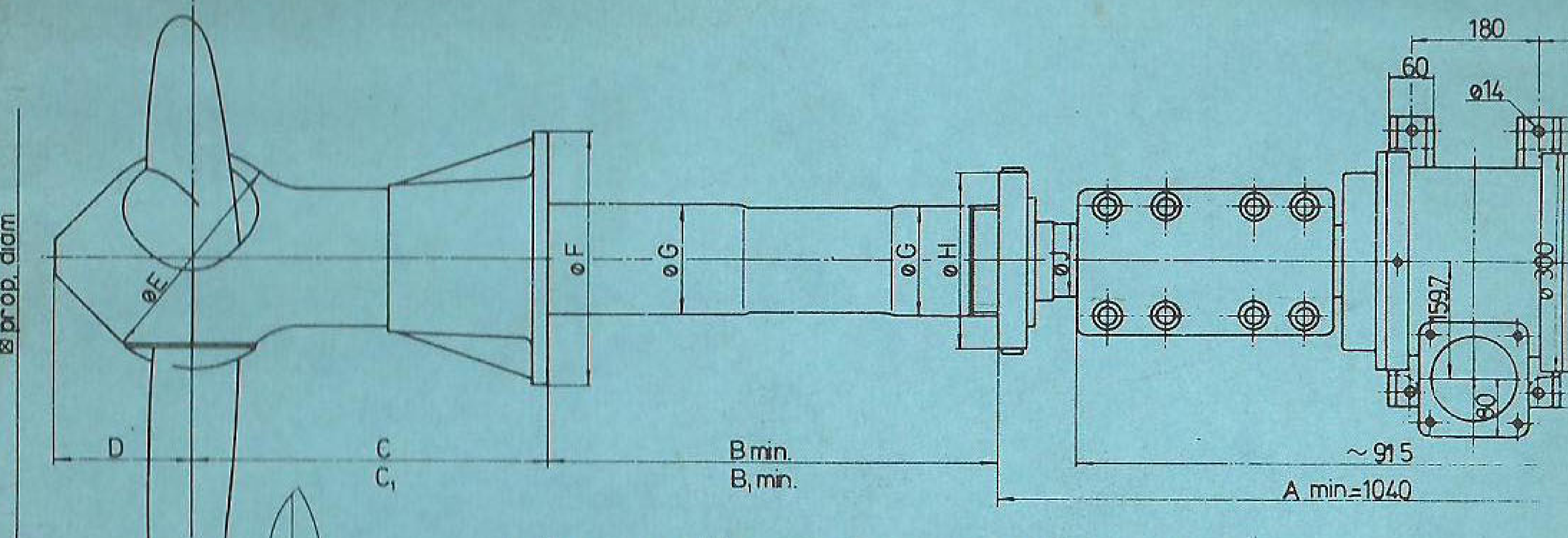
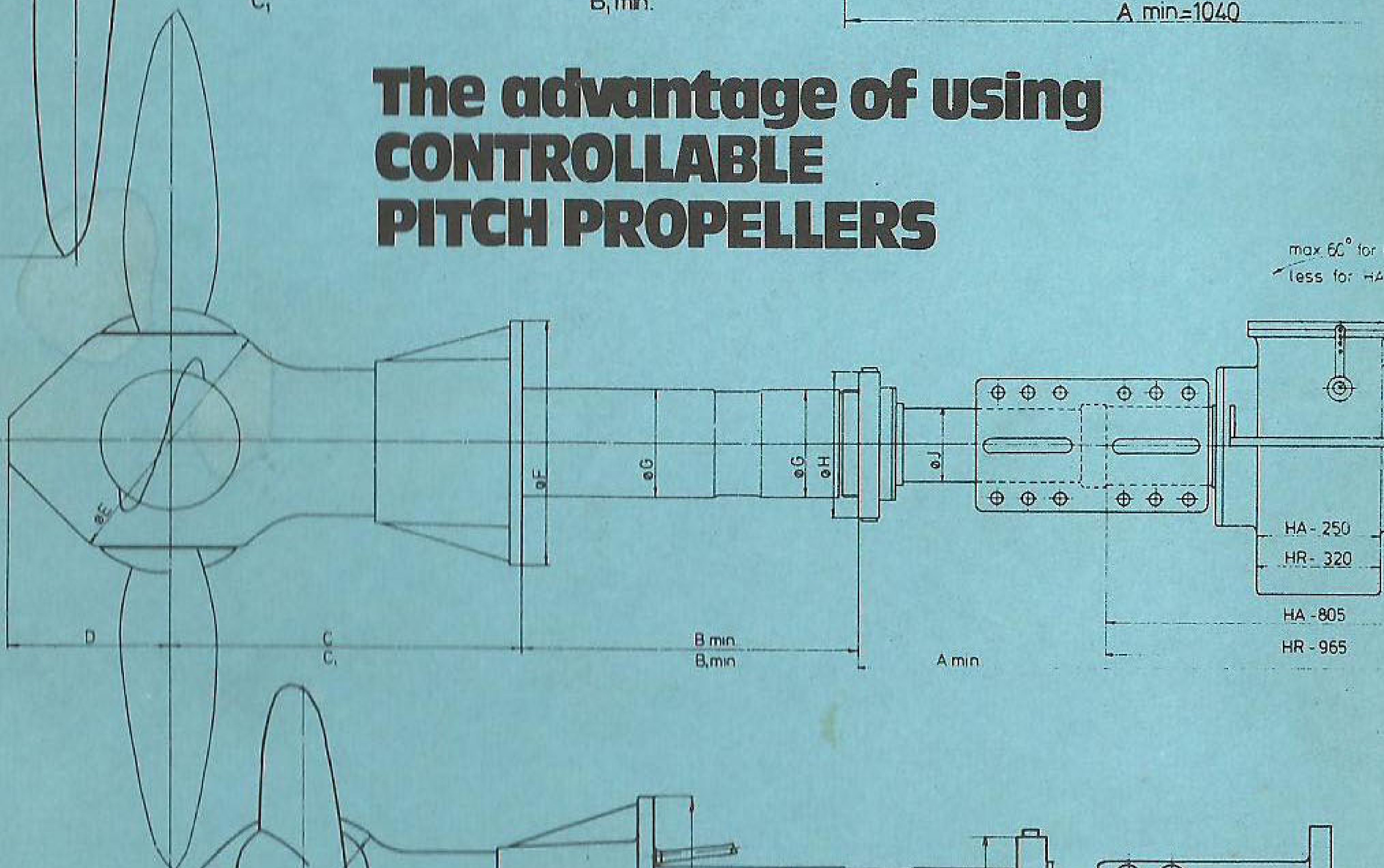
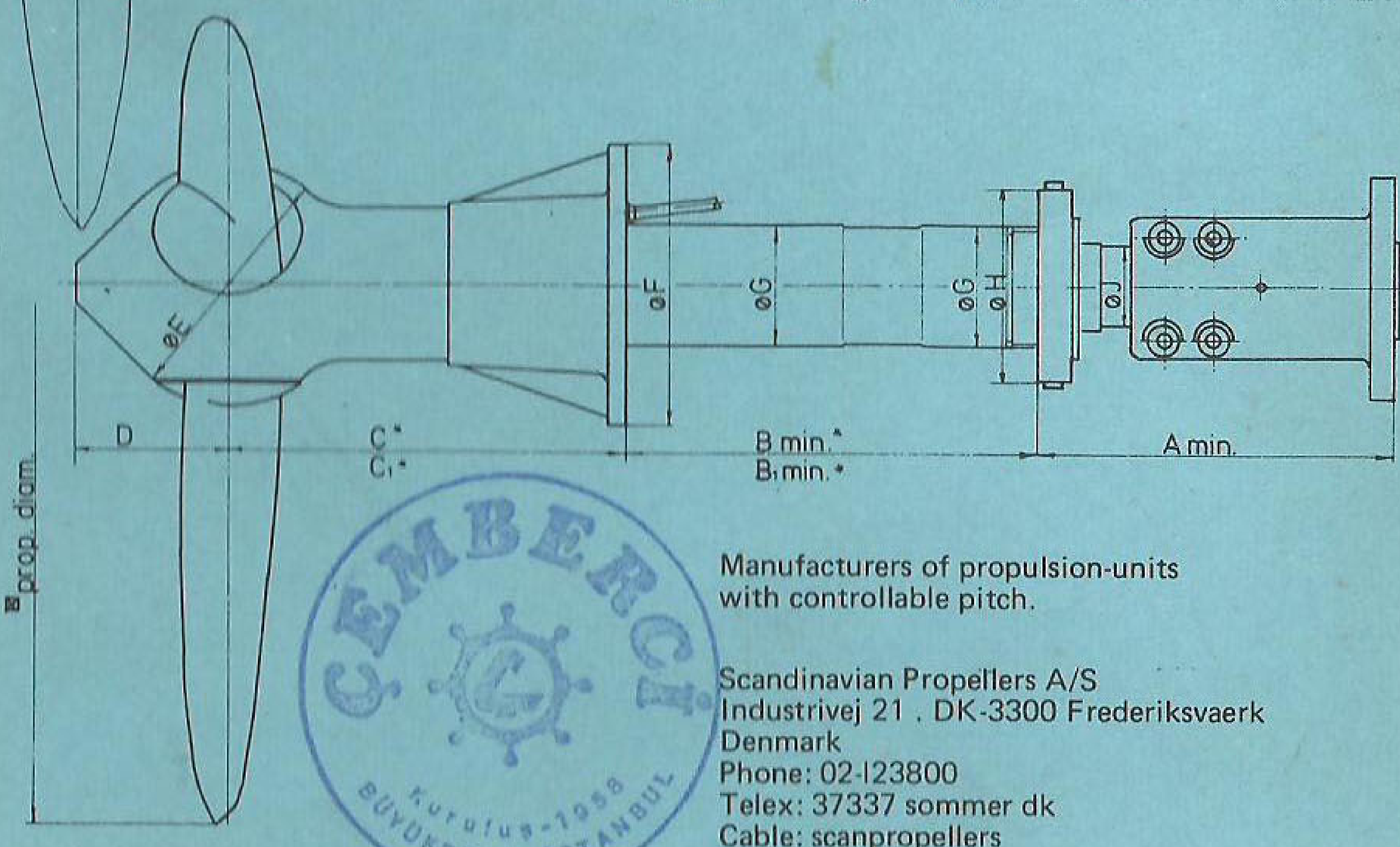


