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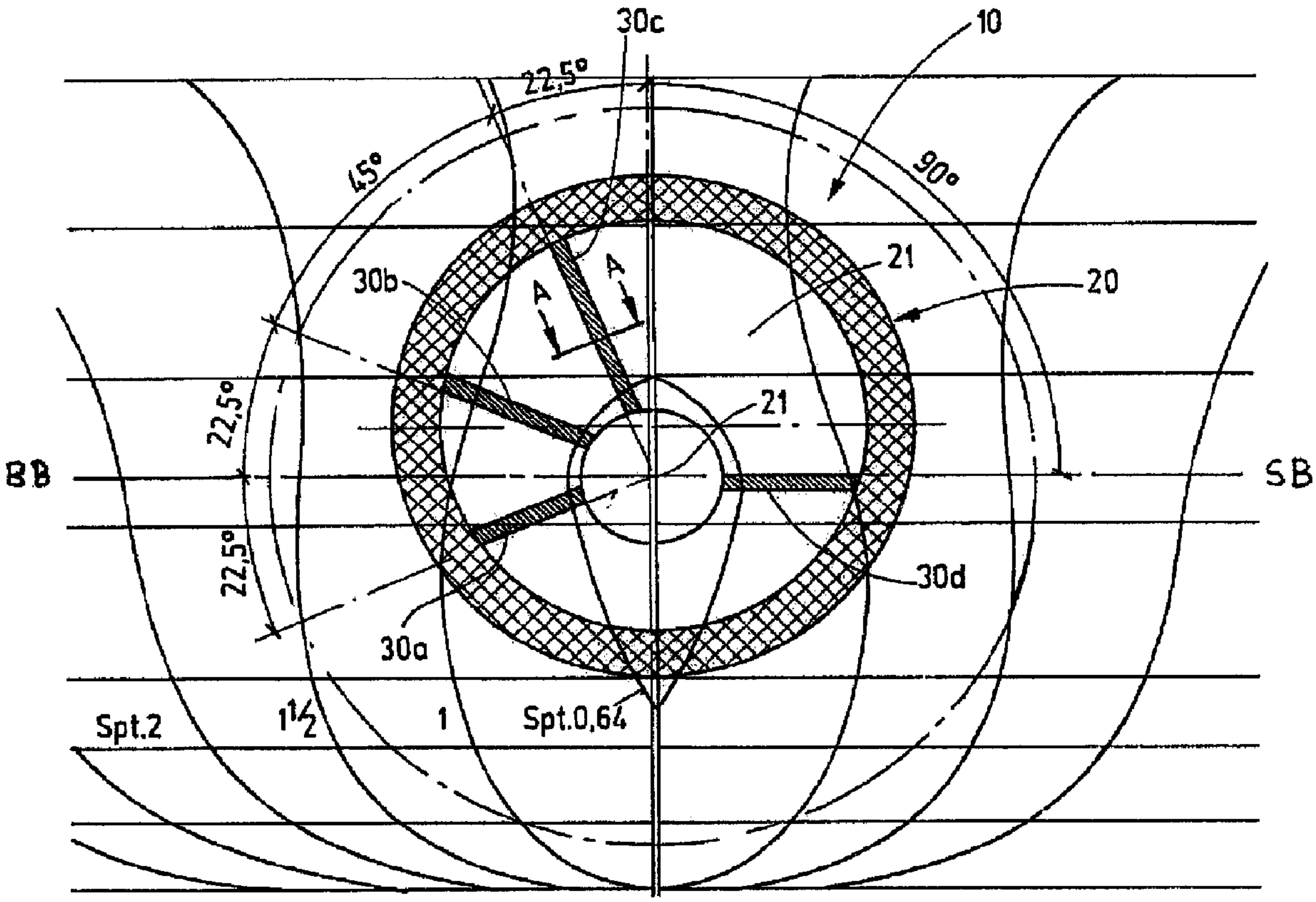
(54) Title: DEVICE FOR REDUCING THE POWER DEMAND FOR THE PROPULSION OF A SHIP



(57) Abrégé/Abstract:
A device (10) for reducing the power demand for the propulsion of a ship, and for broad-built or non-broad-built not-very-fast ships of any type is de- signed in such a way that the device (10), which is affixed to the hull (100) at a short distance upstream of the propeller, comprises a fore-nozzle (20) with fins or hydrofoils (30; 30a, 30b, 30c, 30d) that are arranged within the fore-nozzle, wherein the fore-nozzle, at the top, can be tilted forwards, pref- erably by up to 8°, on a horizontal transverse axis that extends through the centre of the fore-nozzle.

Abstract

A device (10) for reducing the power demand for the propulsion of a ship, and for broad-built or non-broad-built not-very-fast ships of any type is designed in such a way that the device (10), which is affixed to the hull (100) at a short distance upstream of the propeller, comprises a fore-nozzle (20) with fins or hydrofoils (30; 30a, 30b, 30c, 30d) that are arranged within the fore-nozzle, wherein the fore-nozzle, at the top, can be tilted forwards, preferably by up to 8°, on a horizontal transverse axis that extends through the centre of the fore-nozzle.

(Fig. 2)

Device for reducing the power demand for the propulsion of a ship

The invention relates to a device for reducing the power demand for the propulsion of a single-propeller or multi-propeller ship, in particular for broad-built or non-broad-built ships that are not very fast.

From DE 42 23 570 C1 a flow guide surface for a controllable-pitch propeller is known. This flow guide surface provides for a ring-shaped nozzle that is arranged upstream to influence the flow in the manner of a diffuser. To this effect deceleration of the flow in the near region, and acceleration of the flow in the outer region is carried out. The diffusor diameter is smaller than 65% of the propeller diameter. Such a nozzle is designed as a deceleration nozzle or diffuser with an outwardly curved ring-shaped nozzle. This diffusor decelerates the flow in its region, which can only result in an improvement of propulsion efficiency if very thick hubs are used, such as in the case of controllable-pitch propellers. Such a nozzle is thus not designed as an acceleration nozzle with an inwards curvature of the ring-shaped nozzle. The nozzle presented in the above-mentioned printed publication thus does not accelerate the flow in its region, and is not suitable for all propeller types, in particular it is not suitable for fixed propellers. DE 42 23 570 C1 does not describe an effective principle of a fore-nozzle, which principle consists of increasing the propeller flow speed in regions where the main stream is very high.

From JP 07 267189 A a propeller arrangement comprising a ring-shaped nozzle and fins that are arranged in a star-shape is known. The propeller diameter approximately corresponds to the ring diameter of the nozzle.

JP 58 000492 A shows a further propeller arrangement which is said to result in an improvement in the efficiency and a reduction in the power demand for propulsion. This arrangement also comprises fins, as well as a structure comprising six elements arranged in a honeycomb-like manner.

It is the object of the present invention to create a device that serves to reduce the power demand for the propulsion of a ship. Some embodiments may provide an improvement in the efficiency, and matching of the fins or hydrofoils to the flow. Some embodiments may provide an improved flow against the propeller.

According to an aspect of the present invention, there is provided a device for reducing the power demand for the propulsion of a single-propeller or multi-propeller ship, wherein the device is attached to a hull of the ship proximal and upstream of the propeller, said device comprising a fore-nozzle with fins or hydrofoils that are arranged within the fore-nozzle, wherein a top of the fore-nozzle is tilted forwards relative to a horizontal transverse axis that extends through the center of the fore-nozzle, wherein the internal diameter of the fore-nozzle is less than 90% of the propeller diameter, and wherein the fore-nozzle is arranged rotationally symmetric about an upwards-shifted axis, said upwards-shifted axis is situated above the propeller axis.

According to the above, the device according to the invention is designed in such a way that the device, which is attached to the hull at a short distance from the propeller, comprises a fore-nozzle with fins or hydrofoils that are arranged within the fore-nozzle, wherein the fore-nozzle, at the top, can be tilted forwards, in some embodiments by up to 8°, and, in some embodiments on a horizontal transverse axis that extends through the centre of the fore-nozzle.

With a device designed in this manner it is possible to reduce the power demand for the propulsion of a ship. The possible gain increases as the extent of thrust loading on the propeller increases. The device is particularly suitable for slow, broad-built ships, such as tankers, bulk transports and tugs, and also for not-very-fast ships of any type. The device itself is affixed to the hull so that it is upstream of the propeller of the ship, with said device comprising the two functional elements of fore-nozzle and fins or hydrofoils.

