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Datasheet for the decision of 8 October 2015

Case Number: T 1861/14 - 3.2.01

Application Number: 09171591.2

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Title of invention:
Automatic anti-roll stabilization system of a watercraft

Patent Proprietor:
CMC Marine S.r.l.

Opponents:
(1) Quantum Controls B.V./Sleipner Motor AS/ ABT. TRAC Arcturus Marine System dba
(2) Naiad Maritime Group, Inc.

Headword:

Relevant legal provisions:
EPC Art. 54, 56, 123(2)

Keyword:
Added subject-matter (no)
Novelty (yes)
Inventive step (yes)

Decisions cited:

Catchword:

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Case Number: T 1861/14 - 3.2.01

D E C I S I O N
of Technical Board of Appeal 3.2.01
of 8 October 2015

Appellant I: (Patent Proprietor)	CMC Marine S.r.l. Via Grecia 52 56021 Cascina (PI) (IT)
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Decision under appeal:	**Interlocutory decision of the Opposition Division of the European Patent Office posted on 11 July 2014 concerning maintenance of the European Patent No. 2172394 in amended form.**

Composition of the Board:

Chairman	G. Pricolo
Members:	C. Narcisi
	O. Loizou

Summary of Facts and Submissions

I. European patent No. 2 172 394 was maintained in amended form by the decision of the Opposition Division posted on 11 July 2014. An appeal was lodged by Opponent 1 (joint Opponents acting under joint representation) and by Opponent 2, on 11 September 2014 and on 22 September 2014 respectively, and the appeal fees were paid at the same time. The statements of grounds of appeal were filed both by Opponent 1 and Opponent 2 on 21 November 2014. The Patentee lodged an appeal on 11 September 2014 and paid the appeal fee at the same time. The statement of grounds of appeal was filed on 7 November 2014.

II. Oral proceedings were held on 8 October 2015. Appellants II and III (Opponents 1 and 2) requested that the appealed decision be set aside and that the patent be revoked. Appellant I withdrew its appeal during the oral proceedings and requested as Respondent (Patentee) that the appeals be dismissed.

III. Claim 1 as upheld by the appealed decision reads as follows:

"An automatic anti-roll system for the stabilization of the rolling of a watercraft at anchor, comprising :
- a stabilizing fin (12) that can turn about an axis (18), the stabilizing fin (12) being configured for being mounted in a transverse direction with respect to the hull of the watercraft and having a hydrodynamic profile which, in use, is impinged upon by the flow of water in relative motion with respect to the hull to generate a force of hydrodynamic lift;

- an actuator assembly (14), designed to govern rotation of said stabilizing fin (12) about said axis (18); and
- a regulating system (16), designed to govern said actuator assembly (14) as a function of signals indicating rolling of the watercraft, said regulation system (16) comprising sensor means (30), designed to supply a signal indicating rolling of the watercraft; characterized in that:
a) said actuator assembly (14) comprises an electric motor (26) connected to said stabilizing fin (12) via an epicyclic reduction gear (28), wherein an input shaft of said reduction gear (28) is fitted on an output shaft of said electric motor (26) and the output shaft of said reduction gear (28) is fixed with respect to a shaft (22) that bears said stabilizing fin (12), and
b) said regulating system is arranged for carrying out control of the angular position of the stabilizing fin (12) by means of an encoder (36) associated to said electric motor (26) and comprises:
- a microprocessor regulating unit (32), designed to process the data on rolling of the watercraft supplied by said sensor means (30); and
- a driving unit (34) for governing said electric motor (16)."