The advantage of using CONTROLLABLE PITCH PROPELLERS





Manufacturers of propulsion-units
with controllable pitch.

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Scandinavian Propellers a|s

CONTENTS

(1) Increasing world-wide interest in the controllable pitch propeller

Propellers with controllable pitch were introduced in Scandinavia more than 80 years ago, and the majority of Scandinavian fishing vessels have since then used this system.

The controllable pitch propeller has gradually spread over the world in applications ranging from diminutive open boats to huge vessels, with engines developing several thousand h.p.

The energy crisis has accelerated this move towards general and world-wide acceptance of the CP propeller, but some operators, who could obtain substantial advantages by using CP propellers, are still hesitant. This may partly be due to traditional local conservatism, and partly to various misconceptions, in some cases caused by confusing or exaggerated public statements for — or against — the CP system.

World-wide acceptance of the CP propeller is also being accelerated by the increase in auxiliary-power-loads, which are obtained through p.t.o.'s fitted on the main engine. Such auxiliary equipment calls for reasonably high and constant engine rpm, and this is possible, if manoeuvring of the vessel is carried out by change of propeller pitch.

(2) Who can profit by using a CP propeller ?

Any vessel operating under conditions causing variable resistance to forward motion will find good use for a CP propeller. Trawlers and tugs, and also freight vessels, which may alternate between running empty or heavily loaded, are all natural examples.

(3) Can any fuel saving be obtained by using a CP propeller ?

It might be tempting to claim that the use of a CP propeller will reduce the fuel consumption by 20 or 30%. A claim of this nature would, however, not be correct. There will always be an improvement, due to the fact that the engine can operate at its most economical combination of speed and load (see Fig.I), BUT it is more significant that the CP propeller can make full use of the available engine power, obtaining higher performance (higher trawling speed, resulting in better catch of fish, or higher towing speed with a tug, resulting in shorter time to tow an object).

An improvement in performance causes an unavoidable increase in fuel consumption per hour and this can easily overshadow a basic REDUCTION in fuel consumption per mile. The net result of using the higher performance is however improved overall economy, when the increased income created by the increased performance is compared with the total operating costs of the vessel. In other words: 3 fishing boats with CP propellers will often be able to provide the same amount of catch in a season, as 4 similar boats can do with fixed pitch propeller. Even if each of the 3 with CP propellers might be using more fuel than each of the 4 which have fixed propellers, then the net result IS improved economy and profit for the fleet.

(4) Basic principles behind the selection of a propeller

We will concentrate upon the requirements of typical heavy seagoing fishing vessels, and will examine the basic principles behind selection of a suitable propeller, where parameters, such as diameter, number of blades, blade area, and propeller shaft speed, all have to be taken into consideration.

<u>Choice of engine power ?</u>

The choice of engine has in most cases been made long before the propeller manufacturer is consulted with regard to supply of a propeller, which can make the best possible use of the available engine power.

Influence on the choice of reduction gear ratio is fortunately often possible at this stage, and early consultation with the propeller manufacturer on this point is strongly recommended, as it can give positive results with regard to future performance and economy.

<u>No need for »overpowering» a vessel</u>

The tendency has, in many countries, been to fit engines with 10 to 30% more power than justified by the hull dimensions (including the size of propeller aperture) and by the requirements of the fishing equipment.

This tendency to fit engines with too much power did not influence operating costs alarmingly in the days of cheap fuel oil, but it should be abandoned now, and it can in particular be abandoned, when controllable pitch propellers are employed. A vessel with controllable pitch can achieve the same results in terms of free-running-speed and trawling speed, as a vessel with a fixed pitch propeller, using an engine of for instance 20% higher horsepower. The vessel with controllable pitch propeller and smaller engine will use less fuel, the initial purchase price of the engine will be lower, and the cost of maintenance and repair of the smaller engine will also be lower than for the big engine.

Propeller shaft speed

A low speed propeller is generally desirable, as it will reduce the risk of cavitation and — at normal trawling speeds — result in maximum thrust from the energy provided by the engine.

Propeller diameter

Maximum diameter is also desirable: the biggest possible diameter must be used in order to allow the lowest possible propeller speed, these two basic parameters are always interconnected. Scandinavian vessels have, for this reason, always been designed with very small tip clearances, preferably 50 to 75 mm, but in many cases as little as 25 mm, combined with »cut-outs» in the keel.

Combination of diameter & rotational speed

A rough guide based on long experience is provided by the following formula:

$$\text{Diameter} = \left(\frac{\text{horsepower}^{0.2}}{\text{shaft speed in rpm}^{0.6}}\right) \text{ multiplied by } '\beta'$$

where 'β' is a constant to suit 3 blades, this constant being increased when using a 2-blade propeller and decreased for a 4-blade propeller.

Number of blades

This question is — as indicated above — also influenced by the max. diameter allowed by the shape of the hull.

3, 4 or 5 blades might be used on a fixed propeller, the number of blades f.inst. increasing, if diameter and rpm remain constant, while engine power is increased. CP propellers can either have 2, 3 or 4 blades, and towing power is better for a big propeller with few blades than for a smaller propeller with more blades.

Propeller tip speed

The tip speed is another factor which must be considered, as excessive tip speed will result in cavitation, which in its turn causes propeller corrosion (and fuel wastage).

A guideline for the vessels we consider here is not to exceed 36 mtrs/sec. when using standard blades (= 110 ft/sec.).