In this arrangement the effective principle of the fore-nozzle consists of increasing the speed of the flow against the propeller in areas where the main stream is very high, and of decreasing the flow against the propeller in areas where the main stream is low, wherein the nozzle itself generates thrust, while the effective principle of the fins or hydrofoils arranged within the fore-nozzle consists of generating a pre-swirl, wherein both functional elements target different sources of losses, namely the fore-nozzle aims at a reduction in the effective thrust loading, and the fins or hydrofoils target a reduction in the swirl losses in the propeller stream. Both effects result in an increase in the efficiency of the propulsion system.

As a result of the device being affixed as closely as possible upstream of the propeller, the best-possible effect is achieved, even in different load cases.

In addition to the above, the device according to the invention is not only suitable for broad-build ships; it can be used to the same effect in the case of all ships that are not very fast, for example V ≤ 25 kn. The use of the device in very large container ships is also possible.

In order to achieve the best-possible effect, the trailing edge of the device or of the fore-nozzle is affixed no further than 0.3 times the propeller diameter upstream of the propeller plane. Preferably, at the top, the fore-nozzle is tilted forwards by approximately 4°.

According to a further embodiment, the fore-nozzle is laterally rotated, on a vertical axis that preferably extends through the centre of the fore-nozzle, such that the fore-nozzle is tilted forwards on the upwards-beating side of the propeller.

Some embodiments provide for the fore-nozzle to be laterally rotated by up to 3°, preferably by 1°, on a vertical axis that preferably extends through the centre of the fore-nozzle, such that the fore-nozzle is rotated forwards on the upwards-beating side of the propeller, wherein rotation can also be 0°, but not in the other direction.

Furthermore, some embodiments provide for the thickness of the profile of the fore-nozzle to be less than 12% of its length. Advantageously, the thickness of the profile of the fore-nozzle can be 7.5% or 9% of its length.

A further embodiment provides for the fins or hydrofoils in radial direction to comprise a variable angle of incidence, wherein the fins or hydrofoils are twisted such that said fins or hydrofoils on the inside of the ship are directed upwards, with the angle of incidence decreasing on the outside towards the fore-nozzle.

Thus the fore-nozzle is rotation-symmetrically arranged with an upwards-shifted axis that is preferably situated above the propeller axis, wherein the internal diameter of the fore-nozzle is at most 90% of the propeller diameter.

Preferably, four fins or hydrofoils are arranged asymmetrically within the fore-nozzle, and radially to the propeller axis, wherein the fins or hydrofoils connect the hull to the fore-nozzle and are arranged at the rear end of the fore-nozzle, wherein the curved side of the hydrofoil-shaped and also lenticular cross-sectional profile of the fin or of the hydrofoil is directed upwards on the upwards-beating side of the propeller, and is directed downwards on the downwards-beating side of the propeller. However, the arrangement of four fins or hydrofoils in the interior space of the fore-nozzle is not to be interpreted as a limitation; it is also possible for a smaller number or a greater number of fins or hydrofoils to be provided.

The drawing shows exemplary embodiments of a ship with a propeller of the device according to the invention, which propeller at the top rotates towards starboard, as follows:

Fig. 1 in a lateral view from starboard the device according to an embodiment of the invention, which device comprises a fore-nozzle with fins or hydrofoils that are arranged in the interior space of said device;

Fig. 2 a rear view of the device, wherein the fins or hydrofoils are shown without incidence;

Fig. 3 an enlarged cross-section of the profile of a fin or a hydrofoil;

Fig. 4 a lateral view of the stern contour;

Fig. 5 a body plan of the after-body;

Fig. 6 the fore-nozzle with fins or hydrofoils according to Fig. 1, arranged in its interior space, with position arrangements of the fins;

Fig. 7 a lateral view of the device with the fore-nozzle at the top being tilted forwards by 4°;

Fig. 8 a view of the fore-nozzle with the fins on the inside of the ship being directed upwards and twisted;

Fig. 9 a diagram showing power savings with the use of the device according to an embodiment of the invention;

Fig. 10 a diagram showing the power demand with and without the device according to an embodiment of the invention; and

Fig. 11 a diagram showing power savings with the use of the device according to an embodiment of the invention with various types of ships.

According to Fig. 1, in the device 10 according to an embodiment of the invention, a fore-nozzle 20 of a cylindrical shape or some other shape or cross-section is provided directly upstream of the propeller (not shown in the drawing) of a hull 100, which fore-nozzle 20 is affixed to the hull. In the interior space 20a of the fore-nozzle 20, fins or hydrofoils 30 are arranged. The fore-nozzle 20 is arranged on the hull so as to be rotationally symmetrical with its axis 21 shifted upwards.

In the exemplary embodiment shown in Fig. 2, four fins or hydrofoils 30a, 30b, 30c, 30d with different fin lengths or hydrofoil lengths are arranged in the interior space 20a of the fore-nozzle 20. These four fins or hydrofoils are arranged asymmetrically within the fore-nozzle and radially to the propeller axis PA. In this arrangement the fins or hydrofoils 30a, 30b, 30c, 30d connect the fore-nozzle 20 to the hull 100, and are arranged at the rear end of the fore-nozzle 20, which rear end faces the propeller, wherein the curved side 32 of the hydrofoil-shaped or lenticular cross-sectional profile 31 of the fins or of the hydrofoils 30, 30a, 30b, 30c, 30d is directed upwards on the port side of the ship or on the upwards-beating side of the propeller, and is directed downwards on the starboard side of the ship or on the downwards-beating side of the propeller. Furthermore, the fins or hydrofoils 30a, 30b, 30c, 30d are directed upwards at the front on the port side, and downwards at the front on the starboard side (Figs 2 and 3). The direction of rotation of the propeller is in the direction of the arrow X (Fig. 1). The angular positions of the fins or hydrofoils 30, 30a, 30b, 30c, 30d that are arranged in the interior space 20a of the fore-nozzle 20 are adjustable, and their set angular positions are lockable.

According to an exemplary embodiment with the propeller rotating upwards to starboard, the fins or hydrofoils 30a, 30b, 30c, 30d assume the following preferred radial angular positions and initial angular positions:

		Fin angle	Angle of incidence
Port (BB)	Bottom fin (30a)	247.5°	14°
Port (BB)	Middle fin (30b)	292.5°	12°
Port (BB)	Top fin (30c)	337.5°	8°
Starboard (SB)	Fin (30d)	90.0°	10°

namely at a fin angle definition, viewed from behind, of: 12 o'clock = 0° increasing clockwise, wherein the fin angles and the angles of incidence can deviate from the values stated.

According to the embodiment shown in Figs 1, 3 and 6, the fins or hydrofoils comprise a lenticular cross-sectional profile 31 with a curved sidewall 32 and with a straight base area 33. In this setup the arrangement and the position, for example, of the two fins 30 relative to the propeller axis PA are such that the base area 33 of the top fin extends approximately parallel to the propeller axis PA, whereas the lower fin assumes a position in which its base area 33 extends at an angle α of at least 5°, preferably of 10°, relative to the propeller axis PA. Other angular positions of the fins are possible. Overall, preferably the fins 30a, 30b, 30c, 30d are in the positions shown in Fig. 2.

The fore-nozzle 20 according to Figs 1 and 6 comprises a shaped body 25 with a cross-sectional profile 26 with a wall section 26a that is situated on the outside and that extends so as to be inclined at an angle to the propeller axis PA, and a wall section 26b that is situated on the inside and that extends in a straight line and parallel to the propeller axis PA, which wall section 26b in the region facing away from the propeller comprises a curved wall section 26c that makes a transition to the outside wall section 26a. The wall section 26a that is situated on the outside can also be curved. The propeller side is indicated at PS in Fig. 6.

As shown in Fig. 7, the device 10 has been affixed to the hull 100 with little distance upstream of the propeller 101. In this arrangement the device 10 is to be arranged as closely as possible upstream of the propeller 101. In this arrangement the fore-nozzle 20 is arranged on a horizontal transverse axis that preferably extends through the centre of the fore-nozzle, preferably so that at the top it is rotated forwards by up to 8°. In Fig. 7 the top of the fore-nozzle 20 is tilted forwards by 4°. In this arrangement the trailing edge of the fore-nozzle 20 is affixed no further than 0.3 times the propeller diameter upstream of the propeller plane.

