(NASA-Case-LAR-13233-1) HELICOPTER ANTI-TORQUE SYSTEM USING STRAKES Patent Application (NASA) 12 p HC A02/MF A01 CSCL 01C
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G3/05 22782

NASA CASE NO. LAR-13,233-1

PRINT FIG. 1

NOTICE

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S.N. 649,329
Filed: 9-11-84

LaRC

THIS NASA INVENTION APPEARS TO HAVE EXCELLENT COMMERCIAL POTENTIAL

HELICOPTER ANTI-TORQUE SYSTEM USING STRAKES

AWARDS ABSTRACT

NASA Case No. LAR 13233-1

This invention relates to a means of helicpter torque control which reduce the power and size requirements of conventional anti-torque systems. The torque-countering forces are generated by controlling the interaction of the main rotor downwash and the helicopter fuselage using strake/spoiler devices 16 attached to the aft fuselage section 11, as shown in FIG. 3.

The strake device 16 is positioned so as to disrupt main rotor downwash and cause flow separation from the aft fuselage 11 on the side facing the approaching rotor blade 12. The specific location of the strake is determined by the particular helicopter wash pattern and fuselage configuration, generally being located between 20° and 80° of top dead center of the fuselage and on the side facing rotor blade approach, as depicted in FIG. 7. The strake generally extends along the entire aft fuselage, but may be segmented to avoid interference with stabilizers or other aerodynamic surfaces.

The novel features of this invention are the improvements in helicopter performance gained through control of the fuselage flow field. These improvements include better slideslip maneuverability, improved hover performance, increased speed, range and load capacity. Additionally, a simple modification to existing helicopters can result in providing a substantial part of the mentioned benefits.

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HELICOPTER ANTI-TORQUE SYSTEM USING FUSELAGE STRAKES

ORIGIN OF THE INVENTION

The invention described herein was made by employees of the United States Government and may be used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to helicopters, and more particularly to the improvement of the helicopter torque control system.

At low to medium forward speeds, helicopter performance is limited by the effectiveness of the means for counteracting main rotor torque and for counteracting sideslip air loads. In order to provide sufficient torque control and adequate sideslip ability, most prior designs have employed a combination of tail fin and a relatively large, power consuming, tail rotor. The problems associated with the use of this type tail rotor are well documented in the prior art. The foremost problem is the hazard presented by the tail rotor, particularly to ground personnel. Additionally, in military helicopters, the tail rotor is vulnerable to combat damage which can result in catastrophic loss of control of the helicopter. Also, the reliability and maintainability problems of a tail rotor, with its gearboxes, bearings, and drive shafts, are severe. Further, during high speed flight the tail rotor requirement can be reduced, since yaw control can be provided by aerodynamic surfaces. However, the typical tail rotor continues to use excessive engine power and to produce adverse drag effects.

In order to avoid these problems, efforts have been made to eliminate tail rotors. In U.S. Patent No. 4,200,252 (Logan) and earlier referenced patents, helicopter anti-torque systems are disclosed which employ the principles of fuselage circulation control using the main rotor downwash. These inventions describe how exhaust or other engine driven air may be ducted into the helicopter aft fuselage section and then be injected tangential to the fuselage in order to induce more circulation. This increase in circulation is achieved by use of main rotor downwash to produce additional lateral forces on the fuselage which oppose main rotor torque.

However, it is established in prior art that main rotor downwash does not flow over the fuselage during high speed flight. The forward velocity of the helicopter moves the fuselage clear before the wash can reach it. Viewed from within the helicopter, the downwash pattern appears to have a large rearward horizontal component Thus, a supplemental means of directional control, other than circulation control alone, is necessary. These supplemental means include tail rotors, aerodynamic fins, and reaction jets.

Two U.S. patents specifically address circulation control, Logan supra and No. 3,807,662. Both of these patents contemplate increasing the favorable lateral forces on the helicopter fuselage. These types of devices result in increased complexity and weight. The ducting, plenum and nozzle arrangements require considerable redesign and modification of the helicopter. Further, the possibility of mechanical failure and the increased vulnerability in the case of a military helicopter remain inherent deficiencies.