IV. The submissions of Appellants II and III may be summarized as follows:

The subject-matter of claim 1 contravenes the requirements of Article 123 (2) EPC since the term "epicyclic reduction gear" was not originally disclosed in the application documents as filed. Indeed, in the originally filed application as published (hereinafter designated as EP-A) merely the term "epicyclic motor reducer" can be found (see paragraphs [0015] and [0022]). Further, the feature reading "an epicyclic reduction gear (28), wherein an input shaft of said reduction gear (28) is fitted on an output shaft of said electric motor (26) and the output shaft of said reduction gear (28) is fixed with respect to a shaft (22) that bears said stabilizing fin (12)" is derived from paragraph [0022] of EP-A, albeit by omission of the wording "an epicyclic reducer with input and output at 90° apart". This likewise leads to a generalization implying an extension of the content of the application as originally filed.

The subject-matter of claim 1 is not new over O8 (Master Thesis of Pang Qiang entitled "Design and Research about electric drive systems of stabilizing fins in ships", at Harbin Engineering University, December 1, 2006), in conjunction with O8T (partial English translation of O8) and O8T2 (additional partial English translation of O8, including "Abstract" and "Chapter 1 Introduction"), since O8 (in conjunction with O8T, O8T2) discloses feature a) and also the remaining features of claim 1. Specifically O8 generally discloses a ship fin stabilizer control system, suitable for control of rolling at anchor, as shown in figure 1.1 and as described on pages 8 to 12 of O8T2. Although the "follow-up system" of figure 1.1 is described as including an electro-hydraulic actuator (see O8T2, page 9), the "follow-up system" investigated in the master thesis employs a fin stabilizer electrical servo system, as shown in figure 2.1 and described in section 2.2 of O8T2 in detail. In particular, the conventional electro-hydraulic system is replaced by a three-phase AC asynchronous motor driving the fin via a harmonic wave speed reducer (harmonic reduction gear). According to O9 (Excerpts from Johannes Volmer (Herausgeber) et al., "Getriebetechnik-Umlaufrädergetriebe", Verlag Technik Berlin, 1990, Vorwort, Inhaltsverzeichnis and pages 70-82) a harmonic reduction gear is an epicyclic reduction gear. Further, according to O8 (see figure 2.1) the electric motor 6 is directly coupled to the harmonic drive gear 7, which is directly coupled to the stabilizing fin 8. Finally, the position and velocity of the electric motor is detected by means of an incremental optical encoder (see O8T2, page 17). The remaining features of claim 1 being evidently known from O8 it ensues that claim 1 lacks novelty over O8.

The subject-matter of claim 1 lacks an inventive step in view of D1 (B. Stafford and N. Osborne, "Technology Development for steering and stabilizers", Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, 1 June 2008, pages 41-52), D3 (S. J. O'Neil, Motion Control Handbook, Micro Mo Electronics, Inc., Dec. 1998, pages 1-36) and the skilled person's common general knowledge. D1 discloses all the features of claim 1 except for said feature a), which reads "said actuator assembly (14) comprises an electric motor (26) connected to said stabilizing fin (12) via an epicyclic reduction gear (28), wherein an input shaft of said reduction gear (28) is fitted on an output shaft of said electric motor (26) and the output shaft of said reduction gear (28) is fixed with respect to a shaft (22) that bears said stabilizing fin (12)". The skilled person would aim at simplifying the structure and configuration of the anti-roll system of D1. D1 already hints in this direction, for it states (see D1, page 51, chapter 7) that "cost savings could be realized by using a single actuator to drive each fin rather than two actuators, although this will require changes to the tiller arm and fin bearing and so would only be cost effective for new builds". Therefore the skilled person would modify the system of D1 by using one single actuator. Further, as is taught in handbook D3 (see page 23, figure 8), the skilled person would envisage using a direct coupling between the electric motor and the load, in an attempt to further simplify and reduce the costs of the known system of D1. By doing this, there would be no more any need for a tiller arm and the skilled person would arrive in an obvious manner at the subject-matter of claim 1.