Furthermore, the fore-nozzle 20 is rotatable, on a vertical axis that preferably extends through the centre of the fore-nozzle, laterally, e.g. by up to 3°, such that the fore-nozzle is rotated forwards on the upwards-beating side of the propeller 101. In this arrangement rotations of up to 1° appear to be optimal. Rotation of 0° can also be applicable, but not in the other direction.

The thickness of the profile of the fore-nozzle 20 is less than 12% of its length. Preferably, the thickness of the profile of the fore-nozzle 20 is 7.5% or 9% of its length.

The fins or hydrofoils 30, 30a, 30b, 30c, 30d in radial direction can comprise a variable angle of incidence, wherein the fins or hydrofoils are twisted such that said fins or hydrofoils on the inside of the ship are directed upwards, with the angle of incidence decreasing on the outside towards the fore-nozzle 20 (Fig. 8).

The thickness design of the profile of the fore-nozzle 20, and the design according to which the fins or hydrofoils 30, 30a, 30b, 30c 30d in radial direction comprise a variable angle of incidence are indispensable for very broad-built ships; they can also be used with fast ships.

The design, according to the invention, of the device 10 results in significant power savings, as is evident from the diagram of Fig. 9, which shows the power savings with the use of the device 10 in relation to three ships, of which two ships have different drafts (X = design speed).

The diagram according to Fig. 10 shows the power demand of a bulk carrier of a deadweight capacity of 118,000 DWT with and without the device 10.

Particularly high gains are, for example in ships of 12,000 DWT, to be attributed to a thick hub in the case of a controllable-pitch propeller, whose losses are reduced by means of the device 10.

The extent of thrust loading is particularly great in the case of very large slow ships. The diagram of Fig. 11 shows the possible power savings with the use of the device 10 depending on the C_{Th}-value. The lower part of Fig. 11 provides an allocation to ship types.

With the device 10 a novel device improving the propulsion for broad-built slow ships has been developed due to which fuel is being saved or ships can be quicker. The device consists of two elements mounted fixedly on the ship: a nozzle directly in front of the propeller and a fin system integrated therein. The nozzle improves the propeller afflux in the area of unfavourable wake and produces itself thrust; the fin system reduces the losses in the propeller jet and in the propeller boss swirl due to preswirl production so that the propeller thrust is increasing for the same driving power. The effects are complementary.

The power savings which can be achieved by the device depend substantially on the propeller load, they are from 3 % for small multi-purpose ships to 9 % for big tankers and bulkers. The power savings are almost independent of the draught of the ship and from the speed. The device is convenient for new ships and for subsequent equipment.

List of reference characters

10	Device
20	Fore-nozzle
20a	Interior space
21	Axis of the fore-nozzle
25	Shaped body
26	Cross-sectional profile
26a	Wall section
26b	Wall section
26c	Wall section
30	Fin/hydrofoil
30a	Fin/hydrofoil
30b	Fin/hydrofoil
30c	Fin/hydrofoil
30d	Fin/hydrofoil
31	Cross-sectional profile
32	Curved sidewall
33	Base area
100	Hull
101	Propeller
BB	Port
SB	Starboard
PA	Propeller axis
PS	Propeller side
X	Direction of rotation of the propeller
α	Angle

CLAIMS:

1. A device for reducing the power demand for the propulsion of a single-propeller or multi-propeller ship, wherein the device is attached to a hull of the ship proximal and upstream of the propeller, said device comprising a fore-nozzle with fins or hydrofoils that are arranged within the fore-nozzle, wherein a top of the fore-nozzle is tilted forwards relative to a horizontal transverse axis that extends through the center of the fore-nozzle, wherein the internal diameter of the fore-nozzle is less than 90% of the propeller diameter, and wherein the fore-nozzle is arranged rotationally symmetric about an upwards-shifted axis, said upwards-shifted axis is situated above the propeller axis.

2. The device according to claim 1, wherein the trailing edge of the device or fore-nozzle is affixed no further than 0.3 times the propeller diameter upstream of a propeller plane.

3. The device according to one of claims 1 or 2, wherein the fore-nozzle, at the top, is tilted forwards by approximately 4°.

4. The device according to any one of claims 1 to 3, wherein the propeller has an upwards-beating side and a downwards-beating side, and the fore-nozzle is laterally rotated on a vertical axis such that the fore-nozzle is shifted forwards on the upwards-beating side of the propeller.

5. The device according to claim 4, wherein the vertical axis extends through the centre of the fore-nozzle.

6. The device according to claim 4 or 5, wherein

the fore-nozzle is laterally rotatable by up to 3° on said vertical axis such that the fore-nozzle is rotated forwards on the upwards-beating side of the propeller.

7. The device according to claim 4 or 5, wherein

the fore-nozzle is laterally rotatable by 1° on said vertical axis such that the fore-nozzle is rotated forwards on the upwards-beating side of the propeller.

8. The device according to any one of claims 4 to 7, wherein the fins or hydrofoils connect the hull to the fore-nozzle and are arranged at the rear end of the fore-nozzle, wherein the fin or the hydrofoil has a lenticular cross-sectional profile, the profile having a curved side that is directed upwards on the upwards-beating side of the propeller, and is directed downwards on the downwards-beating side of the propeller.

9. The device according to any one of claims 1 to 3, wherein the fins or hydrofoils connect the hull to the fore-nozzle and are arranged at the rear end of the fore-nozzle, wherein the fin or the hydrofoil has a lenticular cross-sectional profile, the profile having a curved side that is directed upwards on an upwards-beating side of the propeller, and is directed downwards on a downwards-beating side of the propeller.

10. The device according to any one of claims 1 to 9, wherein the fore-nozzle is defined by a wall having a thickness of less than 12 % of the length of the fore-nozzle.

11. The device according to claim 10, wherein the thickness of the wall of the fore-nozzle is 7.5 % or 9 % of the length of the fore-nozzle.

12. The device according to any one of claims 1 to 11, wherein

the fins or hydrofoils in a radial direction comprise a variable angle of incidence, wherein the fins or hydrofoils are twisted.

13. The device according to any one of claims 1 to 12, wherein

four fins or hydrofoils are arranged asymmetrically in an interior space of the fore-nozzle and radially to the propeller axis.

14. The device according to any one of claims 1 to 13, wherein the fins or hydrofoils assume the following preferred radial angular positions and initial angular positions:

		Fin angle	Angle of incidence
Port (BB)	Bottom fin (30a)	247.5°	14°
Port (BB)	Middle fin (30b)	292.5°	12°
Port (BB)	Top fin (30c)	337.5°	8°
Starboard (SB)	Fin (30d)	90.0°	10°.

15. The use of a device with the characteristics of any one of claims 1 to 14 for reducing the power demand for the propulsion of a ship, for improving the flow against the propeller, and for generating pre-swirl.

16. The use of the device according to claim 15, wherein the ship is a slow, broad-built ship, or a non broad-built ship.

17. The use of the device according to claim 15, wherein the ship is a tanker, or a bulk transport ship, or a tug, or a not-very-fast ship of any type.

