Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 3218705 A1 2024/06/16

(21) 3 218 705

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2023/11/02

(41) Mise à la disp. pub./Open to Public Insp.: 2024/06/16

(30) Priorité/Priority: 2022/12/16 (EP22306906.3)

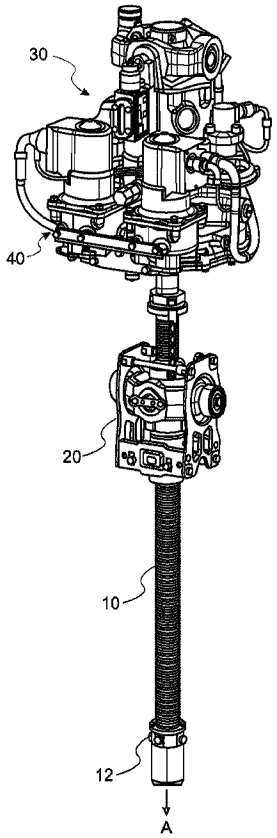
(51) Cl.Int./Int.Cl. *B64C 13/34* (2006.01), *B64C 5/00* (2006.01), *F16H 25/24* (2006.01)

(71) Demandeur/Applicant:
GOODRICH ACTUATION SYSTEMS SAS, FR

(72) Inventeurs/Inventors:
ABDUL-BARI, ANH-VU, FR;
SERRAND, MAXIME JULIEN FLORENT, FR

(74) Agent: NORTON ROSE FULBRIGHT CANADA LLP/S.E.N.C.R.L., S.R.L.

(54) Titre : ACTIONNEUR DE STABILISATION HORIZONTALE AJUSTABLE
(54) Title: TRIMMABLE HORIZONTAL STABILISATION ACTUATOR



(57) Abrégé/Abstract:
A linear actuator comprising: a screw shaft (100); a nut assembly (200) mounted to the screw shaft to move linearly along the screw shaft as the screw shaft is rotated; and a motor (300a) to rotate the screw shaft, wherein the motor is an axial flux motor.

ABSTRACT

TRIMMABLE HORIZONTAL STABILISATION ACTUATOR

A linear actuator comprising: a screw shaft (100); a nut assembly (200) mounted to the screw shaft to move linearly along the screw shaft as the screw shaft is rotated; and a motor (300a) to rotate the screw shaft, wherein the motor is an axial flux motor.

[FIG. 6]

Date Reçue/Date Received 2023-11-02

TRIMMABLE HORIZONTAL STABILISATION ACTUATOR

TECHNICAL FIELD

The present disclosure relates to a new design for a flight actuator such as a trimmable horizontal stabiliser actuator.

BACKGROUND

A horizontal stabiliser is an aircraft component that stabilises the airframe during flight. Typically, they are found at the rear of the fuselage, and incorporate a moveable surface for adjustment in response to trim signals from the pilot or the flight control computer. The moveable surfaces are controlled by an actuator, known as a trimmable horizontal stabiliser actuator ("THSA"). This is controlled by a hydraulic and/or electric motor that is connected to the aircraft fuselage.

The THSA comprises a number of moving components, including a rotating screw shaft, rotation of which is caused by the hydraulic and/or electric motors, via a gear system. This rotating screw shaft causes axial movement of a nut, which in turn drives the moveable surface of the horizontal stabiliser.

No-back brakes are commonly used in screw actuators like this to prevent feedback forces generated by loading the nut of the actuator, from feeding back into the actuator's motor. When a nut of a screw actuator is loaded by an external force (i.e. forces other than that from motor driving the screw shaft, such as forces created through air flow on a stabilizer) the interaction of the nut with the screw shaft will tend to rotate the screw shaft, as the nut tries to translate along the screw shaft in the direction of the external force. A no-back brake may be provided on the screw shaft to prevent or at least minimise rotation of the screw shaft induced in this manner.

Typically, the motor driving the screw shaft is a radial flux motor. Radial flux motors are high speed, low torque motors. To provide the required high torque to move the flight control surface, the THSA includes gears to allow for torque summing.

