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(54) Automatic control system in a ship provided with rotatable propeller devices

(57) The invention concerns an automatic control system in a ship provided with rotatable propeller devices for automatic maintenance of the course of the ship and for controlling the course in accordance with a preset course. The ship (S) is provided with one or several pairs of propeller devices, in which the propeller devices (1,2) that constitute a pair have been arranged symmetrically in relation to the centre line (L) of the ship and are connected to the central unit of the automatic control system, which unit can be connected optionally to control the propeller devices (1,2) that form a pair symmetrically or asymmetrically. In the invention, the automatic control system is provided with a control unit, by whose means, irrespective of the situation of operation of the central unit of the automatic control system, the propeller devices (1,2) that form a pair can be connected to stick out by turning the propeller devices (1,2) in opposite directions in relation to the longitudinal centre line (L) of the ship (S) so as to regulate the speed of the ship (S).

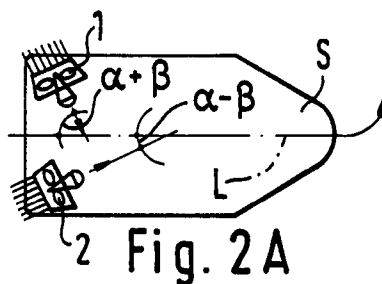


Fig. 2A

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Description

The invention concerns an automatic control system in a ship provided with rotatable propeller devices for automatic maintenance of the course of the ship and for controlling the course in accordance with a preset course, said ship being provided with one or several pairs of propeller devices, in which the propeller devices that constitute a pair have been arranged symmetrically in relation to the centre line of the ship and are connected to the central unit of the automatic control system, which unit can be connected optionally to control the propeller devices that form a pair symmetrically or asymmetrically.

Automatic control is used in ships for automatic maintenance of the course and for automatic control of the course in compliance with a preset course. Automatic control is used both in ships provided with rotatable propeller devices and in so-called conventional ships, which are steered by means of a rudder. The conduct of ships provided with rotatable propeller devices, however, differs considerably from that of ships provided with a rudder. This is why the principles of control of the automatic control in these ships also differ from one another. In this connection, a rotatable propeller device is understood as meaning, for example, such propeller devices rotatable around a vertical shaft through 360° as have been described in the prior art, for example, in the published patents and patent applications FI 830373, FI 853173, FI 79,991, and FI 82,007.

The properties of the rotatable propeller devices include the generation of the force needed for both pushing and steering the ship. In normal ship applications, the ship has two rotatable propeller devices, which are used in route navigation for steering the ship. Of course, there are also other applications, in which the number of the propeller devices is different from two, but, as a rule, automatic control is used for the control of one or two propeller devices.

In a ship, the propeller devices have control systems of their own, which systems control both the thrust and the turning angle of the propeller device under manual control. The automatic control, i.e. the "autopilot", gives the propeller device control system a request concerning a change in the course, which request is converted by the control system to a turning angle of the propeller device. In the conventional prior-art systems, the operator switches on the automatic control so that he manually selects the automatic control to control either the left propeller device or the right propeller device or both of them at the same time.

The biggest problem that has been encountered in these prior-art systems has occurred in the situations of operation in which the automatic control has been switched to control either one, the left or the right one, of the propeller devices, and when this propeller device that is subjected to automatic control is placed at the side of the outside curve during a change in the course, the running of the curve itself is usually successful. A

problem, however, arises when the automatic control attempts to adapt the course of the ship after the curve to the instruction given, i.e. when the course is aligned after the curve. Then, the setting has not always been successful, but the operator has had to bring the ship to the correct course by choosing the automatic control either for the propeller device at the inside curve or for both of the propeller devices. Even this has not been enough in all situations, but sometimes, in aligning the ship after the curve, it has been necessary to use manual control.