The subject-matter of claim 1 is not inventive over O8. Indeed, on the assumption that said feature a) is not known from O8, it would be obvious for the skilled person to replace the harmonic reduction gear with an epicyclic reduction gear, by directly coupling the input and output of said epicyclic reduction gear respectively to the output of the electric motor and to the input of the stabilizing fin. Indeed, as suggested by O9, D12 (Excerpt from Wikipedia: "Epicyclic gearing"), or D10 (US-B2-7 418 912), the skilled person would realize that reduction gears similar or equivalent to harmonic reduction gears can be used, in particular epicyclic gears, which provide equivalent or at least similar advantages, such as high torque capability and gear ratio, coaxial input and output shafts and high torque to weight ratio. Also, the skilled person is taught by D15 (A C Fairlie-Clarke "Some novel design features for ship stabilisers and steering gears", Trans IMarE (Transactions of the Institute of Marine Engineers), Vol. 106, Part I, pp. 27-41, 1994) to directly couple a harmonic gear drive in between the output of the electric motor and the input of the fin stabilizer (see D15, page 30, left column; figure 1). Alternatively, this measure would be implemented by the skilled person as an obvious technical measure forming part of its common general knowledge (see D3, page 23, figure 8) in order to simplify the system of O8. Therefore, the skilled person would arrive at the claimed subject-matter in an obvious way.

The subject-matter of claim 1 lacks an inventive step over D8 (Luo YanMing "Research on fin stabilizer at zero speed and its electro-servo system for ship", PhD Thesis Harbin Engineering University, 2007, 127 pages" (in conjunction with D8A and D8B (partial English translations of D8)) in view of documents D10 (US-B2-7 418 912), D12, D15 and O8. D8 discloses a ship fin stabilizer control system, suitable for control of rolling at anchor (control at zero speed being evidently included in the control system of D8), disclosing all features of claim 1 with the only exception that merely a "reduction gear" is specified in D8 (see D8B, chapter 1.4, figures 1.8 and 1.9 and text connected therewith) instead of an epicyclic reduction gear, as required by claim 1. However, this feature cannot involve an inventive step, given that epicyclic reduction gears are well known to the skilled person, as derivable for instance from D10 (column 4, lines 18-22), D12, D15 and O8. Such gears provide known advantages (such as high reduction ratio, high torque to load ratio etc.) and would obviously be envisaged by the skilled person for use as a reduction gear in the system of D8. Hence the subject-matter of claim 1 lacks an inventive step.

V. The Respondent's submissions may be summarized as follows:

The subject-matter of claim 1 complies with the requirements of Article 123 (2) EPC, for the term "epicyclic reduction gear" is based on paragraphs [0015] and [0022] of EP-A and on claim 6 of EP-A. Further, the omission of the wording "input and output at 90° apart" in feature a) of claim 1 does not lead to subject-matter extending beyond the content of the application as filed.

The subject-matter of claim 1 is new over O8. Indeed O8 fails to disclose an anti-roll control system for stabilization at anchor, for the mentioned angular speed (see O8T2, chapter 2.1; 29.2°/sec) of the fin is not apt to ensure stabilization at anchor; higher values of the angular speed are needed, as disclosed in the patent in suit (see patent specification (hereinafter designated as EP-B), mentioning 45°-60°/ sec, paragraph [0013]). Further, O8 does not disclose an epicyclic reduction gear but merely a harmonic reduction gear, given that whatever the meaning of the German word "Umlaufrädergetriebe" might be, in the English technical literature (see for instance D12) a clear distinction between harmonic drive gears and epicyclic reduction gears is made. Finally, figure 2.1 in O8 is only a schematic drawing of the control system and of the apparatus, and it does not give any hint as to whether the harmonic drive gear is "fitted on the output shaft of the electric motor" and is "fixed to the shaft that bears the stabilizing fin" (see claim 1, feature a). Hence the subject-matter of claim 1 is new over O8.

