INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA

C.M. 1988/B:15
Fish Capture Committee

WHY FEW DUTCH BEAM TRAWLERS USE A CONTROLLABLE PITCH PROPELLER

by

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INTRODUCTION

Before discussing the direct facts, first some backgrounds:
For those who aren't familiar with the Dutch beamer see figure 1 (vessel) and figure 2 (fishing method).
About 70 % of the Dutch see-going fleet (500 vessels, shellfish excluded) uses the beamtrawls for flatfish several months a year and about 40 % even uses nothing else but the beamtrawl. So you may say there is a lot of experience especially since the mid sixties, when the beamtrawl came extensively up for flatfish-fishing. Before these years the Dutch fishermen only knew the beamtrawl for shrimp fishing in the estuaries and along the coast.

The flatfish beamtrawl speed is 4 miles for the smaller vessels, up to 7 miles for the vessels of 1800 kW (2500 hp) and more. To get the flatfish, especially the commercial attractive sole, you need a speed of over four miles with a big pull: the greater the speed (with heavy beamtrawls) the higher the percentage in sole catch. So what the skippers always require is: an optimal pull-propeller at a weekly fishing/steaming partition of 80/20 percent. Generally speaking for the Dutch beamtrawl fisheries only two types of propellers are interesting, namely:
- a ducted fixed pitch propeller (F.P.P.) (figure 3), or
- a ducted controllable pitch propeller (C.P.P.) (figure 4).
Because propellers without a duct (or so-called nozzle) have on forehand a lower pull (ca. 15 %) at the fishing speed than the ducted propellers (figure 5). That means less catch capacity and besides a vulnerable construction with regard to the gear handling.
Concerning ducted or open propellers for fishing craft an interesting article has recently been published in Fishing News International, here given as enclosure 1.

A comparison of two types shows:
Firstly the fixed bladed propeller with the controllable pitch propeller, both designed for max. pull for fishing at 4 knots.

As you can see in figure 6, for the C.P.P. the full main engine performance can be used also at free-running speed, where at F.P.P. only can take about 85 % of the engine power.
Especially for those beamers with distance offshore fishing grounds this is an advantage resulting in a higher steaming speed of about 0,5 knots. However, the C.P.P. efficiency at fishing speed is about 3 - 4 % less owing to the big boss for the controll-gear (figure 4) and to the greater clearance between the nozzle and propeller blades necessary for turning of the blades.
At steaming the C.P.P. has an extra power of 15 to 20 %.
With the brief comparison above, the vital pulling force (dis)advantages have been given.
Before conclusions can be drawn, two design aspects must be considered yet, namely:

- the propulsion plant layout (power takes off or not),
- the cost-effects.

<u>Layout CPP/FPP installation:</u>
When using power takes off (PTO) for boardnet generators the CPP-installation offers a great advantage, because of constant revolutions of the propeller shaft, nevertheless the load condition of the propulsion diesel engine. To this I like to refer to an interesting study (and trials) of our English SFIA colleagues: Power autit trials of Scottish seiner "Acorn" (figures 7 - 8), where from an economical point of view of fuel usage it is better to reduce the RPM at maximum pitch!
On the other hand owing to the modern micro-electronics, it is no technical and layout problem anymore to use PTO's on a propeller shaft with varying revolutions, the S.C.R. (silicon controlled rectifier) system. This has already been installed on some beamers (very expensive), although the majority of the Dutch beamer skippers prefer separate boardnet generators and no PTO's (See RIVO report TO 84-03 (in Dutch)).

So the CPP advantage of constant rev's isn't here decisive; up to now the only reasons for application of this propeller are distant fishing grounds and ofcourse the cost-effects (<30 % of the week steaming).

Cost-effects:
As you can see in figure 3 and figure 4, the CPP-installation is more complicated than a sturdy ducted FPP propeller.
The extra components of a CPP-installation are amongst others:

- blades turning in the boss, mostly controlled by a rod through the hollow propeller shaft; electronically steered servo pump for serving of the rod; altogether about *f* 200.000,= ($ 100.000) more than a fixed propeller of 1500 kW (2040 hp) 3000 mm ø. This means an extra investment of two percent of the new-building price (about *f* 5 million).

Besides a special problem connected with the application of a CPP in a nozzle consists of dismounting and dismantling of a damaged propeller blade resulting in extra costs for repair and extra delay in fishing time.
Altogether a costly and to the opinion of the Dutch skippers a vulnerable propulsion plant with no clear improvement or even reduction of fishing efforts in beam trawling. Nevertheless there are some beamers with CPP's.

CPP outboard beamers:
Up to now we considered the Dutch beamers as fishing vessels on the same fishing grounds. But the North Sea bottom shows differences, namely in the northern part we have flat sandy and/or muddy bottom structures, while in the southern part (Channel area) there are many sand ridges (or underwater dunes). Here the use of a good adjustable pull is profitable, one of the not yet mentioned CPP-advantages!
Besides the CPP beamers (2) which have been involved in the heavy fleet trials/tests (1980 - 1984) appeared to be very suitbale for this type of installation.

Conclusion:

- In spite of the benefits of controllable pitch propellers, only 4 beamers of the 120 new build beamers in the last 6 years have a controllable pitch propeller and well only those for the Southern North Sea.
- Costs are unfavourable in relation to the benefits, while the vulnerability and repair costs result in loss of fishing time.
- fishing efforts on near fishing grounds with a low flatfish population over wide spread areas.
- However, owing to the overcapacity problems in the Dutch beamtrawl fisheries things are changing in beamer design and distant water voyages. Maybe then the CPP will become in favour.

Enclosures:
- Article of mr. Williams
- Conclusions of SFIA-report

Literature list:
W.C. Blom - Auxiliaries on 1300 kW beamers (Dutch, 1984).
W.C. Blom - Measurements on power at the UK 173 (Dutch, 1986).
S.F.I.A. Report "Power autit trials on Scottish séiner "Acorn".
G. de Wit - Study grading technical highschool over CPP at beamers (Dutch, 1987).

FIG. 1

2000 BHP
BEAMER

$L_{O.A.}$ = 40 metre
B_m = 9 "
D = 5.10 "
d_{aft} = ~ 5. "

