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**Datasheet for the decision
of 25 July 2019**

Case Number: T 0216/18 - 3.2.01

Application Number: 07842302.7

Publication Number: 2076436

IPC: B64C27/00, B64C27/10, B64C27/72

Language of the proceedings: EN

Title of invention:
DUAL HIGHER HARMONIC CONTROL (HHC) FOR A COUNTER-ROTATING,
COAXIAL ROTOR SYSTEM

Applicant:
Sikorsky Aircraft Corporation

Headword:

Relevant legal provisions:
EPC Art. 83, 84, 56

Keyword:
Sufficiency of disclosure - (yes)
Claims - clarity - (yes)
Inventive step - (yes)

Decisions cited:

Catchword:



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Case Number: T 0216/18 - 3.2.01

D E C I S I O N
of Technical Board of Appeal 3.2.01
of 25 July 2019

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Decision under appeal: **Decision of the Examining Division of the
European Patent Office posted on 28 August 2017
refusing European patent application No.
07842302.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman G. Pricolo
Members: J. J. de Acha González
O. Loizou

Summary of Facts and Submissions

- I. The appeal is against the decision of the Examining Division refusing European Patent application 07 842 302.7.
- II. The Examining Division considered that claim 1 of the applicant's main request did not meet the requirements of Articles 84, 83 and 56 EPC. The applicant's auxiliary request was rejected for non-compliance with the requirements of Article 123(2) EPC.
- III. The invention as defined in claim 1 underlying the decision under appeal relates to a rotary-wing aircraft comprising a dual, counter-rotating, coaxial rotor system having an upper rotor system and a lower rotor system rotatable about a common axis of rotation. The invention aims at reducing vibrations in the aircraft essentially by providing the aircraft with a higher harmonic control (HHC) system wherein control of the HHC actuator system for the lower rotor system is independent of the control of the HHC actuator system for the upper rotor system.
- IV. The Examining Division held that the wording of claim 1 was not clear (Article 84 EPC) because it recited that the upper and lower HHC *actuator systems* were configured to control actuators instead of reciting that this function was performed by the HHC *controller*. Furthermore, the feature: "the upper rotor control system and the lower rotor control system are overlaid with pilot inputs with the upper HHC actuator system and the lower HHC actuator system" was considered to be "rather obscure".

As regards inventive step (Article 56 EPC), the Examining Division considered that document

D2: EP 0 729 883 A1,

disclosing a single-rotor helicopter, represented the closest prior art, and further that it would be obvious to apply the HHC control according to D2 to a dual, counter-rotating, coaxial rotor system, simply by doubling the control system of D2.

In its reasoning, the Examining Division referred also to document

D6: "Towards generalized active control of helicopters", by Roesch et al., Paper N° A1, Nineteenth European Rotorcraft Forum, September 14-16, 1993, Cernobbio (Como), Italy,

as indicative of the fact that the basics of HHC were part of the general knowledge of the skilled person; and to document

D4: US 2005/0236518 A1,

disclosing an appropriate arrangement of upper and lower HHC actuators in a dual, counter-rotating, coaxial rotor-helicopter.

The Examining Division further took an alternative approach taking D4 as the starting point for the assessment of inventive step, and concluded that the skilled person, facing the problem of implementing an HHC-based fuselage vibration and noise reduction, would obviously implement the basic control known from D2/D6 and thus arrive at the invention.

As regards sufficiency of disclosure (Article 83 EPC), the Examining Division stated that an HHC actuator system comprising a fore-aft cyclic actuator, a left-right cyclic actuator and a collective actuator, as defined by claim 1, necessarily acted on a swashplate. The swashplate being only an optional feature of the aircraft of claim 1, the latter comprised embodiments not having swashplates, which were neither disclosed nor known to a person skilled in the art.

Finally, the Examining Division held that the subject-matter of independent claim 3 of the main request, directed to a method and including method steps corresponding essentially to the structural features of claim 1, did not involve an inventive step for the same reasons as claim 1.