In order to solve the control problem described above, in the earlier Finnish Patent No. 92,378, the applicant suggested a novel automatic course control for a ship provided with rotatable propeller devices, in which ship the propeller devices have been arranged as a symmetric pair of propeller devices and connected to the central unit of the automatic control, which unit can be connected optionally to control either one or both of the propeller devices that constitute a pair. According to this prior-art solution, when both propeller devices are connected to the automatic course control, the automatic control shifts the control devices of the propeller devices to an asymmetric state of operation, in which case, when the automatic control gives a command of making a curve, the automatic control always selects the propeller device at the side of the inside curve for the propeller device that turns the ship, in which case the force that turns the ship remains sufficient. By means of this arrangement, compared with the prior art, a remarkable improvement and advantage were obtained, the most important advantage being the fact that the force that turns the ship is also maintained in difficult situations of aligning after a curve. Further, by means of this arrangement, compared with conventional control systems, a more agreeable conduct of the ship was achieved, because the operation of the control was "smooth".

However, in certain particular situations, also in the system of the FI Patent 92,378, a certain problem occurred. This problem was manifested in particular in slow running and at very low travel speeds. Such very low travel speeds must be used, e.g., in various rescue operations, in collecting of oil, in keeping the ship immobile, etc. Very low running speeds are, of course, achieved by reducing the speed of rotation of the propellers, but in such a case the steering capacity is also lowered, because the thrust curve of the propeller is lowered in proportion to the second power. Further, in the ships it is not possible to lower the speed of rotation of the propeller below the minimum speed of rotation of the propeller. For example, collecting of oil requires a speed of about 1.5 knots, and in order that this speed could be reached by lowering the speed of rotation of the propeller alone, in quite a number of cases it would be necessary to go to a speed of rotation of the main engine below its minimum speed of rotation. Thus, at these low travel speeds, it has not been possible to use the automatic control, but it has been necessary to con-

control the ship manually. Manual control at low speeds is, however, very laborious and, moreover, quite inaccurate. This is why it would be desirable to be able to use the automatic control of the ship also at said low running speeds. The present invention is supposed to provide a solution for the problems expressly related to said low travel speeds.

In view of achieving the objectives of the invention described above and also to be described in the following, the present invention is mainly characterized in that the automatic control system is provided with a control unit, by whose means, irrespective of the situation of operation of the central unit of the automatic control system, the propeller devices that form a pair can be connected to stick out by turning the propeller devices in opposite directions in relation to the longitudinal centre line of the ship so as to regulate the speed of the ship.

Compared with the prior-art solutions, by means of the present invention a number of remarkable advantages are obtained, of which the following are described herein. The most important and the most significant advantage of the invention is expressly the fact that automatic control can be used at low travel speeds. In the way suggested in the invention, efficient steering is also obtained at low speeds, because the speed of rotation of the propellers does not have to be lowered to a very low level, in which case the thrust of the propeller remains good and, out of this reason, the steering capacity is also good. If necessary, the propeller powers can be even increased in order to intensify the steering. When operating in ice, the propeller devices can be used for clearing the furrow in the ice by turning the propeller devices to positive sticking out and by directing strong propeller currents to the sides. It is a further remarkable advantage of the invention that the invention can be carried into effect in existing control systems in a very simple way with a little modification. The further advantages and characteristic features of the invention will come out from the following detailed description of the invention.

In the following, the invention will be described by way of example with reference to the figures in the accompanying drawing.

Figures 1A...1D are schematic illustrations of the formation of the sticking-out angle of the propeller devices while running straight.

Figures 2A...2C illustrate various modes of steering in accordance with the invention in situations of sticking out of the propeller devices.

Figure 3 is a schematic illustration of an embodiment of the invention in which a negative sticking-out angle is used in the control of the propeller devices.

Figure 4 is a schematic illustration of an embodiment of the invention in which the propeller devices are placed at the fore of the ship.

Figure 5 is a fully schematic illustration of a ship control system in accordance with the invention in the form of a block diagram.