The subject-matter of claim 1 is inventive in view of D1 and D3. D1 does not disclose feature a) of claim 1 and this feature is not made obvious by the disclosure of D3. There is no suggestion in D1 to dispense with the tiller arm and to directly connect an epicyclic reduction gear between the output shaft of the electric motor and the input shaft of the stabilizing fin, for D1 (see chapter 7) merely contemplates (as a future development) using a single actuator to drive each fin by modifying the tiller arm, but no elimination of the tiller arm is suggested. This would likewise not be obvious for the skilled person.

The subject-matter of claim 1 is inventive over O8 in view of O9, D10, D12 and D15. Firstly, O8 would not be taken at all into consideration by the skilled person since it does not deal with an anti-roll system for stabilization at anchor (see above) and with the improvement of such a system particularly with regard to its dynamic response (see EP-B, paragraphs [0009], [0013], [0014]), which is the actual object of the invention. Even assuming that the skilled person would consider O8, then still the skilled person would note that O8 is merely a computer simulation and is not based on any real experimental test. Thus, O8 being essentially a computational research work, the details of the mechanical coupling between the electric motor and the stabilizing fin are not described in O8 and a disclosure of feature a) of claim 1 is therefore entirely missing in O8. Also, a harmonic drive gear clearly distinguishes from an epicyclic reduction gear (see above) and the skilled person would not have any incentive to replace the harmonic drive gear employed according to O8 with an epicyclic reduction gear as known from D10, D12 or O9. Likewise, the combination of O8 and D15 would not be obvious and would not lead to the claimed subject-matter. In effect, D15 is directed to the design, development and testing of a 4t-weight scale model vessel of a 2400 t-weight naval design. It is doubtful whether the skilled person would at all consider this document given that its relevance to actual vessels employed in the real world is questionable. Even taking D15 into account, the skilled person would have no motivation to replace the harmonic drive gear employed in the stabilization system of D15 with an epicyclic reduction gear.

The subject-matter of claim 1 is inventive over D8 when considered in combination with anyone of the further cited documents D10, D12, D15, O8. D8 deals with a scientific study done at research laboratories of Harbin University using an equipment comprising a control unit for controlling an electric servo system, an execution mechanism, a detection and control mechanism and a loading device (see D8B, chapter 1.4). However, the execution mechanism is not described in any sufficient detail, only the use of a reduction gear is generally disclosed and the mechanical coupling between the electric motor and the stabilizing fin is not shown in any detail. Therefore at least feature a) is clearly missing in D8 and, keeping in mind that D8 represents merely theoretical scientific research, the combination of D8 with D10, D12, D15 or O8 would not be obvious for the skilled person and moreover it would likewise not lead to the subject-matter of claim 1.

Reasons for the Decision

1. The appeals are admissible.

2. The term "epicyclic reduction gear" included in claim 1 does not infringe Article 123(2) EPC. In particular, it is disclosed in paragraphs [0015] and [0022] of EP-A that a "motor reducer 28" is preferably an "epicyclic motor reducer", "set between the electric motor and the

axis of rotation of the stabilizing fin". In claim 6 (depending on claim 1) of EP-A a "reduction gear (28)" is disclosed connecting the motor to said stabilizing fin. Therefore it ensues that terms "motor reducer 28" and "reduction gear 28" are employed in an equivalent manner and that therefore the terms "epicyclic motor reducer" and "epicyclic reduction gear" are likewise equivalent. As to the wording "an epicyclic reducer with input and output at 90° apart" (see paragraph [0022] in EP-A) its omission in claim 1 is justified by the fact that in paragraph [0015] of EP-A a more general feature is disclosed, which reads "set between the electric motor and the axis of rotation of the stabilizing fin is a motor-reducer unit, preferably an epicyclic reducer". Here clearly no limitation or restriction to an angle of 90° between input and output applies. It is concluded that the subject-matter of claim 1 complies with Article 123(2) EPC.