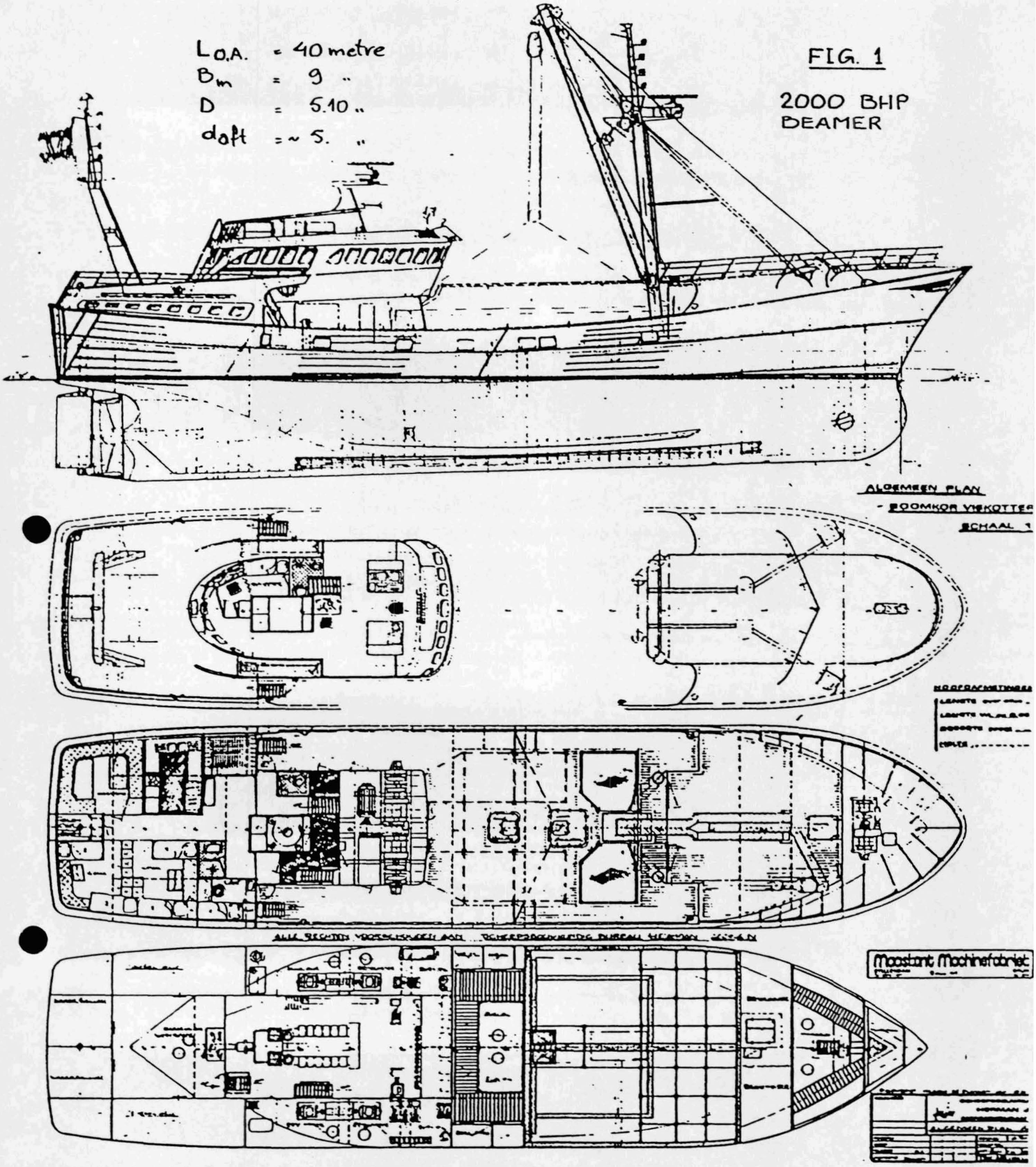


FIG. 2

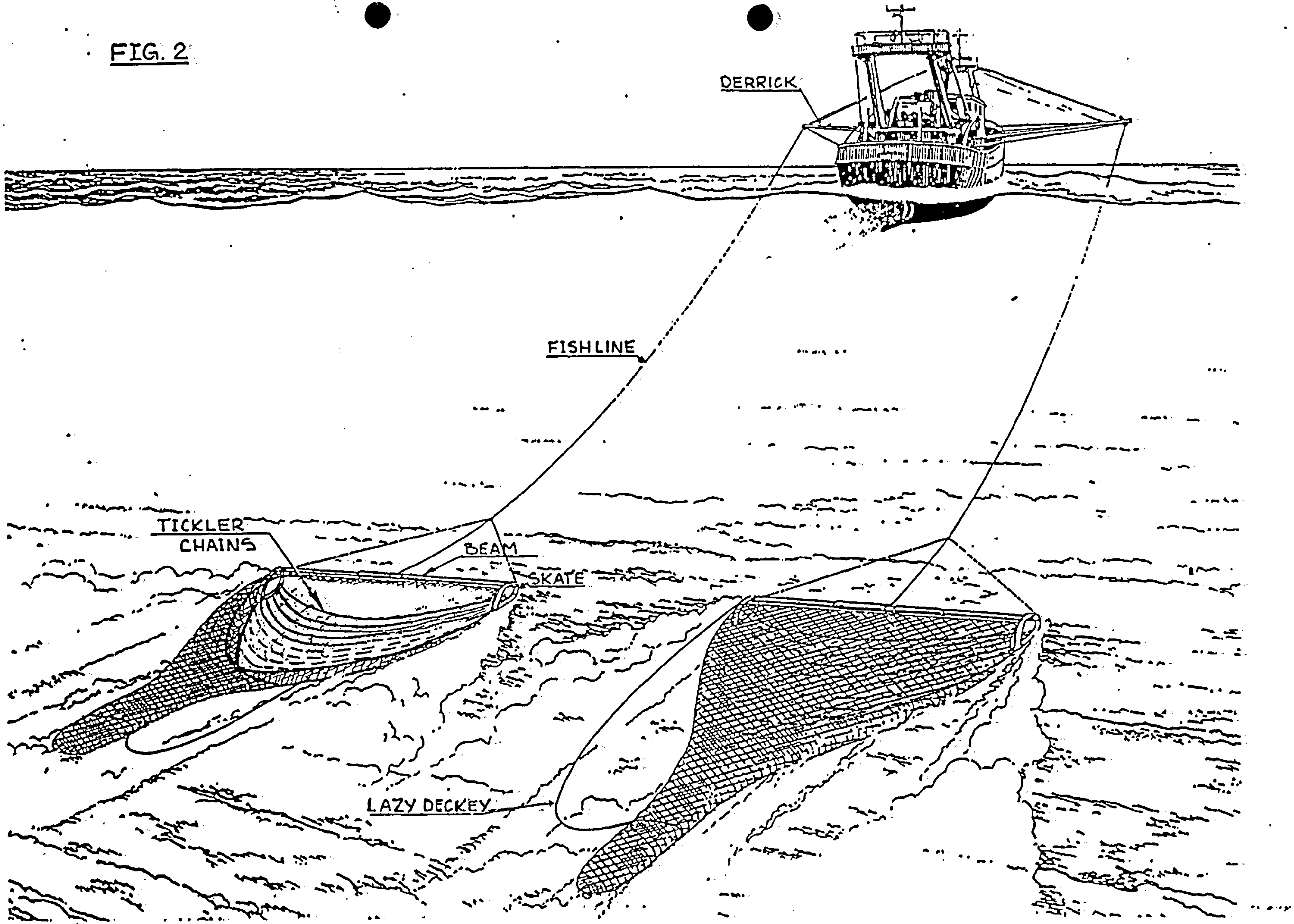
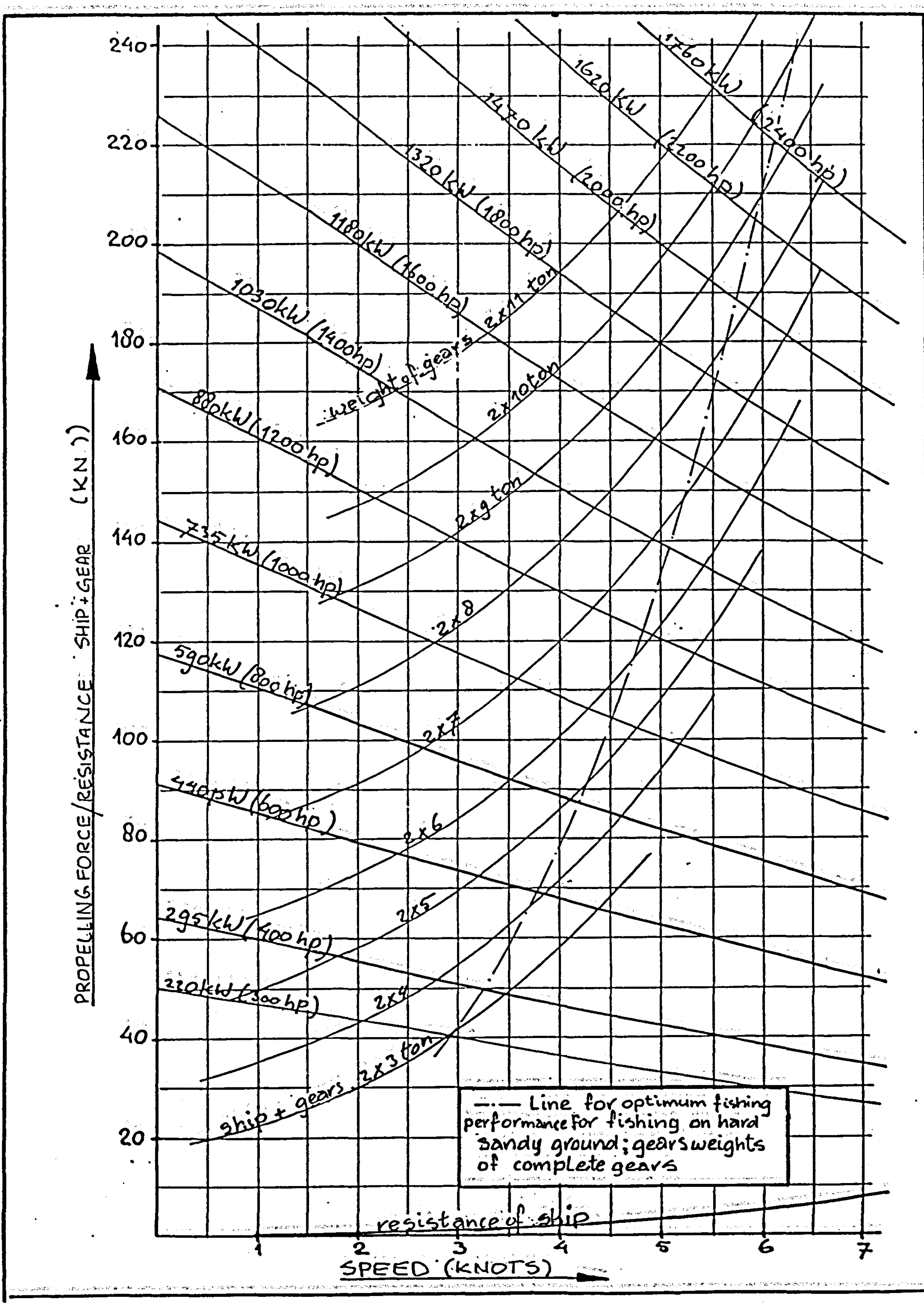


