presentation: "This paper highlights some of the salient points in the satisfactory application of machines to various processing operations, and also shows up clearly the formidable gaps which still exist in our armoury of machines and equipment to fully mechanize or automate the processing line. The great importance of the quality of the raw material and the loss of flexibility inherent in all mechanized processing lines are rightly emphasized. The major gaps (for all or most varieties) are: 1) equipment for selection and sizing (grading) of the catch at the beginning of the processing line; 2) equipment for correct orientation and feeding of fish working machines, and 3) filling of consumer and other packs in a manner which ensures the all-important attractive presentation and convenience which will command the best price from the consumer housewife.

"It seems clear that the British preference for delaying most of the machine and other processing operations until the catch is landed is the best choice in most fisheries and preserves maximum flexibility. This is where the gutting and heading machines (with or without gill removal) come into their own, and it is interesting that headless frozen blocks were only discontinued in early British freezer trawlers because the crew were reluctant to do the heading manually, and incidentally to increase the time needed to fill the fish hold. With heading reintroduced, and the more settled state of the international market, there will be a clear case for fitting fishmeal plants on board to produce the top quality high protein fishmeal only possible from really fresh fish.

"Could Mr. Drews please explain what he means by slabs versus blocks? "

Mr. Drews: "In the production of fish portions or fish sticks from frozen blocks the blocks are usually divided into several smaller oblong blocks with rectangular cross section, having two dimensions of the final portion. These smaller blocks are referred to as slabs. The final portions can be produced by single cuts from slabs."

With reference to the paper by Messrs. Nishimura and Yamanaka, *Commander Ranken* asked the authors to say what was the minimum size of fish which they could identify with their equipment, at what maximum depth, and how close to the bottom or to the surface. He also asked about frequency of the sound.

The authors of the paper, following the conference, provided the following in reply:

"Our experiments showed that the minimum size identified is around 10 to 15 cm. The maximum depth is at present 300 meters, but it can be increased as deep as 500 meters by intensifying the power. Our experiments show that a target placed 1.5 m apart from the bottom was clearly identified.

"Our instruments have two transducers, 28 and 200 KHz respectively. We used only 28KHz in our experiments this time because; (a) the high frequency seemed rather unpreferable for basic experiments because it is affected by DSL more than by the low frequency; (b) by several experiments the reflection from a fish is more fluctuable in the case of a high frequency, and (c) empirically it has been shown that 28KHz is adequate for a pelagic fish like tuna and it has been commercially used."

Mr. Morris also had a question for Messrs. Nishimura and Yamanaka: "Is it intended to carry out fishing trials in connection with the fish counter to establish correlation between indicated fish abundance and actual rate of catch? "

The answer returned was as follows:

"Needless to say we are planning to do so. As a preliminary study we are now collecting acoustic trace records of commercial tuna longliners and are comparing them with the catch per effort data. From a wide viewpoint they are correlated. But the one to one corresponding is rather ambiguous. It is, however, not surprising, because the former indicate the local density of fish, while the latter do the wide range average both in time and space."

SESSION 4

Moderator – Henri Legaré,
Representing Dr. Leonce Chenard, Deputy
Minister of Fisheries, New Brunswick.

Transfer of Catches at Sea – Progress With British Fishing Vessels

Mr. Hopper

by

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Mr. Hopper is Senior Naval Architect with the Industrial Development Unit of the White Fish Authority, Hull, England. After serving in the Merchant Navy for nine years as a Deck Officer, he left the sea in 1958 to study naval architecture and shipbuilding. During the next five years he was at Vickers Armstrongs Shipbuilders on the Tyne and obtained a Higher National Diploma in Naval Architecture in 1961. In the same year he became an Associate Member of the Royal Institution of Naval Architects, He joined the I.D.U. in 1963 at its formative stage and since that time has been responsible for projects dealing with handling and stowage of fish, deck mechanization and transfer at sea. More recently he has been concerned with design studies for new types of fishing vessels.

ABSTRACT

A system of transfer of fish at sea has been developed by the White Fish Authority's Industrial Development Unit for the British distant water fleet. This system has proved satisfactory under commercial conditions off Iceland. Some improvement in the rates of transfer is required but this is believed to be straightforward. The commercial trials followed a pre-arranged fleet plan for three ships which was evaluated by the computer simulation method. Close control of operations and adherence to decision rules is necessary in order to reap maximum benefits.

1. INTRODUCTION

The ability to transfer catches at sea offers several possible advantages: a higher degree of utilization of expensive vessels and equipment; better use of scarce manpower; improvements in costs and earnings; a reduction in the delay between catching and consumption of the fish.

The English trawling fleets in the North Sea formerly transferred their catches in boxes to carrier vessels, using open rowing boats. The method was arduous and dangerous and was abandoned in the 1930s. With rates of catch falling on the North Atlantic grounds, necessitating longer voyages farther afield, the profitability of large distant water side trawlers, using ice as a means of preservation, has declined. Since many of these vessels had some years of remaining useful life, there has been in recent years a renewed interest in the possibilities of transferring catches in the open sea.

This practice is of course well established and apparently successful in the Russian and Japanese fleets and in others, but it was not possible to copy their methods as the United

Kingdom did not possess the large motherships which form the nucleus of these fleets. It was thought desirable instead to develop a system which employed only the existing catching vessels.

In 1960 experiments were carried out into the effect of transfer upon quality of product (reference 1). These experiments tended to emphasise the difficulties of the problem rather than to solve it. In 1966 the White Fish Authority actively undertook the development of a system of transferring catches suitable for use by large side trawlers and which did not have adverse effects upon quality. The work has led to successful commercial trials which took place in 1968.

2. THE BRITISH DISTANT WATER FLEET

The fleet is made up of three types of vessels.

2.1 *Wet Fish Side Trawlers*

There are about 140 of these vessels, built between the late 1940s and the early 1960s, and they have the following main features:

length overall	142 ft. to 208 ft.
fish hold capacity	11,500 ft.^{3} to 18,500 ft.^{3}
engine power	1300 IHP to 1800 SHP
endurance without refuelling	up to 31 days
Crew	17 to 21 men

The fish is preserved in melting ice and the normal acceptable age limit for sale for human consumption is 16 days on ice. For the majority of vessels this limit fixes the voyage length at a maximum of 22 or 23 days.

2.2. *Freezer and Factory Stern Trawlers*

These are relatively modern diesel trawlers built since 1961 and at present there are 33 in service. The throughput of the processing plant is usually large in relation to the average rate of catch at slack seasons of fishing. There is therefore the possibility of utilizing it more effectively at such times by transferring catches from side trawlers. Voyages are limited by hold capacity, fuel endurance, or the need to relieve the crew.

2.3. *Wet Fish Stern Trawlers*

Two such vessels now operate on distant water grounds from the United Kingdom.

3. INITIAL CONSIDERATIONS IN THE DESIGN OF THE SYSTEM

In the preliminary stages of the Industrial Development Unit's investigation, and before a program of work could be established, a number of important aspects had to be considered.

3.1. *Quality*

The British market is extremely sensitive to changes in quality of fish, or the apparent changes caused by a difference in appearance. Joint experiments carried out by Torry Research Station and Northern Trawlers Ltd. in 1960 (reference 1) clearly showed that some loss of quality would be inevitable if the transfer method required re-immersion of the fish in the sea for more than a few minutes. Even fish frozen on board the receiving vessel after re-immersion in the sea for a long period could be expected to be inferior to fish frozen on the catching vessel. This tended to rule out methods in which net bags or similar containers were floated between the ships.

Quality could also be expected to suffer if the fish were kept on the deck of the catcher un-iced or un-gutted for some hours before transfer, and it was impractical to think that fish could be transferred immediately after capture on every occasion. The method devised had to allow for long periods of properly holding the fish on the catcher because of separation of the fleet, bad weather, mechanical breakdown or other inevitable delays.

3.2. *Vessel Design*

As even the largest of the vessels is relatively small, and has been designed exclusively as a fishing vessel, there are limits to the type of transfer equipment which can be used. In most cases this precluded the installation of specialized winches or other equipment which would interfere with the ability of the vessel to fish, and which would have to be amortized over the remaining life of the vessel.

3.3. *Remuneration*

The normal method of sale of wet fish catches is by auctions on the quayside. It is desirable to have ready means of identifying the ship that had actually caught the fish, as well as the ship that landed it, and it was desirable that the method of transfer should allow easy and rapid agreement between crews as to how much fish had been transferred.

4. DESCRIPTION OF TRANSFER TECHNIQUE

During 1966-1967 a system was developed which took into account all these considerations. The system underwent trials in the North Sea on chartered trawlers, and sufficient progress was made to allow the planning of full scale commercial trials off Iceland in the summer of 1968. The system operated as follows:

4.1. *Stowage on Board*

Following catching, the fish was immediately gutted and packed with ice in aluminium containers. Each container held about 100 lbs of fish and 50 lbs of ice and they were stowed in the catching vessel's fishroom. This practice is recommended by Torry and the Industrial Development Unit as the best method of fish stowage, regardless of whether the fish is to be transferred or not. If the catch is transferred, the fish remain in ice and undisturbed throughout the operations.

4.2. *Transfer between vessels*

Each vessel was equipped with three 40 ft x 7 ft diameter pneumatic fenders (see figure 1) which were inflated and arranged along the contact side of the ships (see fender design below). These fenders allowed the vessels to lie alongside each other in the open sea so that the fish could be transferred directly from one to the other.

The boxes were transferred between the vessels by a union purchase rig. This consisted of a simple hoist wire on each ship passing through a pulley block directly over the hatchway. The two hoist wires were joined together at the lifting end (see figure 2). The transfer sequence was to lift the load clear of the hatch on one hoist, draw it across to the other ship until the load was taken by the other hoist and then lower it down. The hoist wires were hauled on the warping end of the ship's trawl winch.

It would have been preferable to fit special high speed winches, but space for these winches on the deck of the smaller trawlers could not easily be found. Because of the type of rig used and the hatch dimensions the size of load lifted was restricted to four boxes (gross weight 600 lbs), and a special pallet was provided for the purpose.

4.3. *Fender Design*

One of the major problems in the program was the development of suitable fenders, so that the ships could be brought close enough together to avoid immersion of the fish during transfer.

It was decided to provide pneumatic fenders with large air volume at low pressure. In this way the reaction forces of the vessels could be distributed over a wide area of the hulls, thus avoiding high point loadings associated with small hard fenders. Fenders of large diameter were necessary to keep the ships well apart at all times.

From trials with 100 ft. x 5 ft. diameter Dracones (marketed as flexible barges) it was found that the greatest loads came on the fenders during berthing. At this moment the kinetic energy of the two moving vessels had to be dissipated, and the vessels brought to rest. Some of the kinetic energy before impact is however converted into movement after impact, i.e. re-bound and rotation. Other energy is lost in displacing the mass of water from between the two vessels, so the fenders are not required to absorb the total energy.

Energy is absorbed by the fender by:

a) compression of the volume of air and the resulting change of pressure;
b) extension of the fabric caused by the increase in pressure.

Calculation of the peak forces and the energy to be absorbed by the fenders is very difficult. A more practical approach is to conduct full scale trials and measure the pressures attained in the fenders in a wide range of conditions.