Higher tip speed may be allowed, but will require special blade design.

The various limits are often reached in modern trawlers, which generally have excessive engine power in relation to the size of propeller aperture (and thereby in relation to the maximum possible propeller diameter).

Profiles with »pitch release» towards the blade tip are incidentally generally recommended, thereby decreasing the danger of cavitation. (This applies only to free-swinging propeller without nozzle).

Blade area

The choice of ideal blade area is influenced by the number of blades, and the general principle is to choose a blade area which can keep the surface load down, and prevent cavitation created by water re-circulating from the thrust- (aft) face of the blades to the suction- (forward) face of the blades.

Interrelation between pitch, diameter, tip speed, and blade area

All the above factors are »interconnected», and some principles for the best relationships are already described. An additional rough guideline might be mentioned:-

Pitch/Diameter Ratio (P/D) to be between 0.6 and 1.0 for typical trawlers.

- P/D below 0.8: increase D by 10-15%
- P/D between 0.8 and 0.9: increase D by 5%
- P/D between 0.9 and 1.1: no influence on D
- P/D between 1.1 and 1.2: decrease D by 5%
- P/D higher than 1.2: decrease D by 10%

(5) Computer design

The guidelines quoted above are not sufficient for design of the optimum propeller, and the complex nature and interrelation of all factors involved has in fact been the subject of decades of intensive study by several research institutes.

Complicated formulas and curves have been created as a result of such studies, combined with a wealth of data, obtained not only in laboratories, but also during exhaustive tests in actual service.

Some of the world's leading Marine-institutes have created highly sophisticated computer programmes which can provide answers to questions on the subject of propellers, a process which previously would call for weeks of »hit and miss arithmetics» before the ideal propeller configuration for a given application could be decided upon.

Computer design by for instance the Hydraulic Institute of the Royal Danish Technical University (this Institute having a particularly high reputation for propeller design) is extremely expensive, but the result is a very exact blade design, consisting of a detailed 6 to 8 page list of ideal blade profile dimensions, including items such as bending stresses, surface loads and pitch variation (related to propeller shaft centre line distance).

All propeller blades used by SCANDINAVIAN PROPELLERS A/S are developed on the basis of such a detailed computer programme, giving assurance of optimum performance in every application.

The computer takes many more factors, than those we have mentioned above, into consideration, factors which we will not attempt to describe here, except for one: – the pitch variation.

A typical I metre diameter blade can have a pitch (at its trawling setting) which is varying from for instance 560 mm at the blade-foot increasing gradually to 804 mm and finally decreasing again to 785 mm at the blade tip. This decrease in pitch at the tip (called: »pitch relief») reduces the risk of water re-circulating round (or »over») the blade tip from the thrust side (aft side) to the forward side (suction side) of the blade tip.

The above describes some of the basic parameters used in the choice of a propeller, and underlines the fact that design of the optimum propeller blade – particularly for use on a CP propeller – calls for use of advanced methods, leaving nothing to chance.

(6) Controllable pitch – why is it the ideal solution ?

Controllable Pitch Propeller Systems (also known as: Variable Pitch, Reversible Pitch or Multi Pitch System) provide the only truly efficient method for obtaining optimum performance in vessels, operating under influence from a multitude of »variable factors».

Examples of »variable factors»:

- trawl nets of varying sizes (or of varying contents)
- trawl nets towed at varying depths, resulting in varying trawl resistance
- wind resistance
- waves
- hull loading (empty or full hold)
- sometimes even currents play a role: current on the surface, moving in opposite direction to the current at the sea bed, will result in variation in the trawl-wire-load, when trawling identical nets in opposite directions.
- power requirement for winch operation can restrict power available at the propeller shaft, a limitation which either can be compensated for by »slipping» a hydraulic clutch in order to reduce the speed of propeller rotation, or by reducing the propeller pitch on a controllable propeller.

<u>Engine characteristics</u>

One of the reasons for the superiority of the CP propeller lies in the great variations in fuel consumption over the operating range of any engine, depending on the combinations of engine speed and engine power utilized at any given moment. The effects of this are illustrated later in the text.

Parameters used

The parameters influencing engine load and boatspeed are specified as follows:

(1): – available engine power
(2): – propeller rotational speed
(3): – »boat resistance» (which expressed itself in (4))
(4): – shaft horsepower required to turn the propeller (influenced by (2) and (3))
(5): – boat speed through the water (influenced by (3) and (6))
(6): – propeller pitch

All factors are interrelated. The boat resistance is for instance influenced by the tension in the trawl wires and also by the pay-load carried in the hold, plus the resistance created by wind or waves.

Re: boat resistance

A moving vessel creates a certain »boat resistance», consisting of:

- hull resistance
- wind resistance
- wave-motion-resistance
- towing-load-resistance

Any specific boat speed will require a certain propeller thrust in order to be achieved, and this propeller thrust can be obtained with different combinations of rotational speed and pitch, ranging from high rotational speed with modest pitch to low rotational propeller speed with coarse pitch, or a multitude of variations between such two extremes.

The relationships between propeller speed and engine speed is normally constant, a two-speed reduction gearbox or hydraulic »slip-arrangement» can however allow the propeller to rotate slower, than it normally would do. A »slip-system» causes energy wastage demonstrated by the cooling required for the transmission oil.

A two-speed gearbox suffers from another limitation:
The propeller can never be ideal, – if it for instance is designed for trawling while the high ratio is engaged, then the propeller is of excessive diameter for free running, when the low ratio is engaged. The opposite applies if the propeller is made ideal for free running, it can then not be ideal for trawling. A two-speed gearbox is therefore a solution which does not achieve the same economy as a controllable pitch propeller.

The choice of ideal propeller speed and ideal pitch is governed by two parameters:

- *Propeller-efficiency:* (and thereby again fuel economy), i.e. the level of efficiency at which shaft horsepower is transformed into thrust in water. Too coarse a propeller pitch compared with the boat speed is inefficient (and may also cause harmful cavitation), while too fine a pitch in its turn also can be inefficient.
- *Engine-efficiency:* the rotational speed and relative load decide fuel economy. Time is however also a factor to be taken into account, and a high boat speed is generally preferred.
  Operation with a »fairly high» load and a »fairly high» speed often ensures good over-all economy, and a good »rule of thumb» is to use the engine at 80-90% of max. rpm developing slightly less than the highest power available at that speed.

Change in trawl-resistance (ref. Fig. IV and VI)

Any trawl will create a steady increase in the resistance against its motion through the water, as it gradually is filled with fish.

A vessel with fixed pitch propeller will – in this situation – experience a corresponding reduction of the obtainable engine speed. This reduces in its turn the available power, causing a further drop in speed, a process which continues to accelerate.

A vessel with CP propeller can counteract the increased trawl-load by a gradual decrease in pitch, allowing the engine to continue to run at its optimum speed. The reduction in boat speed is in this case negligible compared with the situation for a vessel with fixed pitch propeller, and a greater amount of fish is consequently caught by the vessel with CP propeller during a given period of operation.

Fuel economy related to engine power actually used

Fig. I illustrates fuel consumption curves at any combination of speed and load for a typical diesel engine, and it is noticeable that the lowest specific fuel consumption per horsepower is provided close to full load and at an engine speed roughly equal to 2/3 of max. engine speed.

The area called »100%» represents the best possible fuel economy for the engine in question. The economy is poorest at the highest (and at the lowest) rpm and is — at all rpm — poor at low loads.

If fuel economy was the only point to consider, then we would operate in the area marked »100%» in Fig. I.

The capital investment in the whole ship and its equipment plus the running costs — including wages to the crew — makes it however necessary to load the engine harder in order to enable the vessel to catch as much as possible in any given period of time.

Therefore we choose to operate in the »shaded» area in Fig. I. Most engines will work happily near to the max. output (but »eased off» slightly below the max.) and the fuel economy (the amount of fuel used per horsepower produced) is in this »area of operation» close to the optimum available.