FIG 2A



240
220
200
180
160
140
120
100
80
60
40
20
1
2
3
4
5
6
7
PROPELLING FORCE/RESISTANCE SHIP + GEAR (KN)
SPEED (KNOTS)
1760 kW (2400 hp)
1620 kW (2200 hp)
1470 kW (2000 hp)
1320 kW (1800 hp)
1180 kW (1600 hp)
1030 kW (1400 hp)
880 kW (1200 hp)
735 kW (1000 hp)
590 kW (800 hp)
440 kW (600 hp)
295 kW (400 hp)
220 kW (300 hp)
weight of gears 2x11 ton
2x10 ton
2x9 ton
2x8
2x7
2x6
2x5
2x4
ship + gears 2x3 ton
resistance of ship
—·— Line for optimum fishing performance for fishing on hard sandy ground; gears weights of complete gears

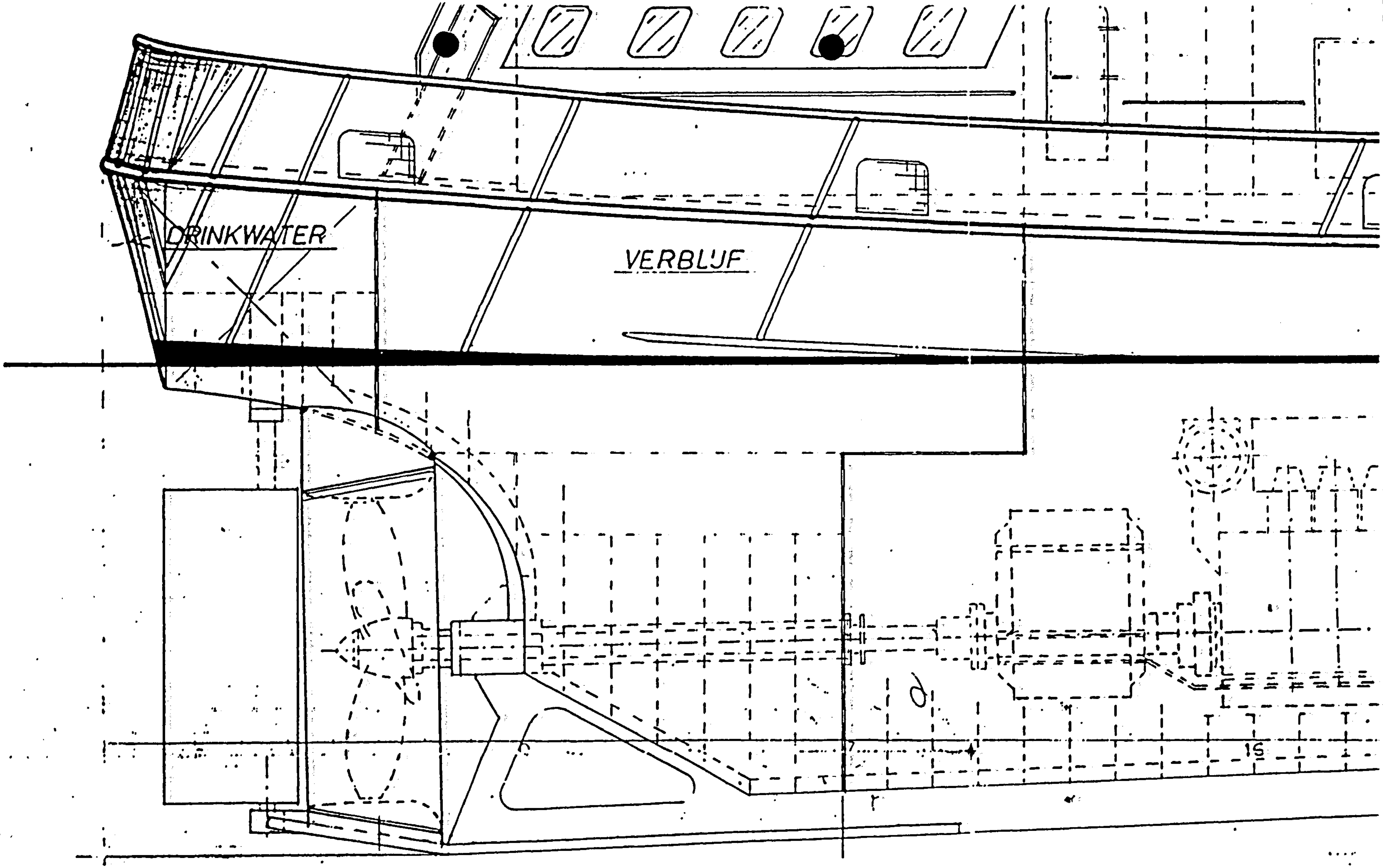
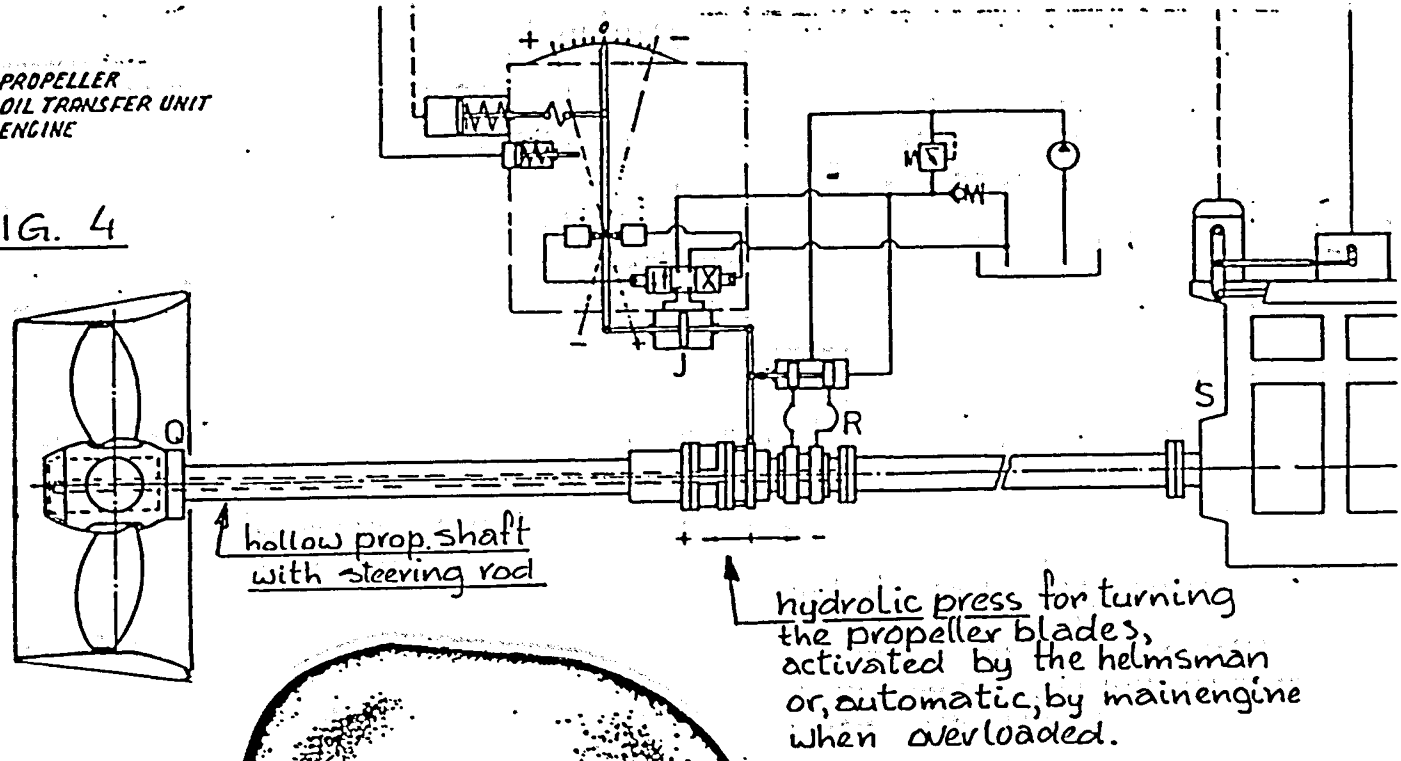