After trials of this kind using the Dracones, the new fenders were made from fabrics of the same strength, i.e. 800 - 1000 lbs tensile strength per inch width of fabric. A basic size of 40 ft. x 7 ft. diameter was selected. Three fenders were arranged along the contact side of each vessel so that when they were together the effective separation between the ships was 14 ft. They were inflated to a pressure of 0.25 lb/in^2. Two types of fenders were made to this size – one in nylon reinforced neoprene and the other type from a nylon fabric sprayed with polyurethane.

Further proving trials were then carried out in the North Sea with pressure transducers fitted to the fenders, and continuously monitored on a paper trace recorder. The failure pressure was calculated at 11 lb/in^2 but the maximum pressure change experienced under heavy berthing conditions was 3.5 lb/in^2, and most of the time the change did not exceed 1.0 lb/in^2. This gave enough confidence to proceed to trials using the fenders under commercial conditions.

4.4. *Handling the Fenders*

The fenders each weighed 600 lbs, and could be inflated on the deck of the trawler, and then launched over side by hand. They were secured to the ship's side by two girth ropes around the fender which in turn were chained through holes low down in the bulwark. This prevented the fenders riding up over the ship's rail and onto the deck.

Inflation was by 500 $ft.^3/min$ electric blower driven off the ship's electric supply. The inflation pressure was 0.25 lb/in^2 and the inflation time was six minutes for each fender.

4.5 *Moorings*

Each vessel was provided with combination mooring ropes made from 2¾-in. circumference 6/24 steel wire rope, and 5-in. circumference plaited nylon rope. The nylon allowed a high level of flexibility and the steel wire rope was used in parts where chafe could be expected. The breaking load of the combined rope was 21.1 tons.

The normal arrangements used for mooring the ships are shown in figure 3.

5. FLEETING

In parallel with the technical study an economic study was made of possible fleeting systems. With a fleet made up of widely differing vessels such as described in Section 2 there are various ways in which transfer could be used. Even when a system is decided upon other variables such as catch rate, fishing grounds and quantities of fish to be transferred make it difficult to determine the best method of operating it, and the correct decision rules for the skippers and fleet managers. Each option was therefore examined by computer simulation.

A mathematical model of the proposed operation was built in the form of a computer program. Full account was taken of the variations in steaming time to and from the grounds, time spent in port, weather and catch rates. The input of the program also gave all the essential numerical details such as the number of vessels, hold capacity, endurance, maximum quantity of fish available for transfer and the operating costs of the vessels. The operations of a fleet were described in detail on a day-to-day basis, and the computer was able to run a year's operation in about five minutes.

The system it was decided to subject to commercial trials involved three side trawlers; the vessels were to be scheduled in such a manner that the first caught fish from one was to be transferred to the next due to return home. Later the pattern would be repeated by the first vessel herself receiving fish from the third vessel. The fishing and transfer operations were to take place off Iceland.

The transferred fish would be boxed and iced and subsequently sold as such. The purpose of this particular fleet plan was to either increase the ratio of fishing time to steaming time by in effect allowing the vessel to do two fishing periods on one voyage, or to maintain the normal voyage length and increase the proportion of fresh fish landed.

The control variables in the program were the quantity of fish to be transferred and the "lost" time allowed between a vessel being ready to transfer its catch and the receiving vessel being ready to depart for home. The "lost" time allowed for weather, breakdown or convenience of timing. Sample input data are tabulated in the Appendix. Catch rates and weather frequencies were compiled from realistic data for Iceland obtained by the Industrial Development Unit staff on voyages to the area. Figure 4 shows the expected change in net profit, per ship, per year for the three-ship fleet and indicates the optimum quantity of fish to be transferred to be 70 tons. It also shows that a difference of 1% in net profit could be expected from a change of 1-day stack time to 1.5 day.

6. COMMERCIAL TRIALS AT ICELAND

The trials followed the fleeting plan described in Section 5. The main purposes of the commercial trials were to test the transfer system (see Section 4) under real conditions, to examine the problems of managing a fleet and to provide first hand input data for the computer when studying other fleeting plans.

The fleet consisted of the three vessels, the details of which are given in the following table:

Table I

	Length Over-all ft.	Gross Ton-nage	Year Built	Fish-room Capa-city ft^3	Crew	Endu-rance Days
"St. Andronicus"	170	576	1951	12640	19	27
"St. Achillius"	170	576	1951	12640	19	27
"St. Apollo"	182	658	1948	15270	19	27

All the vessels were conventional side trawlers making 21 day voyages from Hull to the distant water grounds and bringing back on average between 60 and 120 tons of fish stowed in melting ice.

In Section 5 it was shown that the optimum quantity of fish for transfer was about 70 tons. Because the rates of transfer could only be estimated, and because the crews were unfamiliar with the technique, it was decided to reduce the quantity initially to a maximum of 35 tons and increase it only as experience was gained.

In the summer of 1968 there was a glut of fish on almost every day of landing. Consequently only top quality fish was being sold at the auctions and large quantities of fish were being sent for reduction to fishmeal. In these circumstances the decision was taken to operate the fleeting system so as to bring back fresher fish on voyages of the same total duration as before.

In May a single trial was carried out off North Cape, Iceland, using the "St. Andronicus" and "St. Achilleus" and transferring 200 boxes. The full fleeting plan started operating the following month, and terminated in September. During this period nine out of a possible eleven transfers were successfully accomplished. Of the two missed transfers, one was caused by mechanical breakdown and the other by one vessel filling up her hold before the other had time to catch a significant quantity of fish.

Figure 5 shows in bar chart form the schedule for the four month period and Table II gives details of each occasion.

Table II

Transfer Number	Vessel	Date of Transfer 1968	Location	Weather	Wind Force Beaufort Scale	Total Time Along-side Hours	Boxes Transferred (each containing approx. 100 lbs of fish)	Average Transfer Rate (boxes/hour) dis-counting stoppages
1	St. Achilleus St. Apollo	29.6	S.E. Iceland	Heavy rain mod. swell	3/7	11.0	395	65-80
2	St. Andronicus St. Achilleus	3/4.7	"	Low swell	3	10.7	500	50-90
3	St. Apollo St. Andronicus	13.7	"	Low swell	1	10.3	587	70-90
4	St. Achilleus St. Apollo	18.7	"	Calm	2	7.0	587	98
5	St. Apollo St. Andronicus	3/4.8	"	Heavy swell	3/5	4.3	314	80
6	St. Achilleus St. Apollo	8.8	"	Low swell	2/3	9.8	650	88
7	St. Andronicus St. Achilleus	15.8	N.W. Iceland	Heavy swell	2/3	6.0	226	No data
8	St. Achilleus St. Apollo	1.9	"	No	data	5.0	310	90-100
9	St. Andronicus St. Achilleus	8.9	"	Very Heavy swell	5	5.0	379	No data

7. RESULTS OF THE COMMERCIAL TRIALS

The vessels transferred fish on ten occasions, including the May trial, in open water off Iceland and in a range of weather conditions from Beaufort forces 0 to 7. The worst condition for berthing however was Beaufort force 5, and it is suggested that this is the upper safe limit. Under these conditions, with due caution on the part of the skippers, the chance of severe damage occuring is extremely remote, but some risk of superficial damage to the ship's superstructure, rails and bulwarks will always remain. Some minor damage to the forecastle occurred on three occasions, but it is believed that even this risk will become smaller as experience is gained. In many cases the skippers and crews were performing the operation for the first time.

An important rule evolved during these trials is that only one of the vessels must execute the berthing and undocking manoeuvres. The other must play an entirely passive role, but may be either steaming slowly on a fixed course, stopped, or at anchor. The equipment described in Section 4 functioned satisfactorily and the fenders effectively absorbed the energy of berthing. The large (7 ft.) diameter of the fenders was important, and the fenders arranged in parallel allowed free movement of the vessels independently of each other. The fendering and mooring system should be satisfactory for use by other vessels in the distant water fleet.

A disappointing feature of the trials was the poor rate of transfer. This was a maximum of 138 boxes/hour (5.5 tons/hour) and an average of 98 boxes/hour (4.0 tons/hour) which was well below the rate predicted from earlier trials and used in the computer program, viz.; 10 tons/hour. The poor rate of transfer was largely caused by difficulties of stowage in the fishroom: the boxes were too heavy for manual handling and either a smaller box of about 100 lb total weight should have been used, or mechanical assistance provided. The slow speed of the winches on these rather old steam trawlers and the limited size of load (600 lbs) both aggravated the situation.

The oldest fish landed was 12 days on ice, whereas from a conventional voyage the same fish would have been 17 or 18 days on ice. In the prevailing market conditions the effect was to convert the value of the fish from fishmeal price to fresh fish price. Allowing for the costs of lost fishing time when the vessels were engaged in transfer, the net gain for the three vessels over the three months was calculated at just over £2,500 (Can. $6400). This gain was not insignificant but it could have been substantially higher had the optimum number of boxes been carried, or if the market situation had been normal for the time of the year.

Improvements in results would undoubtedly come through savings in time when carrying out rendezvous and transfer, through more strict control of the fleet and by better collaboration between the skippers on the grounds. It will take time to make the fundamental change of attitude from independent operation to fleet operation, but there is no reason to suppose that this will not take place as the financial and economic advantages become appreciated.

8. CONCLUSIONS

8.1. The transfer at sea system described in this paper has been satisfactorily tested under commercial conditions at Iceland in a range of weathers; berthing can take place up to Beaufort force 5 and transfer can continue in worse weather. The fendering and mooring system will be suitable for other vessels in the British distant water fleet.

8.2. Direct ship to ship transfer of boxed fish caused no loss of quality from intermediate handling of the fish. The stowage of fish in ice in the boxes allowed the transfer operation to be arranged at a time mutually convenient to both vessels.

8.3. The transfer rates of 4 ton/hour were disappointing and work is necessary to reduce the work involved in the operation. A smaller box of 100 lbs gross weight, together with faster winches and larger hatchways, would assist in improving the rate.

8.4. The operation must be to a pre-arranged fleet plan and subsequent strict management of the fleet is necessary to ensure efficient operating of the plan. This requires a new attitude of mind on the part of all concerned, but there is no reason to believe that this will not develop as the advantages become appreciated.

8.5. The fleet plan used for the commercial trials showed a small increase in earnings. This figure could have been higher had the number of boxes transferred on each occasion been greater, and had better market conditions prevailed. It is reasonable to conclude that the successful exploitation of this and other fleet systems can show significant economic gains for traditional fishing vessels.

REFERENCES

1. A preliminary report on experiments on the transfer of fish at sea. G. C. Eddie and J. J. Waterman – Torry Research Report No. 3.