- V. With the statement of grounds of appeal the appellant submitted a main and an auxiliary request. Claim 1 of the main request was amended by reciting that the HHC controller is configured to control the actuators of the upper and lower HHC systems and by removing the above-mentioned obscure feature. As regards inventive step, the appellant essentially argued as follows: Reducing rotor-blade induced vibrations in a dual, counter-rotating, coaxial rotor system was complicated as control inputs to the upper rotor control system and lower rotor control system were typically linked or slaved. As one example, the document

D8: "Design of Higher Harmonic Control for the ABC", J. O'Leary and W. Miao, 1980 AHS (American Helicopter Society),

was cited in the description as describing the

originally HHC proposed system. Such system did control six "signal" actuators to provide HHC inputs to the main servos, i.e. three inputs to the signal actuators inputting into main servo of the upper rotor and three inputs to the signal actuators inputting into the main servos of the lower rotor. However, the three inputs to the upper signal actuators were fixed multiples of the three inputs to the lower signal actuators such that the upper rotor signal inputs were "slaved" to the lower rotor inputs. The pilot flight controls for the upper and lower rotors were also slaved together. Thus, following this slaving philosophy for the HHC inputs was a natural approach. It was apparent in D8 that the analyses projected imperfect vibration control. This was because the slaving process only produced a total of three unique controls whereas there were up to six vibratory hub loads that required suppression for excellent vibration reduction.

- VI. The Board issued a communication indicating that the amendments to claim 1 of the main request appeared to overcome the objections under Article 84 EPC and that the subject-matter of independent claims 1 and 3 was not obvious in view of the closest prior art. However, the objection under Article 83 EPC raised by the Examining Division appeared to be well-founded in respect of the invention as defined in claim 1 and also in claim 3. The appellant was thus invited to file an amended main request overcoming such objection, in which case the Board would then remit the case to the Examining Division with the order to grant a patent on the basis of the set of claims according to the amended request and a description to be adapted.
- VII. With letter of 19 October 2018 the appellant submitted an amended main request in response to the

communication of the Board.

VIII. The claims of this request read as follows:

"1. A rotary-wing aircraft (10) comprising:

a dual, counter-rotating, coaxial rotor system (12) having an upper rotor system (16) and a lower rotor system (18) rotatable about a common axis of rotation (A);

a sensor system (56) within an airframe (F);

an upper HHC actuator system (58) to control said upper rotor system (16) in an X-Y-Z axis;

a lower HHC actuator system (60) to control said lower rotor system (18) in an X-Y-Z axis;

wherein said upper HHC actuator system (58) and said lower HHC actuator system (60) each include a fore-aft cyclic actuator; a left-right cyclic actuator and a collective actuator, and are configured to respectively control an upper swashplate (48) of said upper rotor system (16) and a lower swashplate (40) of said lower rotor system (18),

a HHC controller (54) in communication with said sensor system (56), said upper HHC actuator system (58), and said lower HHC actuator system (60) to individually control said upper rotor system (16) and said lower rotor system (18) to reduce vibration,

wherein said upper HHC actuator system (58) and said lower HHC actuator system (60) are configured to respectively control an upper rotor control system (44) of said upper rotor system (16) and a lower rotor control system (36) of said lower rotor system (18),

wherein the HHC controller (54) is configured to individually control the fore-aft cyclic actuator, the left-right cyclic actuator and the collective actuator of the upper rotor system (16), and is configured to individually control the fore-aft cyclic actuator, the

left-right cyclic actuator and the collective actuator of the lower rotor system (18) independent of the fore-aft cyclic actuator, the left-right cyclic actuator and the collective actuator of the upper rotor system (16).", and

"2. A method of reducing vibration in a rotary wing aircraft (10) having a dual, counter-rotating, coaxial rotor system (12) comprising:

individually controlling an upper rotor system (16) with an upper HHC actuator system (58) in an X-Y-Z axis and a lower rotor system (18) with a lower HHC actuator system (60) in an X-Y-Z axis to reduce vibration within an airframe (F) of the aircraft, wherein said upper HHC actuator system (58) and said lower HHC actuator system (60) are configured to respectively control an upper swashplate (48) of said upper rotor system (16) and a lower swashplate (40) of said lower rotor system (18) and respectively control an upper rotor control system (44) of said upper rotor system (16) and a lower rotor control system (36) of said lower rotor system (18);

wherein said individually controlling further comprises: individually controlling a fore-aft cyclic, a left-right cyclic and a collective of the upper rotor system (16); and

individually controlling a fore-aft cyclic, a left-right cyclic and a collective of the lower rotor system (18) independent of the fore-aft cyclic, the left-right cyclic and the collective of the upper rotor system (16).".

Reasons for the Decision

1. Claim 1 is based on originally filed claims 5, 6 and 7 (directed to an aircraft) together with the wording of claims 8 and 9 (directed to a method). No new technical information is added by combining features of the apparatus claims with those of method claims, as the respective features are linked by the functioning of the actuator systems and of the HHC controller.

In fact, claim 1 corresponds to claim 1 underlying the decision under appeal, for which no objections under Article 123(2) were raised, it being amended such as to overcome the objections under Article 84 EPC raised by the Opposition Division. In this respect, the Board is satisfied that the objections under Article 84 EPC no longer apply because i) claim 1 now defines that it is the HHC controller which is configured to control the upper and lower actuator systems and ii) the obscure feature (see point IV above) has been deleted.