3. The subject-matter of claim 1 is new over O8, for feature a) is not disclosed therein. Indeed, a harmonic reduction gear, as employed by the control system of O8 (see O8T2, page 15,16; figure 2.1), does not constitute an "epicyclic reduction gear" as known and defined in the English technical literature. According to D12, for instance, in an epicyclic gear train "the center of one gear revolves around the center of the other". This is manifestly not the case for harmonic drive gears as defined and shown in O9, for they do not include any gear whose center revolves around the center of a different gear. Actually, according to O9 harmonic drive gears are designated as "Wellgetriebe" (see O9, index and page 70, chapter 3. Wellgetriebe), by contrast to "Umlaufrädergetriebe", which is the title of said manual or handbook O9. The reason why harmonic drive gears, defined as "Wellgetriebe", have

nevertheless been included in a handbook about "Umlaufrädergetriebe", remains unclear from O9. Be that as it may, for the reasons indicated above harmonic reduction gears clearly differ from epicyclic gears as commonly defined. Hence this feature is not known from O8. Further, the remaining technical measures included in feature a) of claim 1 (i.e. "wherein an input shaft of said reduction gear (28) is fitted on an output shaft of said electric motor (26) and the output shaft of said reduction gear (28) is fixed with respect to a shaft (22) that bears said stabilizing fin (12)") are clearly not disclosed in O8, given that the way in which said harmonic drive gear is connected to the electric motor and to the fin stabilizer is not described at all in O8. For these reasons the subject-matter of claim 1 is new over O8 (Article 54 EPC).

4. The subject-matter of claim 1 is not obvious in view of D1, D3 and the skilled person's common general knowledge. D1 discloses an anti-roll system for stabilizing a ship, which system does not disclose feature a) of claim 1. From figures 3, 4, 7 and 8 of D1 it is recognized that each fin stabilizer is actuated by a tiller arm coupled to two electromechanical actuators essentially including each an electric servo motor and a planetary roller screw, which is connected to the tiller arm. Therefore, in order to implement feature a) of claim 1 it would be necessary for the skilled person to use a single actuator and to dispense with the tiller arm. This runs counter to the technical teaching of D1, since obviously the tiller arm is particularly effective in providing torque multiplication for the actuation of the stabilizer. Indeed, contrary to the opinion of the Appellants, D1 only suggests as a possible improvement (see chapter 7, "Future Work") realizing an anti-roll system comprising

a single actuator for each fin stabilizer and implementing the corresponding necessary changes to the tiller arm. However, D1 does not hint at a radical change such as using a single actuator and at the same time doing away with the tiller arm. The same conclusion is reached considering D1 in conjunction with D3 and the skilled person's common general knowledge. In effect, it is not disputed that the coupling of the electric motor, the reduction gear and the load according to said feature a) is similar or analogous to the coupling shown in D3 (page 23, figure 8). Nevertheless, for the stated reasons, the skilled person would not contemplate modifying the system of D1 as shown in D3. It is therefore concluded that in view of the above mentioned prior art the skilled person would not arrive in an obvious manner to the claimed subject-matter.

5. The subject-matter of claim 1 is not made obvious for the skilled person by the disclosure of O8 in view of further documents O9, D10, D12 and D15. As discussed above (see point 3), the anti-roll system disclosed in O8 differs from the subject-matter of claim 1 in that it does not comprise said feature a). O8 represents a computer simulation (see for instance Abstract, "The paper simulate the control system of fin stabilizers ..") of an anti-roll system including a fin stabilizer and compares the results obtained with a conventional electro-hydraulic servo system, with an electric motor servo system with vector control and with an electric motor servo system with fuzzy control. O8 concludes (see Abstract) that "the simulation results demonstrate that the fin stabilizers, that used the electrical servo system that based on asynchronous motor vector control, can follow the changing signal of fin stabilizers angle with rapid response and little

dynamic error". In other words, O8 is a highly theoretical scientific paper, which does not even disclose an anti-roll system including all its actual substantial mechanical components and does not contain any figure or drawing showing a mechanical arrangement apt for putting into effect said control system. As stated in O8 (see above), "the paper simulate the control system of fin stabilizers".