Accordingly, it is an object of the present invention to provide a fuselage strake which will alter the air flow around the helicopter tail boom so as to decrease circulation on the side of the boom which faces the approaching main rotor.

It is a further object of the present invention to reduce the load requirements on the helicopter torque control means.

Yet another object of the invention is to reduce the size of the helicopter torque control means by using fuselage air loads to provide part of the needed torque control.

A further object of the invention is to increase helicopter sideslip ability by controlling air flow circulation around the fuselage.

Another object of the invention is to provide a retraction/extension mechanism whereby the strake may be positioned for optimal performance.

A further object of the invention is to prevent interference between aerodynamic surfaces by providing a segmented strake.

Another object of the invention is to provide improved reliability and maintainability for the helicopter torque control means by reducing power and load requirements.

Still another object of the present invention is to improve helicopter performance through increased speed, increased fuel savings and increased load capacity by decreasing power required from the torque control, by decreasing drag inherent in the torque control, and by reducing weight of the torque control means.

SUMMARY OF THE INVENTION

These and other objects of the invention are achieved by providing a fuselage-mounted strake, fabricated of metal or other suitable material, which extends along the aft fuselage section. The strake alters the air flow around the fuselage by separating the flow so as to produce lateral air loads on the tail boom which oppose the main-rotor torque. This result is achieved in a converse manner to prior methods, the present method being to reduce or reverse adverse air loads, that is, those loads on the main-rotor-blade-approach side of the fuselage, whereas prior methods achieved a similar result by increasing favorable forces on the opposite side of the fuselage. Control of circulation around the fuselage is a subtle aerodynamic phenomenon which is greatly affected by minor changes in configuration. The effect can be dramatic, sometimes changing a low pressure region to a high pressure one. Successful circulation control depends on many parameters including the direction and speed of the flow, the cross-section of the fuselage, and the strake location, orientation and size. The strake is to some degree analogous to a catalyst in that small strake changes can create substantial changes in the flow field/fuselage interactions.

The present invention interrupts air flow over the fuselage resulting in flow separation. Once separated, the flow no longer produces a lateral lifting in the direction of the rotor torque. Achieving this effect requires no internal ducting, no drives or mechanisms, and no engine power. The only addition is a small strip extending along the fuselage exterior. This addition can be easily attached to existing helicopters at little expense.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and for further objects and advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a representative helicopter having an attached fuselage strake according to the present invention;

FIG. 2 is a sectional view taken along lines II-II of the helicopter fuselage and attached strake of FIG. 1;

FIG. 3 is a top view of the helicopter showing the strake location with a break at the horizontal stabilizer;

FIG. 4 is an alternate configuration showing a side view of the strake without a break for the horizontal stabilizer;

FIG. 5 is a perspective view of the strake showing the attachment of actuators;

FIG. 6 is a depiction of downwash flow patterns around the helicopter fuselage without the strake;

FIG. 7 is a depiction of downwash flow patterns around the fuselage with the strakes installed;

FIG. 8 shows an alternate torque control means using a lateral-thrusting jet in conjunction with the strake to achieve the necessary torque control.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a representative helicopter designated generally by the reference numeral 10 comprising a cabin fuselage section 18 and the boom or aft fuselage section 11 with a main rotor 12. Attached to the aft fuselage is the upper and lower vertical fin 13, and a torque control means 14 in this embodiment shown as a tail rotor. A horizontal stabilizer 15 may be part of the design or may be absent. The present invention is the strake 16 shown in a representative configuration wherein a break is provided for the horizontal stabilizer.

The strake is angularly displaced from top dead center (TDC) 17 of the fuselage as shown in FIG. 2, a cross-sectional view along line II-II from FIG. 1. Other embodiments include configurations with the strake 16 located between 20° and 80° from TDC.

The location of the strake is also shown in FIG. 3. The strake 16 of the present invention is located on the upper quadrant of the aft fuselage 11 facing the approaching rear main rotor blade 12.

