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INTERNATIONAL COUNCIL FOR THE
EXPLORATION OF THE SEA

C.M. 1980/B : 2
Fish Capture Committee

REPORT OF THE WORKING GROUP ON RESEARCH AND ENGINEERING ASPECTS OF FISHING GEAR, VESSELS AND EQUIPMENT

(Meeting 1980)

* General Secretary, I.C.E.S.,
Palægade 2-4, DK 1261 Copenhagen K
Denmark

[redacted]

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Exploration of the Sea

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REPORT OF THE WORKING GROUP ON RESEARCH AND ENGINEERING ASPECTS OF FISHING GEAR, VESSELS AND EQUIPMENT

(Meeting 1980)

Convenor and rapporteur	:	E.J. de Boer Netherlands Institute for Fishery Investigations, IJmuiden - The Netherlands
Meeting time and place	:	5 and 6 May, 1980 Reykjavik - Iceland
Terms of reference	:	C. Res. 1979/2:13 (a) The Working Group on Research on Engineering Aspects of Fishing Gear, Vessels and Equipment, convened by Mr. E.J. de Boer, to evaluate technical aspects of fishing gear, fishing vessels and fishing methods, with special reference to energy consumption of different types of fishing methods and possible ways of energy saving.

This report has not yet been approved by the International Council for the Exploration of the Sea; it has therefore at present the status of an internal document and does not represent an advice given on behalf of the Council.

The proviso that it shall not be cited without the consent of the Council should be strictly observed.

*) General Secretary, I.C.E.S., Palægade 2-4, DK-1261 Copenhagen K, Denmark.

PARTICIPANTS

Belgium	
G. van den Broucke	Fisheries Research Station - Ostend
Canada	
R.H. McIlwaine	Department of Fisheries and Oceans-Vancouver
France	
G. Kurc	Institut Scientifique et Technique des Pêches Maritimes - Nantes
J. Prado	" " - Lorient
J.C. Brabant	" " - Boulogne sur Mer
Fearöes	
B. Thomsen	Fiskirannsöknarstovan Debessartrød-Torshavn
Federal Republic of Germany	
G. Freytag	Institut für Fangtechnik-Hamburg
K. Lange	" " "
H. Hirschle	Dornier GmbH-Friedrichshafen
P. Pfeifer	Technical University-Aachen
Finland	
M. Törmä	Wärtsilä Turku Shipyards-Turku
Iceland	
G. Thorsteinsson	Marine Research Institute-Reykjavik
G. Gurnarsson	Hampibjan H.E.-Reykjavik
A. Agústsson	Fisheries Association of Iceland-Reykjavik
Netherlands	
B. van Marlen	Netherlands Institute for Fishery Investigations-IJmuiden
E.J. de Boer	
Norway	
A. Endal	Institute of Fisheries Technology Research
I. Bjørkum	" " " Trondheim
S. Olsen	" " " Nordnes
B. Isaksen	" " " "
A. Bredesen	" " " Tromsø
Poland	
S.J. Richert	Sea Fisheries Institute-Gdynia
U.S.A.	
J.B. Soomala	C.S. Draper Laboratory-Cambridge, Ma
A. Blott	National Marine Fisheries Service Gloucester Laboratory-Gloucester, Mass.

United Kingdom

P. Stewart	Marine Laboratory-Aberdeen
D.N. MacLennan	" " "
R.E. Craig	" " "
C.S. Wardle	" " "
M. Hatfield	White Fish Authority-Hull
D.A. Wileman	" " "

U.S.S.R.

E. Postnikov	Department of Commercial Fisheries,
G. Guennadi	Ministry of Fisheries of the U.S.S.R.-Moscow

F.A.O.

J. Schärfe	Fisheries Department-Rome

AGENDA

1. Progress reports

2. Presentation of papers, films and video-recordings and verbal contributions

   2.1. Estimated fuel saving potential in Norwegian fisheries
   Anders Endal

   2.2. Fuel consumption of the Icelandic fishing fleet
   A. Augustsson and E. Ragnarsson

   2.3. Fishing vessel speed and fuel economy
   Torbjørn Digernes and Anders Endal

   2.4. Certain problems concerning fuel consumption of small fishing trawlers
   Józef Krępa and Marian Szatybelko

   2.5. Presentation of films on
   - Automated long-lining (W.F.A.-U.K.)
   - Modeltests with rope trawls on scale 1:4 (F.R.G.-Neth.)
   - Icebreaker operating in Antarctic winter conditions (Finland)

   2.6. Report of the expert group meeting in Aberdeen (5-7 February 1980) on the Draft Code of Practice for the Conduct of Fishing Gear Experiments (C.Res 1979/2:14)

   2.7. Presentation of video-tape recordings on
   - The behaviour of trawls in action and the reaction of fish to the approaching gear
     C.S. Wardle
   - Modelexperiments with a tuna purse-seine
     Joël Prado

   2.8. Engineering trials with a conventional and a rope trawl of 2700 meshes circumference
   David N. MacLennan and Bob van Marlen

   2.9. Preliminary report of the blue whiting fishing experiments east/south-east of the Faroe-Islands in Jan-March 1980
   Stein Hjalti i Jakobstovu and Bjørnur Isaksen

   2.10. Problems encountered in the correlation between the results of engineering performance trials of full scale trawls at sea and scaled model trawls tested in the White Fish Authority Flume Tank, Hull
   D.A. Wileman

2.11. An investigation into the towing drag and design of a pelagic net
H. Hirschle and H. Pfeifer

2.12. Scallop drag tests and development
Alan J. Blott and Vernon E. Nulk

2.13. A new era for krill catching is dawning
Matti T. Törmä

2.14. Latest development on gear instrumentation
Peter Stewart

2.15 Model experiments on rope trawls, scale 1:4
Bob van Marlen

3. Recommendations

Progress reports - agenda item 1.

Objective of the progress reports is to inform the participants about recently started and planned activities by member countries in the fields of gear technology, equipment and vessel development.

Belgium

A new type of bobbin-groundrope for shrimptrawls was tested. The bobbins are of rubber and connected to a chain. It is expected that this type of bobbin-groundrope will have a better resistance against abrasion.

Comparative fishing experiments with beamtrawls were furthered.

Three types of semi-pelagic nets in combination with two sweep systems were tested for the coastal fleet.

The potentials of oval otterboards (polyvalent-type) were tested for application in coastal fisheries.

Polyamid and Polyethylene yarns were tested on their elongation/ shrinkage characteristics after repeated moistening and drying. It was reported that in Belgium about 65% of the synthetic yarns used in fisheries are of Polyamid. The remainder 35% is Polyethylene. The I.S.O.-standards for yarn, etc are only used by the Fisheries Research Institute.

An on-board flatfish grader of Dutch design was tested.

The development of an underwater, battery powered pulse-generator for shrimp fishing was started. This generator will be put into the operation mode by means of a pressure switch.

A study into the possibilities of saving energy onboard fishing vessels is planned.

Canada

In Newfoundland a trial with bottom-set long-lines fishing for cod was carried out. The objective was to compare the hooking rate of spun nylon and monofilament gangions (snoods). The monofilament gangions yielded 47.5 fish per hundred hooks as compared with only 19.1 for the spun nylon gangions.

Trials with a rope-wing midwater trawl in contact with the seabed when fishing for cod were not successful. Although the netsounder indicated that the net behaved properly and even though commercial trawlers caught cod with bottom trawls in the area the catch of the rope-wing midwater trawl was almost nil.

Comparison of ship sounder with netsounder traces indicated that cod was avoiding the trawl.

Squid jigging experiments were conducted in the Halifax region by two 12 metre inshore vessels. For commercial demonstration these vessels were fitted with automated Japanese equipment.

In the New Brunswick area pair bottom trawling with inshore vessels was demonstrated. The pair trawl was twice as large as the net towed by single boat operation.

The development and promotion of stern drum seining on the east-coast continued with the outfitting of a 13.5 metre vessel.

Both for commercial operation and for demonstration a 13 metre Norwegian fibreglass sjark class vessel has been fitted with a full shelterdeck and a complete 11.000 hook Mustad Autoline-system.

On the west coast a proto-type of a combination midwater/bottom door was tested. This door has features of both the German Süberkrüb- and the French Portier-door. The aspect ratio is 1.3 and the tow plates are fully adjustable.

The development of rope trawls was furthered. Tests were carried out with pressed aluminium eyes and spliceable ropes of 7/8" and 9/16" diameter.

The development of an escape mechanism for lost traps in the black cod fisheries has started. Practice has shown that the normally used cotton panels last too long.

A project has started to catch rock fish onboard a 25.5 metre combination seiner/long-liner with the Mustad Autoline-system on hard bottom ground in the area of the Queen Charlotte Islands. The latter system is housed in an aluminium container which in off-season can be stored onshore.

Experiments with hexagonal meshes in salmon seiner are planned.

Trials and demonstrations with very large mesh trawls are planned.

Finland

Full scale trawling experiments in ice conditions were conducted onboard the Finnish ice-operating trawler "Järvsaar". This 30 metre vessel with a propulsive power of 1000 h.p. can, when the ice coverage is less than 80 percent, operate in 30 cm pack ice. The operations in solid ice is restricted to 5 cm ice thickness.

Model tests with trawling under the ice in different ice conditions were started. These tests revealed that operation in solid ice up-to 30 cm thickness is feasible. Depending ice coverage ratio, in pack ice of up-to 50 cm can be trawled.

Model and full scale experiments were carried out with the "Wärtsilä Air Bubbling System" (WABS) for clearing the aft area of the stern of ice blocks when shooting and hauling the gear.

Model tests were conducted to locate the optimum position of the sonar onboard ice operating fishing vessels.

A proto-type of a year-round operating krill factory trawler was designed. The onboard processing lines will deliver peeled krill, krill meal and krill oil.

France

The very large mesh two-boat midwater trawls are fully introduced in the coastal fleet. Small trawlers up-to 600 h.p. use these gears successfully.

In 1979 a new type of rigging permitting bottom trawling in shallow waters with this type of trawls was developed. In this rigging four doors are used. In addition to the two commonly used otterdoors two small midwater doors of the Süberkrüb-type are positioned at the ends of the upper sweeps. The main advantage is that it is not necessary to change doors when changing over to bottom trawling.

The shrinkage of polyamid webbing is contineously creating problems for especially the fishermen fishing for Nephrops. Special attention is given to this problem.

A new type four panel high-headline bottom trawl is tested in the Mediterranean. The top panel and the upper part of the side panels is constructed of 800 mm meshes. The webbing of the lower panel and the bottom part of the side panels has a meshsize of 200 mm.

In co-operation with the Institut für Fangtechnik (Hamburg) comparative fishing experiments were carried out in the English Channel onboard the German FRV "Solea". Objects of comparison were a German rope trawl and a French trawl with very large meshes. These comparative experiments will be continued in June 1980 in the Baltic Sea.

The results of tests with a sorting panel for Nephrops rigged inside an ordinary bottom trawl were encouraging.

In the sardine fishery in the Gulf of Biscay traditionally purse-seines with a floatline length of 200 to 300 metres are used. The theoretical depth of these seines is 60 metres. Measurements under commercial operation revealed an actual depth of 23 metres; the sinking speed was in the order of 10 to 20 metres/minute.

A Norwegian and a French type of long-line were tested.

A distant-water trawler made in October/November 1979 an exploratory krill fishing expedition during which both bottom and midwater trawls were tested.

The performance of scale models (1:40) of tuna purse-seines were observed in a basin.

The construction of several 1:20 models of doors has started. These doors will be tested when in operating with a model of a trawler.

A sailing vessel for tuna fishing (trolling) is under construction.

Federal Republic of Germany

The tests with models of trawls on scale 1:4 in the Mediterranean were in 1979 directed to the performance of rope trawls. Research subjects were rope trawls and spherical otterboards.

In the Waddensea area experiments to catch grey mullets with gill nets (PA monofilament) were carried out.

The development of an electrified gear for catching sole was finalized. The research and development activities will now be directed to catch plaice with an electrified system.

In co-operation with the I.S.T.P.M. (France) the differences in catching and engineering performance (e.g. resistance) of a rope trawl and very large mesh trawl were studied.

In the Baltic Sea experiments were carried out to catch cod with two-boat midwater trawling. One of the main objectives of these experiments was to establish the level of fuel saving which can be obtained with this method.

Gillnet fishing was further introduced into the coastal fleet. Adaptation on the local hydrographic conditions was necessary.

The (further) introduction of low-energy fishing methods as anchor seining and long-lining (cod) are in the planning stage.

An automation project has been carried out in an eel farm which uses the cooling water of a power plant.

During three cruises of the New-Zealand project mesh selection experiments were carried out.

The integrated fishfinding system (sonar-echosounder-netsounder) is installed onboard the FRV "Walter Herwig".

The report of the 1978/79 Antarctic Expedition is finalized. One of the interesting observations is that krill could be detected by standard 30-33 kC sounders.

Windtunnel tests on sheet webbing were carried out by the University of Aachen and the Dornier Aircraft Company.

Iceland

Experimental fishing on blue whiting was carried out with rope trawls and high-headline bottom trawls. The handling of the rope trawls created problems. The amount of catch was in some cases much less than could be expected when examing the echosounder traces. At the various fishing grounds the blue whiting showed different behaviour patterns.

Performance measurements of different types of otterboards were carried out. Among others, the door- and wing-end spread of the gear was measured.

Selectivity experiments with four-panel prawn trawls were carried out. The selection factor of 40 mm codend meshes was determined. It was observed that only a few prawns escaped in the wings.

The catching of squid by midwater trawls was tested. Due to incorrect meshsize in the belly part of the gear many squids meshed in that area. The squid, which only frequents the area every 5th or 6th year, is mainly used as long-line bait.

Various types of fishing materials, e.g. purse-seine netting, has been tested.

An experiment to catch blue whiting by high-headline trawls is in the planning stage.

The Netherlands

The research group developing an efficient electrical barrier which prevents fresh water fish to enter the cooling intake and/or discharge systems of industrial plants studied and analized the behaviour of small fishes (5 and 8 cm length) in electrical fields. These behaviour studies were carried out in a small flume tank (6m x 0.8m). Under optimum conditions 95 percent of the fishes did not pass the electrical barrier.

The prototype of the flatfish grader was further tested on board a powerful commercial beamtrawler fishing in an area where the composition of the catch and the condition of the seabed differed from previous tests. In addition to research into the influence of the grader on the survival rate of discarded flatfish also technical and ergonomical research was carried out.

Research was carried out into the possibilities and conditions of using heavy and blended fuel oils for the propulsive machinery of different types and powerranges of fishing vessels.

In 1979 the activities in relation to catching flatfish species by means of electric stimulation were limited to the development of a new type of pulse-generator and analysis of the results obtained in recent years.

The study into the application of multi-chine hull forms was continued. The parameter study to be used when designing the optimum (beam) trawler was extended with data of 16-27 metre vessels. As a result this study covers vessels in the 16-40 metres range.

The geometry of rigging and net-opening of a rope trawl from the D.D.R. and a large meshed trawl of almost identical dimensions were studied during a cruise of the FRV "Tridens" in which also staff and instruments of the Marine Laboratory, Aberdeen participated. During this cruise also new developed and converted instruments for gear performance measurements were further tested.

In co-operation with the Institut für Fangtechnik, Hamburg model research on models (scale 1:4) of rope trawls was carried out. Model research on a 1:10 scale model of a Dutch roundfish trawl designed for an area with sandridges was carried out in the flume tank of the Fisheries Training Centre, Hull. In addition the full scale gear was tested during instrumented gear trials in said area.

Experiments with Danish pair seines were carried out and this relatively selective and low-energy fishing method was further introduced in the fishing industry.

Technical research in the field of mussel farming was directed to further improve the hydraulic transport of mussels from the seabed into the hold.

In co-operation with the diving team of the Marine Laboratory, Aberdeen observations of a high-headline roundfish trawl for fishing cod in area's with sandridges and a beamtrawl were recorded on video-tape. Also some reactions of fish to the approaching gear and in the net were observed.

Norway

Gear research and development and related subjects

The study into the parameters of influence, among others hook shape, on the efficiency of long-lines was furthered. Experiments with the wide-gap hook, of which the point of the hook is directed to the attachment of the snood, showed a 30 percent increase in catch-rate of ling and tusk.

The influence of hook- and bait size on the selectivity was studied.

The Mustad Autoline system is fully in operation onboard larger vessels. A smaller version, the Mini-line system, is in the prototype stage.

Because of the growing interest in squid trials with squid jigging machines of Norwegian design were carried out.

In the field of gillnet fishing the influence of the amount of floatation, haging ratio, etc on both the selectivity and the catch rate was studied.

Research to limit the catch of fish by lost gillnets, the so-called "ghost-nets", is in the planning stage.

The influence of the netting material on the quality of the catch is subject of a study.

In Nephrops fishing baited pots and hauling systems are introduced.

In the trawling sector of the industry the main effort was directed into a joint project of Iceland, Far Oer and Norway in blue whiting fishing. In this project a midwater trawl was used of which the front part consisted of braided hexagonal ropes.

In co-operation with the Marine Laboratory (Aberdeen) in the summer of 1980 pair trawling experiments in the North Sea will be carried out.

The development work on a shrimp sorting trawl has been finalized. At the moment tests are conducted to determine the effect of the sweep length on the by-catch of fish during shrimping.

The purse-seine with hexagonal meshes is in use or on order for several commercial vessels. This new type of purse-seine proved very successful when catching capelin. The main advantages are: the weight of the nylon is reduced by 15.5%; the same sinking speed can be obtained with about 67% of the weight (lead) and the hydrodynamic resistance is less.

The development of mechanized nethandling systems onboard purse-seines is extended to larger vessels.

Vessel research and development and related subjects

The activities in this field are directed to (A) the design of new vessels, (B) the safety and working conditions onboard and (C) the energy efficiency of fishing operations.

ad.(A) designing of fishing vessels
deck machinery for gear handling systems
catch handling and storage systems

ad.(B) seaworthiness and seakindliness studies
safety and lifesaving equipment
wheelhouse lay-out and instrumentation
noise reduction
accident analysis

ad.(C) energy economy
resistance and propulsion
machinery systems
waste heat recovery

United States of America

Gear research and fish behavior studies in the U.S. are carried on by the National Marine Fisheries Service (N.M.F.S.), state agencies, universities, and individuals. Much of the work is involved with conservation gear, sampling gear, gear efficiency and technology transfer. Following are some of the projects under-way in various parts of the U.S.

Massachusetts Institute of Technology is planning comparison studies of the hydrofoil door for this summer. The doors are currently being commercially produced. Aluminum trawl doors for shrimp trawls are being developed, and the development of a semiautomatic trawl door hookup has been completed.

Studies on large mesh and rope trawls are planned in conjunction with Massachusetts Maritime Academy. In addition, Massachusetts Maritime Academy is testing a modified Boris Goshawk to determine its performance on hard bottom and is working on a towed camera vehicle for observing trawls.

In Virginia, midwater pair trawls have been introduced for the bluefish, mackerel and sea trout fisheries.

A hydraulic oyster dradge is being tested by commercial fishermen.

University of Florida investigators have used their flume tank for the development of shrimp beam trawls now being used commercially and are currently testing 1/10 scale doors of their design.

The University of Georgia is developing a 3 wing tongue trawl for the shrimp fishery. This will allow shrimpers to use smaller doors to achieve the same spread with a higher headrope height. The use of the trawl will reduce fuel consumption.

Various laboratories of the National Marine Fisheries Service have ongoing projects which were reported on last year. These include the sea turtle excluder shrimp trawl. Testing of the experimental trawl is completed, and the data is being analyzed.

A satellite transmitter and a radio transmitter were attached to a loggerhead turtle which was released in the Gulf of Mexico. Between October and December, the turtle was located twice by satellite and several times by airplane-mounted receivers.

The porpoise tracking programme is also continuing with a second generation system under development, and seine-related porpoise mortality is still being investigated. Current work concerns correlating different set conditions with variations in the mortality rate.

A spanish semi-pelagic trawl is being tested to determine its ability to selectivity catch shortbelly rockfish on hard bottom off California.

The NMFS Gloucester Laboratory has some continuing projects which were mentioned last year. They include a study of existing scallop drags and the design of a new one, and an investigation of beam trawls for the small boat fleet. A Dutch beam trawl has recently been ordered for this purpose. In addition, we have under study juvenile fish samplers and a new groundfish survey trawl for the assessment biologists.

United Kingdom

Scotland

Semi-pelagic trawls

A range of semi-pelagic trawls has been developed which can be used to catch both pelagic and demersal species. The main design feature which contributes to the duel role of the trawl is the smaller mesh size in the belly compared with the top and side panels. Thus the trawls have the large mouth opening and low drag characteristics of pelagic nets, while the belly mesh size is appropriate for the retention of whitefish.

This implies a larger area of twine in the lower panel compared with the top and sides however, and full scale tests have shown that the ratio of twine area in the belly to the other three panels must be less than a critical value (around 0.55) to avoid distortion of the net. Several commercial fishing vessels have been using the 200 and 600 HP version of the trawl with considerable success.

Rope trawls
Experiments with rope trawls have continued in collaboration with the Netherlands Institute for Fishery Investigations, IJmuiden. A team from the Marine Laboratory, Aberdeen, participated in gear trials on board the Dutch research vessel "Tridens" when engineering performance tests were done on rope trawls and for comparison a conventional pelagic trawl. The advantage of rope panels in reducing drag for the same mouth opening has been quantified by these tests, and measurement of the tension in individual ropes has provided useful information for the design of rope panels.

Demersal trawls
Development work has continued on a range of three-bridle bottom trawls which are suitable for use with both light and heavy groundropes. Model tests have been carried out in the White Fish Authority Flume Tank and full scale tests have been done on a 200 HP version of the net.

Other work
Further measurements have been made on the geometry of a pelagic trawl while it is manoeuvred, using an improved computer-based system which can track up to four acoustic pingers attached to the trawl. The analysis of results is still in progress.

The theory of stress distribution and mesh geometry of trawl nets has been investigated, and mathematical models of the net are under development which take account of important features such as selvedge joins. Convergence problems have been experienced with the complicated equation sets involved in these models, and work is continuing.

Research into the effect of trawl gear on exposed pipelines (and vice versa) has been sponsored by the oil industry. This is an international project in which Marine Laboratory staff have been involved as consultants. The results show that 16 inch diameter or larger pipelines, properly reinforced, can safely withstand impacts from the heaviest trawl gear. Smaller pipelines may be damaged if left exposed.

United Kingdom

White Fish Authority
Comparative fishing experiments with electrified beam trawls were furthered. Four experimental cruises were made using the American Oceanharvester equipment. In total in the order of 400-450 tows were made. Analyzing the results the catch rates of the electrified gear turned out to be equal or 10% above those of standard beam trawls. Pulse rate frequencies of 4 and 6.25 p.p.s. were used and the discharge voltage of the electrodes ranged from 170 to 220 V. The optimum trawling speed was 2-2.5 knots. During towing the electrified gear uses 30-40% less fuel than the standard, chain rigged beamtrawl. Over a complete cruise the fuel saving was 12%.

For use as a dual purpose on- and off-bottom trawl a rope trawl was designed for 650 HP vessels.

The prototype "Autoclip" fully automated longline baiting and handling system has at the moment been used under commercial conditions for 13 months. During this period line shooting was usually carried out at 4.5 knots. The crew of the 15 m commercial fishing vessel consisted of 4 men. The costs of the unit is estimated at £ 20.000.-25.000 including a line with 10.000 hooks.

Experiments are carried out to catch roundfish species, mainly saithe, by gillnets on untrawlable grounds of N.W.Scotland.

A feasibility study into the possibilities of energy saving in fishing was started.

Trials were carried out to define the initial size of meshes taking into account the shrinkage. To determine the shrinkage several codends of different material was measured after fishing on and off the bottom.

The Flume Tank has been used for 75% for courses. At an average two courses per month are given. The remaining time is used for testing models of trawls, nets and components, e.g. floats. For demonstration of the geometry and behaviour of fishing gears over 100 models are available. The development work includes at the moment a bottom pair trawl with flying wings, a small bottom trawl for catching sole and a three bridle bottom trawl for vessels of 300 HP. The latter trawl has a vertical netopening of 12 metres.

U.S.S.R.

Experiments with bottom-set longlines fishing for cod were carried out in the coastal area of the Barentz Sea.

Selectivity factors for haddock, cod and red fish were determined when fishing with bottom trawls in the Barentz Sea.

The survival rate of discarded small flounder was determined.

Selectivity experiments when fishing for shrimp (Pandalus borealis) in the Barentz Sea resulted in the application of larger meshes in the codend.

Various types of fishing material (webbing, ropes, etc) has been tested.

In the Norwegian Sea rope trawls are used all year round for catching blue whiting. At an average the catch is 30-40 metric tonnes per 24 hours.

The behaviour and geometry of a midwater trawl was observed by means of underwater camera's.

F.A.O.

Directory of Fishing Technology Institutions and Services

This venture has taken much longer than even the worst pessimists expected and we are still lacking completed satisfactory questionnaires from some institutions of ICES member countries with important fisheries such as the USSR, Poland, the German Democratic Republic, Canada. As you will recall Council Resolution 1977/3:2 requested member countries to cooperate with FAO by providing the necessary information and I do hope that those mentioned above will comply with the least possible delay. Otherwise they will just have to be left out because we cannot wait longer than

June 1980 latest. As can be seen by now the Directory will include some 50 institutions, units or services from 30 to 35 countries, depending on receipt of still outstanding replies to requests and enquiries. Since this cannot go on forever we intend to compile and finalize what we can get by June 1980, and have the first issue printed and distributed as quickly as possible after.
A revised and improved version, based on constructive criticism, corrections and up-dating information we hope to receive will be prepared thereafter as appropriate.

Promotion of Fishing Technology Services/Units

Consultancies provided to developing fisheries included Algeria, the Philippines, Kenya, Tanzania and Zambia. Earlier identification consultancies to Sierra Leone and Indonesia are being followed up by implementation consultancies to assist the local authorities in the actual establishment of national fishing technology units and related planning, programming and initiation of systematic development work. In Sierra Leone it is hoped to mobilize active cooperation and assistance for the new national fishing technology unit from a substantial small scale fisheries development project soon to be started by German bilateral aid. A similar cooperation could hopefully develop with Norway bilateral aid in Tanzania.
The consultant for Indonesia will be our Convener. The FAO/Norway project under the CECAF umbrella for the establishment of a national fishing technology service in Senegal as part of the Direction de l'Océanographie et des Pêches Maritimes has finally been started by end 1979, and is presently being supported by a consultancy by C. Nédélec. Nuclei of national fishing technology services promoted by FAO have been created in Morocco and Tunesia, although the TCP project for Morocco did not materialize.
Recent examples for promotion through contributions to meetings and papers include the enlarged version of The Role of Fishing Technology in the Management and Development of Inland Fisheries in Africa (in English and French), a contribution on request to the magazine Oceanus of the Woods Hole Oceanographic Institution on Fishing Technology for developing countries which are both on display and a contribution on request covering fishing technology for the McGraw-Hill Encyclopedia of Science and Technology.
The TCP project to Brazil providing separate crash courses for the technical upgrading of fisheries extension officers in the fields of fishing technology, fish processing and marine engineering is presently being implemented. The intention is to increase the competence for applied technology of staff for, inter alia, national fishing technology services.

Community Fishery Centre (CFC) Development Concept

In developing fisheries increasing emphasis is being given to the artisanal sector and to an integrated approach at community level. FAO has developed a concept which involves local or regional fisheries technology and extension units (FTEU) servicing clusters of neighbouring fishing communities with technical backstopping.
A paper Community Fishery Centres and the Transfer of Technology to Small-Scale Fisheries by M. Ben Yami, whom many of you know as a prolofic fishing technologist, and who is the main initiator of this concept, is on display. Since fishing technology is a major component of any fishery development the coordination of this concept with national fishing technology services/units is obviously indicated. Some of you may also be interested in this paper with regard to relevant bi-lateral technical assistence ventures.

Training courses

The lecture notes of the joint French (ACTIM) and FAO sponsored Training Course in Fishing Technology for francophone African countries, have been revised and expanded and a copy of this improved version is on display. Also on display is a copy of the preliminary report of the similar Norway funded couse for anglophone countries of the Western Indian Ocean area which was successfully implemented with active participation of Steiner Olsen and some of his staff in Cochin, India, in November/December 1979. FAO is most grateful to the French and Norwegian donars for making these courses possible and for the active assistance and support of our colleagues in the implementation. It is now intended to marry the lecture notes of these two courses to serve as standard background material for similar courses on regional or national level. We hope that we will be able to provide, in due time, English, French and Spanish versions of this course material for general use.

Preparations are unde way for a joint French/FAO course on more advanced marine fishing technology to be held again with active ISTPM-participation in their outpost in Lorient by May 1981.

Request to Norway Aid for one course on fishing technology each for Central American and anglophone African countries are awaiting donor decision.

Two Norway funded Training Courses on Fishing Vessel Design have been held for English speaking participants in Thailand and Spanish participants in Ecuador. Lecture notes from these courses are being compiled as a design manual for small fishing boats to be published in both languages.

FAO Fishing Technology Publications

In the series of FAO Fishing Manuals, Echo-Sounding and Sonar for Fishing and Tuna Fishing with Pole and Line are with the co-publisher Fishing News Books Ltd. and should come out soon. There have been deplorable delays with the finalization of Prof. Fridman's manuscript on Calculations for Fishing Gear Designs which is still with our colleague John Carrothers. The same applies to the manuscript on Squid Jigging with Small Boats which was found to need much more technical and language editing than had been expected and also to the Fisherman's Pocket Book.

We hope to finish these manuscripts latest by Autumn for delivery to the co-publisher Fishing News Books Ltd. There are several more titles in different stages of development.

The first title of the FAO Better Fishing Books ("POP"series) on Pair Trawling with Small Boats to be published by FAO in English, French and Spanish is still with the printers but will hopefully come out soon. The second title Gillnetting is ready in manuscript and awaits printing, also by FAO. More titles of this series which is meant to serve extension workers and semi-literate fishermen are under consideration pending the reaction on the first "test"-issue.

The complement of French literature to the English part of the FAO Fisheries Technical Paper No. 184, Bibliography for Fishermen's Training is on display. The series number is 195.

The third and last part containing Spanish literature is with the printers. You may recall that this material was compiled by Prof. A. von Brandt under FAO contract. Your constructive criticism of this collection with suggestions for additional material on fishing technology is invited.

The English version of the FAO Fisheries Technical Paper No. 189, Bottom Trawls for Small-Scale Fishing, which had been prepared in French by Nédélec and Brabant has come out and is on display. The Spanish version is under final preparation. The manuscript by Dahm and Lange of the FAO Technical Paper on Monitoring Trawls in Action still requires substantial language editing which is under way. Of the publications under the FAO Fisheries Technical Paper series prepared by our boat people in the sub-series Fishing Vessel Design, which are at least partly relevant, the titles Small Trawlers which is being finalized and the further titles Multipurpose Fishing Vessels and Steel Vessels for Offshore Fishing to come out in 1981 should be mentioned. The same applies to another sub-series, Engineering Applications, the first title of which Installation and Maintenance of Engines in Small Fishing Vessels is on display. For the preparation of the second tentative title Mechanically-Operated Hauling Gear for Small-Scale Fishing, your assistance is requested. This paper is intended to present a good selection of devices such as net and line haulers and winches with installation arrangements and accessories for small boat trawling, beach and boat seining, gillnetting, hand- en longlining, trolling, potting, etc of a design suitable for local construction. Presentation and instructions will be of a kind and technical detail that local artisans and workshops can use them as practical guide for production. FAO would like to have as complete a collection as possible of such simple mechanical divices as possible which are or have been in commercial operation and urges those of you who are aware of or can lay their hands on relevant descriptions, sketches, drawings, photos, etc of such auxiliaries to send these to us soonest. Your cooperation in this matter will be highly appreciated. At present we need only mechanical operated devices. Hydraulically driven auxiliaries will be dealt with in a subsequent issue. The contract with the Technical College in Hull for the preparation of film strips on fishing gears and methods did not materialize. Another contract has been made with the German-Israely Fund for Rural Development to prepare such film strips on gillnetting and on purse seining with and without light attraction.

Field Activities

Regarding those relevant to this Meeting, I am sorry to report that no significant progress could be made so far in developing the exploitation of meso-pelagics or lantern fish. In view of the impact of escalating fuel prices on trawling, other techniques than midwater trawling would need to be studied and this is certainly a challenging task.
Again with regard to the need for fuel saving and also the increasing emphasis on small-scale fisheries already mentioned, the revival and further development of sailing fishing boats and of sailing-cum-auxiliary engine concepts gain more and more attention. Active development work in this field is being done in the SIDA funded Development of Small Scale Fisheries in the Bay of Bengal Project (GCP/RAS/040/SWE). This project is also concerned with developing beach and surf landing craft with better fishing capacity than the traditional boats or catamaran log rafts. One 7.4 simply constructed hull with buoyancy provided by polystyrene and another completely enclosed hull are being tested as replacement for the log raft and better sailing rig for local boat trials were started in Sri Lanka where also a double hull configuration for simple beach landing is being considered.

Further evaluation of sail propulsion with auxiliary motor is being carried out in the UNDP/FAO Vessel Construction and Bottom Fishing Demonstration Porject (TON/77/002) in Tonga with double and single hull craft. One of the two boats built during the Danish financed regional Training Course in Small Fishing Boat Construction (GCP/RAF/133/DEN) late 1979 in Sierra Leone, a nine meter dory, will be used to work out a suitable arrangement for pole engine propulsion using a small stationary diesel motor specifically equipped with a 2:1 reduction gear for improved propeller performance.

The Norway financed Development of Extreme Shallow Draft Fishing Vessels Project (GCP/INT/270/NOR) is finally approaching the testing stage. A 32 ft and 42 ft version of the selected prototype being built in Ghana are expected to be ready soon for practical fishing tests in Nigeria to start around August 1980.

Last year we had to report unsatisfactory results of tests in Sri Lanka and India with some prototype units of a novel low cost echo sounder for small scale fisheries in developing countries. The manufacturer has just now indicated his continued interest and will provide some technically improved units for testing by the Development of Small Scale Fisheries in the Bay of Bengal Project (GCP/RAS/040/SWE), probably this autumn in Sri Lanka.

In the field of fishing gears and methods the sail kite revitalized by my colleague M. Ben-Yami, may be mentioned with regard to some initial trials with netsonde monitoring which I could include in test trawling with a high opening bottom trawl with two research vessels of a joint resource assessment project in the Bali Strait. The concept worked quite nicely and would deserve further study to conclusively assess its limitations and operational feasibility for different trawl gear under different conditions. Small boat operation of fish-cum-lobster pots and driftnets for swordfish are to be conducted by the Fishery Development Porject (ALG/77/001) in Algeria. Attempts to reduce gear costs by substituting cheaper synthetics such as polyethylene for polyamide in gillnetting are going on in several countries in SE Asia.

Of general interest for developing tropical fisheries which have resources in small tuna and related species and also of dispersed small pelagics is the concept of fish aggregation with anchored or drifting rafts which is well developed in the Philippines (payao) and Indenesia (rampon), but not known elsewhere. The success of the installation of such rafts of novel design by the US NMFS for instance in Hawai and Samoa has promoted increased interest. Our Regional Fisheries Coordinator Project (RAS/73/025) is actively involved in testing and eventually introducing such fish aggregating rafts in the South Pacific area with starts in Tuva and probably also in Tonga. A TCP Project for testing the feasibility of such devices for the pole and line fishery of the Maldives and similar tests envisaged for Sri Lanka will probably be further expanded to other suitable fisheries.

We are compiling an information paper on this technique for distribution to interested parties.

Coming back finally to the development of latent resources a project idea has been prepared by our WECAF (Western Central Atlantic, INT/77/016) Project to assess commercial fishing opportunities and techniques for oceanic squid. This, as the development of fishing techniques for the latent mesopelagic fish resources, calls for expertise, vessel services and facilities which are beyond most developing fisheries and would, therefore, be quite appropriate and suitable for a donor package project possibly under sub-contract including a research vessel with a team of technical and scientific staff. Both, mesopelagics and even more so oceanoc squid, are quite a challenge for fishing technology and their development deserves much more attention than has been assigned so far.

ESTIMATED FUEL SAVING POTENTIAL IN NORWEGIAN FISHERIES

by: Anders Endal

SUMMARY:
This paper, which will be presented at the forthcoming Statutory Meeting as document C.M.1980/B:14, starts with a review of the energy input of some of the fishing methods as yet applied in Norway. The energy input is thereby expressed as the kilogrammes of fuel oil needed to land one kilogramme of gutted and headed fish. The author next indicates several area's for fuel saving and gives estimates of the fuel saving potentials. Items discussed in the paper include, among others, the potentials of speed and power reduction, choice of fishing methods, improved propulsion systems, use of heavy fuel oils, waste heat recovery, engine de-rating, alternative energy sources and fish forecasting.

FUEL CONSUMPTION OF THE ICELANDIC FISHING FLEET

by: A. Augustsson and E. Ragnarsson

SUMMARY:
The paper will be presented at the forthcoming Statutory Meeting as document C.M.1980/B:5. The main subject of the paper deals with the fuel consumption of different types of vessels.
For the period 1972-'78 figures are given for the total fuel consumption of the Icelandic fleet.
These figures are related to the total installed power and the weight of the catch. Next the fuel consumption of stern trawlers engaged in bottom trawling is analized for the several working conditions of these vessels. In the same way the operation of purse-seiners fishing for capelin and gillnetters is analized.
The paper ends with a comparison of the fuel- and catch rates of different methods for catching demersal species (long lining, gillnetting, trawling).

FISHING VESSEL SPEED AND FUEL ECONOMY

by: Torbjørn Digernes and Anders Endal

SUMMARY:
This paper is a shortened version of the report "Fart og drivstoff-økonomi i fiskeflåten" (Speed and fuel economy in the fishing fleet) by Torbjørn Digernes and will be presented as document C.M.1980/B:15. Paragraphs of the paper have as subject matter: speed and power, speed reduction and fuel saving, the application of fuel saving diagrams, economical speed and the balance between the fuel costs and the "time costs".
The main results are that by reducing the free running speed with 10% the fuel consumption will decrease with 30-40% when steaming.

A 10% reduction in free running speed of the Norwegian fleet will result in an estimated fuel saving of 60.000-80.000 tons of fuel oil. However, the saving in fuel oil is largely depended on the type of fishing method. It is estimated that trawlers can save 10-12% of the annual fuel consumption by reducing their free running speed with 10%. This figure is for longliners 15-20% and for purse seiners 20-25%.

CERTAIN PROBLEMS CONCERNING FUEL CONSUMPTION OF SMALL FISHING TRAWLERS

by: Józef Krępa and Marian Szatybelko

Polish fishery mainly operates trawler type vessels which are the most universal craft for waters in the temperate zone, particularly in the Baltic region. The sudden increase in prices of fuel and lubrucants in recent years has necessitated the search for reduction of fuel consumption per unit of catch.
Investigations are complex and include the following problems:

- the adapting of the size of vessels and their proportion to the conditions existing in the fishing grounds;
- search for new forms of fleet operation organization;
- decrease the resistance of towed fishing gear and changes in the towing system;
- changes in fishing technique for less fuel-consuming.

In the case of small wet-fish trawlers lower fuel consumption per unit of catch has been observed where the ratio of hold capacity to trawler power is higher (Table 1).
The mean diurnal catch yield increases with the trawler driving power. The relationship between the mean diurnal catch yield and the driving power has been presented on the basis of operational data attained by small Polish trawlers the Baltic (figure 1).
As can be seen from the diagram this is a linear dependence where the increments of the catch yield correspond to the similar increments of the driving power of the vessel.
Basing on these data it can be concluded that given the same unit fuel consumption and similar drive in the 80-420 kW range, the increase in the driving power of a small trawler generally has no influence on the annual fuel consumption per unit of catch.
The relationship between the hold capacity and the trawler's driving power affects the fuel consumption, as results from comparison of unit fuel consumption by vessels with 250-420 kW and 80-250 kW driving power (Table 1).
The cruise duration may be limited because of the iced fish; the diurnal catch yield may also show large fluctuations.
Because of these factors, cutters with a higher V/N ratio and a smaller mean diurnal catch yield make fewer cruises to the fishing ground, because of slower loading.
Such a situation is presented in figure 2. This shows the dependence on V/N of the number of cruises with a fully loaded hold, and also the fuel consumed by these cutters per ton of fish taken during one year. A correlation between the number of cruises and fuel consumption per ton fish landed may be deduced from figure 2.
These data show that it would be desirable to increase the hold capacity of the small fish trawlers and also their driving power.
Alternatively a different catch organization (for example: for fish transhipment from fishing ship directly at sea) could be implemented.
These changes could decrease the number of cruises during a year and in the consequence cut the fuel consumption per unit catch.

Table I.

Fuel consumption of small wet-fish trawlers in the Baltic

Type of vessel	Power of main engine /N/ /kW/	Shaft horse-power /Nw/ /measured/ /kW/	Hold capacity /m³/	Number of trips/ vessel	Catch per day /tons/day/	$\frac{V}{N}$ /m³/kW/	kG fuel per kG of fish
K-17	88,23	75,00	35,0	36,5	2,04	0,396	0,163
B-25s	165,40	135,00	80,0	28,0	3,08	0,484	0,158
B-25sA	257,40	175,00	80,0	36,4	3,82	0,310	0,230
B-410	419,00	250,00	90,0	54,0	5,86	0,215	0,214

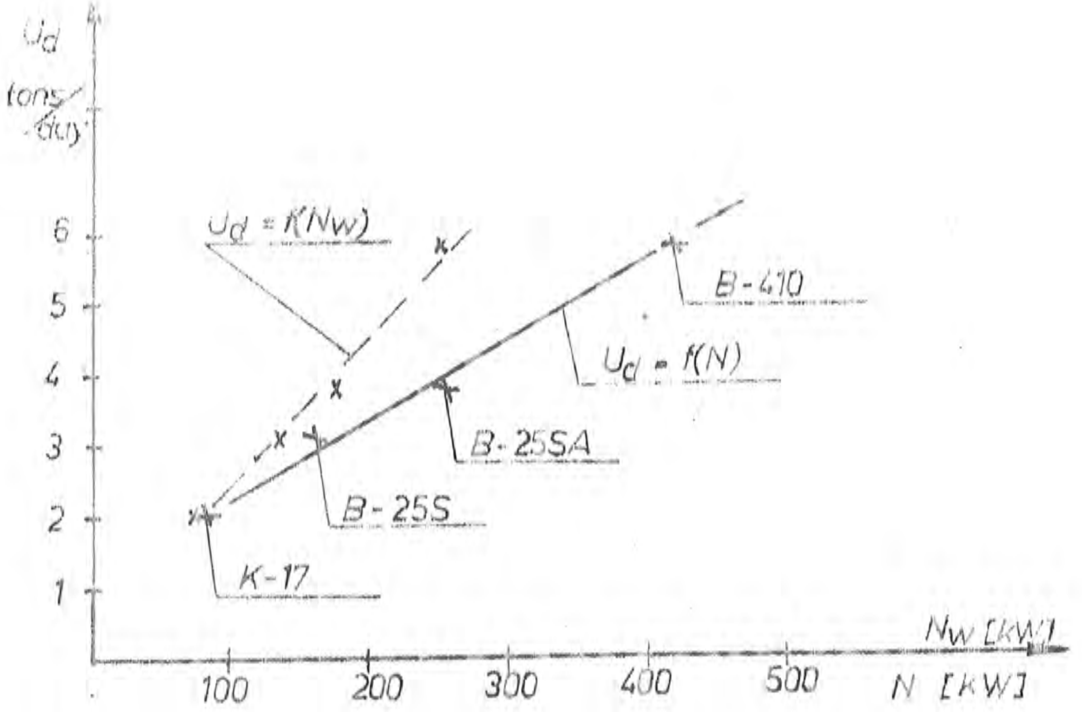

FIGURE 1 - Catch per fishing day of small wet-fish trawlers in the Baltic

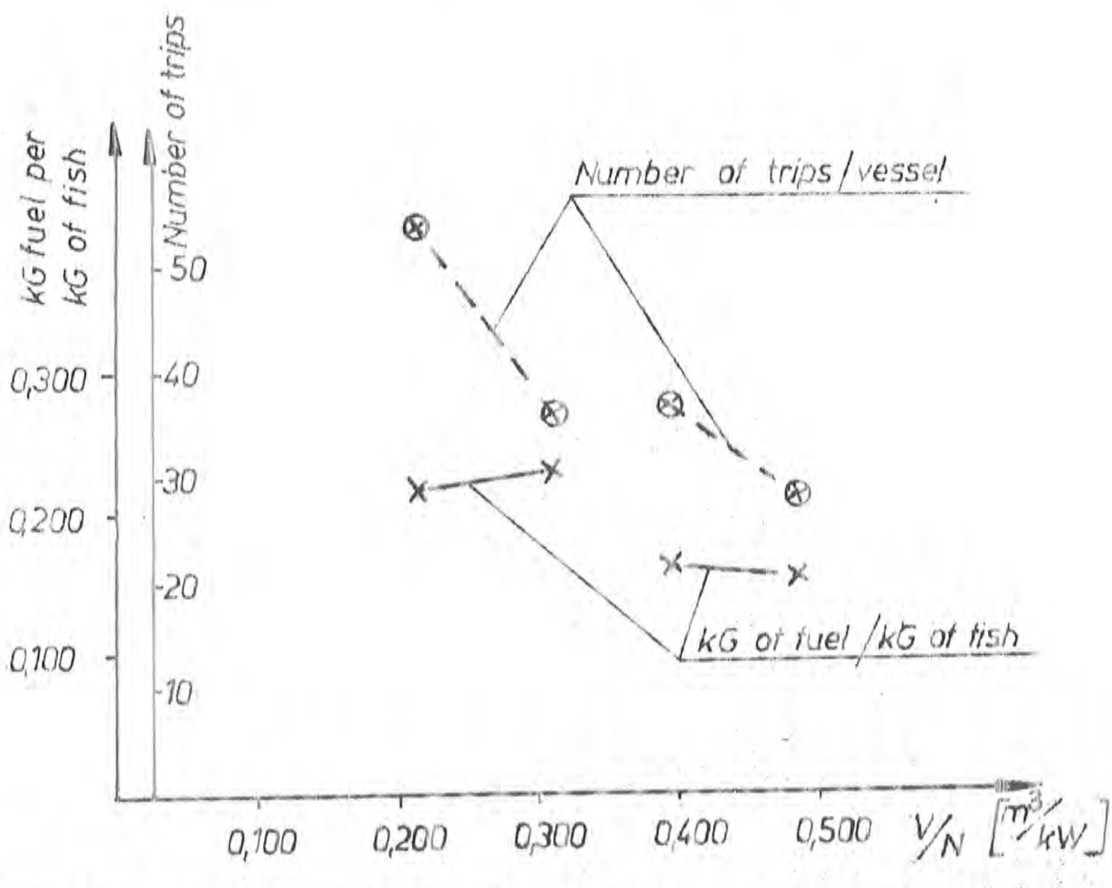

FIGURE 2 - Fuel consumption of small wet-fish trawlers in the Baltic

Presentation of films

The W.F.A.-film on automated long-lining showed the operation of the auto-clip system which in recent years has been developed by the White Fish Authority. As the name indicates the system is based on a small plastic clip with which the snood can be automatically attached to and detached from the main line. This enables the main line to be stored on a reel while the snoods are stored on racks. A full description of the system is given in C.M.1979/B:3.

The film on modeltests with rope trawls on scale 1:4 showed the observations made by the diving team of the Institut für Fangtechnik (Hamburg) of models designed and constructed by the Netherlands Institute for Fishery Investigations. In addition to the observations during this cooperative research cruise measurements of the geometry and resistance of net and rigging were carried out. The rope trawls were derived of a 434x80 cm midwater trawl. Two models were tested and observed. One had a meshed upper square and the shape of the headline was a catenary. The other one had also ropes in the upper panel and the shape of the headline was computer designed.

Because of the growing interest in the exploitation of the Antarctic krill resources the Wärtsilä Shipyard of Turku (Finland) carried out a feasibility and design study on the year-round operation of a krill factory trawler in the Antarctic.
This means that the vessel also has to operate in that area in winter conditions and has to cope with pack and/or solid ice. Therefore the vessel must have performance characteristics comparable with an icebreaker.
The film showed the performance of an icebreaker special designed and constructed for the Antarctic. One of the special features of this vessel is the air bubbling system designed by the yard to improve the icebreaking performance. This system can also be used for clearing the stern area of ice when shooting and hauling the gear.

Report of the expert group meeting in Aberdeen (5-7 February 1980) on the Draft Code of Practice for the Conduct of Fishing Gear Experiments (C.Res.1979/2:14)

The report was presented by the convenor, Mr. D.N. MacLennan (Marine Laboratory, Aberdeen). In introducing the report he gave a review of the work carried out since 1977 which led to the present document.
He informed the participants of the meeting that the revised Data Index Forms are distributed by the ICES Secretariat. The number of forms as yet received by the Marine Laboratory for the pilot data exchange scheme, which will be received after one year (C.Res.1979/4:1), is only 7. It was noted that the returned forms were mainly dealing with selectivity experiments. Members of the Fish Capture Committee and the Working Groups of said Committee were therefore urged to fill in and return some forms.
In the discussion it was mentioned that in preparing the final version of the Code of Practice one can in certain area's refer to Cooperative Research Report No. 66 "Report of the Working Group on Standardization of Scientific Methods for Comparing the Catching Performance of Fishing Gear".
Further items discussed were the marking of e.g. trace records, calibration parameters, checking of key parameters, etc.

It was felt that the draft Code of Practice required further adaptation and editing. Mr. D.N. MacLennan was prepared to prepare a second draft in time for the forthcoming Statutory Maating. This draft will include parts of the contributions to the first draft by Prof. Dr. A.L. Fridman and V.P. Karpenko which were receibed at the beginning of the meeting.
The titles of these contributions are "Papers relevant to the methods of technical tests of fishing gear models" by Prof.Dr. A.L. Fridman and "A contribution to the development of methods of the planning of fast operational-technical tests of fishing gear and the prediction of the essential operational-technical characteristics thereof" by Prof.Dr. A.L. Fridman and V.P. Karpenko.

Presentation of video-tape recordings

Dr. Clem S. Wardle (Marine Laboratory, Aberdeen) showed the participants video-recordings made by the diving team of several fishing gears in action. Not only the geometry and the performance of gear companents but also the behaviour of the fish in relation to the approaching gear could clearly be observed. Among others, the herding effect of bridles and the influence of exhaustion on the behaviour was demonstrated. Next Dr. Wardle informed the meeting on the application of the remote-controlled towed vehicle, recently developed by the Laboratory for underwater observations.

Mr. Joël Prado (I.S.T.P.M.-Lorient) reported on the recent model tests with a tuna purse-seine. Introducing the video-recordings he gave a review of the observations and measurements in 1977 carried out during commercial operation with a tuna purse-seine.
The full scale dimensions of the purse-seine were 1100 x 150 metres; meshsize 100 mm and 110 mm. The model tested in a large basin (50 x 12.5 m) had a floatline of 29 metre length and a (stretched) depth of 4.0 metre. The meshsizes used in the model were 16 mm and 20 mm.
To simulate shooting the basin was equipped with a rotating platform. In addition a mini-pursewinch was installed. For observations of especially the behaviour of the seine when sinking and during pursing two underwater video-camera's were used.
The main objectives of these modeltests were to observe the behaviour of the gear with different shooting and pursing speed and the influence of the purse-line length on the performance.

ENGINEERING TRIALS WITH A CONVENTIONAL AND A ROPE TRAWL OF 2700 MESHES (= 20 cm) CIRCUMFERENCE

by: Bob van Marlen and David N. MacLennan

Summary

During November 1979 engineering experiments were done on 2700 meshes (equal to 20 cm) circumference pelagic trawls, a size commonly used on Dutch stern trawlers today.
The set of trawls tested consisted of a conventional net and a rope trawl designed at the "V.E.B.-Fischkombinat" at Rostock. This trawl and the licence to built it was purchased by a Dutch firm called "Jaczon", partly subsidised by the Dutch Government.
Like in previous years the tests were done on board of the fishery research vessel "Tridens", involving both the Netherlands Institute for Fishery Investigations in IJmuiden and the Marine Laboratory situated in Aberdeen.
Both gears were tested with the same rigging i.e. the same set of Süberkrübdoors (7 m2) and the same bridles (71 fms (=129,93 m) for the upper one and 70 fms (=128.10 m) for the lower one) and bridle weights varying from 720 kg (7063 N) to 1100 kg (10791 N).
The rope trawl was also tested with floats on the headline (230 "Nokalon" floats of 2 ltr. volume each).
For most hauls the warplength was kept constant at 600 m, apart from three hauls where a warplength variation up-to 900 m was included. The warps were attached to two different points on the doors in order to determine their most efficient angle of attack.
Reciprocal courses were sailed to take account of the effect of tide or currents.
Basicly the same set of instruments has been used as during the 1978 trials (see reference (1)). In addition new load cells, recording on a cassette tape were used enabling longer hauls to be made without having to replace them. There was no variation in the length of the bridle extension. The length of the chain weights had not been altered. Several hauls were done with the mere objective to determine the load distribution among the ropes of the rope trawl. It turned out, that the centre ropes of the top and bottom panels were heavier loaded than the ropes at the sides. For the side panels it was found, that the tension in the ropes near the top-panel was slightly higher than that in the ropes near the bottom panel. The load in the top ropes was also more dependent on the speed.
At a speed of 4.5 knots the ropes in the top and bottom panels accounted for 56% of the total load, those in the side panels took 31% and the selvedge ropes 13%.
The measurements were read from the instrument traces, calibrations were applied and the results stored in the Marine Laboratory gear trials data bank.
The addition of 480 kg of weight per side caused the net drag to increase some 5% for both the conventional and the rope trawls. The addition of 230 floats to the rope trawl increased its drag by 13%. This trawl and the conventional one had nearly the same drag with 1100 kg bridle weights. The proportion of the shaft horsepower used to tow the gear seemed to be very consistent for all the gears at the same speed (on average 28% at 4 knots and 32% at 5).