Appendix 1. INPUT DATA TO COMPUTER

No. of ships	3
Hold capacity	175 ton
Maximum trip duration	31 days
Spoilage limit (all fish)	17 days
Steaming time to grounds (random sample from data)	4.5. day average
Catch rate (random sample from data)	8.75 ton/day average
Ratio of port time/trip time (random sample from data)	15.5% average
Time unit for simulation	0.5 day
Length of simulation run	800 time units
Maximum quantity of fish for transfer CONTROL VARIABLE	41.2 to 87.5 tons
Weather allowance (slack time)	1 or 1.5 day
Steaming time per transfer	1 ship for 2 hour
Berthing and undocking time	2 ships for 0.5 hour
Transfer rate	10 ton/hour

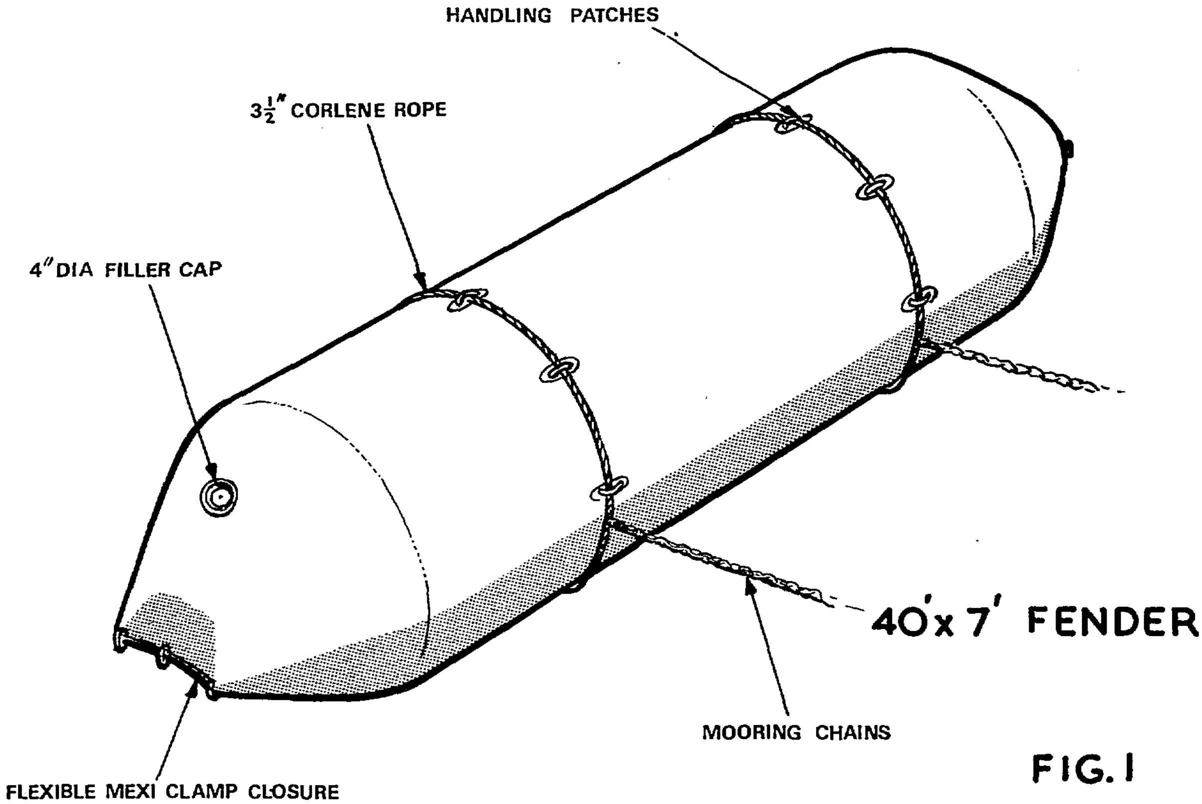


FIG. 1

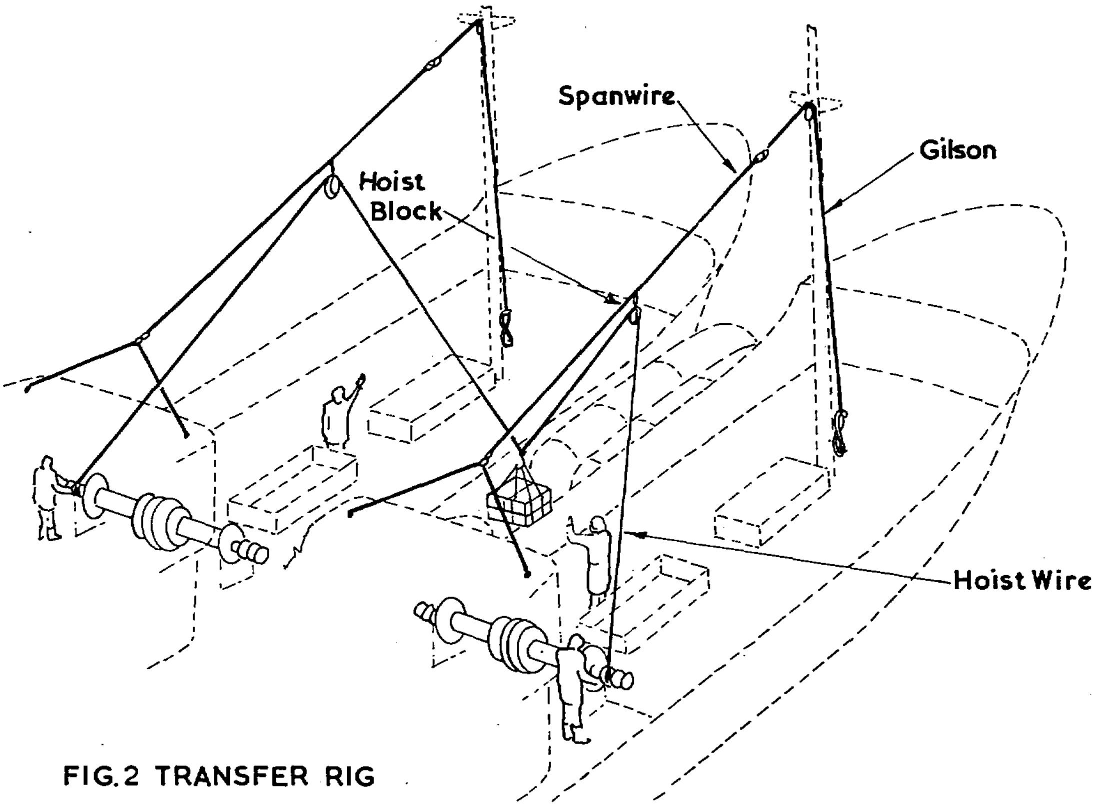


FIG. 2 TRANSFER RIG

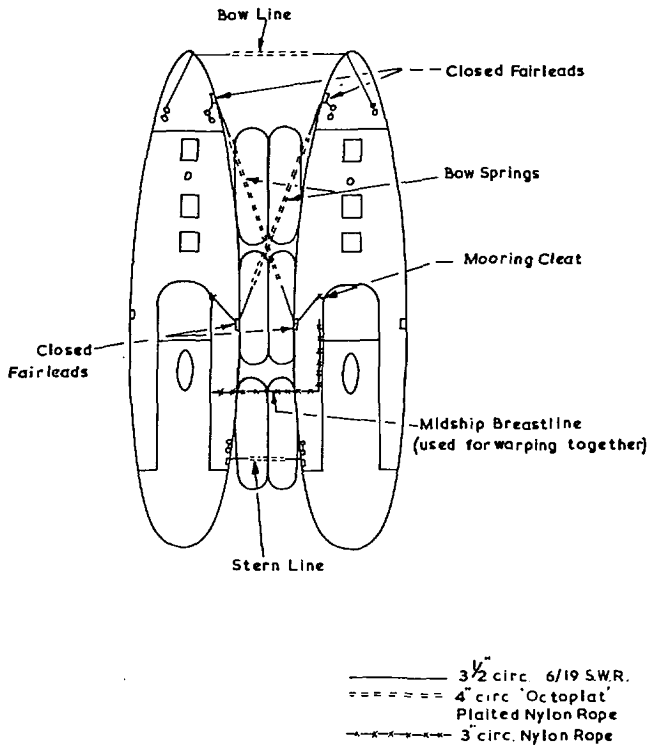
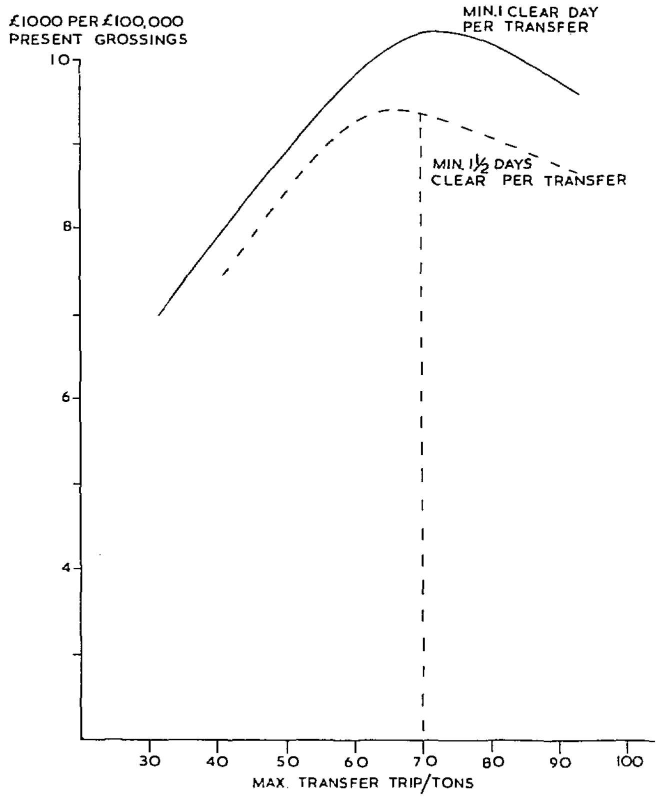


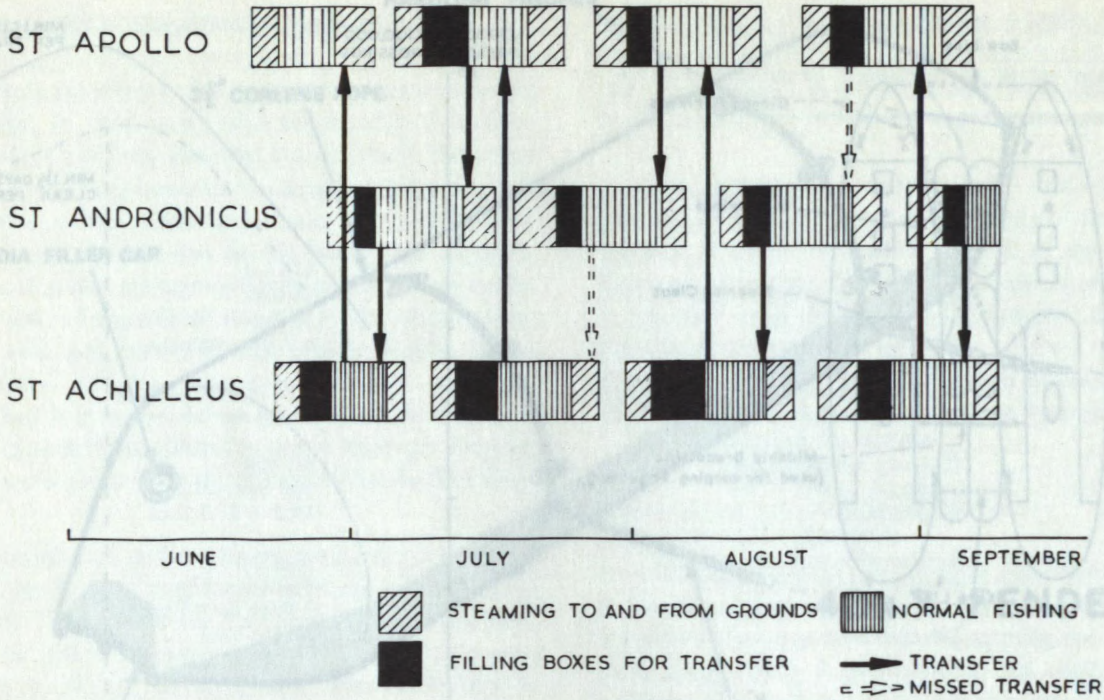
FIG. 3

MOORING ARRANGEMENTS



THREE SHIP FLEET ANTICIPATED CHANGE IN NET PROFIT PER SHIP PER YEAR

FIG. 4



SCHEDULE OF TRANSFER OPERATIONS

FIG. 5

Transfer at sea trials off Iceland.