FIG. 4 shows an alternate embodiment wherein the strake 16 extends, without a break, over the horizontal stabilizer 15 to the end of aft fuselage section 11. Small tail rotor 14 is attached to the aft fuselage. A further alternative embodiment is depicted in FIG. 5 wherein the strake 16 is retractable by use of actuators 51. Slot 52 is sealed by a rubber flap or other suitable means when the strake is retracted.

FIG. 8 is a depiction of an additional torque control means using ducted air jets 81 powered by pressurized air 82 as a replacement for the tail rotor 14. This jet would require less power and would be lighter when used in combination with strake 16 than designs in the prior art.

OPERATION OF THE INVENTION

The present invention uses main rotor downwash to create a lateral component of force to oppose the main rotor torque. During operation at low forward speeds, downwash over the fuselage is at its maximum. During these same conditions, the torque control requirement is also highest. Furthermore, during lateral translational flight in the direction of main rotor blade passage over the aft fuselage, the anti-torque requirement is aggravated substantially, and establishes a limiting operational condition for conventional helicopters. Therefore, flow conditions are ideal for providing fuselage forces to counter torque. This result is unlike the effects of a standard design where fuselage forces typically aggravate the torque control problem.

The resulting effects may be seen by a comparison of flow patterns around the helicopter aft fuselage with and without the strake. FIG. 6 is a schematic representation of air loads on an aft fuselage section without the strake installed. Main rotor downwash 61 flows around aft fuselage section 11 creating low pressure areas 62 and 63 and high pressure area 64. The resulting air load provides a component of force which acts in the same direction as main rotor torque, an adverse force 65 depicted by the vector.

By comparison, FIG. 7 shows a schematic representation of the air loads on an aft fuselage section with the strake 16 installed. Main rotor downwash 61 flows around aft fuselage section 11 as before, but is deflected by strake 16 and separates from the aft fuselage surface. This separation creates a high pressure area 71 in place of the previous low pressure area. The resulting air load now provides a favorable force, depicted as net lateral load 72, acting opposite to the direction of main rotor torque. As a result of the reversal of air loads on the helicopter fuselage, a tail rotor or other torque countering device may be reduced in size or loading. Wind tunnel and flight testing have confirmed reductions in tail rotor loads of 5 to 30 percent for three different helicopter types. In a new design helicopter, the expected unloading would allow a reduction in tail rotor disc area of approximately 20-40%.

The flow pattern over the fuselage is changed by the helicopter velocity, yaw angle and main rotor loading. FIG. 5 shows an arrangement to adjust the extension and retraction position of the strake. For example strake 16 may operate with rudder pedal displacement so as to retract the strake during left sideslip, deploy it partially during hover, and extend it fully during right sideslip. A dynamic pressure sensor can attenuate strake movement as forward velocity increases so that as the airspeed exceeds 40 to 60 knots, the strake will remain fully retracted regardless of pedal position. The actuators may be electrical, hydraulic, pneumatic or mechanical devices.

A further embodiment of the present invention includes the use of segmented strakes so as to avoid interference with other aerodynamic surfacs such as a horizontal stabilizer. An open area in the region of the stabilizer avoids tripping stabilizer flow, while the stabilizer itself prevents fuselage circulation from developing side lift.

As previously noted, fuselage forces alone cannot provide complete torque control. An additional means of torque control is required. Torque control requirements are highest during high power operation, that is, during either very low or very high speed flight. During high speed flight, the necessary torque control can be provided by aerodynamic surfaces, such as fins. However, during low speed flight, these surfaces are ineffective. Therefore, a tail thruster is necessary, typically a tail rotor, and this device and associated drive must be sized for the low speed regime. As a result, the tail rotor is larger and heavier than needed in other flight regimes and produces additional drag and power penalties at high speeds. These factors are cumulative and all result in degradation of helicopter performance, in range, payload, maneuverability and economy. The present invention minimizes these factors by reducing the tail rotor or other torque control device requirements.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