Date Reçue/Date Received 2023-11-02

Although such actuators have proven effective and reliable, the need for large motors and gear systems results in a relatively large, bulky and heavy actuator requiring assembly and maintenance of a relatively large number of parts. Weight and footprint of components as well as assembly and maintenance time are important factors in the aerospace industry, since extra weight on an aircraft results in increased fuel consumption and down time for assembly and maintenance results in high costs. There is a desire to reduce the size and weight, and assembly and maintenance time, of aircraft parts without compromising reliability and, therefore, safety.

SUMMARY

Accordingly, the disclosure provides a linear actuator comprising: a screw shaft; a nut assembly mounted to the screw shaft to move linearly along the screw shaft as the screw shaft is rotated; and a motor to rotate the screw shaft, wherein the motor is an axial flux motor.

BRIEF DESCRIPTION

Examples of an actuator according to the disclosure will be described with reference to the drawings. It should be noted that these are examples only and variations are possible within the scope of the claims.

Figure 1 shows a standard THSA.

Figure 2 shows, schematically, the flux direction of a radial flux motor such as used in an actuator like that shown in Fig. 1.

Figure 3 shows, schematically, the flux direction of an axial flux motor such as used in an actuator like that shown in Fig. 4.

Figure 4 shows an actuator according to the present disclosure.

Figure 5 is a schematic view of a THSA as known in the art.

Figure 6 is a schematic view of an actuator according to the disclosure.

Date Reçue/Date Received 2023-11-02

DETAILED DESCRIPTION

With reference to Fig. 1, a typical known flight control actuator of the trimmable horizontal stabiliser actuator (THSA) type includes a primary load path with a hollow screw 10 which is connected, in use, to the aircraft. The THSA links the aircraft structure to the stabilizer through e.g. upper and lower gimbals. The primary load path further includes a nut assembly 20 mounted on the screw 10. The nut assembly 20 is connected, in use, to the stabiliser of the aircraft. A secondary load path is typically provided by means of a tie bar (not shown) which is within the screw 10 and is connected to the structure of the aircraft. The THSA and the load paths through the screw are known and will not be described further. The screw 10 is rotationally driven by means of a radial flux motor 30 mounted to the screw 10. The screw 10 may be a ballscrew such that movement of said nut assembly 20 is caused due to the presence of balls (not shown) between the nut assembly 20 and the screw shaft 10.The screw shaft 10 is rotated by means of one or two motors 30 that drive a reduction gear assembly 40, which gears cause said screw shaft 10 to rotate. Upon rotation of the screw shaft 10, the nut 20 moves along the screw shaft.

The screw 10 defines an axis A along its length from the end connected 12 to the aircraft and the opposite end to which the motor 30 is attached via the gears. The radial motor 30 is mounted such that the flux, which is generated radially between the motor stator and the motor rotor, as indicated by arrows F_R in Fig. 2, is perpendicular to the screw axis A.

As is known, a radial flux motor includes a rotor and a stator arranged coaxially. Permanent magnets on the stator or rotor interact with coils on the other of the rotor or stator to generate a radial flux F_R as seen in Fig. 2. The flux is therefore generated perpendicular to the axis of rotation A.#

Because a radial flux motor is a high speed, low torque motor, and because the trim or other surface to be moved by the actuator requires a high torque and low speed, gears 40 are required to increase the torque generated by the motor 30 to a higher torque.

Typically, a THSA requires two such radial flux motors to provide redundancy (torque summing).

Date Reçue/Date Received 2023-11-02

An actuator of this type also typically includes a no-back brake mechanism 50 as mentioned above.

The arrangement of the radial flux motors and the gear system 40, mounted around the screw 10, provides a relatively bulky design.

In order to provide a smaller, simpler actuator, according to the present invention, the radial flux motor and gears are replaced by an axial flux motor 300. The geometry of an axial flux motor is different from that of a radial flux motor and the flux is generated parallel to the axis of rotation (as shown by the arrows F_A in Fig. 3). Although axial flux motors per se are known, they have not previously been used in commercial applications due to complexity and cost of manufacturing. In recent times, however, advances in materials such as soft magnetic composite (SMC) materials has made it more feasible to use axial flux motors in practical designs.

In an axial flux motor, the rotor is axially spaced from the stator. Having the rotor on the motor outer diameter means that the motor can produce greater torque for the same or smaller overall motor footprint. The axial flux motor used in the actuator of this disclosure is mounted to the screw shaft 100 such that the flux generated by the motor is parallel to the screw shaft axis A.