As could be expected, adding bridle weight introduced more headline height for both trawls; this improvement was greater at higher speeds. The addition of floats with the rope trawl caused the headline height to increase proportionately more at lower speeds. The side line spread of both nets did not vary much.
The cross section areas of the conventional net decreased starting from the wing end going to the cod end as would be expected with this type of net.
The rope trawl behaved differently in this respect, having a cross section area at the beginning of the netting panels greater than the headline centre area, a fact that could be caused by slack netting in the bottom panel. The rope tension tests seem to indicate in this direction.
From these tests it can also be concluded, that the rope trawl was slightly overspread. A smaller set of doors could have been used for this net. The floatation on the headline of the rope trawl did cause this gear to fish higher relative to the doors.
A measure to compare the performance of different trawls is the net drag per unit area. Compared with the conventional net and with the same weights this quantity was 26% less at 4 knots and 33% less at 5 knots for the rope trawl without floatation.
The floats on the latter trawl increased the net drag per unit area by 10% with 1100 kg bridle weights. The performance of trawls can also be judged from the towing speed multiplied by a cross section area and divided by the net drag, i.e. the "swept volume index" and for this parameter it was also found, that the rope trawl was much superior to the pelagic trawl, irrespective of the bridle weight used.
The doors showed a consistent performance with much less asymmetry than that reported in previous years. With the low bridle weights (720 kg) the doors came near the surface at the higher speeds, indicating this weight to be too low for both gears with these Süberkrüb doors of 7 m^2.
The attachment point of the warp to the door seemed to be of small influence on the behaviour of the doors, with the point closest to the door surface slightly in favour, because of the less varying door spread as seen on the echo-sounder traces.
The heavier weight lead to smaller heel angles for both doors.
A warplength increase from 500 m up-to 900 m did not seem to have a great effect on the horizontal dimensions of the gear.
For North Sea conditions the length of the warps paid out will mostly be determined by the depth of the seabed.
In addition to tests done in 1978 with a 26 mm diameter warp, this year trials have been conducted with a thinner warp, namely of 16 mm diameter.
The pressure drag and skin friction coefficients did not depend significantly on the diameter. There exists a speed dependance however, probably caused by the vibration of the warp, excited by vortex shedding and not by differences in the Reynold's Number.
For all warps commonly used in fishery the following empirical formulae could be derived:

$$C_d = 2.078 - 0.2984 * V$$

$$C_f = 0.00625 + 0.02702/V^{2.465}$$ with V being the speed in m/s.

These coefficients have been used in the analysis of the data described in this report. Conclusively one can state, that rope trawls can be favoured from an engineering point of view, but problems may arise with the handling of these nets and the fishing capability.

Comparative fishing tests will be done in March 1980 on "Tridens" to complete this study.

Summary of conclusions and recommendations

A cooperative research programme like this, involving several institutes (The Netherlands Institute for Fishery Investigations and the Marine Laboratory) proves to be benificial for both. The quality and quantity of measurements done is increasing from year to year, leading to a better reliability and less scatter in the graphs of the report of the 1979 experiments. The cooperation also reduces costs of buying or developing instrumentation for each institute involved. As a by-product some very interesting experiments like the warp-shape experiments could be done merely due to the fact that the trials took place in a very suitable physical environment having both a great depth and a calm seastate. It would be wise to continue and extent such cooperative programmes in the near future leaving room for each party involved to fill in their own needs.

For both gears 720 kg bridle weights seemed to be too little. The doors will get at the surface at higher speeds (around 5 knots). The vertical opening of the nets can be improved considerably by adding more weight (1100 kg), although this will cause the gears to fish deeper. In order to overcome this, floats can be mounted on the headline with the penalty of having more drag.

The 7 m^2 Süberkrüb doors on these gears showed a better performance than found in previous years with the smaller types (4.7 m^2). The best attachment point of the warp turned out to be the one closest to the door surface giving a very smooth hydrodynamical performance. At bigger angles of attack the doors will probably show flow separation at the leading edge resulting in an instable run through the water. With 1100 kg the heel angles of the doors are smaller reducing the tendency of the door to reach the surface at high speeds.

The warplength had a minor influence on the geometry of the net mouth. The length needed will depend mostly on the depth of the seabed in practical applications.
The highest values of door spread/w.e.-spread/side line spread will be found at warplengths above 900 m (≙ 492 fms), but it does not seem worthwhile to use these length because of the time loss during shooting and hauling.

From the rope tension tests it was found, that the ropes were not equally loaded. The centre ropes of the top and bottom panels were heavier loaded, indicating the gear to be overspread. For the side panels it was found, that the ropes in the top parts were heavier loaded. These loads were more dependent on speed than those of the lower ropes.
At 4.5 knots the total load was distributed as follows:

- top and bottom panel 56%
- side panels 31%
- selvedges 13%

From an engineering point of view the rope trawls seemed to have a superior performance. This is hopeful keeping in mind the main objectives of this research programme i.e. to develop a trawl gear with less drag than that of the conventional types and with the possibility to fish close to or on the seabed without suffering net damage. The first mentioned criterion is related to the fuel consumption of the fishing vessel. This will have an important bearing on the economy of fishing operations.

The second criterion applies to costs of material and repair also related to the overall economy of fishing.
Both costs aspects need to be cut down in order to survive as a fishing industry.
On the other hand one needs to catch fish to earn money and the fishing efficiency of the gear should be comparable to commonly used types. Only by comparative fishing tests an insight into a gear's fishing capability can be found. That is why such tests are planned with these rope trawls during March 1980 on FRV "Tridens".
A delicate balancing of the costs-saving aspects and the fishing efficiency (including size and species selectivity) of these new gears is needed to determine whether this development will be feasible.

In addition to the warp shape tests done in 1978 with a 26 mm warp, experiments were done with a 16 mm warp this year.
A suitable set of formulae could be derived for the prediction of skin friction and pressure drag coefficients for trawl warps commonly used in fishery, namely:

$$C_d = 2.078 - 0.2984 * V \quad \text{with V in m/s}$$

$$C_f = 0.00625 + 0.02702/V^{2.465}$$

Fishing tests with smaller (1736 meshes) rope trawls in 1979 casted doubt on the herding effect of ropes at least when fishing close to the bottom. Direct observations from divers on rope trawls lead to the conclusion that the foreward movement of almost parallel ropes can hardly be spotted. Small fishes did not seem to react to the ropes at all. It could be worthwhile to develop a gear with the advantages of the rope trawls such as drag reduction and less damage when having bottom contact and some means to have a better herding effect of the rope panel like arranging the ropes in a lattice with transverse connections.

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Hydrodynamic Characteristics of trawl warps
Scot.Fish.Res.Rep. No. 16, 1979

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Further hydrodynamic force measurements on trawl warps
Marine Laboratory Working Paper 80/5, March 1980

PLANNING OF EXPERIMENTS

haul	net	weights	ext.	warplength	h.p.-range	doors	course
01	A	720	4.47	350	0950-1600	II/b	155°
02	A	720	4.47	600	0905-1570	II/b	205°
03	A	720	4.47	600	0870-1550	II/b	25°
04	A	1100	4.47	600	0875-1780	II/b	205°
05	A	1100	4.47	600-900	0900-1700	II/b	25°
06	A	1100	4.47	600	0937-1832	II/a	205°
07	A	1100	4.47	600	1000-1790	II/a	25°
08	B	1100	4.47	600	0965-1760	II/a	240°
09	B	1100	4.47	600	0970-1650	II/a	60°
10	B	1100	4.47	600	1000-1700	II/b	260°
11	B	1100	4.47	600	0973-1740	II/b	40°
12	A	1100	4.47	600	1276-1810	II/a	255°
13	A	1100	4.47	600	1300-1840	II/a	255°
14	A	1100	4.47	600	1300-1838	II/a	255°
15	A	1100	4.47	600	1385-1843	II/a	250°
16	A	1100	4.47	600	1344-1825	II/a	250°
	Warp shape exp.						
17	C	720	9.82	600	0960-1700	II/a	260°
18	C	720	9.82	600	0910-1560	II/a	80°
19	C	720	9.82	500-900	1260	II/a	250°
20	C	1100	9.82	600	1135-1770	II/a	265°
21	C	1100	9.82	600-900	1197-1830	II/a	70°
22	C	1100	9.82	600	1190-1825	II/a	250°
23	C	720	9.82	600	0970-1625	II/a	70°

TABLE I

	ROPE TRAWL (A)				ROPE TRAWL (B)		PELAGIC TRAWL (C)			
Bridle weights (kg)	720		1100		1100		720		1100	
Speed (knots)	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0
wing-end height (m)	28.0	21.5	32.4	26.9	35.1	27.7	25.3	21.5	30.3	24.7
wing-end spread (m)	64.0	63.9	63.2	66.4	59.9	62.9	53.9	52.6	54.7	55.6
wing-end area (sq.m)	1795	1375	2040	1792	2096	1755	1362	1135	1659	1372
headline height (m)	29.7	19.5	32.8	25.3	39.2	28.3	23.5	19.6	28.7	22.5
sideline spread (m)	49.7	51.6	50.0	53.0	48.4	51.6	47.2	45.3	48.2	49.4
h/l centre area (sq.m)	1472	1019	1631	1356	1886	1480	1111	889	1383	1110
section height (m)	31.0	22.1	34.6	27.1	39.6	30.0	11.9	9.9	14.2	12.8
section spread (m)	50.4	50.8	48.6	52.3	46.6	50.6	26.2	25.4	26.8	28.2
section area (sq.m)	1557	1139	1671	1432	1839	1537	311	253	380	361
headline depth (m)	141.6	13.0	187.9	74.5	150.8	58.8	121.9	29.6	167.3	60.4
door height above the headline (m)	14.0	13.1	19.0	16.1	5.8	7.3	15.5	10.7	16.1	13.0

TABLE XIX

COMPARISON OF THE THREE TRAWLS - GEAR GEOMETRY

TABLE XX

	ROPE TRAWL (A)				ROPE TRAWL (B)		PELAGIC TRAWL (C)			
Bridle weights (kg)	720		1100		1100		720		1100	
Speed (knots)	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0
Net drag (tonnes)	9.73	13.89	10.16	13.94	11.44	15.70	10.97	13.85	11.42	16.10
Gear drag (tonnes)	11.59	15.91	12.55	16.91	12.89	17.59	12.96	16.03	12.57	17.73
Shaft H.P.	1132	1659	1236	1764	1278	1827	1246	1641	1271	1896
Gear H.P.	319	523	348	562	355	581	356	529	341	586
Swept volume index (CV.M/SEC/TONNE)	320	173	338	245	346	233	211	165	251	174
Net drag/area (KGF/SQ.M)	5.60	9.47	5.08	7.72	5.56	8.69	8.24	11.93	6.89	11.47

TABLE XX

COMPARISON OF THE THREE TRAWLS - FORCES AND GENERAL PERFORMANCE

TABLE XXI

	ROPE TRAWL (A)				ROPE TRAWL (B)		PELAGIC TRAWL (C)			
Bridle weights (kg)	720		1100		1100		720		1100	
Speed (knots)	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0	4.0	5.0
Door angles (Deg) HEEL	24.6	40.4	17.4	33.9	15.6	29.4	30.3	39.3	20.9	34.3
Door angles (Deg) TILT	14.3	20.1	10.5	14.9	11.7	14.9	17.3	18.2	13.0	14.2
Door angles (Deg) ATTACK	35.5	32.4	23.9	23.3	21.8	25.4	29.5	26.6	33.0	30.8
Door depth (m)	127.6	-0.1(!)	168.9	58.3	145.0	51.5	106.4	18.9	151.2	47.4
Door spread (m)	143.1	140.9	139.9	147.7	134.3	142.2	126.6	120.3	129.1	132.4
Door spread force (t)	1.40	1.85	1.47	2.03	1.53	2.13	1.39	1.61	1.44	2.05
Warp att. point	b		a + b		a + b		a		a	

Combined data for All trawls

Speed (knots)	4.0	5.0
Door drag (tonnes)	0.77	1.00

TABLE XXI

COMPARISON OF DOOR CHARACTERISTICS-SAME DOORS USED WITH DIFFERENT NETS AND BRIDLE WEIGHTS. COMBINED DATA FOR BOTH WARP ATTACHMENT POINTS.

TABLE XXII

COMPARISON OF DOOR CHARACTERISTICS FOR DIFFERENT WARP ATTACHMENT POINTS

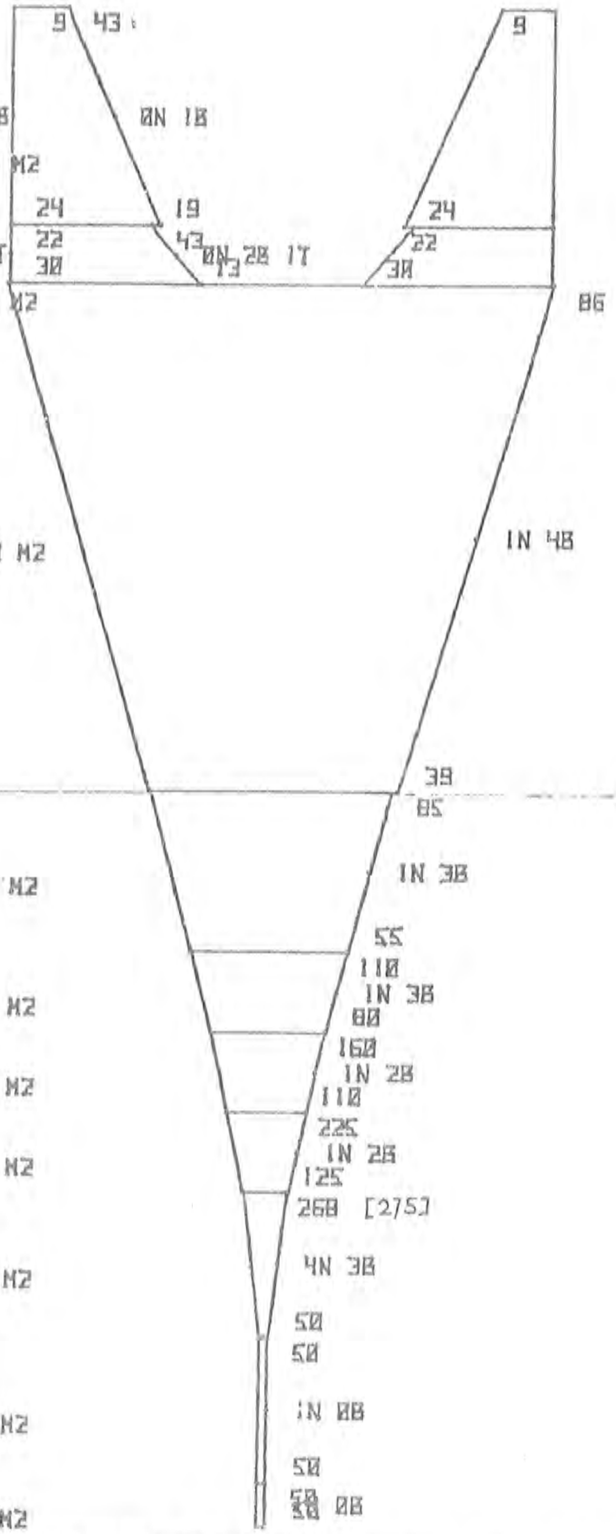
BRIDLE WEIGHTS: - 1100 kg

		Warp att. point	ROPE TRAWL (A)		ROPE TRAWL (B)	
Speed (knots)			4.0	5.0	4.0	5.0
Door Angles (DEG)	HEEL	a	15.6	32.7	15.7	31.4
		b	19.1	36.4	15.2	25.5
	TILT	a	10.3	13.8	10.3	13.6
		b	11.0	16.8	13.2	16.6
	ATTACK	a	21.7	23.4	21.8	25.4
		b	25.9	24.0	-	-
Door spread (m)		a	139.1	148.8	133.5	140.9
		b	140.2	146.1	135.3	143.6

TABLE XXII

BOVENKANT (UPPER SIDE)

FIG.: 1



LENGTE IN MAZEN	WIJDTE (MM)		DIKTE (MM)	BESTREKT (M)
15	1800	IN 08 UI= 0.40 OPP.= 0.864 M2	210/ 8 4.0	27.00
4	1800	IN 08 0T UI= 0.40 OPP.= 0.374 M2	210/ 8 4.0	7.20
35	1800	UI= 0.40 OPP.= 7.854 M2	210/ 8 4.0	63.00
25	800	UI= 0.40 OPP.= 2.100 M2	210/ 8 3.0	20.00
25	400	UI= 0.40 OPP.= 1.235 M2	210/ 8 2.6	10.00
50	200	UI= 0.40 OPP.= 1.350 M2	210/ 8 2.0	10.00
100	100	UI= 0.40 OPP.= 1.750 M2	210/ 8 2.0	10.00
400	45	UI= 0.40 OPP.= 3.293 M2	210/ 8 2.3	18.00
400	45	UI= 0.40 OPP.= 1.035 M2	210/ 8 2.3	18.00
120	45	UI= 0.40 OPP.= 0.311 M2	210/ 8 2.3	5.40

BENAMING: 2700 MAZEN NET (JACZON)
LENGTE BOVENPEES: 87.60 M. (HEADLINE LENGTH)

NR.: 800 A

SCHAAL

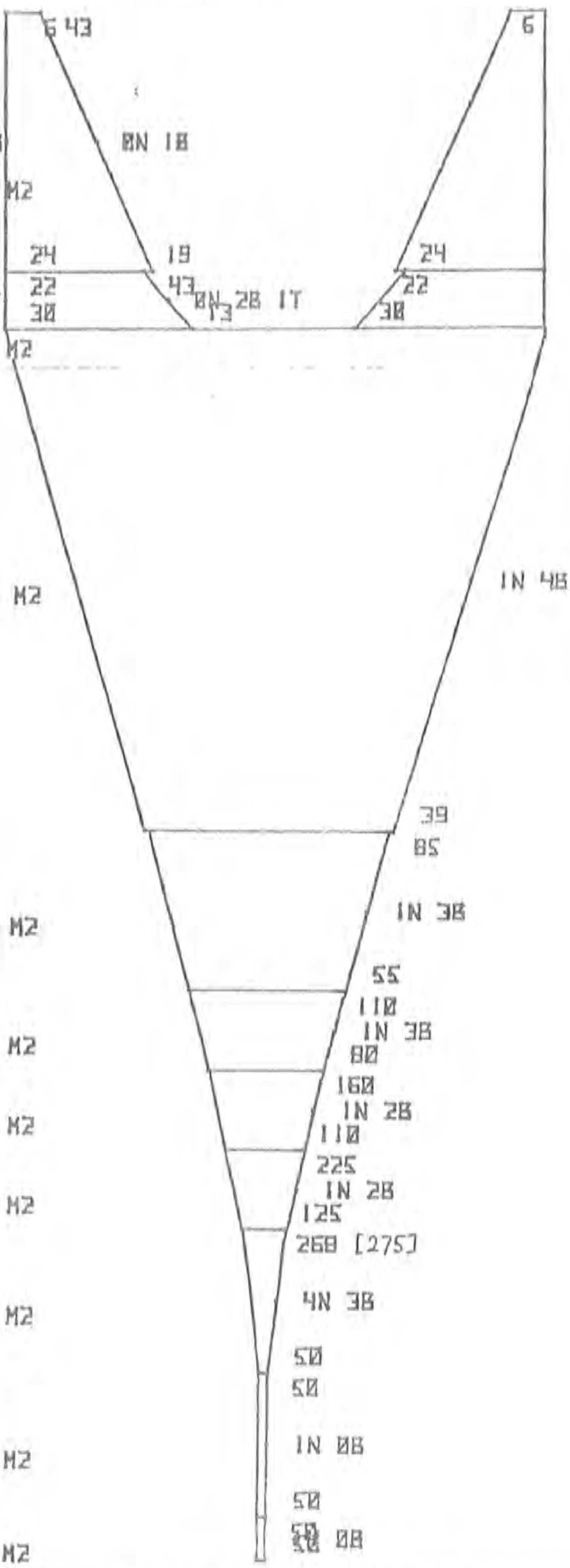
RIVO AFDELING TECHNISCH ONDERZOEK DATUM:

GETEK.: BvM

MAZEN	(MM)	LOWER PANEL.	(MM)	(M)
18	1800	UI= 0.40 OPP.= 0.540 M2	210/ 8 4.8	32.40
4	1800	UI= 0.40 OPP.= 0.374 M2	210/ 8 4.8	7.20
35	1800	UI= 0.40 OPP.= 7.854 M2	210/ 8 4.8	63.00
25	800	UI= 0.40 OPP.= 2.100 M2	210/ 8 3.0	20.00
25	400	UI= 0.40 OPP.= 1.235 M2	210/ 8 2.6	10.00
50	200	UI= 0.40 OPP.= 1.350 M2	210/ 8 2.0	10.00
100	100	UI= 0.40 OPP.= 1.750 M2	210/ 8 2.0	10.00
400	45	UI= 0.40 OPP.= 3.293 M2	210/ 8 2.3	18.00
400	45	UI= 0.40 OPP.= 1.035 M2	210/ 8 2.3	18.00
120	45	UI= 0.40 OPP.= 0.311 M2	210/ 8 2.3	5.40

FIG.: 2

ONDERKANT



BENAMING: 2700 MAZEN PELAGISCH NET (JACZON)
ONDERKANT
LENGTE GRONDPEES: 58.30 M. (FOOT-ROPE LENGTH)

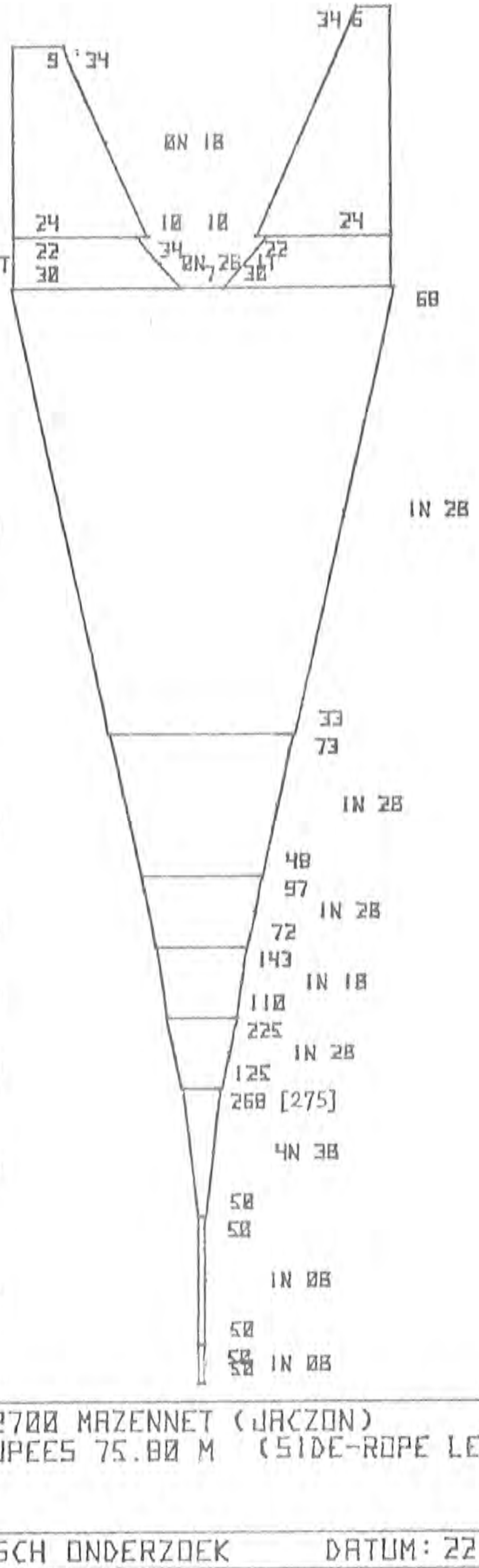
NR.: 800 B

SCHAAL

RIVO AFDELING TECHNISCH ONDERZOEK DATUM: 17 OKT 79 GETEK.: BvM

ZIJKANTEN (SIDE PANELS)

FIG. : 3



[illegible] IN MAZEN	[illegible]WIJDTE (MM)		[illegible] DIKTE (MM)	[illegible] GESTREKT (M)
18 15	1800	IN 08 UI= 0.40 OPP.= 0.891 M2	210/ 8 210/ 8 4.0 4.0	32.40 27.00
4	1800	IN 08 0T UI= 0.40 OPP.= 0.374 M2	210/ 8 4.0	7.20
35	1800	UI= 0.40 OPP.= 6.363 M2	210/ 8 4.0	63.00
25	800	UI= 0.40 OPP.= 1.815 M2	210/ 8 3.0	20.00
25	400	UI= 0.40 OPP.= 1.099 M2	210/ 8 2.6	10.00
50	200	UI= 0.40 OPP.= 1.267 M2	210/ 8 2.0	10.00
100	100	UI= 0.40 OPP.= 1.750 M2	210/ 8 2.0	10.00
400	45	UI= 0.40 OPP.= 3.293 M2	210/ 8 2.3	18.00
400	45	UI= 0.40 OPP.= 1.035 M2	210/ 8 2.3	18.00
120	45	UI= 0.40 OPP.= 0.311 M2	210/ 8 2.3	5.40
				194.00

BENAMING: PELAGISCH 2700 MAZENNET (JACZON)
LENGTE ZIJPEES 75.00 M (SIDE-ROPE LENGTH)

NR.: 800 C

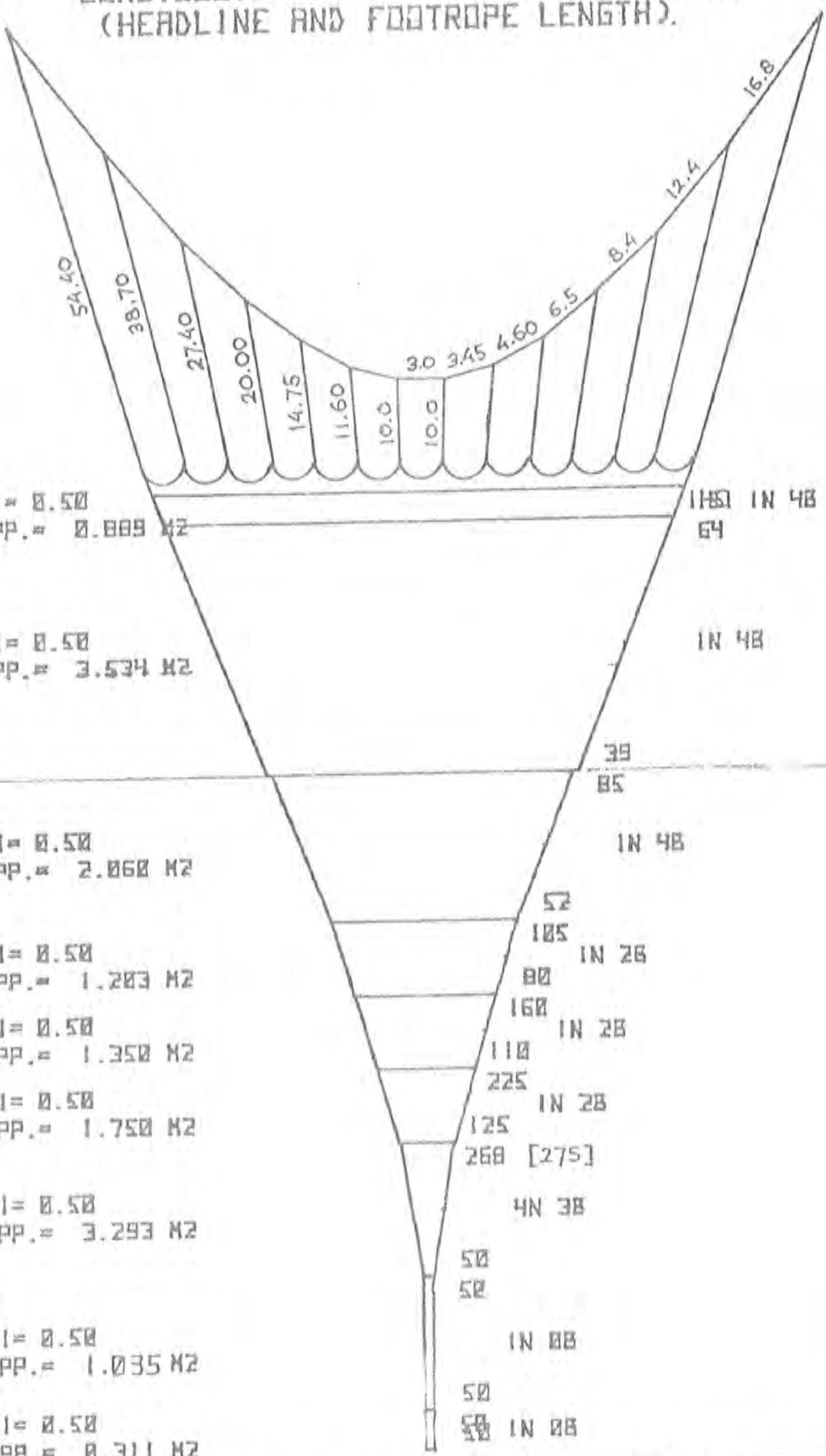
SCHAAL

RIVO AFDELING TECHNISCH ONDERZOEK DATUM: 22 OKT.79 GETEK.: BvM

ONDER- EN BOVENKANT FIG.: 4

UPPER AND LOWER PANEL

LENGTEBOVEN / ONDERPEES = 107.30 M.
(HEADLINE AND FOOTROPE LENGTH).



IN MAZEN	WIJDTE (MM)		DIKTE (MM)	[illegible] (M)
				52.00
7.5	400	UI= 0.50 OPP.= 0.889 M2	210/ 2.6 8	3.20
5	800		3.0	4.00
19	1000	UI= 0.50 OPP.= 3.534 M2	210/ 8 4.0	34.20
25	800	UI= 0.50 OPP.= 2.060 M2	210/ 8 3.0	20.00
25	400	UI= 0.50 OPP.= 1.203 M2	210/ 8 2.6	10.00
50	200	UI= 0.50 OPP.= 1.350 M2	210/ 8 2.0	10.00
100	100	UI= 0.50 OPP.= 1.750 M2	210/ 8 2.0	10.00
400	45	UI= 0.50 OPP.= 3.293 M2	210/ 8 2.3	10.00
400	45	UI= 0.50 OPP.= 1.035 M2	210/ 8 2.3	10.00
120	45	UI= 0.50 OPP.= 0.311 M2	210/ 8 2.3	5.40
			TOTAAL	164.80m

BENAMING: LYNENTRAWL (JACZON), 2700 MAZEN OMTREK
ONTWERP DDR (VEB FISCHKOMBINAT ROSTOCK)
2700 MESHES ROPE TRAWL.

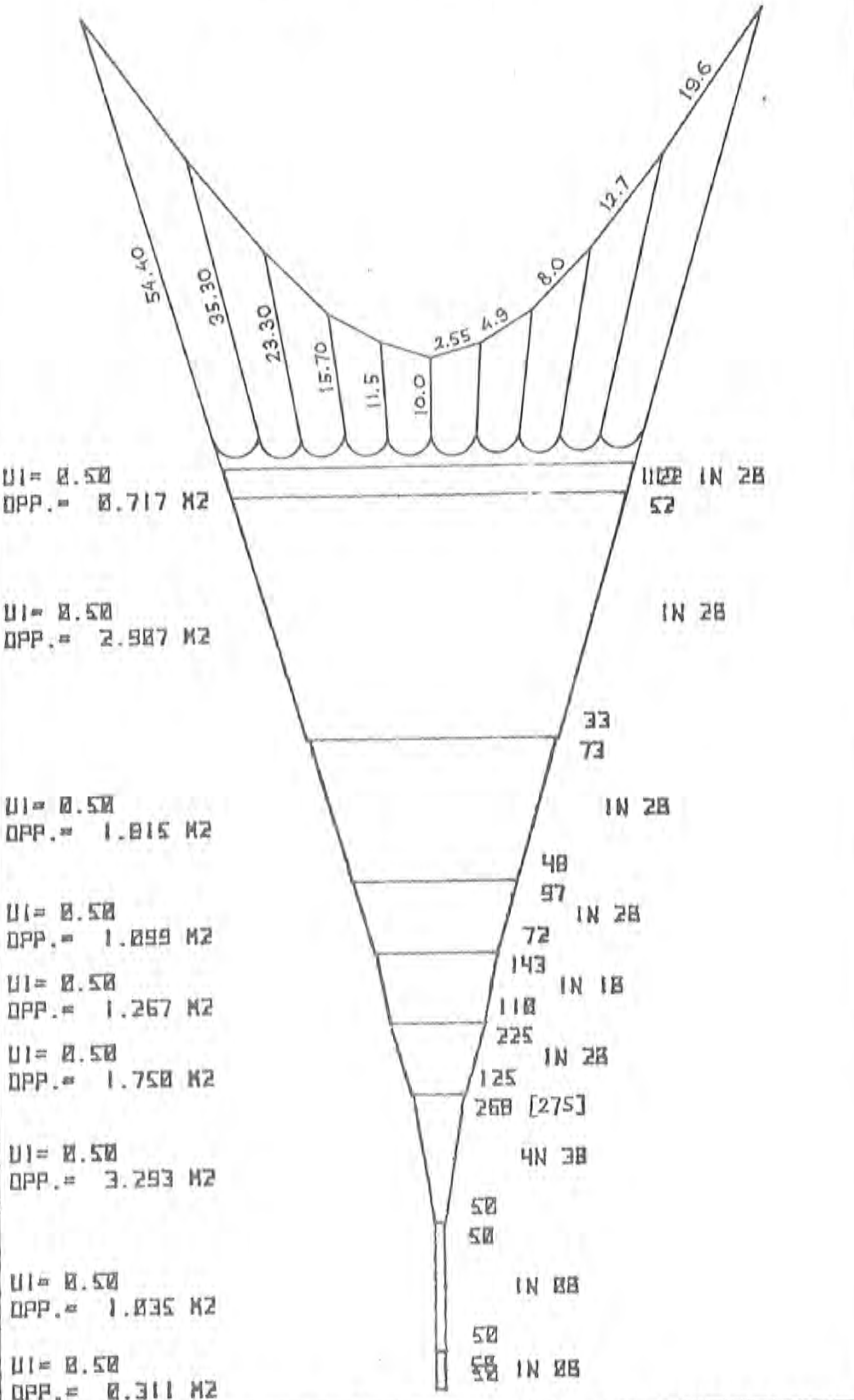
NR.: 001 A

SCHAAL

RIVO AFDELING TECHNISCH ONDERZOEK DATUM: 22 OKT. 79 GETEK.: BM

FIG. 5 ZIJKANTEN (SIDEPANELS)

LENGTE ZIJPEES = 95.50 M.
(SIDE-ROPE LENGTH)



LENGTE IN MAZEN	WIJDTE (MM)	DIKTE (MM)	BESTREEK (M)
			52.00
7.5	400	2.6	3.20
5	800	210/ 3.0	4.00
19	1800	210/ 4.0	34.20
25	800	210/ 3.0	22.00
25	400	210/ 2.6	12.00
50	200	210/ 2.0	12.00
100	100	210/ 2.0	12.00
400	45	210/ 2.3	10.00
420	45	210/ 2.3	16.00
120	45	210/ 2.3	5.40
		TOTAAL	184.80

BENAMING: LIJNENTRAWL (JACZON), OMTREK 2700 MAZEN VAN 20 CM. ONTWERP DDR
(2700 MESHES ROPE TRAWL)

NR.: 801 B

SCHAAL

RIVO AFDELING TECHNISCH ONDERZOEK DATUM: 22 OKT. 75 GETEK.: RvM

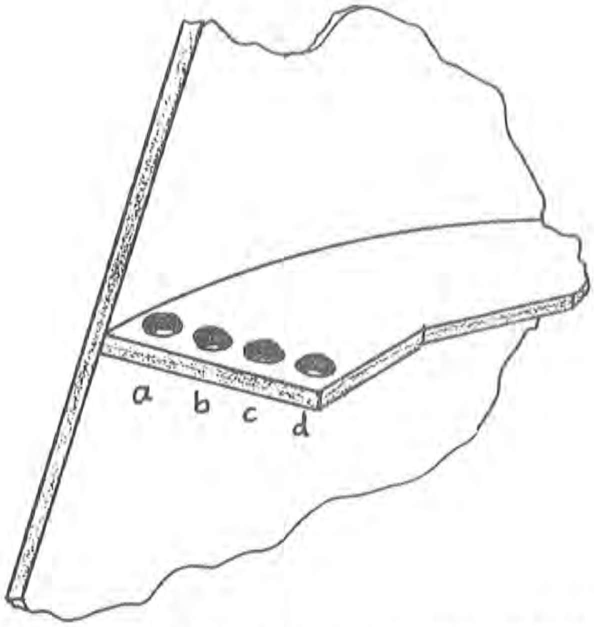
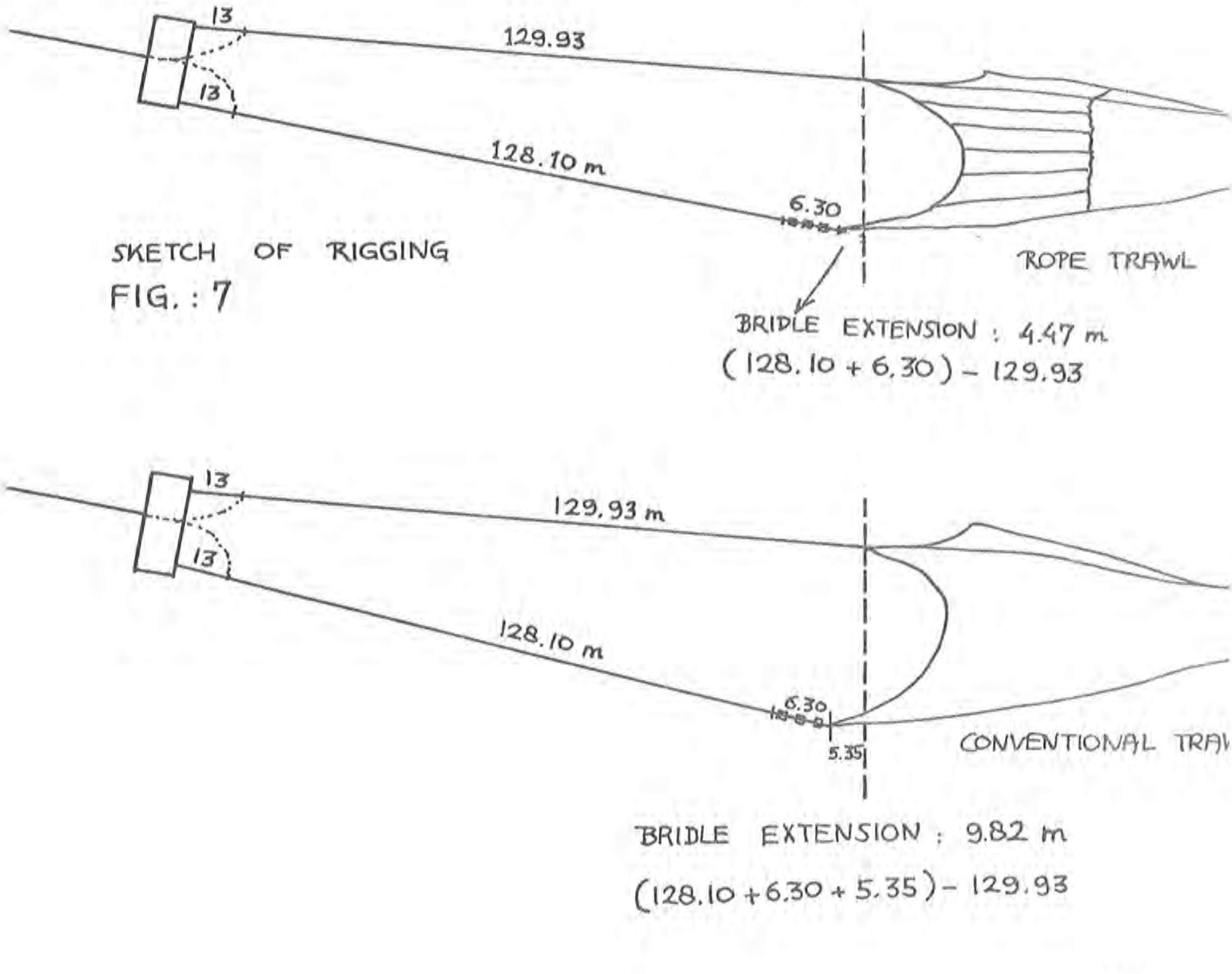


FIG.: 6 WARP ATTACHMENT TO DOORS



SKETCH OF RIGGING
FIG. : 7

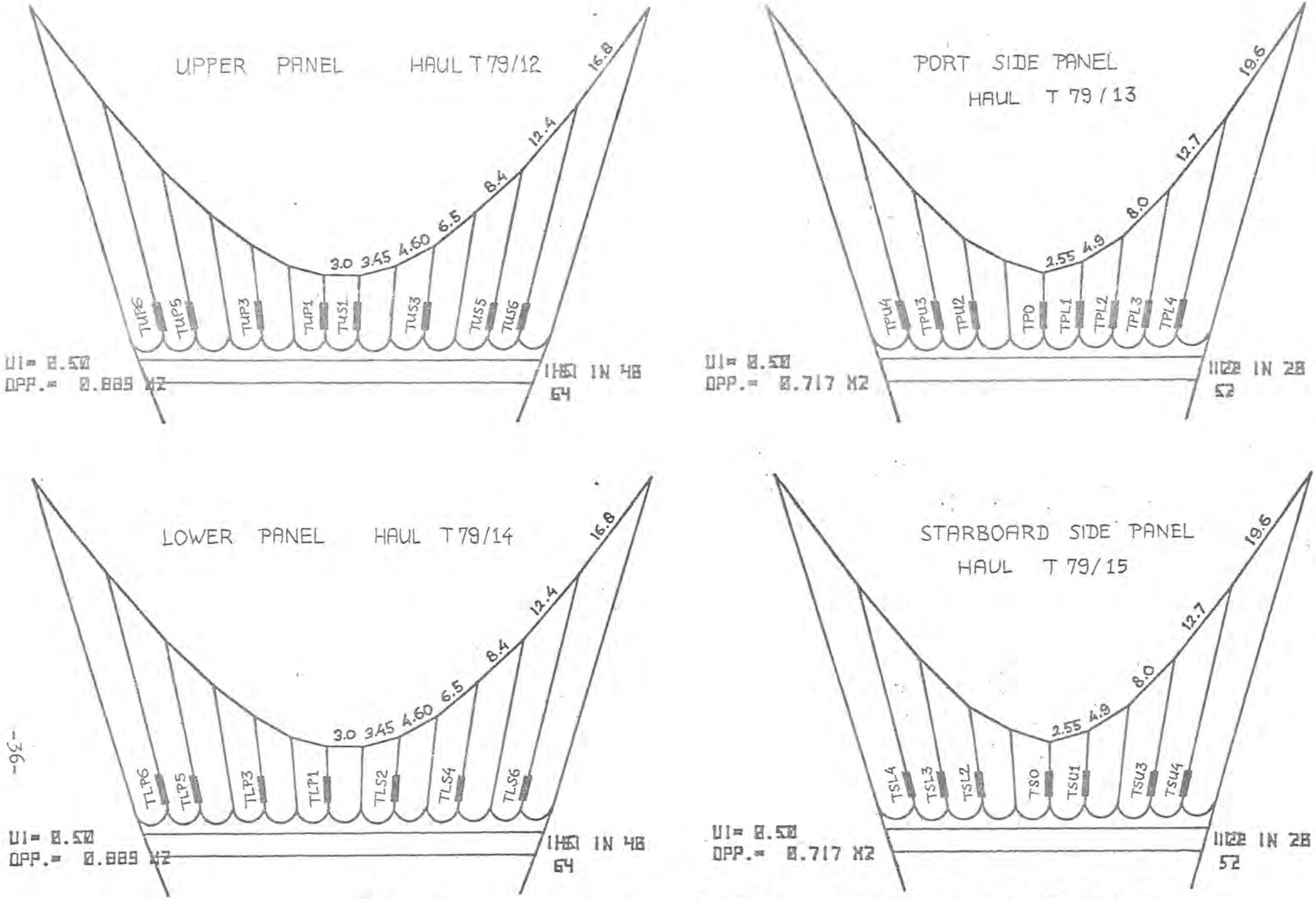
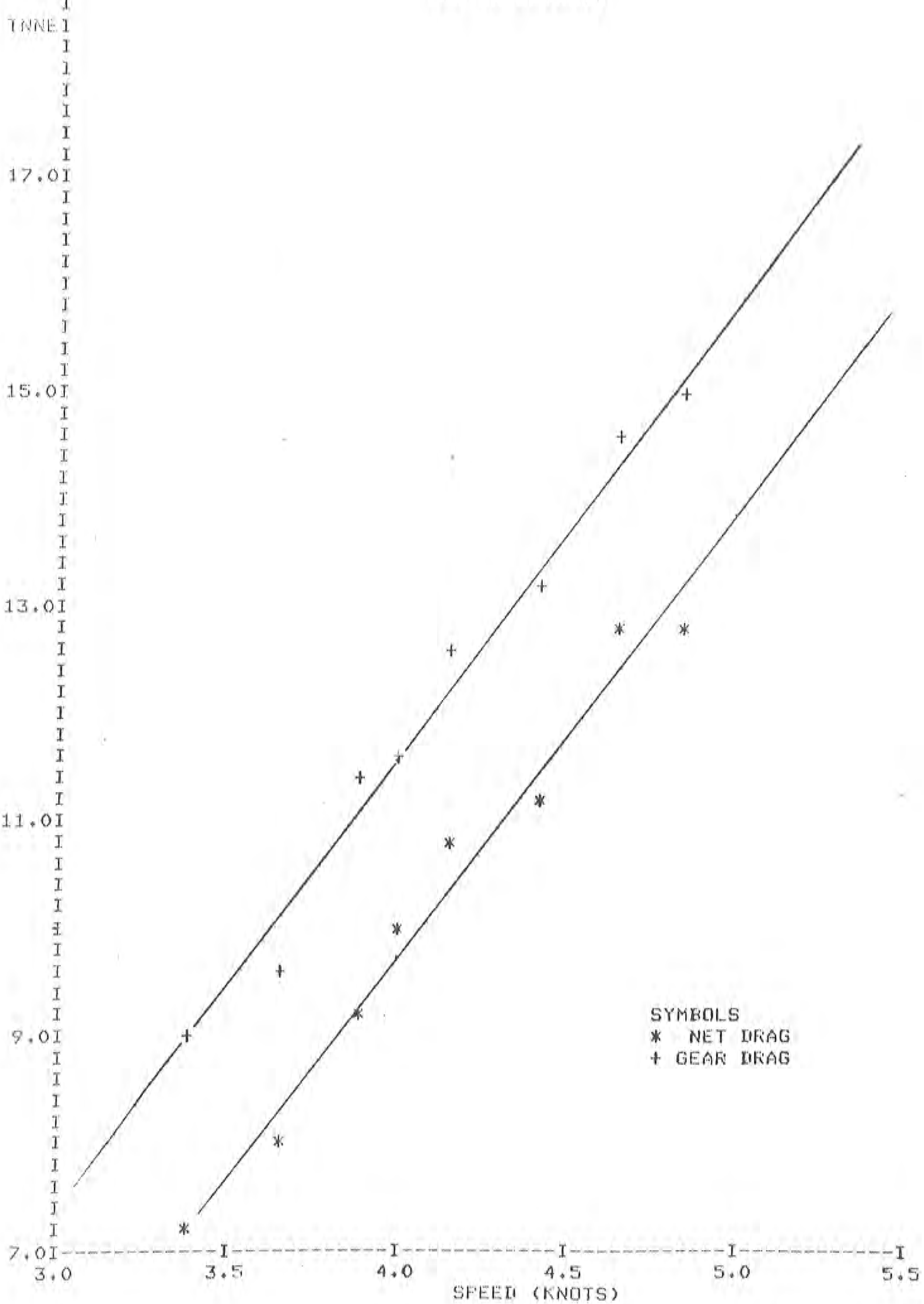


FIG.: 8 ROPE TENSION TESTS, POSITION OF LOAD CELLS.