HELICOPTER ANTI-TORQUE SYSTEM USING FUSELAGE STRAKES

ABSTRACT OF THE INVENTION

A helicopter 10 with a system for controlling main-rotor torque which reduces the power and size requirements of conventional anti-torque means. The torque countering forces are generated by disrupting the main rotor downwash flowing around the fuselage. The downwash flow is separated from the fuselage surface 11 by a strake 16 positioned at a specified location on the fuselage 11. This location is determined by the particular helicopter wash pattern and fuselage configuration, generally being located between 20° before top dead center 17 (TDC) and 80° from TDC on the fuselage side to which the main rotor blade 12 approaches during rotation. The strake 16 extends along the fuselage 11 from the cabin section 18 to the aft end and can be continuous or separated for aerodynamic surfaces such as a horizontal stabilizer 15.

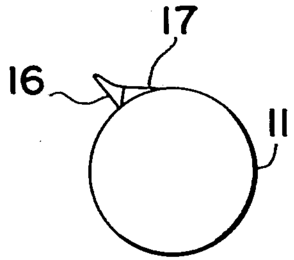

FIG. 2

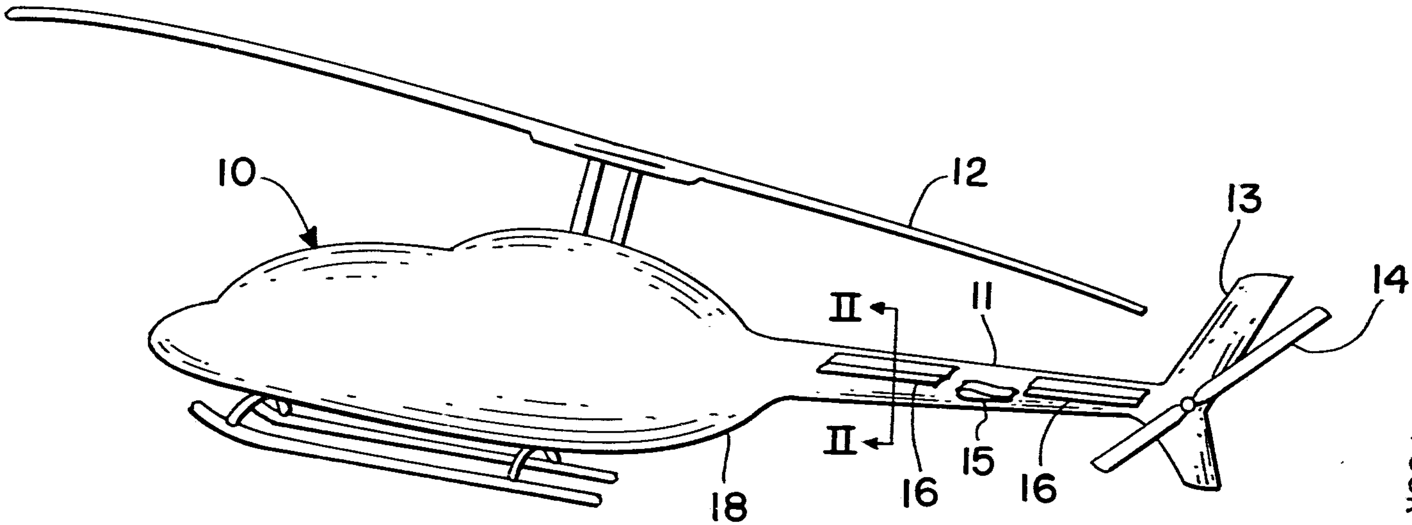

FIG. 1

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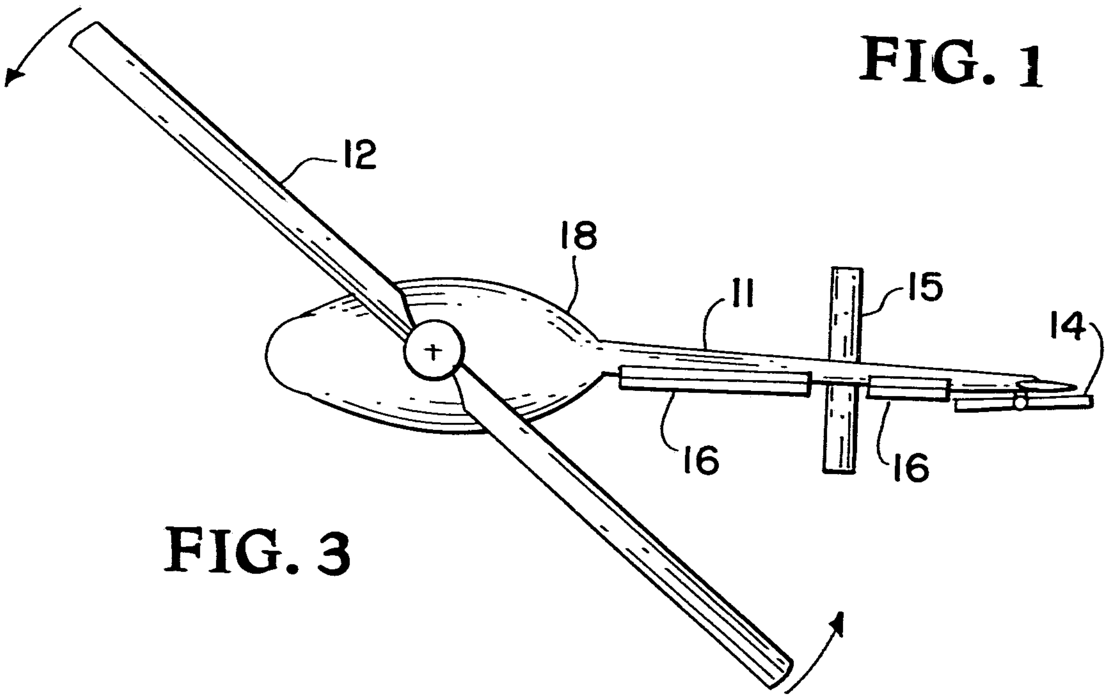