As the axial flux motor has a greater torque, it can directly drive the screw shaft 100 without the need for gears. This together with the relatively flat profile of the axial motor reduces the overall footprint compared to the radial motor arrangement, as can be seen from Fig. 4 as well as Fig. 6 when compared to Fig. 5.

The operation of the nut 200 on the screw shaft 100 is the same as for the conventional THSA and will not be described further.

As with the known designs, the actuator of the disclosure may include motor position sensors. In the present case, these may also detect the ballscrew position thus avoiding the need for resolvers.

A no-back brake NBB 500 may also be provided as in the known system.

The example shown in Fig. 6 has two axial motors 300a, 300b for redundancy in the event of failure of one of the motors. In an alternative embodiment (not shown), a single fault tolerant axial motor may be used thus decreasing the footprint further.
The use of an axial motor instead of a radial motor plus gears results in an actuator with reduced weight, envelope and complexity.

Date Reçue/Date Received 2023-11-02

CLAIMS

1. A linear actuator comprising:
a screw shaft (100);
a nut assembly (200) mounted to the screw shaft to move linearly along the screw shaft as the screw shaft is rotated; and
a motor (300a) to rotate the screw shaft, wherein the motor is an axial flux motor.

2. A linear actuator as claimed in claim 1, further comprising a no-back brake (500) to prevent back-rotation of the motor (300).

3. A linear actuator as claimed in claim 1 or 2, further comprising a second motor (300b) to provide redundancy for the motor (300a).

4. A linear actuator as claimed in claim 1 or 2, wherein the motor (300a) is a single, fault tolerant axial flux motor.

5. A linear actuator as claimed in claim 1, 2 or 3, further comprising a motor position sensor.

6. A linear actuator as claimed in any preceding claim, further comprising means for connecting the screw shaft to an aircraft part to be moved by the linear actuator.

7. A linear actuator as claimed in any preceding claim being a trimmable horizontal stabilisation actuator, THSA, of an aircraft.

8. An aircraft having a flight control part and a THSA as claimed in claim 7 for controlling movement of the flight control part.