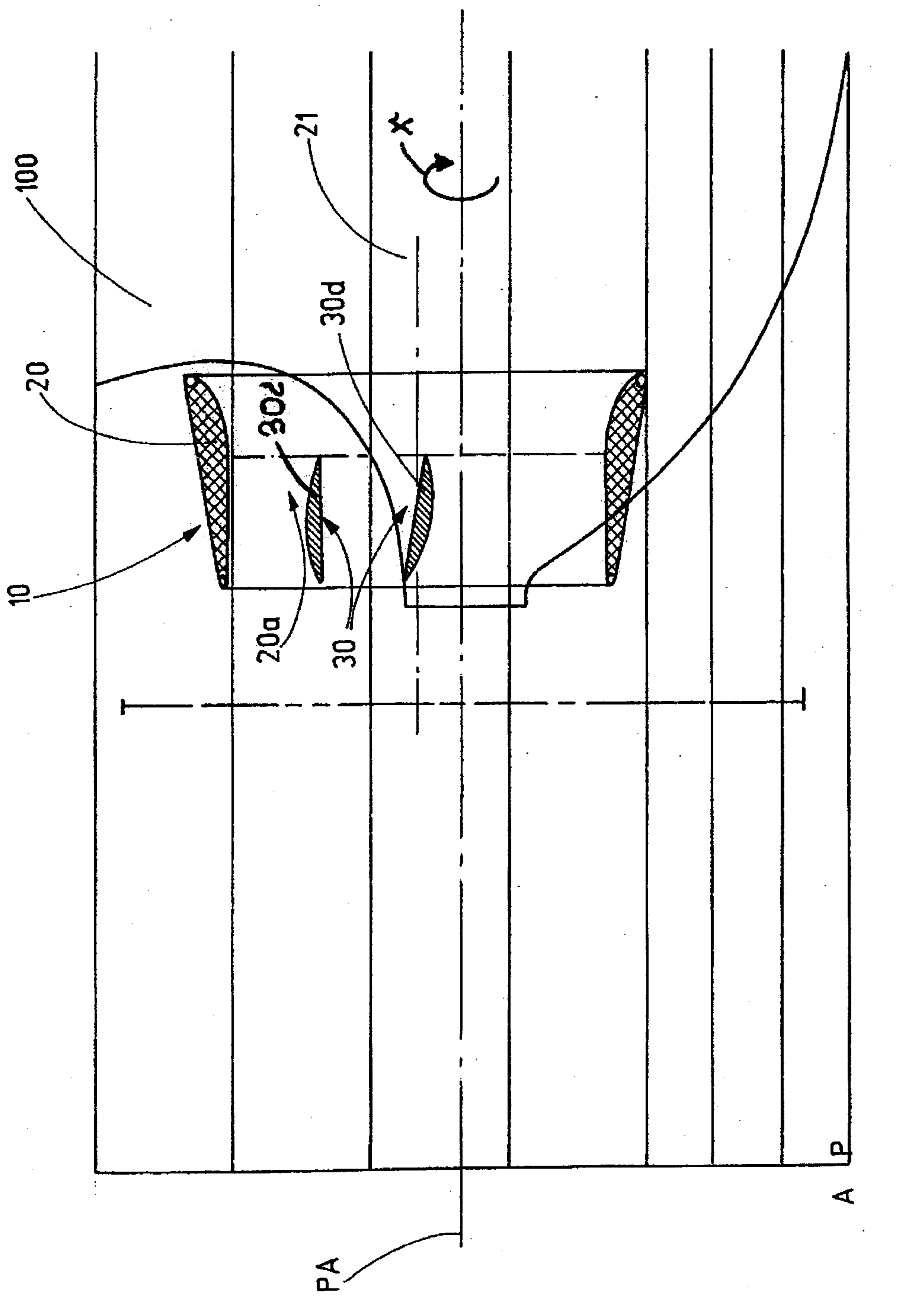


Fig. 1

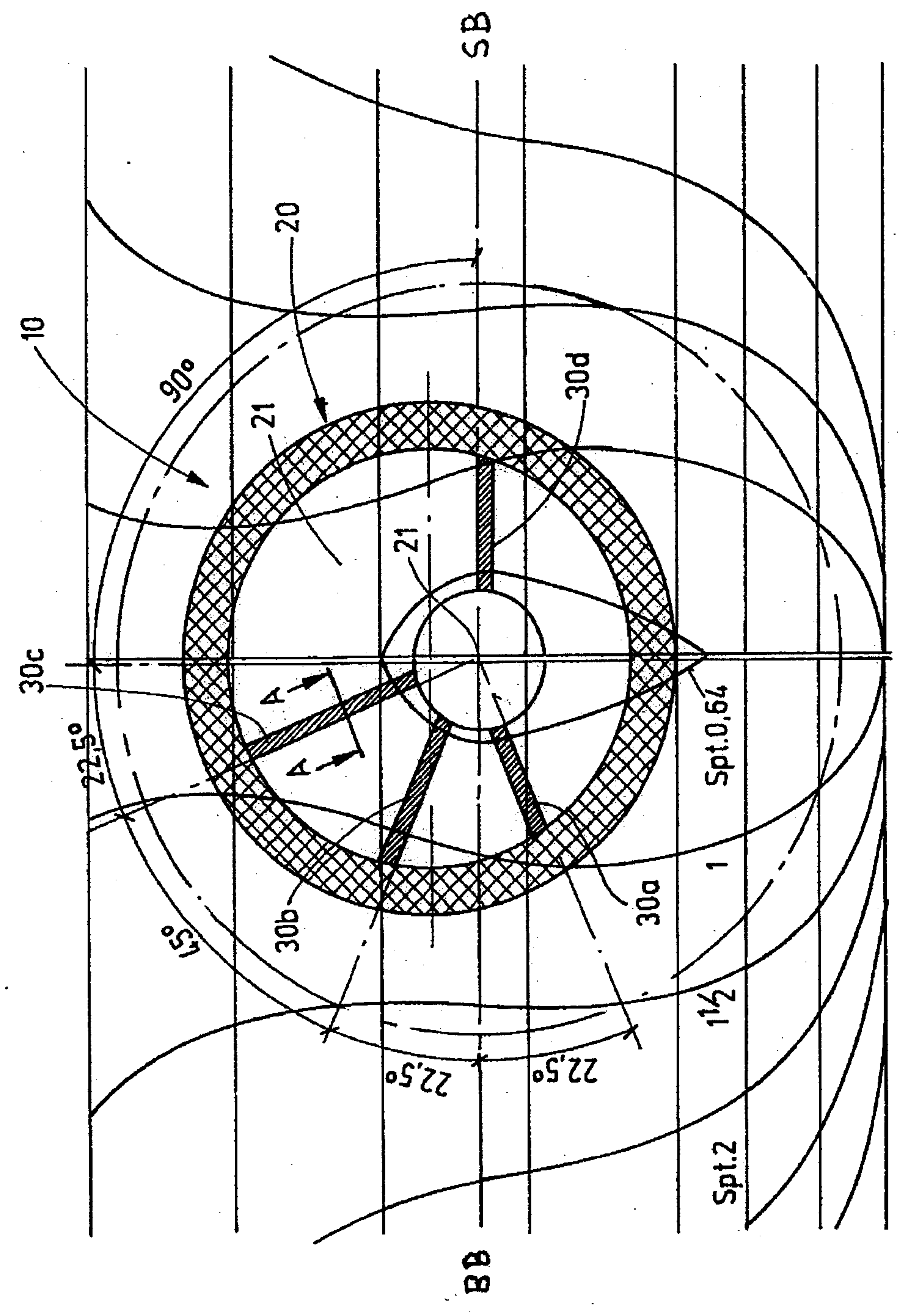

SB
BB
10
20
21
21
90°
30c
30d
30a
30b
22,5°
45°
22,5°
22,5°
A
A
Spt.0,64
1
1½
Spt.2