FIG. 3 FIXED PITCH PROPELLER INSTALLATION

Q. PROPELLER
R. OIL TRANSFER UNIT
S. ENGINE

FIG. 4



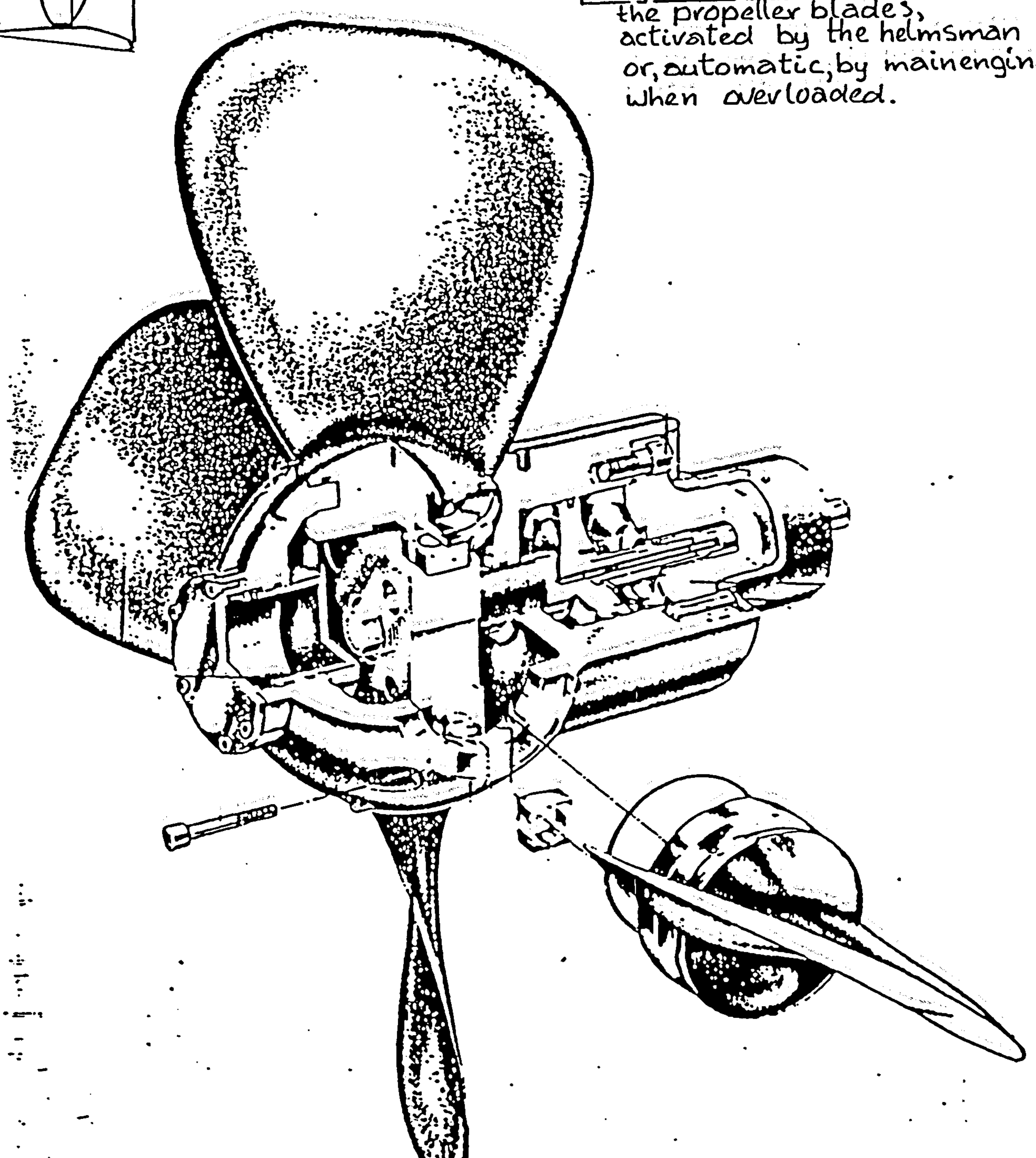
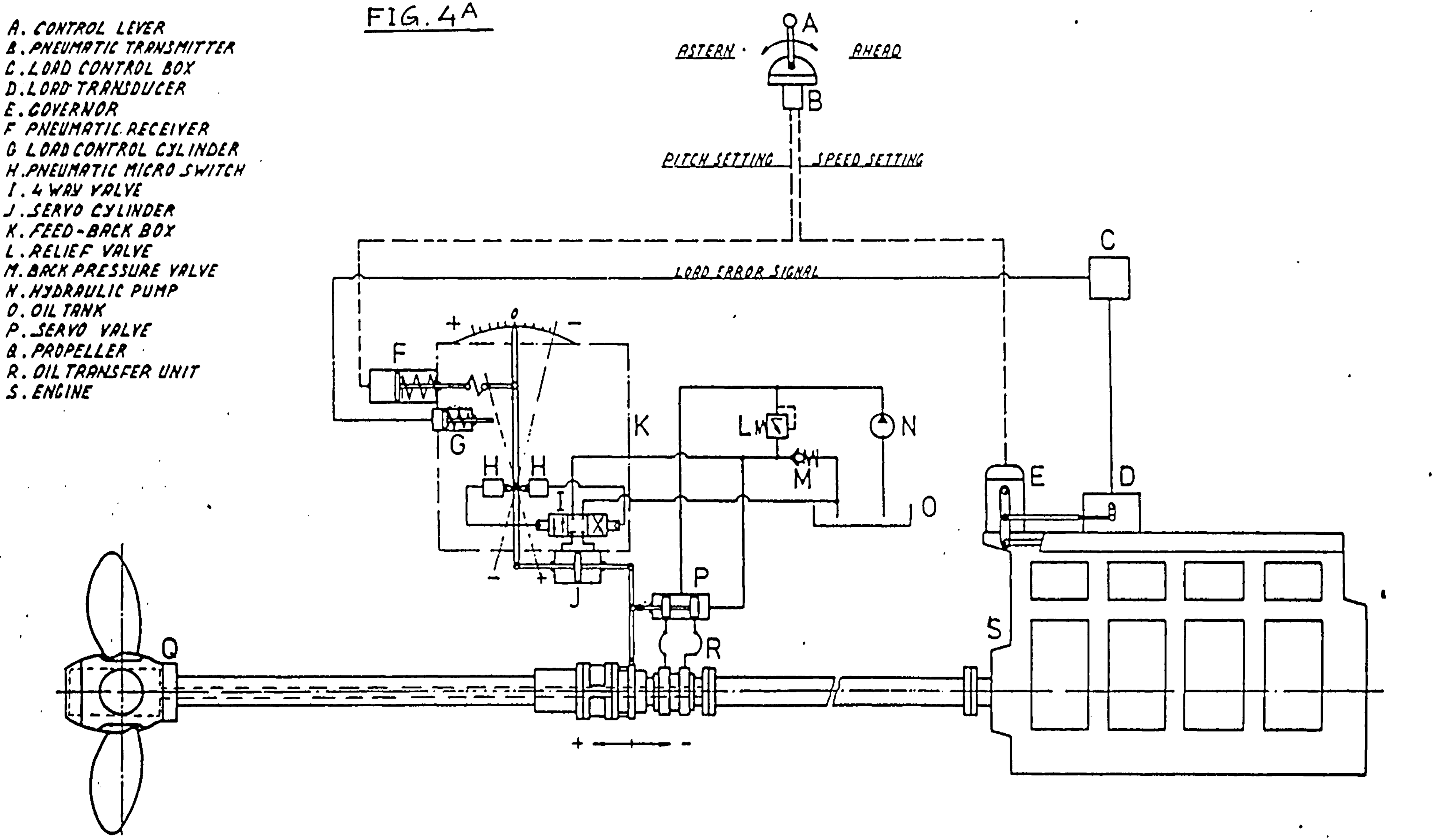
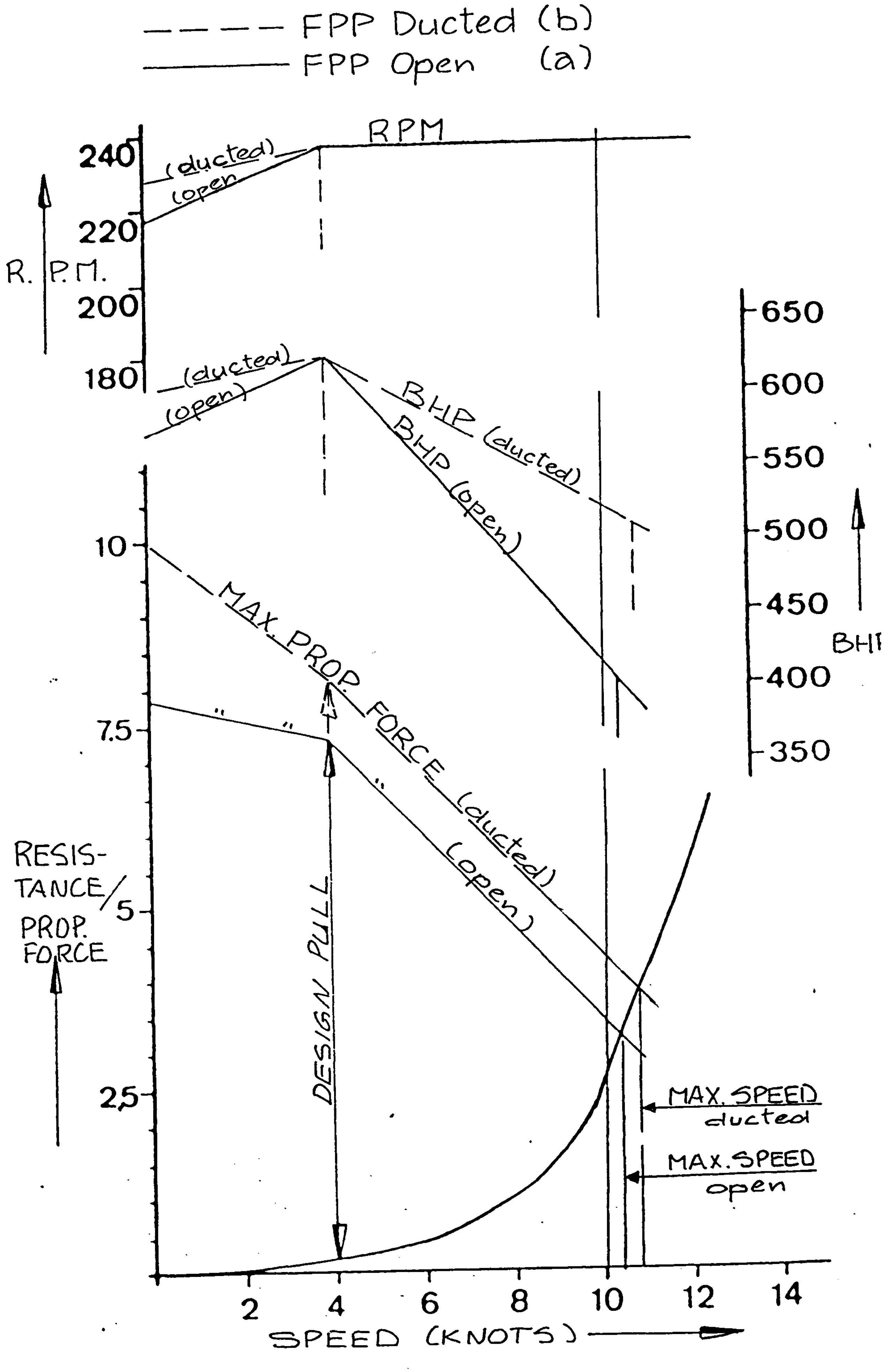