Fish Unloading Systems

Mr. Eisenhauer

by

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Mr. Eisenhauer graduated from Dalhousie University and Nova Scotia Technical College in Mechanical Engineering. Early work experience was gained in mechanical shops and refitting of naval and fishing ships. After spending some time at sea as engineer in a diesel coastal freighter, he worked in the manufacturing industry in Ontario with emphasis on foundry work and new product design. On returning to Nova Scotia in 1947, along with a few associates, he founded the Atlantic Bridge Company Limited, which has now grown to a holding company, ABCO Limited, and five subsidiary companies. Principal activities of these companies are fish processing equipment manufacture and design, trawler construction and repair, manufacture of fishing gear and nets, fiberglass yacht and commercial boat construction, industrial fiberglass fabrication and machinery sales and service. He pioneered the use of aluminum as a material of construction for fish processing equipment in Canada and promoted the construction of the first fiberglass reinforced fishing boat in Eastern Canada.

Abstract

This paper describes and assesses current methods of unloading side and stern trawlers now in use on the Canadian Atlantic Coast. Four different methods are dealt with. (1) Unloading by Tub and Chute, (2) Onboard Conveyor Systems, (3) Shore-based Conveyor Systems, and (4) Two Types of Air Unloading Systems. Capital and operating costs and labour requirements are compared and evaluated. Conclusions are charted in three appendices.

Draft of this paper was prepared by Mr. J.H. Ross, Plant Manager of Atlantic Bridge Company Limited, subsidiary of ABCO Limited, from information supplied by his staff and from operating information supplied by the following fish processing companies: Acadia Fisheries Limited; Atlantic Fish Processors Company Limited; Booth Fisheries Can. Company Limited; High Liner Division, National Sea Products Limited; H.B. Nickerson & Sons Ltd.

Introduction

This paper describes and evaluates equipment and methods now in use for unloading vessels at the larger fish processing plants on the Atlantic Coast. The vessels concerned are either conventional side or stern trawlers and draggers engaged in the offshore ground fishing industry.

STOWAGE

The fish are generally, but not always, eviscerated before stowing in the various pens located in the fish hold. The stowing is arranged so as to provide alternate layers of flake ice and fish in each of the various fish pens. The fish and ice are separated into tiers by means of a knockdown type of shelving to avoid crushing the fish at the lower levels from the weight of the fish and ice stowed higher up. The fronts of the various pens are closed off by means of pen boards so as to provide a clear passageway between the pens along the fore and aft line of the vessel. When the fishing is good and all pens have been filled, it is common practice to fill this passageway with additional layers of fish and ice. If conditions are favourable, additional fish may even be stowed on deck.

BASIC UNLOADING CRITERIA

From the above, it is evident that the sequence of unloading would be to first remove the deck cargo if any, (Unfortunately an infrequent occurrence these days), then remove the fish stowed in the passageway between the fish pens and finally empty each of the individual fish pens. It is also evident that the ice in which the fish are stowed must be off-loaded along with the fish, and that some subsequent means must be provided for separating this ice from the fish before weighing the latter. In order to control the quality of the fish, records are maintained of the date on which fish stowed in the various pens or other stowages were caught, and it is necessary to maintain this date grouping of the fish during the unloading operation. Any practical unloading system must, therefore, be capable of handling both fish and ice, and must be able to avoid mixing together fish which have been caught on different dates. The system should be equally efficient in offloading from any stowage position on the ship, and should not occupy space which would be used for additional fish stowage.

DESIRABLE FEATURES FOR UNLOADING SYSTEMS

A number of features for the ideal unloading system are listed as follows:

1. It must be able to unload at the lowest possible overall cost per pound of fish handled.

2. It must be able to unload at the highest possible rates so as to keep vessel turn around time to a minimum. In practice, rates in excess of 30,000 pounds per hour may create inplant culling and handling problems.

3. Its capital cost should be reasonable.

4. It should be able to operate in all weather conditions. Delays due to foul weather can be costly in terms of:
   (i) Loss of the use of the vessel
   (ii) Possible shutdown of process lines due to lack of fish.
   (iii) Possible deterioration in quality of the fish while awaiting unloading.

5. It should be of simple construction and not prone to frequent or costly breakdown or involved cleaning and maintenance procedures.

6. It should require a minimum of manpower. Quite apart from the economic considerations, a small number of operators is desirable, as unloading at best provides irregular employment and it is difficult to retain reliable men. A small crew could conceivably be employed elsewhere between unloading operations.

7. The crew should be protected from the weather. It is becoming increasingly difficult to retain the services of good workmen to work under uncomfortable conditions.

8. It should be able to unload any type of vessel without need of special onboard equipment. The latter feature may not seem too important to the larger plants that operate their own fleets; however, the following will apply even to those larger plants whose unloading systems require special onboard equipment:
   (i) If they have more than one plant, then all plants must be fitted with compatible onshore equipment to provide complete unloading systems at each plant.
   (ii) If their boats unload at other than their own plants, their onboard equipment may be of no value.
   (iii) Their plants will be unable to offload ships belonging either to other companies or to independent owners, unless a secondary versatile unloading system is fitted.
   (iv) Systems which are built-in to the vessel occupy potential fish stowage space in the hold.

9. It should not damage, or cause a degradation in quality to a significant amount of the fish being handled.

10. It should occupy a minimum of onboard space which could otherwise be used for fish stowage.

11. It should remove the ice from the fish during unloading.

12. It should be able to unload from any position on the vessel including fish stowed on deck.

From the foregoing, it is apparent that while any given unloading system may be superior to the other systems in certain desirable features, it will at the same time probably be inferior in certain other features. The selection of a system, therefore, becomes a matter of compromise and choosing one with a combination of desirable features that are most suitable for the plant and ships under consideration. The four systems being used by the major fish processing plants on the Atlantic Coast of North America are as follows:

System 1

TUBS AND CHUTES (See Fig. 1)

This is the oldest and most common of all the systems in use. It generally consists of two identical units for simultaneous unloading through two hatches, although there is no reason why a single hatch cannot be used. Each unit consists of a hinged chute, one end of which terminates at a culling station and the other end is centered over the ship's hatch and clears the latter by some ten or more feet. Also forming part of the equipment is an electrically driven winch which hoists tubs from the fish hold to the outboard end of the chute. Each tub holds approximately 300 pounds of fish and ice. The winch is located in a sheltered position remote from the chute, and does the hoisting through a series of pulleys and ropes. The operation consists of manually loading a tub in the fish hold, hoisting it to the outboard end of the chute, where it is dumped into the chute by an operator who stands in a pulpit attached to the chute at this location. As the fish slide down the chute towards the culling station, a substantial portion of the ice drops through the bottom of the chute which consists of a series of equally spaced pipes. As one tub is being hoisted and dumped a second tub is being filled in the fish hold. A two-hatch system would require the following personnel:

In fish hold loading tubs and removing pen boards	-	6 men
In pulpits dumping tubs	–	2 men*
Operating winches	–	2 men
Guiding tubs through hatches	–	2 men
Washing pen boards	–	1 man
	Total	13 men

(*Some systems operate with only one man for two chutes)

The main advantages of this system are:

(1) Low capital cost. Approximately $7,000.00 plus low installation costs.
(2) Construction is simple and reliable and maintenance costs are low.
(3) Can unload any type of vessel as no special onboard equipment is required.
(4) Causes negligible damage to fish.
(5) Requires no onboard space.
(6) Achieves some separation of ice and fish.
(7) Can unload from any position on vessel.

The main disadvantages are:

(1) Its unloading costs are very high
(2) Its unloading rate is low
(3) Men in pulpit are exposed to the weather
(4) Manpower requirements are high

System 2

SHIPBOARD BUCKET ELEVATOR (See Fig. 2)

This system consists of the following:

1. On each vessel –
   (i) A conveyor located in the floor of the passageway between the fish pens. It is provided with cover plates which allow the passageway to be filled with fish without loading the conveyor belt.
   (ii) A vertical bucket elevator. This raises the fish and ice from the discharge end of the above conveyor and dumps them onto a further conveyor at deck level for transfer ashore. This bucket elevator can be telescoped vertically so that it can be covered with a watertight hatch when not in use.

2. At the Fish Processing Plant –
   (i) A ship to shore conveyor for transferring the fish and ice from the bucket elevator into the fish plant. This elevator must be hinged at each end and free to move back and forth so as to accommodate both vertical and lateral movement of the vessel.
   (ii) A chute or other device for transferring the fish and ice from the discharge end of the above conveyor to the culling station.

The operation consists of removing one or more cover plates from the discharge end of the conveyor which is located in the floor of the fish hold, and then removing pen boards to permit fish and ice to tumble onto this conveyor. The conveyor then carries the fish and ice to the vertical bucket elevator which raises them to a level above the