FIG. 9 GEAR AND NET DRAG
ROPE TRAWL (A)
220 KG WEIGHTS



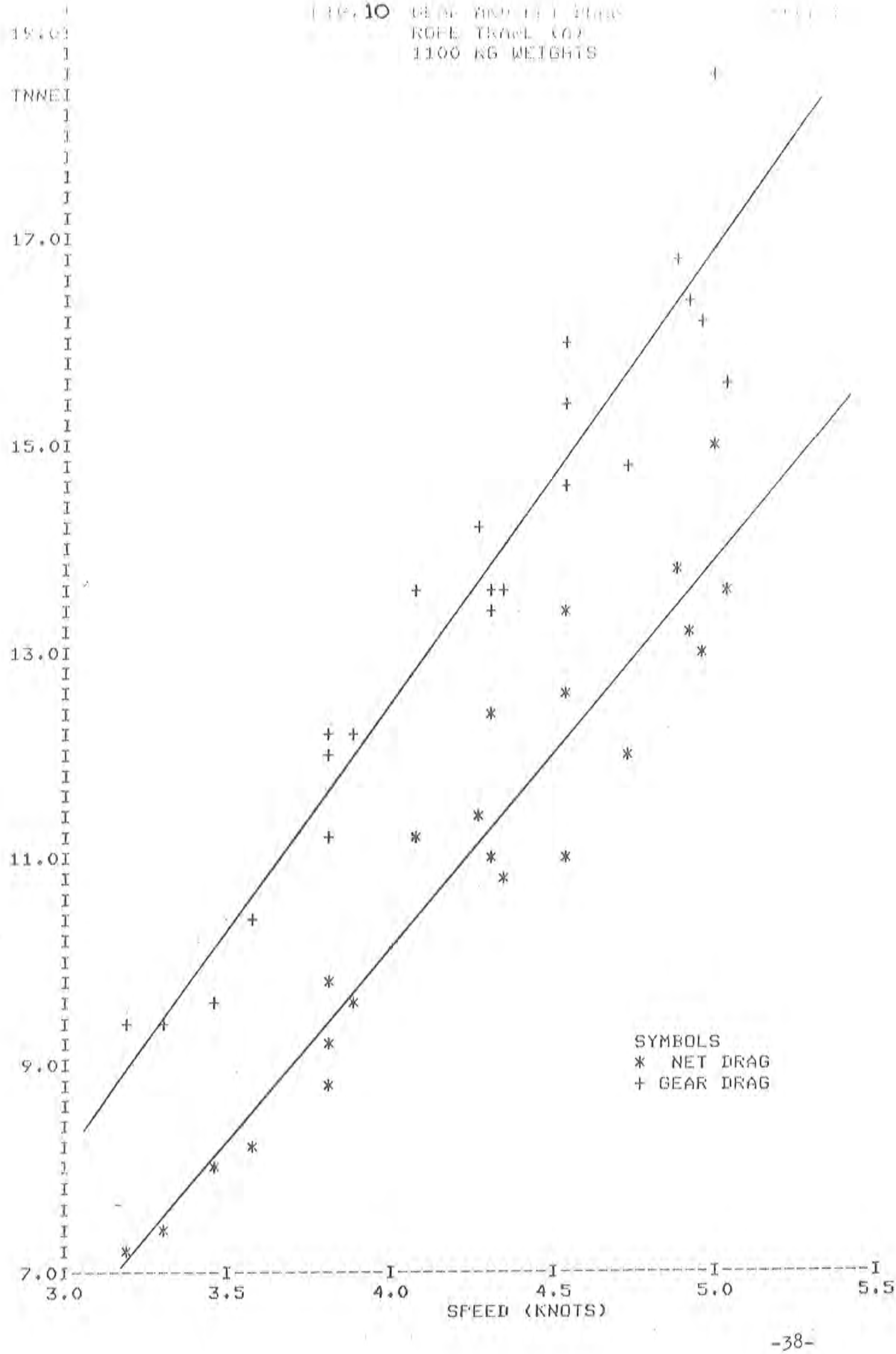


FIG. 10
1100 KG WEIGHTS
TNNE
19.0
17.0
15.0
13.0
11.0
9.0
7.0
3.0
3.5
4.0
4.5
5.0
5.5
SPEED (KNOTS)
SYMBOLS
* NET DRAG
+ GEAR DRAG

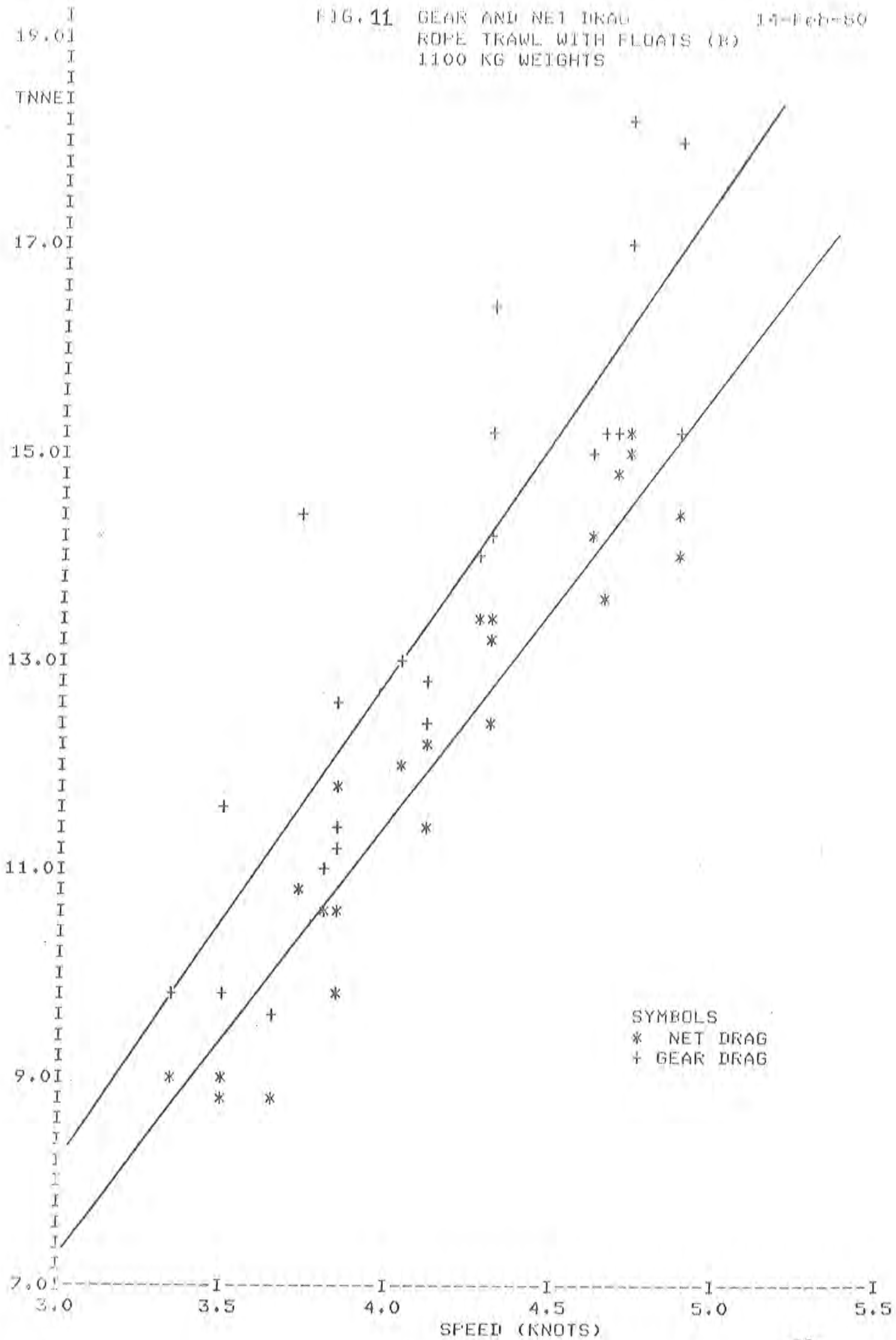


FIG. 11 GEAR AND NET DRAG
ROPE TRAWL WITH FLOATS (B)
1100 KG WEIGHTS
14-Feb-80
TNNE
19.0
17.0
15.0
13.0
11.0
9.0
7.0
3.0
3.5
4.0
4.5
5.0
5.5
SPEED (KNOTS)
SYMBOLS
* NET DRAG
+ GEAR DRAG

FIG. 12 GEAR AND NET DRAG
PELAGIC TRAWL (C)
720 KG WEIGHTS

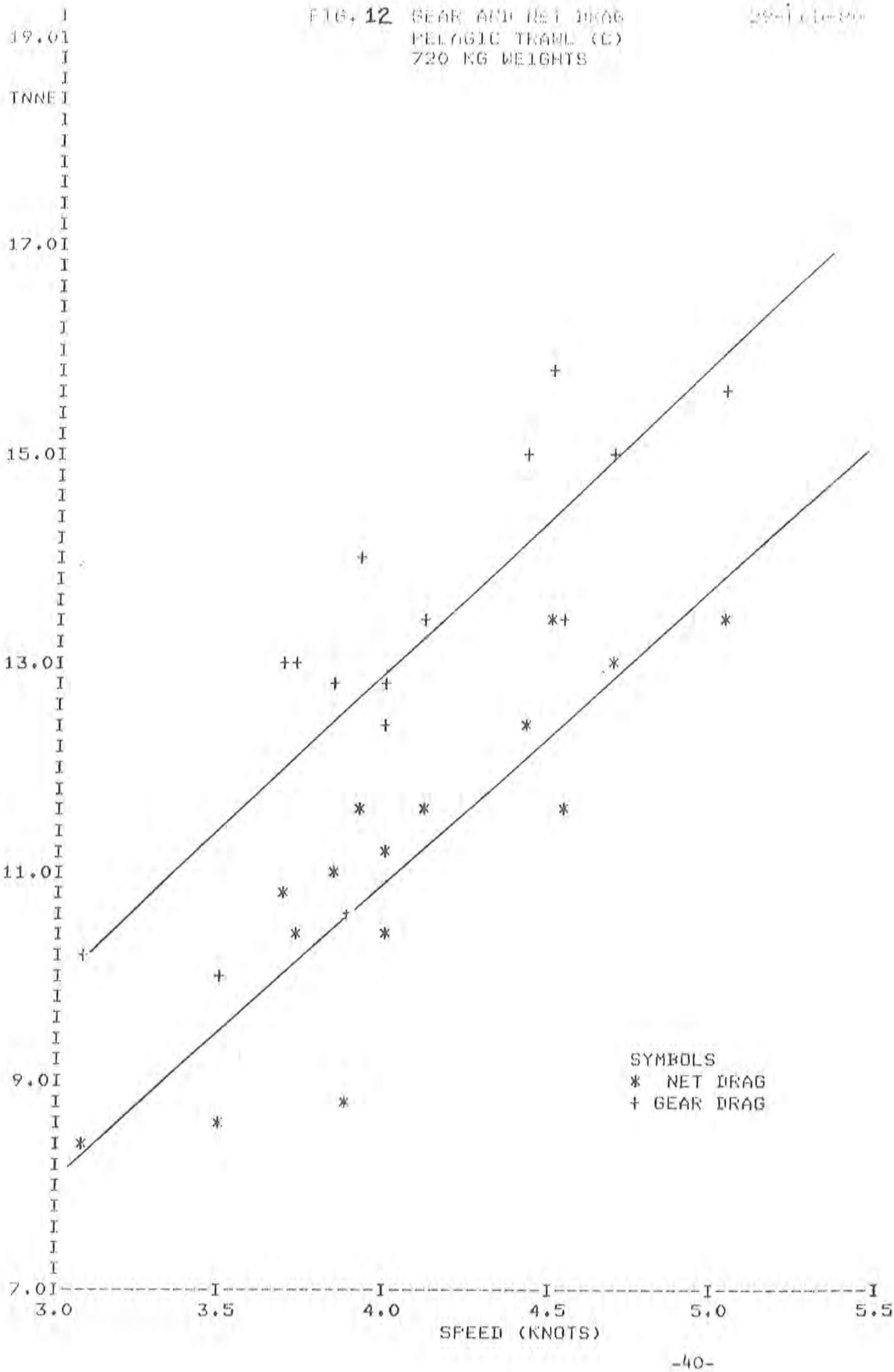


FIG. 13 GEAR AND NET DRAG
PELAGIC TRAWL (C)
1100 KG WEIGHTS

29-Feb-80

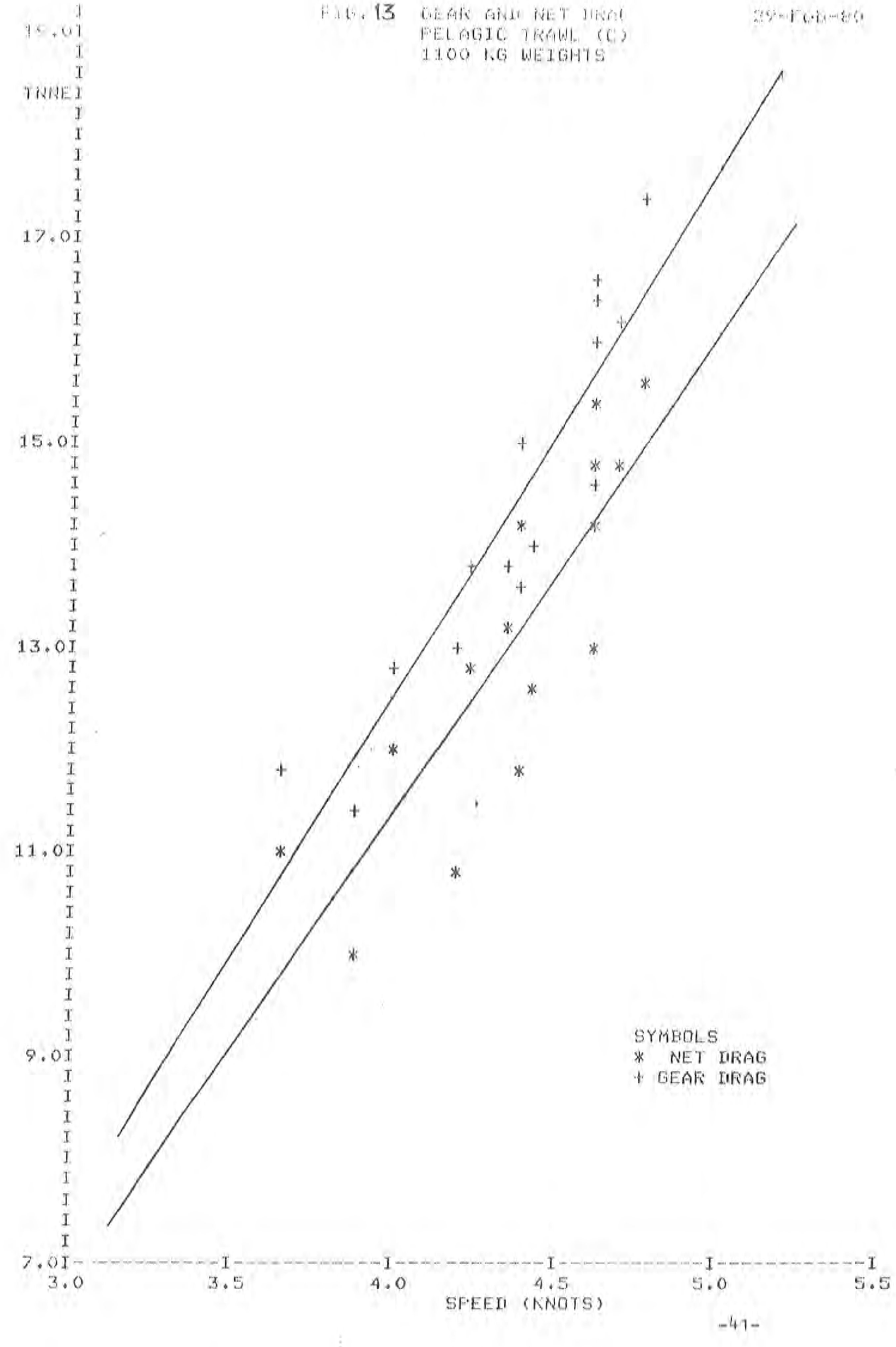


FIG. 34 NET DRAG / CROSS SECTION AREA AT THE HEADLINE CENTRE WITH 720 KG WEIGHTS

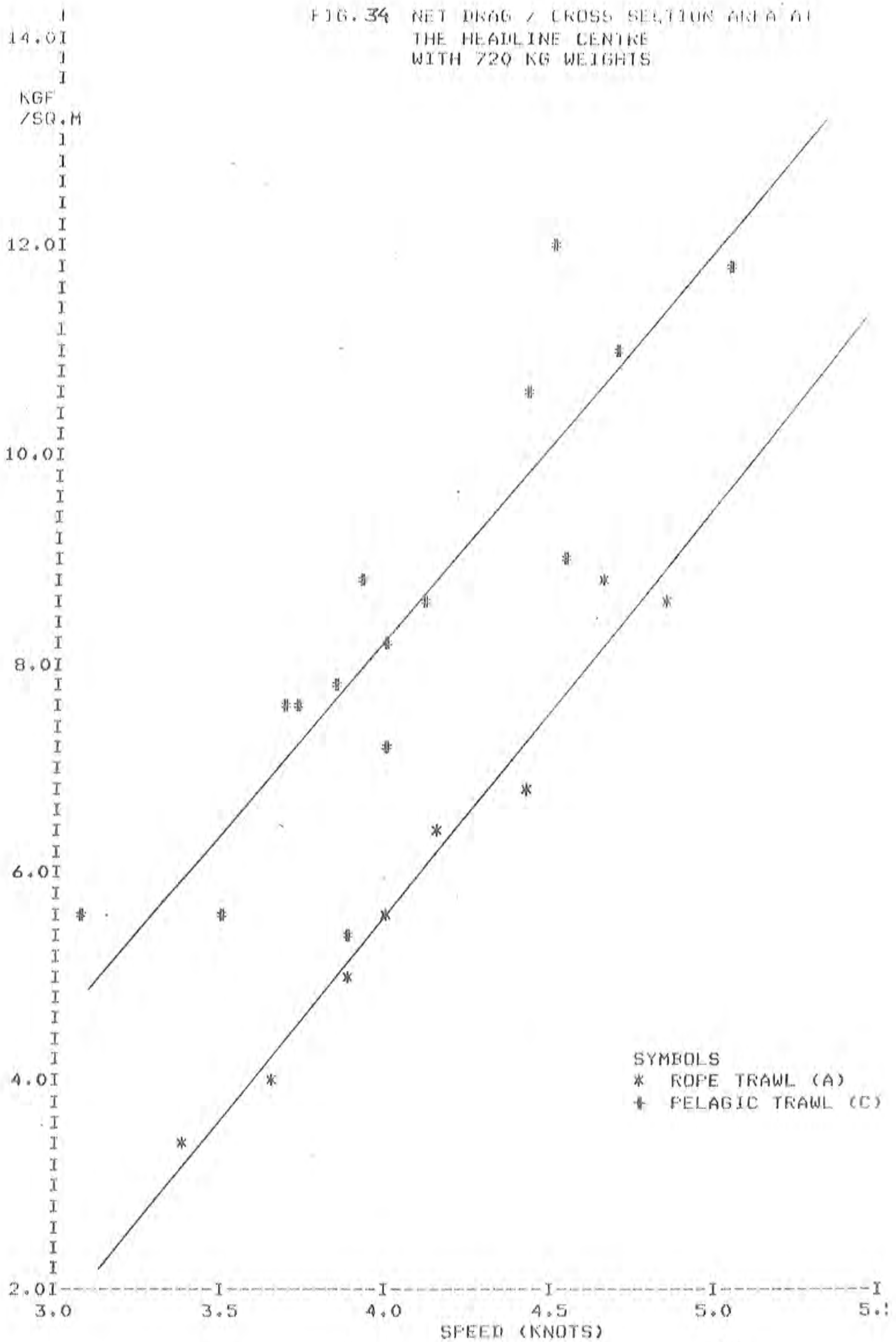


FIG. 35 NET DRAG / CROSS SECTION AREA AT THE HEADLINE CENTRE WITH 1100 KG WEIGHTS

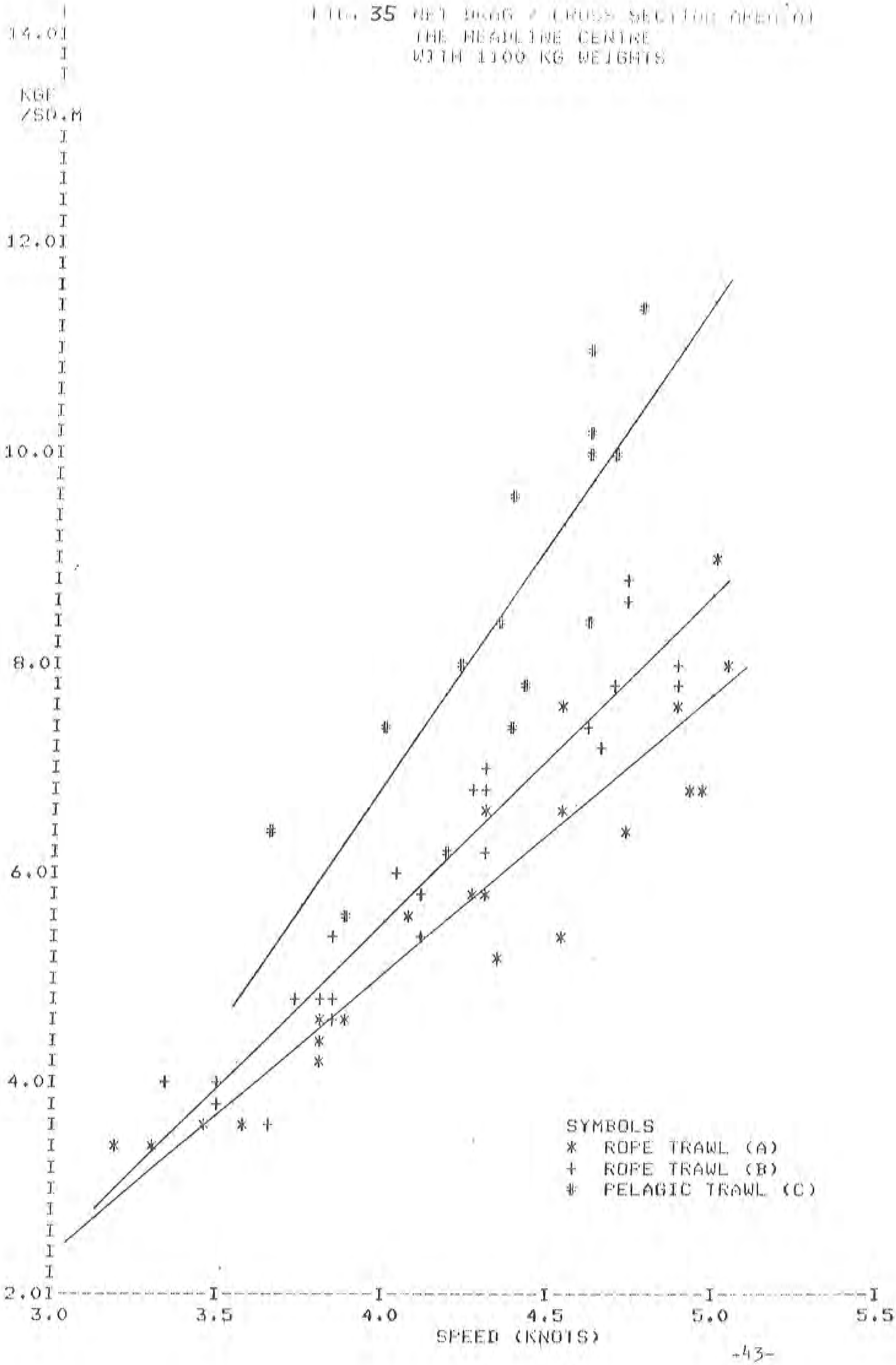


FIG. 36 VOLUME SWEPT PER SECOND
PER UNIT NET DRAG
WITH 720 KG WEIGHTS

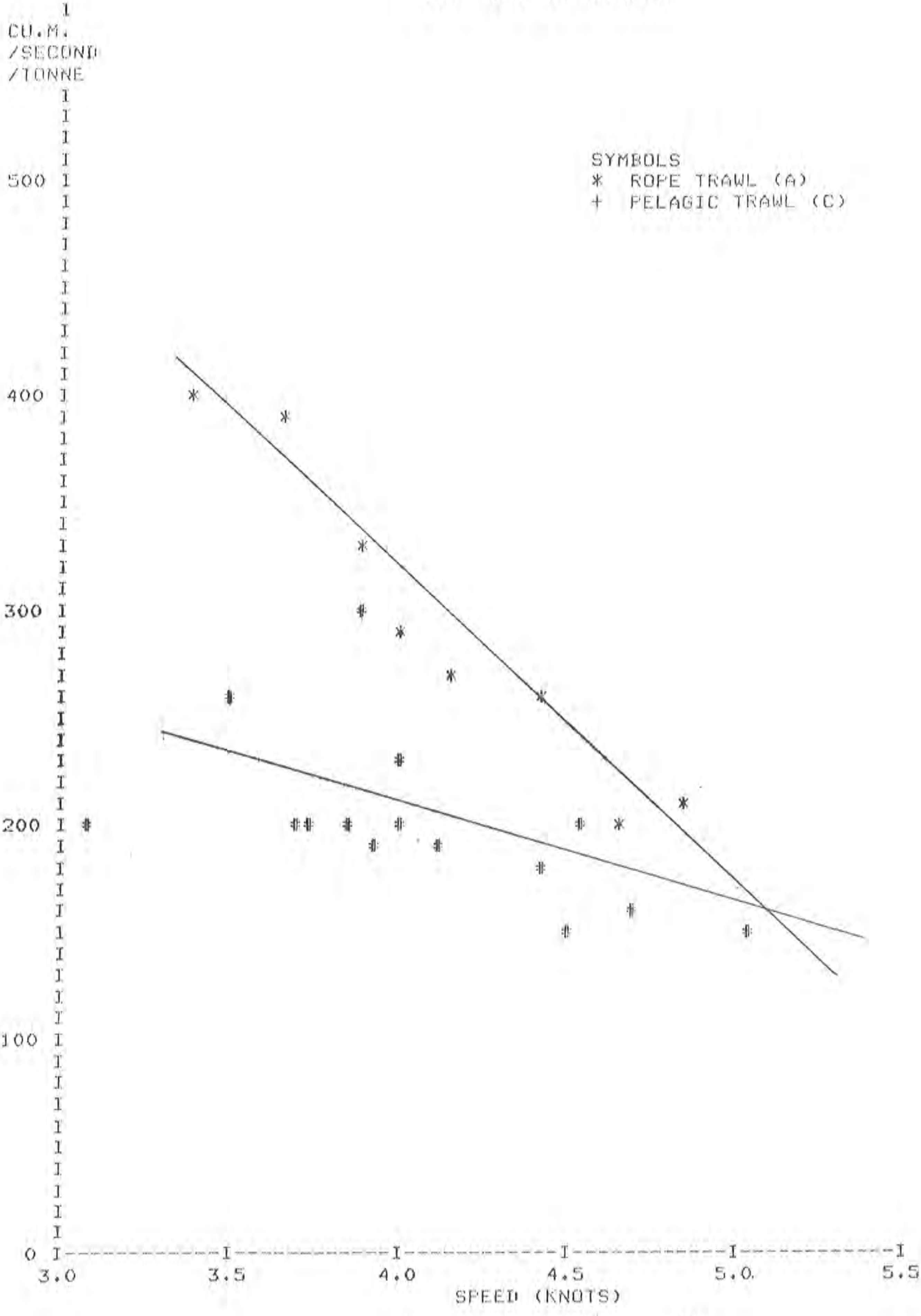
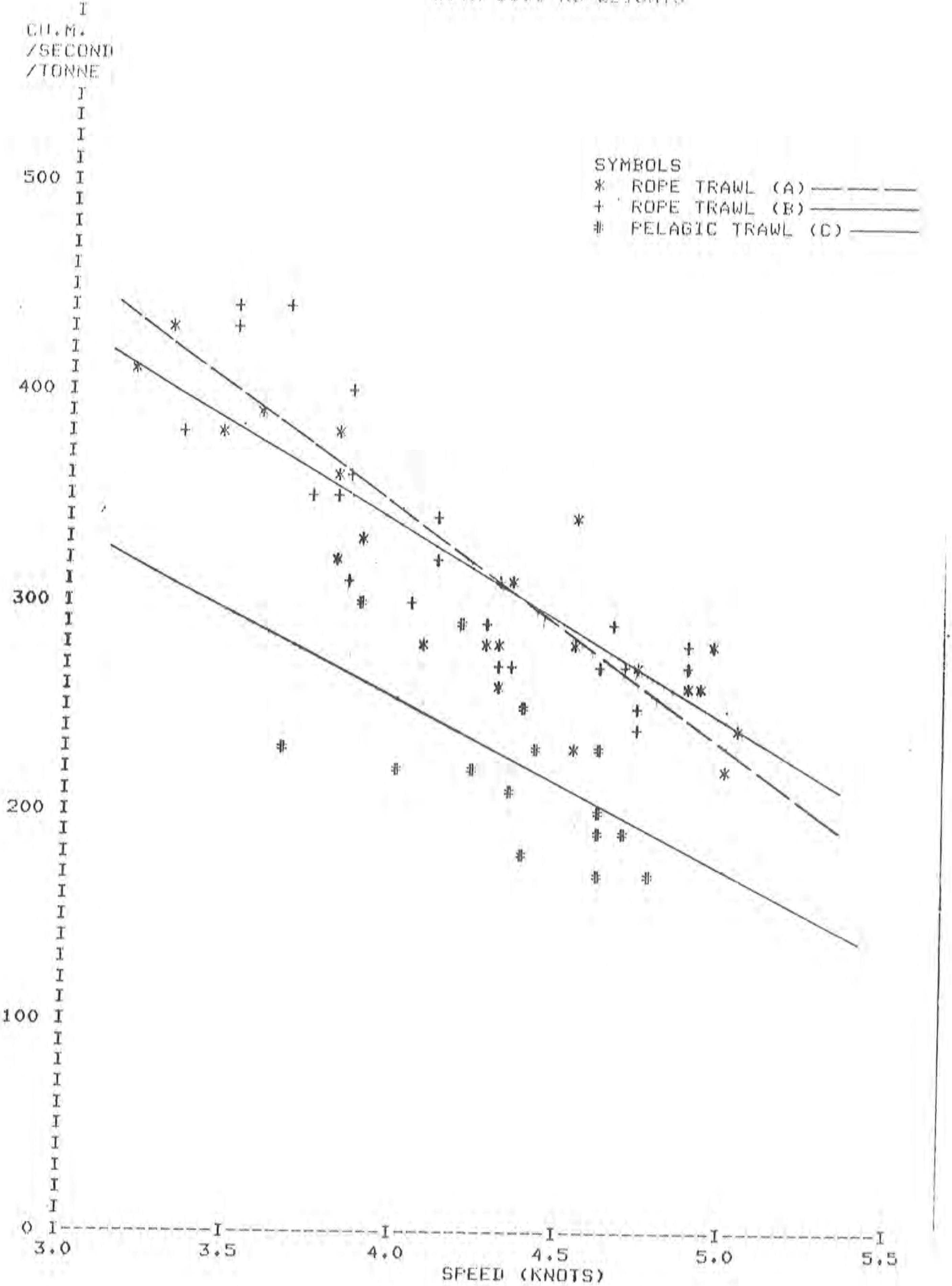


FIG. 37 VOLUME SWEPT PER SECOND
PER UNIT NET DRAG
WITH 1100 KG WEIGHTS



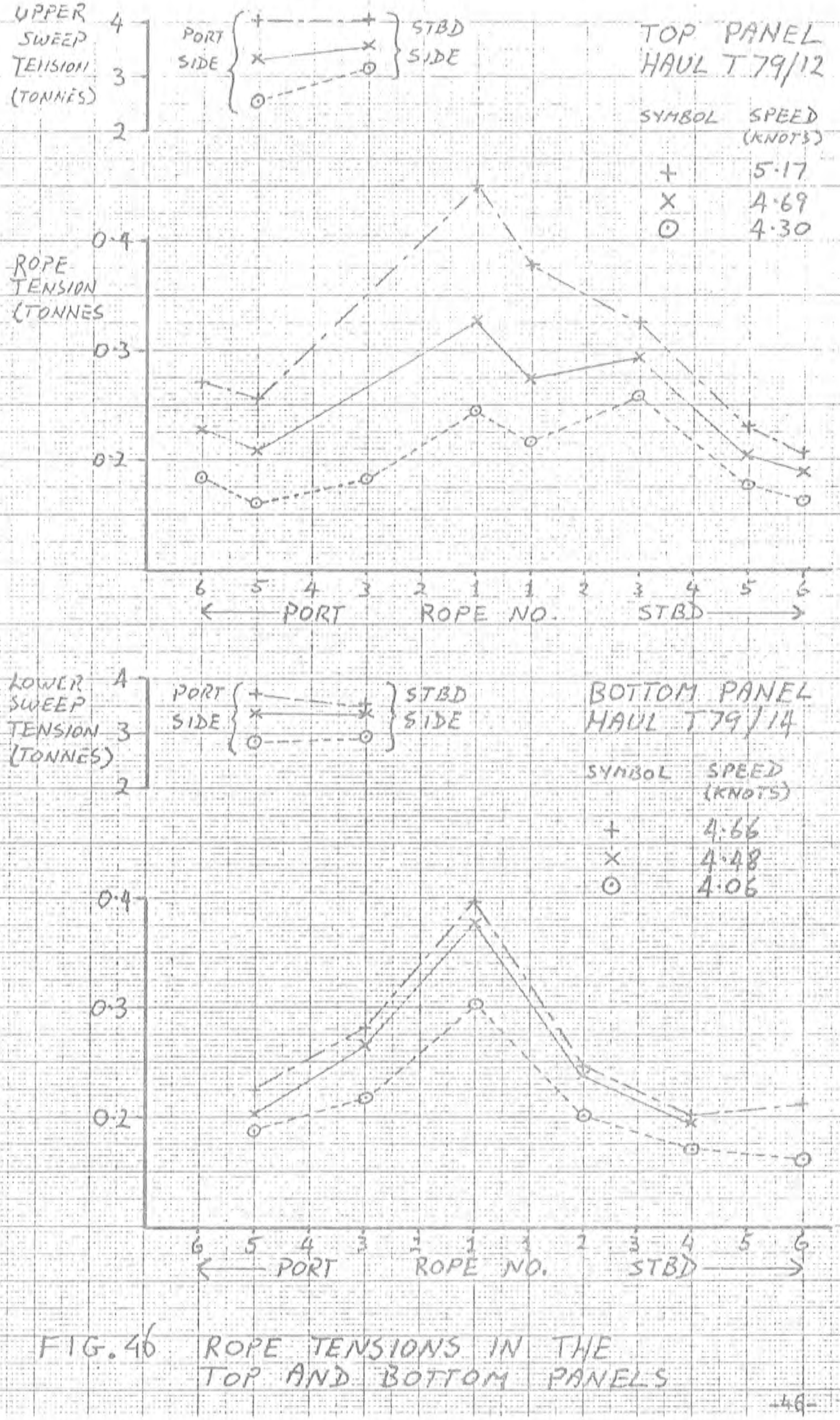


FIG. 46 ROPE TENSIONS IN THE TOP AND BOTTOM PANELS

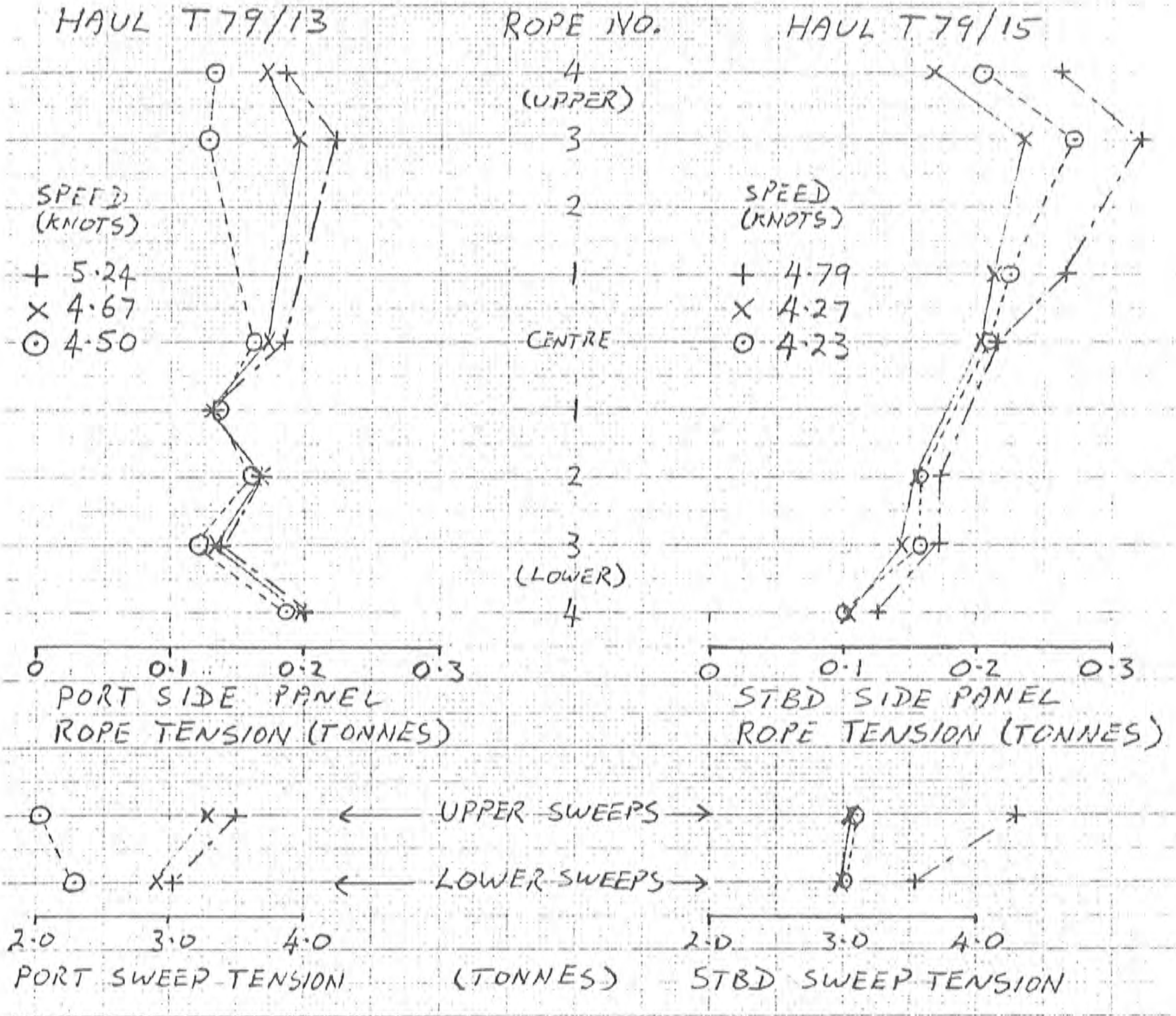


FIG. 47 ROPE TENSIONS IN THE SIDE PANELS

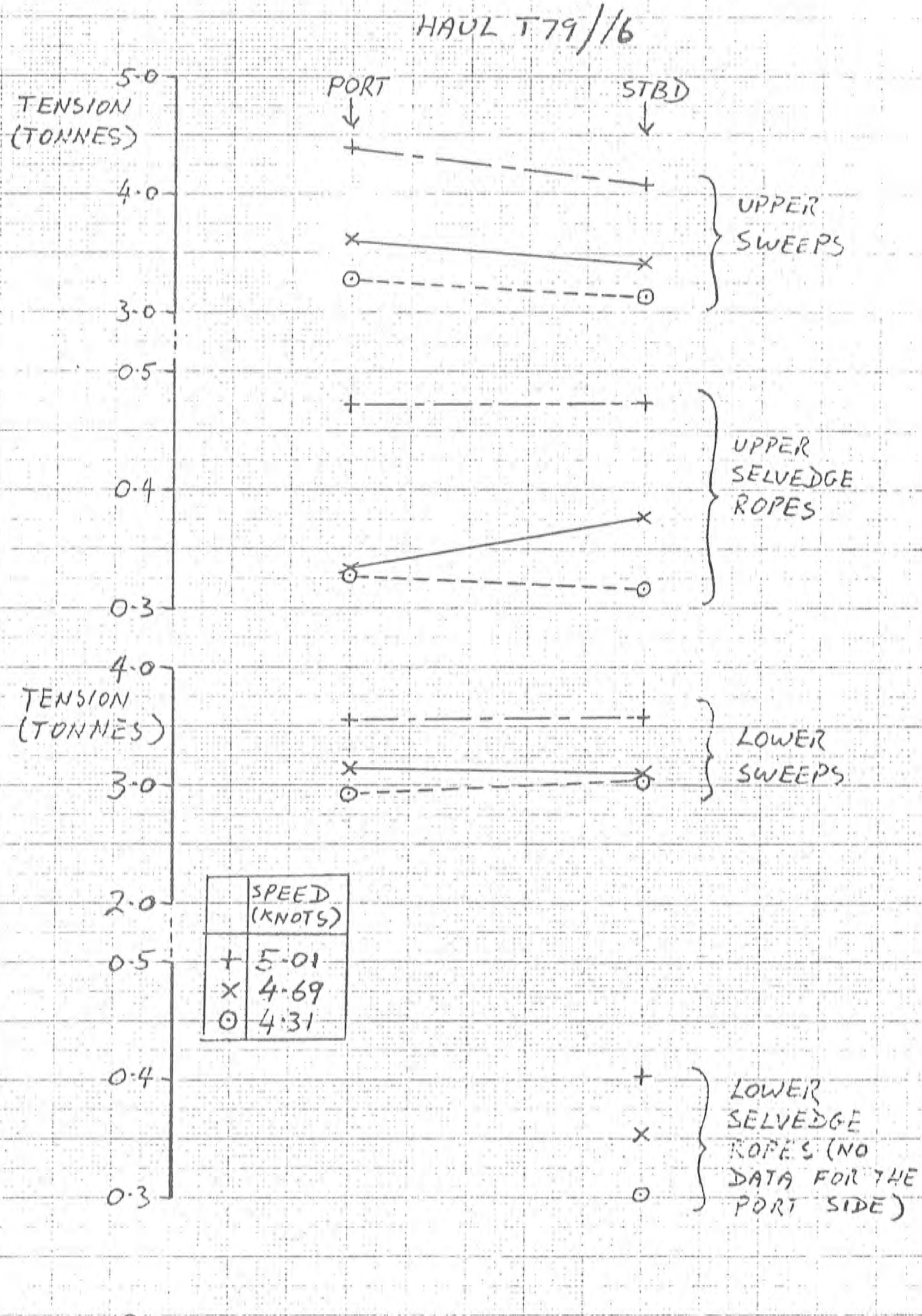


FIG. 48 SELVEDGE ROPE TENSIONS

PRELIMINARY REPORT OF THE BLUE WHITING FISHING EXPERIMENTS EAST/SOUTH-EAST OF THE FAROE ISLANDS IN JANUARY/MARCH 1980

by Stein Hjalti i Jakobstovu and Bjørnar Isaksen

Introduction

On the way to the spawning area, the blue whiting congregate east north-east of the Faroes forming prespawning concentrations, which later start their migration in the southwards direction over the Wyville Thompson Ridge (Schøne 1979). The blue whiting is recorded as a more or less continously narrow layer in this area. At daytime blue whiting is found at 190-220 ftm depth over relatively deep water (270-650 ftm).

Faroes fishing experiments in February/March 1978 and 1979 in the area between Fugløyarbank and the south-east edge of the Faroe Plateau gave catches up-to 25 t/h, but in general the catches were much lower, and too low for successfull industrial fishing (Jakobsson 1978, Jakobstovu 1979).

Materials and methods

Fishing experiments were conducted by the Faroe Marine Research Institute with two chartered vessels, m.s. "Sigmundur Brestisson" with 2800 hp and m.s. "Krünborg" with 2700 hp. These vessels were better powered than those that had been used earlier for this kind of fishing experiments. Both boats are relatively new and built as combined trawlers/purse seiners.

M.s. "Sigmundur Brestisson" used the Faroes 16 m trawl (Jakobstovu 1979), while m.s. "Krünborg" used the Norwegian H-trawl (Isaksen, Jensen and Olsen 1979). This trawl was given on loan from the Institute of Fishery Technology Research, Bergen, in accordance with an internordic project on catch and processing technology of blue whiting. Three scientists of this institute participated in the Faroes fishing experiments which took place during the period 15/1 - 11/3 1980, mainly in the area south-east and east of the Faroes (Figure 1). The double netsonde system was again used to check the herding effect of the very big meshes and gave numerous good recordings.

Results and discussion

The scouting and fishing experiments were conducted only during daytime, due to vertical migration of the blue whiting. Generally the vessels made one haul per day, and in the second half of the chartered period, two.

The experiments started at Fugløyarbank and moved slowly southward according to the migration of the blue whiting. After the chartered period, one of the ships continued fishing about a fortnight on her own account.

In the second half of January catches from 5 to 26 t/h were taken south of Fugløyarbank, with a mean of 12.2 t/h (Tabel 1). The good fishing continued in February with catches rates from 2 to 34 t/h with a mean of 15.5 t/h. In view of the high quality of the prespawning blue whiting these catch rates are considered very good for a fishery for human consumption, and for industrial fishing the catch rates are also quite promising. In a commercial fishery with several boats participating the searching power will increase considerably, and the catch rates will most probably increase.

Both m.s. "Sigmundur Brestisson" and m.s. "Krünborg" stored part of their catches on ice for fileting, the rest was delivered for meal production. On a few occasions the fish for human consumption were kept in RWS with satisfactory results.

The total catches for the ships in the chartered period were 1200 and 1600 ton respectively.

On both vessels the crew were well satisfied with the good towing and operational qualities of these big meshed trawls. To the extent comparative fishing with the two trawls were practicable, there were no unambigious conclusion with regard to which of the trawls that were fishing best. The captains on the boats at least claimed that these trawls gave much higher catch rates than they would have expected with smaller, conventional meshed trawls.
The double netsonde-system were used on the 16 m trawl and altogether 11 trawl hauls were made with the system working.

The locations of the second transducer were: at the changes of mesh size from 160 to 80 cm, 80 to 40 and 40 to 20 cm, respectively.

The echo recordings from the different locations showed that the distance from the fish to the panel in the lower belly changed little from for to aft in the trawl. The recordings furthermore confirmed the earlier experience that the fish do swim along with the trawl inside the belly.

Beneath the trawl at the locations of the second netsonde transducer very few fishes were recorded. This together with the very good catch rates clearly suggests that the big meshes in the fore part of the trawl do herd the blue whiting.

For the time being the impression consequently is that the big meshed trawls in the blue whiting fishery are here to stay.

References

Isaksen, Jensen and Olsen (1979)
Recent developments on blue whiting trawls in Norway
I.C.E.S. CM.1979/B:24

Jakobsson, J. (1978)
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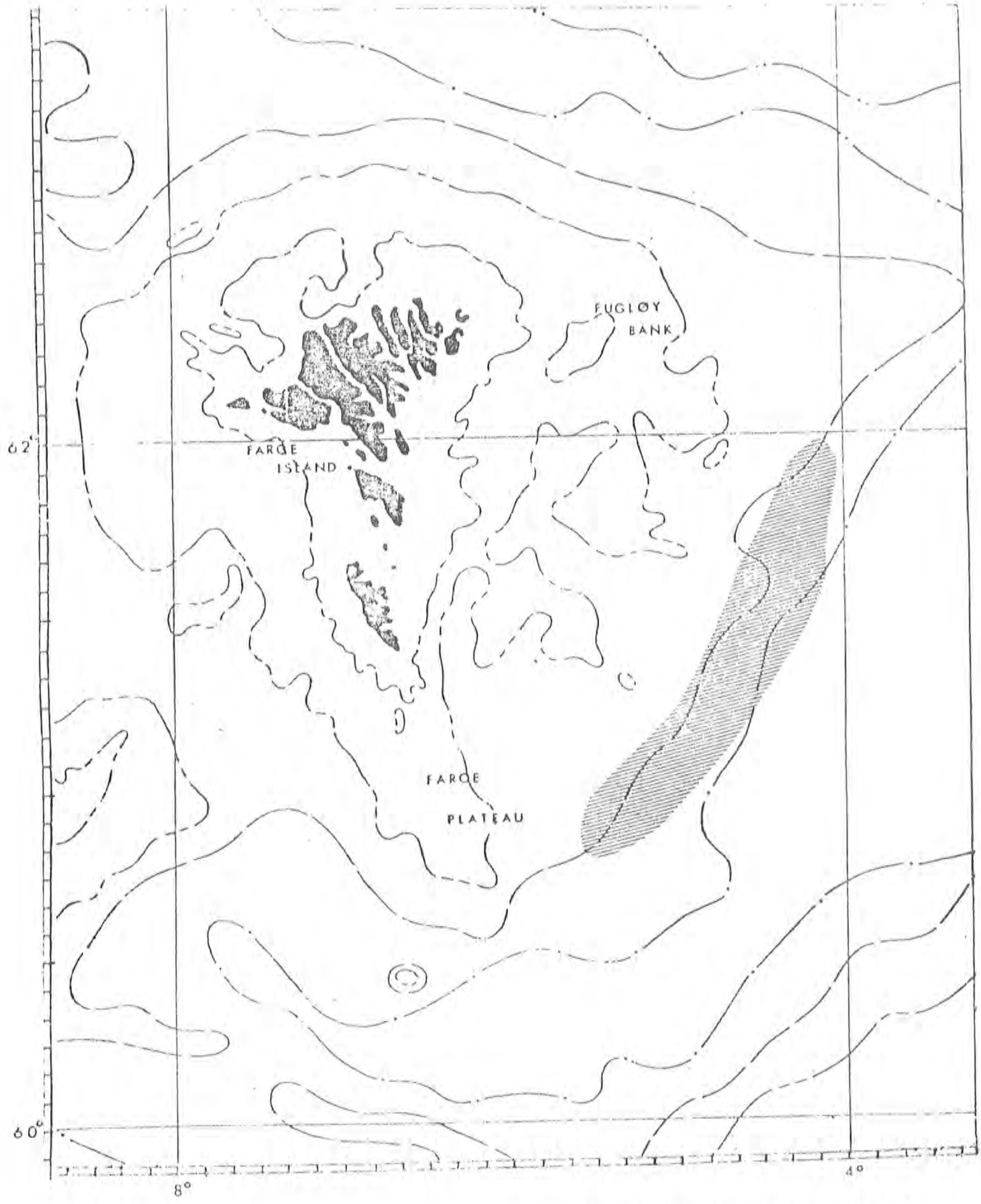


Fig. I. The main fishing area east of Faroe Islands in Jan./March 1980. (hatched).

dagur	kl.	byrjað position	fvn.	kl.	endað position	fvn.	Total fangst tons íalt	Fiskedybde skrift fvn.	Kommentarer viðmerkingar
15/1	12.00	61°27'N-04°28'V	285	15.50	61°36'N-04°17'V	460	40	210-225	
17/1	10.40	61°23'N-04°32'V	450	14.40	61°30'N-04°14'V	600	20	220-230	
19/1	12.25	60°58'N-04°55'V	465	16.10	61°08'N-04°48'V	440	40	210-225	
24/1	14.48	61°19'N-04°46'V	340	17.00	61°25'N-04°35'V	360	30	180-220	
26/1	09.30	61°19'N-04°44'V	300	12.45	61°26'N-04°36'V	300	30	180-220	
26/1	15.00	61°23'N-04°43'V	300	16.30	61°28'N-04°36'V		10	220	
27/1	10.15	61°25'N-04°41'V	300	14.45	61°37'N-04°26'V	350	100	180-230	
2/2	09.50	60°53'N-05°27'V	280	16.00	61°05'N-05°02'V	320	85	210-260	
3/2	08.45	60°49'N-05°47'V	250	14.00	60°57'N-05°20'V	270	100	200-	
3/2	16.30	60°52'N-05°27'V	260	18.00	60°55'N-05°25'V		0	220-	
4/2	09.40	60°50'N-05°41'V	260	12.30	60°55'N-05°24'V	270	70	200-	
5/2	09.00	60°50'N-05°41'V	260	11.20	60°54'N-05°26'V	275	50	200-240	
7/2	13.00	61°33'N-04°26'V	350	16.00	61°42'N-04°23'V	350	50	220-	
10/2	09.25	61°56'N-04°10'V	350	15.15	62°03'N-03°41'V	375	100	170-220	
12/2	11.45	61°43'N-04°23'V	300	16.15	61°55'N-04°11'V	290	0		óklárt
13/2	09.45	61°43'N-04°22'V	325	14.50	61°56'N-04°09'V	300	90	200-240	
14/2	08.45	61°35'N-04°38'V	275	12.00	61°43'N-04°28'V	290	70	220-180	
14/2	14.20	61°38'N-04°33'V	290	16.30	61°29'N-04°39'V	285	60	180-220	
15/2	08.45	61°23'N-04°42'V	325	12.45	61°32'N-04°32'V	475	50	200-230	
15/2	15.30	61°26'N-04°41'V	325	17.30	61°20'N-04°42'V	350	30	200-	
16/2	07.45	61°13'N-04°45'V	500	11.15	61°15'N-04°35'V	460	40	180-230	
16/2	12.50	61°22'N-04°39'V	450	16.30	61°09'N-04°49'V	450	20	220-240	
20/2	09.20	61°39'N-04°24'V	380	12.45	61°50'N-04°12'V	360	15		
20/2	15.00	61°47'N-04°14'V	360	18.00	61°38'N-04°22'V	380	0		
22/2	08.45	61°28'N-04°31'V	420	11.30	61°36'N-04°26'V	380	30	220-250	
22/2	14.15	61°30'N-04°28'V	420	17.15	61°39'N-04°21'V		35		
25/2	08.45	61°15'N-04°44'V	420	16.00	61°34'N-04°28'V	420	50	180-220	
3/3	10.15	60°58'N-05°16'V	300	17.00	61°14'N-04°58'V	290	60	220-240	
4/3	07.45	60°59'N-05°17'V	280	15.45	61°22'N-04°47'V	310	80	200-260	
5/3	09.00	61°11'N-04°58'V	320	16.40	61°33'N-04°35'V	320	40	200-240	
6/3	07.30	60°51'N-05°22'V	400	16.30	61°16'N-04°54'V	300	25	200-250	
7/3	08.00	61°42'N-03°40'V	750	12.15	61°51'N-03°38'V	700		180-200	
7/3	14.30	61°47'N-03°46'V	500	18.45	61°38'N-03°44'V	500	15	180-200	
8/3	07.00	61°28'N-03°52'V	670	15.45	61°58'N-03°39'V	480	100	180-220	

hál nr.	dagur	kl.	position	fvn.	kl.	position	fvn.	tons	viðmerkingar
1	24/1	14.00	60°35'N-05°35'V	420	120 min.	270°		0	
2	25/1	11.30	61°13'N-04°54'V	320	12.45	61°16'N-04°52'V	360	5	vektir flöktar
3	26/1	09.30	61°06'N-04°57'V	410	10.00	61°06'N-04°57'V		0	kápul slitnaður
4	26/1	12.30	61°13'N-04°58'V	360	16.00	61°21'N-04°46'V		0	loddini flökt
5	27/1	09.40	61°20'N-04°53'V	290	15.45	61°15'N-04°55'V	400	30	
6	28/1	09.15	61°11'N-04°59'V	340	12.25	61°17'N-04°52'V	340	40	
7	29/1	08.50	61°32'N-04°44'V	290	13.05		340	110	
	30/1								landað 800 ks. til Bakkafrost
	31/1								landað 182 t til Havsbrún, lemmarnir saman, greiddu restina av degnum
8	2/2	08.40	60°55'N-05°26'V	270	15.15	61°08'N-05°01'V	320	50	mistu 150 t, posin sakk
9	3/2	08.40	60°52'N-05°39'V	260	11.00	60°51'N-05°24'V	370	60	
10	3/2	13.45	60°53'N-05°27'V	320	16.05	60°57'N-05°21'V	280	80	
	4/2								landað 800 ks. Bakkafrost, 158 t Havsbr
11	5/2	15.00	61°04'N-05°03'V	300	16.50	61°07'N-05°00'V	360	0	einki at síggja, 1 t slept út aftur
12	6/2	12.40	61°19'N-04°15'V	620	15.45	61°29'N-03°58'V	670	50	
13	7/2	09.15	61°20'N-04°36'V	480	12.25	61°28'N-04°27'V	450	50	
	8/2								landað 400 ks. Bakkafrost, 94 t Havsb
14	11/2	11.00	61°39'N-04°18'V	410	16.00	61°52'N-04°04'V	370	50	
15	12/2	09.00	61°50'N-04°27'V	260	10.30	61°46'N-04°19'V	340	20	
	13/2								landað 800 ks. Bakkafrost, 53 t Havsbr
16	14/2	09.25	61°43'N-04°28'V	310	11.32	61°49'N-04°25'V	280	30	
17	14/2	13.50	61°48'N-04°28'V	280	17.10	61°36'N-04°37'V	270	30	
18	15/2	08.55	61°18'N-04°48'V	400	12.50	61°22'N-04°33'V	520	80	
19	15/2	15.20	61°18'N-04°33'V	540	17.25	61°24'N-04°36'V	440	40	
20	16/2	07.45	61°13'N-04°22'V	660	11.10	61°21'N-04°34'V	530	40	
21	16/2	13.20	61°19'N-04°36'V	540	16.20	61°06'N-04°47'V		30	
22	17/2	07.20	61°33'N-04°21'V	520	11.55	61°44'N-04°22'V	330	80	landað 400 ks. Bakkafrost 362 t Havsbrú
23	22/2	09.00	61°14'N-04°42'V	500	10.55	61°19'N-04°31'V	500	20	
24	22/2	13.55	61°28'N-04°27'V	540	16.55	61°37'N-04°23'V	400	70	
25	23/2	10.30	61°28'N-04°41'V	270	14.05	61°35'N-04°29'V	360	10	
26	2/3	15.55	61°32'N-04°04'V	680	17.10	61°24'N-04°01'V	680	2	sleptu fiskinum, 1000 kg lodd
27	3/3	14.55	61°03'N-05°12'V	300	17.50	61°09'N-05°02'V	290	18	
	4/3								landað uml. 550 ks. til Bakkafrost
28	5/3	08.30	61°09'N-05°03'V	290	16.20	61°28'N-04°38'V	315	70	500 kg lodd
29	6/3	07.55	60°50'N-05°21'V	400	14.45	61°08'N-05°51'V	460	15	
	7/3								landað 450 ks til Bakkafrost
30	8/3	09.25	61°50'N-03°37'V	580	17.10	61°52'N-03°49'V	420	65	
31	9/3	07.30	61°33'N-04°20'V	520	15.15	61°51'N-03°42'V	520	40	
	10/3								landað 1000 ks til Bakkafrost
	11/3								landað 134 t til Havsbrún

PROBLEMS ENCOUNTERED IN THE CORRELATION BETWEEN THE RESULTS OF ENGINEERING PERFORMANCE TRIALS OF FULL SCALE TRAWLS AT SEA AND SCALED MODEL TRAWLS TESTED IN THE WHITE FISH AUTHORITY FLUME TANK, HULL

by: D.A. Wileman

The Flume Tank of the White Fish Authority, Industrial Development Unit has been in operation for 4 years during which time almost 100 scale models of different designs of trawls have been constructed and tested. This large stock of models is required for demonstration purposes on the Fishing Gear Technology Courses that are run at the Fisheries Training Centre and Flume Tank for the benefit of fishermen and net makers from many different nations.

The flume tank forms the centre piece of the training centre. Structually it is a large re-inforced concrete tank 31m long by 5m wide by 5m deep, built at ground level. It is divided horizontally into two chambers which are interconnected at each end to enable the water to circulate. (See Appendix 6)

Demonstration and testing of the model nets takes place in the centre portion of the tank upper chamber. This area, which is the tank working section, measures 11m long by 5m wide by 2.5m deep. The lower chamber of the tank forms a return passage through which the water recirculates.

For testing model trawls water speed through the tank can be varied from 0 to 1.0m per second (0-2 knots) which, at a scale of 1/10th, represents a maximum full-scale water speed of 6.1 knots. The water speed can be increased to a maximum of 1.5m per second to permit the full-scale testing of small components such as floats, kites and transducer housings.

The basic theory used in the design of these models is that successfully employed by the scientists of the Institute Scientifigue et Technique des Peches Maritimes. They had been testing model trawls in their smaller Flume Tank in Boulogne for several years prior to the consturction of the White Fish Authority Tank. This theory is based upon scaling according to Froude number where the water speed is scaled by the square root of the length scale so that gravity and inertial forces are scaled equally. As it is virtually impossible to obtain sheet netting for the construction of model trawls which has both the twine diameter and mesh size reduced exactly by the scale to which the models overall dimensions are to be reduced further scaling laws had to be developed to ensure that the net drag is correctly reduced for Froude scaling. This further scaling law states that the mesh size and twine diameter should be reduced by an equal ratio (see References 1 to 3 for derivation). This is equivalent to scaling the twine surface area correctly. In spite of the confidence held in these scaling laws it was decided that it would be adviseable to check the accuracy of the models used in the Tank by obtaining measurements at sea of the most important engineering parameters of the full scale trawl such as headline height, door spread, net-spread and warp load. It has also been possible to make a few general comparisons on the detailed shape of model and full scale trawls using film taken by divers of the Marine Laboratory, Aberdeen when observing full scale gear.