As was stated above, the present invention is based on the applicant's FI Patent No. 92,378 of earlier date, which concerns automatic course control in a ship provided with rotatable propeller devices. By means of the present invention, the speed of the ship can be regulated by means of the automatic control device in combination with the course control in accordance with said FI Patent 92,378. In the present invention, the possibility of regulating the speed of the ship has been accomplished so that, in the ship, the propeller devices that constitute a pair are turned towards each other, i.e. so as to stick out, in order to reduce the speed of the ship. This has been illustrated by way of example in Figs. 1A...1D in the drawing, wherein the ship is denoted with the reference S, the longitudinal centre line of the ship with the reference L, the propeller devices with the reference numerals 1 and 2, and the stick-out angle of the propeller devices in relation to the longitudinal axis of the ship with the reference α . In Figs. 1A...1D, the propeller devices 1,2 have not been given a command of steering, i.e. the ship S is not being turned.

In Fig. 1A, the stick-out angle of the propeller devices 1,2 is 0° , i.e. the thrust force produced by the propeller devices 1,2 is parallel to the direction of travel of the ship S. In Fig. 1B, the propeller devices 1,2 have been turned to a stick-out angle α of 45° , in which case, at a speed of rotation of the propellers 1,2 equal to Fig. 1A, in the situation of Fig. 1B the speed of the ship is lower than in Fig. 1A. In Fig. 1C the propeller devices 1,2 have been turned fully against each other, in which case the value of the stick-out angle α of each propeller device is 90° . Finally, in Fig. 1D the propeller devices 1,2 have been turned to a stick-out angle α of 120° in relation to the longitudinal axis L of the ship, in which case the thrust force of the propeller devices 1,2 moves the ship S rearwards. When the propeller devices 1,2 have been turned to a sticking-out position, the control signal of the automatic control system rotates the propeller devices 1,2 in the normal way either symmetrically or asymmetrically and produces the desired steering movement in combination with the reduction of travel speed produced by the sticking out of the propeller devices 1,2.

Thus, the operation of the automatic control system goes on unchanged while the stick-out angle α of the propeller devices 1,2 exclusively affects the travel speed of the ship S. When the stick-out angle α of both propeller devices 1,2 is the same, the automatic control system steers the ship S as if there were no sticking-out function of the propeller devices at all. Thus, by means of the sticking-out function, the automatic control system is "fooled" by turning the propeller devices 1,2 in opposite directions. The automatic control system continues the normal running operation, and the operator can adjust the stick-out angle α to the desired value, thereby regulating the travel speed of the ship S continuously.

By means of regulation of the stick-out angle α in accordance with the present invention, it is also possible

to maintain the desired travel speed of the ship S and to keep said speed invariable. This can be accomplished so that, after the desired speed has been chosen for the ship, said speed is maintained by adjusting the stick-out angle while the other conditions, such as currents, wind, etc., are changed. Moreover, setting of the propeller powers is fully free when the propeller devices are sticking out. If necessary, the propeller power can be increased if this is required by the steering. In particular at low travel speeds, if the steering cannot be controlled otherwise by means of the automatic control system, different powers can be employed in the propeller devices if necessary. The propeller powers can be regulated jointly or separately.

Little values of stick-out angle α have almost no effect on the travel speed of a ship. Also little stick-out angles α are, yet, desirable, for example, during travel in ice. When the propeller devices have been turned to a slight positive stick-out angle α , they are not blocked by ice equally readily as earlier, because the propeller devices take the flows from near the hull of the ship S, where there is less ice. This advantage is noticed especially when the propeller devices are provided with nozzles.

As was stated earlier, when the stick-out function in accordance with the invention is employed, the automatic control system can steer the ship normally so that, when the stick-out function is combined with automatic control, a steering movement combined with a reduction in speed is obtained. In principle, there are two different modes of steering. First, there is a so-called symmetric mode of steering, which is illustrated by Fig. 2A in the drawing. In symmetric steering, both of the propeller devices 1,2 are turned over the same angle unit β in the desired direction. In the case of Fig. 2A, the ship S is steered to the left while both propeller devices 1,2 have been turned. In the case of Fig. 2A, the steering angle β is 20° . However, as can be seen from Fig. 2A, the propeller devices 1,2 have not been directed in the same direction, in spite of the symmetric mode of steering, because the propeller devices 1,2 were turned as sticking-out. The stick-out angle α of each propeller device 1,2 is 45° . Thus, in the case of Fig. 2A, the first propeller device 1 has been turned to an angle of 65° ($\alpha + \beta$) in relation to the longitudinal axis L of the ship S, whereas the second propeller device 2 has been turned to an angle of 25° ($\alpha - \beta$) in relation to the longitudinal axis L.