9. The aircraft of claim 8, wherein the flight control part is a horizontal stabilizer.

Date Reçue/Date Received 2023-11-02

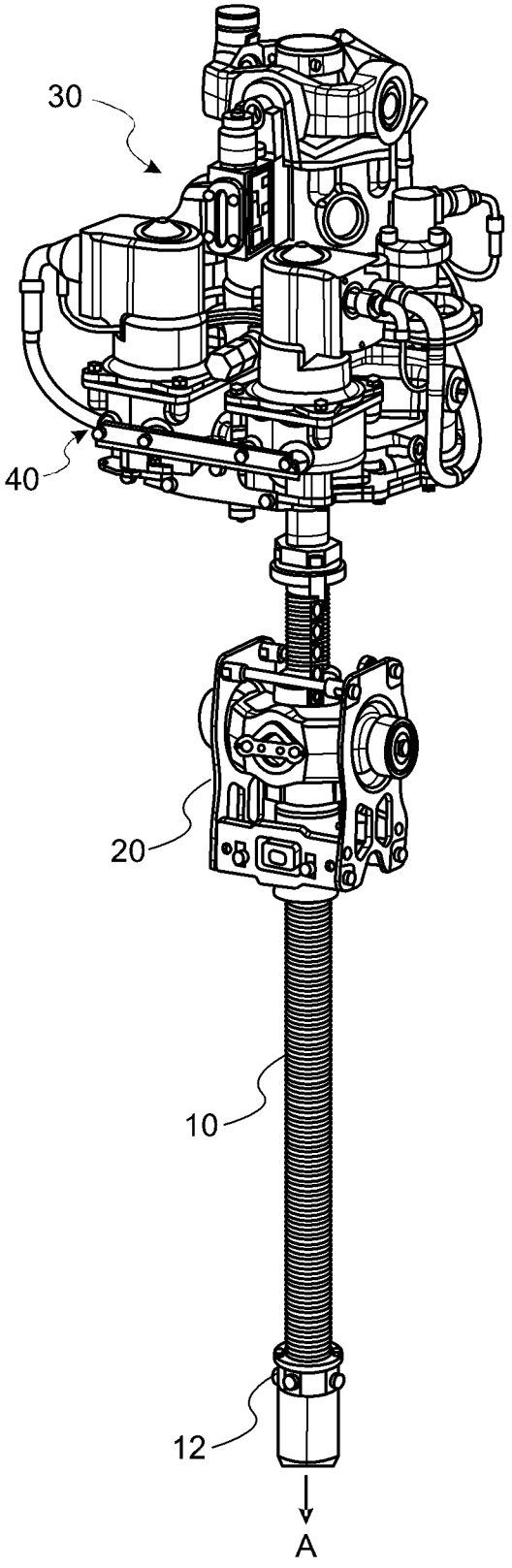


FIG. 1

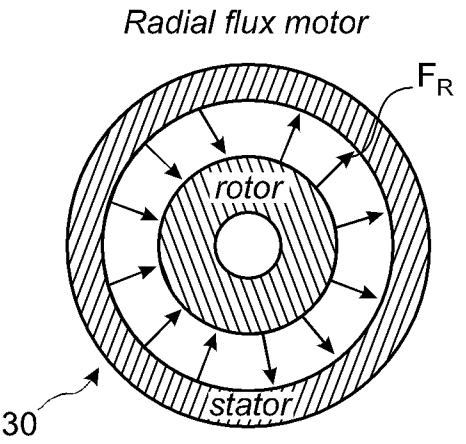


FIG. 2

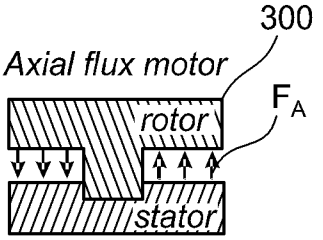


FIG. 3