It is the purpose of this paper to discuss some of the problems that have been encountered when attempting to correlate the model and full scale engineering performance measurements. A specific case history which contained most of the problems associated with such correlation work has been discussed in detail.

Chapter 2. A typical case history. Model tests conducted on Stuart Heavy Board Trawls.

2.1 Description of the Gears under test.

Stuarts of Musselburgh, Scotland make a range of bobbin trawls for inshore boats of 150-500 HP for towing over very hard ground with doors. These trawls which they call Heavy Board Trawls are extremely popular with boats fishing the North Sea and based in South East Scotland and North East England. The trawls are made from polythene netting.

An approximate one tenth size model of the most popular size of these trawls, the 482B, was constructed by the netmakers in 1976 from small mesh netting that they had in stock.

In January 1977 full scale trials were conducted aboard the Ocean Herald II. The 482B trawl was tested together with two larger nets the 542B and the 602B. Field Report No. 573 which forms Appendix 1 contains the results of the full scale sea trials together with a comparison of those obtained with the "rough" model of the 482B.

The 542B trawl has exactly the same headline length of 80ft and footrope length of 100ft as the 482B. This net has been made larger by simply widening the square and wings and lengthening the bellies as is shown in the diagram in Appendix 2. The 602B tested on board the Ocean Herald was the prototype of a new design for a larger net approximately 120ft on the footrope.

In June 1979 it was decided by the W.F.A. to make a 1/10th Scale model of the 542B trawl and to provide Stuarts with special thin model sheet netting to enable them to make a more accurate model of the 482B together with a modified design of the 602B.

At the chosen scale of 1 : 10 it was possible to model the whole of the sweep and bridle rig used at sea together with the last 30 fathoms of warp.

The rest of this chapter details the problems encountered in correlation of the model test results and the results obtained at sea on the Ocean Herald.

2.2 Problems encountered in the design and construction of the scale model nets.

There were only two problems encountered in scaling down the full scale net specification and they both arose because of the properties of the model sheet netting which is made in twisted nylon.

Firstly in making the full scale nets the netting in the wings is stretched past its specified mesh size when it is mounted to the headline. This is common practice in the U.K. and Scandinavia. With this particular design of trawl the amount of stretch is relatively small, the 155mm meshes are mounted on 158mm of headline and once the net has been used for a few heuls at sea the mesh size of the netting becomes permanently stretched to 158mm. The model sheet netting, however, will not stretch permanently with use in the tank and if the netting is mounted in the same manner as the full scale net onto the headline, then it has been found that the headline lies slack and kinked when the model is streamed in the tank. The problem was solved by effectively constructing a model of a "used" net and basing the scaling calculations on a mesh size of 158mm. The model wings are then mounted length for length with the headline.

Secondly the model netting is made from nylon and is heavier than water whereas the full scale netting is made from polythene which is lighter than water. It is to be expected, therefore, that the effective weight in water of the twine of the model trawl, particularly the netting in the mouth, may have an adverse effect upon the height of the headline of the model trawl. To try and quantify this, the discrepancy between the buoyancy in seawater of the full scale polythene wings and square and the weight in freshwater of the equivalent model nylon sections has been calculated in Appendix 3. It has been presumed that the netting in the bellies, lying well behind the headline floatation, will not have a significant effect. It can be seen that in full scale terms this discrepancy is 6.2 kgms weight which could be approximately counteracted by adding the buoyancy of 1.7 x 8 in floats. As there are 38 such floats fitted to the 482B and 542B trawls this is not a very significant discrepancy. Indeed if this counteracting buoyancy was added to the headline centre, it would, in all probability, give a false high headline height measurement as it would give a distortion to the net at the point where the height is actually measured. It can be concluded that no action is necessary to compensate for this small modelling inaccuracy.

2.3 Problems encountered in obtaining exactly the same rigging of the model nets as the fullscale nets.

The results of the model tests carried out on the Stuart Heavy Board Trawls are to be found tabulated in Appendix 5. For easy comparison, the model measurements obtained are tabulated alongside the fullscale measurements from the sea trials on board the Ocean Herald.

The first time the model 482B and 542B nets were tested in the tank it was immediately noticed that the headline heights were lower than those obtained at sea, (see Table 1). On re-examination of the rig drawing contained in the Field Report of the sea trials (Appendix 1 Figure 1) it was noticed that the trawls had been rigged with 38 x 8 in Nautilus light plastic floats. The model had been rigged with 38 x 20mm model floats whose buoyancy scales up to 2.95 kgm fullscale. This is equivalent to the buoyancy of an 8 in Aluminium float. As can be seen from Appendix 4, however, an 8 in light plastic float has considerably more buoyancy 3.6 kgm. This meant that the number of model floats had to be increased to 46.

This modification improved the headline height of the models by about 2 ft (see Table 2). It was noticed that the headline height achieved with the 482B trawl was greater than that achieved with the larger 542B trawl. This was contrary to both the fullscale sea measurements and the netmakers expectations. A reason for this discrepancy was found when it was discovered that both the netmakers and the skippers had altered the rigging of the trawls at about the time of the Ocean Herald trials. Originally both the 482B and the 542B trawls were designed to have a headline length of 78 ft and a footrope of 98 ft. The skippers prefered to work 100 ft of footrope and therefore had to extend the headline by inserting 1 ft of chain extension in each top bridle. The net makers, at a later date, modified the net by adding 1 ft of bare extension to each side of the headline and fishing line so that the trawls became 80 ft on the headline and 100 ft on the footrope. Many skippers, however, still use the 1 ft extension to the top bridles with these new nets as it seems to give slightly better results. It appears that the 482B trawl used on the Ocean Herald was an old net with the 78 ft headline so it was effectively towed with equal bridles. The 542B trawl used was an 80 ft headline trawl so it was effectively towed with a 1 ft extension to the top bridles.

A 1 ft extension was added to the top bridles and the model 542B trawl remeasured. It can be seen from Table 3 that this small modification increased the height of the 542B by almost 3 ft ! This made the height achieved with 542B greater than that achieved by the 482B as found at sea. The results of Table 2 could now be treated with confidence and they provided the theoretically interesting conclusion that the height of a net cannot necessarily be improved by keeping the same headline and footrope frame and simply increasing the amount of netting round the mouth. Presumably the drag of the extra netting inserted counteracts the opening effect of the headline floats and reduces the net height unless the original net had been so short of netting round the mouth that this had been restricting the opening.

The model results still did not correlate very well with the full scale measurements. It is noticeable that the door spreads achieved with the model trawls were considerably less than those achieved at sea. A final inaccuracy in the rigging of the models was discovered. The 7 ft Vee doors used on the

Ocean Herald were unusually high doors - 4 ft 6 in. This gave the full scale doors an area of 31.5 sq ft. The model 7 ft Vee doors had been modelled on a different manufacturer's specification and were only equal to 4 ft 1½ in high giving an area of only 28.7 sq ft. The model 7 ft 6 in Vee doors used in the tank are in fact closer in area to the doors used by the Ocean Herald, they have an area of 32.8 sq, ft. It is also probably justifiable to use a set of model doors that are slightly larger than the theoretically correct scaled size because it has been estimated that as much as 30% of a door's spreading force can be generated by the ground friction and it is doubtful whether the friction generated by the smooth rubber conveyor belt in the tank is as great as that generated when a full scale door digs into a soft seabed. It is worthwhile noting also that different Vee door manufacturers set the warp and backstrop attachment holes in different positions. This causes one manufacturer's door to work at a different angle of attack to another manufacturer's. This can cause discrepancies in the spreading force generated by different doors of the same area. In fact the model 6 ft Vee doors currently in use at the tank generate more spreading force than the larger 6 ft 6 in long doors.

Accordingly the model 7 ft 6 in Vee doors were substituted and a final set of measurements taken.

2.4 Final Correlation of model and full scale results

It can be seen from Table 4 that, once the rigging of the model trawls had been corrected so that it corresponded to the rigging of the trawls on the Ocean Herald, the model and full scale measurements for the 482B and 542B trawls correspond particularly well. It can be seen from studying the field report that at the same towing revolutions of 1550 a speed of 2.6 knots was recorded when towing the 542B trawl, whilst a higher speed of 3.0 knots was recorded with the larger 602B trawl which had a higher warp load. The towing speed may well have actually been similar to that recorded for the 482B trawl - 2.8 knots. Taking this into account the model measurements are all within a 5% variation of the fullscale measurements taken at sea.

This accuracy is far better than can be reasonably expected. Although there is a large supply of sheet netting held at the tank for model construction, the mesh sizes available can only be guaranteed to be within 10% of that theoretically required to scale the twine surface area correctly. Also because of the limited nature of the sea trials on the Ocean Herald when 3 trawls were tested in a single day on one piece of ground the full scale measurements can only be expected to be within 10% of a good average set of readings taken over several days towing over different types of ground and in different weather conditions. Inaccuracies of up to 20% might therefore be expected when correlating measurements from such fullscale and model trials and the readings obtained are certainly well within this accuracy.

It is not valid to make any detailed comparisons between the fullscale and model measurements for the 602B trawl as the design of the prototype net used on the Ocean Herald had been altered prior to the construction of the model. The footrope and headline were made 4 ft longer in the modified net. It can be seen nevertheless that the readings obtained at sea fall within the range of readings obtained in the tank when testing the model with equal bridles and with 1 ft extra in the top bridles.

Chapter 3. Problems encountered in the testing of other model trawls.

Section 3.1 Shortening the length of the wires between the doors and the net.

When model testing the Stuart Heavy Board trawls it had been possible to fit the complete bridle and sweep rig in the tank at the accurate scale of 1 : 10. Because of the size of the tank this is often not possible when testing model bottom trawls which have very long bridle rigs or have a high angle of attack of the bridles. To fit such complete bridle rigs in the tank it would be necessary to reduce the scale of the models substantially to 1:25 or 1:30 and this would result in a considerable loss of modelling accuracy. It is, therefore, often desirable to reduce the length of the bridle wires between the doors and the net, but leaving the net as a 1:10 scale.

The type of rig that has caused problems is, for example, a 40 fathom single sweep plus two 25 fathom twin split bridles. Obviously it is not possible to shorten the split bridles as this will immediately cause a considerable reduction in headline height. The simple solution often tried in the past was to miss out the single sweep and attach the split bridles into the backstrops at the back of the doors. It has been found that this will also give incorrect headline height measurements because the point at which the 2 split bridles separate is above the seabed by half the height of the door. Tests have shown that rigging a model net this way can generate up to 2 ft more height than the full scale situation where the point of separation of the bridles is on or close to the seabed. At least part of the single sweep has to be modelled, therefore, and if this length is very short, 5 to 10 fathoms for instance, it will normally be necessary to artificially increase the weight of the wire-sweep to obtain the correct amount of ground contact. Divers observations at sea or a careful note of the amount of shine on the bridles and sweeps is ideally required as it is often found that the tension in the top bridle is sufficient to pullthe aft end of the single sweep off the bottom at sea.

3.2 Problems associated with the elasticity and stiffness of the model materials.

It has already been mentioned in section 2.2 that it is often impossible when making a model net to stretch the netting past its specified meshsize as is frequently done on fullscale nets when mounting wings cut on the bar. Presumably with large nylon midwater trawls in particular the netting meshes will also stretch past their specified size when the net is actually being towed through the water at sea. The stretch could be in the order of 5-10% and will vary in different sections of the trawl depending on the local strain at that point. It is doubtful whether there is sufficient strain in the model netting when it is being towed to stretch it at all and this definitely appears to affect the detailed shape of the net.

It is particularly noticeable that slack areas of netting in the centre bosom sections of some model nets are particularly pronounced - slack billows of net with wide open meshes can be seen oscillating with the water fluctuations. Divers have often found that the netting in a bosom is often very slack - they can lift it up easily, but it normally forms a neat smooth shape. Presumably at sea the tight netting stretches more than the slack sections and although slack sections of netting have markedly less strain in them there is still sufficient strain to control the shape of the netting. It would appear that elasticity and stiffness do not scale correctly in model trawls where forces are scaled down by the cube of the model scale.

This slackness of netting in the bosom of a trawl associated with possible incorrectly scaled strain distributions also seems to have a marked effect upon the relative positions of the bobbins and fishinglines for bottom trawls. It has been found on occasion that the fishinlines lie over the top of the bobbins in the model trawl and sometimes even get wrapped around the bobbins particularly at low speeds. Divers observations, however, normally show the fishinglines hanging behind the bobbins. Presumably at sea there is sufficient strain in the bosom netting to overcome any friction or stiffness in the connection chains to the bobbins and pull the fishingline back behind the bobbins. It appears that this is often not modelled correctly at low speeds in the tank particularly when using rubber wheel type bobbins which generate a lot of friction between themselves and the conveyor belt bottom and also the adjacent spacers.

3.3 Weight of Codends

Another problem which has arisen, and affects the detailed shape of the model trawls particularly at low speeds, concerns the weight of the nylon codends. In particular for heavy blue whiting type pelagic trawl codends it has been noticed that the model codends sometimes do not tow straight behind the trawl but tend to droop towards the seabed. This has been caused by the number of meshes in the codend being reduced to obtain the correctly scaled twine surface area. If, for example, a 1/20th scale codend has been made in 1/5th the twine diameter and mesh-size but $\frac{1}{4}$ the number of meshes then the weight of the model codend will be approximately 4 times too heavy. It has been found, however, that the codend twine surface area has no significant effect upon the net drag. The codends can be blocked up without affecting the net drag appreciably. The model codends should, therefore, be scaled by considering their weight instead of their drag (twine surface area). This will save a considerable amount of labour because if the codends are made from 2 sheets of netting each of double twine, to date the model equivalent will have to have been made from 4 sheets of single twine laced together. Only one sheet of netting would be required to scale the weight correctly.

3.4 Twine diameter measurements

Obviously the accuracy of the scaling of model nets is completely dependent on obtaining accurate measurements of the full scale twine diameters. This measurement is particularly difficult to obtain as it is not usually specified by the manufacturer. Most twines are specified by their runnage (weight per unit length) apart from braided twines which often have a diameter quoted. Unfortunately these quoted diameters for braided twines are extremely "nominal" - 4m braided polythene is usually 3,5mm in diameter. Measurements of braided twines are extremely difficult to make because they are often flattened in shape rather than round. It is also difficult to try and determine a formula for diameter for these braids dependent on the twine runnage because the basic construction differs from manufacturer to manufacturer, some twines have a centre core some do not, and also the twine shrinks in diameter as it is put under strain. It is not even acceptably accurate to obtain a short sample length from the manufacturer and measure it as the extruded filaments from which the twine is woven vary in thickness from consignment to consignment.

There appears to be no international standard technique for measuring twine diameter. Most methods using calipers, micrometers or taking several turns round a rod must result in either flattening or squashing the sample. Using a travelling microscope and measuring large samples of known runnage seems to be the best solution but it is uncertain how much strain the sample should be subjected to. An empirical formula for determining the twine diameter from its runnage has been developed from the twine diameter measurements made to date. It is

$$\text{Diameter mm} = \sqrt{\frac{K}{\text{Runnage m/kgm}}}$$

where K = 1800 for twisted nylon
= 2000 for twisted polythene

A lot more information is required on how accurate such a formula is and whether the value of the constant should alter dependent on the thickness of the extruded filaments for twisted polythene.

Chapter 4. Conclusions

1. More reliable data on the measurement of twine diameters is urgently required to improve the accuracy of model net design.

2. Data is urgently required on the stretch obtained by trawl netting when it is towed through the water.

3. It is essential that when testing full scale trawls at sea prior to correlation with model tests that an extremely detailed record is kept of the exact rigging of the trawl. Such details as not only the number and size but also the make and type of trawl floats are essential.

4. One tenth scale models of trawls will generate engineering performance measurements that will correlate well with full scale measurements at sea provided that the rigging of the model trawl corresponds exactly to that of the full scale trawl.

APPENDIX 1

WHITE FISH AUTHORITY

Industrial Development Unit

Field Report No. 573 January, 1978

Gear Trials on MFV Ocean Herald II

Introduction

These trials were part of a series planned to obtain various parameters of full scale trawling gears, scale models of which are held in the I.D.U. Flume Tank. Skipper J. McBain of MFV Ocean Herald II agreed to give the Authority the use of his vessel for Friday 16th December, for the purpose of taking measurements on his Stuart 482B Heavy Board Trawl; measurements were also taken on his two other Stuart trawls.

The objectives of the trials were:-

(i) To obtain sufficient full scale data for an evaluation of results obtained from 1/10 scale gears in the Flume Tank

(ii) To determine the hydrodynamic effects, if any, of the I.D.U. headline transducer equipment on gear under test; these effects to be checked by use of a headline manometer.

Vessel Details

Name:	Ocean Herald II. Stern trawler KY 197
Built:	St. Monans. Fife 1975.
LOA:	18.5m (60 ft)
Engine:	Volvo Penta, 300HP at 1800 RPM Fixed Propeller with nozzle.
Deck Gear:	Split net drum, two trawl winches, 1 forward seine net/ discharging winch.
Bridge equipment:	Manual/Automatic steering. Decca navigator and track plotter.

cont/..

Bridge equipment (cont):	Kelvin Hughes echo sounder, Radar, VHF/HF radio telephone.
Crew:	Five
Trials equipment:	1 Furuno netsonde with cable and I.D.U. wing end spread transducers, wheelhouse display/recorder and cable winch. 1 pair three wheeler warp tension meters and portable warp tension readouts. 1 Toho Denton towed log with display 1 Marine Laboratory headline manometer
Trials Personnel:	H. McDiarmid (PFDO), E. Allison (PEE) A. Blenkin (M.F.) K. Hairsine (MET) P. MacMullen (Asst. FDO)

Trawling gears

The gears tested were a Stuart 482B Heavy Board Trawl and the Stuart 540 and 600 trawls of similar configuration. The trawls' designations refer to the number of meshes around the mouth. Rigging details were as in Fig. 1. The same bobbin rig was used on all the gears, 7'0" x 4'6" vee doors locally made were used throughout with single backstrops picking up from the middle of 3 holes. 100 fathoms of 1¼" warp were used for all hauls picking up from the middle towing points.

Trials narrative

Ocean Herald II put out from Pittenween at 0700 on 16th December, and trials commenced at about 0800 on grounds about 3 miles SE of Pittenween. The water depth in this area is 20 - 30 fathoms. Sea conditions were very calm for the whole period of testing.

The first gear tested was the 482B and this was fished firstly with the Marine Laboratory headline manometer. The gear was then hauled and the manometer replaced with the netsonde package. At this point the three wheelers were moved from the gallows to the stern towing post bridles because there was insufficient clearance through the three wheelers to allow shooting and hauling with them in position. The warp circumference (1¼") was also slightly small for these instruments whereas the bridle circumference (3") and position were found to be satisfactory for all subsequent trials. The gear was then shot again and spot readings taken from the warp tension meters and the towed log. Warp divergence was measured over a 6' length as a guide to door spread and engine RPM noted.

The 600B trawl was tested next but after the first tow the gear came fast and sustained some damage. For this reason the trial was abandoned.

Finally the 540B was tested. Four tows were made at various RPM settings and readings taken as before.

Results

Full details of the instrument readings are contained on sheets 1,2 and 3 and discussed below. Although no tidal calculations were made, runs both with and against the tide were made for each gear and power setting. The following figures are averages of the uncorrected data from each gear.

Gear	482	540	600
Warp aft (fm)	100	100	100
log speed (kt)	2.8	2.6	3.0
Warp load (t/warp)	1.4	1.6	1.7
Door spread (ft)	100	100	100
Headline height (ft)	14.5	17	19.5
Wingend spread (ft)	38	35	36
RPM	1500	1550	1550

482B

The data obtained from this trial (Sheet 1) show some inconsistencies. In tows 1 and 4 where headline, height, wing speed and RPM are comparable tension measurements vary by a factor of 2. On tows 2 and 3 the same variation occurs and the magnitude of the tensions (4.4t) must be regarded with some suspicion bearing in mind the HP of the vessel and constant RPM used. In tows 3 and 4 tensions are shown to be very similar but the tows were in opposite directions. The chart diamond for the area suggests tidal currents of about 0.3 kt and in this depth of water.

with medium tides a reasonably constant vertical velocity gradient can expected excepting the bottom boundary layer. The results here indicate considerable experimental error and difficulty has been found in estimating a tide correction as shown in Fig. 2. The possible sources of error are discussed below.

600B. From the results available (Sheet 2) the deck tension readings appear more consistent than previously, though unequally distributed. The headline height varied with no corresponding change in wingend spread. During this trial the gear came fast and the trial was abandoned.

540B. These test results (Sheet 3) also appear to be more consistent than in the first trial but again no tide correction can be made (Fig. 3). Time was running short in this trial and after some variations in engine RPM the test series was terminated.

The main source of error in the warp tension readings was probably operational problems in using the new IDU designed tension meters which were in use for the first time. Also there was probably some change in the zero position of readings between moving the instruments from the gallows to the Samson Post. These latter readings can however be assumed to be more accurate than the former. It should be noted that after the first couple of reading the practice of adjusting w/1 instrument zeros prior to each observation was instituted. The accuracy of the door spread readings is limited by the method used which usually gives a value of about 5% less than the actual spread.

In addition the limited time available for testing each of the three trawls resulted in a relatively small number of observations and a correspondingly reduced amount of data available for analysis.

Evaluation of model results

As an indication of the relationship between full scale and 1/10 scale parameters the averaged, uncorrected data from the 482B is here presented with some typical 1/10 scale readings scaled up to full size. To date 7' equivalent vee doors are not available at the Flume Tank; data here is for 6'6" and 7'6" equivalent doors.

Scale	1/1	1/10	1/10
Speed (kt)	2.8	3.0	3.0
Warp aft (fm)	100	125	125
Doorsize (ft)	7'0"	7'6"	6'6"
Headline height (ft)	14.5.	11.75	12.0
Wingend spread (ft)	38	34	34
doorspread (ft)	100	102	86.5
Warp load (t)	1.4	1.3	1.3

Conclusions

It can be seen, from the above figures that the net performance parameters are of the same order of magnitude as those predicted by the 1/10 scale within the range of speeds normally used for this gear, although the headline height of the model appears to be about 10% low.

It is not felt that valid comparisons can be made between the respective warp tension figures, although they do appear similar.

No firm conclusions can be drawn regarding interference between the I.D.U. headline transducer equipment and the gear under test. Bearing in mind the ideal sea conditions however, and the consistent results obtained minimal interference could be assumed.

P.H. MACMULLEN

SEL. OCEAN HERALD | GEAR. STUART 482B | AREA. FIRTH OF FORTH | SHEET. 1

TOW NO	POSITION	DEPTH (FM)	WARP AFT (FM)	ALL SQUARE	H/L HEIGHT (FT)	W/E SPREAD (FT)			WARP LOAD P	WARP LOAD S	WARP DIVERGENCE	WARP DECLINATION	LOG	ENGINE RPM	COMM HAUL
1	WITH TIDE (ESE)	27	100	0755					0·6	0·95	BOARD SPREAD		2·7	1500	
1	..	..	..	..					0·55	1·35			2·8	1500	
2	AGAINST TIDE (WNW)	27	100	0835					2·15	2·1			3·0	1500	0846
2	..	..	..	..					2·3	2·1			2·8	1500	
3	AGAINST TIDE (WNW)	18	100	0930	15	37-38			1·0	1·3	100		3·4	1500	1015
4	WITH TIDE (ESE)	20	100	1025	14	38-39			1·15	1·25	117		2·6	1500	1035

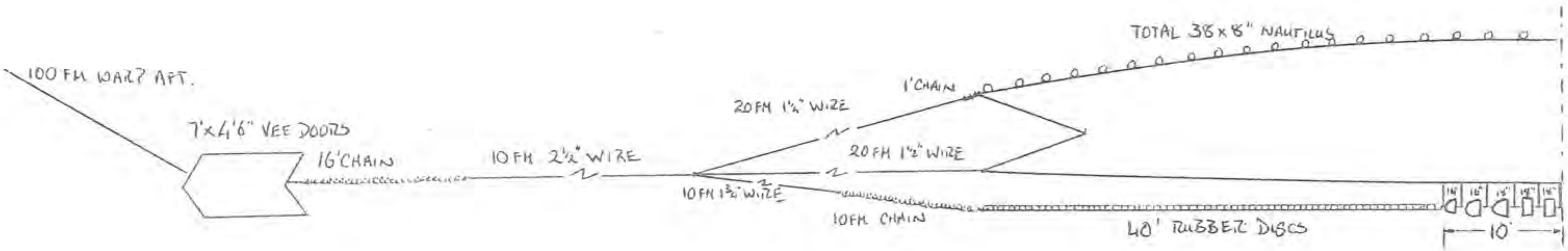
VESSEL: OCEAN HERALD | GEAR: STUART OOD | AREA: FIRTH OF FORTH | SHEET: 2

TOW NO	POSITION	DEPTH (FM)	WARP AFT (FM)	ALL SQUARE	H/L HEIGHT (FT)	W/E SPREAD (FT)			WARP LOAD P	WARP LOAD S	WARP DIVERGENCE (FT)	WARP DECLINATION	LOG	ENGINE RPM.	COMM HAUL
											BOARD SPREAD				
5	SLACK WATER (WSW)	20	100	1150	21	36			1·4	1·95	100		3·1	1550	
5	..	20	100	1205	18	36			1·65	1·75	100		3·0	1550	

CAME FAST COMING AROUND - TRIAL TERMINATED

TOW NO	POSITION	DEPTH (FM)	WARP AFT (FM)	ALL SQUARE	H/L HEIGHT (FT)	W/E SPREAD (FT)			WARP LOAD P	WARP LOAD S	WARP DIVERGENCE (FT)	WARP DECLINATION	LOG	ENGINE R.P.M.	COMM. HAUL
6	AGAINST TIDE	28	100	1340	16	36			1·7	1·9	BOARD SPREAD 100		2·7	1550	
6	..	32	100	1350	16	36			1·7	1·85	100		2·7	1550	
7	WITH TIDE	25	100	1405	18	34			1·5	1·5	100		2·6	1550	
8	WITH TIDE	28	100	1415	16	34			1·8	1·8	100		2·9	1625	
9	WITH TIDE	27	100	1425	18	36			1·4	1·4	100		2·2	1400	1430

figure 1 RIGGING DETAILS



OTES

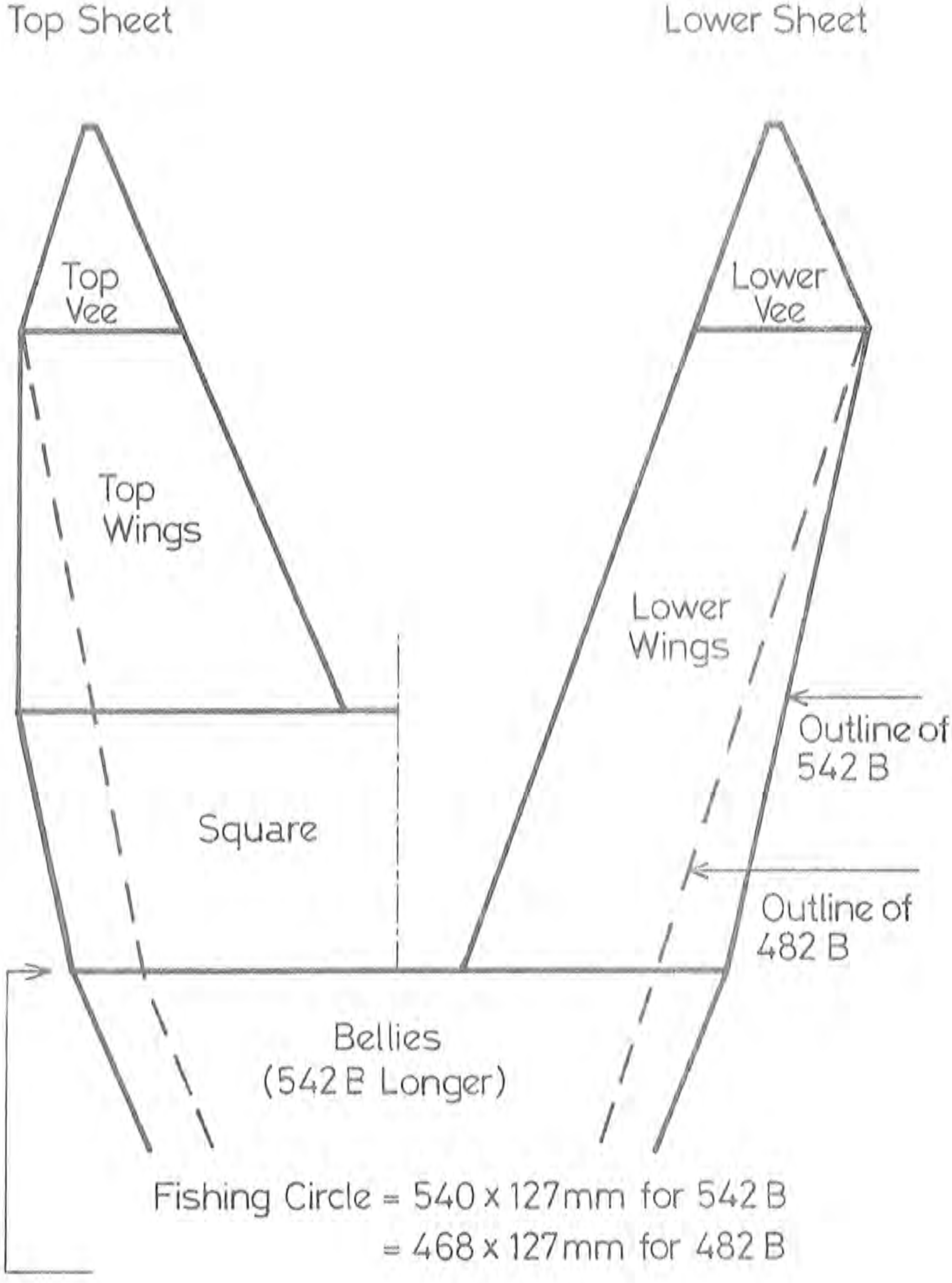
OBBIN RIG. TOTAL 20' COMPRISING EACH SIDE 2x18" WHEELS AND 1x18", 1x16", 1x14" BUNT BOBBINS EACH SPACED WITH 2x7" RUBBER LANCASTERS

182B - HEADLINE 80' x 1 3/4" SALVIPP COMBINATION
FISHING LINE 100'
BOLCHLINE 106' [6' SLACK IN 21' BOSOM SECTION]
GROUND ROPE 2x 40' RUBBER DISCS + 20' BOBBINS = 100
FLOATS 38 x 8" NAUTILUS PLASTIC

40B - EXACTLY AS ABOVE BUT WITH EXTRA 30 MESHES ON TOP AND BOTTOM WINGS

00B - AS ABOVE BUT EXTRA 8' CHAIN ON WINGENDS
FLOATS 40 x 8" NAUTILUS + 2 SIAMESED 8" ON BOSOM

Appendix 2
Comparison of the designs of the Stuart 482 B and 542 B trawls



Comparison of the Buoyancy or Weight of the Netting in the Square and Wings for the Full Scale and Model Stuart 542B Trawl.

$$\text{Weight of twine in air for a net section} = \frac{\text{Meshsize} \times \text{meshes deep} \times (\text{meshes across top + bottom}) \times \text{knot factor}}{\text{Runnage}}$$

a) Full Scale Net

Mesh size = 155mm   Twine Runnage = 404m/kg

Knot factor - 1.33

Dimensions of square   230m to 213m in 20 meshes

Dimensions of topwings   2 x 54m to 92m in 40 meshes

Dimensions of lower wings 2 x 88m to 54m in 62 meshes

Dimensions of vees   4 x 53m to 14m in 25 meshes

Total of meshes deep x (meshes across top + bottom) = 44648

$$\text{Weight of Twine in air} = \frac{0.155 \times 44648 \times 1.33}{404} \text{ kg}$$

$$= 22.8 \text{ kg}$$

Specific gravity of twine (polythene)   = 0.95

Net used in seawater specific gravity   = 1.025

$$\text{Buoyancy of polythene twine} = \frac{22.8 \times (1.025 - 0.95)}{0.95} \text{ kg}$$

$$= 1.8 \text{ kg}$$

b) Model Net at 1 : 10 Scale

Mesh size = 25.9mm   Twine Runnage = 13.4 m/gm

Knot factor = 1.15

Dimensions of square   141m to 132m in 12 meshes

Dimensions of top wings   2 x 55m to 32m in 24 meshes

Dimensions of lower wings 2 x 52m to 32m in 37.5 meshes

Dimensions of vees   4 x 32m to 8m in 15.5 meshes

Total of meshes deep x (meshes across top + bottom) = 16232

Continued / ...

b)

$$\text{Weight of Twine in air} = \frac{0.0259 \times 16232 \times 1.15}{13.4} \text{ gms}$$

$$= 36.1 \text{ gms}$$

Specific gravity of model nylon twine = 1.14

Freshwater used in flume tank specific gravity = 1.0

$$\text{Weight of Model Twine in tank} = \frac{36.1 \times 0.14}{1.14} \text{ gms} = 4.4 \text{ gms}$$

Weight of twine at sea = 4.4 kg fullscale.

Discrepancy

It can be seen that the total discrepancy is 6.2 kg.

APPENDIX 4

Buoyancy produced by different sizes and makes of trawl floats

Diameter		Make	Material	Type	Static Buoyancy
inches	mm				Kg
5	127	Phillips	Aluminium	Twin Lug	0.7
5	127	Nokalon	Plastic	Sideholes	0.8
5	127	More	Plastic	?	0.85
5	127	Nautilus	Plastic	Sideholes	0.85
5	127	North Star	Plastic	?	0.95
5	127	Permolift Minor	Plastic	Twin Lug	1.1
6	152	Phillips	Aluminium	Twin Lug	1.3
6	152	Arra	Plastic	Sideholes	1.3
6	152	Nokalon	Plastic	Sideholes	1.55
8	203	Nokalon	Plastic (Yellow)	Centrehole Deep Sea	2.4
8	203	Rosendahl	Plastic	Deep sea centrehole	2.85
8	203	Phillips	Aluminium	Twin Lug	2.95
8	203	Italian (Cosalt)	Plastic (White)	Twin Lug	3.05
8	203	Nokalon	Plastic (Blue)	Sideholes	3.25
8	203	Nokalon	Plastic (Orange)	Sideholes	3.6
8	203	Arra	Plastic	Sideholes	3.65
10	254		Plastic	Twin Lug	4.55
11	275	Rosendahl	Plastic	Side Lugs	8.8
11	280	Nokalon	Plastic	Centrehole	9.0

APPENDIX 5

Measurements taken of the scale model Stuart Heavy Board Trawls in the Flume Tank.

Table 1. First Try

Trawl	STUART 482B MODEL		STUART 482B FULLSCALE	STUART 542B MODEL		STUART 542B FULLSCALE
Speed (knots)	2.5	3.0	2.8	2.5	3.0	2.6
Ht. headline centre (ft)	14.9	12.6	14.5	14.4	12.3	17
Headline spread (ft)	34	35.3	38	32.7	35.3	35
Door Spread (ft)	88.4	93.6	100	86.8	91.3	100
Warp Loads (tons)	1.05t	1.35t	1.4t	1.1t	1.4t	1.6t

Rig :- Doors 7ft x 4ft 1½ in = 28.7 sq ft
Bridles single 10 fms + 3 x 20 fms
Floats 38 x 8 in Aluminium.

Table 2. Corrected headline floatation

Trawl	STUART 482B MODEL		STUART 482B FULLSCALE	STUART 542B MODEL		STUART 542B FULLSCALE
Speed (knots)	2.5	3.0	2.8	2.5	3.0	2.6
Height headline centre (ft)	17.7	15.2	14.5	16.1	14.1	17
Headline spread (ft)	32.7	34	38	34	34	35
Door Spread (ft)	86	91.4	100	84.5	87.5	100
Warp Load (tons)	1.2t	1.5t	1.4t	1.15t	1.5t	1.6t

Rig :- Doors 7ft x 4ft 1½ in = 28.7 sq ft
Bridles single 10 fms + 3 x 20 fms
Floats 38 x 8 in light plastic

Table 3 Corrected Top Bridle Adjustments

Trawl	STUART 482B MODEL		STUART 482B FULLSCALE	STUART 542B MODEL		STUART 542B FULLSCALE
Speed (knots)	2.5	3.0	2.8	2.5	3.0	2.6
Ht. Headline centre (ft)	17.7	15.2	14.5	19.0	16.7	17
Headline spread (ft)	32.7	34	38	34	34	35
Doorspread (ft)	86	91.4	100	83.5	84.8	100
Warp Load (tons)	1.2t	1.5t	1.4t	1.2t	1.6t	1.6t

Rig :- Doors 7ft x 4ft 1½ in = 28.7 sq. ft

Cont./..

Appendix 5 - Cont/....

Table 3.

Bridles single 10 fms + 3 x 20 fms with 1 ft extra in top bridle for 542B only.

Floats 38 x 8 in light plastic.

Table 4. Corrected Door Size

	STUART 482B			STUART 542B		
Trawl	MODEL		FULLSCALE	MODEL		FULLSCALE
Speed	2.5	3.0	2.8	2.5	3.0	2.6
Ht. Headline centre (ft)	16.2	14.0	14.5	18.2	16.4	17
Headline spread (ft)	36.5	36.5	38	34.6	35.3	35
Door spread (ft)	99.2	106.5	100	96.6	103.8	100
Warp load (tons)	1.2t	1.5t	1.4t	1.2t	1.6t	1.6t

Rig :- Model doors 7ft 6in x 4ft $4\frac{1}{2}$ in = 32.8 sq ft

(Doors used by Ocean Herald 7ft x 4ft 6in = 31.5 sq ft)

Bridles single 10 fms + 3 x 20 fms with 1 ft extra in top bridle for 542B only

Floats 38 x 8 in light plstic

Table 5. Stuart 602B Trawl

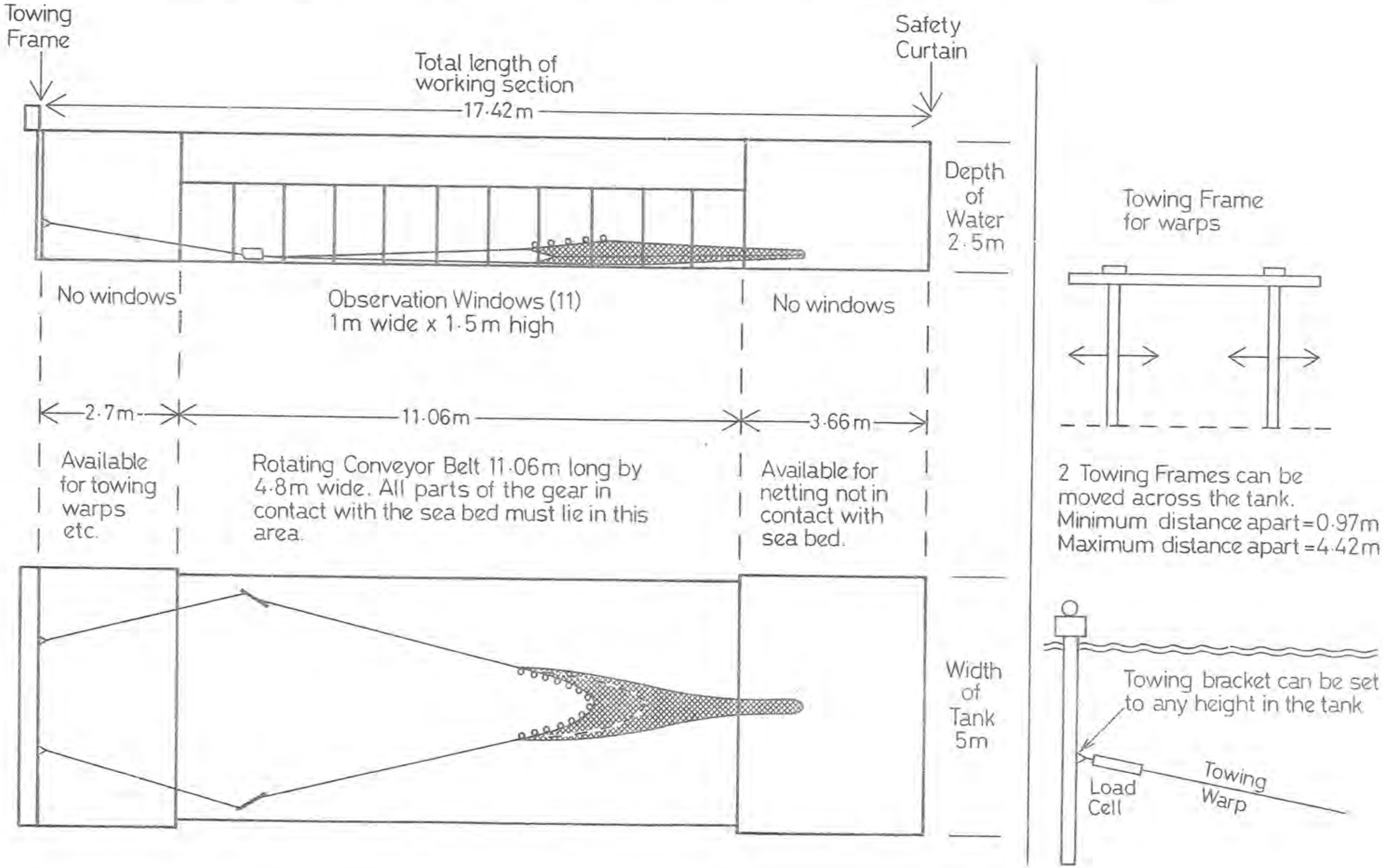
Scale	1 : 10 MODEL				FULL SCALE
Speed (knots)	2.5	3	2.5	3	3
Ht. headline centre (ft)	20.3	17.7	23.5	22.0	19.5
Headline spread (ft)	38	39.3	36.6	38	36
Door spread (ft)	90	96.6	88.8	91.5	100
Warp Load (tons)	1.5	1.9	1.5	1.9	1.7
Bridles	Equal		+ 1ft top		+ 1ft top

Rig :- Model
- Floats 50 x 8in light plastic
- Doors 7 ft 6 in x 4 ft $4\frac{1}{2}$ in = 32.8 sq ft
- Footrope 120 ft
- Headline 91 ft

Full Scale
- Floats 40 x 8in light plastic + 2 x Siamese 8 in
- Doors 7 ft x 4 ft 6 in = 31.5 sq ft
- Footrope 116 ft
- Headline 87 ft 6 in

APPENDIX 6

WHITE FISH AUTHORITY FLUME TANK DIMENSIONS OF WORKING SECTION



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AN INVESTIGATION INTO THE TOWING DRAG AND DESIGN OF A PELAGIC NET

by: H. Hirschle and H. Pfeifer

1. INTRODUCTION

The rapid development of the trawl fishing industry in recent years and the continuously changing conditions has to be reflected in the design of pelagic nets.

Until a few years ago in international fishery, there were no sufficiently precise design methods or calculation procedures which could enable theory to derive the net's drag, the distribution of the mesh, or its mechanical properties, such as the development of the tension in the net and stress points.

The calculation methods for pelagic nets are based on the accurate knowledge of the hydrodynamic drag and lift coefficients of the net fabric.

The angles-of-attack for current pelagic nets are mainly within the small range $0 \leq \alpha \leq 25^{o}$. This represents the range of interest for net calculation methods.

However, only very unprecise or insufficient results are available for this angle-of-attack range.

To obtain a load function for drag and lift, with the highest possible precision, force and moment measurements were carried out with Rod-Lattice models in Dornier's wind tunnel.

For the description of the pelagic net, an analytical design procedure was best suited, since the hydrodynamic force coefficients determined in the wind tunnel with the netlike Rod-Lattice model can be used directly. In addition, this procedure permits a wide variation of the net's parameters.

This project was conducted under contract from the "Institut für Fangtechnik" in Hamburg.

2. ESTIMATION OF THE DRAG AND LIFT OF A PLANE NET FABRIC OF SMALL ANGLES-OF-ATTACK

2.1 Overview of the Present State-of-Art

According to the state-of-art, the hydrodynamic force coefficients of plane net fabrics, for a stationary oncoming flow, can be represented as dependent on the following dimensionless independent parameters. (Notation is defined in the annex):

$$C_{W,A} = ({}^{d}/_{a},\ u_1,\ \alpha,\ d_{K/d},\ D_{K/d},\ Re\text{-}d) \qquad (1)$$

Further quantities (elongation, type of material, extended Froude number) are negligible according to SCHARPING (1).

In the last few years, the following principal investigations were carried out for determining the force coefficients of pelagic nets:

The most extensive force coefficients, determined up to now, were by STENGEL/FISCHER [2.2, 2.3]. The drag and lift coefficients of net fabrics in tube frames are subject to extreme error, in particular in the small angle range, due to the follow-up flow and the mutual reaction of the fixing frame and the net fabric.

Recently, a new method was found to determine the coefficients, see [2.4], [2.5], [2.6] and [2.7].
This method excludes the undesirable influence of the frame and the net's deflection. This is achieved by rigid Rod-Lattice models welded together out of welding rods. The investigation is conducted in a water channel or a wind tunnel with freely suspended net lattice models. However, only very a few results are available to date.

2.2 Test Procedure

On the basis of the Rod-Lattice model method [2.8], [2.9], [2.10] and [2.11] an improved model type and test procedure has been developed by Dornier. For these kind of force and moment measurements, a water channel and a wind tunnel are available at Dornier. Due to the simpler test arrangement and the less complex measurement problems, the decision was taken in favour of the wind tunnel.

The eliminate the influences of the finite model, boundary vortices, aspect ratio, length, the model is set up so that the resulting forces and moments are measured only on an inner net section; while the outer area is used to represent the surrounding net. The inner net section is connected to the balance and is separated from the surrounding net by a small gap of 1 mm, see fig. 2.1. The surrounding net is rigidly mounted but always aligned with the inner net. The application of this model arrangement offers the advantage that the measured results are independent of the shape and dimensions of the measured part of the net.

A 6-component strain gauge balance was used for the force and moment measurements.

The model suspension and the test arrangement are represented in the figures 2.2, 2.3 and 2.4 with various Rod-Lattice models.

The forces and moments measured by the balance were determined around 3 axes. The measured signals were stored on magnetic tape as preliminary values and evaluated and plotted by a large computer off line.

During the measurements, the Rod-Lattice models were displaced continuously within a range between $\alpha = -6$ and $+90^{\circ}$ with a speed of about $0.5^{\circ}/s$.

This model and measurement method led to a very high measurement accuracy and a continuous and rapid performance of the test.

2.3 Test Object - Net Lattice Model

Based on the practical requirements of the present state-of-art and the technical capability to determine drag and lift coefficients for plane net fabrics in the small angle-of-attack range, plane net grids manufactured of cylindrical rods were selected as test objects.

Compared to net fabrics attached to frames, the Rod-Lattice model offers the following important advantages in the small angle-of-attack range:

- It is very important that the lattice is placed in an undisturbed flow, without the influence of the frame, so that the mutual flow interference caused by the fixing frame is eliminated.
- Furthermore, the attachments holding the net fabric on the frame, (eye rings, net cords) which affecting the boundary-layer behaviour of the flow around the frame, are not required.
- It is not necessary to take the sensitivity of the tube frame with regard to the Reynolds number into account.
- Since the mesh geometry can be observed exactly, and no distortions occur, an accurate mesh arrangement and d/a ratio is possible.
- Due to the use of a rigid lattice, the deflection due to the flow forces can largely be avoided.

The disadvantage of Rod-Lattice models consists in the fact that it is not possible to guarantee exactly a realistic surface and intersection structure, see [2.8]. References [2.5], [2.6] and [2.7] indicate suitable procedures to overcome this disadvantage.

The grids were manufactured from steel rods with a diameter of 6 mm and welded together at the crossing points with a welding jig. The steel bar diameter resulted from the rigidity requirements. To keep the deflection of both net parts as low as possible, a model scale of 2:1 was selected. The net knots were represented by split wooden balls with a diameter of $D_k = 18$ mm ($D_k = 3 \cdot d$).

Fig. 2.5 shows the basic smooth model without an applied surface structure, and fig. 2.6 displays a smooth model, this time with knots.

For some Rod-Lattice models, the roughness of the net cords was represented. For this purpose, the lattice model received at thin plastic coating onto which a quartz sand, with a grain of 0.5 ÷ 0.7 mm (approx. 1/10 of the diameter), was applied, see fig. 2.7.

2.4 Test Program

In practice, a knowledge of the following parameter dependencies is especially important:

$$C_{W,A} = (d/a,\ \mu_1,\ \alpha,\ R_e - d) \qquad (2)$$

These were investigated with 12 Rod-Lattice models with the following parameter values:

$$0^\circ \leq \alpha \leq 90^\circ \qquad (3)$$

$$0.03 \leq d/a \leq 0.12$$

$$15^\circ \leq \beta \leq 45^\circ$$

$$0.7 \cdot 10^4 \leq R_e - d = 1.52 \cdot 10^4$$

The influence of the relative roughness of the rods d_k/d was also investigated separately with various Rod-Lattice models. Correction values for the parameters of equation (2) were introduced. To determine the effect of the net knots, measurements with and without knots were executed.

To establish the surrounding net size, and the number of rods for the inner net, preliminary tests were carried out in which the number of the meshes of the measured element were varied.

2.5 Measured Results

Some of the systematic wind tunnel measurements, performed according to the test procedures laid down in paragraph 2.2 , are described and discussed below.

Influence of the Mesh Angle

In fig. 2.8 to 2.10, the axial force coefficient and normal force coefficients are represented as functions of the angle of attack for different d/a = 0.03, 0.06 and 0.12. The investigations were made for the mesh angles $\beta = 15^\circ$ to 45°.

It can be seen from the figures that the influence of the mesh angles on the force coefficients C_x and C_z is very high.

Furthermore it is evident that the axial force coefficient rises with the mesh angle β increasing.

The figures show that a reduction of the mesh angle simultaneously leads to a smaller axial force coefficient C_x for all nets.

In the angle-of-attack range $\alpha \leq 20^o$, the normal force coefficient C_z grows as the mesh angle β increases.

In the angle-of-attack range $\alpha > 20^o$ however, the trend is reversed and normal force coefficient can be observed decreasing while the mesh angle increases. The maximum normal force coefficient is achieved for an angle of attack of about 50^o.

Influence of the Cord Diameter/Mesh Width Ratio

Fig.2.11 displays the normal force and axial force coefficients as functions of the angle of attack for the d/a= 0.03, 0.06 and 0.12. The mesh angle had a value of 15^o. In principle it can be seen that the influence of the d/a ratio on the force coefficients C_x and C_z is low for very small angles of attack α. In the angle-of-attack range > 20^o the axial force and normal force coefficients rise with the d/a ratio increasing.

Influence of the Surrounding Net

To test the quality of the measurements the influence of the environmental net was investigated.

The measurements of the Rod Lattice models with and withouth environmental net proved a great influence on the axial force coefficient C_x, above all for small angles of attack.

The axial force increase without the environmental net amounted up to 50 %, see fig. 2.12.

With regard to the normal force coefficient C_z the deviations are, for the most part, within the range of the accuracy of the reproduceability measurements. The environmental net could be reduced to 4 bars (in flow direction) without a measurable modification of the force coefficients, see fig. 2.12.

This demonstrates that the selected test arrangement accurately represents the flow forces, actually occur on the net at all angles-of-attack and that it eliminates the effects of the finite model, boundary vortices, aspect ratio, and length.

Influence of the Reynolds Number

The influence of the Reynolds number on the axial force and normal force coefficients in relation to the cord diameter is very low, in the range $0.7 \cdot 10^4 \leq R_e\text{-}d \leq 1.52 \cdot 10^4$, and remains within the limits reproduceability. This statement results from the investigations of STENGEL [3] and KRUSE [10].

Influence of the Net Knots

Fig.2.13 illustrates the effect of the modelled smooth net knot balls on the axial force and normal force coefficients on the rod lattice model ($d/a = 0.03$ and $\beta = 25^0$). The measurement resulted in a reduced axial force coefficient, although the reduction of the aera presented to the flow had already been taken into account in determinating the coefficients.

Therefore it can be seen that nets without knots have a considerably lower resistance.

With regard to the normal force coefficient C_z, however, the knot influence was very small and unimportant.

Influence of the Roughness

The influence of the roughness is represented in fig. 2.14. As can be seen from fig. 2.14 the axial force was increased by the roughness. This influence is taken into account in the practical calculation by means of correction values.

For the angles-of-attack occuring in practice, the effect on the normal force coefficient C_z is low and of no importance for practical application.

To be able to guarantee reliable statements, on the transferability of the measurement results obtained with Rod Lattice models to real net cloths with structured cord shapes, further tests are necessary.

2.6 Conclusions

With the test results briefly presented here regarding the axial force and normal force of plane Rod-Lattice models in the small angle-of-attack range, exact coefficients are available for the calculation of pelagic nets. The evaluation showed that the applied test procedure is well suited for wind tunnel experiments. The force coefficients determined experimentally in this investigation are very accurate compared with previous measurements, particularly in the small angle-of-attack range $\alpha \leq 15^0$. This results especially from the model system which consists of two Rod-Lattices.

Furthermore, a continuous and rapid test performance was possible with this measuring and test procedure.