Under these circumstances the Board estimates that the skilled person would not regard O8 as a suitable starting point for achieving an actual and real anti-roll stabilization system (to be employed in practice), necessarily including all its substantial mechanical components. Particularly, O8 does not represent a suitable starting point for modifying the actual mechanical actuator assembly such as to improve the dynamic response of the overall anti-roll stabilization system (see EP-B paragraphs [0033], [0036], [0027], [0008]), as implied by said feature a) of claim 1, and thereby achieving the object the invention (as resulting from the heretofore cited passages of EP-B). Specifically, the skilled person would not know (at least as far as partial translations O8T and O8T2 are concerned) which mechanical actuator assembly is actually described and approximated by the model functions and transfer functions used in the computational simulation of the control system according to O8. For instance no details are given on the structure and configuration of the mechanical coupling between the asynchronous electric motor and the fin stabilizer indicated in the respective boxes (or blocks) of the control scheme illustrated in figure 2.1 of O8 (see O8T2). A box (or block) merely indicates the use of a harmonic drive gear which is linked in some non-specified manner to an electric servo motor (asynchronous electric motor) and to a fin stabilizer. The configuration or physical properties of the fin stabilizer are likewise not shown or described. This constitutes no basis for further improvement of the mechanical actuator assembly in view of the stated object of the invention and as achieved by feature a). Summarizing it is therefore concluded that O8 would not be considered by the skilled person as an appropriate starting point in view of the mentioned object of the invention.

The skilled person, even on the assumption that it would retain O8 as an appropriate starting point for achieving the above mentioned aim of the invention, would nevertheless not arrive in an obvious manner at said feature a) of claim 1. In effect, O8 is a highly theoretical scientific work focusing mainly on the advantages of using an asynchronous electric motor with vector control in a control system for a fin stabilizer, as compared to the use of an electro-hydraulic servo system (see above). O8 states that "simulation results demonstrate that the fin stabilizers, which used the electrical servo system that based on asynchronous motor vector control, can follow the changing signal of fin stabilizers with rapid response and little dynamic error" (see O8, Abstract). The mechanical actuator and coupling is described in O8 merely at margin and in no greater detail (see figure 2.1 and O8T2, page 16), wherein a harmonic drive was presumably used on account of its advantageous very high reduction (see O8T2, page 16 see O9, page 81, 3.3.6). Indeed, it is not even clear (at least not from the partial translations O8T and O8T2) if and how the mechanical actuator assembly (including the harmonic drive gear) enters and affects, if at all, the computational simulation in O8. Thus, O8 contains no suggestion whatsoever for the skilled person to modify the mechanical coupling and the type of reduction mechanism according to feature a) in order to improve the dynamic response. Moreover, even if it were clear in which way the mechanical actuator assembly enters and affects said computational control simulation, O8 being a computational simulation based on the use of a specific power drive train including inter alia a harmonic drive gear, it would not be obvious for the skilled person to make substantial changes such as the implementation of said feature a) of claim 1. In effect, the dynamic response of an electro-mechanical control system very sensitively depends on the interplay of all the electrical and mechanical components of the power drive train (including the electric servo motor and its control method, as established in O8 by the use of an asynchronous electric motor with vector control) and the validity of the results obtained in O8 on the dynamic response are highly dependent on the assumptions made, particularly concerning the configuration and the components of the power drive train. Indeed, in nowadays control systems a response time of milliseconds or even a fraction of a millisecond is not unusual (see for instance O8T2, page 5) and computer simulations of specific control systems using Lagrangian mechanics or other numerical methods for the simulation of its mechanical components (e.g. gear trains) and of their dynamic response are often performed to determine even very small differences in dynamic response.