The »ideal area of operation» lies consequently between 80 and 90% of max. rpm and slightly below the full available power at this speed.

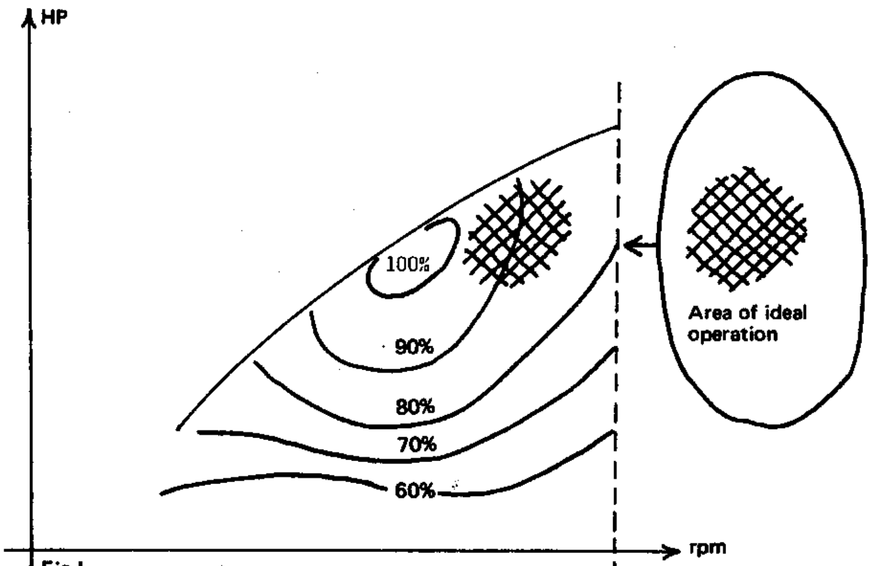


Fig.I

Fuel economy at varying rpm and loads expressed as percentage of best possible fuel economy.

Horsepower required to rotate (»turn») a propeller

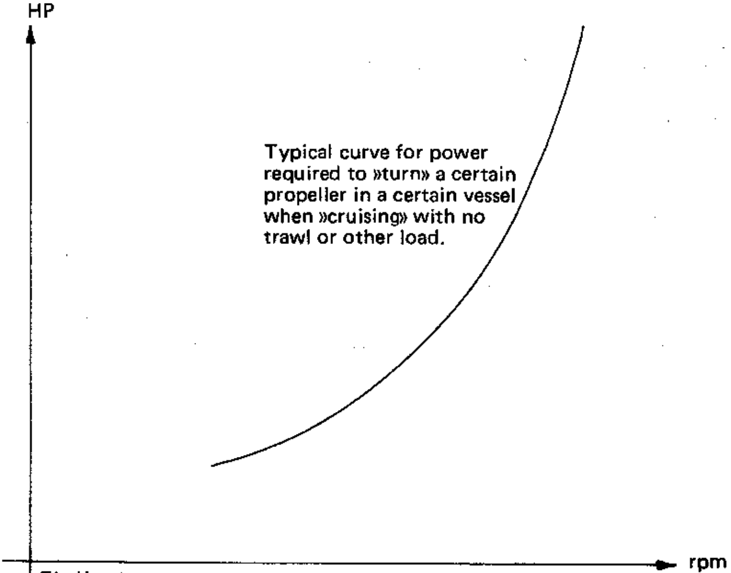
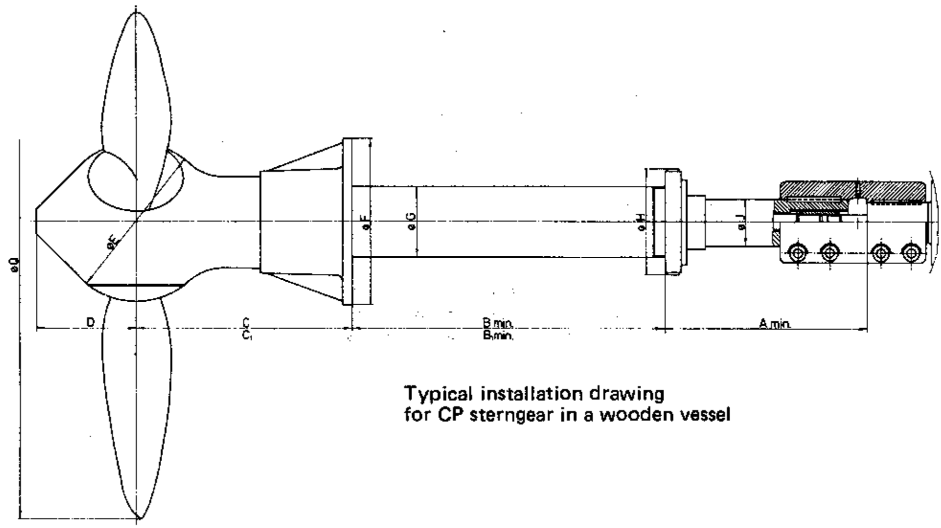


Fig.11



Typical installation drawing
for CP sterngear in a wooden vessel

Power required to »turn» a propeller with a given diameter and blade area using gradual change of pitch, all on a certain vessel

Fig. III, below is an illustration of how the power required to turn a propeller of a given diameter and blade area will vary depending on the pitch chosen for such a propeller.

(Dotted line situations not obtainable due to insufficient engine power at rpm in question)