Used Designations

a [m]	mesh side length	
d [m]	rod diameter	see Fig. 2.15
D [m]	knot diameter (3 x d)	
β [°]	mesh angle	
u_1 [-]	horizontal mesh arrangement coefficient (u_1 = sin β)	
u_2 [-]	vertical mesh arrangement coefficient (u_2 = cos β)	
α	angle-of-attack, angle between the flow direction and the grid plane	
x, y, z	reference axes given in fig. 2.16 (if the grid rotates around the y-axis the coordinate system remains body fixed).	
X, Z	forces in the directions of the corresponding axes	
$C_A = \frac{A}{q\infty \cdot A}$	Lift coefficient	
$C_W = \frac{W}{q\infty \cdot A}$	Drag coefficient	
$C_X = \frac{X}{q\infty \cdot A}$	axial force coefficient	
$C_Z = \frac{Z}{q\infty \cdot A}$	normal force coefficient	

whereby

$q\infty = \rho/_2 \cdot V^2$ [kp/m²] dynamic pressure of the wind tunnel flow

ρ $[\frac{kp\ \rho^2}{m^4}]$ air density

$v \infty$ [m/s]	speed of the wind tunnel flow
$A = A_{net} \times$	degree of coverage (B) [m^2]
	whereby,
	A_{net} is the total surface of the measured net
$B = \frac{1}{u_1 \cdot u_2}$	$[d/a + (d/a)^2 \times 0.5]$
	with D = 3 x d
$R_e - d = \frac{d \cdot v \infty}{\gamma}$	Reynolds number
γ	viscosity of the flow medium air

3. MATHEMATICAL DESCRIPTION OF A PELAGIC NET

3.1 Introduction

For the control of pelagic nets it is important to know their resistance and for the calculation of the net thread strength it is required to determine the net load on each point of the net surface. Solution possibilities are given with the analytical calculation of net patterns (3.1), (3.2), (3.3), (3.4).

In this case, a distinction has to be made between draft and post-calculation (3.5). In the first case the net pattern in the water is given. Net arrangement, mesh number, and thread tensile forces and net resistance depending on the oncoming flow are calculated. In the second case the mesh number is known, and based on this the other factors are determined.

In this case the draft is more important since it is of higher significance for the further development of catching technique. The most advanced procedure is the one mentioned in 3.4, and the following report is partially based on this procedure.

3.2 Prerequisites

- A model net is assumed and expressed in cylinder coordinates whose mesh sides run in the direction of the main parameters ϕ = const and x = const. The external forces that act upon this net are the same as the ones exerted on the real net. Forces can only be taken up in the direction of the parameter curve (fig. 3.1). Generally, the mesh sides are not vertically arranged on top of each other.
- Stretches in the net cloth are neglected.
- The weight of the net is neglected against the force flows.
- The influence and the receding of the sweep line forces which are led in the form of points into the net are assumed to be linear to the cod end:

  $c\ (x_N) = 1;\ c\ (x_o) = 0.$

- In the case of a 4 shackle net the cross section in the sweep line point of attack of the net which is conceived at first without headline is composed of a hyperbola and an ellipse; in the case of a 2-shackel net it is assumed to be elliptical.
- Due to the symmetry of the net the examinations can be restricted to one quadrant.
- The undisturbed oncoming flow is to act on each net point that is examined.
- The coordinate zero point starts at the transition from cod end to net.

3.3 Mathematical net model

The position vector describing the net surface (fig. 3.2) is:

$$\vec{r} = x \cdot \vec{e}_x + (\eta \cos\phi) \cdot \vec{e}_y + (\eta \sin\phi) \cdot \vec{e}_z \tag{3.1}$$

η in this case is the function which describes the cross section:

$$\eta = \frac{b}{1 - .\cos\phi^2} [1 + c(x) \cdot (\zeta - 1)] \tag{3.2}$$

for the 4-shackle net

$$\eta = \frac{b}{1 - \varepsilon \cos\phi^2} \tag{3.3}$$

for the 2-shackle net.

The term indicates the hyperbola part which occurs in the 4-shackle net:

$$\zeta = (1/\cos\phi_1) - 1.4727375 \cdot 10^{-10} \cdot \cosh(26 \cdot \phi_1) \tag{3.4}$$

$\phi_1 = \arctan[(a/b)\tan\phi]$

a and b are half the width and half the height of the net opening.

The longitudinal surface intersection curve a(x) in the main line of intersection $\phi = 0$ of the net is assumed to be a 3rd degree polynomial. It is determined by the following values:

1. Initial radius of the net = cod end radius
2. Half the width of the net opening
3. Angle of inclination of the surface intersection curve $\phi = 0$ at the cod end against the x-axis
4. Angle of inclination of the surface intersection curve $\phi = 0$ at the net opening against the x-axis
5. Net length without cod end.

The second longitudinal surface intersection curve is assumed in such a way that at the cod end a/b is 1 and at the net opening it is 2. It is:

$$b(x) = a(x) / (1 + c(x)) \tag{3.6}$$

Thus, a closed presentation of the surface intersection curve is given. This presentation is preferred since net ring dimensions are hardly known.

3.4 Differential equation for net forces

Based on fig. 3.3 and by means of differential geometry a differential equation in vector form can be set up for the forces acting upon one area element of the net surface:

$$\frac{\partial\,(\sqrt{G}\cdot\sigma_1\cdot\vec{e}_1)}{\partial x} + \frac{\partial\,(\sqrt{E}\cdot\sigma_2\cdot\vec{e}_2)}{\partial y} + \sqrt{EG}\,(-p_{t1}\cdot\vec{e}_1 + p_{t2}\cdot\vec{e}_2 - p_n\cdot\vec{e}_3)\cdot$$

$$\cdot\,dx\,d\phi\,\sin\omega = 0 \qquad (3.7)$$

This equation is an initial value problem for σ_1 and σ_2. For the cod end these values are relatively easy to calculate; the equation can then be solved by means of the Runge-Kutta method (3.7). For this purpose the equation is prepared in such a way that it is given in the components of the three main directions e_1, e_2 and e_3.

To solve the equation (3.7) one marginal condition has to be fulfilled which was formulated already by Baranov [3.6]. It implies that the forces σ_1 and σ_2 which are related to length are linked to each other via the mesh arrangement u_1:

$$\frac{\sigma_1^*}{\sigma_2^*} = \frac{1-u_1^2}{u_1^2} = \bar{u} \qquad (3.8)$$

The indexing of the forces is related to the fact that the mesh diagonals are not vertical on one another. According to [3.4] the following applies to this extended case:

$$\frac{\sigma_1\,(\sigma_1 + \sigma_2\,\sin\omega)}{\sigma_2\,(\sigma_2 + \sigma_1\,\sin\omega)} = \bar{u} \qquad (3.9)$$

This marginal condition implies that the net form to be given should correspond largely to the real form, which occurs during the oncoming flow. If this is not the case the mathematical formulation has to be changed accordingly.

3.5 Calculation of the headline and footrope

At first, the net is calculated without the headline up to the wing tips. Then, the headline is intersected in the net. For this purpose, an initial force T_o is assumed in the middle of the net surface ($y = \pi/2$) at an assumed distance from the wing tips. The headline is calculated in the form of segments by means of the forces which are known at each point of the net. The following force equilibrium exists on point P_1 of the headline (fig. 3.4):

$$\vec{F}_{Mi} - \vec{F}_{Mi+1}\ \vec{F}_{Ni} + \vec{A}_i = 0 \qquad (3.10)$$

$\vec{F}_{Mi}$ are those tensile forces in the headline which occur only in the headline direction. $\vec{F}_{Ni}$ are the net forces and $\vec{A}_i$ stands for the loft which provides that the headline is in the net surface.

In point P_o a value T_o is assumed for $\vec{F}_{Mo}$. The equation (3.10) is solved via an auxiliary plane which is vertical on the resultant of the forces in the x-y-plane [3.7]. Should the initial force T_o be selected wrong the wing tip is not hit, and an iteration is required then according to [3.4].

3.6 Numerical procedure

The equations (3.7) and (3.10) are solved by means of a computer program which was prepared for the Cyber 175 of the RWTH Aachen. Library sub-programs of the computer center are available for the algorithm. The force coefficients obtained from wind tunnel tests are put into a table and are then interpolated by means of a Hermite-Spline-function.

The initial value for the integration is supplied by a separate drag calculation for the net cod end whereby the wind tunnel data indicated in paragraph 2 are applied.

The following geometric data of the net can be put in for the further calculation:

α_o and α_L as the inclination of the net against the x-axis when $\phi = 0^o$ as well as half the width of the net opening. The net form can be varied well with these three parameters.

Subsequent to this the mesh ratio d/a can either be assumed to be constant for the total net or it can change from net ring to net ring. A further possibility for control consists in the selection of the shackle number which can be either 2 or 4.

Up to the wing tips the net is calculated as a closed system, then the net is intersected in the headline. The following data can be requested at any arbitrary point of the net surface:

- tension in longitudinal and cross direction σ_1 and σ_2
- angle of mesh arrangement β
- flow angle α
- thread tensile forces in mesh T_1 and T_2
- for the net end (without headline) or for each integration section the total resistance and the mesh number can be indicated from the size
- geometry of the net in form of a coordinate list for $\phi = 0^o$ and $\phi = 90^o$
- geometry and forces of headlines in tabular form.

3.7 Example calculation

3.7.1 Input data

The twin-shackle net with 664 # size made of knotted net fabric in the speed range of 3 kts, 3.5 kts, and 4 kts. is taken as model case.

The initial value for the solution to the differential equation results from a specific cod end calculation according to (3.9).

When v = 0 the angle of inclination of the net surface intersection curve is assumed to be $\alpha_0 = 5^o$ at $\phi = 0^o$ and $\alpha_L = 5^o$ at $x = L_N$. When stretched the net has a length of 70.6 m and at v = 3 kts. $L_N = 60$ m including wing tips.

Although it is possible to vary the d/a ratio via the net length the example is calculated with a constant d/a = 0.018, a value which is in the middle of the really processed d/a data.

3.7.2 Results

The results refer to two net cross sections:

- $L_N = 50$ m (assumption: bosom centre)
- $L_N = 60$ m (assumption: net end)

At L = 50 the following data are put out for the three speeds at the three points $\phi = 0$, $\phi = 45^o$ and $\phi = 90^o$:

- tensions in axial (σ_1) and peripheral direction (σ_2)
- mesh arrangement angle β
- flow angle α
- thread tensile forces in mesh T_1 and T_2
- total resistance up to the length R_{N50}
- net size at this point U_{N50}
- mesh number at this size n_{M50}.

The total drag is given for $L_N = 60$ m as a comparison to the head line calculation, from which the actual net resistance results. In addition to this, the net geometry is given at v = 3 kts. (semi-axes a and b of the ellipses as f (x)).

Since no publication is available of large tests on the pure net resistance (only the wrap drag was measured) the drag coefficients have to be compared which are related to the net opening surface. A coefficient of $c_W = 0.067$ for the empty net is mentioned in [3.10] for nets with trailing equipment. Taking into account approximately 5 % for the net trailing equipment $c_W = 0.0637$. The following c_W values are obtained for the three speeds at $L_N = 50$ m (without headline and wing)

v in kts.	3.0	3.5	4.0
c_W	0.0667	0.0644	0.0635

The real net resistance at v = 3 kts results from the calculation of the headline for L_N = 60 m:

R_K = [illegible] R_N (half the headline) = 4,5534 N = 22.136 kN

R_N = 2.26 Mp

For this drag coefficient is c_W = 0.0636.
Conformity with [3.10] is very good.

3.8 Conclusion

- Net length and cod end resistance have comparatively little influence on the total resistance. The crucial criterium is the net opening surface.

- The resistance from headline calculation lies well between the total net calculations with the given lengths of 50 m and 60 m from which a good acquisition of the headline calculations can be concluded.

- The high z-components of the headline force and of the lift at the end of the headline are caused by lateral shearing force which is not taken into account. For the calculated example total lift until 2 m before the end of the headline is approximately A = 6 kN.

4. PROSPECTS FOR FURTHER ACTIVITIES

After the termination of these investigations the following further activities can be suggested in the areas of the improvement and securing of the results, the extension of the findings to the design of pelagic nets and the adaptation to the net development:

- Further net grid models for other supporting points within and outside the investigated parameter range.
- Additional investigations to ensure a more exact determination of the surface structure by means of rod lattice models.
- Experiments with model nets or large nets are necessary to obtain information on the accuracy and to improve the selected mathematical model. These tests should be carried out to determine the actual shape, mesh arrangement, and net resistance.
- This analytic calculation method should be extended to the calculation of the rope nets.

Table 3.1: **Input data**

				origin Quelle
v in kn	3,0	3,5	4,0	
v in m/s	1,54	1,80	2,06	coo end calculation
r_o in m	0,37	0,37	0,37	Steertberechnung
r_L in m	13,5	14,5	15,0	[3.8]
L_N in m	60	62,5	65	assumption Annahme
σ_{10} N/m	879	1201	1573	Steertberechnung

Table 3.2: **Results for L_N = 50 m**

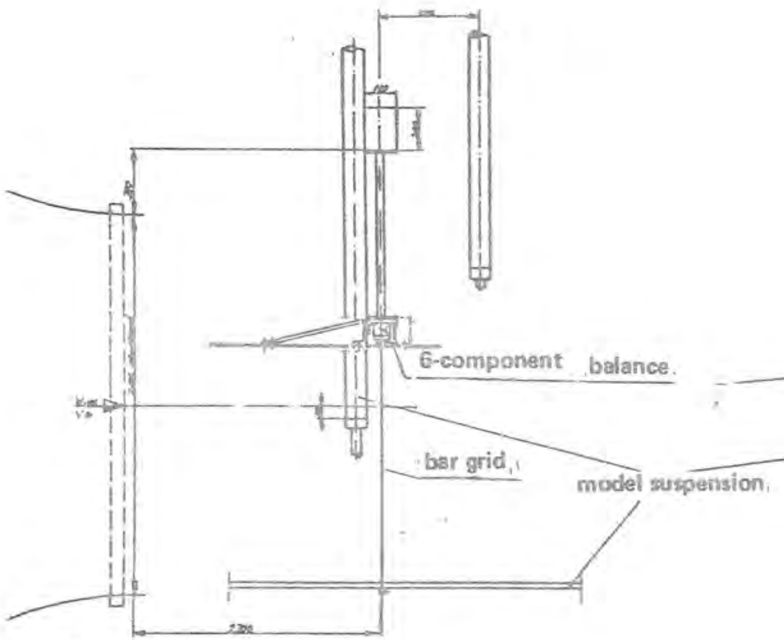
v in kn	3,0			3,5			4,0		
	φ = 0°	φ = 45°	φ = 90°	φ = 0°	φ = 45°	φ = 90°	φ = 0°	φ = 45°	φ = 90°
σ_1 in N/m	323	340	386	460	464	525	603	605	674
σ_2 in N/m	32	55	69	49	79	98	67	105	121
β in °	17,3	22	23	18,2	22,4	23,3	18,4	22,6	23
α in °	11,1	3,8	2,7	12,4	4,7	3,5	13,2	5,4	4,1
T_1 in N	10	13	16	15	19	23	20	25	29
T_2 in N	10	14	16	15	19	23	20	26	29
R_{N50} in kN	20,141			29,226			38,191		
U_{N50} in m	59,7			62,4			62,6		
n_{M50}	834			838			835		

Table 3.3: Net geometry

x m	A m	B m
0.00	.37000000	.37000000
1.71	.53891258	.52394279
3.43	.74421874	.70397370
5.14	.90371200	.93505126
6.86	1.25518710	1.12545176
8.57	1.55644197	1.36183672
10.29	1.88526572	1.60737318
12.00	2.23945470	1.86621225
13.71	2.61630323	2.12995612
15.43	3.01510564	2.38237949
17.14	3.43215625	2.66945486
18.86	3.86574740	2.94133107
20.57	4.31347942	3.21231445
22.29	4.77374062	3.49085254
24.00	5.24372735	3.74551754
25.71	5.72143393	4.00500375
27.43	6.20465467	4.25807635
29.14	6.69118395	4.50363150
30.86	7.17831605	4.74372758
32.57	7.66534531	4.96327737
34.29	8.14855607	5.18545114
36.00	8.62627265	5.39142041
37.71	9.09625938	5.58542242
39.43	9.55632058	5.76574518
41.14	10.00425060	5.93472493
42.86	10.43784375	6.08374219
44.57	10.85497436	6.22921808
46.29	11.25317677	6.35261108
48.00	11.63054530	6.45141405
49.71	11.98473428	6.55415156
51.43	12.31355803	6.63337740
53.14	12.61431090	6.58767245
54.86	12.88629720	6.73164257
56.57	13.12573126	6.75591083
58.29	13.33108742	6.75214579
60.00	13.50000000	6.75000000

Table 3.4: Head- and footline calculation

x_M m	y_M m	z_M m	F_{Mx} N	F_{My} N	F_{Mz} N	A N
50,00	0	6,57	0	3500	16	32
50,51	3,15	6,37	1205	3480	463	32
51,03	4,44	6,16	1687	3461	655	32
51,49	5,32	5,98	2008	3446	792	32
52,00	6,16	5,78	2310	3430	931	33
52,57	6,96	5,55	2595	3414	1074	34
53,05	7,57	5,35	2812	3402	1195	35
53,55	8,16	5,13	3020	3391	1322	38
54,06	8,73	4,90	3220	3381	1460	40
55,00	9,67	4,46	3556	3367	1737	48
55,56	10,19	4,18	3741	3361	1926	55
55,97	10,56	3,97	3878	3358	2089	61
56,54	11,03	3,66	4058	3356	2346	74
57,10	11,49	3,32	4237	3355	2668	93
57,52	11,82	3,05	4372	3357	2973	114
57,96	12,14	2,76	4508	3360	3362	146
58,49	12,53	2,33	4694	3366	4100	221
59,01	12,90	1,85	4890	3376	5343	390
59,49	13,21	1,29	5101	3389	8011	926
59,98	13,50	0,04	5534	3425		



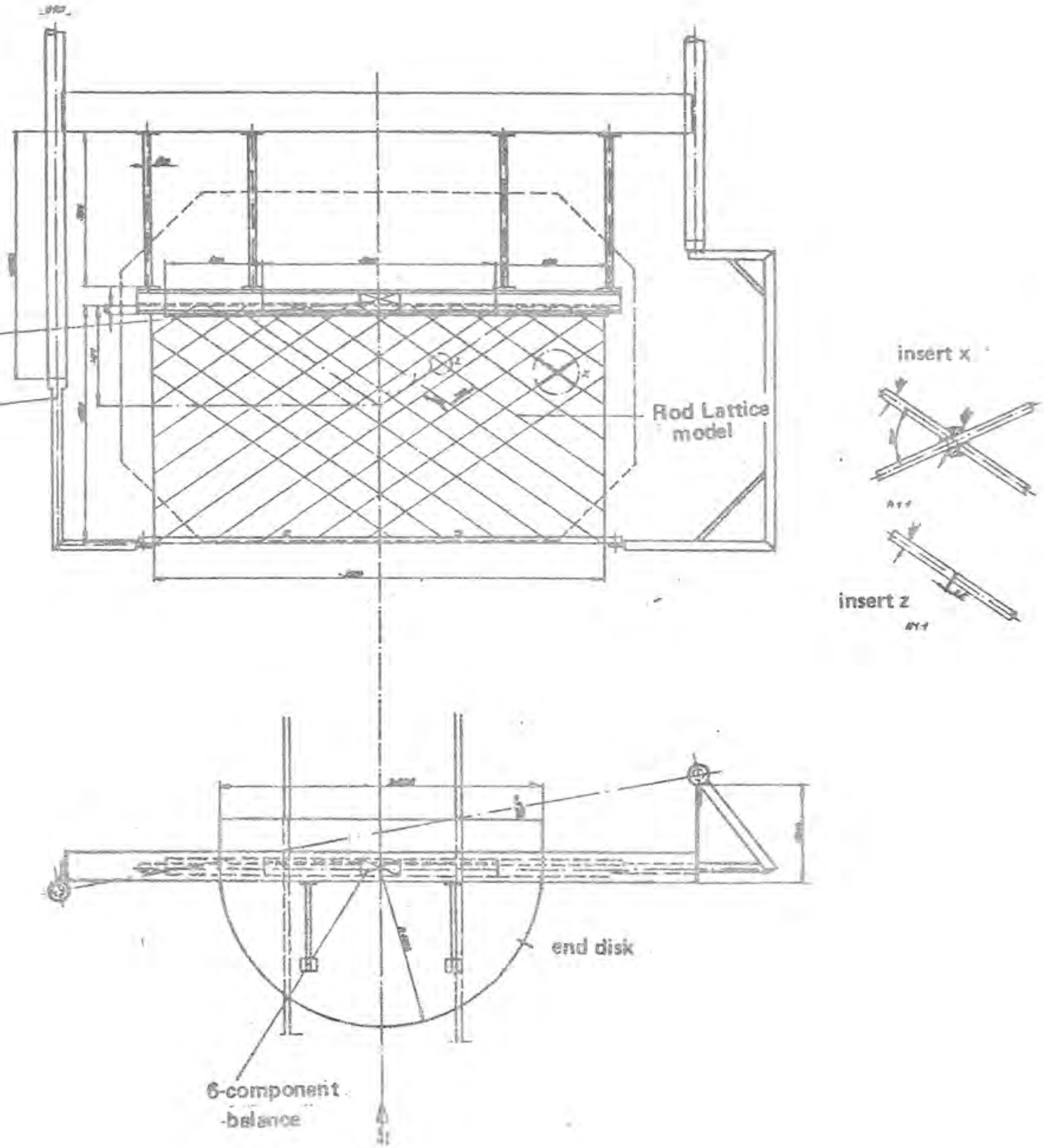


Fig. 2.1: Model suspension

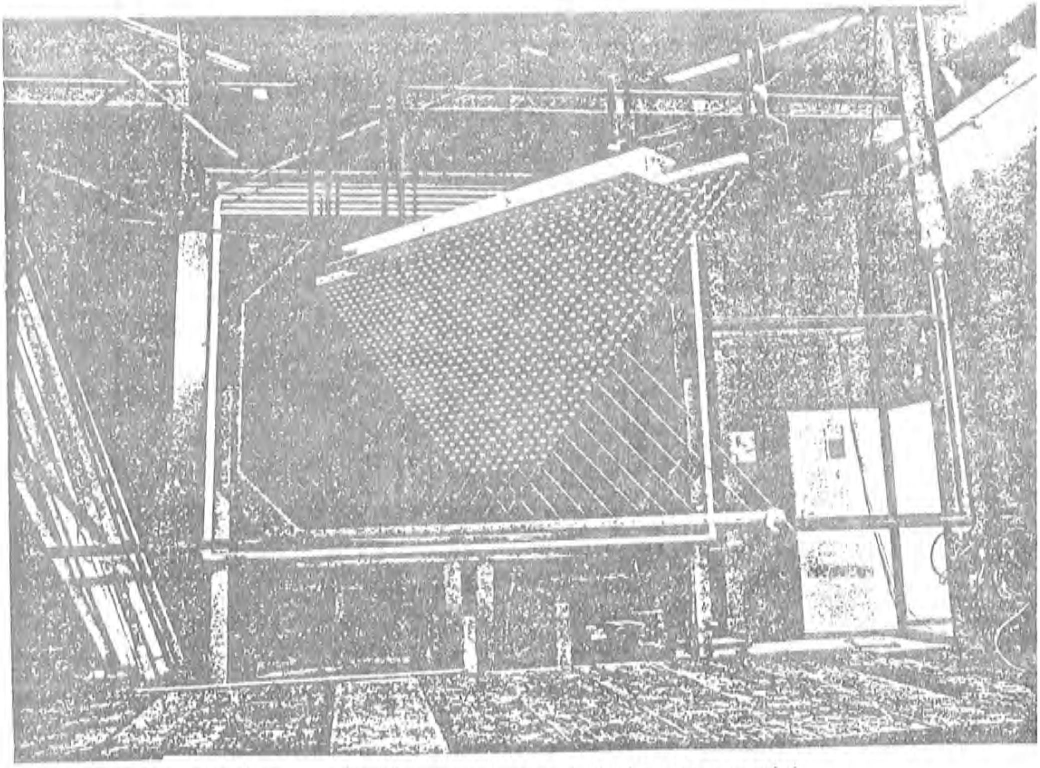


Fig. 2.2: Model suspension and Rod Lattice model
(d/a = 0,12 and γ

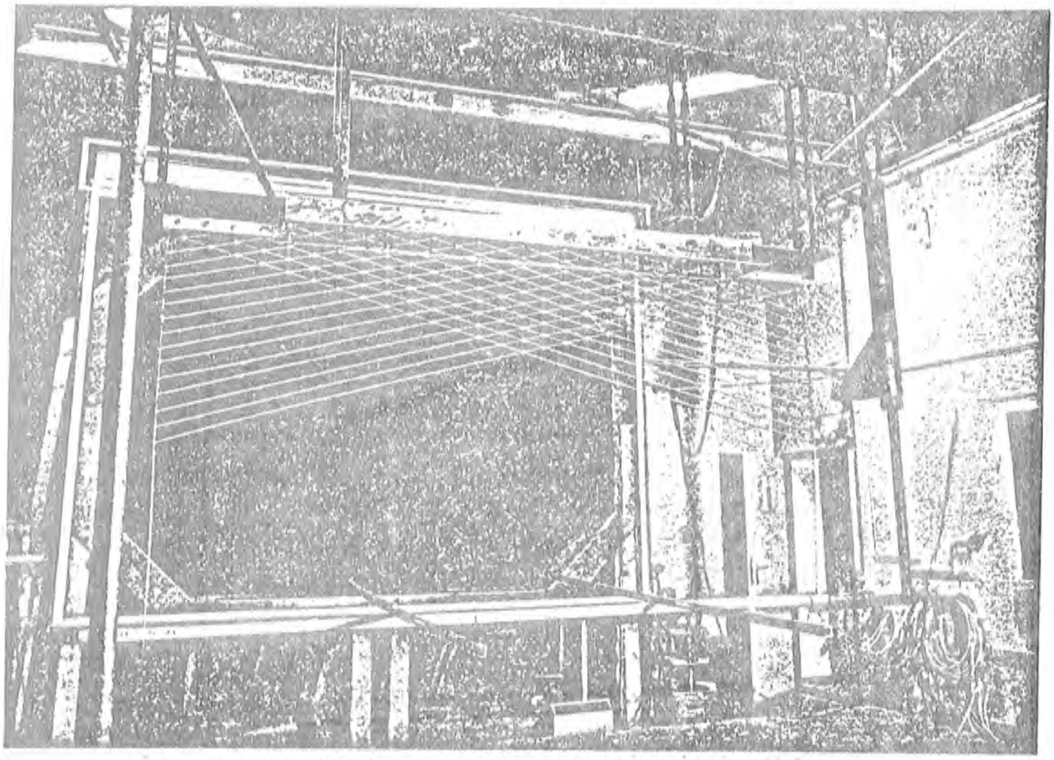


Fig. 2.3: Model suspension and Rod Lattice model
(d/a = 0,09 and β = 25°)

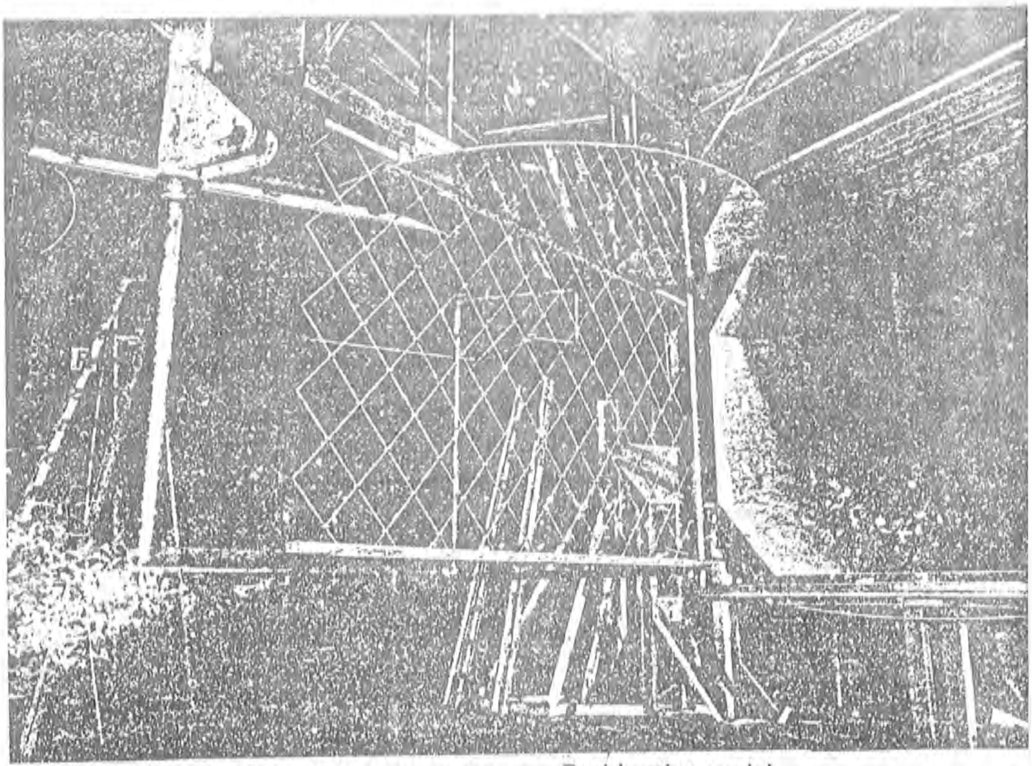


Fig. 2.4: Model suspension and Rod Lattice model
(d/a = 0,03 und $\beta = 45^0$)

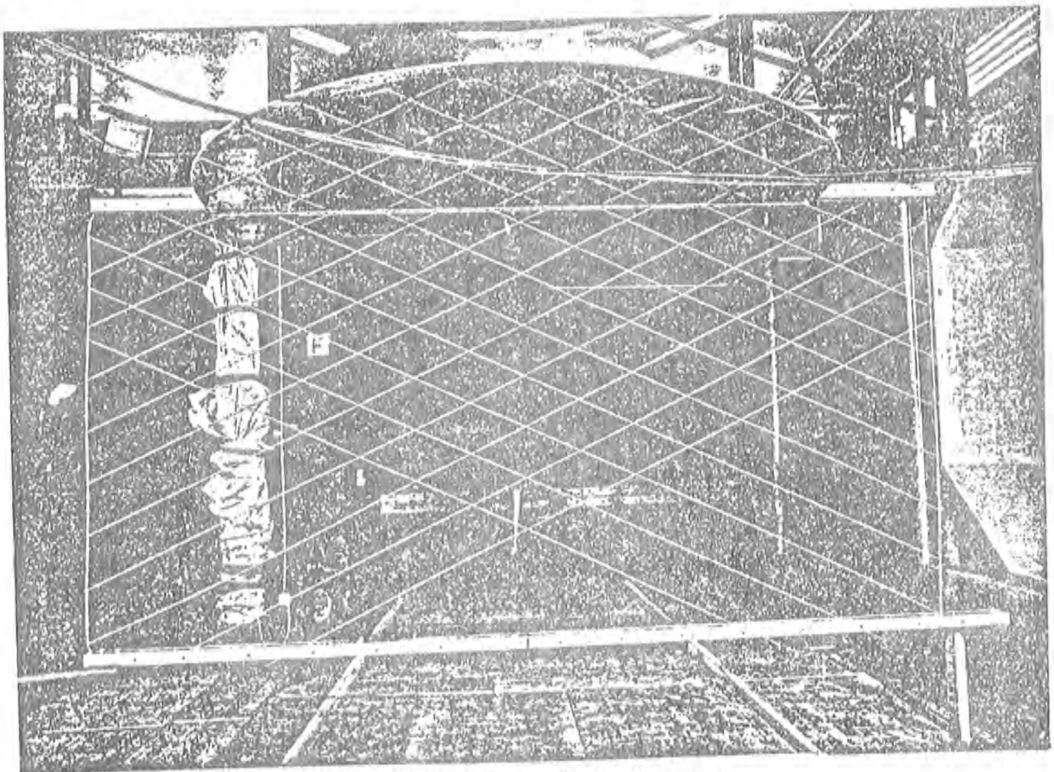


Fig. 2.5: Model without surface structure

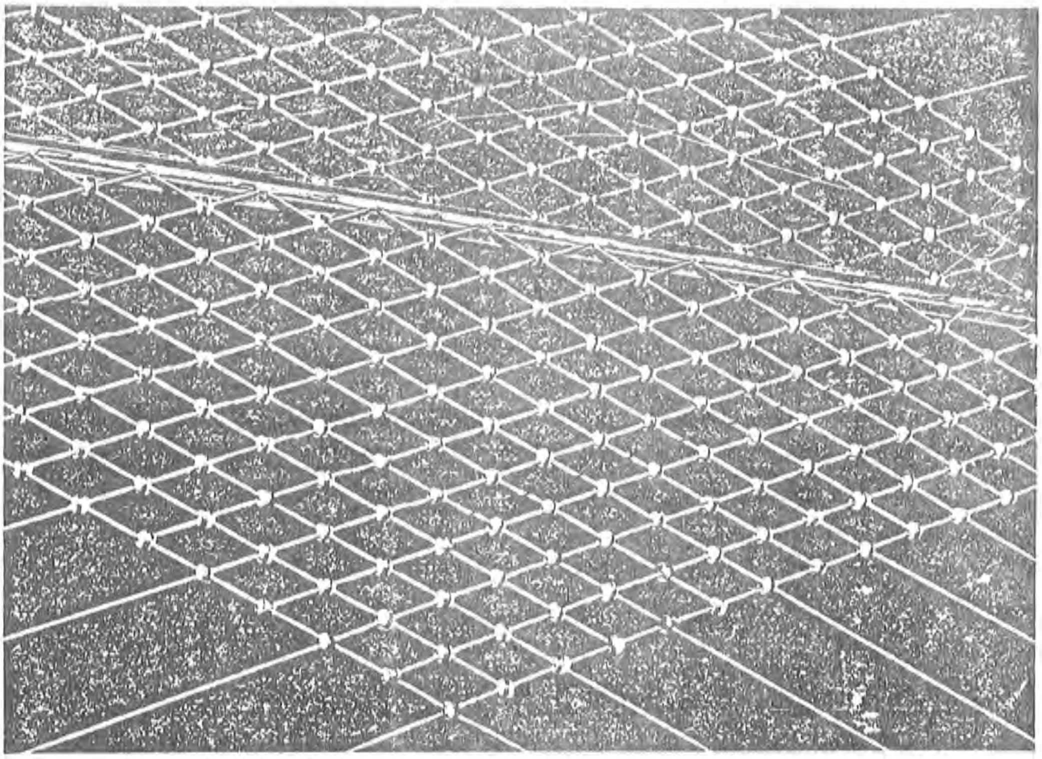


Fig. 2.6: : Rod Lattice model with knots represented

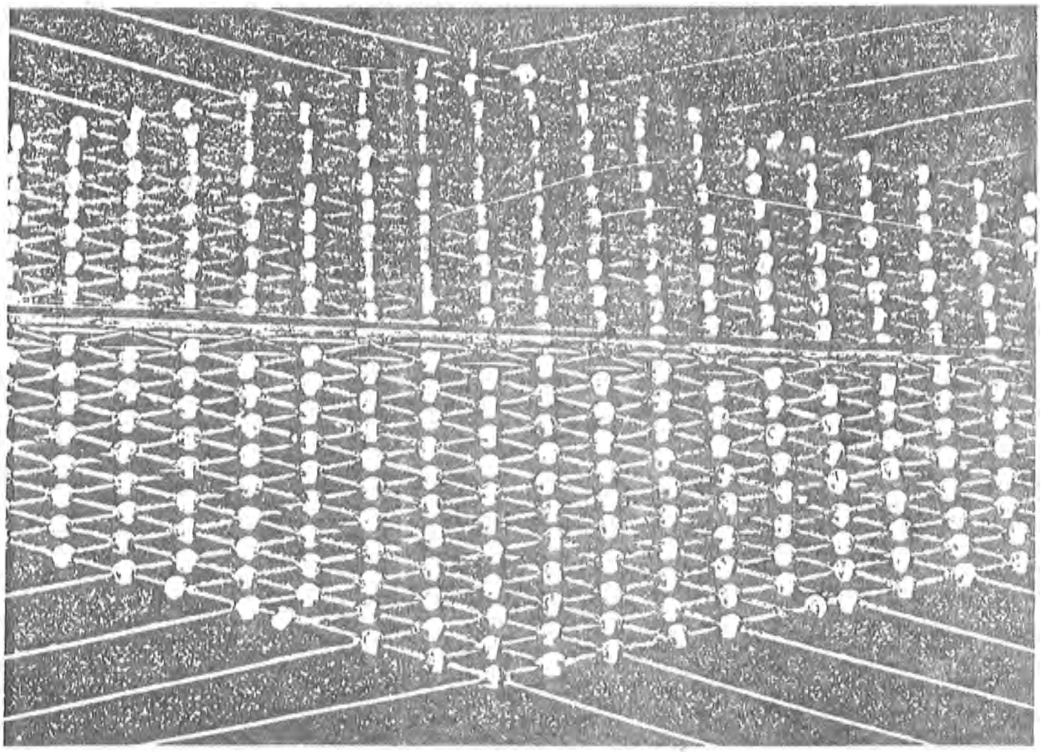


Fig. 2.7: Rod Lattice model with knots and surface roughness represented

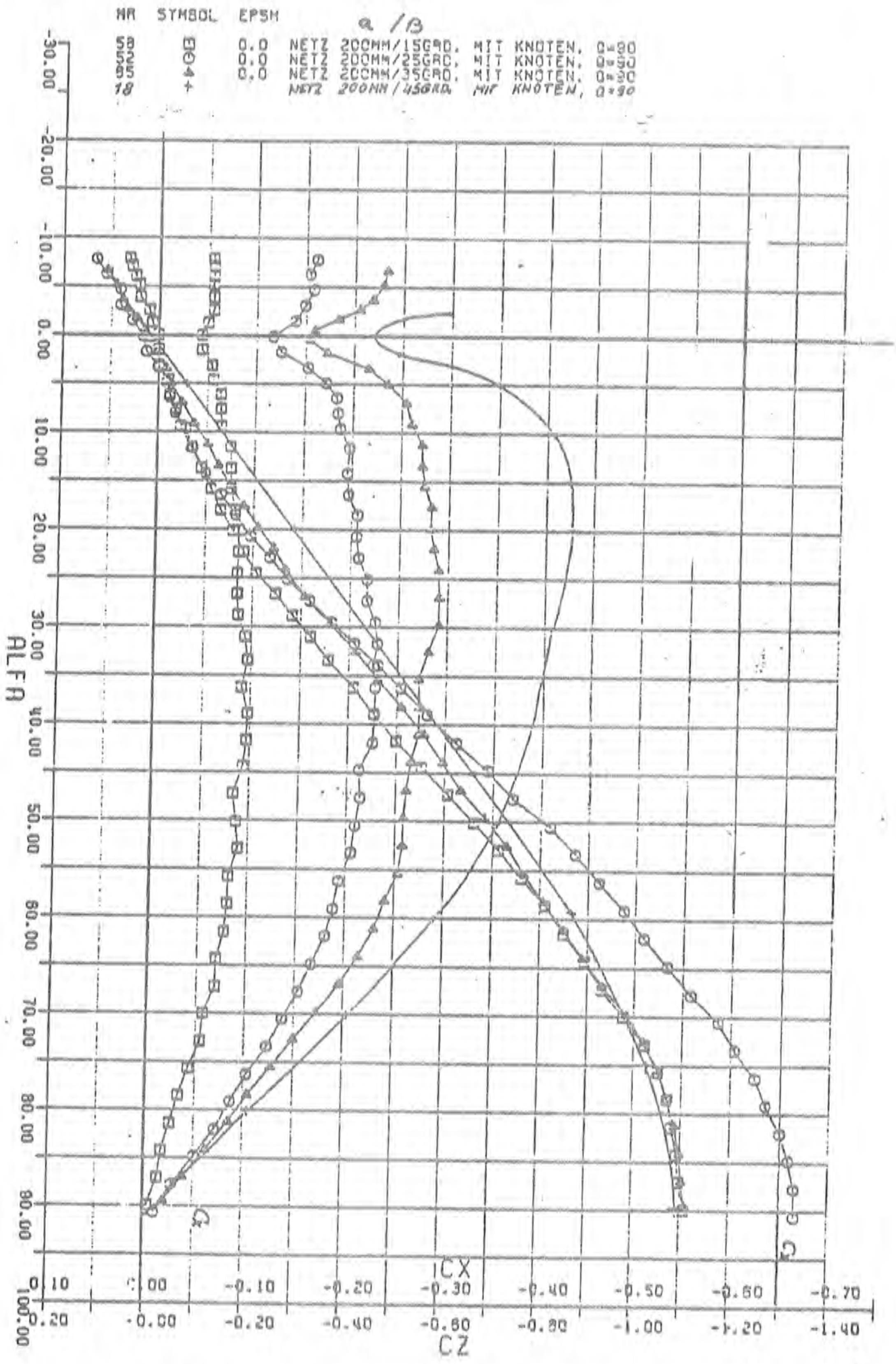


Fig. 2.8: Influence of the mesh angle, with knots (d/s = 6/200 mm)

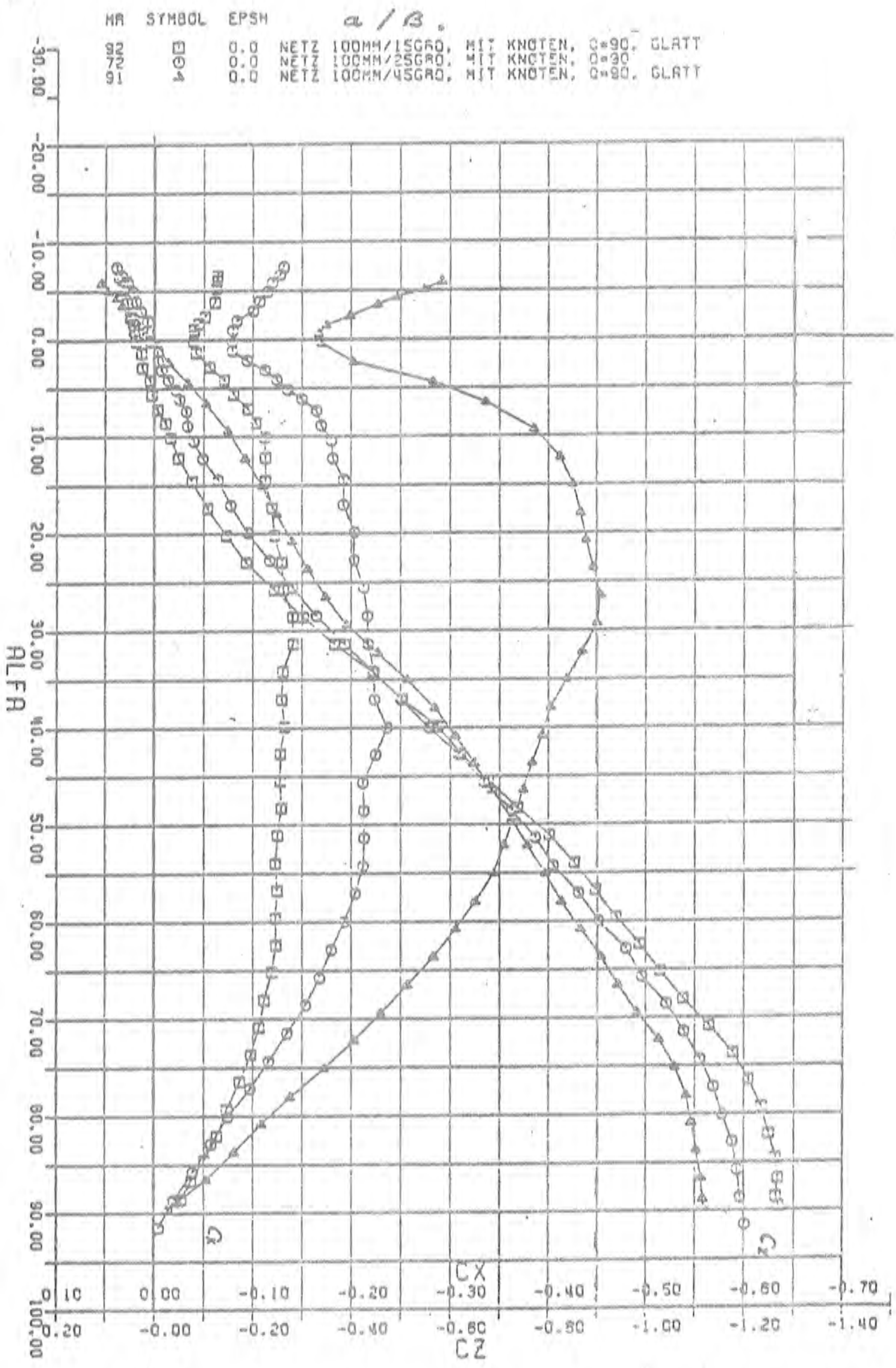


Fig. 2.9: Influence of the mesh angle
(d/a = 6/100 mm)

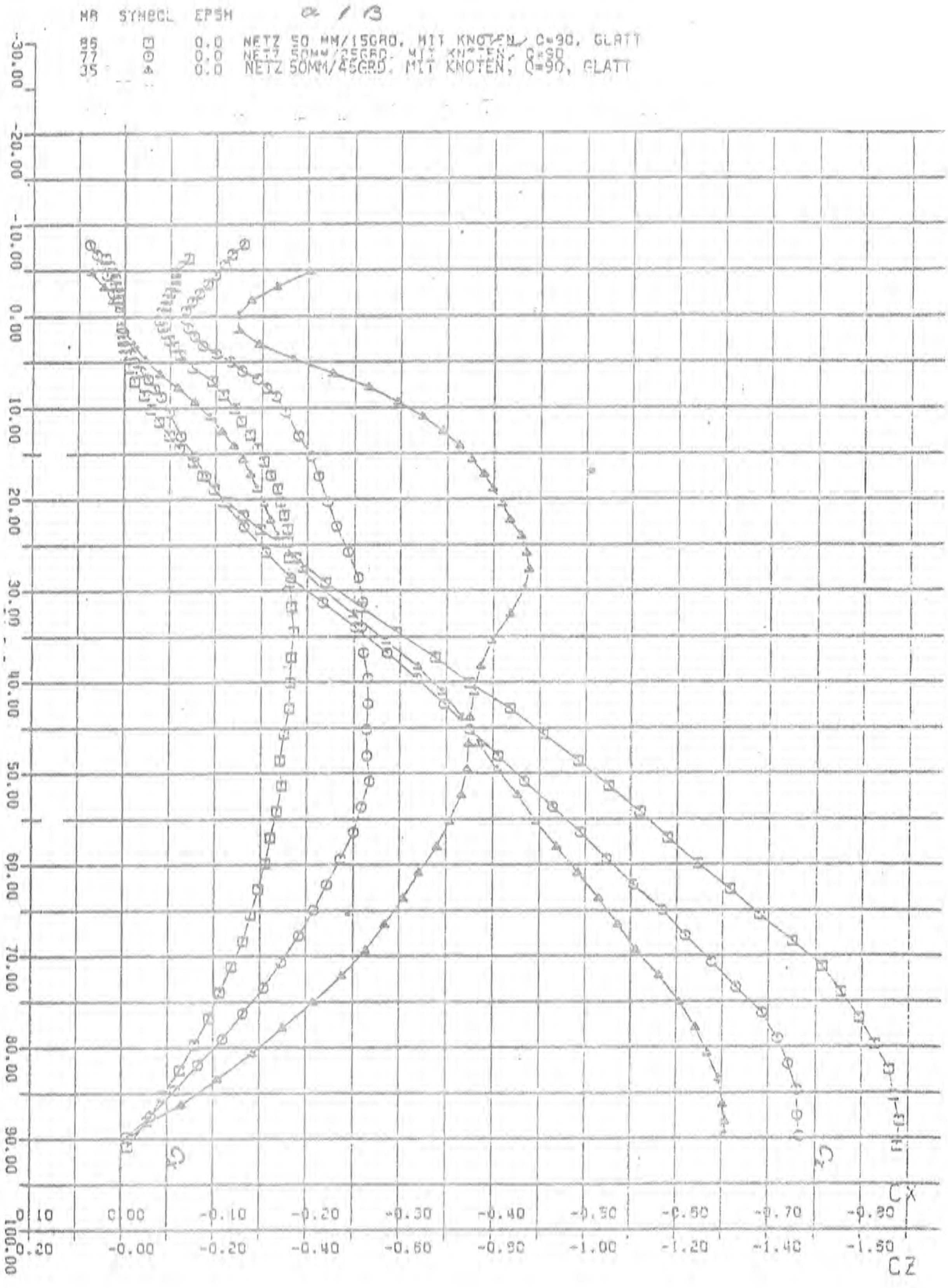


Fig. 2.10: Influence of the mesh angle (d/a = 6/50 mm)

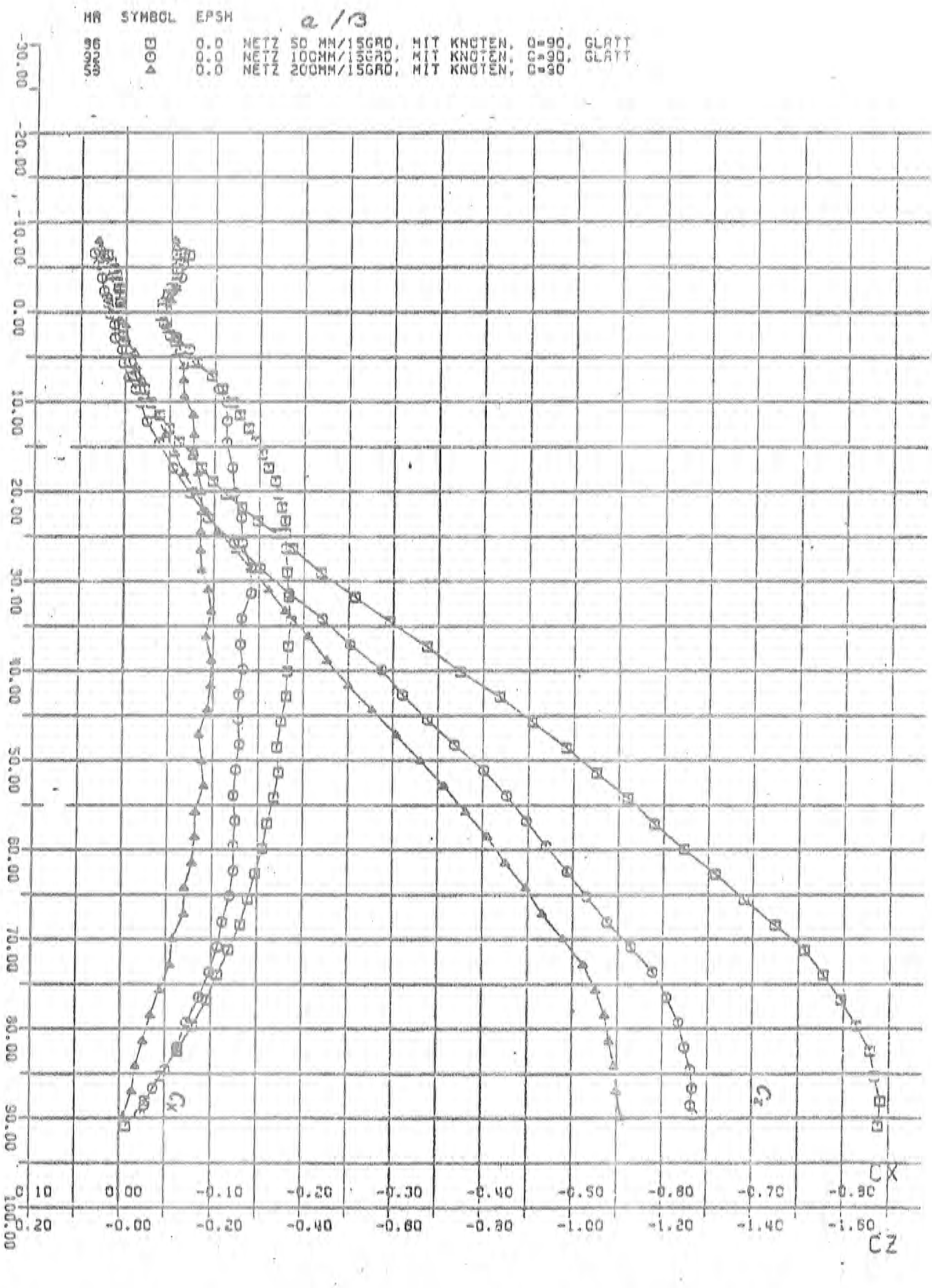


Fig. 2.11: Influence of the d/a ratio at $\beta = 15^{\circ}$ (Mesh incidence angle)

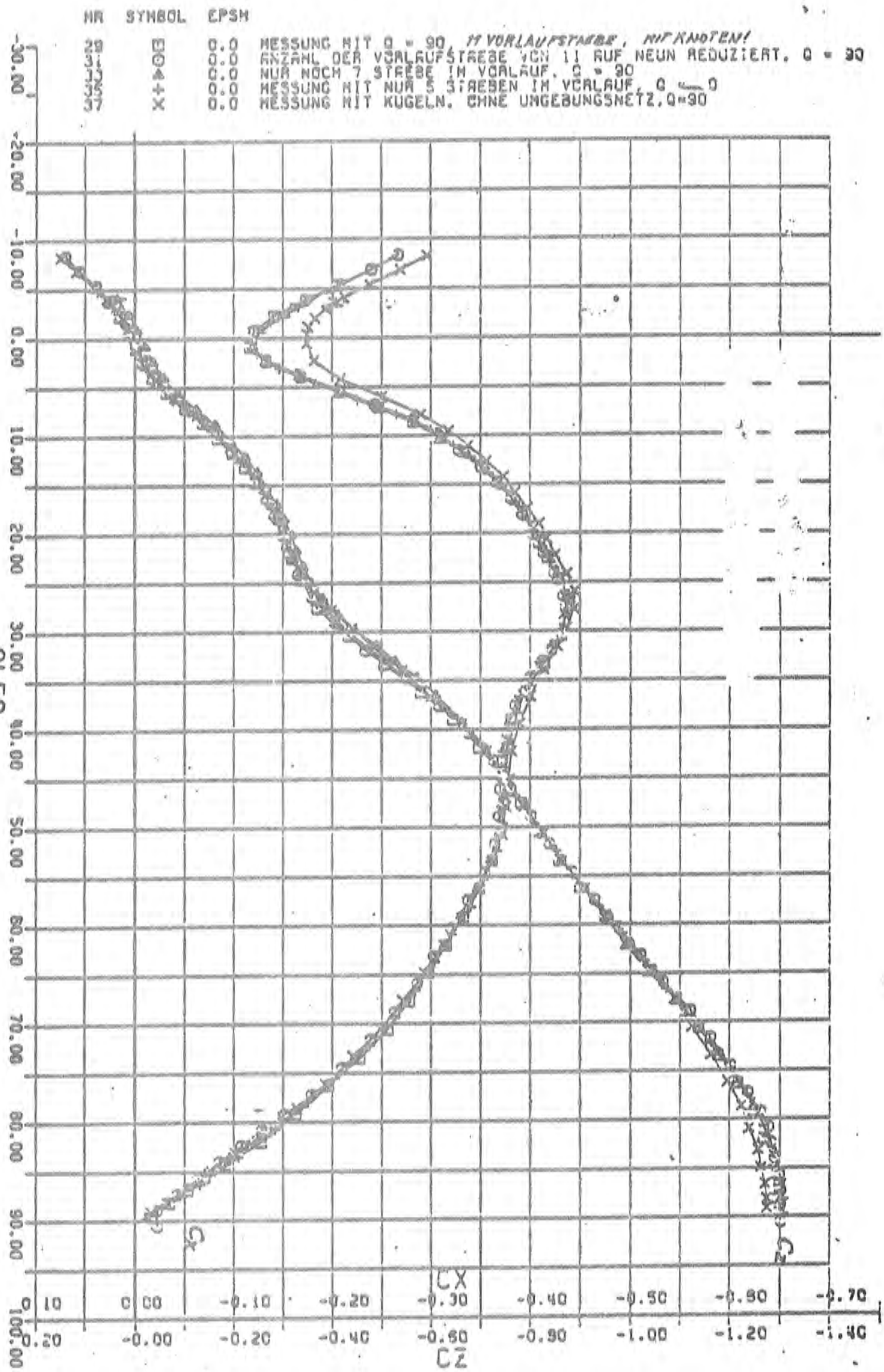


Fig. 2.12: Surrounding net influence
(a = 50 mm, d = 6 mm, β = 45°, smooth)