In this situation the Board considers that the skilled person would not obviously attempt to modify the control system of O8 by introducing said feature a) since O8 contains no suggestion in this respect and since this would imply a substantial and radical change, given that O8 is based on the simulation study of a specific system and the validity of the results obtained is consequently limited to this specific system. Moreover, documents O9, D10, D12 and D15 do not give any hint at attaining the mentioned object of the invention. In particular, O9 and D12 only do mention and compare generic known mechanical properties of harmonic and/or epicyclic gears, the dynamic response not being taken into account at all. D10 discloses the use of gear trains such as planetary gear trains in a vessel's rudder steering system, wherein however several linkages are employed (to couple the electric motor to the rudder (see D10, column 2, lines 28-40)), contrary to feature a) of claim 1, and no mention of dynamic response is included, as D10 is not directed to and does not deal with the control of the steering system, by contrast to the invention. D15 likewise (similarly to O8) only discloses the use of a harmonic drive gear in order to obtain a very high reduction of about 200:1 (see D5, page 30, left column, third paragraph) in the very specific technical context of a fin stabilizer system for a 4 t scale model vessel of a 2400 t naval design. This system is moreover mainly designed to counteract nose down pitch instability at high speeds (D15, page 27, "Introduction", left column, first paragraph). As it emerges clearly from D15 (see cited passage on page 30), a harmonic drive gear is selected in order to fulfil the specific requirements resulting from the specific vessel model under study. Here again no specific mention or discussion of dynamic response is to be found. It is therefore concluded that the subject-matter of claim 1 would not be obvious for the skilled person in view of the aforementioned prior art (Article 56 EPC).

6. The subject-matter of claim 1 would not be obvious for the skilled person in view D8 (in conjunction with partial translations D8A and D8B) and further documents D10, D12, D15 and O8. It is noted first that D8 concerns a "research work of the electric servo system of fin stabilizer" which has been carried out at Harbin Engineering University (see D8B, chapter 1.4, page 1, last paragraph). The main focus of D8 lies in the study of the application of a peculiar so-called Weis-Fogh mechanism to the design of fin stabilizers at zero speed. This mechanism was found by the British biologist Weis-Fogh through observing wasp's clapping and flying movement (see D8, Abstract, page 1, last paragraph). D8 develops the mathematical hydrodynamic model of double wing and single wing fin stabilizers for rectangular flat thin wings both when the ship is sailing and at zero speed (with fin's oscillating movement of the fin). Mathematical expressions for the lift and torque are derived and their validity is confirmed by simulation results (see Abstract, page 2, first to third paragraphs). The aforesaid model is applied to a control system with an AC asynchronous servo motor with direct torque control (DTC) (see D8 Abstract, page 2; D8A, chapter 5.2), where "the character of lift depends on the capability of servo system, especially the speediness of startup and stability of operation", such that "control of electromagnetic torque is the key of servo system for the disturbance of waves" (see D8, Abstract, page 2, last paragraph).
As opposed to these two central aspects mentioned in D8 (i.e. mathematical model with simulation for Weis-Fogh mechanism and DTC control method for AC motor) the mechanical actuator assembly is only poorly described, as seen from D8A (chapter 1.4, figures 1.8, 1.9, 1.10 and related description). In particular, it is stated

that the "execution mechanism" or "execution body mainly comprises a motor and a servo controller which is composed of a driving device unit, a mechanical body composed of a reduction gear, a driving shaft and a braking unit". Thus the "main" components are described only in very general terms and the mechanical coupling between the electric motor, the reduction gear and the fin is not described nor illustrated in said figures 1.8 to 1.10 in any detail. Moreover the kind of reduction gear used is not indicated in D8. Under these circumstances, for essentially the same reasons as stated above in relation to O8, the Board considers that the skilled person would not retain D8 as an appropriate starting point for modifying the actual mechanical actuator assembly in order to improve the dynamic response of the overall anti-roll stabilization system, according to the object of the invention.