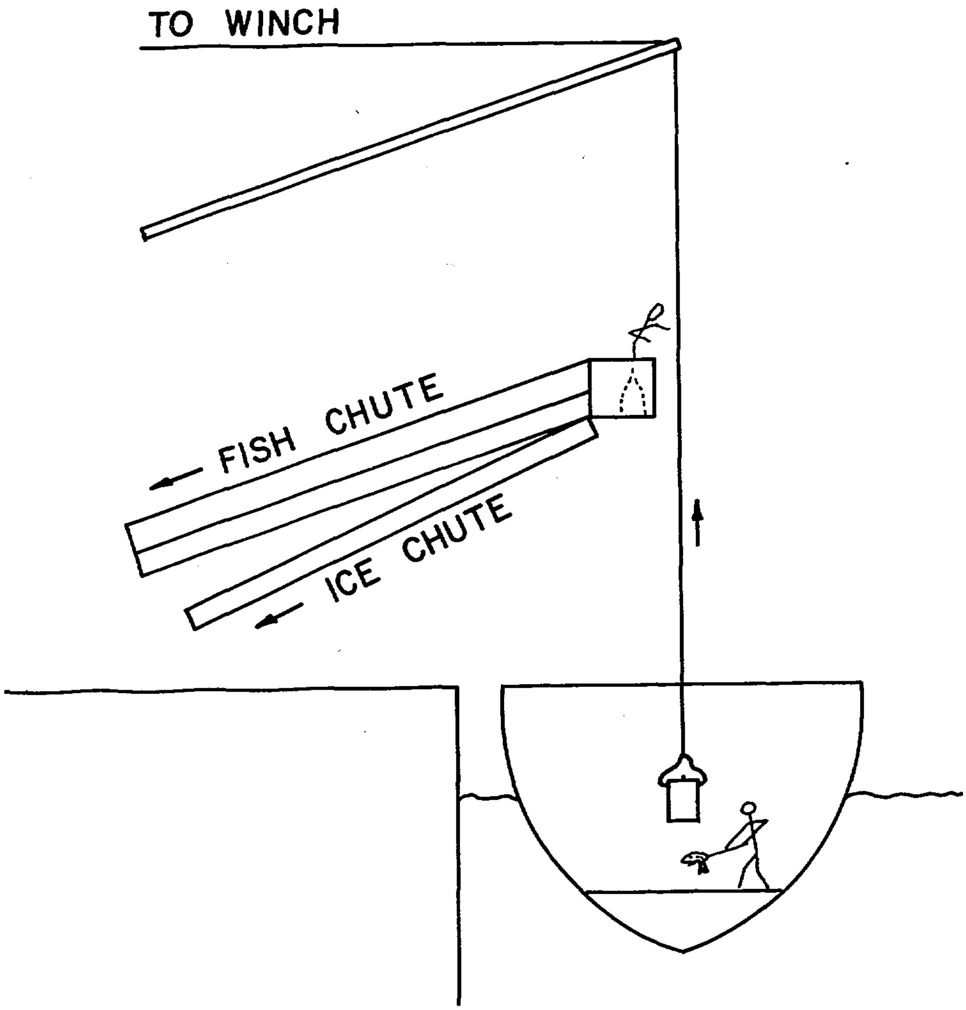

Fig. I TUBS and CHUTE

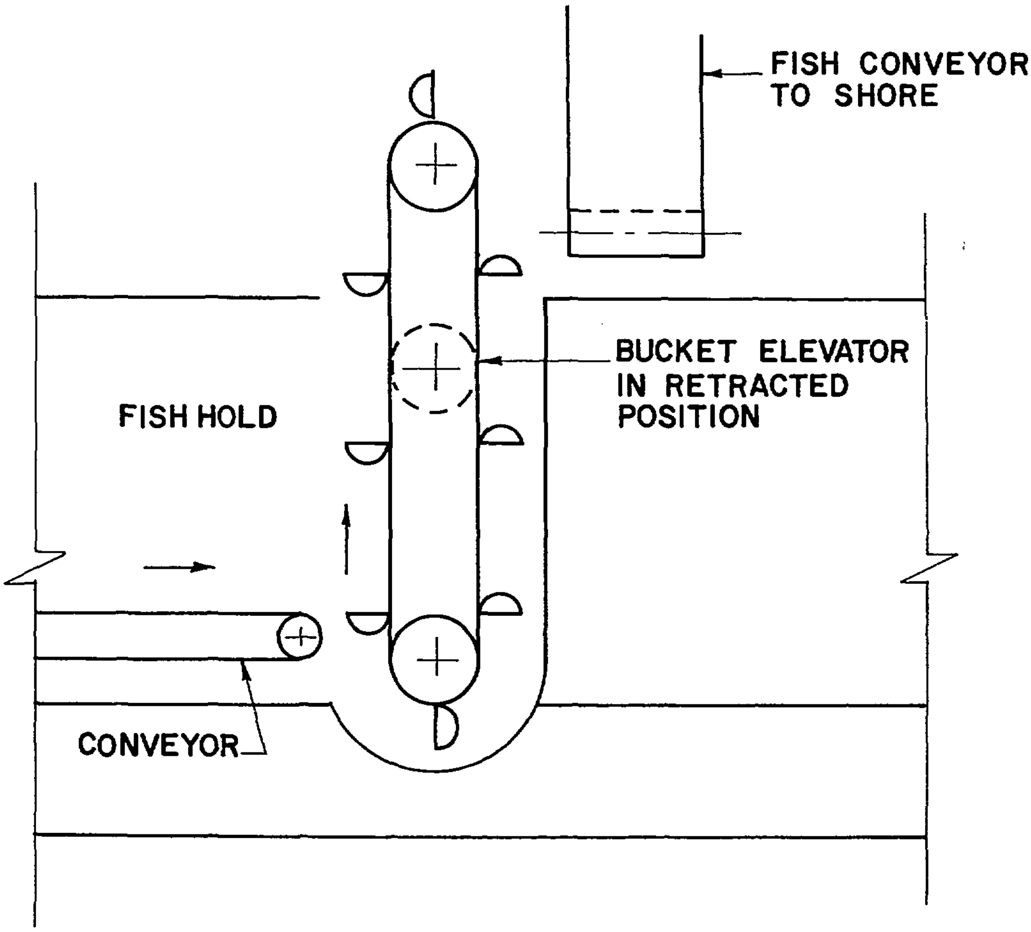

Fig. 2 SHIPBOARD BUCKET ELEVATOR

weather-deck. This latter elevator then dumps the fish and ice into the ship-to-shore transfer conveyor which carries them into the fish plant. The latter conveyor then discharges into a chute or other suitable device for transferring the fish and ice to the culling station. Once an initial quantity of fish and ice has tumbled from the fish pens onto the fish hold floor conveyor, it is necessary to manually place the remainder (which is by far the greater quantity), onto this same conveyor. As the passageway and pens are emptied, further covers are removed from over the hold conveyor and the above operation continued. The personnel required to operate the system are as follows:

In hold, loading floor conveyor and removing pen boards	–	5 men
Washing pen boards	–	2 men
Total		7 men

The main advantages of this system are:
(1) High Unloading Rate
(2) Can operate in all weather conditions
(3) Manpower requirements are low
(4) Unloading crew are all sheltered from the weather
(5) Can achieve limited separation of ice and fish

The main disadvantages are:
(1) Overall unloading costs are high
(2) Capital cost is high. *Approximately $22,200.00 per vessel, plus high installation costs (less subsidy).
(3) Equipment is complex and prone to breakdown
(4) Use is limited to vessels with special onboard equipment
(5) Tends to damage larger fish
(6) Occupies substantial onboard space
(7) Can unload from fish hold only
(8) Separate arrangements required for separating ice and fish
(9) Relatively high maintenance and cleaning expense.

*Onboard equipment per vessel – value $20,000.00 (35% paid by subsidy)

Onshore equipment per vessel – value $2,200.00

Total onshore equipment value is approximately $15,000.00. Assuming a 7 ship fleet, this works out to $2,200.00 per vessel.

A fleet of 7 vessels has been assumed throughout this paper, as it would require this many vessels to produce an annual catch of 30,000,000 pounds.

System 3

SHOREBORNE BUCKET ELEVATOR (See Fig. 3)

This system consists of the following:

(1) On each vessel:
   (i) A conveyor located in the floor of the passageway between the fish pens. This is provided with cover plates similar to System 2.
   (ii) A well located at the discharge end of the above conveyor to accept the bottom of a transportable bucket elevator.

(2) At the fish processing plant:
   (i) A transportable vertical bucket elevator which is stored onshore when not in use, and which is placed onboard leading from the fish hold to the weatherdeck when in use.
   (ii) A crane for handling the above bucket elevator
   (iii) A storage stand for the bucket elevator when not in use
   (iv) A ship-to-shore conveyor or chute for transferring the fish and ice from the discharge point of the bucket elevator to the culling station in the fish plant.

To operate the system, the bucket elevator is lowered into position and the ship-to-shore conveyor (or chute) placed in position. The remainder of the operation is then identical to System 2. The personnel required are as follows:

In hold, loading deck conveyor and removing pen boards	–	5 men
Washing pen boards	–	2 men
Total		7 men

The main advantages of this system are:
(1) Overall unloading costs are very low
(2) Unloading rate is high
(3) Can operate in all weather conditions
(4) Manpower requirements are low
(5) Unloading crew are all sheltered from the weather

The main disadvantages are:
(1) Capital costs are high. *Approximately $10,200.00 per vessel plus high installation costs (less subsidy).
(2) System is complex and prone to breakdown
(3) Use is restricted to vessels with special onboard equipment

(4) Tends to damage larger fish
(5) Occupies useful onboard space
(6) Can unload from fish hold only
(7) Separate arrangements required for separating ice from fish
(8) Relatively high maintenance and cleaning expense.

*Total onshore equipment value is approximately $36,500.00. Assuming a 7 ship fleet, this works out to approximately $5,200.00 per vessel. Value of onboard equipment for each vessel is approximately $5,000.00 (less 35% subsidy).

Section 4

AIR UNLOADER – BASIC DESCRIPTION (See Fig. 4)

A basic air unloading system consists of the following components: (See diagram– Basic Air Unloader).

1. A vacuum chamber to receive the fish and ice.
2. An exhaust fan to maintain the vacuum in the above vacuum chamber.
3. A hose or ducting for conveying the fish and ice from the vessel to the vacuum chamber.
4. A water seal to permit removal of the fish from the vacuum chamber without loss of vacuum.
5. Either a conveyor or flume for discharging the fish through the water seal.

On starting the system the fan will draw air from the vacuum chamber, thereby creating a partial vacuum in the unit. This partial vacuum will be maintained as long as the fan is kept running and will result in the following:

(i) A change in the effective head of water at the water seal to balance the partial vacuum.
(ii) A high velocity flow of air through the ducting from the inlet to the vacuum chamber.

Any fish and ice which are brought close to the inlet become entrained in this high velocity air flow and are carried along through the ducting into the vacuum chamber. At this latter point, the fish and ice separate from the air stream due to their momentum and/or gravity, the separation being assisted by the greatly reduced velocity of the air in the vacuum chamber. This reduction in velocity is due to the vacuum chamber having a much greater cross sectional area than the ducting. The fish and ice now drop into the water-trap where the fish sink onto the conveyor and are discharged from the unit. As an alternative, the conveyor may be omitted, and by changing the design of water outlet and increasing the flow of water, the fish can be flumed from the unit.

In a practical unit, it is evident that the above ducting must be smooth internally and all bends must have large radii. A further requirement is that the fish on entering the vacuum chamber should be gently decelerated before entering the water seal.

The following is a brief description of two units now being used by the fishing industry.

System 4(a)

AIR UNLOADER – (See Fig. 4a)

This system is very similar to the basic system described above. In this unit, the fish and ice enter the vacuum chamber at the top and separate from the air flow as previously described. The fish and ice continue on into the water seal striking the surface of the water at right angles while travelling at high velocity. The fish and ice settle through the water onto the conveyor and are then discharged from the unit.

This system works very well with the firmer varieties of fish such as shrimp, flounder and red fish. Unfortunately, it causes substantial damage to the softer fish such as haddock and cod. At least three plants on the Atlantic Coast have discontinued using this type of unloader due to the damage which is caused to these latter species. Two of these plants have replaced their units with the system subsequently described with completely satisfactory results.