FIG. 4A



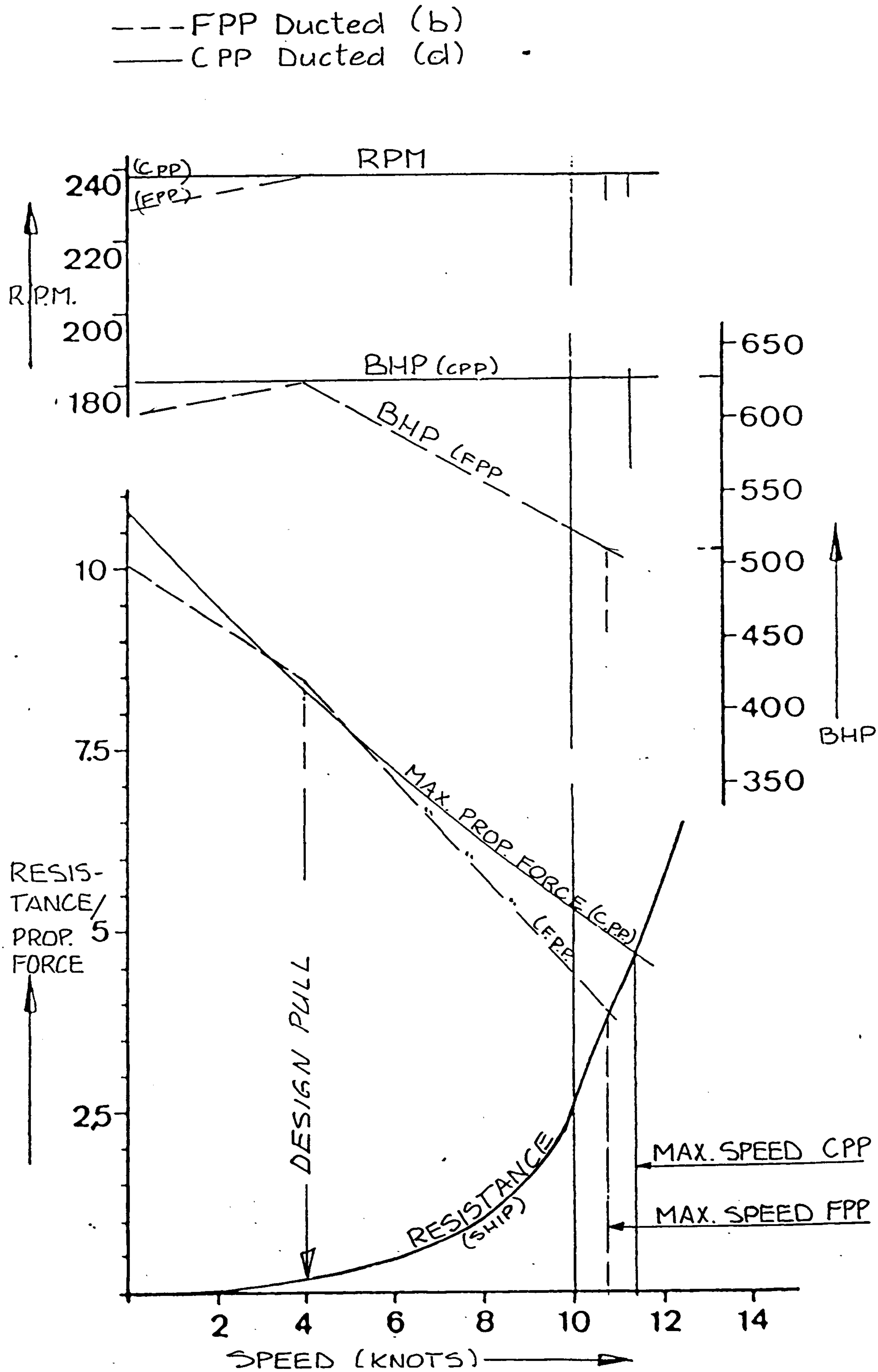
PNEUM.-HYDR. REMOTE CONTROL SYSTEM WITH LOAD CONTROL

FIG.5



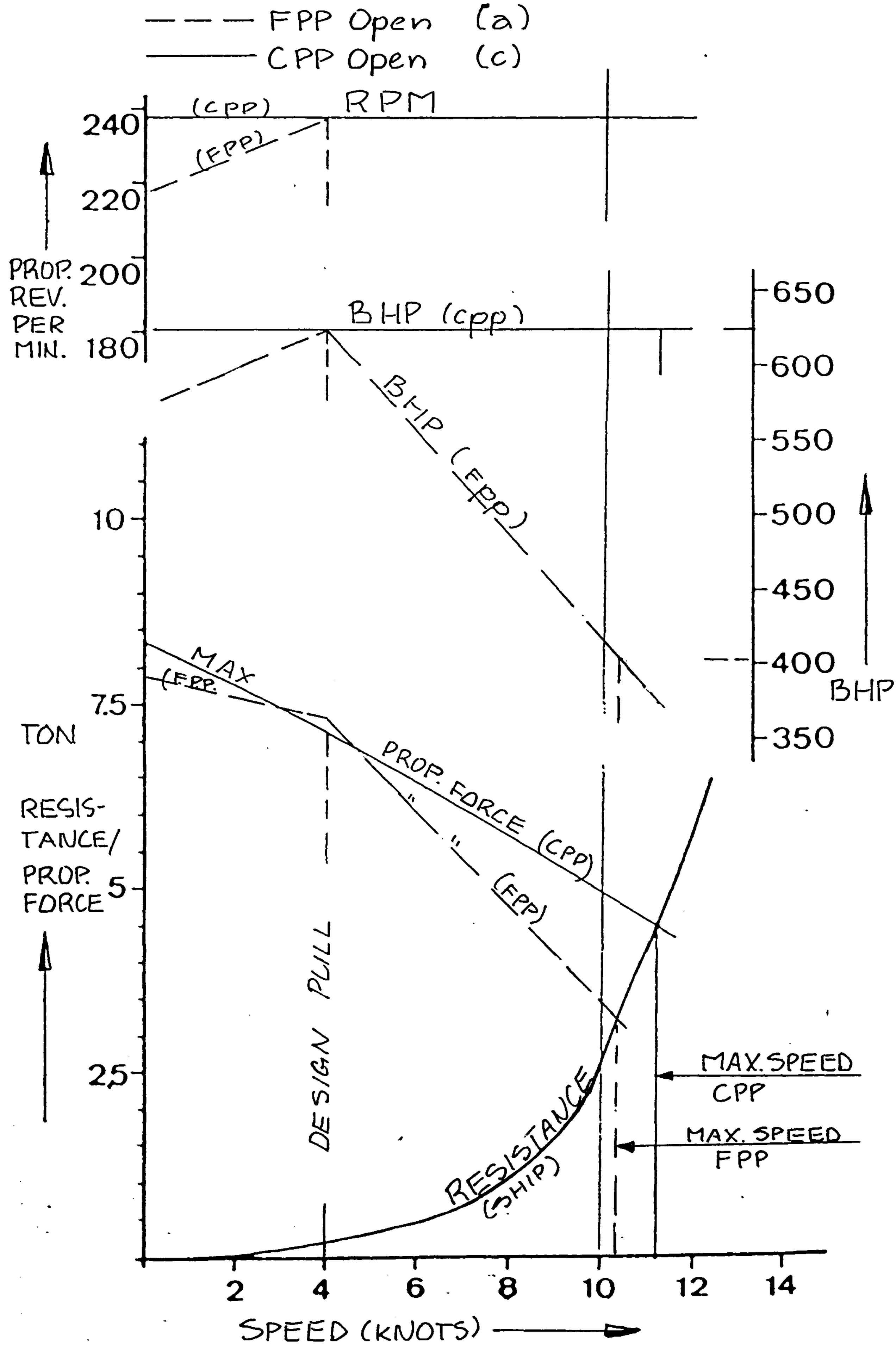
FPP Ducted (b)
FPP Open (a)
RPM
R.P.M.
240
220
200
180
(ducted)
(open)
BHP (ducted)
BHP (open)
650
600
550
500
450
400
350
BHP
10
7.5
5
2,5
MAX. PROP. FORCE (ducted)
(open)
DESIGN PULL
RESISTANCE/PROP. FORCE
MAX. SPEED ducted