FIG. 3

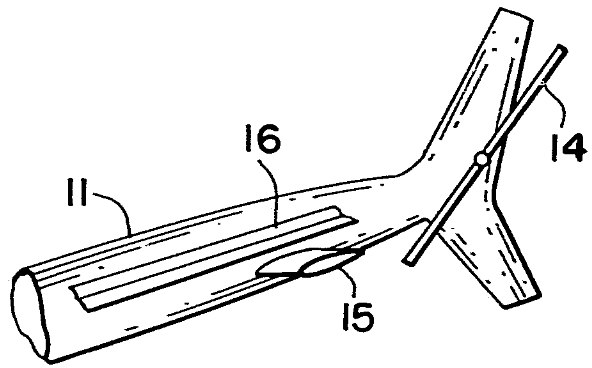

FIG. 4

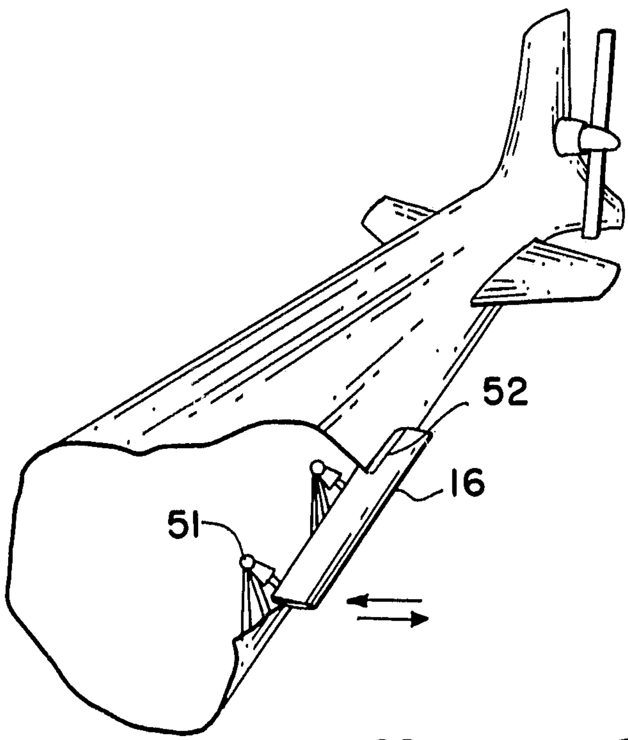

FIG. 5

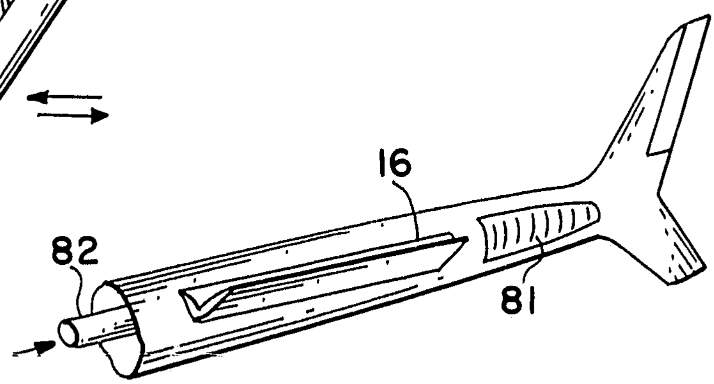

FIG. 8

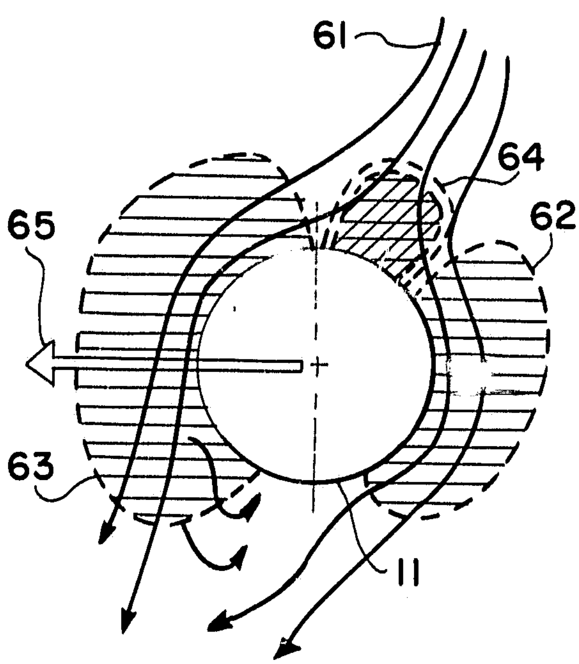

FIG. 6

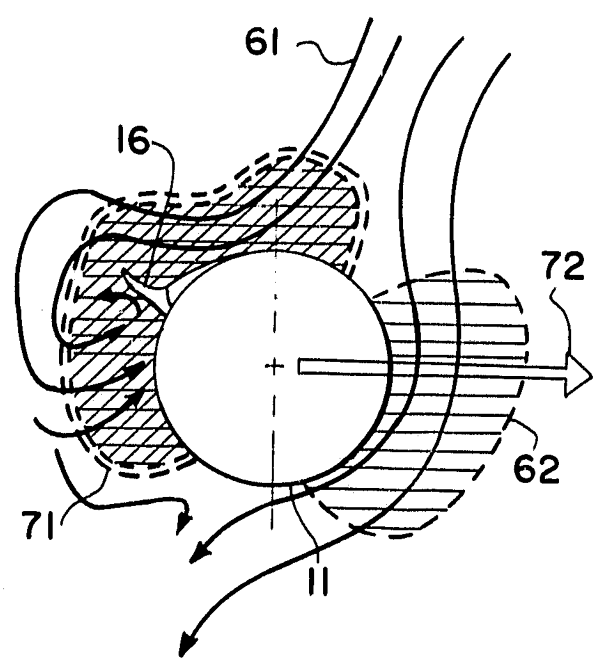

FIG. 7