The personnel requirements for a two unit system for simultaneous unloading through two hatches are:

In hold, feeding fish and ice to the units	– 8 men
Washing pen boards	– 2 men
Total	10 men

The main advantages of this system are:

(1) High unloading rate
(2) Low overall unloading costs
(3) Low capital cost – Approximately $32,000.00 total.
(4) Can operate in all weather conditions
(5) Simple construction – not prone to breakdown
(6) Unloading crew are all sheltered from the weather

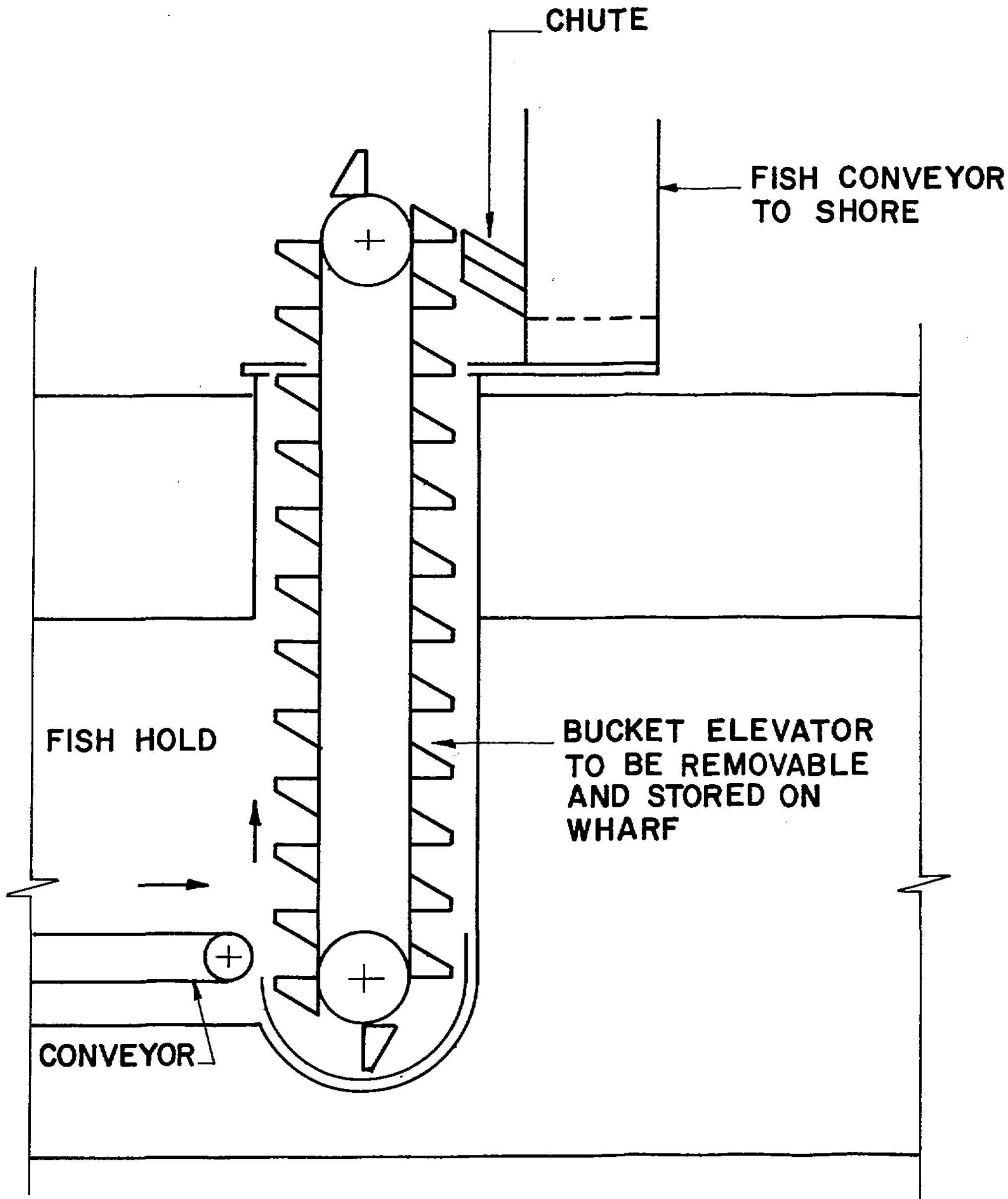

Fig. 3 SHOREBORNE BUCKET ELEVATOR

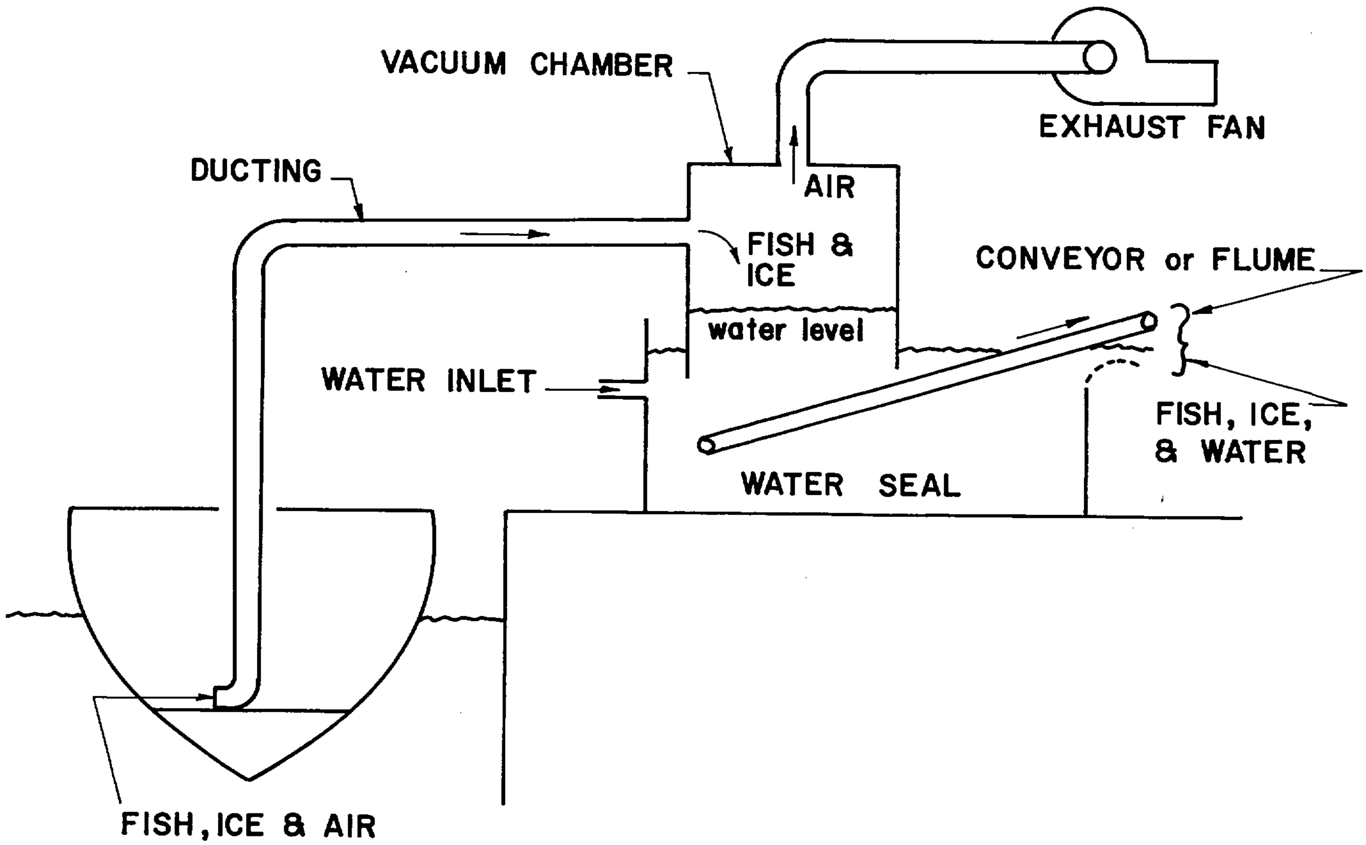

Fig. 4 BASIC AIR UNLOADER

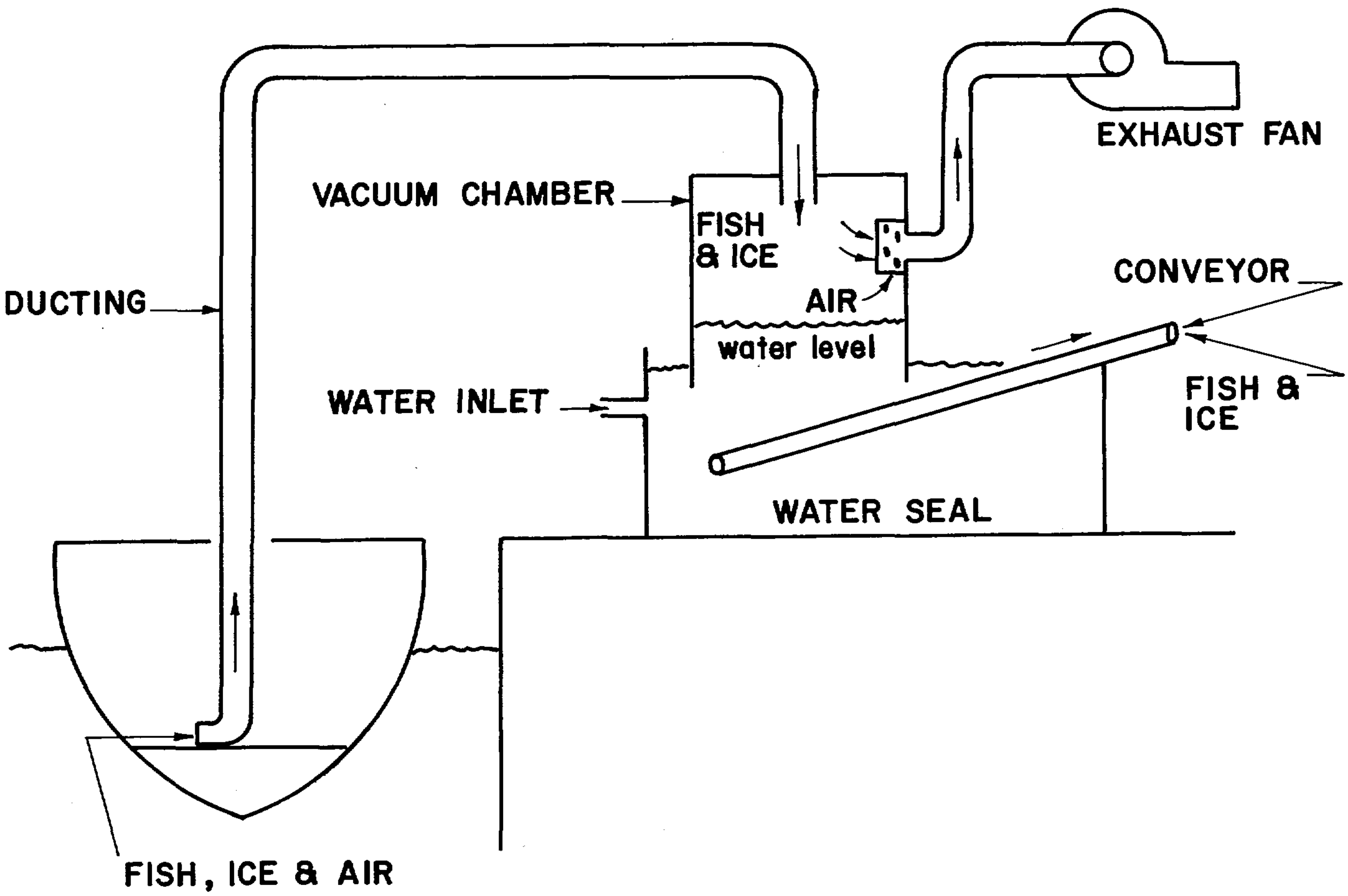

Fig. 4A AIR UNLOADER SYSTEM 4A

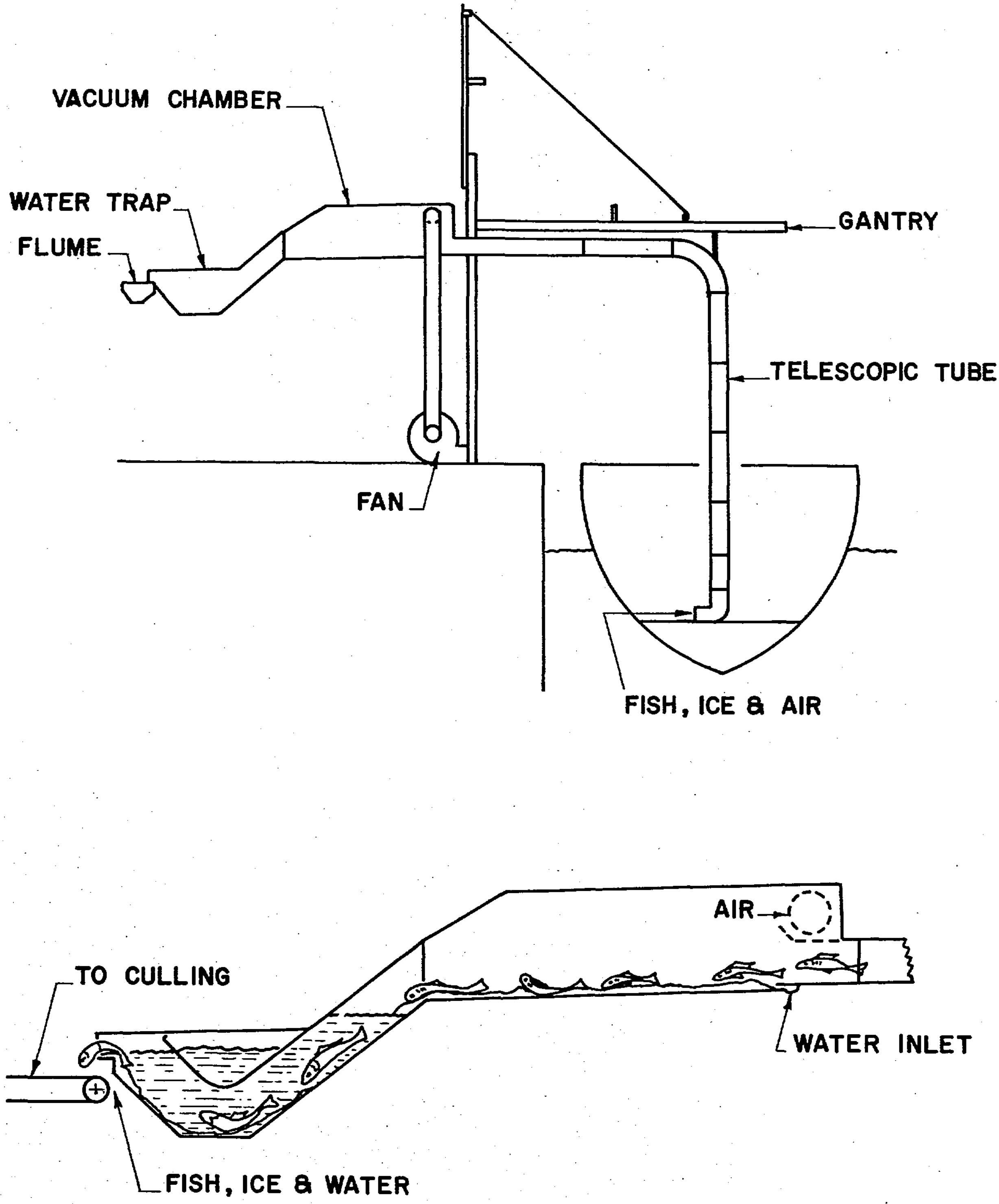

Fig. 4B AIR UNLOADER SYSTEM 4B

(7) Can unload any type of vessel
(8) Requires no onboard space
(9) Separates a substantial quantity of ice from the fish.
(10) Can unload from any location on the vessel

The main disadvantages are:

(1) Requires a larger crew than the elevator type unloader
(2) Causes substantial damage to cod, haddock and similar soft species.

System 4(b)
AIR UNLOADER – See Diagram

This system has been developed to overcome the damaging effect on softer fish which is inherent in other air unloaders. This has been achieved by building the vacuum chamber in the form of a rectangular box, the floor of which is covered with a stream of water. This water enters the chamber at the same end as the fish, then spreads uniformly over the floor and flows out through water trap at the opposite end of the vacuum chamber. The fish and ice enter the chamber at floor level and are gradually decelerated as they slide through the water stream towards the water seal. They reach the latter at a low velocity and meet the surface of the water at an acute angle where they flow on out through the water trap. The bulk of the ice is dissolved in passing through the system and the little that remains is easily removed at the culling station. On leaving the unit, the fish are deposited either directly on the culling belt or into a flume or conveyor to suit any particular plant arrangement.

The main advantages of this system are:
(1) High unloading rate
(2) Low overall unloading costs
(3) Low capital cost – Approximately $32,000.00 total
(4) Can operate in all weather conditions
(5) Simple construction – not prone to breakdown
(6) Unloading crew are all sheltered from the weather
(7) Can unload any type of vessel
(8) Requires no onboard space
(9) Separates practically all the ice from the fish
(10) Can unload from any location on the vessel
(11) Causes no significant damage to any species of fish
(12) Low maintenance and cleaning cost

The main disadvantages are:

(1) It requires a larger crew than the bucket elevator systems
(2) It requires a large volume of water.

APPENDICES

Cost Comparisons

Appendices 1 and 2 show a comparison of costs between the four systems, while Appendix 3 tabulates a comparison of their various features. In this latter appendix, the two types of air unloaders have been tabulated separately due to their difference in effect on the fish.

CONCLUSION

It is evident that no one system possesses all the desirable features, while at the same time having none of the undesirable features. Therefore, compromise must be used in making a selection. The selection of a system for any given establishment must take into consideration those features which provide maximum benefit to their overall operation including plant, vessels and personnel. From a consideration of initial costs, only the tubs and chute system appears really attractive. However, for plants handling around 30,000,000 pounds per year, its unloading costs are high. From a total unloading cost consideration, the shoreborne bucket elevator appears attractive, system despite its relatively high initial cost. This latter system, however, requires that all vessels should be specially designed and equipped with the required onboard equipment to accommodate the elevator. To change an existing plant and fleet to this type of system would appear to be impracticable and prohibitively costly. The same arguments would also apply for the shipboard bucket elevator system. The air unloading system does not require any modification to the vessels, and can be installed in most existing plants at modest cost. The latter would then appear to be the only practical system capable of offering high unloading rates to those plants having an adequate supply of water available. It can also be installed as a single unit for unloading through one hatch at a time. Unloading rates and capital costs would then be one-half those values previously stated. Single unit installations are now handling all the fish being landed at two large plants on the Atlantic Coast and are being installed in two additional plants.