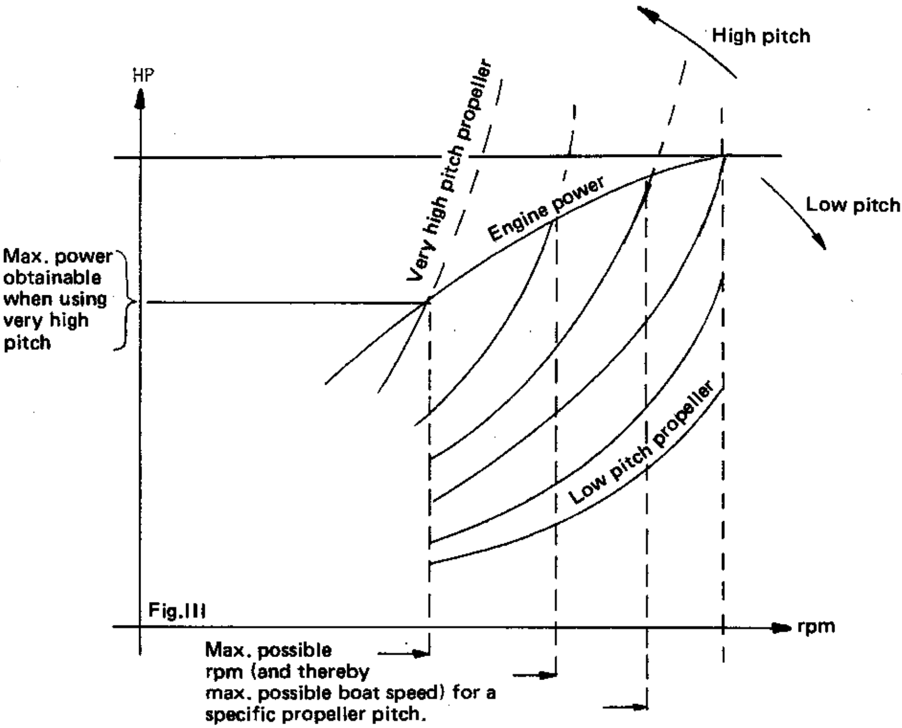


Fig.III

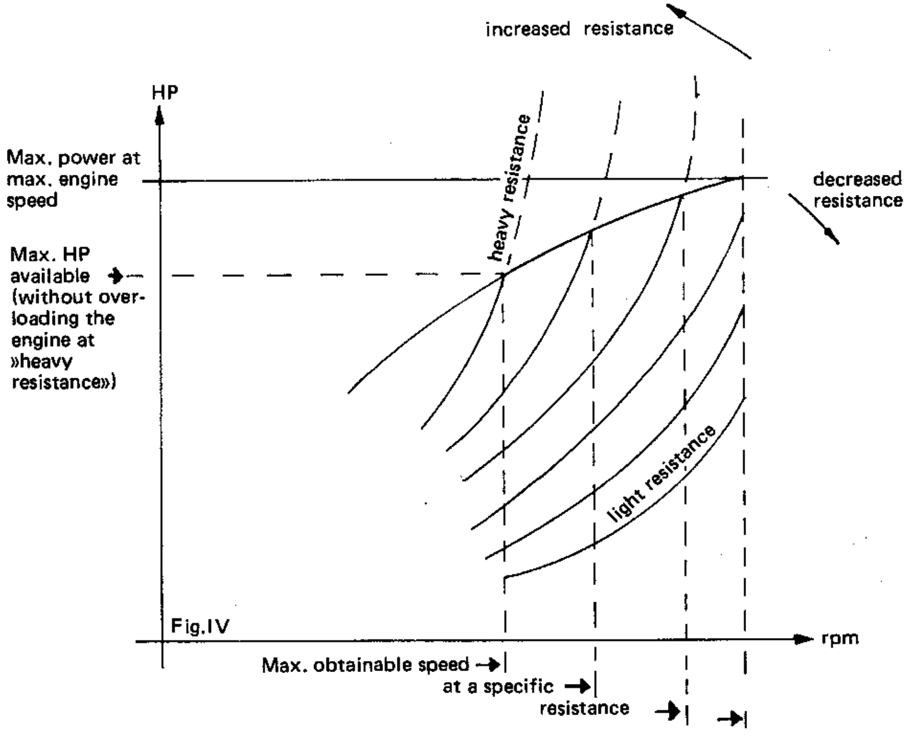
»Fixed items»:
- boat resistance
- available engine power

»Variable item»:
- propeller pitch

Conclusion:
- power required to turn propeller at constant engine speed varies with pitch
- (maximum possible boat speed varies correspondingly)

Situation using fixed pitch propeller and encountering variable boat resistance
(Resistance can vary greatly: trawlnet out or not, headwind or following wind etc.)

The »propeller curve», (showing the horsepower requirement for turning a given propeller) represents the horsepower required when the vessel causes a certain »boat resistance», in other words the power required to turn a given propeller depends on how »difficult» it is to push the boat in question through the water at any given moment. If it is easy to push the boat through the water, even at fairly high speed, then the power required to turn the propeller is not very high. If, on the other hand, the vessel is extremely difficult to push through the water, then the horsepower required to move the vessel by swinging the given propeller will, of course, become much bigger, and illustration IV should clearly demonstrate this situation.



»Fixed items»:
– propeller pitch
– available engine power

»Variable item»:
– boat resistance

Conclusion:
– the power requirement depends on the boat resistance

Fixed (single pitch) propeller for steaming ('free running') chosen for max. boat speed

Fig. V is a typical representation (as made by a ship designer) illustrating the ideal propeller for steaming, using all the available engine power at the max. rpm.

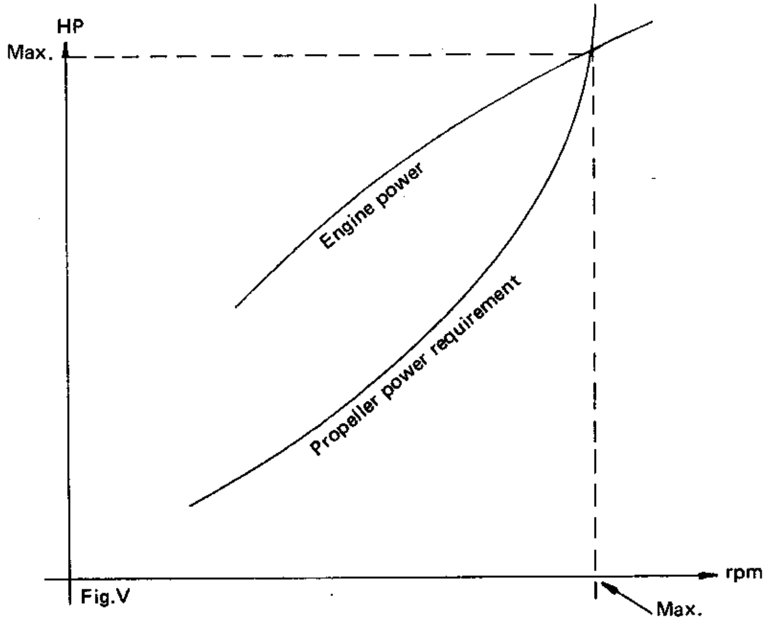


Fig.V

»Fixed items»:
- available engine power
- propeller pitch

Presumed to be »fixed»:
- boat resistance
- power requirement in relation to rpm (and to boat speed)
  (these can however vary due to changes in wind, waves and load in fish hold)

Conclusion
- fine, as long as nothing starts to change ......

Fixed (single pitch) propeller chosen for max. boat speed ('free running'), but now used for trawling

The propeller illustrated in Fig.V is now used for trawling, i.e. we are using it in a situation, where the boat resistance has increased. It is consequently not possible to push the engine to its max. rpm. We are limited to a lower rpm, and to a correspondingly lower horsepower, and the engine is furthermore labouring hard.

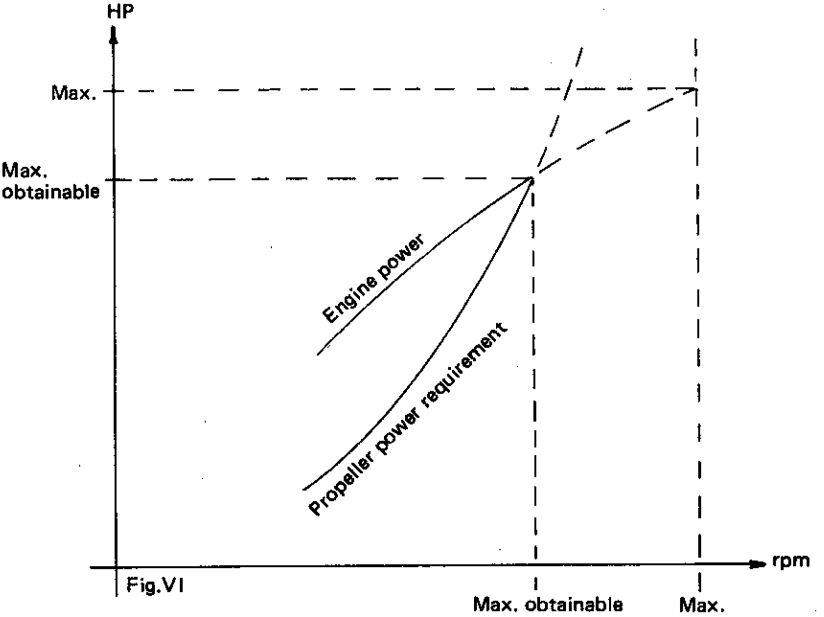


Fig.VI

»Fixed items»:
- available engine power
- propeller pitch
- boat resistance in relation to rpm
- boat speed in relation to rpm

»Variable»(?):
- Nothing (except wind, waves, current, trawlwire load etc.)

Result:
- Poor performance, as engine is labouring hard at a low speed

Fixed (single pitch) propeller chosen for trawling and (in this example) also used for trawling

Fig.VII illustrates a solution to the loading problem when trawling, which could be a propeller which is ideal for trawling, so that max. rpm (and thereby max. horsepower) can be used. (The chances of 'hitting' those exact ideal combinations of pitch, diameter and area are however extremely remote.)