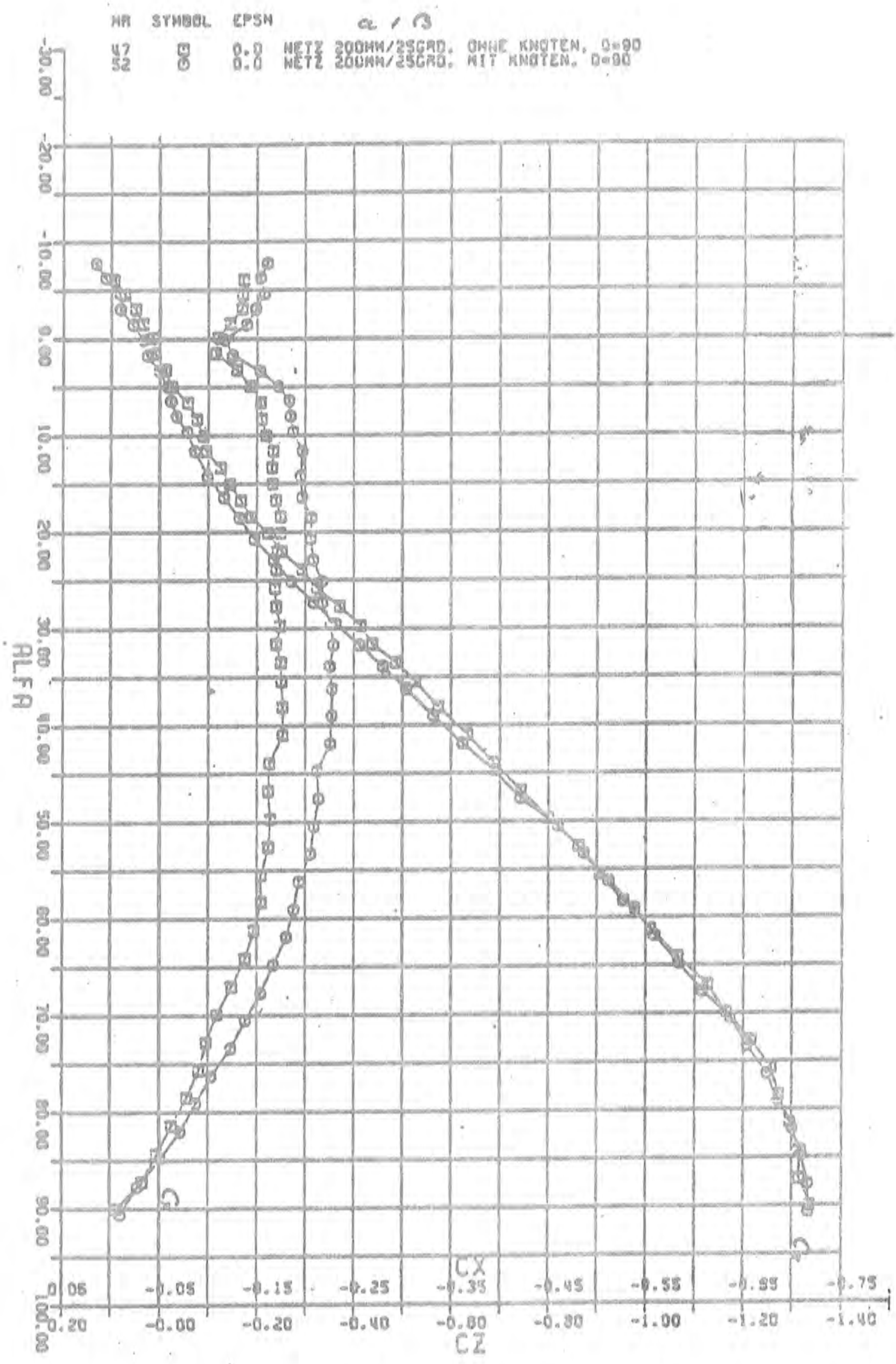


Fig. 2.13: **Influence of the Net's knots**
(a = 200 mm, d = 6 mm, β = 25°)

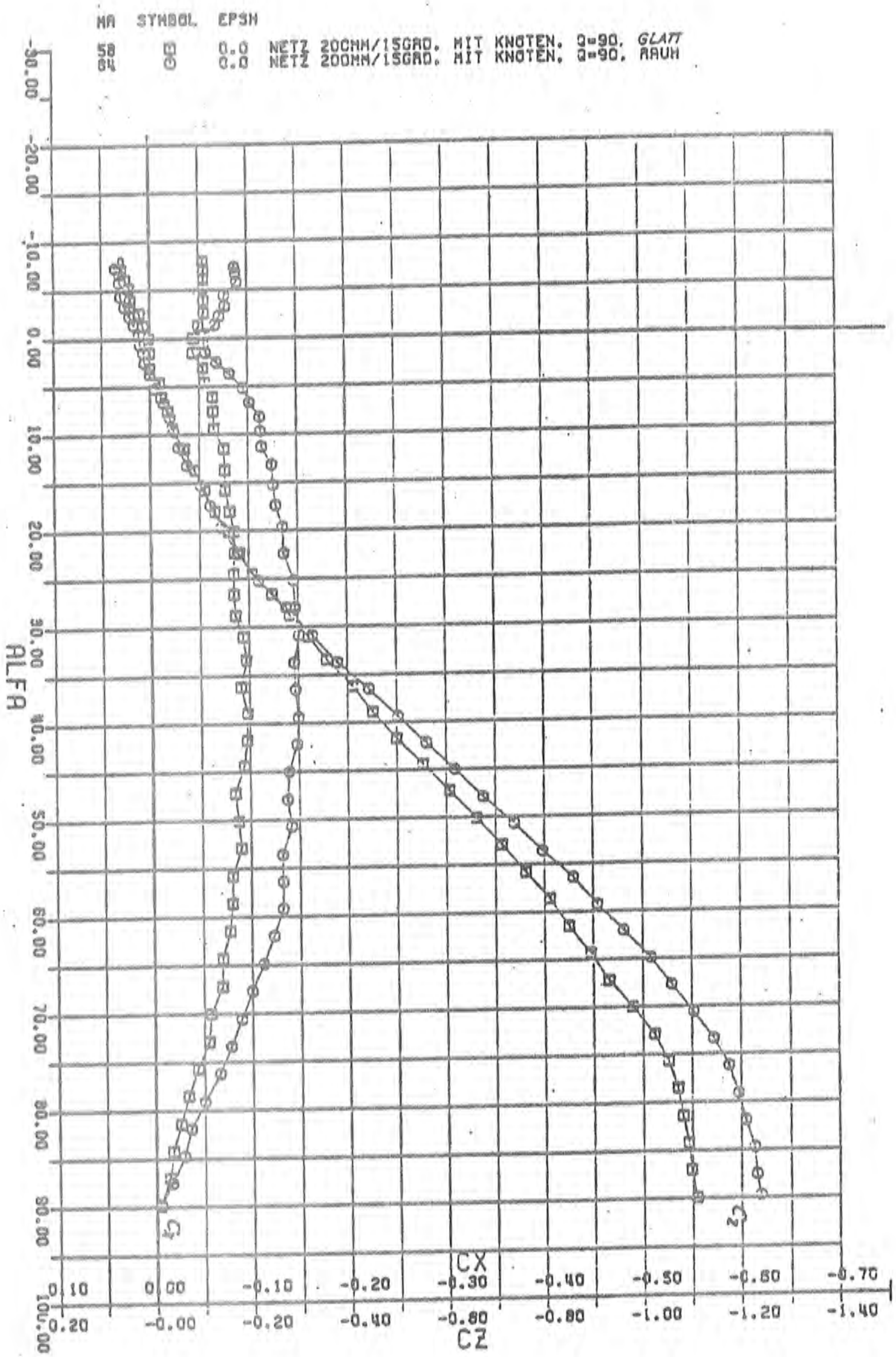


Fig. 2.14: **Influence of the cord roughness**

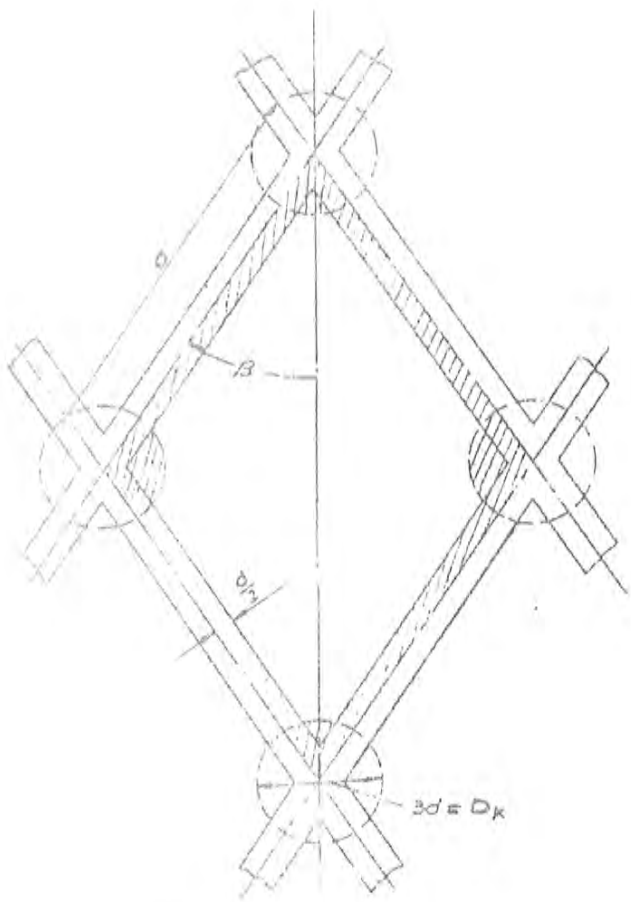


Fig. 2.15: Sketch of a single mesh

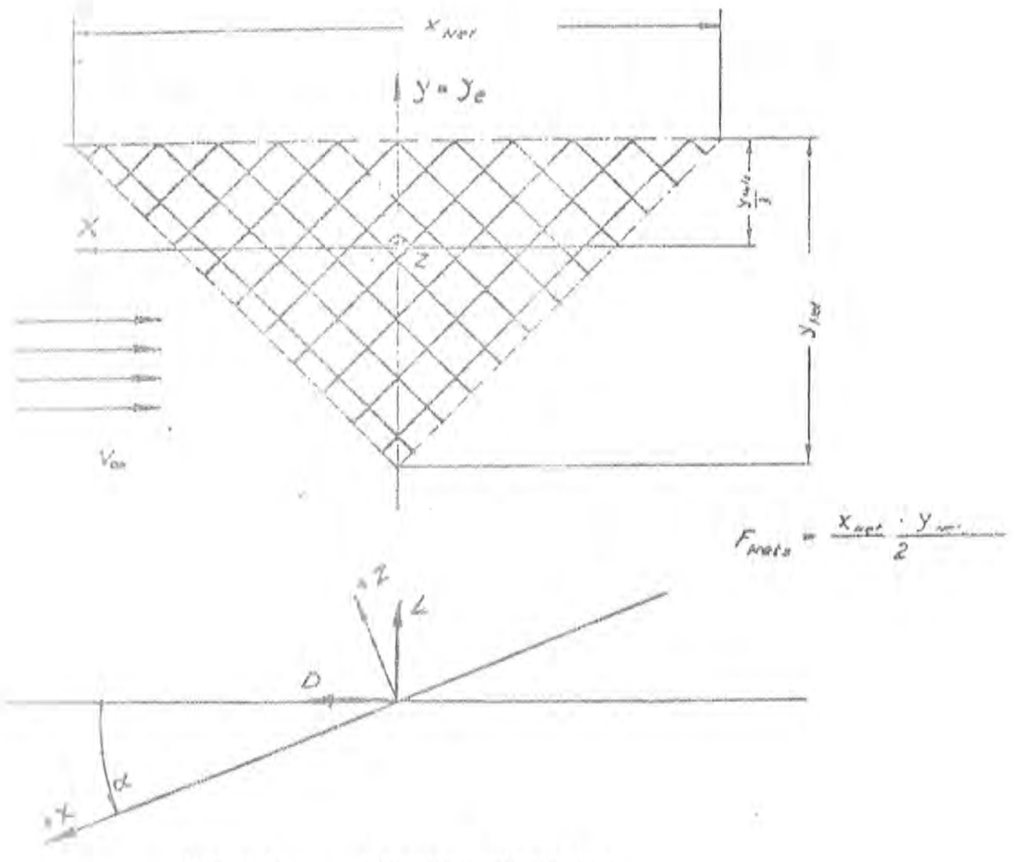


Fig. 2.16: Measurement system

Fig. 3.1: Substitute model of the net according to [3.4]

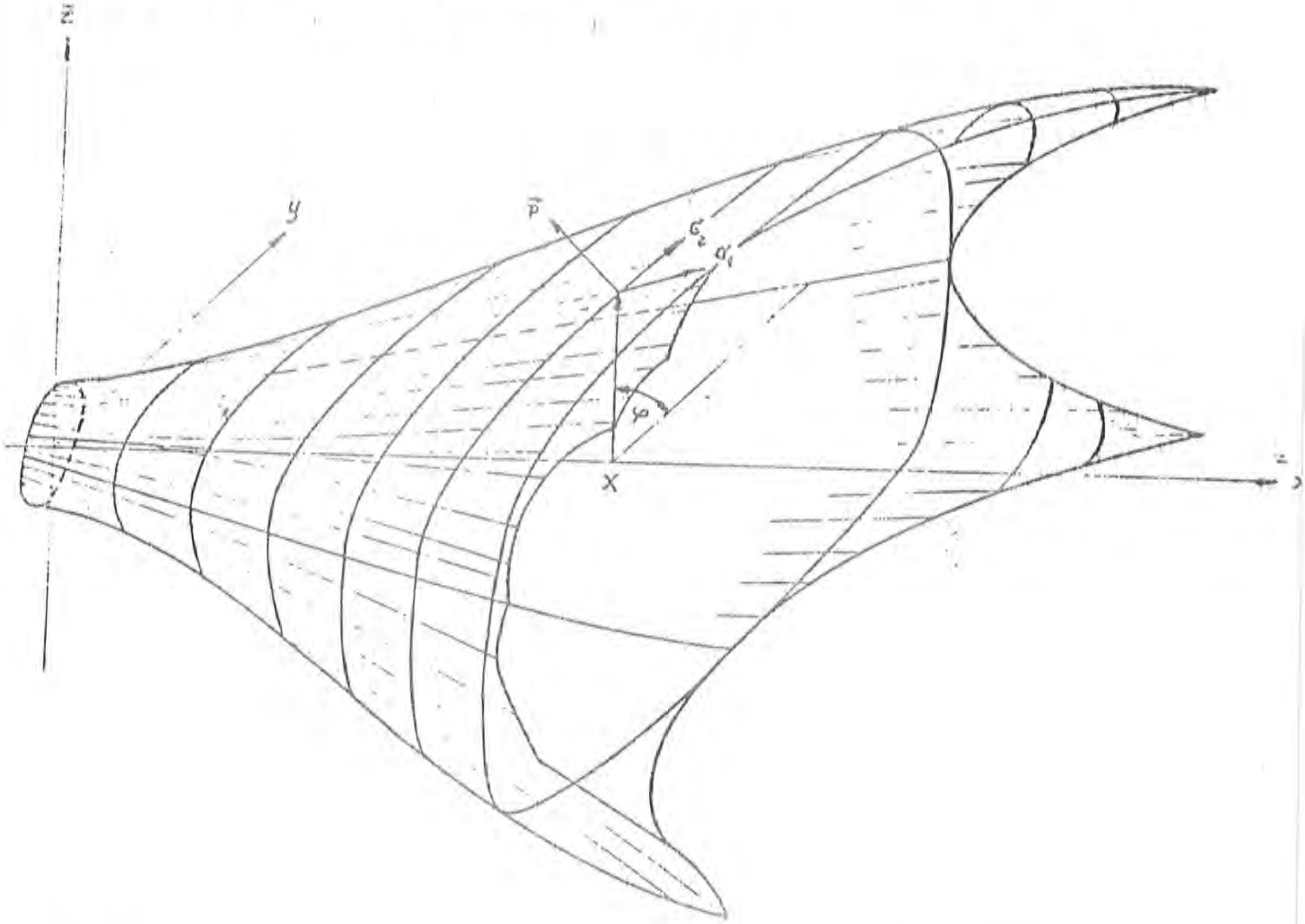
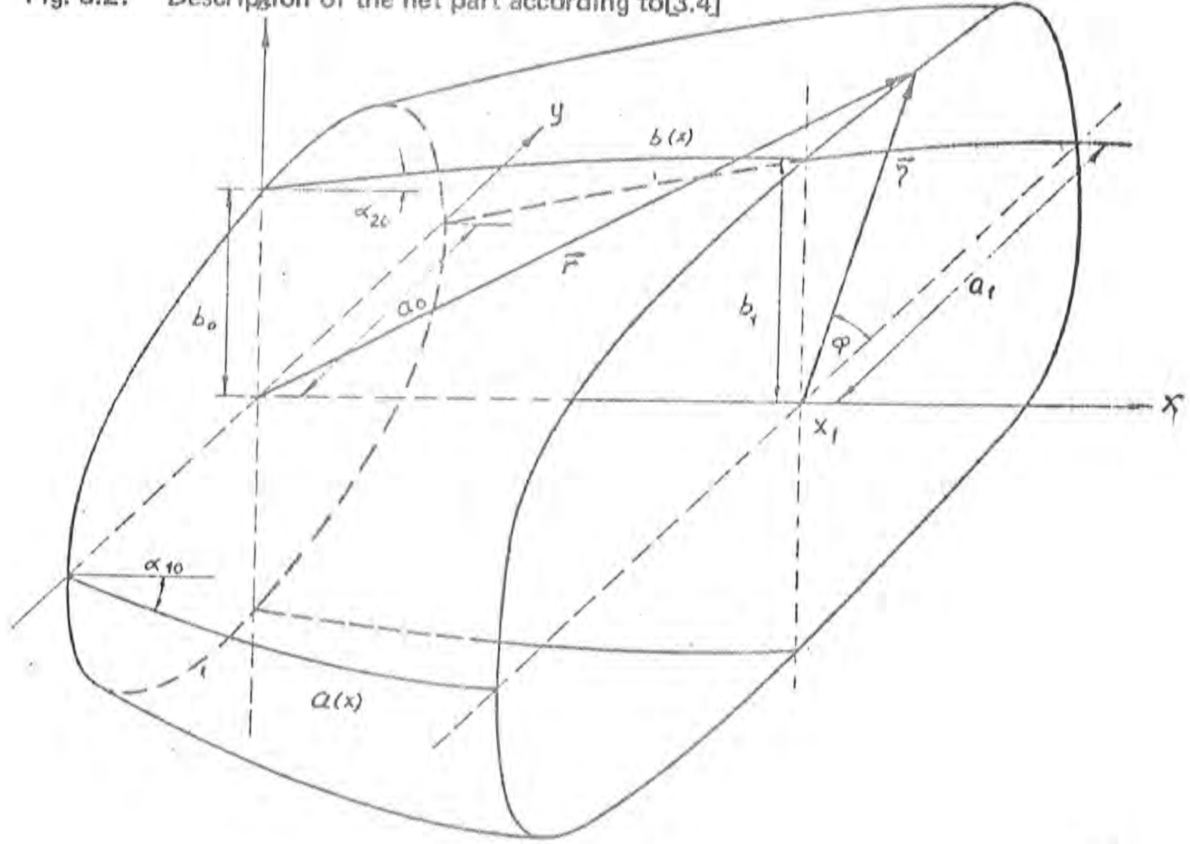


Fig. 3.2: Description of the net part according to [3.4]



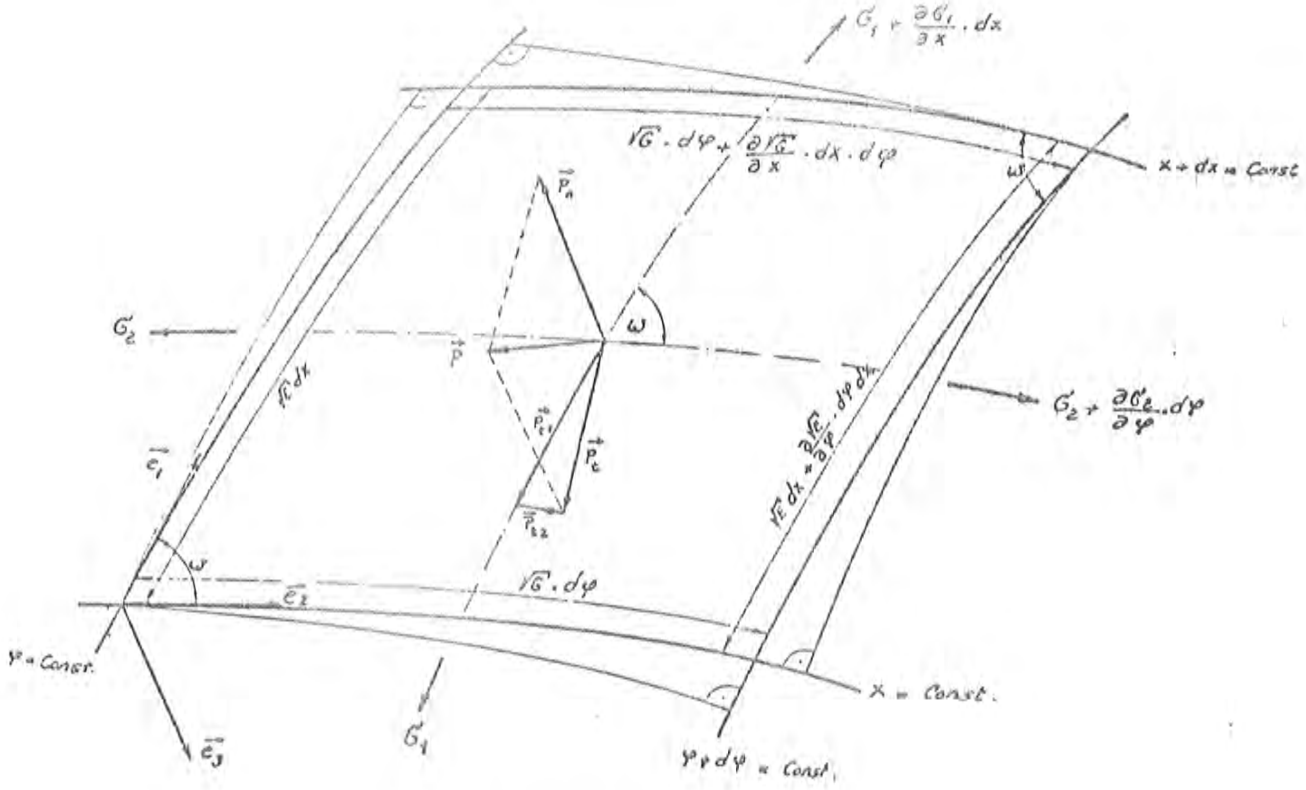


Fig. 3.3: Plane element according to [3.4]

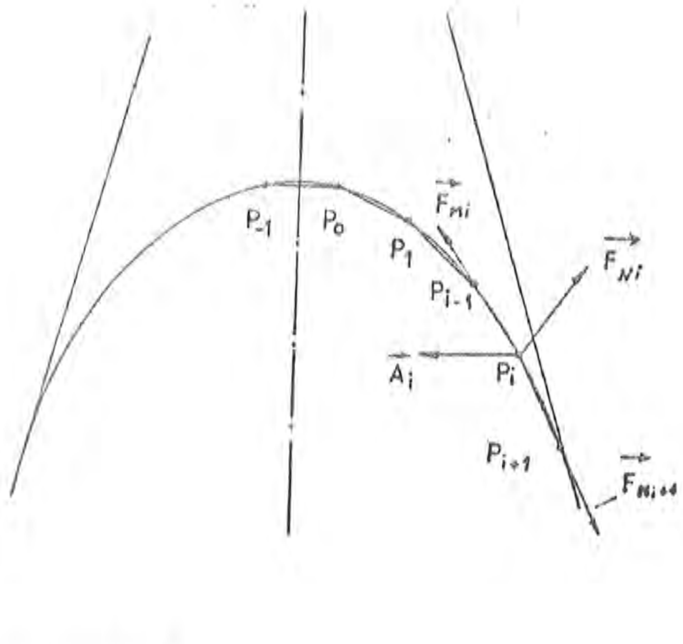


Fig. 3.4: Head line forces at P_i

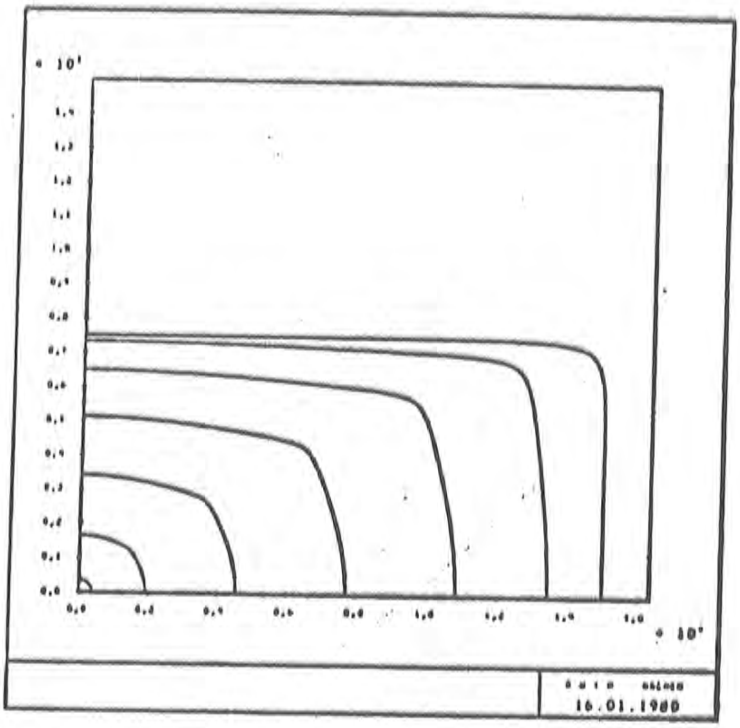


Fig. 3.5: Cross section of a 4–shackle net

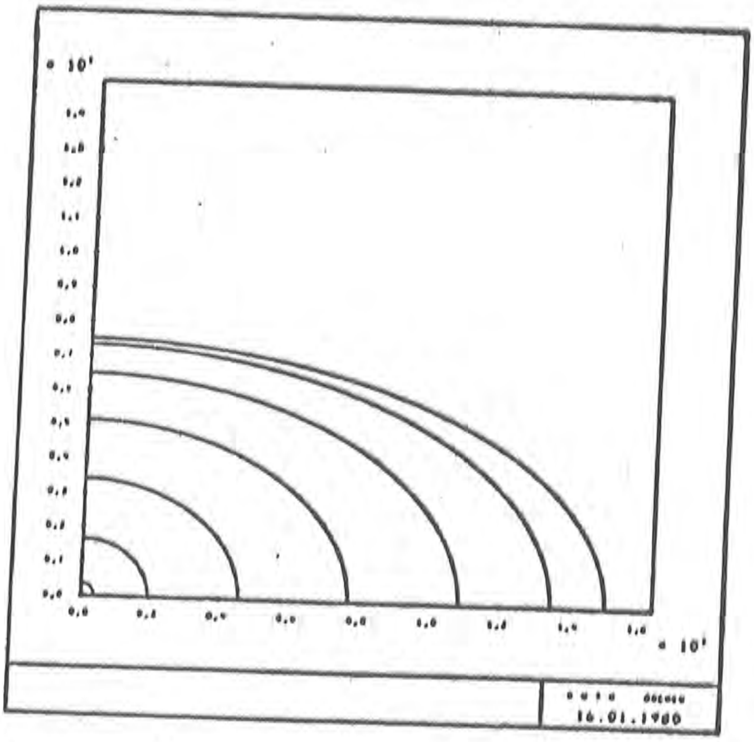


Fig. 3.6: Cross section of a 2–shackle net

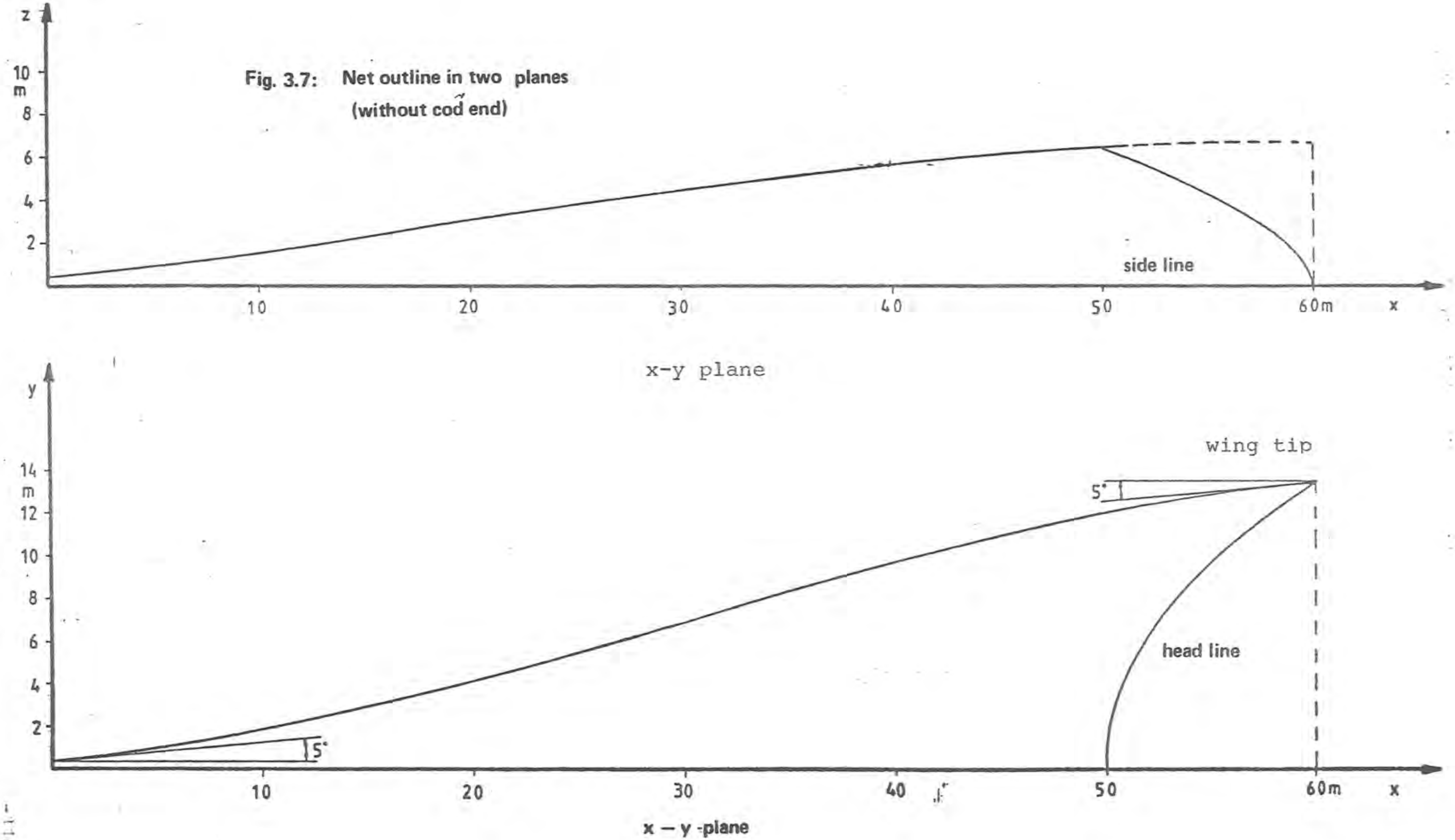
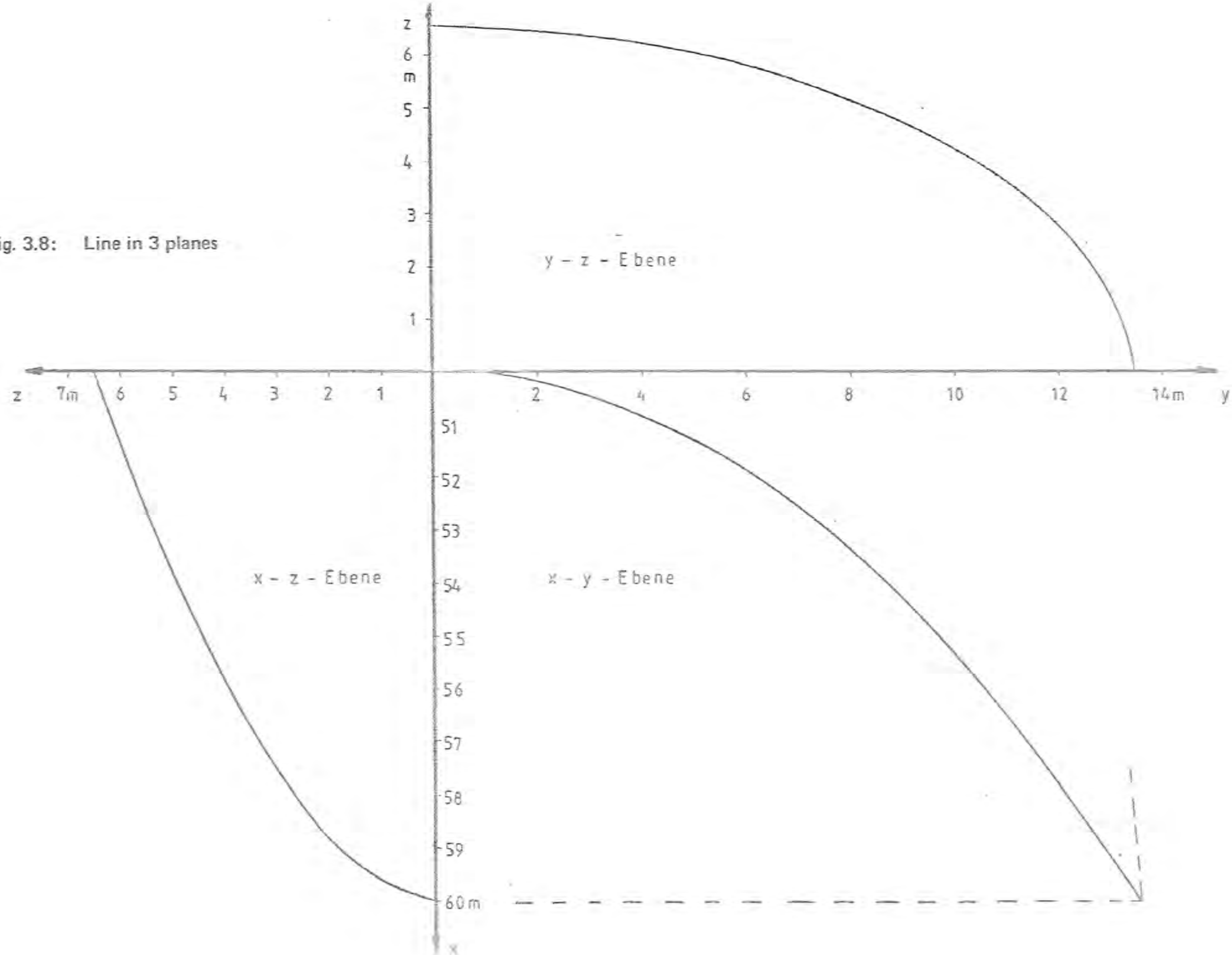


Fig. 3.7: Net outline in two planes (without cod end)

Fig. 3.8: Line in 3 planes



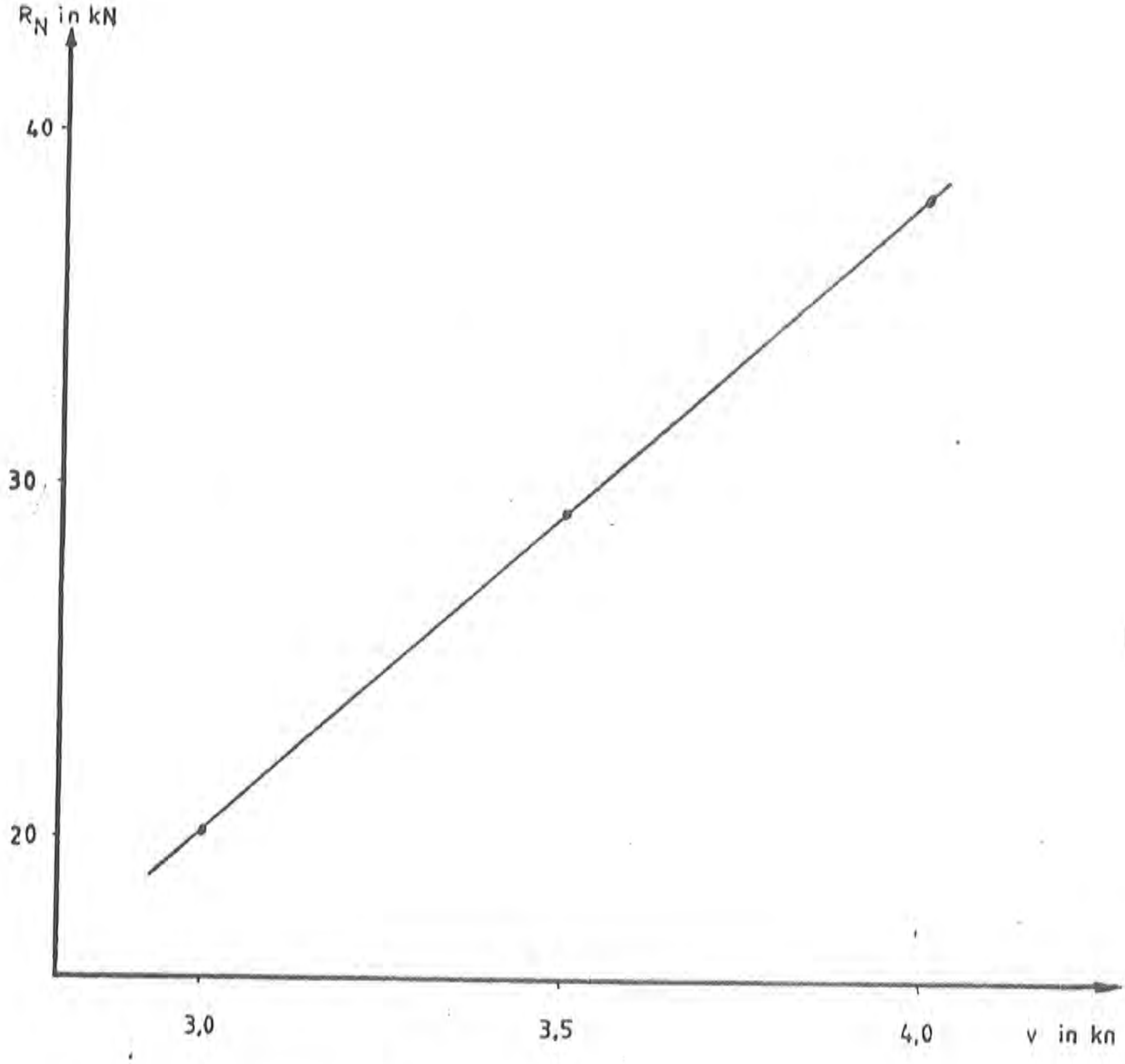


Fig. 3.9: Net resistance at L_N = 50 m

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SCALLOP DRAG TESTS AND DEVELOPMENT

by: Alan J. Blott and Vernon E. Nulk

The sea scallop, Placopectin magellanicus, fishery is an important segment of the fishing industry of the East Coast of the United States. In 1979, 31.5 million pounds of meats (the adducter muscle only) worth about $103 million were landed. Over 200 documented vessels are involved in the fishery. However, studies have shown that commercial scallop gear, called scallop drags or dredges, may be only 10 to 20 percent efficient, depending on scallop size; and gear-related mortality may approach 20 percent. In addition, present gear with 3 inch rings is nonselective between 3 year old and 5 year old scallops, approximately 62 and 106 mm respectively. Between the ages of 3 and 5 years old, the meat weight of scallops quadruples, so gear which selectively fished for the older scallops might increase yield per recruit significantly. Investigations have shown that increasing the ring size does decrease the catch of smaller scallops, but fishermen have argued that because of the large amount of trash caught, using larger rings would be ineffective. One Canadian investigator concluded that changing to the 4 inch ring would not make the drag significantly more selective, so he suggested development of an entirely new piece of gear.

Studies on gear-related mortality have shown that scallops are forced into mud under the drag or crushed on hard bottom. Bottom disturbance by drags may reduce the settlement of spat. Undersized scallops brought up in the gear are dumped, culled, shoveled, and exposed to extremes of temperature, thus reducing their chance of surviving when returned to the water.

In spite of all the investigations conducted to date, there are many unanswered questions remaining. The Northeast Regional Management Council realized it would be difficult to manage the scallop resource unless more were known about the gear used in the fishery; therefore, a study was funded to look at the New Bedford scallop drag using divers and color underwater television.

The purpose of the initial study in the summer of 1979 was to develop the techniques for divers to ride the 8 ft. drag and handle the camera and lights. Also, it was hoped that methods of determining mortality, selectivity, and avoidance could be worked out during the initial stage. After the divers became familiar with riding the dredge, they were able to ride and handle the camera. One diver aimed the camera and another tended the electrical cable. The diver operating the camera was directed by a coordinator watching a video monitor on the vessel who was in voice contact with the diver.

Another method was developed where the camera on a two wheel trolley was lowered down the towing warp after the drag had been set. Using the trolley, observations can be made without divers. While looking for areas of bottom suitable for towing or for concentrations of scallops, the camera, with a pole sticking out in front of the lens, was lowered on a line to the bottom. As the boat drifted, the line was adjusted so the end of the pole just touched the bottom. Also, a net and frame were constructed to attach to the top of the frame of the scallop drag to catch any small scallops which exhibited the reported avoidance behavior of swimming up over the top of the drag.

The use of the color underwater television camera and divers for observing the operation of the dredge at 1 1/2 to 2 knots worked well. However, in the 9 days available in 1979, the correct combination of shallow depth, good visibility, and adequate concentrations of scallops was not found so most of the observations were of dredge performance not scallop behavior.

It was found that the bail of the drag towed at an angle so the tow point was up to 4 ft. off the bottom, and the cutting bar--the lower horizontal member of the rigid frame at the mouth of the drag--was always several inches off bottom except in areas of sand ridges where the bar plowed through the tops of the ridges. The sweep chain tended bottom well, digging into soft sand and lightly scraping hard bottom. In areas of sand ridges, it was hard to tell how well the sweep was tending because of billows of sand obscuring the chain. The water flow around the cutting bar was indicated by the flow streams of sediment above and below the bar. The flow patterns show that objects on the bottom may be moved as the cutting bar passes over.

Current drag designs have a depressor plate mounted on the upper horizontal member of the rigid frame at the mouth. This is supposed to help the gear tend bottom better. The depressor plate angles downward towards the front of the drag; but when the drag is fishing, the plate is almost parallel to the sea bed so it doesn't affect the performance of the gear. We also observed that the after section of the bag was always collapsed because of the weight of the rings, whereas the twine back--the section over the sweep chain--opens up similar to a trawl. The weight of the rings and the club stick is very likely to damage undersized scallops in the bag and uncaught scallops that the gear passes over.

Using what was learned from the video, a new drag is being designed to overcome some of the problems. The first concern is to reduce gear-related mortality by changing the rear section of the drag. The forward framework will closely resemble that of existing New Bedford drags. The depressor plate will be larger and hinged so the angle of attack will be adjustable. By changing the depressor angle, the downward force on the drag will be altered. A bolt-on cutting bar will be used so different cross-sectional shapes can be tested. The shapes being considered include a quarter circle which is intended to deflect water flow down to the sea bottom to dislodge scallops laying in depressions. Another shape is an inverted hydrofoil, which may lift the scallops out of the depressions. The height of the cutting bar off the bottom will be adjustable.

The after section will be a rigid cage similar to the Victorian scallop dredge fished in Australia. The major difference from the Australian dredge will be that the new design will have a heavy sweep chain similar to existing New Bedford drags. The sweep will be mated to the rigid cage with a flexible scallop ring apron. The Australian dredge features a rigid scraper bar which would not work on the rocky bottom that the New Bedford drags are fished on. There will be a hinge between the forward section and the rigid cage which will ride above the bottom on two runners. By reducing the bottom contact of the gear, gear-related mortality of uncaught scallops should be reduced. The top and bottom steel mesh panels of the cage will be removable so different size meshes can be tested to determine selectivity.

This dredge will be tested in the summer of 1980, and it is expected to significantly reduce fishing mortality of the uncaught scallops.

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A NEW ERA FOR KRILL CATCHING

By Matti T. Törmä *

The harvesting and utilization of krill has been a subject of keen international interest already for several years. Many countries have carried out large-scale expeditions when studying the behaviour and biomass of krill as well as the possibilities to catch it feasibly. The whole research work is directed by an international program BIOMASS (Biological Investigations of Marine Antarctic Systems and Stocks). The main purpose of all this research is to have sufficient knowledge on krill stocks so that when the full scale harvesting of krill is started, it can be managed sensibly. The total potential catch of krill could allow a substantial increase of the world's catch of abt. 75 million tons, up to doubling it.

*
Mr. M.Törmä is the chief naval architect at Wärtsilä Turku Shipyards, Marine Resources department, Turku , Finland. He is a specialist on seakeeping and ice-going operability of vessels and is in charge of the design of krill factory vessels.

Penguins are one of the major users of the huge krill stocks. Thanks to the cracks in the ice fields they can survive during the severe winter conditions.

Part of the krill catch for peeling. The size of a krill is about the same as a match.

THE PROBLEMS OF FEASIBILITY

The reasons for the lack of vast harvesting of krill already in the seventies are simple. As everybody knows the main areas of krill swarms lay far off south beyond the Antarctic Convergence. The vessels capable to use krill economically were non-existing due to the fact that the catches have to be processed rapidly after taking it onboard due to fast autolysis of krill. Secondly the relation of the trawling capacity of the conventional trawlers and their processing capacity is uneconomical: the large catches by single hauls could not be utilized. Thridly the development of the processing equipment was not so fast as was expected. Fourth and the most important factor has been the too short time of operation due to difficult environmental conditions. However, significant progress has been made on all of the above mentioned items. The Finnish shipyard group Wärtsilä known as the world's leading builder and designer of icebreakers and polarvessels is showing a new solution in the economical utilization of krill.

THE ENVIRONMENT - A CHALLENGE TO BE CONQUERED

The waters around the Antarctic are known to be the world's most difficult for navigation. The vessels operating in these latitudes must be safe, efficient and sea worthy. The problems which one may meet there are not only the gales and fog but also icebergs, low temperatures and drifting ice. Even in summer the krill areas could be covered with floating pack-ice. The period of open water is short, only a few months. To lengthen the catching season of the krill vessel it has to be designed to operate and catch also in ice conditions.

Figure 1. Typical view of the Antarctic seas in winter. The waters of South Orkney's are surrounded with icebergs and thick pack-ice.

Figure 2. The ice pressure on the hull demands a special construction and design of the vessel. This figure is taken on the trip of Wärtsilä-built icebreaker "Almirante Irizar" near the South Orkney's in October 1979.

A typical picture of the krill area in winter time is as shown in fig 1., which is taken near the South Orkneys Islands last October. The drifting pack-ice covers the sea with a few icebergs here and there. For conventional fishing vessels it is impossible to operate safely in these waters, because the rapidly changing ice conditions can demolish her easily making the hull plating wrinkled as a raisin. The ice thikness and the ice pressures can be imagined seeing fig.2 which is taken only abt. twenty miles off eastward South Orkneys. (The figures 1. and 2. are taken during the trip of the Wärtsilä - built Antarctic icebreaker "Almirante Irizar" last October at the Atlantic sector of krill areas.) The icy environment of the far- off southern krill are quite similar to those of far-off northern seas of Finland. The Finns have succesfully navigating during winter time for over a hundred years and have gained experience second to none of ice operating vessels. Now it is time to use this knowledge also for the starting of winter operations in krill areas.

ICE-OPERATING KRILL FACTORY TRAWLER

Operation in these circumstances require special vessels, which are not only capable of overcoming the environmental threads but also can carry out their main task: the harvesting of krill. Wärtsilä has developed a ship to operate in these waters. Combining the vast icebreaking and polar navigation know-how with the experiences of ice trawling has made in this vessel capable of coping with the Antarctic challenge.
The main characteristics of the vessel can be seen in figures 3 and 4.
She is a stern trawler with the possibility of lowering the warps under the ice, featuring a totally covered trawl deck and is equipped with the Wärtsilä air bubbling system to reduce the ice resistance.

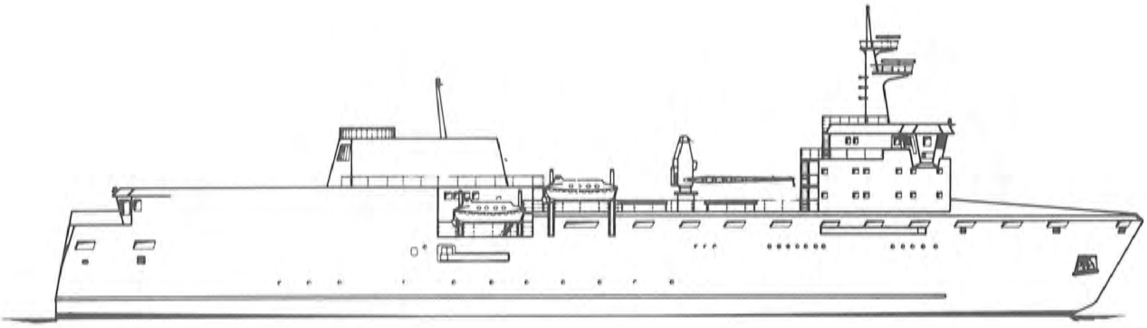


Figure 3. Krill factory trawler for operating in icy conditions of the Antarctic. The length of the vessel exceeds 100 meters and she resembles more an icebreaker than a trawler.

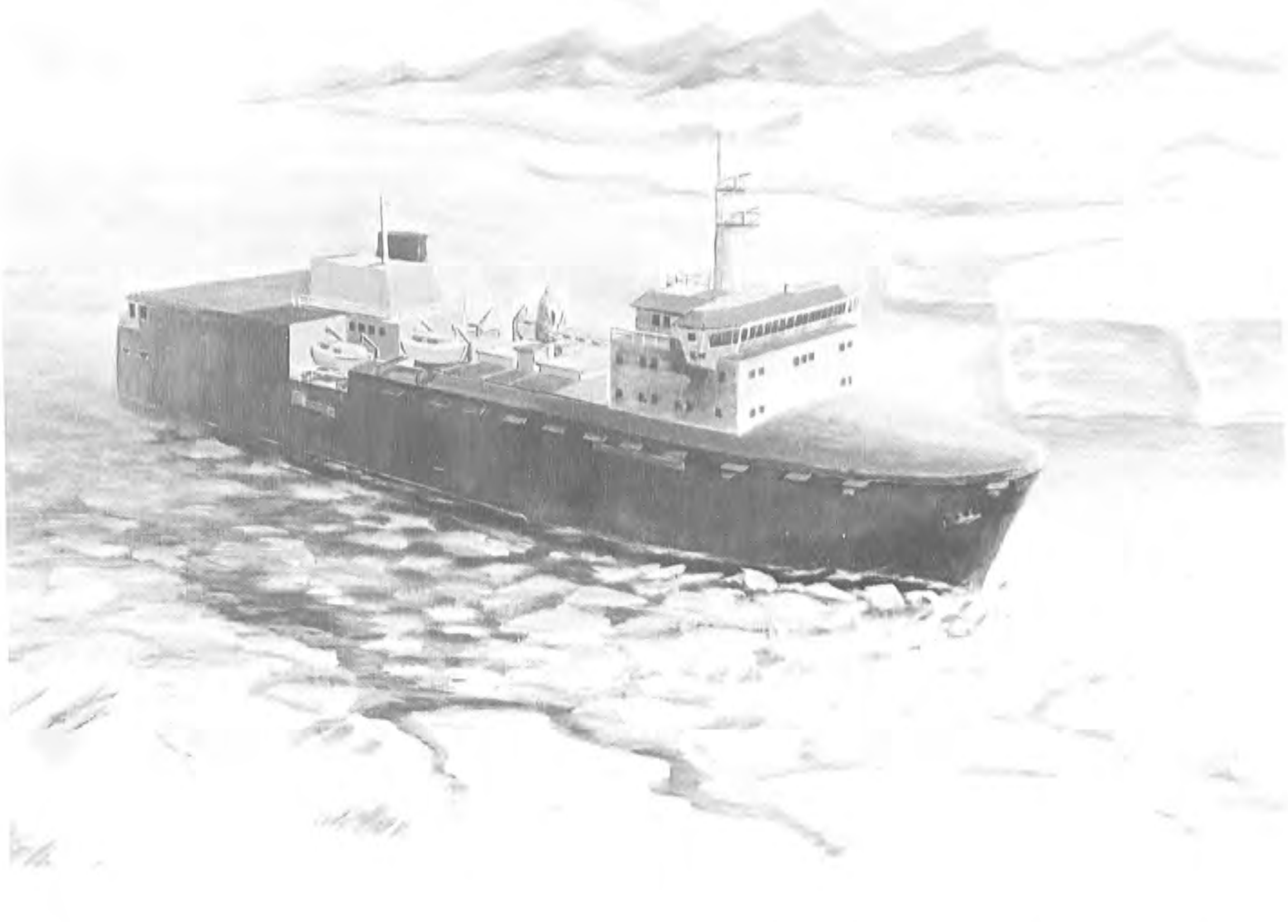


Figure 4. The artist's impression of Wärtsilä's design operating in the Antarctic waters. These vessels should harvest krill also in winter times.