In asymmetric mode of steering, which is illustrated by Figs. 2B and 2C, primarily one propeller device is turned first, and when the steering request is intensified, the other propeller device can be engaged in the steering. Thus, in this respect, the mode of steering is similar to that described in the applicant's FI Patent No. 92,378 of earlier date. Asymmetric steering can be carried out in two ways, i.e. as a mode of steering that reduces the speed or as a mode of steering that increases the speed. Fig. 2B illustrates a mode of steering that lowers the speed. In the case of Fig. 2B, when the automatic

steering system is engaged, the propeller device at the side of the inside curve, i.e. the first propeller device 1 (in the figure the left propeller device because the ship S is turning left), is turned against the travel direction of the ship S and slows down the speed of the ship and produces turning of the ship. The second propeller device 2 is not turned, at least not as yet with little steering angles. In the case of Fig. 2B, the value of the steering angle β is 20° . Since the sticking-out function has been switched on, in the situation in Fig. 2B both of the propeller devices 1,2 have been turned. The first propeller device 1 has turned by the sum of the steering angle and the stick-out angle, and the second propeller device 2 has turned by the stick-out angle α . In Fig. 2B, the value of the stick-out angle α is 45° . When the steering angle β becomes sufficiently large (for example, 30° or larger), both of the propeller devices 1,2 are turned so that they steer the ship. In such a case, a symmetric mode of steering similar to Fig. 2A is concerned.

Asymmetric steering can also be used so that it increases the speed, and this mode of steering is illustrated in Fig. 2C. In asymmetric steering that increases the travel speed, the automatic control system first turns the propeller device placed at the side of the outside curve, i.e., in the case of Fig. 2C, the second propeller device 2, which turns in relation to the travel direction of the ship S and increases the speed of the ship and produces turning. When steering takes place with little steering angles, the first propeller device 1, i.e. the propeller device at the side of the inside curve, does not turn. In the case of Fig. 2C, the value of the steering angle β is 20° . As can be seen from Fig. 2C, both of the propeller devices 1,2 have been turned in relation to the middle position, because the propeller devices 1,2 are in the sticking-out function. In the case of Fig. 2C, the value of the stick-out angle α is 45° . Thus, in the situation of Fig. 2C, the first propeller device 1 has been turned in relation to the longitudinal axis L by the stick-out angle α , i.e. 45° , and the second propeller device 2 has been turned by the difference between the stick-out angle α and the steering angle β , i.e. 25° .

In Fig. 3, an embodiment of the invention is illustrated in which so-called negative sticking-out is employed. In such a case, the propeller devices 1,2 of the ship S are turned inwards so that the same steering properties are retained. In Fig. 3, the value of the stick-out angle is -45° . No steering command has been given, so that the course of the ship S is straight ahead. The type of the propeller devices 1,2, however, imposes certain limitations on such negative sticking out, for it depends on the type of said propeller devices to what extent the propeller currents can be controlled against each other without damage to the equipment.

In Fig. 4, attempts have just been made to illustrate the fact that the sticking-out function in accordance with the invention can also be applied with other propeller devices besides those fitted in the stern of the ship S. Thus, in the embodiment of Fig. 4, it is illustrated that the propeller devices 1',2' may also be placed at the fore

of the ship. With such propeller devices placed at the fore, it is also possible to use both positive and negative sticking out. In the situation shown in Fig. 4, no steering command has been given, and the stick-out angle of the propeller devices is 45°.

In the invention, the value of the stick-out angle α of the propeller devices may vary within a very wide range. The value of the stick-out angle α is not confined to 90°, but it may be considerably larger. In principle, the stick-out angle α can be increased up to 180°. However, in practice, a limit value of the stick-out angle α may already be encountered at 135°. A corresponding range of stick-out angle can be applied both to positive and to negative sticking out.