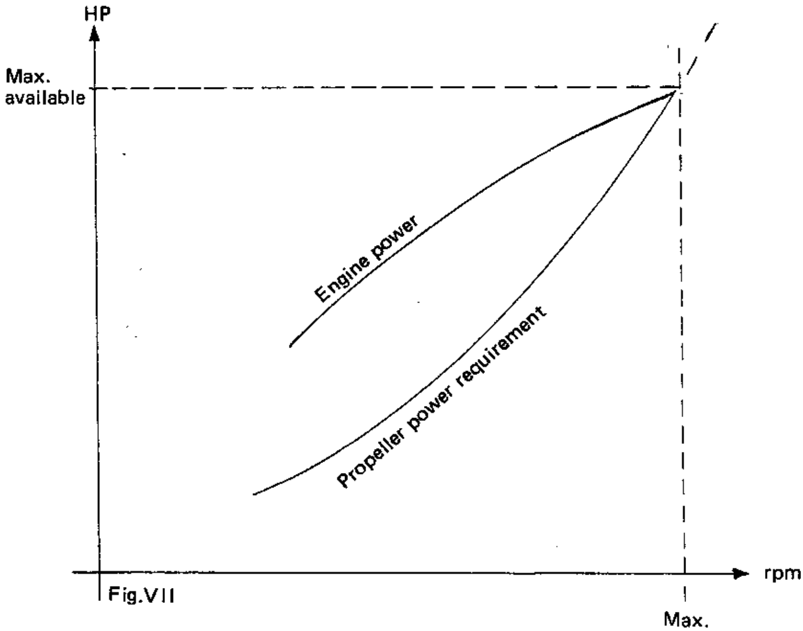


Fig.VII

»Fixed items»:

— available engine power
— propeller pitch
— boat resistance in relation to rpm

»Variable»(?):

— »Nothing» (except: wind, waves, current, trawlwire load etc.)

Result:

— fine trawling-performance (but insufficient speed when 'steaming' see Fig.VIII)

Fixed (single pitch) propeller chosen for trawling, but used for steaming ('free running')

Fig.VIII illustrates the unsatisfactory result when steaming with a propeller, which has been designed for trawling only. We cannot make use of the full horsepower from the engine at max. rpm, as the propeller is »underpitched», and we are not obtaining the steaming speed we would like.

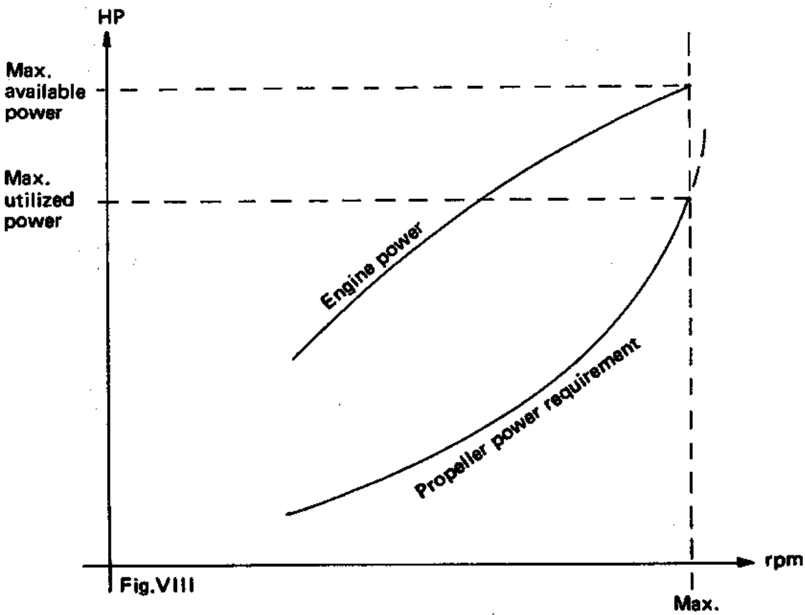


Fig.VIII

»Fixed items»:

- available engine power
- propeller pitch
- boat resistance in relation to rpm
- boat speed in relation to rpm

»Variables»(?):

- Nothing (even if wind and waves vary, then the boat speed will hardly change)

Result:

- low speed

»Ideal» 2-pitch propeller when steaming (free running)

One possible solution would be to have a two pitch propeller. Fig.IXa shows two fixed pitch positions, a high position and a low pitch position.

(max. engine speed is however NEVER used for extended periods, therefore situation remains theoretical)

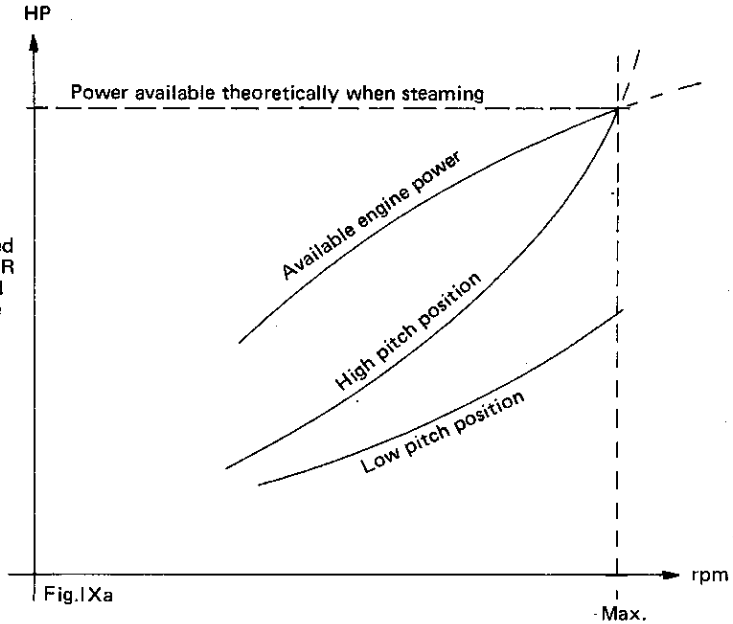


Fig.IXa

Fig. IXb indicates how unsatisfactory a two pitch propeller can be (just as a single pitch propeller) and the general habit of operating somewhat below the max. rpm for the engine excludes the possibility of utilizing the available power properly, as the propeller is »under-pitched» for use at speeds below the max. rpm. An alternative could be to have an »over-pitched» propeller for steaming, but most operators and ship designers are reluctant to choose such a combination.

Power utilized at actual rpm used is only:

Actual practice: Engine is operated below max. rpm and available power is not utilized.

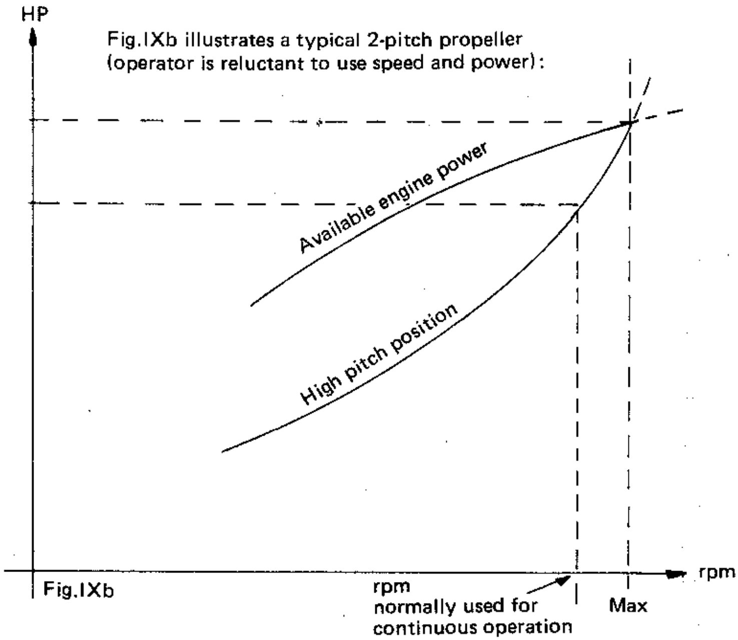


Fig.IXb

(7) Nozzles

Propeller nozzles are also able to provide increased propeller thrust together with controllable pitch propellers, and this is in particular the case if a reversgear is incorporated, as the range of possible propeller pitch changes can be restricted to the »ahead-mode» only. (Fully reversing propeller blades of the fashionable wide »Kaplan-style» often used in nozzles would require a fairly big clearance between the nozzle and the outer tip ends to allow the blades to swing through the »zero-pitch» position, and such increased clearance will reduce the obtainable level of efficiency from the nozzle).