Fig. 2

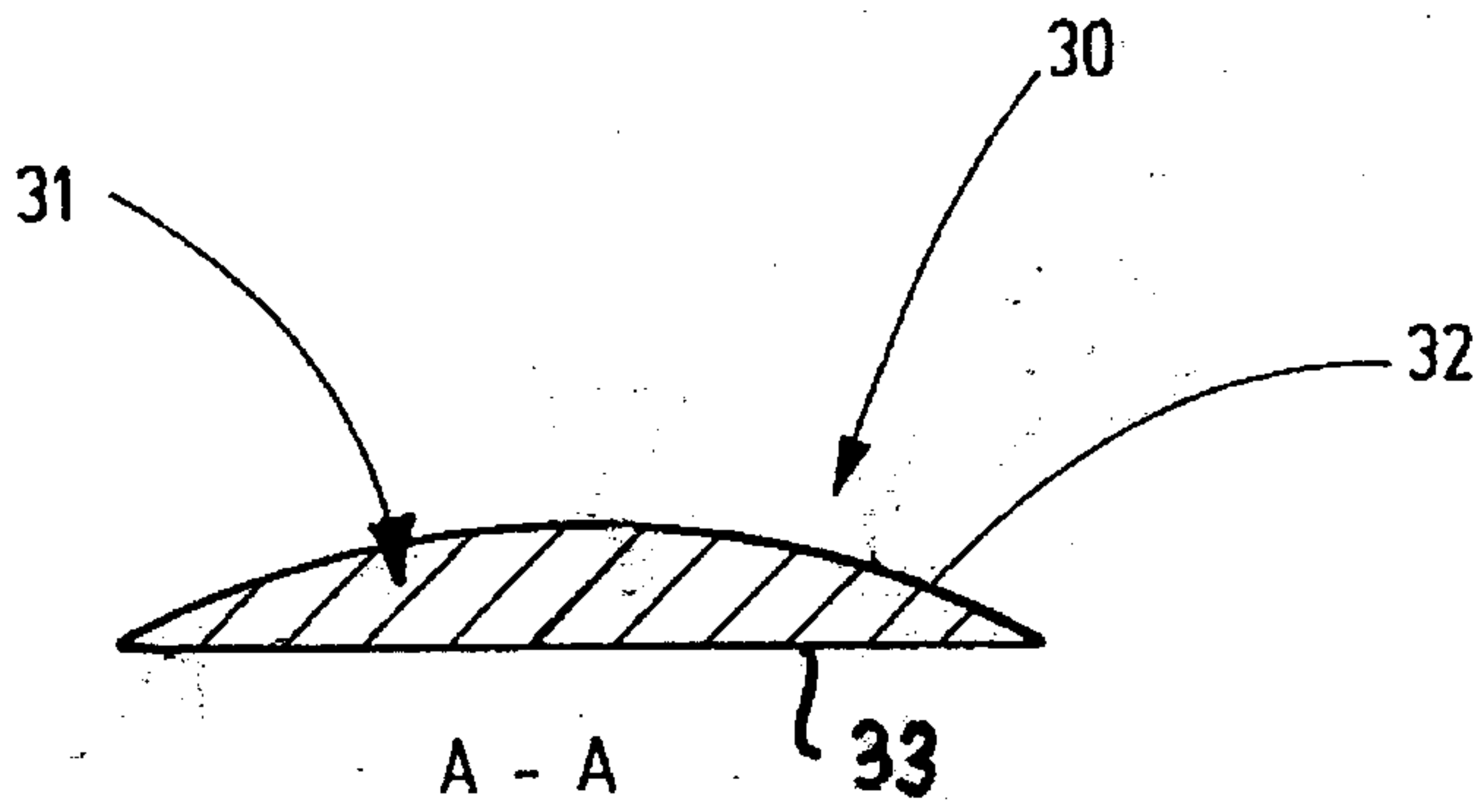


Fig. 3

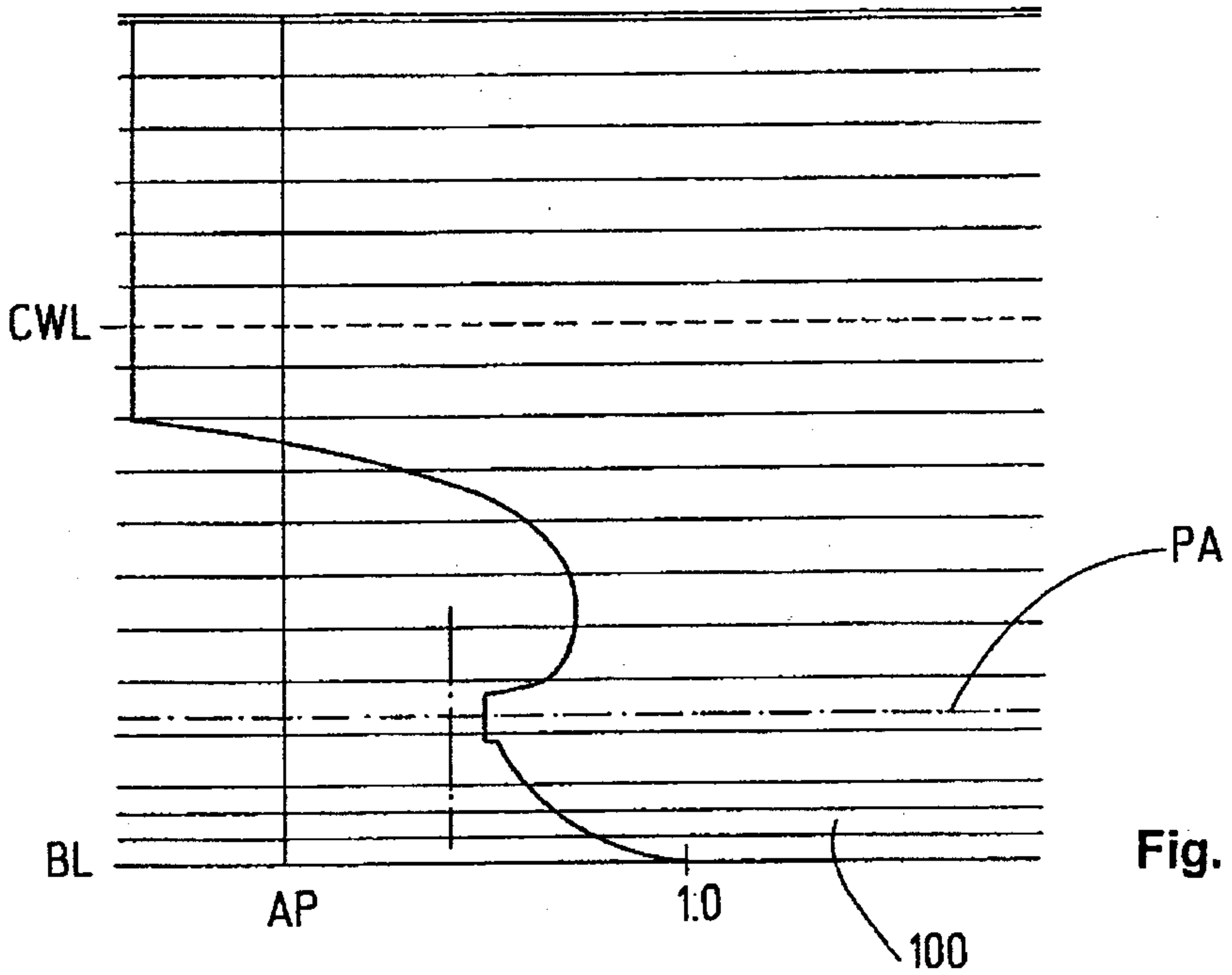


Fig. 4

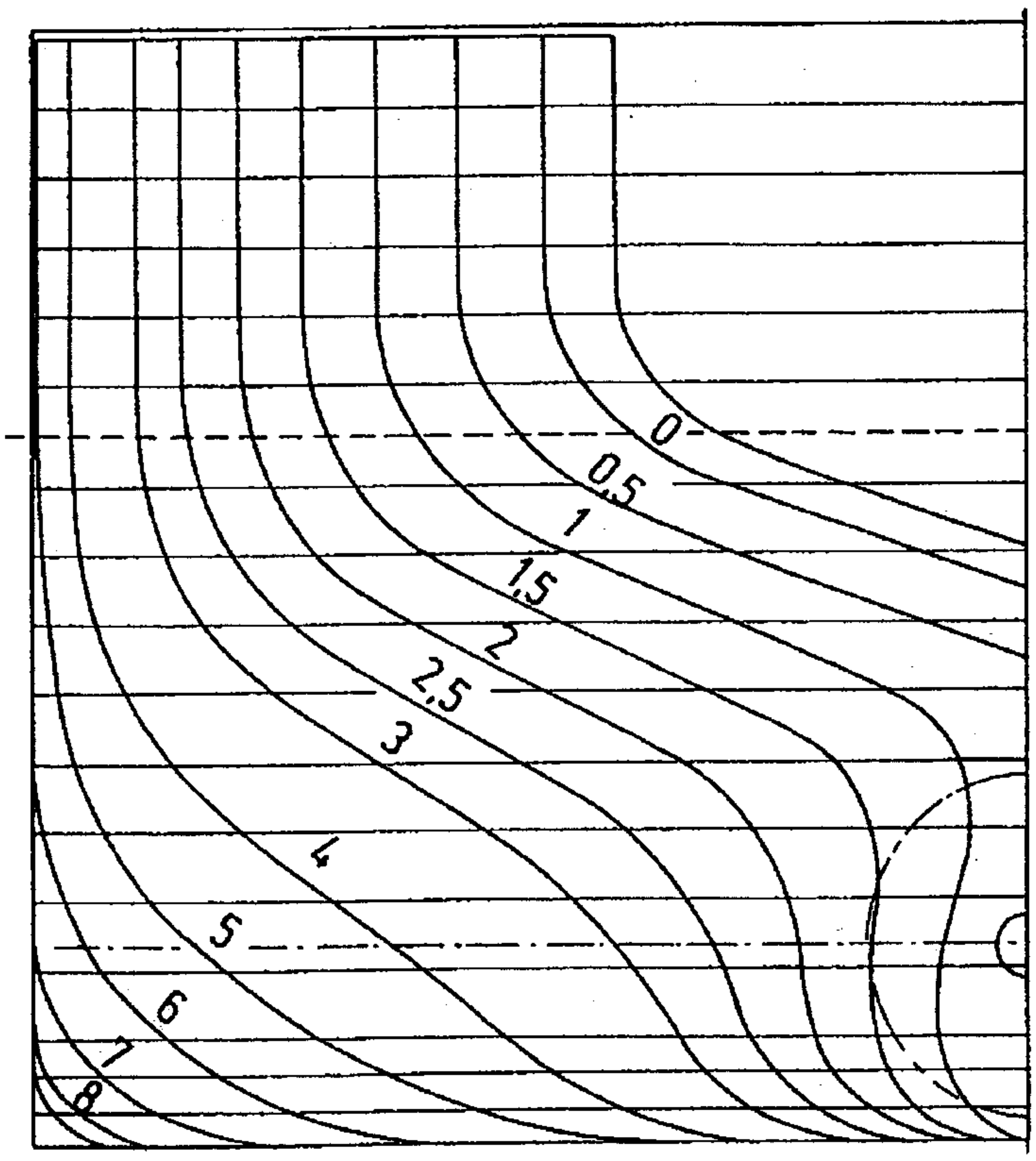


Fig. 5

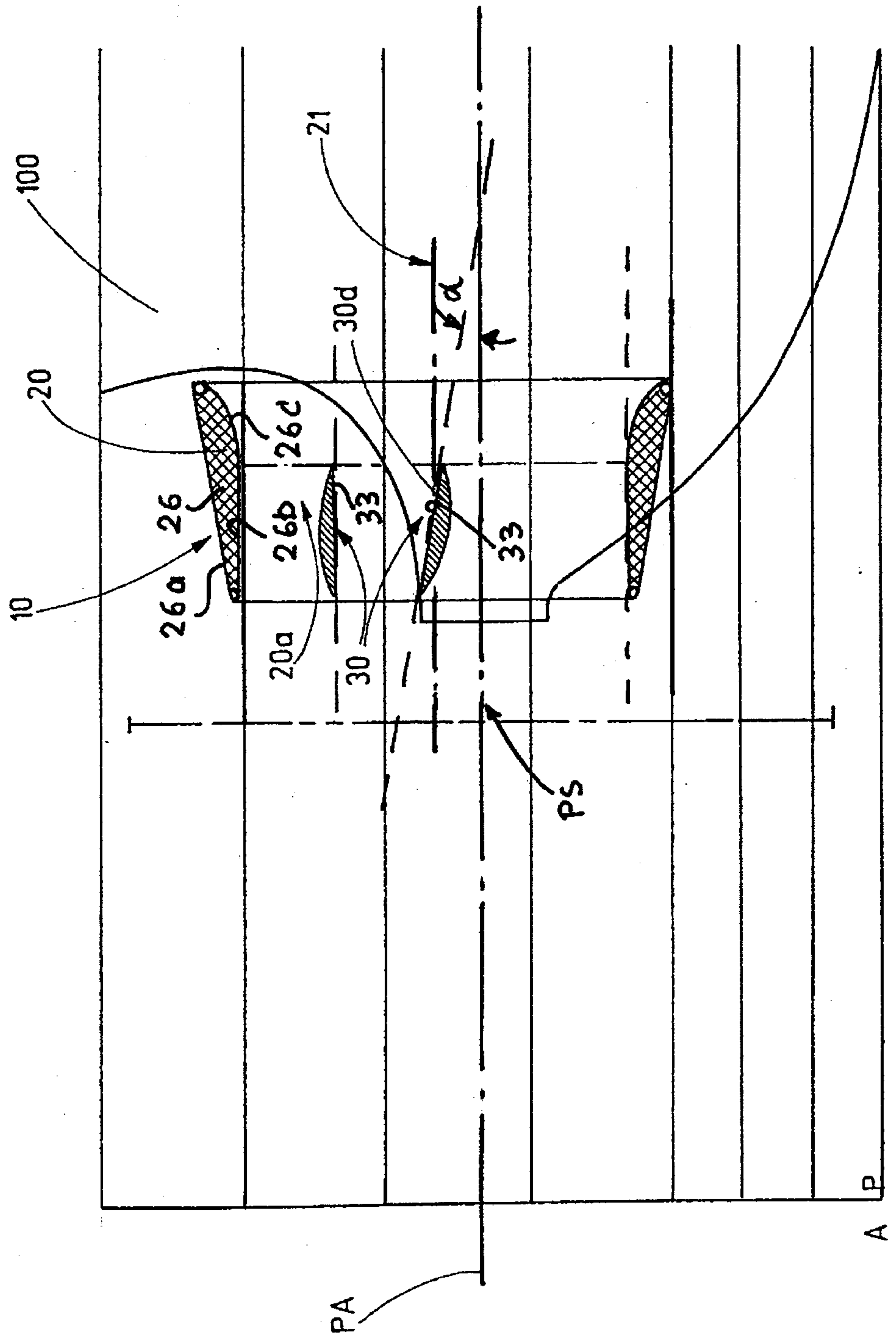