Finally, in Fig. 5, the principle of the control system in accordance with the present invention is illustrated as a fully schematic block diagram. As a whole and in general, in Fig. 5 the control system is denoted with the reference numeral 10. For the propeller devices, the corresponding reference numerals 1 and 2 have been used as were used in connection with the figures discussed above. As is shown in Fig. 5, each of the propeller devices 1,2 is provided with a control device 13,14 of its own. The control devices of each of the propeller devices 1,2 are connected to the central unit 11 of the automatic control, i.e. to the autopilot. In addition to the above, the automatic control system in accordance with the invention is provided with a stick-out angle control unit 12, which can be connected with the control system when needed so as to regulate the stick-out angles of the propeller devices 1,2 in the desired way. Of course, it is obvious that the propeller devices 1,2 are additionally provided with a possibility for manual control even if this possibility is not illustrated in Fig. 5.

In practice, the sticking out of the propeller devices 1,2 is carried into effect so that the control device 13,14 of each propeller device is given a common stick-out guide value by means of the separate stick-out angle control unit 12. When the central unit 11 of the automatic control has been switched on to control the propeller devices 1,2, it controls the propeller devices in accordance with the preset course irrespective of whether the stick-out angle control unit 12 has been switched on or not. The effecting of the sticking out is, however, not confined to the diagram shown in Fig. 5 alone, but it can also be carried into effect in a number of different ways. However, from the point of view of the present invention, it is essential that, as a result, regulation of the travel speed of the ship is achieved by means of the propeller devices by sticking out while the automatic control has been switched on. In stead of a separate stick-out angle control unit 12, the regulation of the stick-out angle might also be carried out as an internal operation in the central unit 11 of the automatic control so that, in view of the objectives of the invention, the result is the same as in the embodiment as illustrated in Fig. 5.

Above, the invention has been described by way of example with reference to the figures in the accompany-

ing drawing. The invention is, however, not confined to the exemplifying embodiments illustrated in the figures alone, but different embodiments of the invention may show variation within the scope of the inventive idea defined in the accompanying patent claims.

Claims

1. An automatic control system in a ship provided with rotatable propeller devices for automatic maintenance of the course of the ship and for controlling the course in accordance with a preset course, said ship (S) being provided with one or several pairs of propeller devices, in which the propeller devices (1,2) that constitute a pair have been arranged symmetrically in relation to the centre line (L) of the ship and are connected to the central unit (11) of the automatic control system (10), which unit can be connected optionally to control the propeller devices (1,2) that form a pair symmetrically or asymmetrically, **characterized** in that the automatic control system (10) is provided with a control unit (12), by whose means, irrespective of the situation of operation of the central unit (11) of the automatic control system, the propeller devices (1,2) that form a pair can be connected to stick out by turning the propeller devices (1,2) in opposite directions in relation to the longitudinal centre line (L) of the ship (S) so as to regulate the speed of the ship (S).
2. An automatic control system as claimed in claim 1 in a ship provided with rotatable propeller devices, **characterized** in that the stick-out angle control unit (12) of the propeller devices is accomplished as a unit separate from the central unit (11) of the automatic control system.
3. An automatic control system as claimed in claim 1 in a ship provided with rotatable propeller devices, **characterized** in that the stick-out angle control unit of the propeller devices is integrated in the central unit (11) of the automatic control system so that the switching of the propeller devices (1,2) to sticking-out is carried out as an internal operation in the central unit (11) of the automatic control system.
4. An automatic control system as claimed in any of the preceding claims in a ship provided with rotatable propeller devices, **characterized** in that the propeller devices (1,2) can be connected either to positive sticking-out, in which the propeller currents of the propeller devices (1,2) have been turned away from each other, or to negative sticking-out, in which the propeller currents of the propeller devices (1,2) have been turned towards each other.
5. An automatic control system as claimed in any of the preceding claims in a ship provided with rotata-

ble propeller devices, **characterized** in that the stick-out angle (α) of the propeller devices (1,2) is continuously adjustable.