Improved propeller thrust results in improved economy (either obtained by the increased trawling speed possible, or obtained by reduced fuel consumption with unaltered trawling speed), but nozzles can ONLY provide such improved propeller performance, if the shape of the hull will allow the max. obtainable nozzle diameter to be only slightly less than the max. possible diameter for a free swinging propeller.*

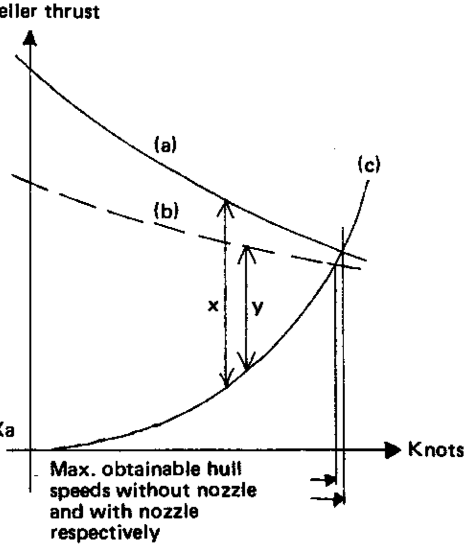
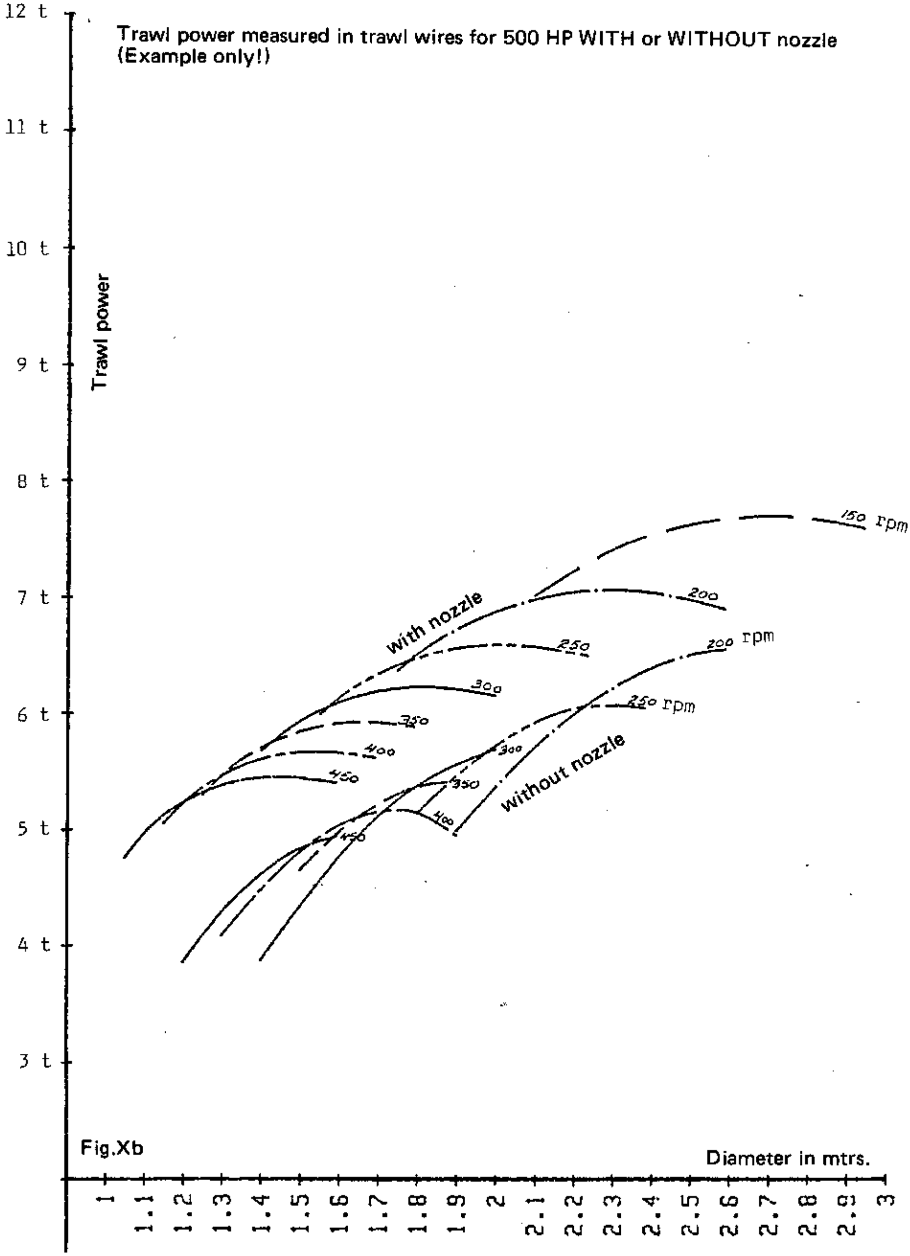


Fig.Xa

(a) = thrust available with nozzle
(b) = thrust available without nozzle
(c) = thrust required to push bare hull through the water
x = Difference between (a) and (c) represents the thrust available for the trawl wires at the speed in question, and with a nozzle.
y = Difference between (b) and (c) represents the thrust available for the trawl wires at the speed in question, and without nozzle.

* The above mentioned diameter requirement must be fulfilled in order to justify a nozzle, but there are in any event a few additional advantages which can be obtained by using a nozzle, and they can be listed as follows:

- reduced propeller noise and vibration
- protection against fouling of propeller by nets or wires
- reduced pitching of hull in heavy swell



Notice that f.inst. 2.6 mtrs dia and 200 rpm will give 6.6 t for the free propeller (lower set of curves). This is also obtained by a nozzle propeller of 1.85 mtr diameter (upper set of curves) while a nozzle propeller of f.inst. 2.3 mtrs will provide 7.1 t at 200 rpm.

(8) Variable pitch is the best of several compromises

A vessel equipped with fully variable pitch propeller can – as explained – operate at any point in the whole »area» represented by a fine meshed »net» of »propeller power absorption curves», and a typical method of operation can be described as follows:

(1) – set engine to maximum speed
(2) – increase propeller pitch gradually, until engine is working at its max. allowable continuous load, (use »engine load meter», or fuel consumption meter, or exhaust temp. gauge to find the max. load, or simply detect slight drop in max. engine speed).
(3) – reduce engine revs. fractionally (say 5%), if you wish to give the engine an easier life, 5% down in revs. will mean app. 8% down in load.
(4) –check again on exhaust temp. or similar indicator.

This procedure will allow the engine to give optimum performance, without »labouring too hard», as it is operated slightly below the highest available power.

The above is the method to obtain the best TOTAL economy (where fuel cost and other operating costs are included), except in the free running condition for a vessel which has excessive engine power in relation to the natural speed of the hull.

Such a vessel (with f.inst. an engine giving max. power at 1800 rpm) might achieve its most economical cruising speed at f.inst. 1300 rpm with a fairly high propeller pitch.

The procedure is the same as described above, except that 1300 rpm is regarded as »max. speed».

If such a vessel runs parallel with a sistership of similar engine power, but fitted with a fixed pitch propeller, then the sistership will have to run its engine close to max. rpm to achieve the same speed, and it will use more fuel and wear the engine out sooner, than the vessel with CP propeller.

All alterations to the CP propeller, which are intended to cater for the varying conditions in vessels, which sometimes are cruising, and sometimes are pulling a heavy load, are unavoidably compromises.