Date Reçue/Date Received 2023-11-02

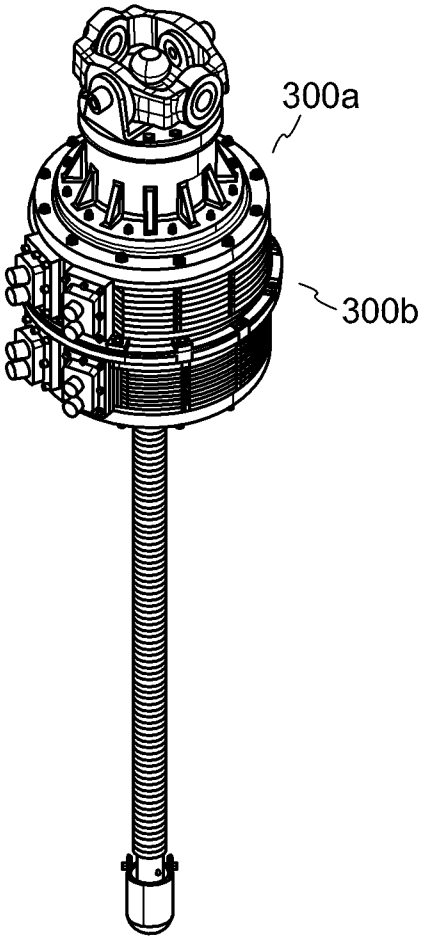


FIG. 4

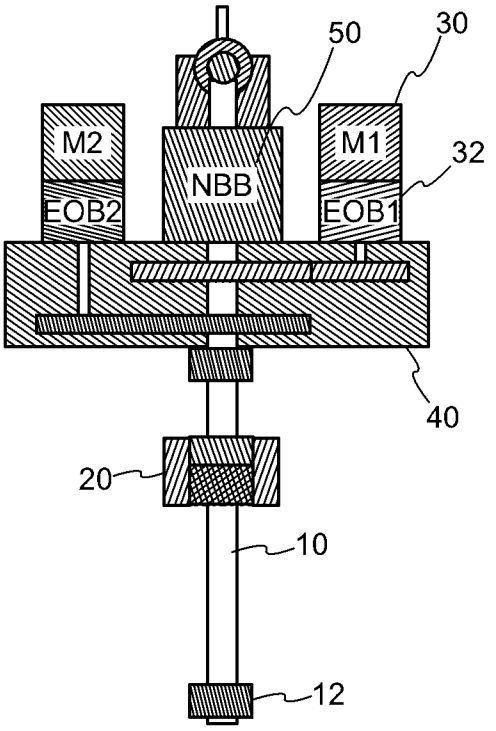


FIG. 5

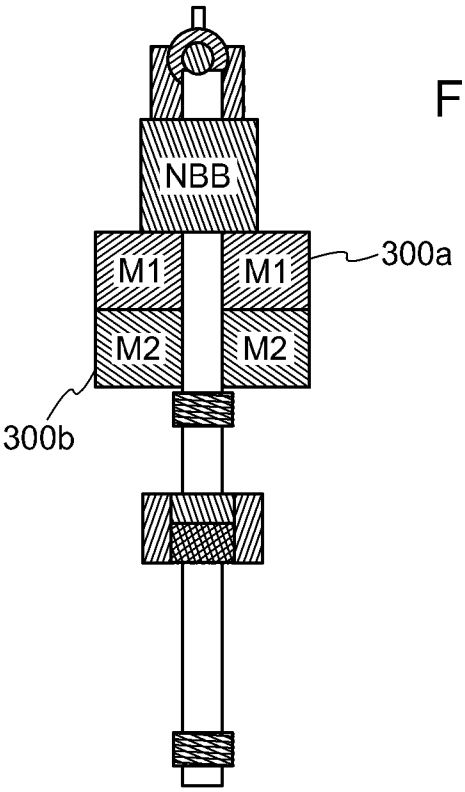
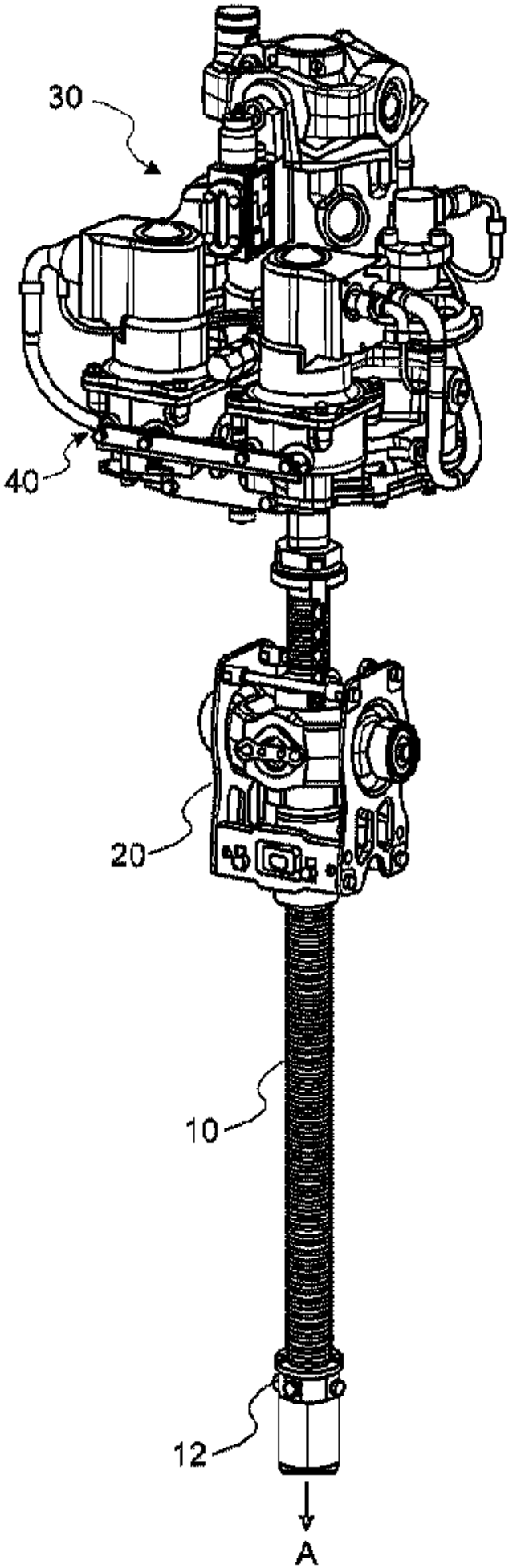


FIG. 6

Date Reçue/Date Received 2023-11-02


30
40
20
10
12
A