MAX. SPEED open
2
4
6
8
10
12
14
SPEED (KNOTS)

FIG. 6



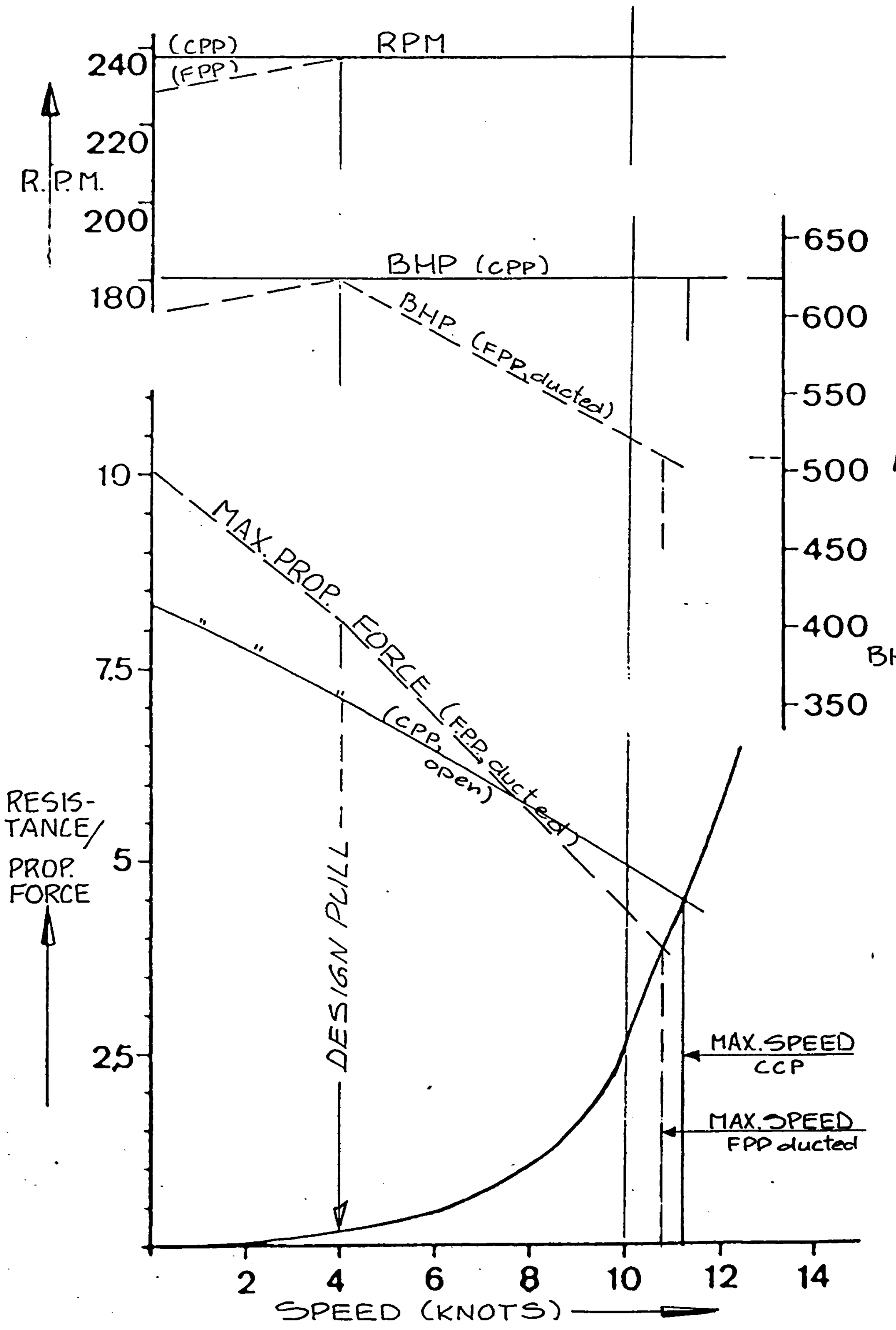
--- FPP Ducted (b)
—— CPP Ducted (d)
RPM
(CPP)
(FPP)
240
220
R.P.M.
200
180
BHP (CPP)
BHP (FPP
650
600
550
500
450
400
350
BHP
10
7.5
5
2,5
RESIS-TANCE/PROP. FORCE
MAX. PROP. FORCE (C.P.P)
(F.P.P
DESIGN PULL
RESISTANCE (SHIP)
MAX. SPEED CPP
MAX. SPEED FPP
2
4
6
8
10
12
14
SPEED (KNOTS)