APPENDIX 1 – Comparison of Unloading Labour Costs

Type of System	Maximum unloading rate lbs per hr.	Average unloading rate lbs/ hr.	Operating personnel					Average unloading rate lbs/ man hr.	Unloading labour cost per lb. @ $2.00/man hr
			In hold	On chutes	On winches	Washing pen boards	Total		
System 1 Tubs and chute 2 units working 2 hatches	24,000	18,000	8	2	2	1	13	1,390	$0.00145
System 2 Shipboard bucket elevator Single unit	50,000	30,000	5	–	–	2	7	4,290	$0.00047
System 3 Shoreborne bucket elevator Single unit	50,000	30,000	5	–	–	2	7	4,290	$0.00047
System 4 (A & B) Air unloader 2 units working 2 units working 2 hatches	44,000	30,000	8	–	–	2	10	3,000	$0.00067

Note: The labour rate of $2.00 per hour includes salary and benefits

APPENDIX 2

Comparison of Total Unloading Costs Based on 7 Vessel Fleet
Landing 30,000,000 Pounds Per Year

	System 1	System 2	System 3	System 4 (A & B)
1. Type of System	Tubs and chute (7vessels or more)	Shipboard bucket elevator (7 vessels)	Shoreborne bucket elevator (7 vessels)	Air unloader (7 vessels or more)
2. Approx. initial cost (less 35% subsidy on shipboard items)	$ 7,000	$100,000	$ 59,500	$32,000
3. Estimated maintenance and repair over 10 year period.	75% of above $ 5,000	100% of above $100,000	100% of above $ 59,500	75% of above $24,000
Total of (2) & (3)	$12,000	$200,000	$119,000	$56,000
4. Average annual cost to write off in 10 yrs. (Does not include interest on investment)	$ 1,200	$ 20,000	$ 11,900	$ 5,600
5. Equipment cost per 1,000,000 lbs. (Total landings assumed to be 30,000,000 lbs./year). (Does not include interest on investment)	$ 40	$ 670	$ 395	$ 187
6. Labour cost per 1,000,000 lbs. @ 2.00/hr.	$ 1,450	$ 470	$ 470	$ 670
7. Electricity costs per 1,000,000 lbs. @ 0.015/h.p. hr.	$ 5	$ 5	$ 5	$ 50
8. Water costs per 1,000,000 lbs.	–	–	–	$ *75
9. Total unloading costs per 1,000,000 lbs. (5 + 6 + 7 + 8)	$ 1,495	$ 1,145	$ 870	$ 982

* If clean salt water is available, this cost can be reduced or, alternatively, the water from the unloader may be used for offal fluming within the plant, thus reducing this cost figure.

This comparison chart does not take into account the cost of the capital investment required for each system, because various methods of financing are used by different corporations.

APPENDIX 3 – Comparison of System Features

Desirable Features	Rating				
	Tubs and chute System 1	Shipboard elevator System 2	Shoreborne elevator System 3	Air unloader system 4 (a)	Air unloader system 4 (b)
1. Low overall unloading costs	Poor	Poor	Best	Good	Good
2. High unloading rates	Poor	Excellent	Excellent	Excellent	Excellent
3. Low capital costs	Best	Poor	Good	Excellent	Excellent
4. Ability to operate in all weather	Poor	Excellent	Excellent	Excellent	Excellent
5. Reliable – not prone to failure	Excellent	Poor	Poor	Excellent	Excellent
6. Low manpower requirements	Poor	Excellent	Excellent	Good	Good
7. Crew sheltered from weather	Poor	Excellent	Excellent	Excellent	Excellent
8. Able to unload any vessel	Excellent	Poor	Poor	Excellent	Excellent
9. Little damage to product	Best	Good	Good	Poor	Excellent
10. Requires little onboard space	Excellent	Poor	Poor	Excellent	Excellent
11. Separates ice from fish	Good	Poor	Poor	Excellent	Best
12. Able to unload from any stowage	Excellent	Poor	Poor	Excellent	Excellent

The Role of Air Transportation in the Fishing Industry

by
F. R. Laflamme,
Manager, Air Freight Sales,
Air Canada

Born and educated in Ottawa, Mr. Laflamme graduated from Glebe Collegiate in that city. He has lectured at business administration schools in Montreal and London on Total Distribution.

He served five years in the Canadian Army in Canada and Northeast Europe; enlisted as private, and was discharged with confirmed rank of Infantry Captain.

Mr. Laflamme commenced work with the C.N.R. Freight Traffic Department in Ottawa in 1928, and also worked for that company in Toronto and Montreal. He transferred to Trans-Canada Airlines in 1949 as Supervisor of Rates & Tariffs, was appointed Cargo Sales Manager, Montreal, in 1952 and System Manager of Air Freight Sales in 1962.