6. An automatic control system as claimed in any of the preceding claims in a ship provided with rotatable propeller devices, **characterized** in that the value of the stick-out angle (α) of the propeller devices (1,2) can be adjusted within the range of 0...180° in relation to the longitudinal centre line (L) of the ship (S).
7. An automatic control system as claimed in any of the preceding claims in a ship provided with rotatable propeller devices, **characterized** in that the control system is arranged to maintain the desired speed of the ship (S) and/or to keep said speed invariable by adjusting the stick-out angle (α) of the propeller devices (1,2).

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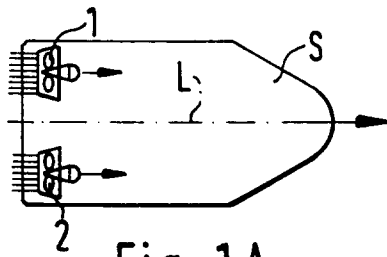


Fig. 1A

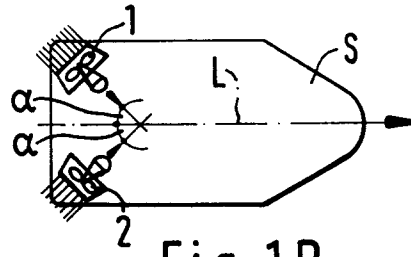


Fig. 1B

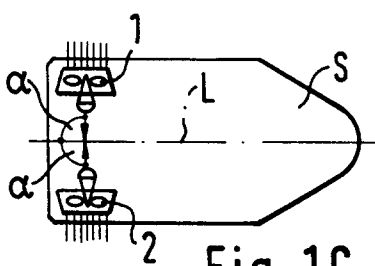


Fig. 1C

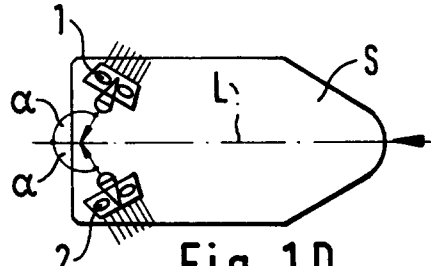


Fig. 1D