FIG. 6A

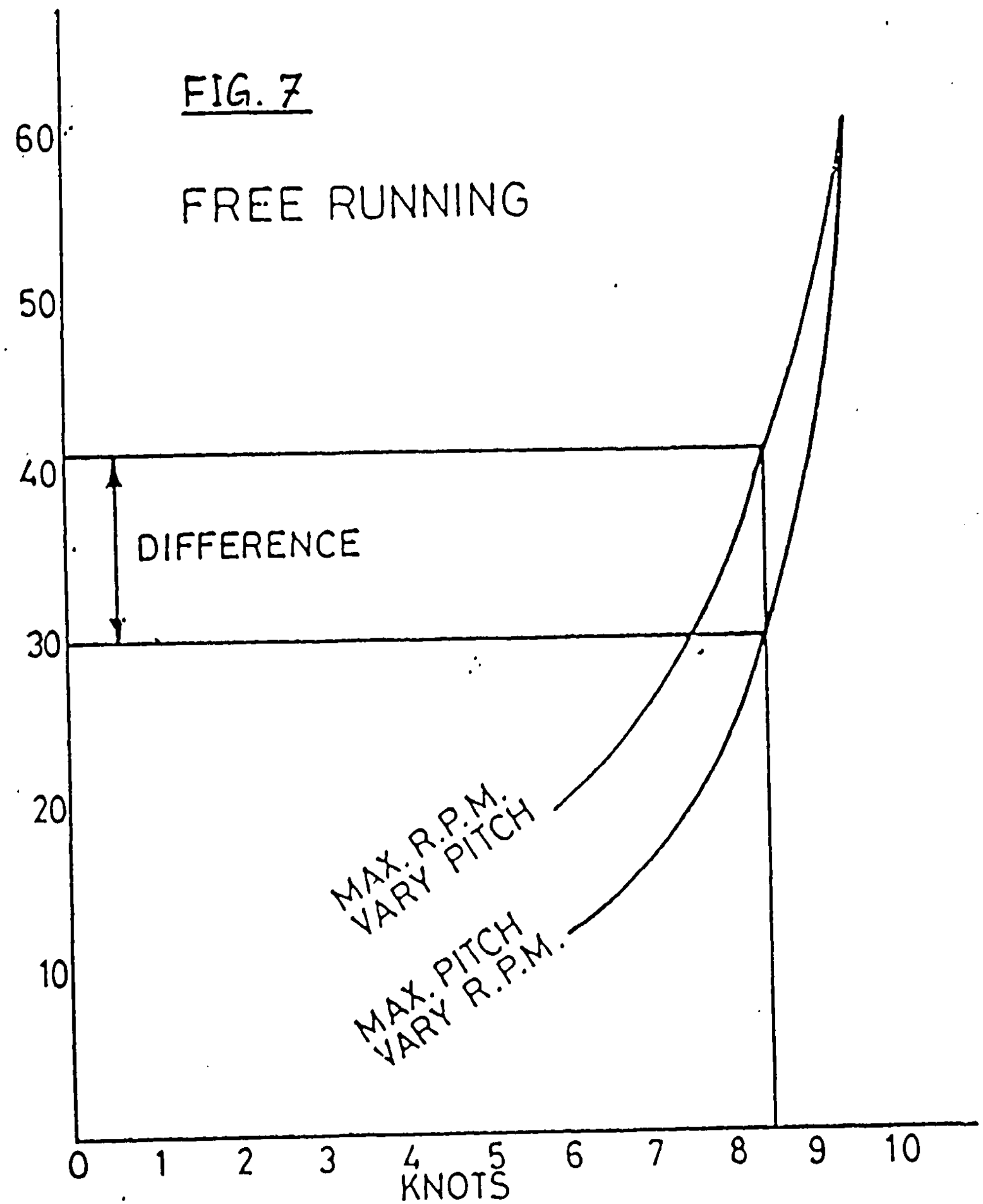


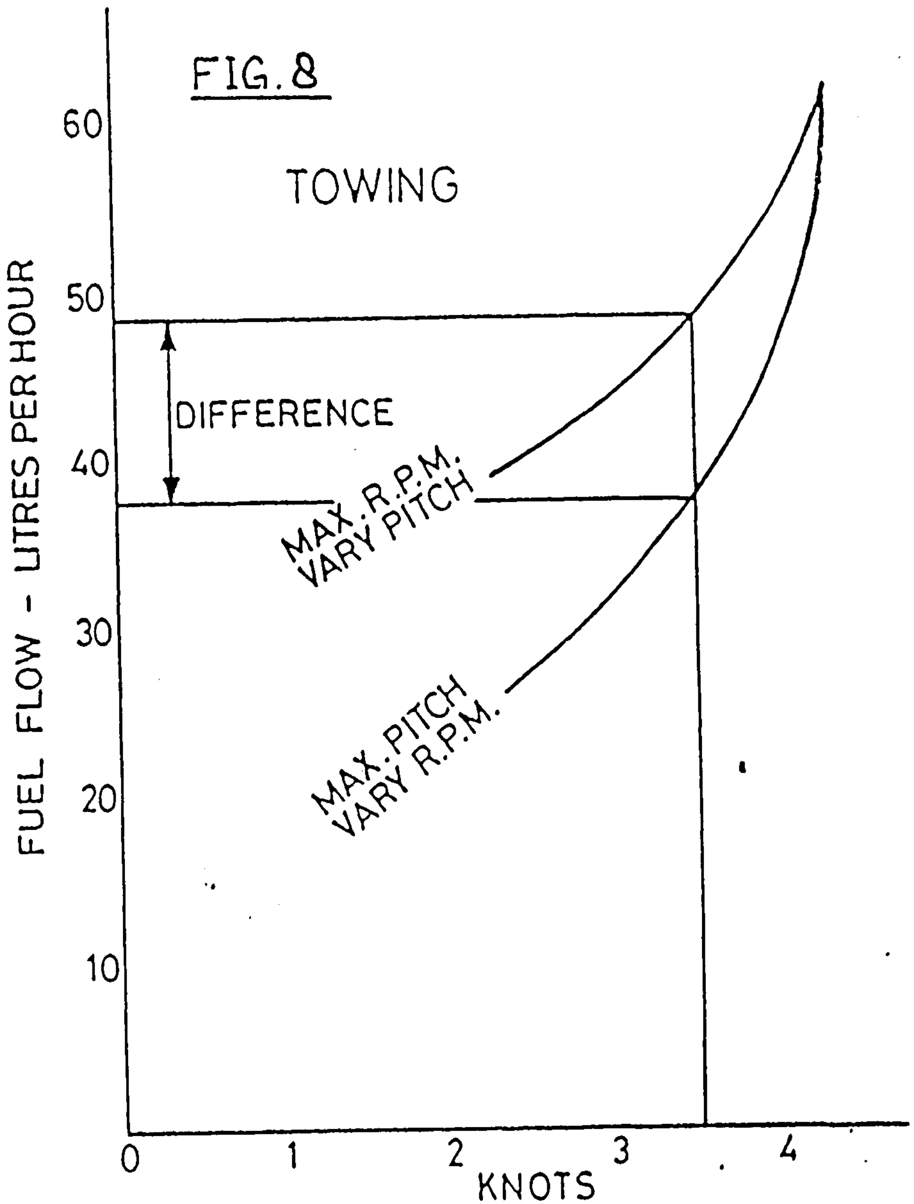
FPP Open (a)
CPP Open (c)
RPM
(CPP)
(FPP)
240
220
200
180
PROP. REV. PER MIN.
BHP (cpp)
BHP (FPP)
650
600
550
500
450
400
350
BHP
10
7.5
5
2,5
TON
RESISTANCE/ PROP. FORCE
MAX (FPP)
PROP. FORCE (CPP)
(FPP)
DESIGN PULL
RESISTANCE (SHIP)
MAX. SPEED CPP
MAX. SPEED FPP
2
4
6
8
10
12
14
SPEED (KNOTS)

FIG. 6B



--- FPP Ducted (b)
—— CPP Open (c)
(CPP)
(FPP)
RPM
240
220
R.P.M.
200
180
BHP (CPP)
BHP (FPP, ducted)
650
600
550
500
450
400
350
BHP
10
7.5
5
2.5
RESISTANCE/PROP. FORCE
MAX. PROP. FORCE (FPP, ducted)
" " " (CPP, open)
DESIGN PULL
MAX. SPEED CCP
MAX. SPEED FPP ducted
2
4
6
8
10
12
14
SPEED (KNOTS)



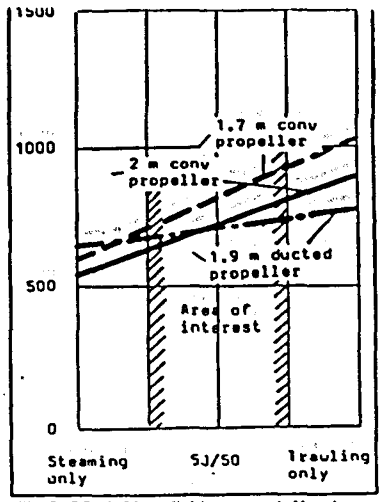


RESULTS CONDENSED FROM ACTUAL SEA TRIALS
M.F.V. CONSTELLATION

ENCL. 1

THE writer graduated from Chalmers University of Technology in Gothenburg in 1959. He joined SSPA in 1951. For most of his time in the company he has worked with large Swedish and foreign yards and shipping companies. Then, at the end of 1984, he started his present work with SSPA Skeppskonsult, a special section which serves domestic shipping, and fishing and small yards within Scandinavia.