Even if the skilled person were to consider D8 as an appropriate starting point in view of the stated object of the invention, it would nonetheless not arrive at the subject-matter of claim 1 in view of further cited documents D10, D12, D15 and O8. In much the same way as discussed above in relation to O8, the mechanical actuator and coupling is described in D8 merely at margin, in a schematic way and in no greater detail (see D8B, chapter 1.4, figures 1.8, 1.9, 1.10), wherein the employed reduction gear is not specified at all. Thus, as discussed previously in relation to O8, it is not clear (at least not from partial translations D8A and D8B) on which kind of reduction gear (and actual mechanical actuator assembly) the control system is based, and even if it were clear, specific computational or simulation studies of control systems are of limited validity (due to specific assumptions, as discussed in relation to O8). Hence the skilled person would have no reason to suppose that improvement of dynamic response may be obtained through modification of the mechanical actuator assembly and D8 contains no suggestion whatsoever for the skilled person to employ, in order to improve the dynamic response, a specific sort of reduction gear and a particular mechanical coupling of the reduction gear with the electric motor and with the fin stabilizer according to feature a). This is also not suggested by documents D10, D12, D15 and O8, as already discussed above (see point 5). In effect none of these documents comes anywhere near to dealing with the dynamic response of control systems employing epicyclic reduction gears which are directly coupled to the electric servo motor and to the load. Specifically, as seen above, D12 is a general manual disclosing mechanical properties of epicyclic gears, D10 discloses only a mechanical steering system for a rudder comprising various linkages and an epicyclic gear coupled thereto, D15 and O8 disclose the use of harmonic reduction gears in specific control systems designed to meet particular requirements. For these reasons the combination of D8 with any of the cited documents would not be obvious and it would moreover not lead to the subject-matter of claim 1 (Article 56 EPC).

7. The arguments of the Appellants could not convince the Board. In particular the Board notes that it is emphasized consistently throughout the entirety of the patent specification (EP-B) that the improvement of the dynamic response of the control system for the fin stabilizer according to the invention crucially depends on the improved dynamic response of the mechanical actuator assembly (see EP-B, paragraphs [0008], [0033], [0036]) which comprises both the electric motor and the

motor reducer (epicyclic gear) (see EP-B, paragraph [0027]). The arguments provided by the Appellants could not convince the Board that these aspects of the invention as disclosed in EP-B would be obvious for the skilled person.

In the Board's view the compact configuration (implying high torque transmission in a small volume with low axial inertia) resulting from the direct coupling of the reduction gear to the electric motor on one side and to the fin shaft on the other side (thus eliminating all superfluous linkages) significantly contributes to the improvement of the dynamic response, due to a more effective transmission of the force. In addition, the specific choice of an epicyclic reduction gear leads to more evenly and symmetrically distributed forces around the axis of the epicyclic gear (due to the presence of a plurality of planetary gears), and leads therefore at the same time to a more uniform and stable transmission of the force, as compared for instance to a harmonic reduction gear (where only two essentially diametrically opposed contact or transmission points are present). Moreover, as compared to a harmonic reduction gear, an epicyclic reduction gear has a greater torsional stiffness (low rotational elastic deformation) and negligible lost motion, by contrast to the lower torsional stiffness and higher lost motion of the harmonic drive gear resulting from the flexible elliptical spline deformation.

In the Board's judgement it may reasonably be stated in view of the above, however only with hindsight (since for the previously given reasons this is not suggested or rendered obvious by the available prior art), that all these technical aspects contribute substantially to the improvement of the dynamic response of the anti-roll fin stabilizer according to the invention. In effect, it is the present invention's merit that it has recognized and realized that the implementation of the combination of said features a) leads to the mentioned result.

Order

For these reasons it is decided that:

The appeals are dismissed.

The Registrar: The Chairman:

A. Vottner G. Pricolo

Decision electronically authenticated