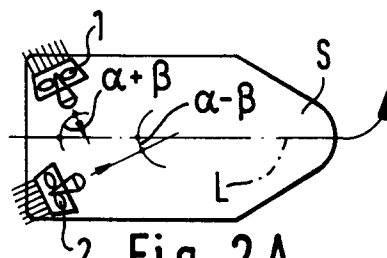


Fig. 2A

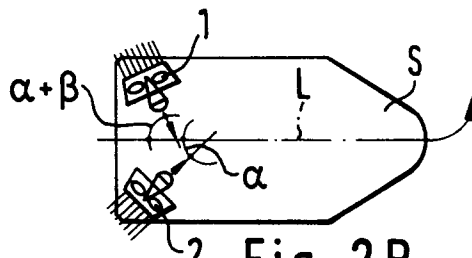


Fig. 2B

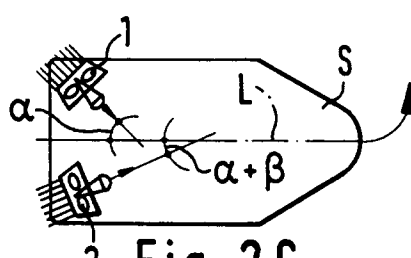


Fig. 2C

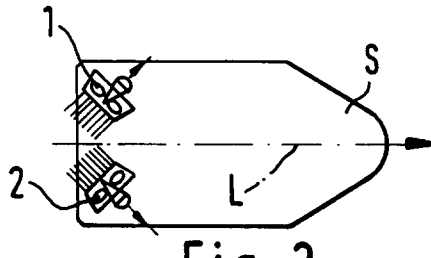


Fig. 3

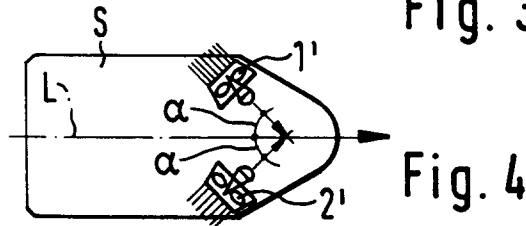


Fig. 4

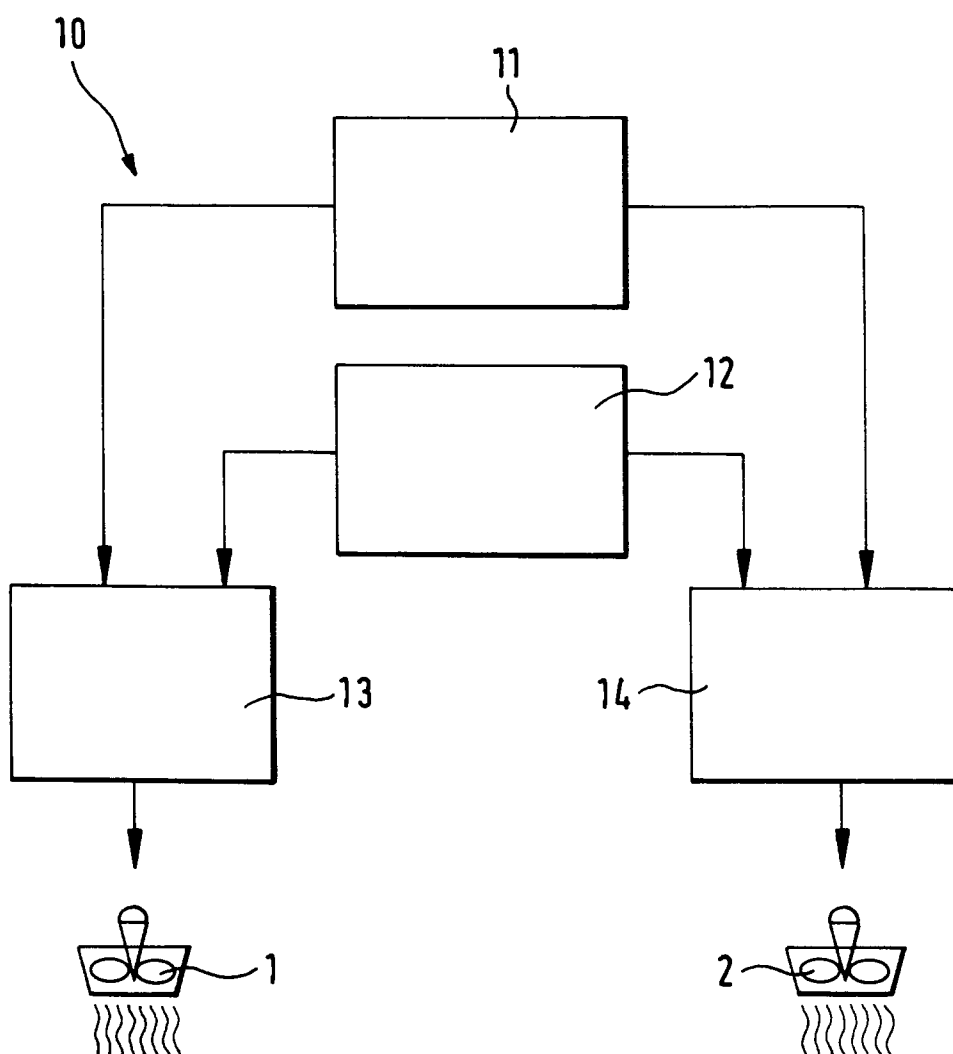


Fig. 5



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 85 0052

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	GB-A-2 259 490 (AQUAMASTER-RAUMA OY) * abstract; figures *	1	B63H25/04 B63H25/42
A,D	& FI-B-92 378 ---	1	
A	EP-A-0 035 859 (ISHIKAWAJIMA SHIP & CHEMICAL PLANT CO) * abstract; claim 1; figures *	1-7	
A	US-A-4 271 780 (A.ETOH) * abstract; figures * -----	1-7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			B63H
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		10 June 1996	Stierman, E
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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