He is keenly interested in sports and was Canadian cross-country ski champion in 1936. He is a former Director of the Ottawa Ski Club and the Ottawa Tennis Club, and a member of several championship basketball teams in the Capital. At present he is a member of the Montreal Traffic Club, Board of Trade, German Canadian Association and a Director of the Canadian Physical Distribution Association.

ABSTRACT

In this paper the author makes the distinction between marketing and sales. He then goes on to explain how improved air transportation can greatly assist the fishing industry in these areas. He also describes how air freight with new techniques and methods can broaden the market and increase the demand for fish, particularly for the fresh groundfish species. This is achieved by more efficient and attractive packaging, speedy movement to the markets and more efficient refrigeration techniques. Finally he states that the air transportation industry is fully prepared to provide dependable transportation for seafood products to all markets of the world.

MAIN FACTORS

A recent definition of the terms "marketing" and "sales" might be worthy of consideration. It was stated that marketing involved the production and sale of a product designed to meet the customers' needs. Sales, on the other hand, represented the attempt to convince customers that they required the commodity produced. To illustrate, recently the chairman of the company with which I am associated stated that in future we would place a greater stress on marketing the products we offer to the travelling and shipping public.

This policy decision developed after a thorough review of the company's operations, which indicated that individual departments were establishing objectives which actually conflicted with the overall company objective. What in fact happens in a company such as ours is that we end up with a product designed to meet our limitations and requirements, with the sales people allocated the task of convincing the public it is an attractive purchase.

While the initial steps might be more complex, the long range results would be considerably more beneficial if the customers' requirements were kept constantly in the forefront through all phases of the company's operations, including extensive research of the market to ensure that the requirements are in fact understood.

I am confident if we examine the past history of the fishing industry we would find a parallel to our own experience. I do not think it can be denied that, generally speaking, the public has been offered a product that evolved from the limitations of the industry as it exists today. To the best of my knowledge, it is only in the recent past that any extensive research related to the customer has been undertaken.

Let me give a specific example. Some five years ago I was informed by leading producers that by 1970 there would be no demand for fresh fish in Canada, but that the housewife would be purchasing the frozen variety exclusively. Recent research studies indicated that the demand for fresh fish has grown extensively, with the result the industry is just now searching for better ways to meet this requirement. I think we can all agree that the per capita consumption of fish in this country would have increased significantly if the customers' requirements had been recognized several years ago.

I would like to suggest that, while this is basically a technical seminar, we are actually engaged in the initial stage of marketing with an overall objective of delivering to the retail stores of the world a product that will prove attractive to the potential buyer and one he has a desire to purchase. The mere fact that you have invited the airline industry to participate indicates to me that the prime objective has been recognized and fast transportation has a part to play in reaching our goal.

The air industry has already given some indication of the role it can play in creating more benefits to the consumer. I use the latter term deliberately, because as a salesman I have learned we can only be successful in creating a desire for our products if we can convince the customer he has something to gain by the purchase of our service.

Using Canada as an example, perhaps the most significant part we have played is the elimination of the distance factor. Because they are only literally hours away, new markets have been opened up for various varieties of seafood. Demands have been met for lobsters, shrimp, crab and even groundfish that could not be supplied by surface transportation. In addition, interior markets in North America are now offering fish in much better condition than was previously available. The mere fact that fish processed as late as Tuesday or Wednesday can still be marketed almost anywhere on this continent permits greater flexibility on the part of the processor and puts a better product before the consumer.

Last, but not least, is the fact that fast transportation can result in a more healthy industry. A better product with a wider marketing area produces more revenue, which in turn releases more capital for modernization of plant and equipment. Again, this cycle can only be beneficial to the consumer who will have available to him an ever improving product.

We in the air industry are confident that we can fulfil our obligation of keeping abreast of increasing transportation requirements during the coming decade. I am frank to admit that seafood products are attractive to the airlines. While considerable capital outlay is required to ensure their safekeeping and they also must be handled with a high priority, these factors are more than offset by the density of the commodity, which fact is reflected in the attractive low rates we have established.

We have already made considerable headway in our efforts to provide safe handling of this perishable commodity. Cold rooms have been established at most major airports, and in so far as my own company is concerned these are incorporated as modifications to current terminals or when new buildings are planned.

Tests are continually underway to ensure that the main body as well as the compartments in our aircraft maintain suitable temperatures for the movement of fresh fish products.

During the past year the airlines have successfully moved full plane loads of frozen shrimp across the Atlantic. The ability to lower the cabin temperature, together with the volume involved resulted in the product arriving at destination with a minimum change in temperature. However, we fully recognize the urgent need to provide suitable space to move smaller lots, and experiments are well advanced towards this end.

We are currently looking at a self-refrigerated container which has refrigeration units providing for temperatures ranging from -10 to 60 Fahrenheit. This would be of 6000 pound capacity and shaped like our regular igloo containers. The lack of regular, international, refrigerated steamship service increases the need of the airlines to fill this vacuum. It would be quite reasonable to assume that the two units which fit into the insulated igloo could be loaded at the shipper's plant and thereby eliminate the requirement for refrigerated truck transport to the airport. Similar handling could of course be provided at destination.

Perhaps the greatest contribution towards making air transportation more viable has been accomplished by our associates in the packaging trade. They have met the challenge of supplying suitable containers for handling such products as lobsters, crab, fresh shrimp, eels and whole round fish such as salmon. Their research departments have been hard at work for the past couple of years to provide an ideal carton for the transportation of fresh ground fish fillets. Recent experiments indicate their efforts have been successful, and it is apparent that we are now in a position to move the bulk of the fish destined to interior North American markets by air.

I believe this seminar indicates that the technical people employed in the fishing industry, and I use this term in the broad sense to include all those involved from the sea to the retail counter, are playing their part in the total marketing task. Speaking from the salesman's point of view, I can say the end result will greatly simplify his task because he is being asked to dispose of a product that the customer will want to buy. As spokesman for the airlines, I can confidently state that we are ready, willing and able to play our role as a dependable medium for the transportation of all seafood products to the markets of the world wherever they may be.

Warehousing of Fishery Products

.Mr. Hayes

by

W.F. Hayes,
President,
Winnipeg Cold Storage Company, Limited

Mr. Hayes is President and Director of the Winnipeg Cold Storage, Canadian Northland Foods, Manitoba Cold Storage and Fish Services (1963) Ltd. He is also National Vice-Chairman of the Refrigeration Sector of the Canadian Warehousing Association. He was a graduate of the University of Saskatchewan in 1947, having obtained a B.Sc. degree in Mechanical Engineering. He is also a qualified first class Stationary Engineer. He is a member of the Engineering Institute of Canada, the Association of Professional Engineers of Manitoba and the American Society of Heating, Refrigerating and Air Conditioning Engineers.

Mr. Hayes has spent 20 years in the food industry, including design, construction and operation of processing and cold storage facilities. He lives in Winnipeg and is married, with a family of four children.

ABSTRACT

This paper selects various developments in the operation of a cold storage warehousing facility, and cites their adaptation to the processing and holding of fishery products. Experience in the processing and preservation field indicates the trend toward the integration of storage and processing facilities, with the final goal being to achieve economic advantage, with a quality product which is more diversified and acceptable to the consumer.

INTRODUCTION

Warehousing of fish and fishery products generally requires the warehouse operator to perform one or more operations necessary to provide the industry with the service it requires to produce a quality product. In many cases the warehouse complex provides the service from boat hold to consumer. Facilities which can be utilized on a "when required" basis can in most cases provide an economic advantage to the fishery. From the fresh handling of fish through to the freezing processes and then to storage, utilizing various media and methods, they are of prime importance to the industry, and in the past few years significant progress has been made in all areas of fish production. Considerations must be based on total cost concept; that is, every cost must be taken into consideration, from the harvest to ultimate consumer, keeping in mind of course that quality of product should always maintain precedence.

Developments in cryogenic, immersion, blast freezing, all tend toward this end. Each method will certainly make its mark and have its place in the many and varied facets of the fishing industry.

Operational procedures and physical features in warehousing, from the engine room where automation is making great strides in economics, as well as contributing to the quality control of the product, to the sophisticated materials handling arrangements, all contribute to increase the use of our natural resource, through offering good quality food products to the consumer, at the same time maintaining an economic balance between market supply and production, a problem which has plagued the food industry for many years.

HANDLING AND STORAGE

The practice of processing plants linking up with large cold storage facilities is a recent trend which offers many advantages to a processing company. Because of the flexibility of large complexes it is much easier for the large plant to adapt itself to new and better methods of storage, handling and freezing of fishery products, where alone it generally affords less economic advantage for the fishery.

With a definite trend toward lower freezer holding temperatures, products leaving these areas are more vulnerable to atmospheric conditions on docks and during transportation, where the dew point temperature of the air is higher than the surface temperature of the product or its package. When this occurs condensation on the surface results. This takes the form of ice crystals and, dependent on the length of time and temperature, may form into free water. When conditions such as this exist and it is not possible to keep the product from being subjected to the warmer air, controlled atmosphere space to temper the product exterior is necessary. Again, depending upon the condition of the atmosphere and the time the product is subjected to same, the exterior of the package should be brought to a point past the dew point in the atmosphere it is moving to. Tempering, of course, means delay and possibly extra expense. However, it may be better to have a delay than wet soggy cartons or snow covered product, resulting in poor acceptance by the consumer.

Machinery used in handling and stacking of fishery products is dependent on physical features of the plant. Many types of lift trucks are available and the most common are the stand-up pallet trucks, walkie pallet trucks, sit-down fork lift trucks and stand-up fork lift trucks. The motive power used to operate this type of equipment should be supplied by chargeable batteries, because of the absence of fumes from exhaust gases, which in the confined space of cold storage rooms will concentrate and adversely affect the product and personnel.

Handling of fishery products to and from cold storage areas should be an integral part of the total process. To effect cost reduction and improve quality from the fresh fish state to the consumer package, the integration of processing and effective handling must be as one to ensure the best result. Between each stage of processing or distribution the product is handled in one form or another, and in almost all cases quality is the item which is affected most by whether or not the handling is carried out in a proper manner.

Palletizing of fishery products, whether with cartoned units from a production line, or box type holding loose product, has the very distinct advantage of being adaptable to each step of the total process of the storage, transportation and distribution chain.

It affords the most economical means of handling product, whether it be palletized for delivery to further processing, or unitized for export shipment.

One of the main difficulties with palletizing and unitizing loads has been the problem of adequately stabilizing the material placed on the pallet, especially when they are subjected to high rates of acceleration and deceleration.

Shrink wrapping of palletized loads, using a polyethylene film, may be an effective way of improving quality of fish product during storage, as well as being a handling asset in regard to stabilization of unitized loads. The polyethylene film available in various mil thickness is slipped over a palletized load and passed through a heat shrink tunnel, anchoring the load to the pallet, as is shown in Figure 1. It is claimed that the heat does not have any effect on the product because of the short time it is subjected to heat in the shrink process. The cost of equipment necessary for this operation can be spread over many types of goods where the processing and storage is done in large warehouses, and will make the application more feasible in regard to fishery products.

Advantages which are claimed are as follows:

1) the film is transparent and allows for easy checking;

2) less pilferring takes place;

3) packaged pallets are more carefully handled because of their neat appearance;

4) load is fully stabilized, omitting strapping, gluing and banding.

Extensive testing, to my knowledge, has not been made on the shrink wrapping and holding of fishery products; however, film is being used with excellent results on meat