SSPA Maritime Consulting AB was formerly the Swedish State Shipbuilding Experiment Tank. Some years ago it became a limited company with the Swedish government as a shareholder. Its services include shipping, naval, offshore and general hydrodynamics. It has a number of laboratories, including a towing tank, wave basin and cavitation tunnel.



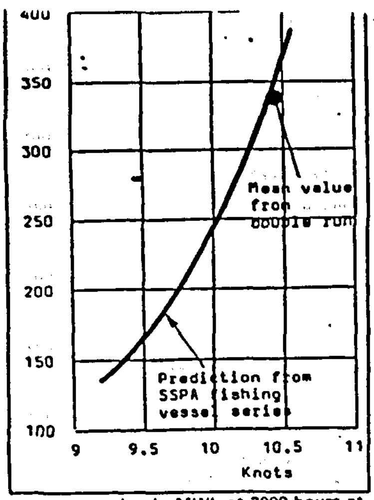


Fig 3: SSPA 20 m fishing vessel. Yearly energy consumption in MWh at 2000 hours at sea a year. Fig 4: A 23 m trawler with conventional propeller. At trials, free running. Full engine power in kW.

Propellers for fishing craft

Ducted or not?

By AKE WILLIAMS,
SSPA Maritime Consulting AB, Gothenburg

DURING the past two years, extensive systematic model tests for fishing vessels have been carried out by SSPA Maritime Consulting AB (formerly the Swedish State Shipbuilding Experiment Tank) in Gothenburg. The aim of the tests is to gain knowledge about the importance of hull forms and propellers to the trawling and free running characteristics of fishing vessels.

Some of the tests have been performed in order to compare conventional with ducted propellers. The comparision has included the free running, trawling and the bollard pull conditions.

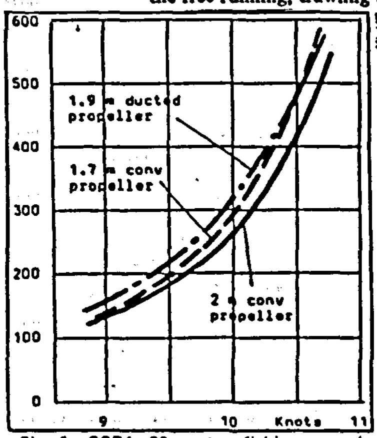
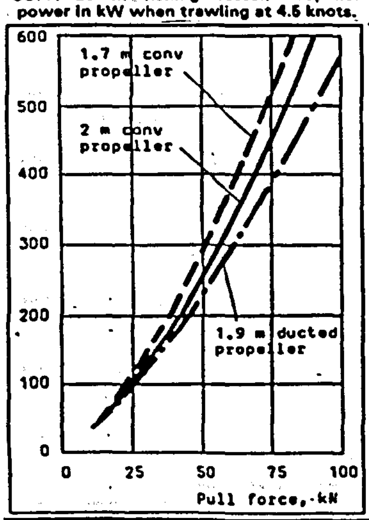


Fig 1: SSPA 20 metre fishing vessel. Propeller power in kW at steaming. Fig 2: SSPA 20 m fishing vessel. Propeller power in kW when trawling at 4.5 knots.



Last June two similar trawlers were delivered from Swedish fishing boat yards, the first with conventional propeller and the second fitted with ducted propeller. With financial support from the Swedish Board of Fishery and the Swedish Transport Research Board, extensive and accurate tests have been performed with the two vessels covering speed, power and bollard pull.

The results from the systematical model tests have been fully confirmed by full-scale tests with the two trawlers. The use of a ducted propeller means a considerably higher pull force trawling at low speed while the vessel with an open propeller attains a somewhat higher speed free-running at constant engine power.

Improved

As with merchant ships, fishing vessels have recently been equipped with larger and slower running propellers. In this way their propeller efficiency has been improved and, therefore fuel costs have been reduced. However, as very few model tests are carried out for fishing vessels, the propellers are usually designed without the aid of model test results by which comparison of alternative propellers can be carried out regarding demand of engine power, pull force at trawling, free running speed, etc.

When high pull force at trawling is specially desirable, the solution will often be a ducted propeller instead of a large slow-running propeller (which may increase the draught of the vessel beyond acceptable figures). But even the choice of a ducted propeller seems to be made without knowing the effect, for instance, on fuel economy at steaming. In general, the fishing vessels are built "one and one" and, therefore, no yard or private owner can afford to carry out comparative tests for obtaining evidence of the profit or loss with a ducted propeller.

Two conventional and one ducted propeller models have been tested on a hull form from SSPA's fishing vessel series.

The larger one of the two conventional propellers can be designated "large and slow-running". It is becoming more and more usual to choose such a propeller for higher propeller efficiency. From Fig. 1 it can be seen that this propeller demands the lowest engine power. It will also be noted that, at nearly all ship speeds, the required engine power of the ducted propeller is even higher than for the "small and fast-running" propeller. But, the order of merit for the different propellers is valid only for the free-running condition of the ship.

Ducted better

At trawling at low speeds, the ducted propeller is definitely better than the two conventional propellers (see Fig. 2). Results of the model tests indicate that the pull force is increased by about 15 per cent by the ducted propeller at an engine output of 500 kW.

Also, bollard pull tests have been carried out and they indicate a gain of nearly 30 per cent by use of the ducted propeller. This may be of small practical value for a fishing vessel but it is useful when recalculating the results from a bollard pull test to be valid for trawling at, say 4 knots.

Starting from information about running time at steaming and trawling, the yearly energy consumption of fishing vessels with different propellers can now be shown (Fig. 3).

The results of the systematic model tests are the basis of the curves of the diagram going from 100 per cent steaming to 100 per cent trawling (on a time basis).

Fishing vessels with most of their time at sea devoted to trawling will get most advantage of a ducted propeller. But vessels with long distances to travel to grounds and which spend long periods searching for fish, will gain more from a large slow-running propeller than from a ducted propeller.

Consumption

The yearly energy consumption shown in Fig. 3 is based on 2000 hours a year at sea and is expressed in the appropriate unit MWh (megawat hours). For those who prefer amount of fuel as measure of energy consumption, 1000 MWh is approximately equal to 300 cubic metres of diesel oil.

In order to have the results from the systematic model tests confirmed, full-scale tests were carried out with two new fishing vessels.

These vessels were delivered and tested in June 1987. Their length is in the range 20-25 metres, which is somewhat larger than the vessel in the model test series. However, ENCL. 2.1

Sea Fish Industry Authority
Industrial Development Unit

Technical Report No. 249 August 1984

POWER AUDIT TRIALS ON SCOTTISH SEINER ACORN

SUMMARY

Scottish seining now accounts for 13% of the fishing vessels in the Scottish fishing fleet. Over the last 18 years, since the SFIA last investigated the performance of this class of vessel, power levels have increased and there is now a wider use of hydraulic deck and auxiliary machinery.

The report gives results of an instrumented trial carried out on the modern Scottish 24m seiner ACORN of 575hp. The trials were aimed at quantifying the proportions of power used in the different areas of consumption (propulsion, winches, electrical circuits, etc.) at all periods of the operating cycle of the vessel, both as an aid to identification of possibilities in power consumption savings and also to identify the levels of waste heat which might be usefully recovered. Recommendations are made for potential savings on this and similar vessels and comparisons are made with the OPPORTUNE II trial of 16 years ago.

In the event the trials showed the ACORN to be of extremely efficient design in most of its specification and the consumption achieved provides "yardstick" values against which other skippers might wish to compare their own operations, or builders to compare the specification for a new vessel.

W. Siddle,
Principal Mechanical Engineer

9. CONCLUSIONS

9.1 General

The ACORN is a good example of a fuel efficient fishing vessel and the results obtained on these trials can be used as a "yardstick" by which other vessels may compare their performance.

There are three main reasons for this efficiency:

i. Vessel management by a fuel conscious skipper.

ii. Prosecuting a fuel-efficient method of catching fish in terms of fuel per kg of fish captured, i.e. Scottish seining (or flydragging).

iii. The main engine is direct drive, slow speed and has a level specific fuel consumption throughout the operating range.

The propulsion package thus takes advantage of the established principle that for maximum propulsive efficiency systems, the propeller should be as large a diameter as possible and correspondingly run as slow as possible.

There are two areas where significant fuel savings might be made on ACORN. These concern generating sets whereby better matching of rating to demand could have been made and where installation of a heat recovery system for accommodation and domestic water heating could have reduced overall demand.