These features are standard solutions for an icegoing fishing vessel, but this one has also several other features which put her in class of her own when considering operational characteristics in the Antarctic. With her engine power she is capable to go through an field of two feet thick ice maintaining a trawling speed.

BRINGING THE HUGE KRILL CATCHES TO THE MARKET

The most attractive aspects in catching of the krill are the huge potentials of krill and the relative easiness of catching. From the large krill swarms, a daily catch of several hundred tons can be retrieved. The processing capacity of the Wärtsilä's design is up to 200 tons krill per day. The processing of krill is concentrated into three major products: peeled krill, krill meal and krill oil. The processing of all these products has developed rapidly within the last year, and the process are available for usage. Because the products compatible with products of to-days market of small shrimps, fish meal and fish oil, there should be no major problems in introducing them to the market.

The main purpose of the vessel is to catch and process krill, so the cargo space is not designed to carry all the products of one trip onborad. The ship is capable for independent operation up to three months, after which a transport vessel supply the factory, take the products and bring the replacement crew.

Krill flowing through a peeler. The peeling tests have given promising results in last years.

Peeled krill is small of size but can be used as cocktail shrimps or raw material for "krill pins" etc.

Members of Wärtsilä Shipyards at ice-going trials of the icebreaker "Almirante Irizar" on the Antarctic waters in October 1979.

Icebreaker "Almirante Irizar" built by Wärtsilä Helsinki Shipyard having the high Finnish ice-going know-how to ensure the operating in the Antarctic water both in summer and winter times.

Latest development on gear instrumentation

by Peter Stewart

Dr. Peter Stewart informed the meeting on the latest developments in gear instrumentation for trawl engineering studies at the Marine Laboratory (Aberdeen).
At the moment a new type of underwater loadcell and a net speed log with a 12 hour recording capacity are under development.
The development of a spreadmeter and otterboard instruments measuring the angles of heel, tilt and attack is completed.
Deck loadcells and headline height meters are commercial available.
Dr. Stewart called attention to a new shackle-type of loadcell.
In the discussion several applications of doppler-log and wireless netsounder were mentioned.

MODEL EXPERIMENTS ON ROPE TRAWLS, SCALE 1 : 4

by: B. van Marlen

1. Introduction

In September 1978 and July 1979 trials were done on 1/4th scale models in the vicinity of Sardinia.
This research was a co-operative programme of the Institut für Fangtechnik in Hamburg, W. Germany and the Netherlands Institute for Fishery Investigations in IJmuiden, Holland.
The main objective was to make pictures and films of several rope trawl models and to do measurements in order to compare these with the full scale trials done aboard the FRV "Tridens" on similar nets in November 1977 and 1978.
Several construction problems were dealt with, like the cutting of the "shark teeth" at the junction of the ropes to the adjacent netting panels and the design of the shape of the framelines and the lengths of the ropes.
Direct observation is the only way to find out the extent of distortion in parts of the net. The area chosen was very suitable for this purpose. A very nice sea temperature combined with a good visibility made the working conditions easy for the divers. Other requirements were a calm sea state and a sandy bottom for bottom trawl experiments not mentioned here. The depth of the sea bed should not be much over 15 meters.

2. Gears tested

The models, scale 1:4, were derived from a 1736 meshes pelagic rope trawl (see figures 1 and 2) on which extended tests have been done in the years 1977 and 1978 (see reference).
The shape of the framelines is based on the catenary curve leading to the rope lengths given in the drawing.
In addition to this gear a similar net with a meshed upper square has been studied.

The second model was identical but for the front part, the design of which has been done with a computer programme especially written for this purpose. This routine calculates the length of the ropes and the frame-line sections using the assumption that the ropes are equally loaded and the elongation could be neglected (a correction of elongation due to a nominal load has been taken into account when constructing the net).
The dimensions of these rope panels are given in figures 5 and 6.

The mesh/twine-size scale factor has not been kept constant over the full length of the nets, because some small-mesh net material was not available at the time. For panels IV to VII this scale factor was chosen at 1/2 instead of 1/4, leading to a reduction factor for the number of meshes in normal and twine directions of 1/2, in order to scale the twine area proportionally with the factor $(1/4)^2 = 1/16$.

$$N_m = \left\{ \frac{\alpha L}{\alpha_a = \alpha_d} \right\} * N_{fs}$$

with: N_m = number of meshes of model across and in depth, <u>not in an area.</u>

N_{fs} = same for full scale net

αL = length scale factor => (1/4) for this case

α_a = mesh size scale factor
α_d = twine diameter scale factor in this case 1/2
} => mostly: $\boxed{\alpha_a = \alpha_d}$

Hence: $N_m = \frac{1/4}{1/2} * N_{fs}$ => $\boxed{\frac{1}{2} * N_{fs} = N_m}$

The position of floats on the headline of the models is given in figure 8. The magnitude of floatation has been scaled down according to the scale factor of forces, weights, volumes, etc ($=(1/4)^3$), leading to a certain amount of floats of a given diameter and buoyancy.

The Süberkrüb doors of 4.7 m^2 were scaled down to the size (1/4th scale) and the weight. Even the centre of gravity of both doors was kept in accordance with the full size ones. Other parts of the rigging were scaled down to the size rather than the weight, except for the bridle weights.

Several ways of cutting the "shark teeth" have been tried. The best results were found with cutting C (figure 7), based on the method of cutting used at the V.E.B. Fischkombinat at Rostock (see Chapter 6).

3. Trials technique

The experiments on the scale models were done on small fishing boats around Sardinia, an area perfectly suitable for underwater filming.
The following parameters were measured during the trials:
- towing speed
- port and starboard warp load
- headline height
- depth of the headline
- door spread
- wing-end spread
- wing-end height
- section height (at junction of ropes to netting)
- the depth of the seabed

200 Kc transducers were placed on the headline centre, the starboard wing-end, at the junction of ropes to netting and on top of the starboard door. The warp loads were measured with 500 kg load cells attached to the warps and the ship. The speed was measured with Ott-log, mounted on a special strut to keep it well away from the ship's hull. Direct observations were done by a team of divers from the German Navy, in collaboration with the Institut für Fangtechnik in Hamburg, under the guidance of ing. W. Horn, who took most pictures and films. Changes to the gear could easily be made by the divers without the necessity to heave up. The effect of tide and currents was judged to be neglectable, no reciprocal courses were sailed. The technique used for full scale measurement has been described in reference (2) and (3) to a great detail and will not be mentioned here.

4. Comparison of model experiments with full scale results

4.1. Rope trawl with meshed upper square

The full scale values are higher over the range of speeds used, irrespective of the bridle weight, although with 750 kgf weight the difference decreases with speed. Both the wing-end spread as the headline height are bigger in full scale, the difference being largest with 750 kgf bridle weight.

The door spread did not match the full scale value, indicating the model doors being hydrodynamically less efficient.
These results agree with the drag of the model being considerably bigger than the comparative full scale value. The more drag a gear has the less it opens. In figure 12 the drags of two models are plotted against speed together with the full scale values of the rope trawl with the meshed upper square. At 4.0 knots the model with the meshed upper square has 70% more drag, at 5.0 knots the difference turned out to be 60%.

4.2. Rope trawl with floatation, catenary shaped headline

The wing-end area is plotted against speed in figure 13 for the 600 kgf weight case and in figure 14 for the 750 kgf case.
Both show the same tendency, the wing-end area of the full scale trawls is considerably larger (some 40% at 4.5 knots).
The addition of 150 kg bridle weight on each side had a similar effect on both model and full scale trawls. The wing-end areas are increased by some 5%.
With 600 kg the headline height diminished at the same rate for model and prototype, but with 750 kg the full scale gear seemed to have a headline height, that reduces faster when increasing speed. The differences in wing-end area decrease slightly with rising speed, but the rate of change is not very much dependent on the magnitude of the weights on the lower wing-ends (figure 15 and 16).
The discrepancies in drag are not as large as with the trawl with meshed upper square. The model results seem to be rather sensitive to the length of warps paid out, in contrast with the full scale values, where this dependancy is not so distinct. At 4.0 knots the model has 15% more drag and with 5 knots the difference rises to 38% (figure 17).

5. The effect of floatation on the computer designed rope trawl

In figure 18 the wing-end area of the computer designed rope trawl is plotted against speed, for two different values of the bridle weight. The influence of the floats on the headline is hard to distinguish. At low speeds the no-floats condition seems to lead to larger wing-end areas, whereas at 5.5 knots there is no difference at all, irrespective of the bridle weights used.
The model floats were chosen in order to scale the buoyancy in the right order and not the size, and therefore not the drag. This may account for the undistinctive results at high speeds.

6. Results of direct observation

A lot of information can be learned from direct observation of the gears, either by taking pictures or films.
The rope trawl with meshed upper square did not show any significant distortion, apart from the pieces of netting used to connect the top panel to the sides. It can be clearly seen from figures 19a-g, that this netting is much too slack. The overall shape of the net looks quite well. The netsonde cable and the wing-end transducers can be distinguished on figure 19g.
Figures 20a-j show details of the computer designed rope trawl without floatation. The shape of the trawl is very well indeed, with the attachment point of ropes to netting almost in one perpendicular plane. The "sharkteeth" cutting of the toppanel (see figure 8 and 20h,i,j) gives the least distortion, that of side and lower panel considerably more.

A similar design of the toppanel cutting is therefore favourable from a net shape point of view. It is based on having a narrow band of smaller meshes, at the junction of ropes to netting.
From figure 20d it can clearly be seen, that the assumption of straight line sections along the framelines is a valid one.
There seem to be no significant differences in net shape between the computer aided design and the design based on the catenary shape.
Finally a scale model of the Süberkrüb doors (4.7 m^2 full scale) is shown in figure 21, with a transducer on top (200 KC) looking across to the other door. In most cases the doors were heeling inward and were tilted backwards.

References

(1) Modelonderzoek aan gesleepte vistuigen
RIVO, TO 77-08, August 1977, Bob van Marlen

(2) Rope trawl development
RIVO, TO 78-02, May 1978, Bob van Marlen

(3) Rope trawl development - further experiments
RIVO, TO 79-03, May 1979, Bob van Marlen and David N. MacLennan

TABLE OF EXPERIMENTS

1. Rope trawl with meshed upper square, catenary headline, no floats

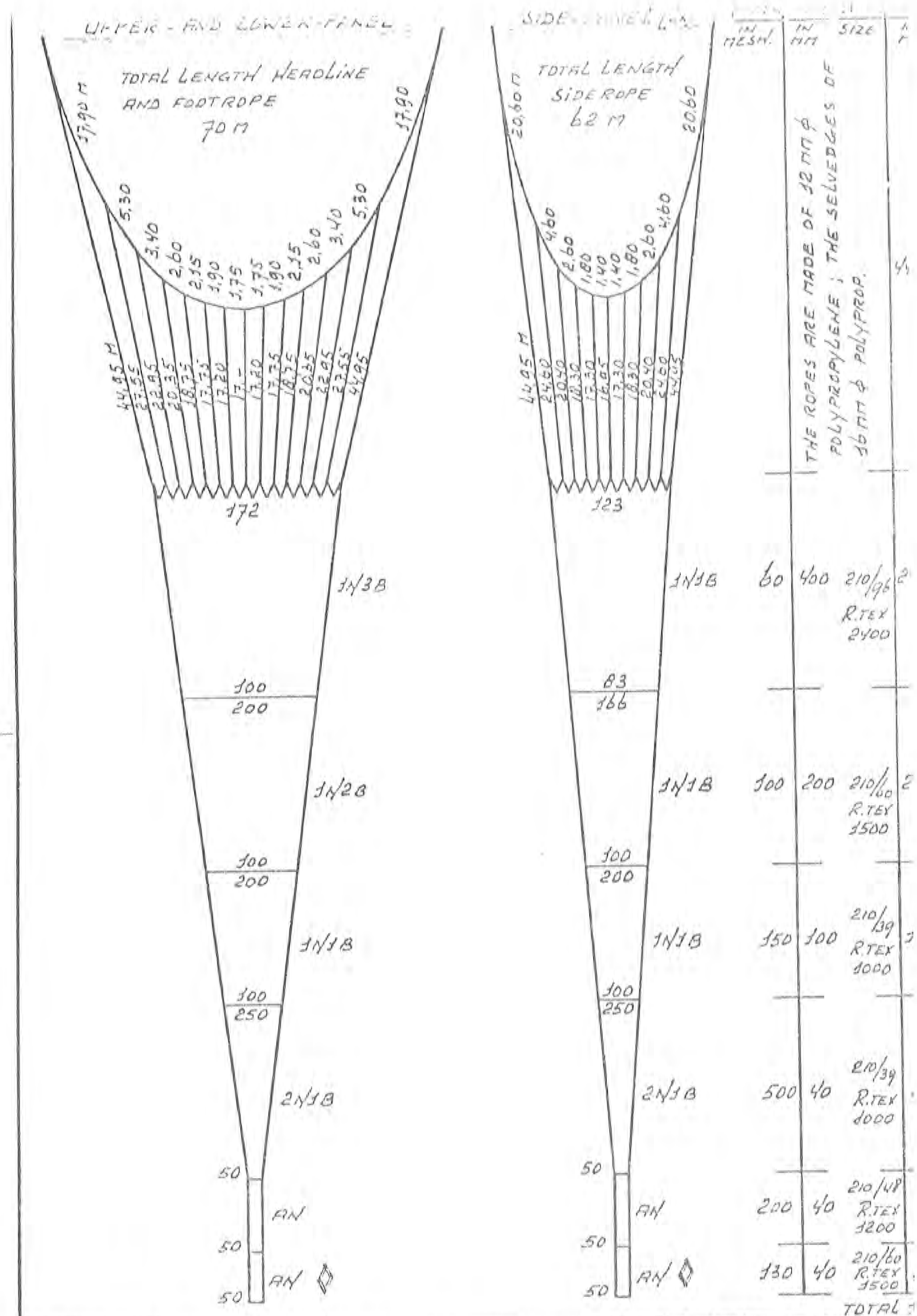
Haul no.	Scale	Bridle extension (m)	warp-length (m)	bridle weights (kgf)
T78/2,3	1:1	4.4	450-650	600
VF79/1	1:4	4.4	300	600
VF79/2	1:4	2.4	400	600
T77/2,3	1:1	4.4	450-650	750
T78/5,6	1:1	4.4	550	750
VF79/3	1:4	2.4	400	750

2. Rope trawl with floatation, catenary shaped headline

Haul no.	Scale	Bridle extension (m)	Warp-length (m)	Bridle weights (kgf)
T77/15	1:1	4.4	450-650	600
T78/9	1:1	4.4	550	600
T78/10	1:1	4.4	550-850	600
VF78/6	1:4	4.4	400	600
VF78/7	1:4	2.4	400	600
T77/12,13	1:1	2.4	450-650	750
T78/7,8	1:1	4.4	550	750
T77/14	1:1	4.4	450-650	750
VF78/8	1:4	2.4	400	750
VF78/9	1:4	2.4	600	750

3. Computer designed rope trawl

Haul no.	Scale	Bridle extension (m)	Warp-length (m)	Bridle weights (kgf)	float
VF78/2	1:4	4.4	400	600	yes
VF78/3	1:4	2.4	400	600	yes
VF79/6	1:4	2.4	400	600	no
VF79/8	1:4	4.4	400	600	no
VF78/4	1:4	2.4	400	750	yes
VF78/5	1:4	2.4	600	750	yes
VF79/7	1:4	2.4	400	750	no



Benaming FIG.: 1 ROPE - TRAWL FULL - SCALE 1000 -1200 HP.			DERIVED FROM A4
			Formaat A4 734 d
RIVO TECHN. RES. DEP.	Schaal 1:500	Gecontroleerd	
Auteursrecht voorbehouden volgens de wet	Getekend D. Verbaan	Gezien 24-10-'78	Rangschikmerk

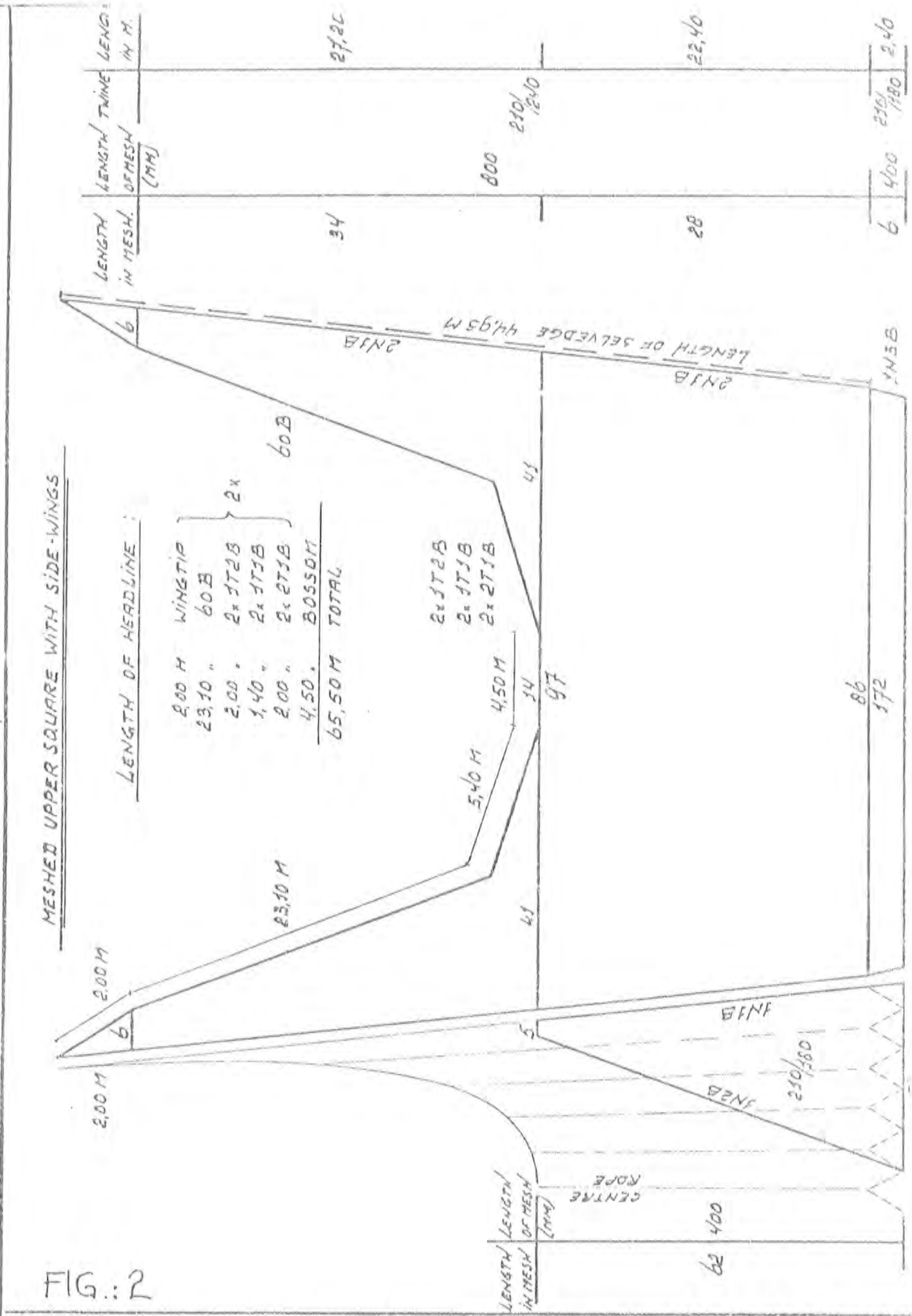
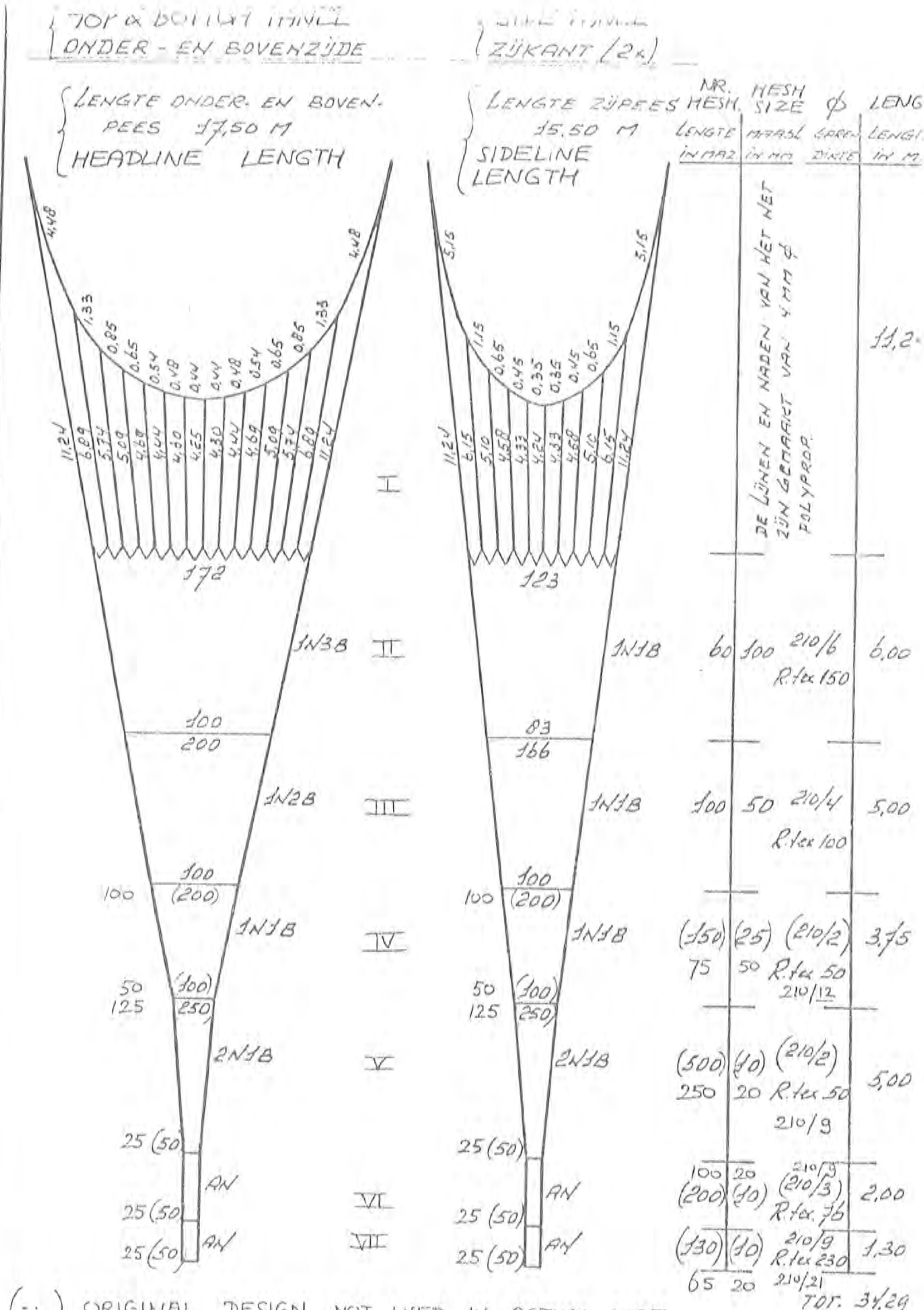


FIG.: 2

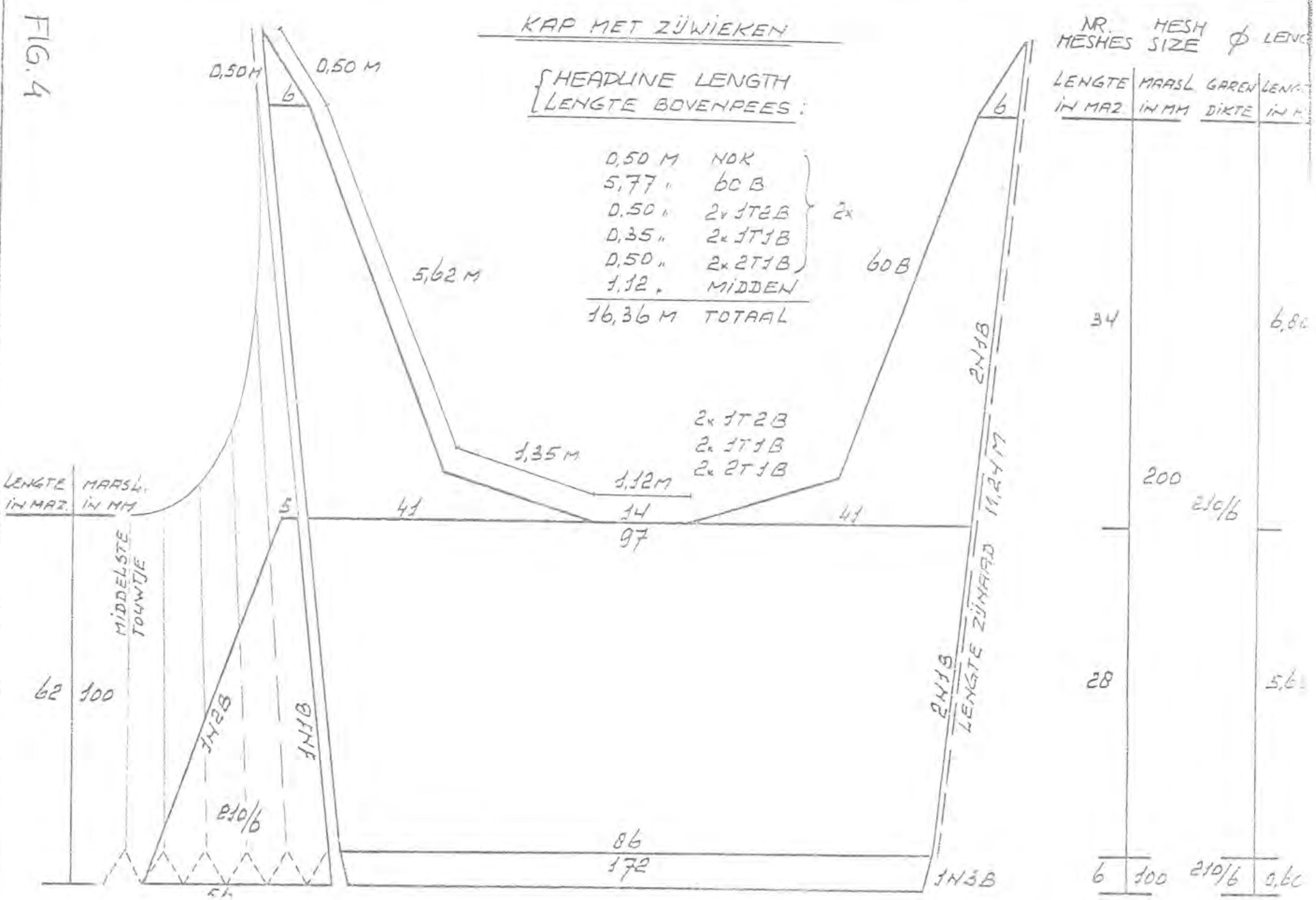
Benaming MESHED UPPER SQUARE WITH SIDE-WINGS FULL SCALE FOR ROPE-TRAWL		BELONGS TO A4/734
		Formaat A4 — 754 C
TECHNICAL RESEARCH DEPARTM.	Schaal 1:300 — Gecontroleerd	
Auteursrecht voorbehouden volgens de wet	Getekend — Gezien 13-10-78	Rangschikmerk



(..) ORIGINAL DESIGN, NOT USED IN ACTUAL MODEL

Benaming FIG. 3 MODEL VAN LIJNENNET MODELTRAWL 1/4 VAN WARE GROOTTE (SCALE 1/4)		AFGELEID VAN 734 C	
		Formaat A4	736 C
RIVO AFD. TECHN. ONDERZ.	Schaal 1:150	Gecontroleerd	
Auteursrecht voorbehouden volgens de wet	Getekend [signature]	Gezien 30-5-'79	Rangschikmerk

FIG. 4



Benaming MESHED UPPER SQUARE FOR ROPE TRAWL
KAP MET ZIJWIEKEN VOOR MODELLIJNENTRAWL
1/4 VAN WARE GROOTTE

RIVO AFD. TECHN. ONDERZ.

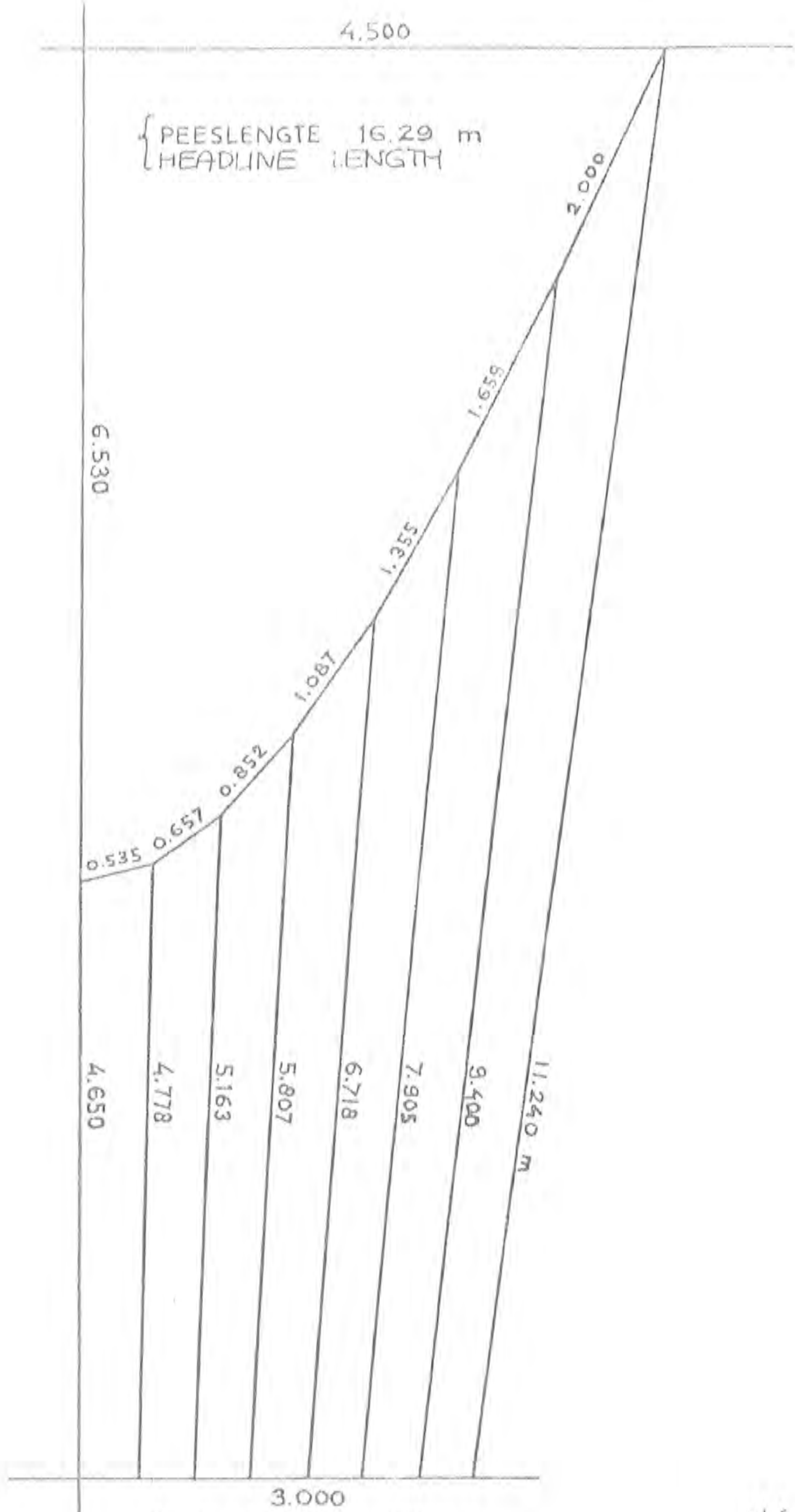
Schaal 1:75 | Getekend | Gecontroleerd | Gezien 6-6-79

BEHOORT BIJ A4/7.76

Formaat A4

754 d

Rangschikmerk

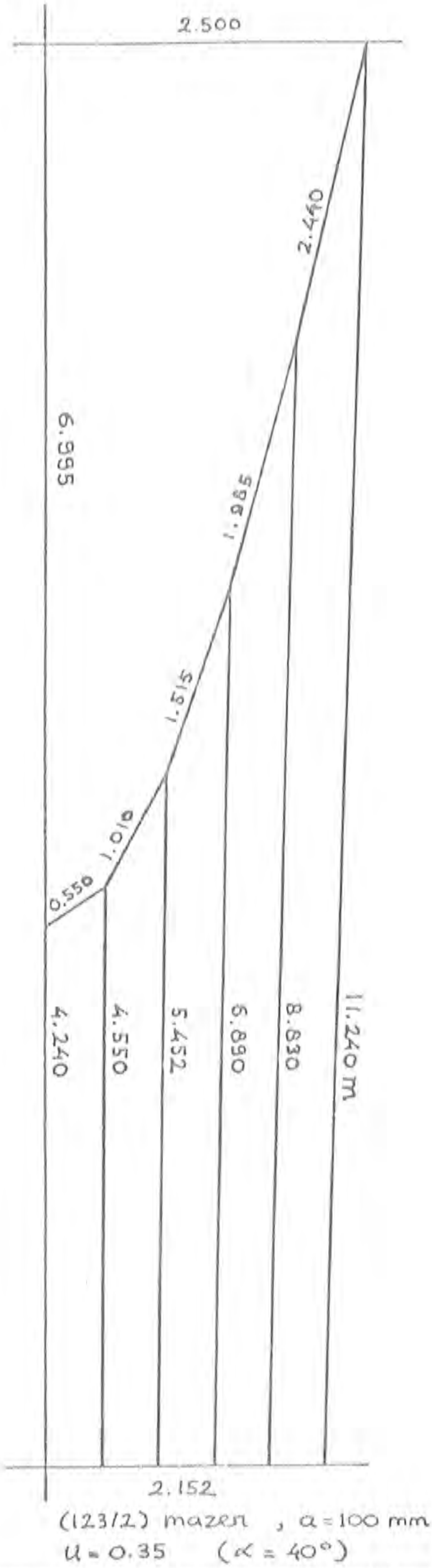


86 mazen , a = 100 mm

u = x/a = 0.35 (α = 40°)

FIG. 5

Benaming VERDELING ONDER- EN BOVENPEES LIJNENNET SCHAAL 1:4 TOPPANEL COMPUTER DESIGNED ROPE TRAWL			GELIJKE VERLENGING
DATUM 26 JUNI 1978	Schaal 1 : 50	Gecontroleerd	Formaat A4 — NR. 736 a
Auteursrecht voorbehouden volgens de wet	Getekend BvH	Gezien	Rangschikmerk



{PEESLENGTE : 15.00 m
LENGTH OF SIDELINE

FIG. 6
SIDE PANEL ROPE TRAWL 1/4th SCALE DESIGNED WITH COMPUTER

a = maaswijdte
α = instelhoek
a = MESH SIZE
α = HANGING ANGLE

Benaming VERDELING ZIJPEZEN (VERSMALD) LIJNENNET SCHAAL 1:4			GELIJKE VERLENGING
			Formaat A4 NR.: 736 b
DATUM 26 JUNI 1978	Schaal 1:50	Gecontroleerd	
Auteursrecht voorbehouden volgens de wet	Getekend BvM	Gezien	Rangschikmerk -147-

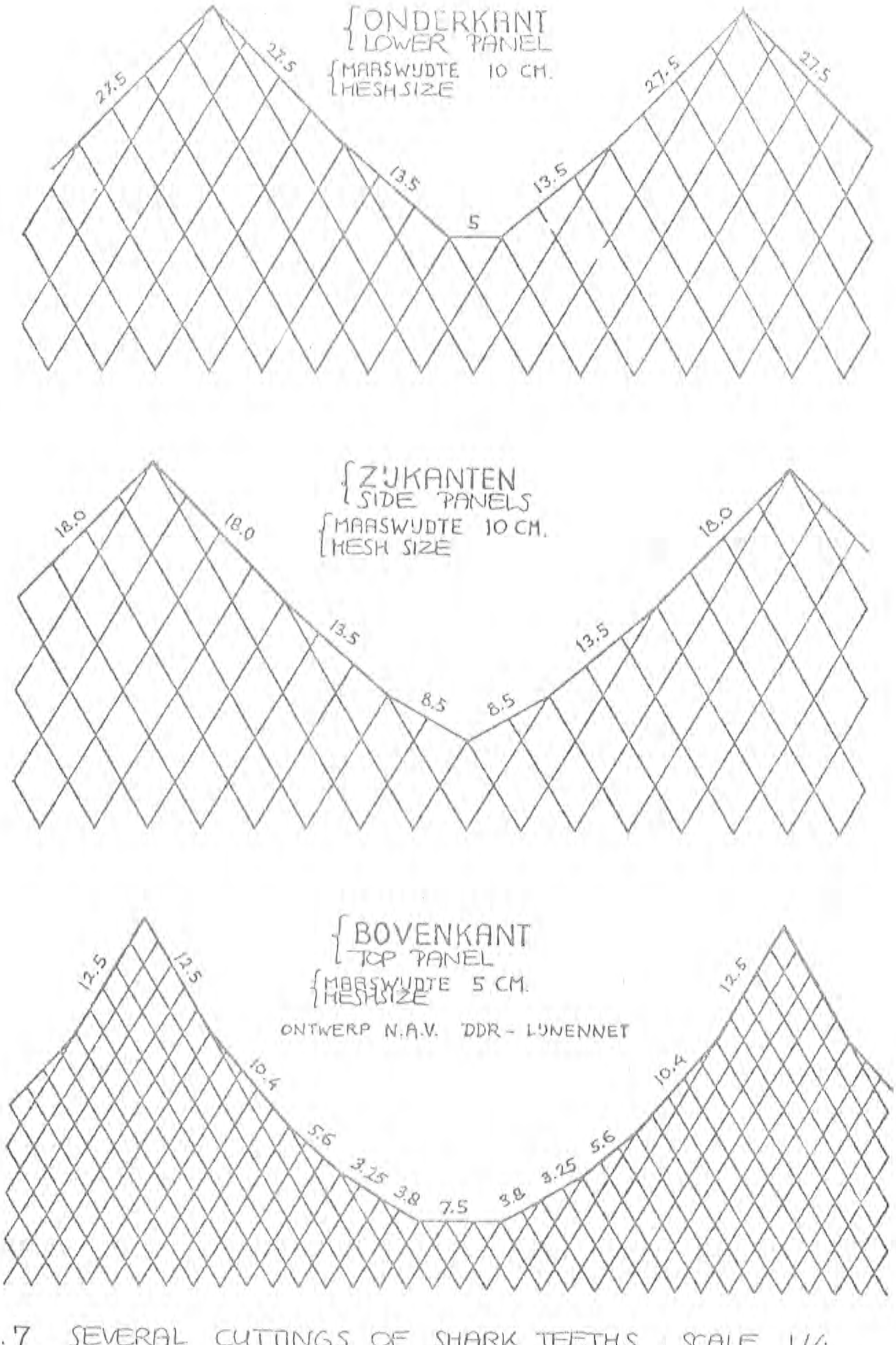
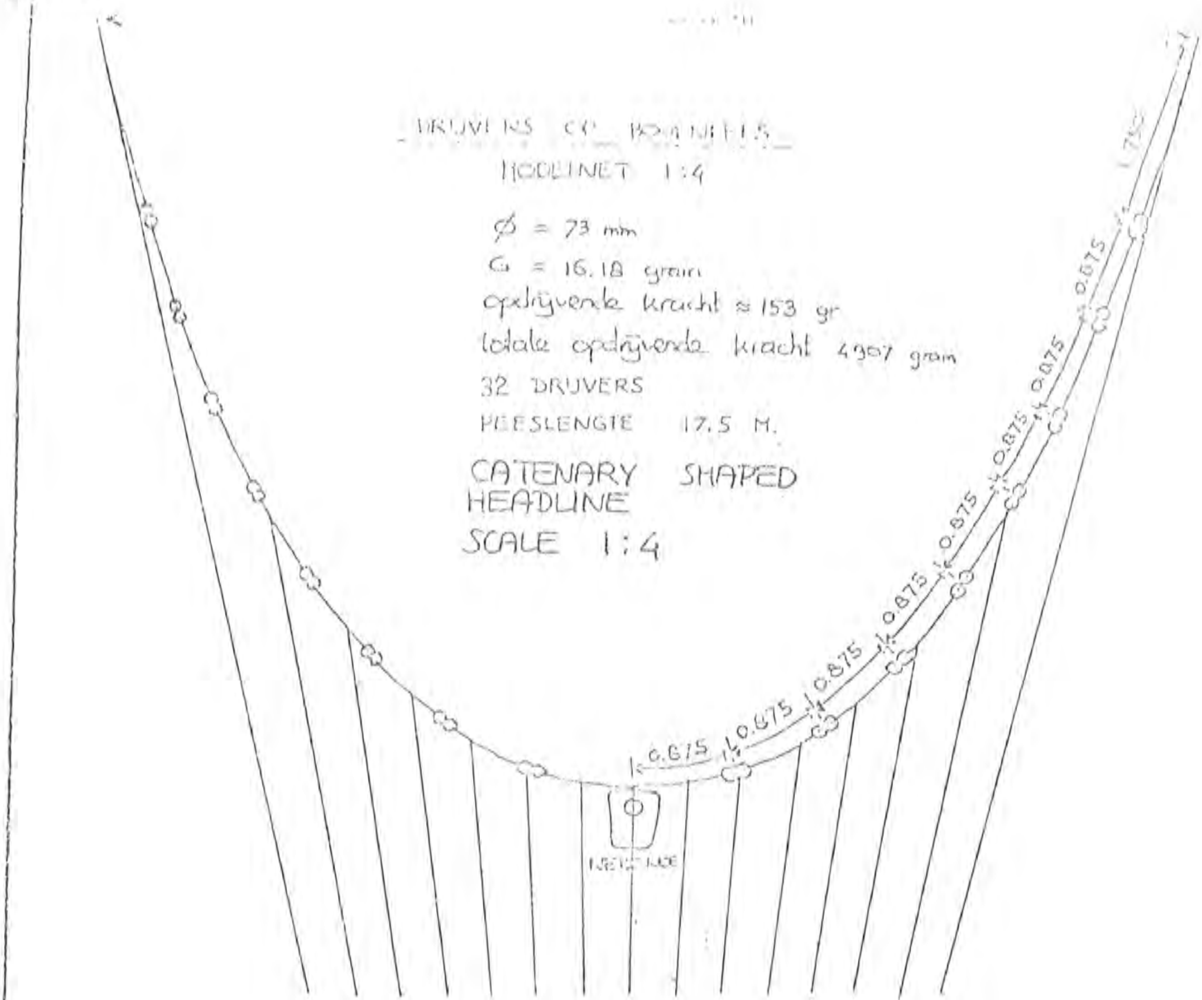


FIG. 7 SEVERAL CUTTINGS OF SHARK TEETHS , SCALE 1/4.

Benaming DIVERSE SNITVORMEN BIJ OVERGANG VAN LIJNEN IN NETWERK VOOR MODELNET 736 (1:4)		Formaat A4	NR. 736 D
COMPUTER DESIGNED ROPE TRAWL.	Schaal	Gecontroleerd	
	Getekend BvM	Gezien 2-10-1973	Rangschikmerk -148-



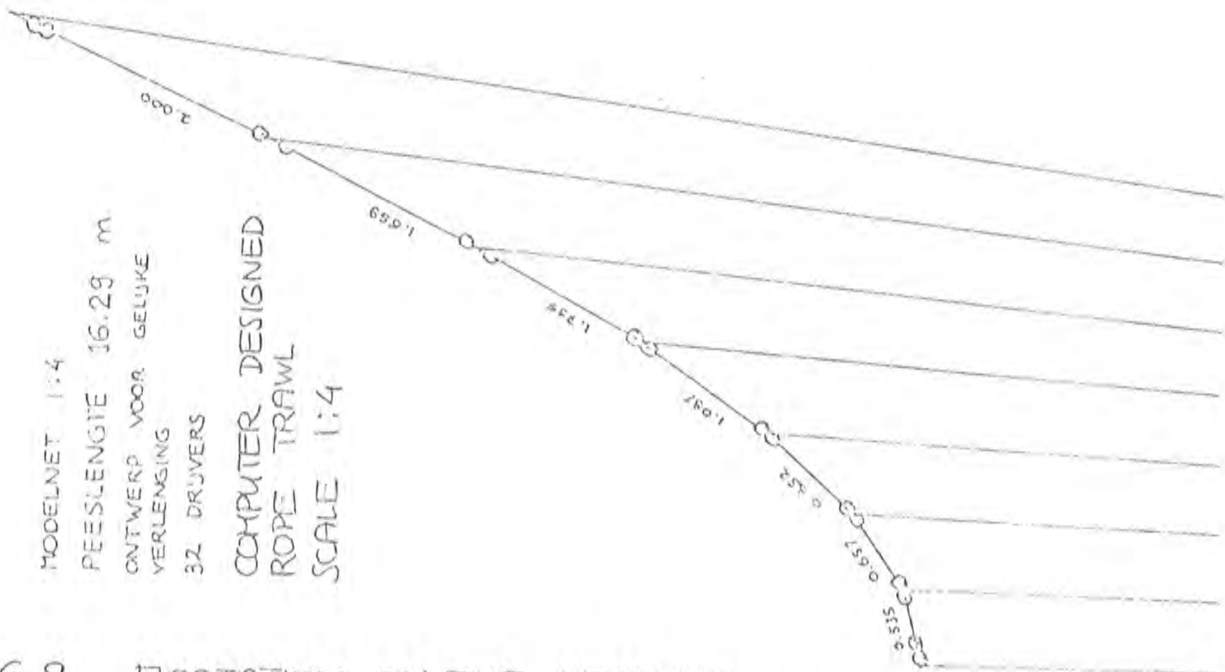
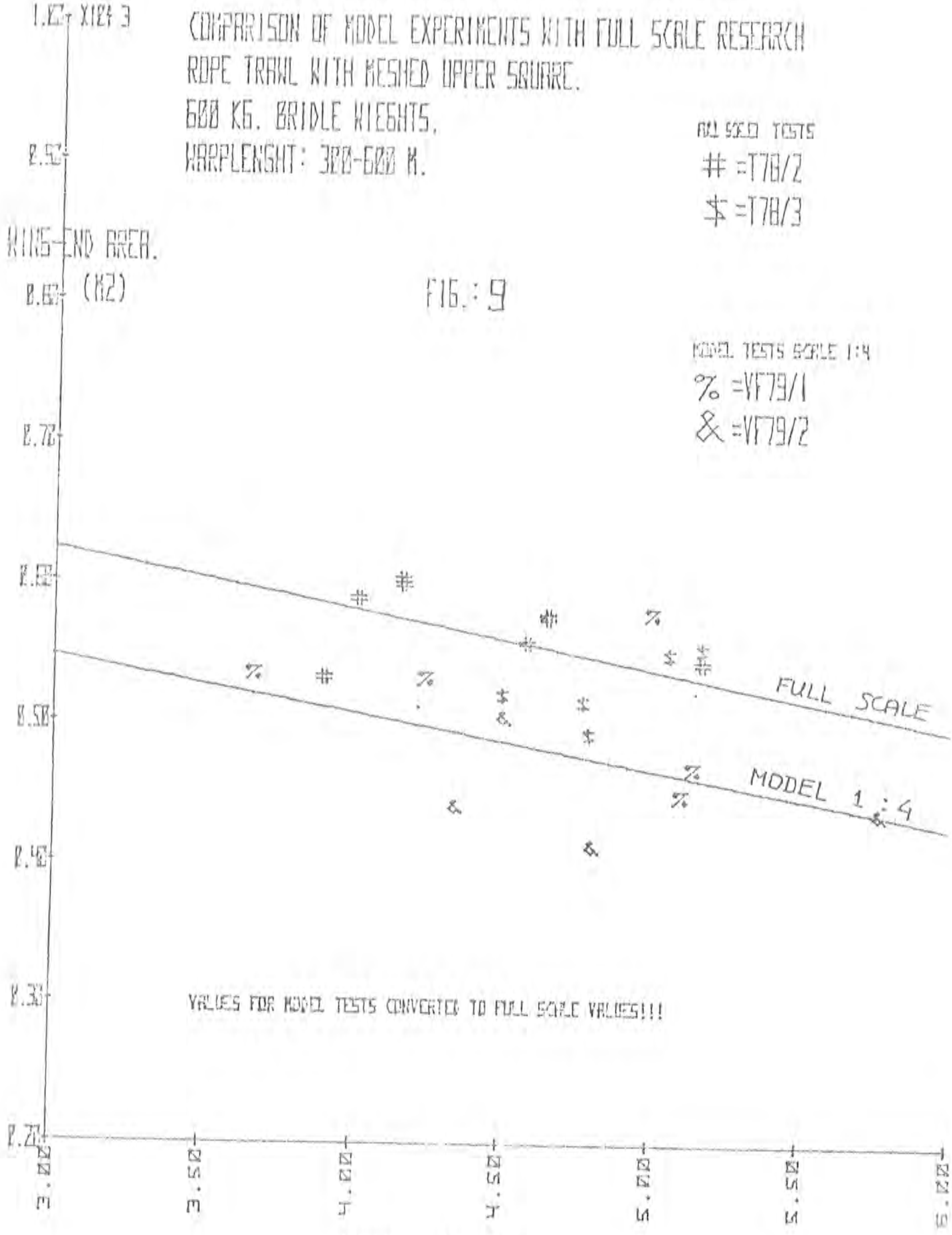


FIG. 8 FLOATATION ON THE HEADLINE

Tekening: VERDELING DRUVERS OP DE BOVENPEES		Formaat: A4
Datum: 3 JULI 1978	Schaal: 1:50	-149-
	Getekend: BvM	



COMPARISON OF MODEL EXPERIMENTS WITH FULL SCALE RESEARCH
ROPE TRAWL WITH MESHED UPPER SQUARE.
600 KG. BRIDLE WIEGHTS.
WARPLENGHT: 300-600 M.
FULL SCALE TESTS
=T78/2
$ =T78/3
WING-END AREA.
(M2)
FIG.: 9
MODEL TESTS SCALE 1:4
% =VF79/1
& =VF79/2
FULL SCALE
MODEL 1 : 4
VALUES FOR MODEL TESTS CONVERTED TO FULL SCALE VALUES!!!
3.00
3.50
4.00
4.50
5.00
5.50
6.00
SPEED (KNOTS)

FIG.: 10

COMPARISON OF MODEL TESTS WITH FULL SCALE RESEARCH.
ROPE TRAWL WITH MESHED UPPER SQUARE (1736 MESHES)
750 KG. BRIDLE WEIGHTS.
WARPLENGTH: 400-550 M.
EXT. 4.4 M. 1:1 ; 2.4 M. 1:4