Fig. 6

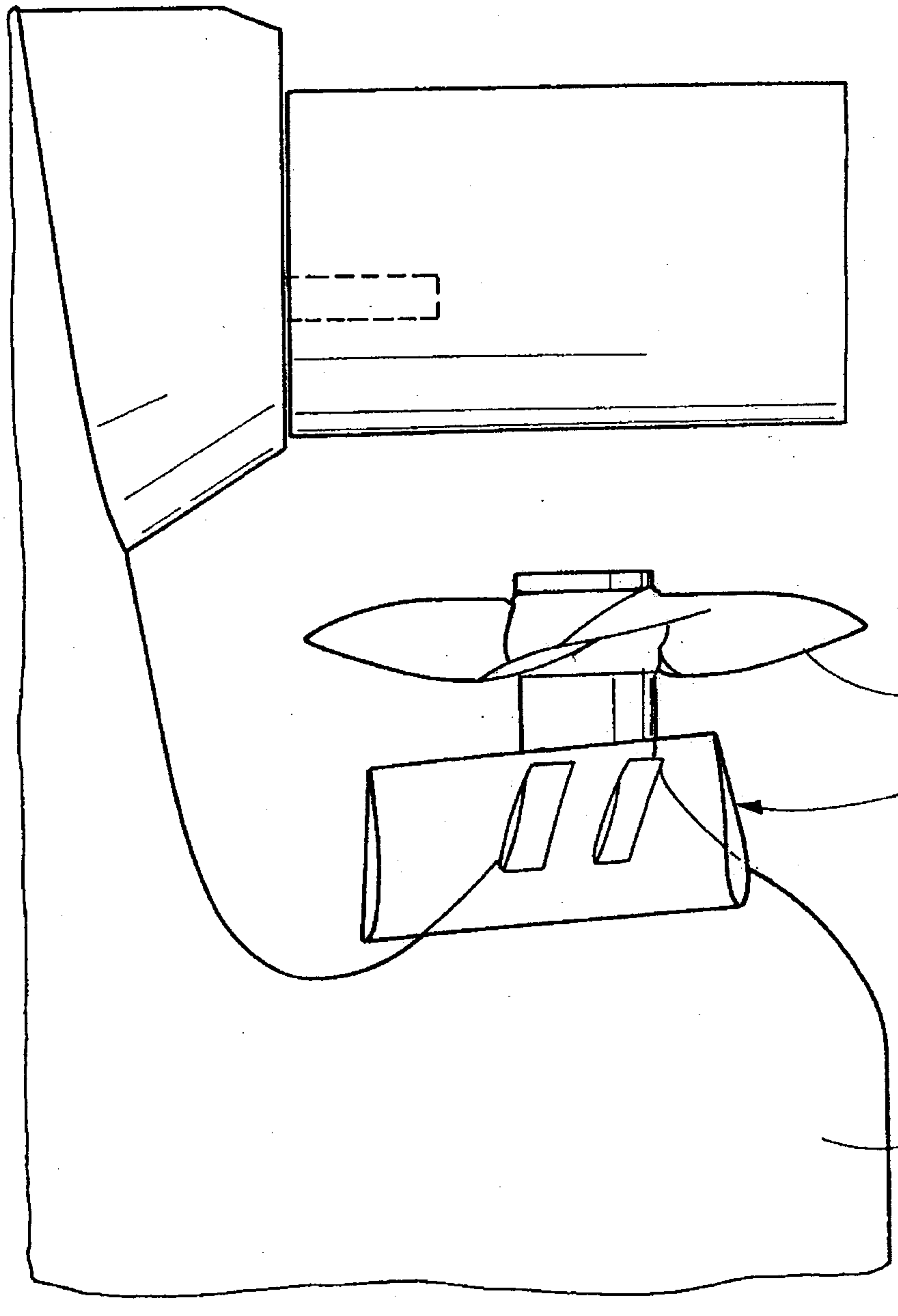


Fig. 7

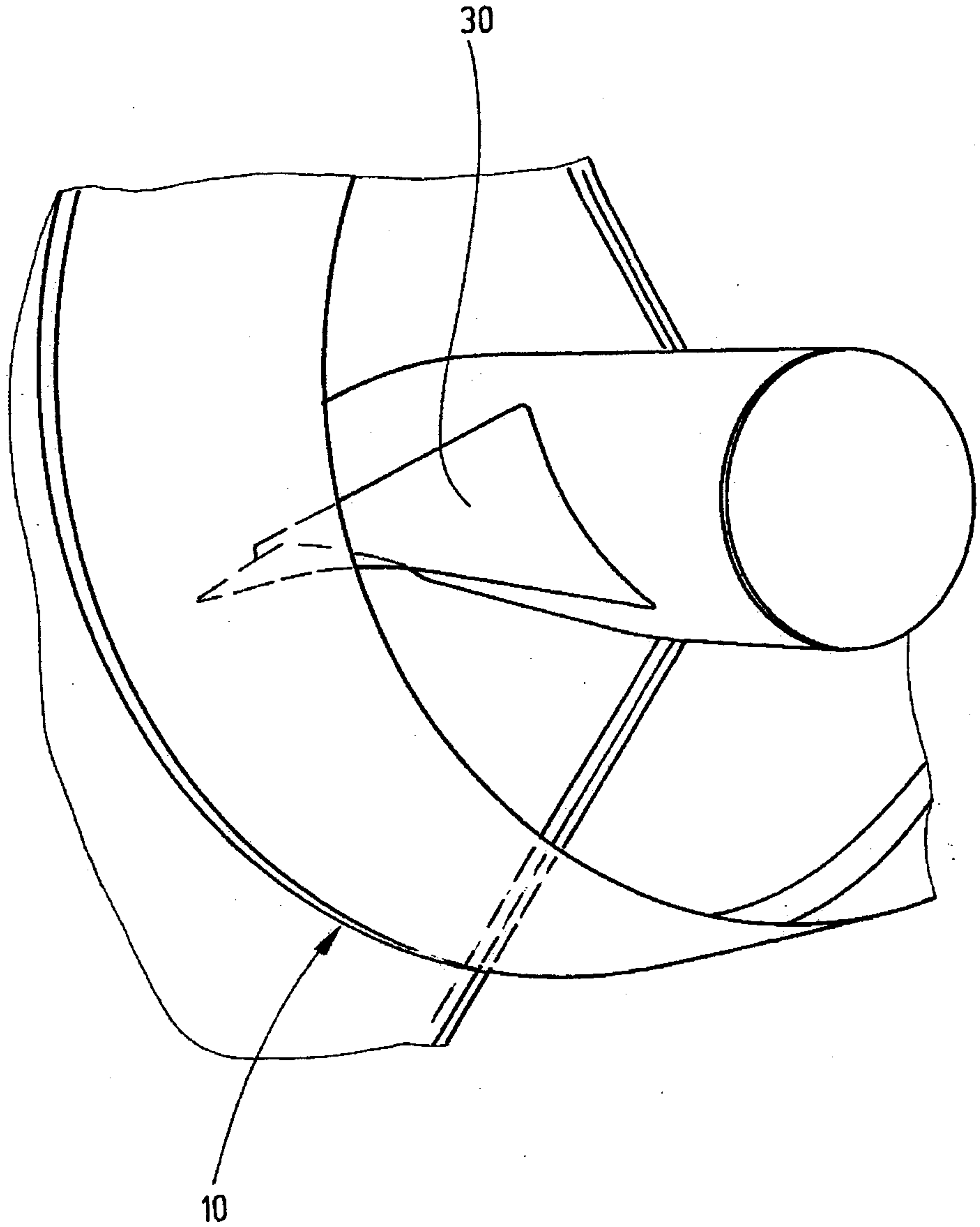


Fig. 8

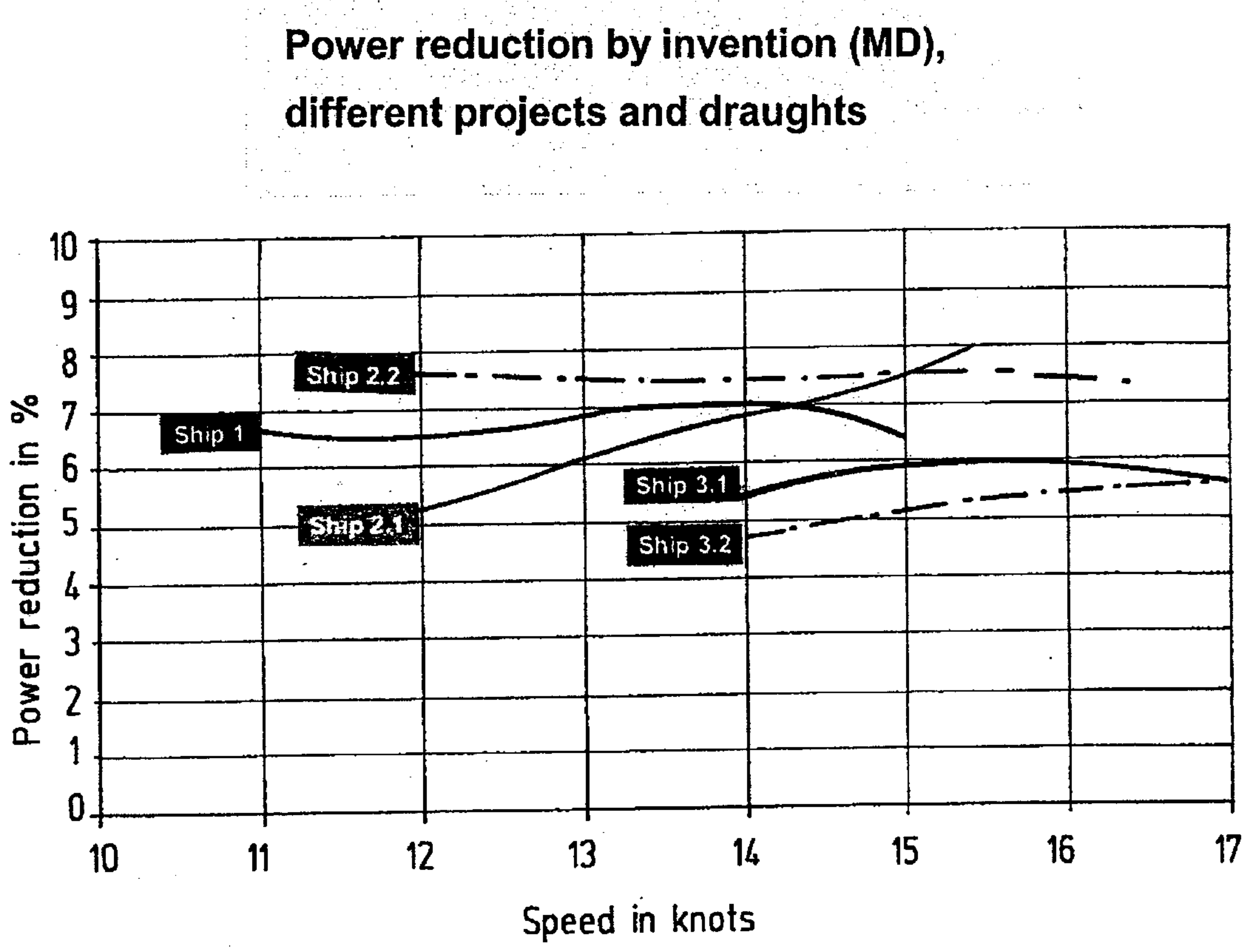

Power reduction by invention (MD),
different projects and draughts
Ship 2.2
Ship 1
Ship 3.1
Ship 2.1
Ship 3.2
Power reduction in %
10
9
8
7
6
5
4
3
2
1
0
10
11
12
13
14
15
16
17
Speed in knots