Gearboxes with »slipping clutches» will unfortunately cause fuel wastage (although such gearboxes in some applications can be very good in combination with a controllable pitch propeller), and gearboxes with two different ratios represent an unsatisfactory compromise, catering for only two sets of rigidly determined operating conditions.

The same applies to two-pitch propellers, where only two modes of operations can be used, while the fully controllable pitch system provides a multitude of settings, catering for the unavoidable variations in trawling load and other load factors.

One may compare the two pitch system to a heavy long distance truck, with only two gears in the gearbox, this arrangement is of course better than a gearbox with only one ratio (which can be compared to the standard fixed pitch propeller), but the best solution for a long distance truck is a 12 speed or a 16 speed gearbox, where the driver always is able to choose the ratio which is most suitable for the load on the vehicle and the gradient of the road.

An argument in favour of the two pitch system, which sometimes is mentioned, is that it prevents its operator in the vessel from »overpitching» the propeller, but the same argument would not be accepted by a truck owner, as a good reason to choose a two speed gearbox instead of a 16 speed gearbox. The truck owner would, if necessary, educate the truck driver to use the 16 speed gearbox correctly, and a fishing boat owner would educate the skipper in a similar manner to use the controllable pitch propeller correctly.

Reference can finally be made to the latest type of gearbox, containing a reversgear together with a hydraulic mechanism for control of the propeller pitch. It is with such a gearbox not necessary to be able to use reverse pitch, as is the case with the traditional solution, where a controllable pitch propeller is combined with a reduction gear with no reversgear. The range of possible pitch settings can therefore be restricted to ahead (from zero pitch to max. high pitch) only, resulting in the ability to achieve not only the two settings which are provided by a two pitch system, but any setting between the two, plus pitch settings above or below the only two settings available in the two pitch system

Controllable pitch is – as explained – the best of all possible compromises for obtaining max. overall efficiency in a trawler, as it offers the operator the great advantage of being able to select a pitch setting in accordance with exactly those conditions which are ruling at any given moment. Safety against overpitching by an inexperienced operator can – if required – be obtained by restriction of the movement of the hydraulic pitch control mechanism, thereby preventing selection of a pitch, which is too high.

(9) CP propellers are robust

Some operators not familiar with controllable pitch propellers may fear that such propellers are more complicated, or more vulnerable than fixed pitch propellers. Some designs – NOT constructed in Scandinavia – are admittedly complicated with many seals and often with oil lubrication of the propeller hub. This is however not the case for the designs from SCANDINAVIAN PROPELLERS A/S, as these designs are based on generations of experience, and use a safe and very simple lubrication system with water soluble grease in the hub, a solution which accepts (and even welcomes) penetration of water, so no complicated seals are required. Experience furthermore shows that the system has a long life, and blades can be multilated in accidents and crippled beyond recognition, without breaking the blade feet or damaging the hub.

Individual blades can furthermore be replaced promptly (even under water), so that the vessel immediately can operate again, while the damaged blades are being repaired.

Sound and simple design of the propeller shaft furthermore guarantees against corrosion and ensures a long life, combined with easily replaceable liners for the bearings.

The modern controllable pitch propellers from SCANDINAVIAN PROPELLERS A/S are therefore very robust and very easy to service and maintain.

(10) Summary

The conclusion is obvious:

Unless a vessel always is operating with constant boat resistance, then a variable pitch propeller provides optimum flexibility and manoeuvrability together with optimum overall economy.

The more the boat resistance can vary, the more pronounced is the need for a fully controllable pitch propeller.

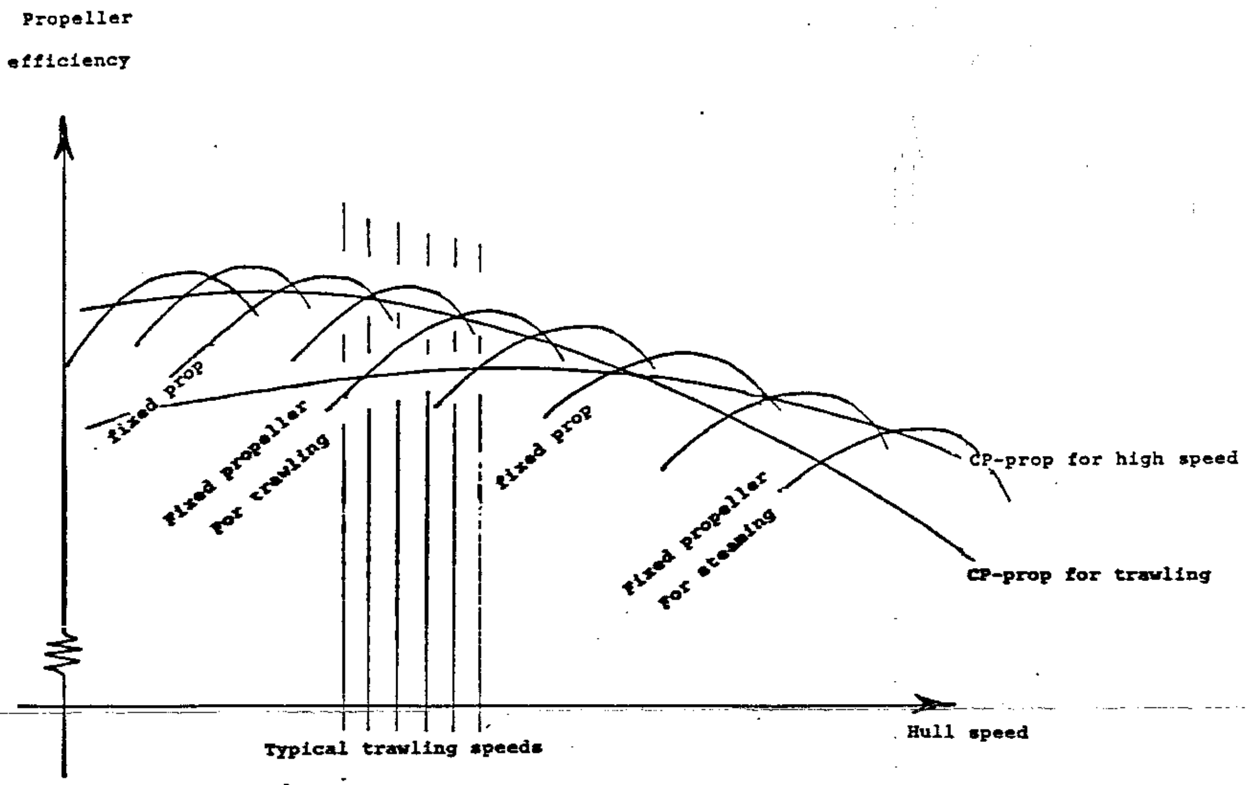
Two speed gearboxes, two pitch propellers, slipping hydraulic clutches and similar solutions can only be described as »half-hearted» attempts to reach the goal: A system achieving maximum efficiency under all operating conditions.

PROPELLER EFFICIENCY:

Naval architects may ask about propeller efficiency comparisons between CP-propellers and fixed propellers.
To compare the efficiency of a CP-propeller with the efficiency of a fixed propeller is difficult, as factors such as rpm, hull speed and total resistance all have to be taken into account, but the following might serve as an answer:

Any fixed pitch propeller has an optimum efficiency at a "designed" hull speed plus a "designed" rpm.
This efficiency falls off rapidly when a fixed propeller is used at a hull speed and/or rpm other than the ideal.
The CP-propeller is - in comparison with each of the "ideal" fixed propellers - at a slight disadvantage, when operating at the hull speed and the rpm which is ideal for this particular fixed propeller, and this disadvantage is due to the CP hub diameter and due to the fact that the CP-blades always are designed as a compromise, to suit a range of pitch settings.

The CP-propeller will however, under varying conditions, always be better than any "unsuitable" fixed propeller and will only be inferior to the "one and only" fixed propeller which is designed to suit "one situation only".



A CP-propeller can be designed with blades which are particularly good for high hull speeds, or with blades which are particularly good at trawling speed.