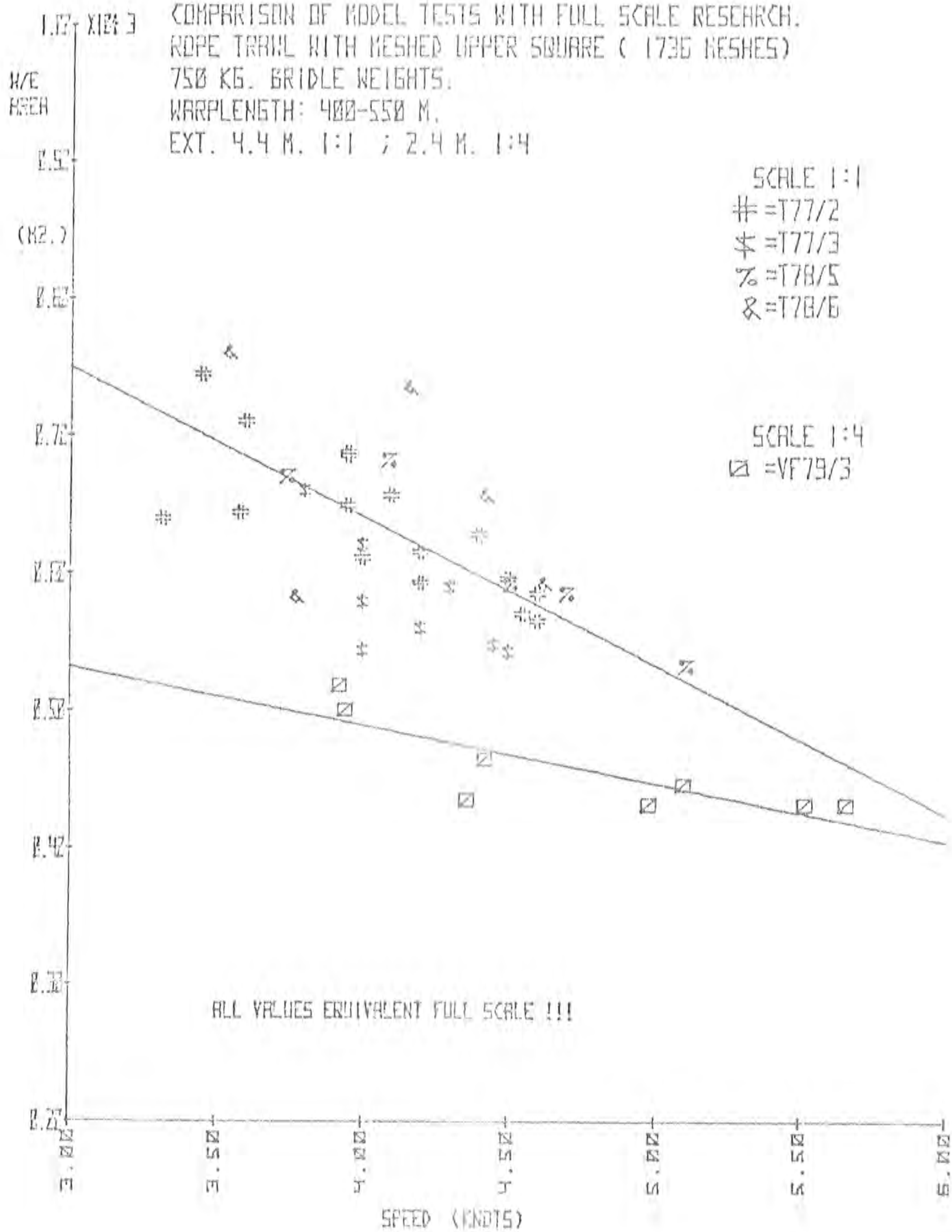
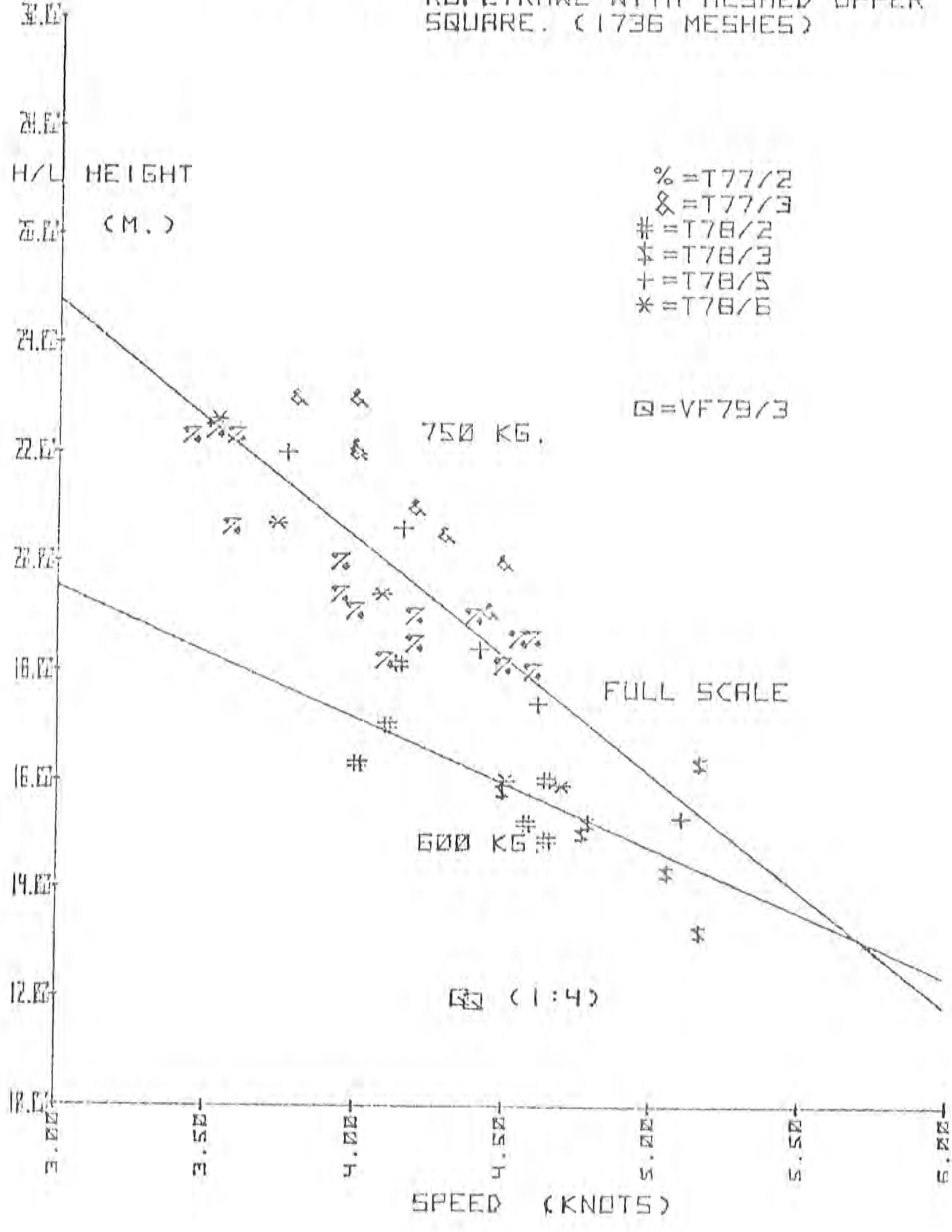


FIG. : 11 MODEL TESTS VS. FULL SCALE ROPETRAWL WITH MESHED UPPER SQUARE. (1736 MESHES)



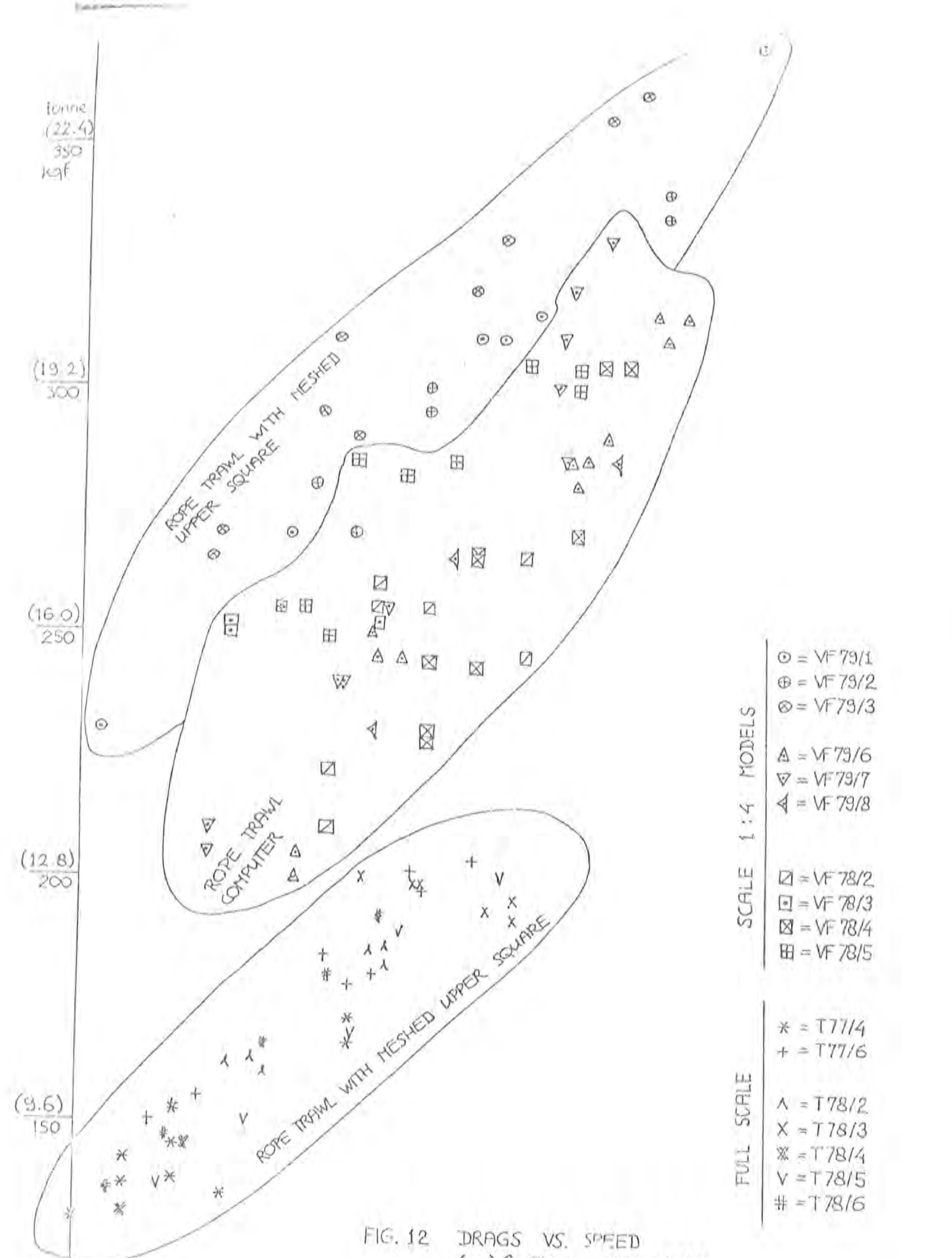


FIG. 12 DRAGS VS. SPEED
(...) ≙ FULL SIZE VALUE

FIG.: 13

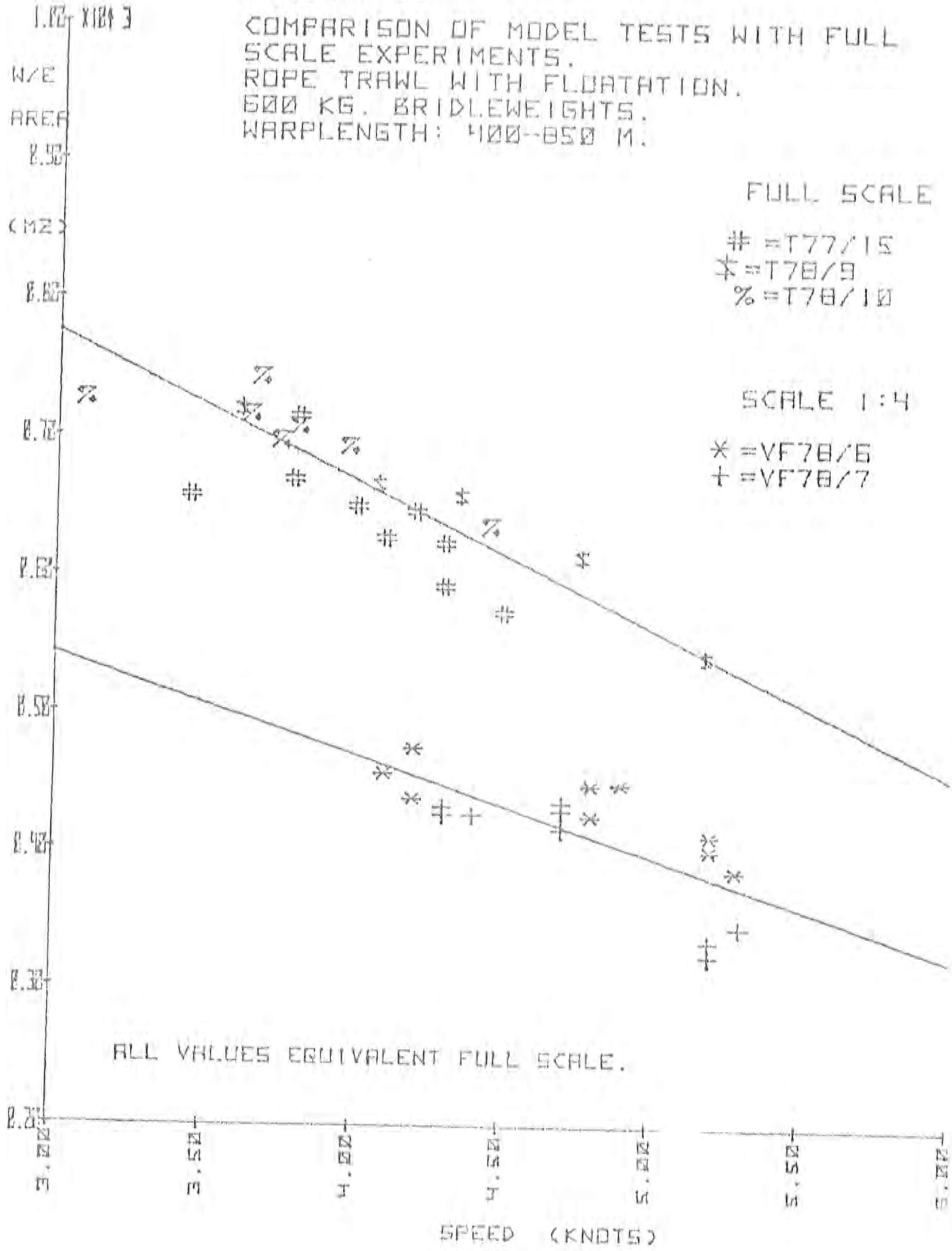

COMPARISON OF MODEL TESTS WITH FULL SCALE EXPERIMENTS.
ROPE TRAWL WITH FLOATATION.
600 KG. BRIDLEWEIGHTS.
WARPLENGTH: 400--850 M.
FULL SCALE
=T77/15
=T78/9
% =T78/10
SCALE 1:4
* =VF78/6
+ =VF78/7
W/E AREA (M2)
ALL VALUES EQUIVALENT FULL SCALE.
SPEED (KNOTS)

FIG. : 14

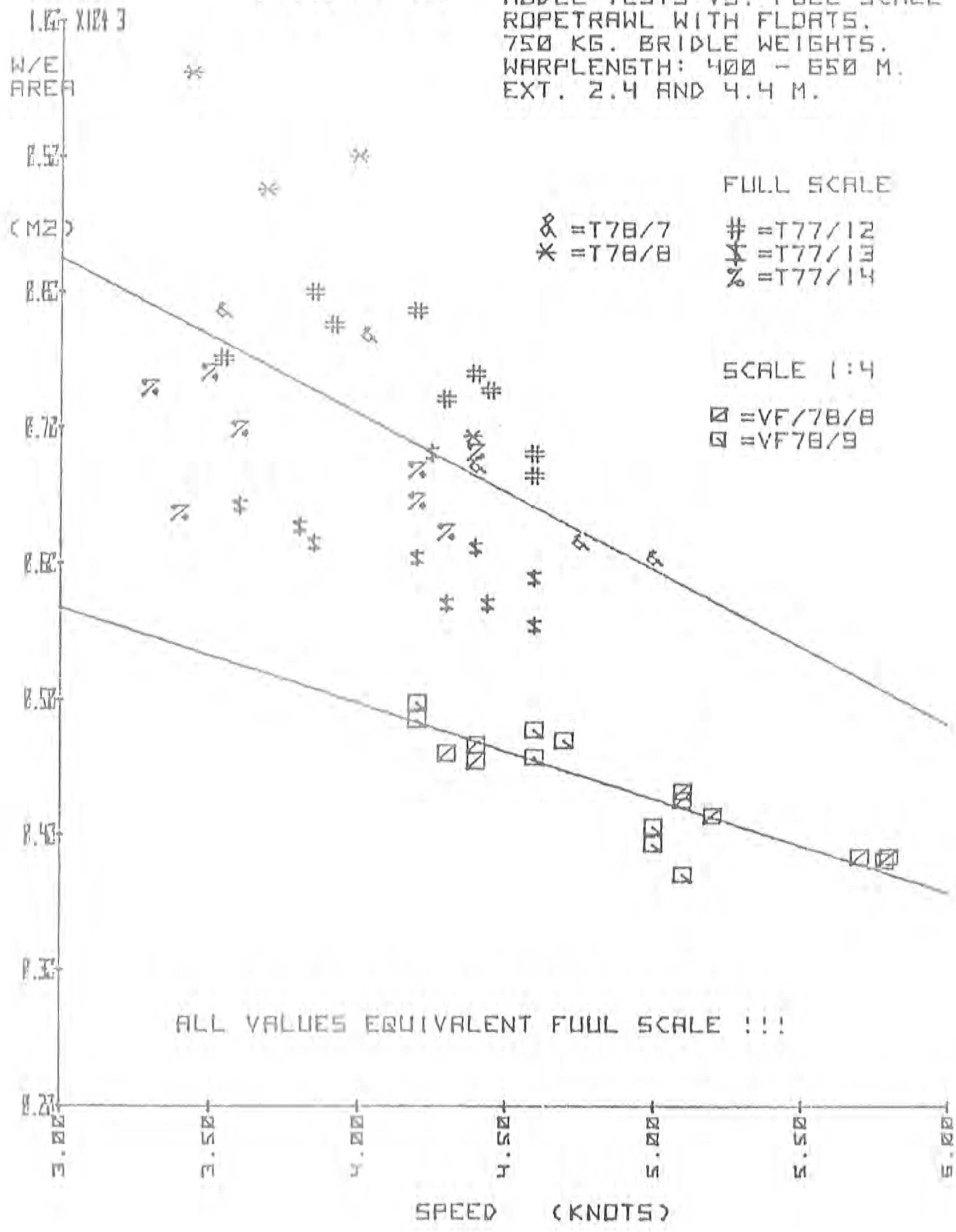
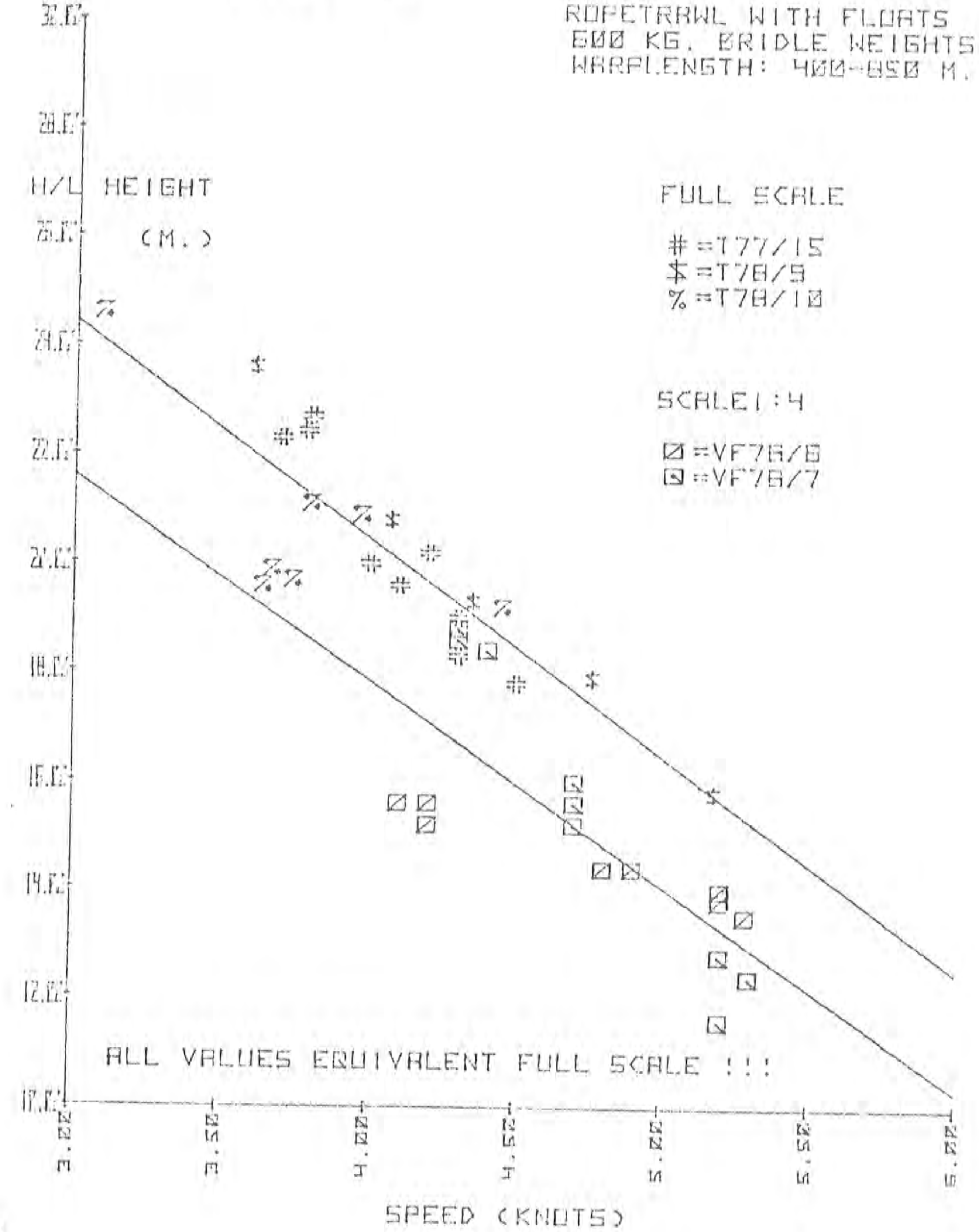
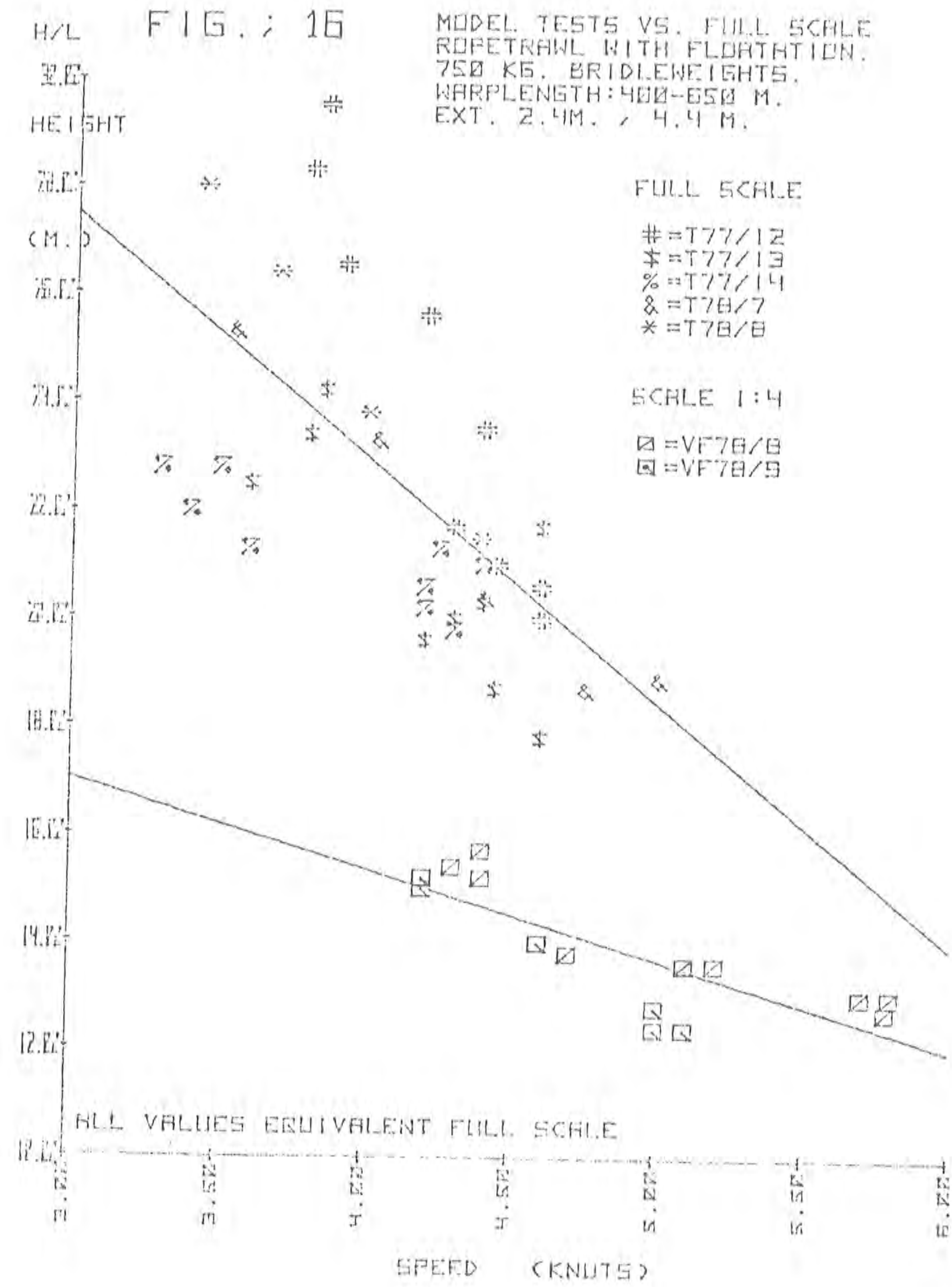

MODEL TESTS VS. FULL SCALE
ROPETRAWL WITH FLOATS.
750 KG. BRIDLE WEIGHTS.
WARPLENGTH: 400 - 650 M.
EXT. 2.4 AND 4.4 M.
W/E AREA (M2)
FULL SCALE
& =T78/7
* =T78/8
# =T77/12
$ =T77/13
% =T77/14
SCALE 1:4
=VF/78/8
=VF78/9
ALL VALUES EQUIVALENT FUUL SCALE !!!
SPEED (KNOTS)

FIG.: 15

MODEL TESTS VS. FULL SCALE
ROPETRAWL WITH FLOATS
600 KG. BRIDLE WEIGHTS
WARPLENGTH: 400-850 M.





H/L
FIG.: 16
MODEL TESTS VS. FULL SCALE
ROPETRAWL WITH FLOATATION.
750 KG. BRIDLEWEIGHTS.
WARPLENGTH:400-650 M.
EXT. 2.4M. / 4.4 M.
HEIGHT
(M.)
FULL SCALE
#=T77/12
$=T77/13
%=T77/14
&=T78/7
*=T78/8
SCALE 1:4
=VF78/8
=VF78/9
ALL VALUES EQUIVALENT FULL SCALE
SPEED (KNOTS)

FIG. 17 DRAGS VS. SPEED
ROPE TRAWL WITH FLOATATION
CATENARY SHAPED HEADLINE

(··) = FULL SCALE VALUE

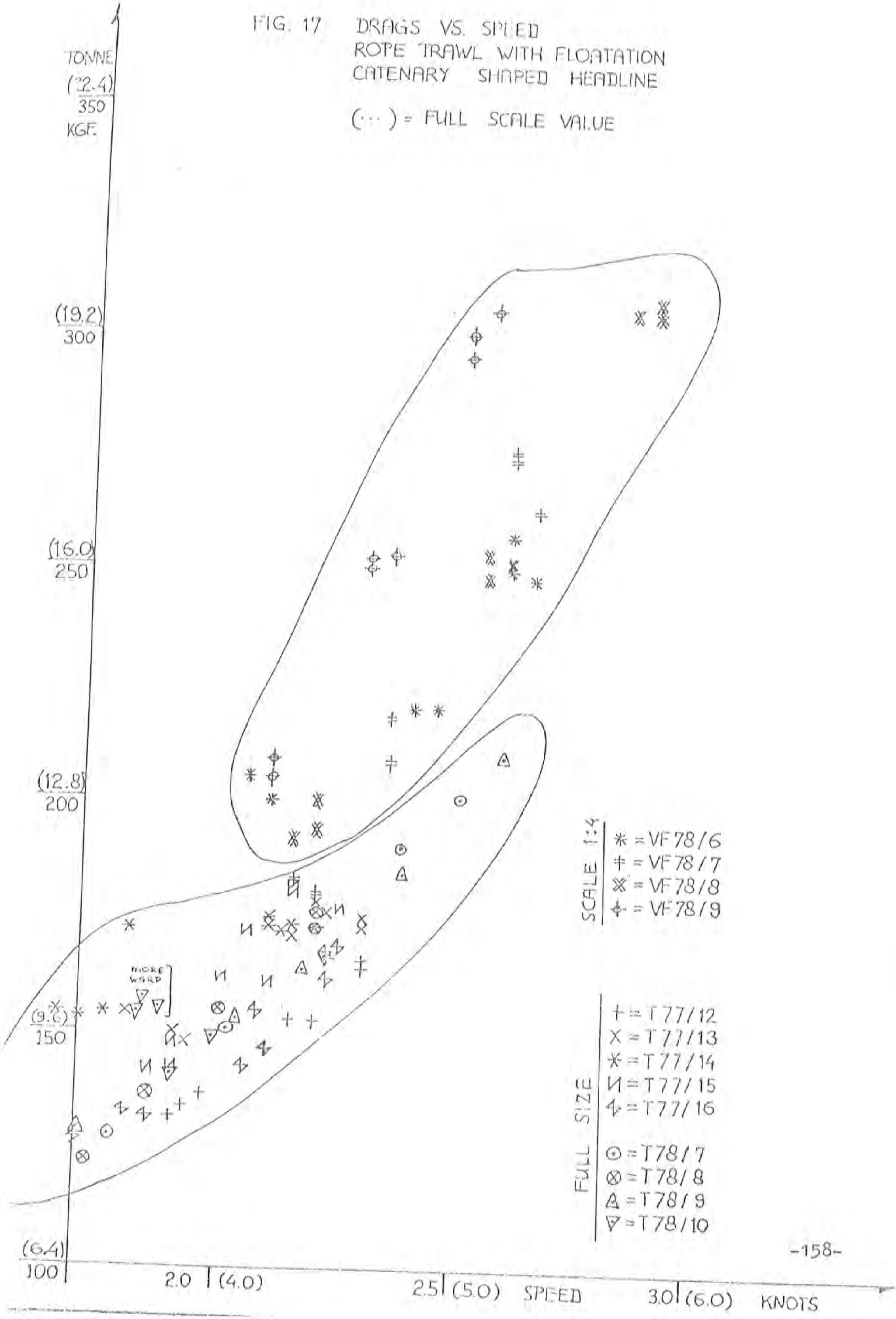


FIG. : 18

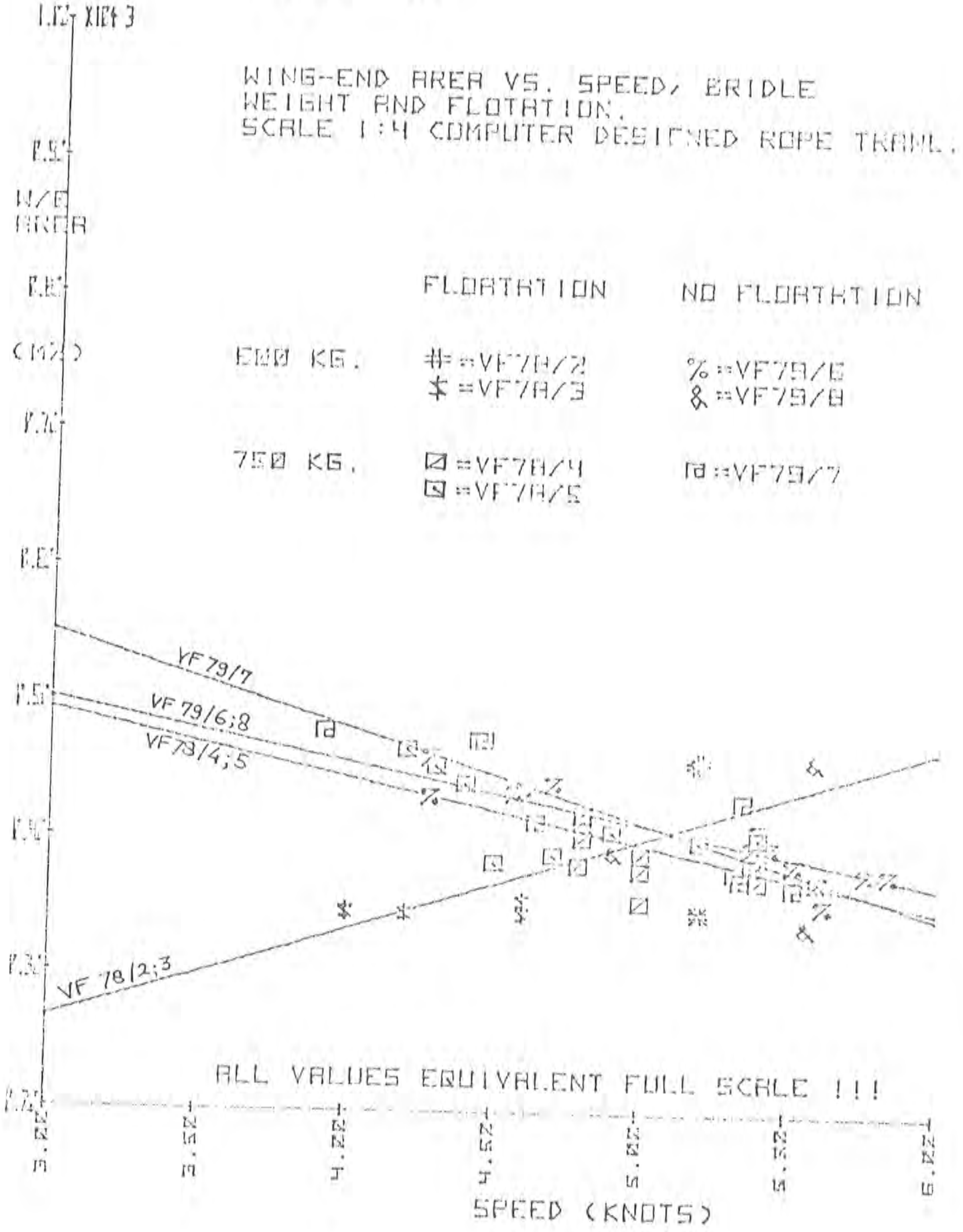

WING-END AREA VS. SPEED, BRIDLE
WEIGHT AND FLOTATION.
SCALE 1:4 COMPUTER DESIGNED ROPE TRAWL.
W/E
AREA
(M2)
FLOATATION
NO FLOATATION
600 KG.
=VF78/2
$ =VF78/3
% =VF79/6
& =VF79/8
750 KG.
=VF78/4
=VF78/5
=VF79/7
VF 79/7
VF 79/6;8
VF 78/4;5
VF 78/2;3
ALL VALUES EQUIVALENT FULL SCALE !!!
SPEED (KNOTS)

FIG. : 19 a
ROPE TRAWL WITH MESHED
UPPER SQUARE , SCALE 1:4

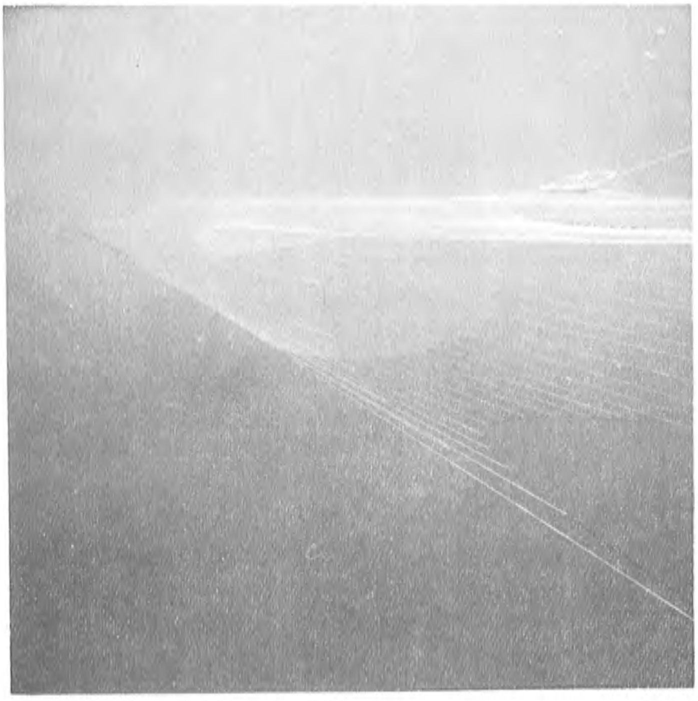


FIG. : 19 b
FRONT VIEUW

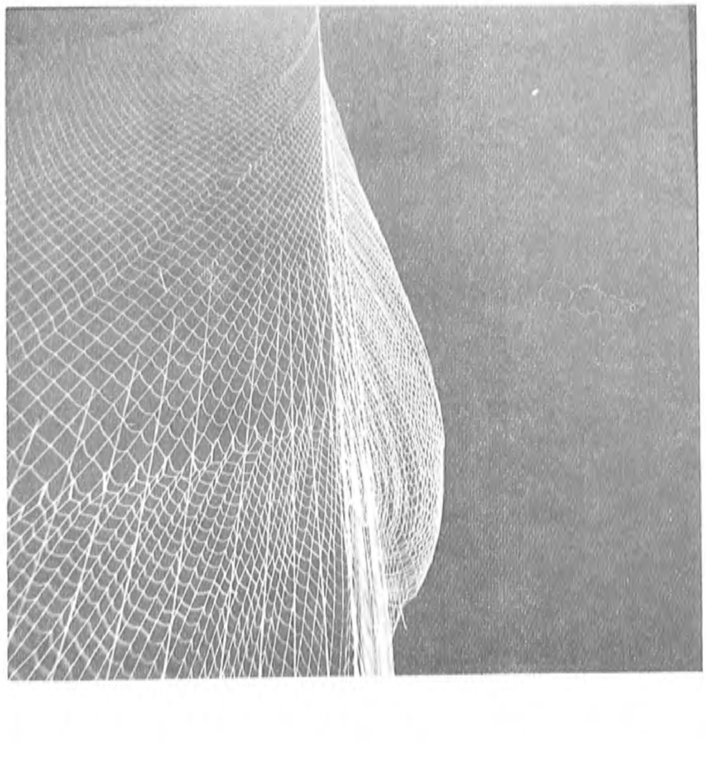


FIG.: 19c
VIEW FROM ABOVE
STARBOARD SIDE

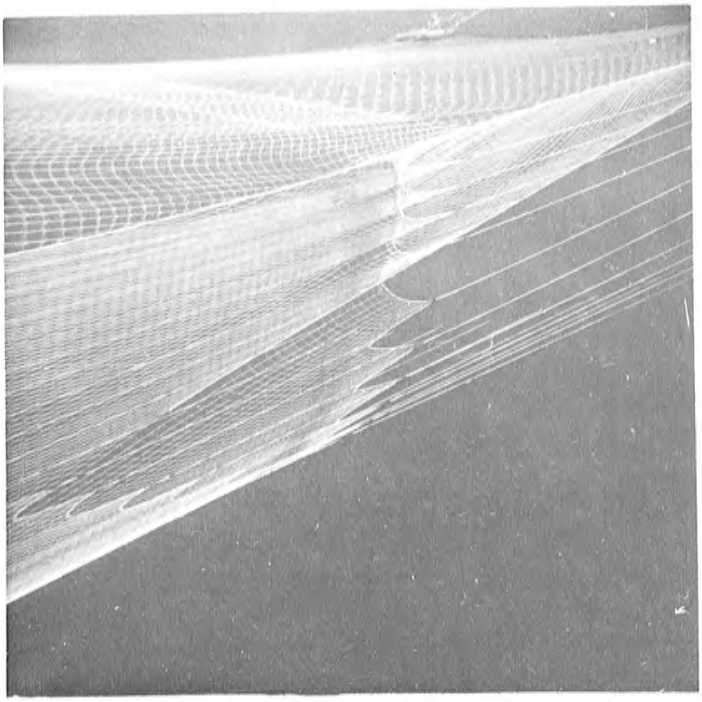


FIG. : 19 d
SIDE VIEUW ROPES TO NETTING

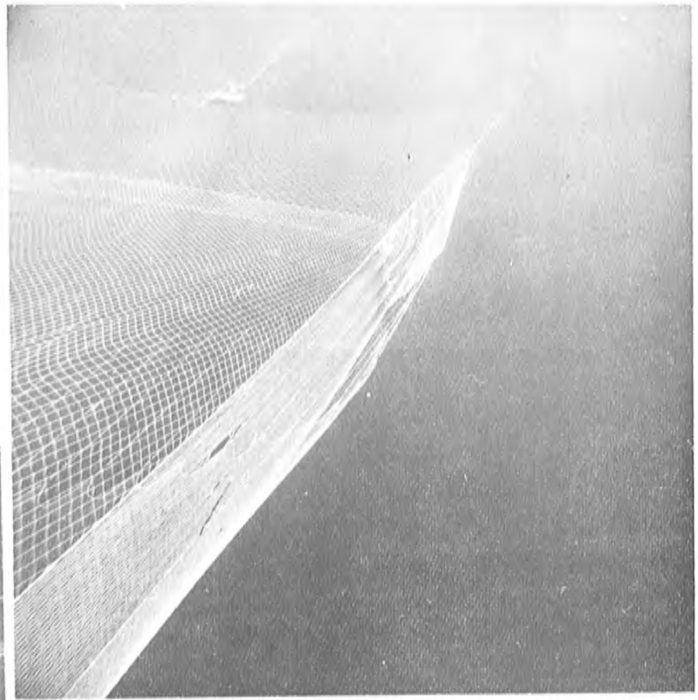
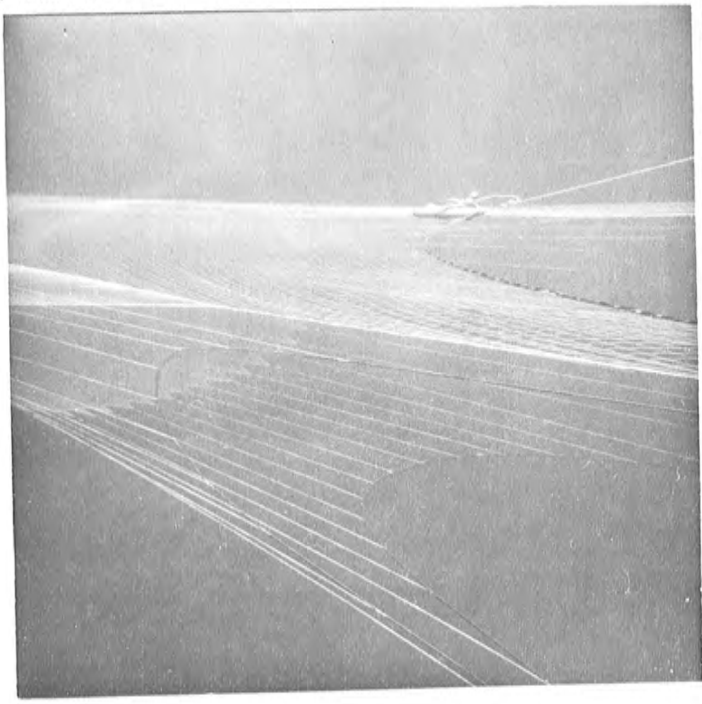


FIG. : 19 f

FIG. : 19 e



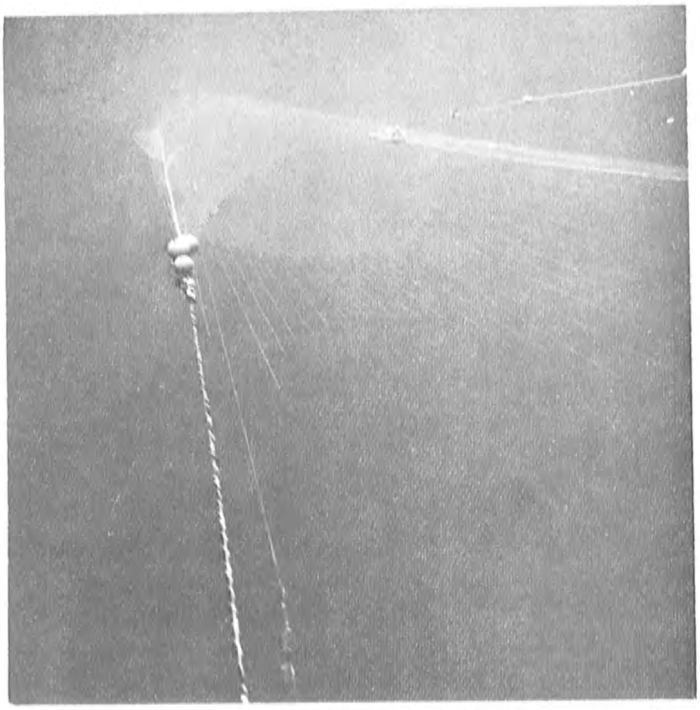


FIG.: 19 g FRONT VIEW
WITH TRANSDUCERS
ON WING - END AND
HEADLINE

FIG.: 20
COMPUTER DESIGNED ROPE TRAWL
NETMOUTH FRONT VIEW

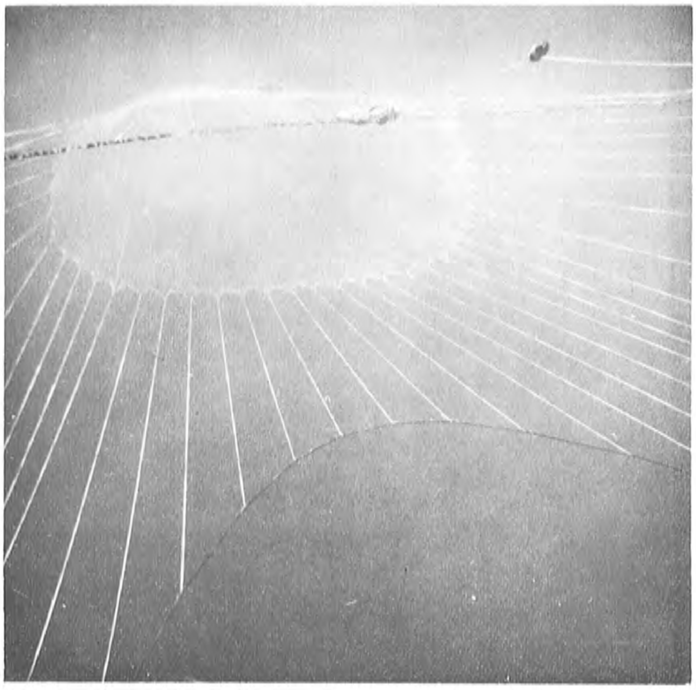


FIG.: 20a

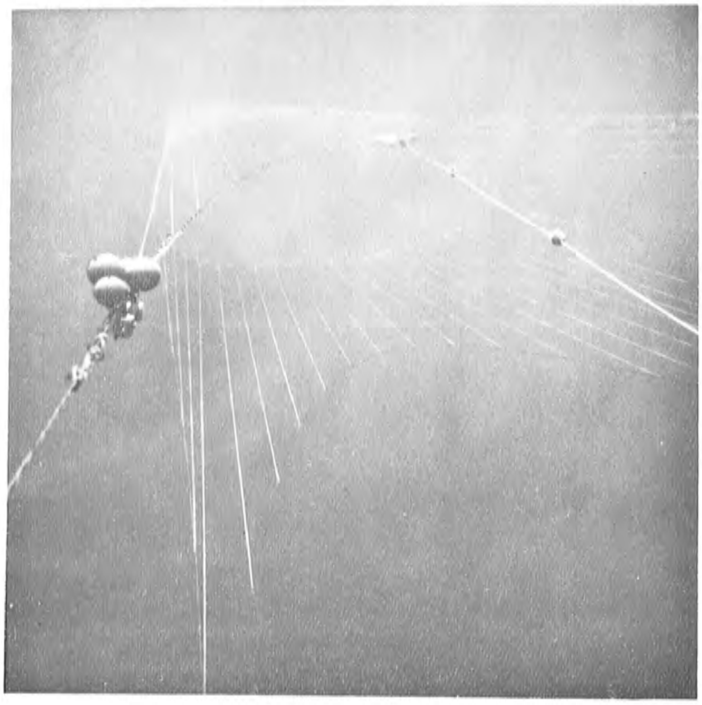


FIG.: 20b

FIG.: 20c

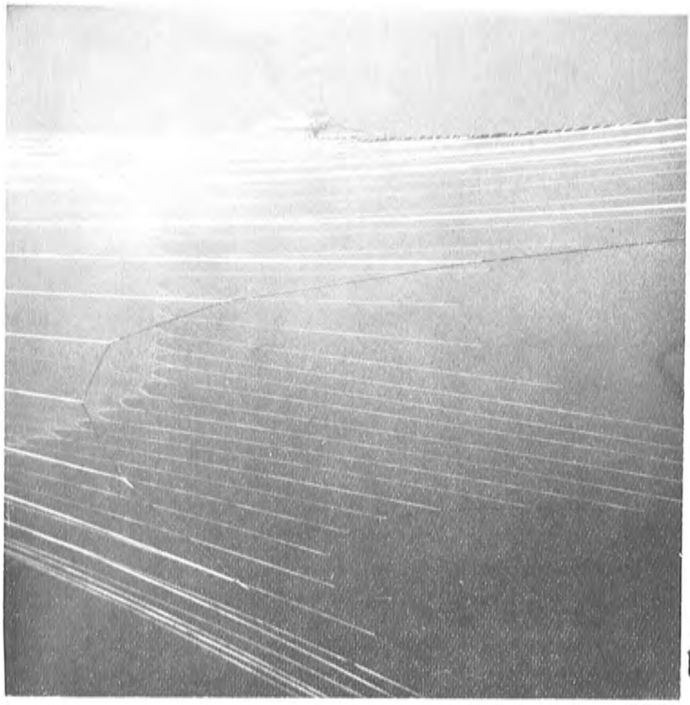


FIG.: 20d

FIG.: 20 e
STARBOARD SIDE PANEL

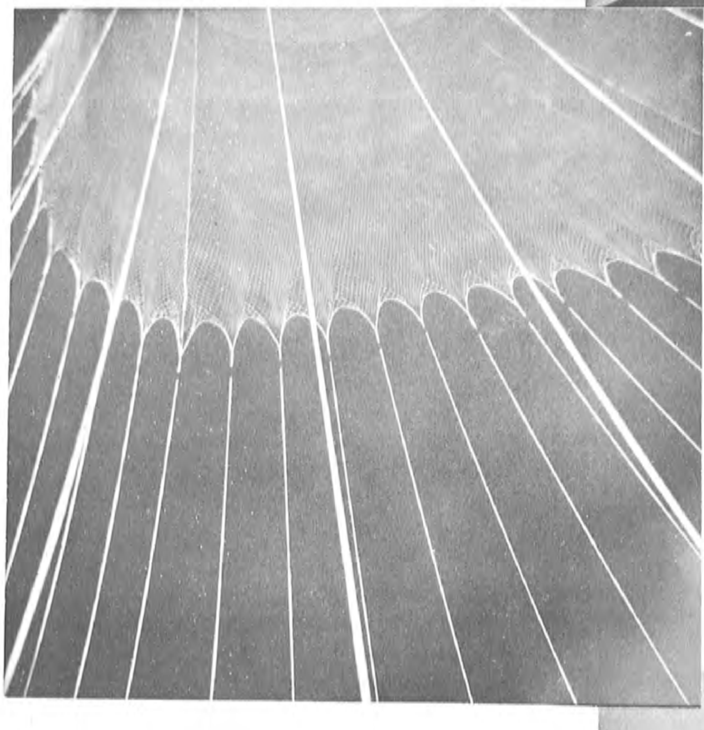


FIG.: 20 f
LOWER PANEL

FIG. : 20 g
STARBOARD SIDE PANEL

COMPUTER DESIGNED
ROPE TRAWL

SCALE 1:4

TOPPANEL WITH
SHARK TEETH

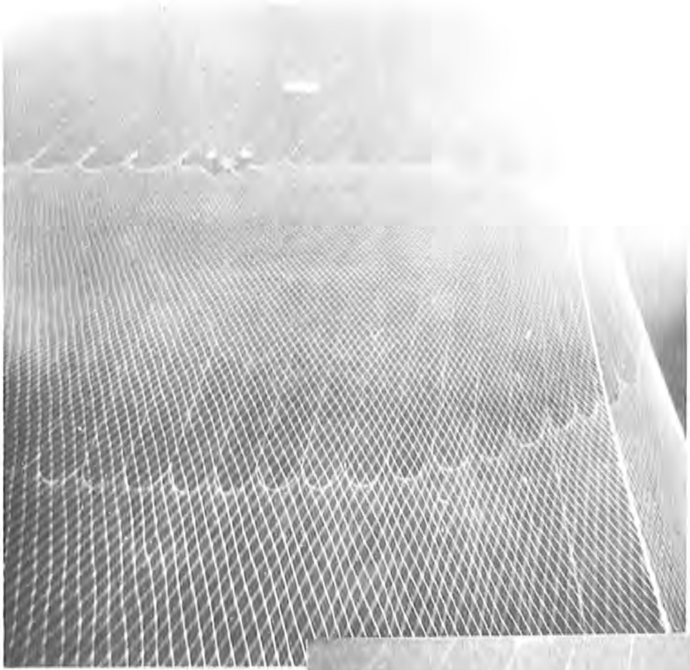


FIG.: 20i

FIG.: 20j

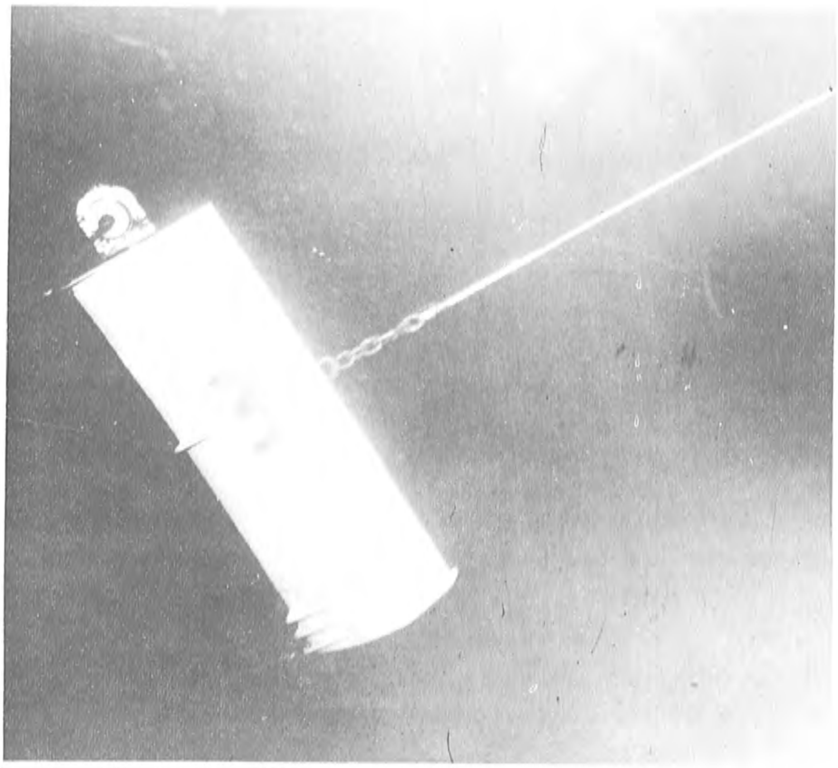


FIG. : 21
SCALE MODEL OF SUBERKRUB DOOR ($4.7 m^2$ Full Scale) WITH TRANSDUCER ON TOP.

3. Recommendations

At the end of the meeting the convenor raised the question of the next meeting place and asked suggestions for a special topic for the 1981 Working Group-meeting.
The Committee Chairman Dr. G. Kurc invited both the Engineering and Fish Reaction Working Group to meet simultaneously in Nantes (France) from 4-8 May 1981. This invitation was accepted with thanks.
Next in the discussion on the special topic it was noted that in general far too less attention is paid by the Working Group on low-energy fishing methods. It was further noted that some member countries have research in this field planned.
The meeting accepted therefore the following recommendation:

- In view of the continuing concern about the effect of the high cost of energy on fishing activities,
- it is recommended that the Working Group on Research and Engineering Aspects of Fishing Gear, Vessels and Equipment should meet in Nantes from 4-8 May 1981, to consider in particular low energy consumption fishing methods, recent developments in this field and requirements for future research.