Fig. 9

Power requirement with and without invention (MD) Bulk carrier 118,00 DWT

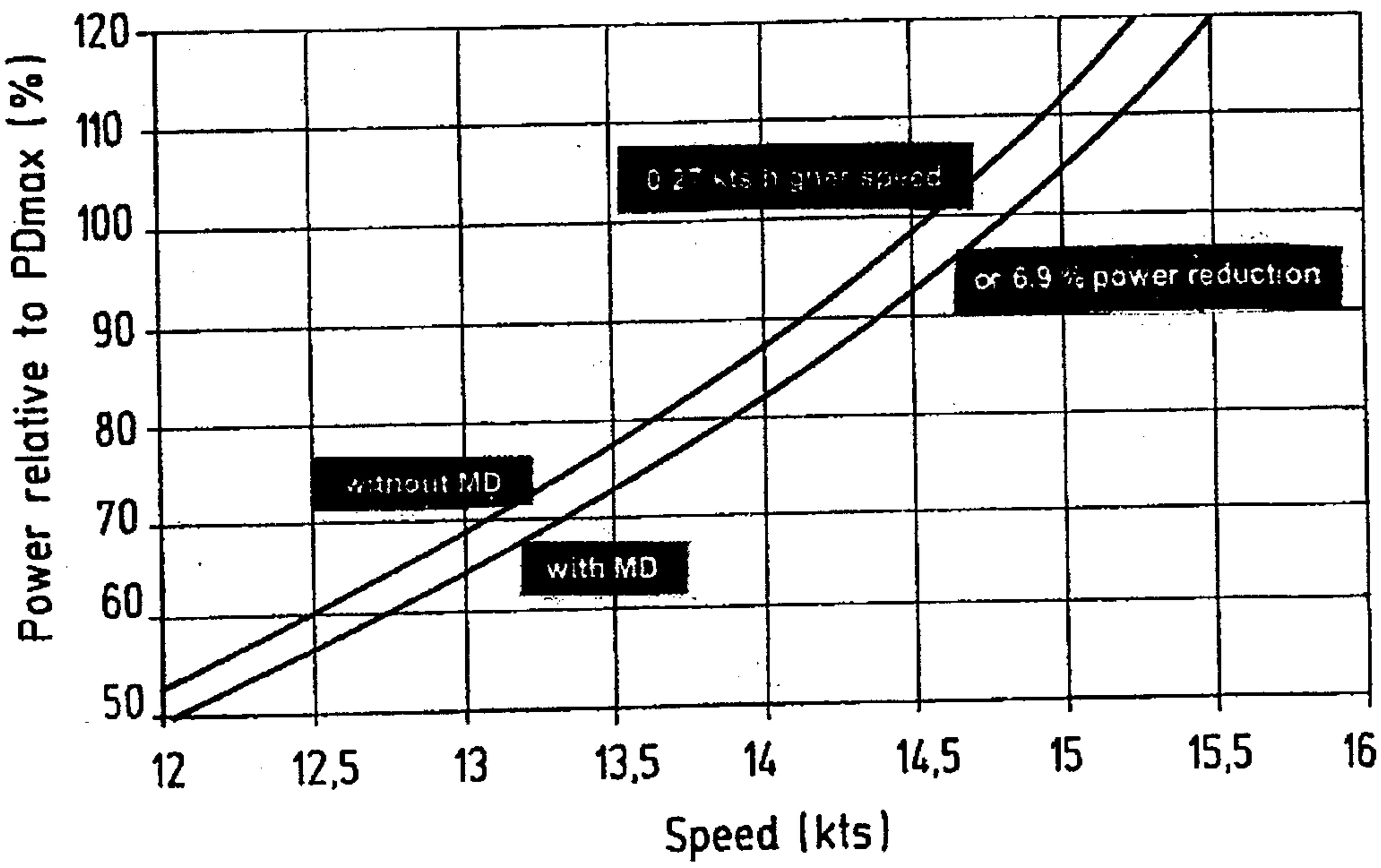


Fig. 10

Possible power reduction by invention (MD)

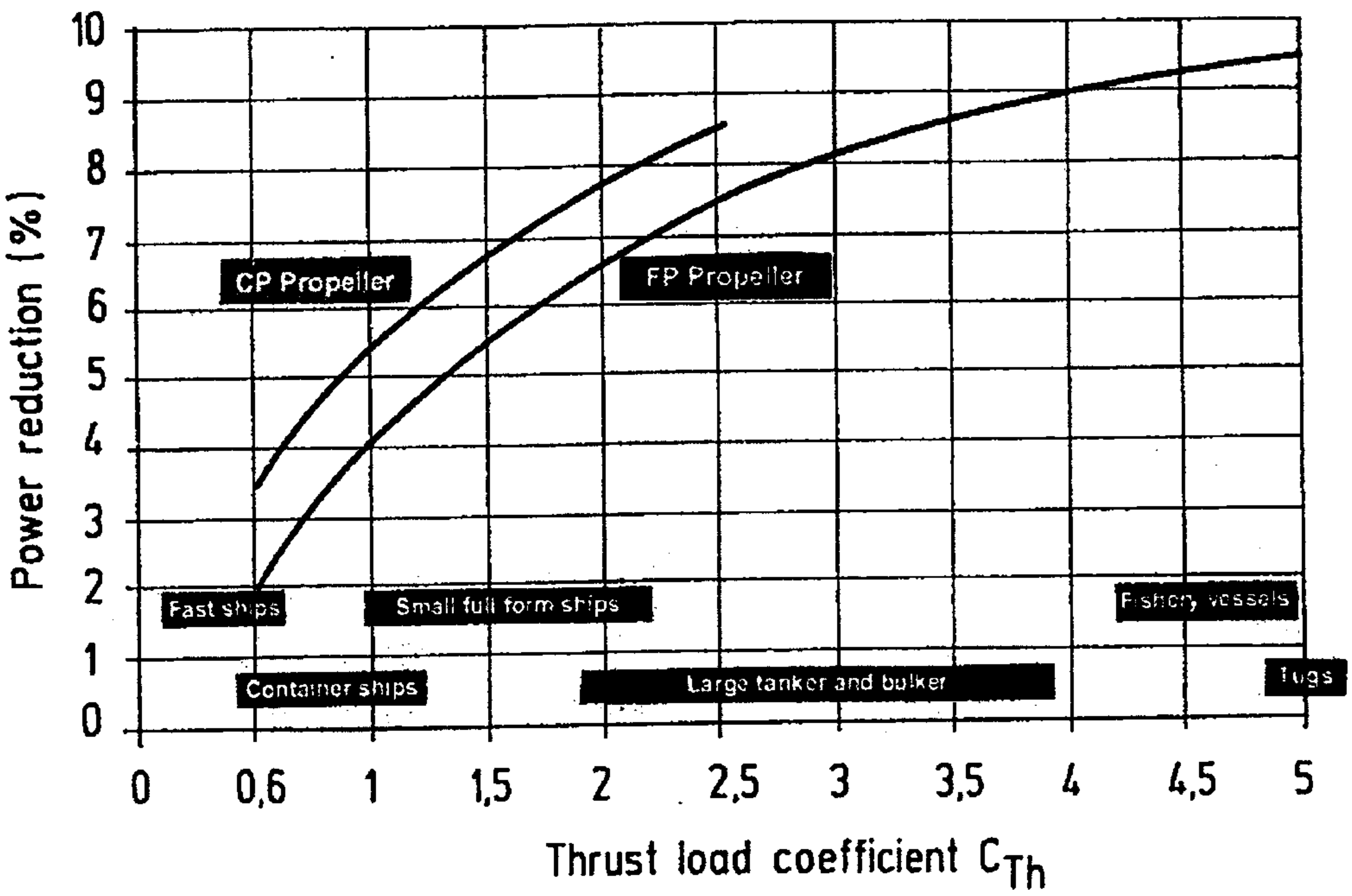


Fig. 11

30c
10
22,5°
45°
90°
21
20
30b
A
A
21
22,5°
BB
SB
22,5°
30d
30a
Spt.2
1½
1
Spt.0,64