Feb. 17, 1953 M. D. BUIVID 2,628,686

ANTIFLAPPING LOCK

Filed Aug. 18, 1951 2 SHEETS—SHEET 1

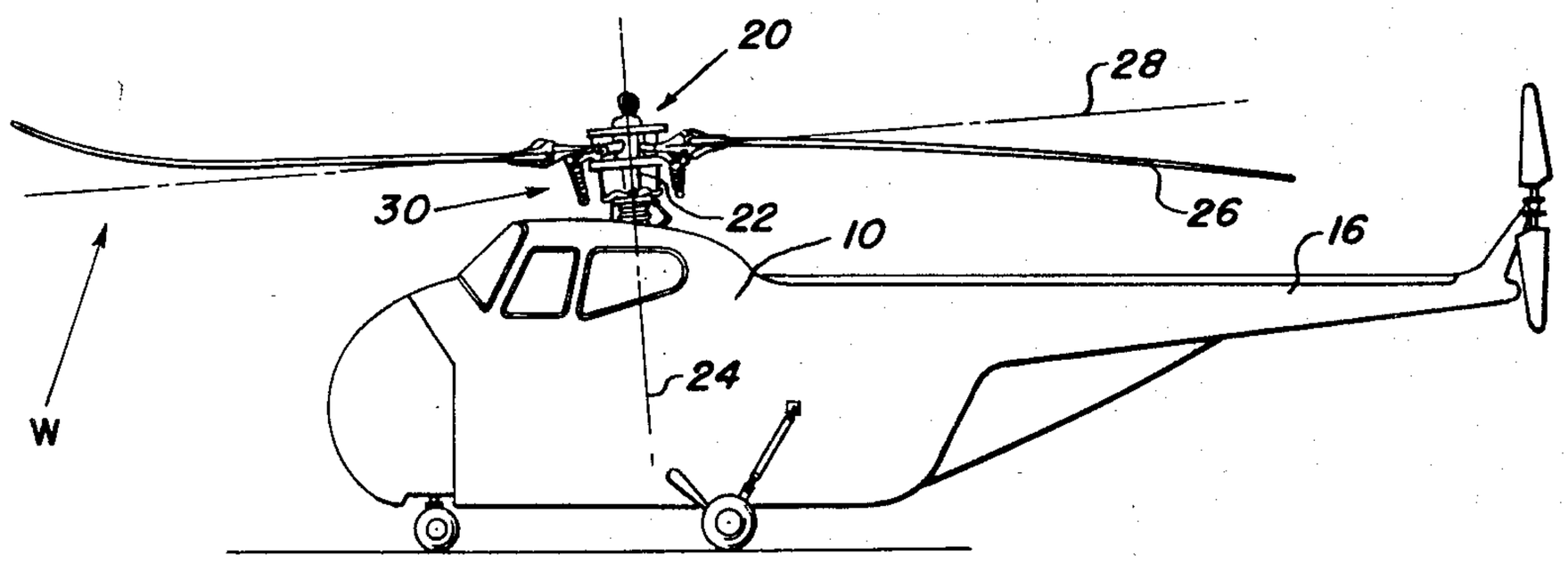

Fig. 1

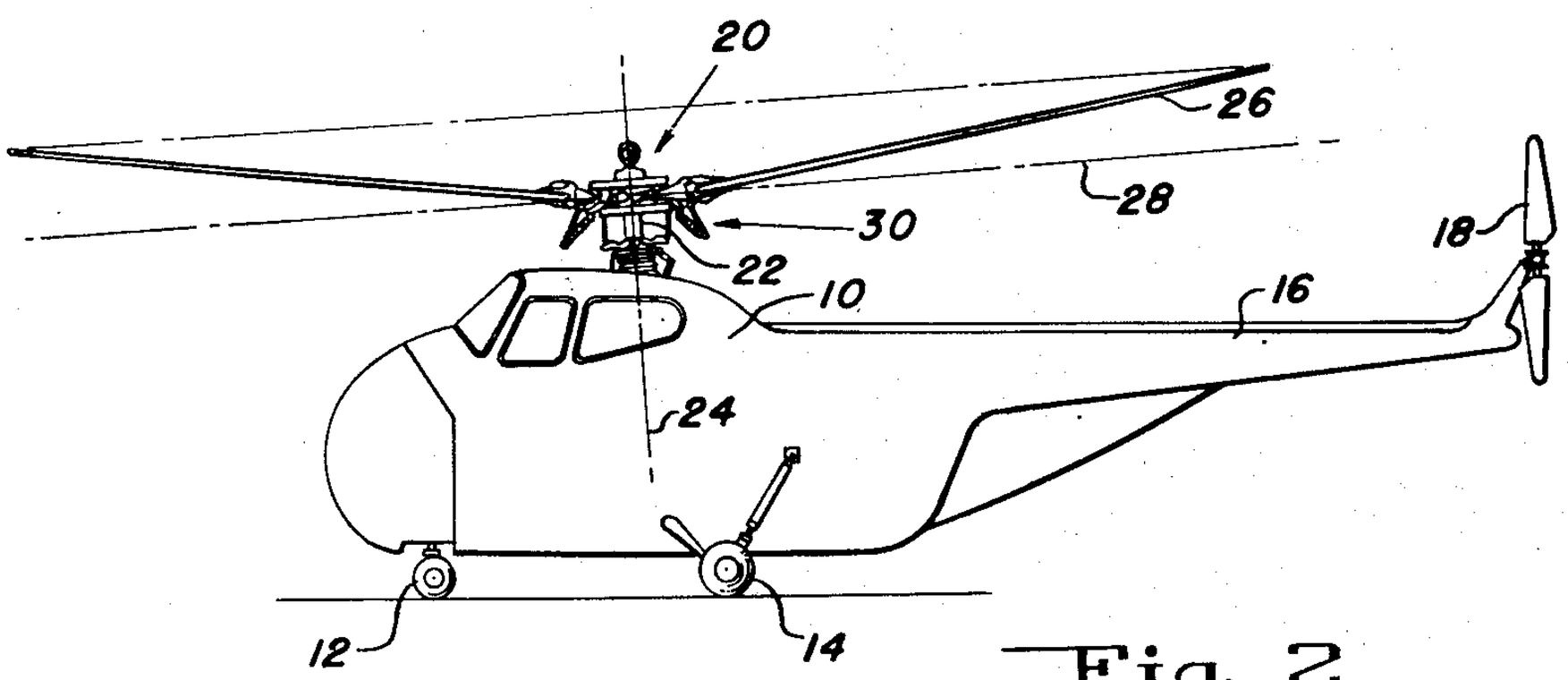