Independent method claim 2 is based on original claims 8 and 9 together with claims 5, 6 and 7.

2. The objection under Article 83 EPC (see point IV above) is also overcome as the independent claims include the feature of originally filed claim 7 according to which the upper HHC actuator system and the lower HHC actuator system respectively control an upper swashplate of said upper rotor system and a lower swashplate of said lower rotor system.

3. Inventive step - Article 56 EPC

3.1 The Opposition Division considered that document D2 which discloses a single-rotor helicopter represents the closest prior art and that it would be obvious to apply the HHC control according to D2 to a dual, counter-rotating, coaxial rotor system, simply by doubling the control system of D2.

The Board takes the view that the choice of the starting point is not correct. Single rotors and coaxial rotors are significantly different systems. Starting from a single-rotor system with HHC with and posing the problem of adapting the system to a coaxial rotor system is not a realistic approach considering that coaxial rotors with HHC are known, see D4 and D8.

Both documents are equivalent in terms of disclosure and can be taken as the starting point. Taking in particular document D8 which is acknowledged in the application on page 2, the only difference over the subject-matter of claim 1 is that the HHC controller is configured to control the actuators of the upper rotor system independent of the actuators of the lower rotor system.

3.2 This has the effect of improving vibration reduction (see page 2, lines 15 to 17 of the application). Thus, the problem solved is to improve vibration reduction.

3.3 In the absence of evidence to the contrary, the applicant's assertion that in the prior art the upper and lower rotor system are slaved as regards pilot flight controls must be accepted as correct. In fact, D4 discloses (see paragraph [0027]) that each rotor system is independently controlled through a separate

swash plate assembly and that the swash plate assemblies translate and/or tilt by a separate servo mechanism which selectively articulates each rotor system independently in both cyclic and collective in response to a rotor control system. This, however, does not mean that the control carried out by the rotor control system is such that the control of one rotor system is independent from the control of the other system. On the contrary, it is clear from paragraph [0029] that although the swashplates are not mechanically linked together, the control of each swashplate takes into account the relative positions of the swashplates, i.e. the control of one swashplate is linked to the control of the other. This corresponds to the statement in the application (see page 1, lines 27 to 29) according to which control inputs to the upper rotor control system and lower rotor control system are typically linked or slaved. Furthermore, D4 discloses the use of HHC (see paragraph [0030]) but gives no detail on how the control is carried out. In particular, the pilot flight controls to the rotors from D4 being slaved, it cannot thus be inferred that its HHC controls are not slaved.

As regards D8, according to the description of the present application (see page 2, lines 4 to 17) and to the appellant's assertion in the statement of grounds of appeal, in this prior art the inputs to the upper signal actuators are fixed multiples of the inputs to the lower signal actuators. Although there is no passage in D8 which would clearly confirm this statement, the Board sees no reason, in the absence of any evidence to the contrary, to put this in question.

In the absence of any indications in the prior art (of all the documents cited in examination proceedings only

D4 and D8 relate to dual, counter-rotating, coaxial rotor systems) that slaved control of higher harmonic vibratory loads in dual, counter-rotating, coaxial rotor systems poses a concrete limit to the reduction of vibration, as the vibratory loads on the upper rotor would not typically be automatically counteracted with a corresponding slave control of the lower motor, the claimed invention cannot be regarded as obvious.

Analogous considerations apply for method claim 2, which defines method features corresponding to the structural features of claim 1.

- 3.4 It follows from the above that also starting from document D4, in accordance with the alternative approach taken by the Examining Division, the skilled person would not arrive at the claimed invention in an obvious manner.

4. Accordingly, the set of claims filed by the appellant define patentable subject-matter. However, the statements of invention in the description still need to be adapted to reflect the valid present independent claims. Furthermore, it should be considered whether the title of the invention needs to be adapted to the amended claims. Thus, the application is not yet formally ready for grant. Since the outstanding matters may be most expediently dealt with by the Examining Division, the Board considers it appropriate to remit the case to the Examining Division under Article 111(1) EPC for further prosecution regarding the adaptation of the description.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the Examining Division with the order to grant a European patent on the basis of the following claims and drawings, and a description to be adapted:
 - Claims: 1 and 2 filed with letter dated 19 October 2018;
 - Drawings: sheets 1/6 to 6/6 as published.

The Registrar:

The Chairman:



A. Pinna

G. Pricolo

Decision electronically authenticated