Fig. 2

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ANTIFLAPPING LOCK

Filed Aug. 18, 1951 2 SHEETS—SHEET 2

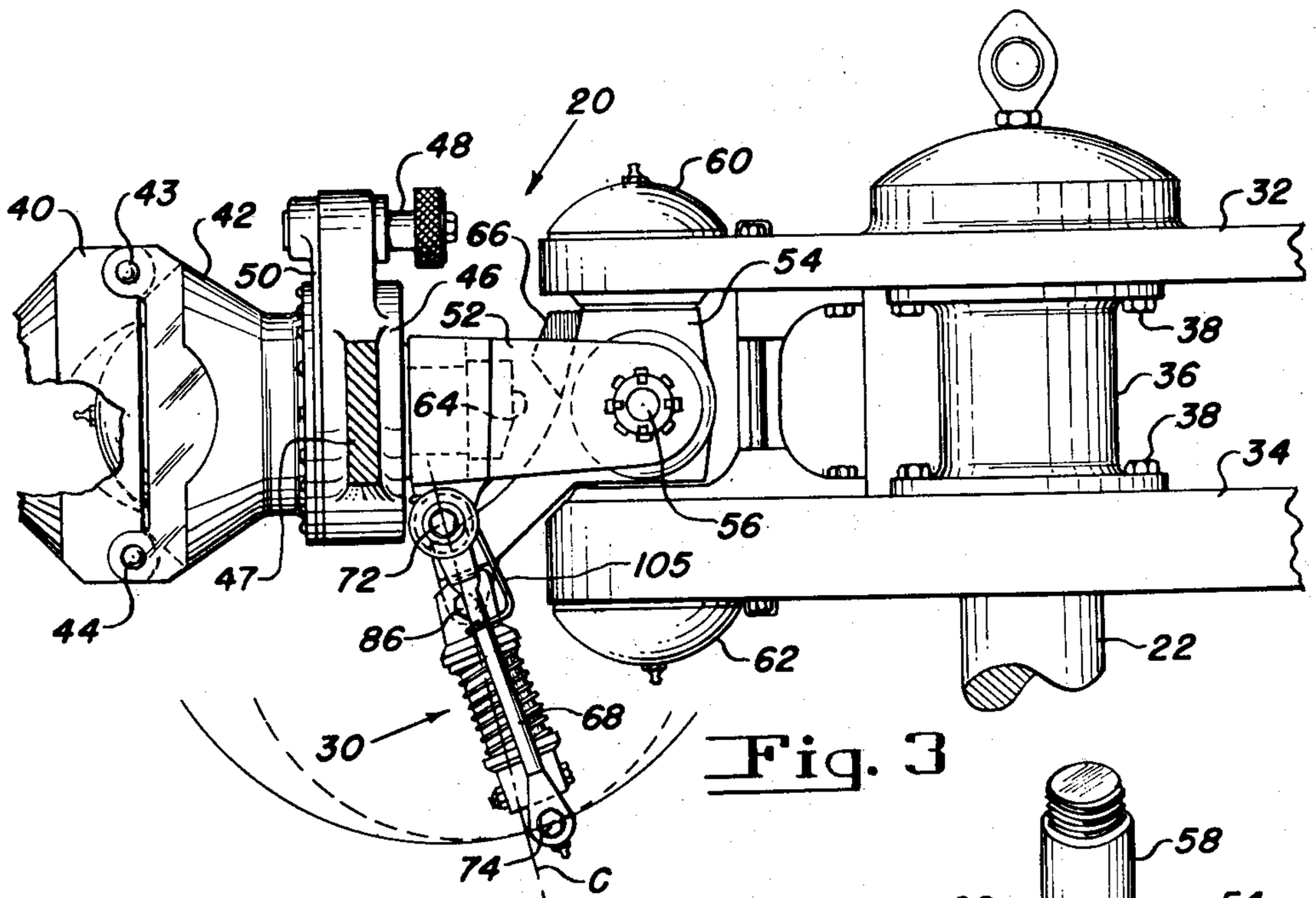

Fig. 3

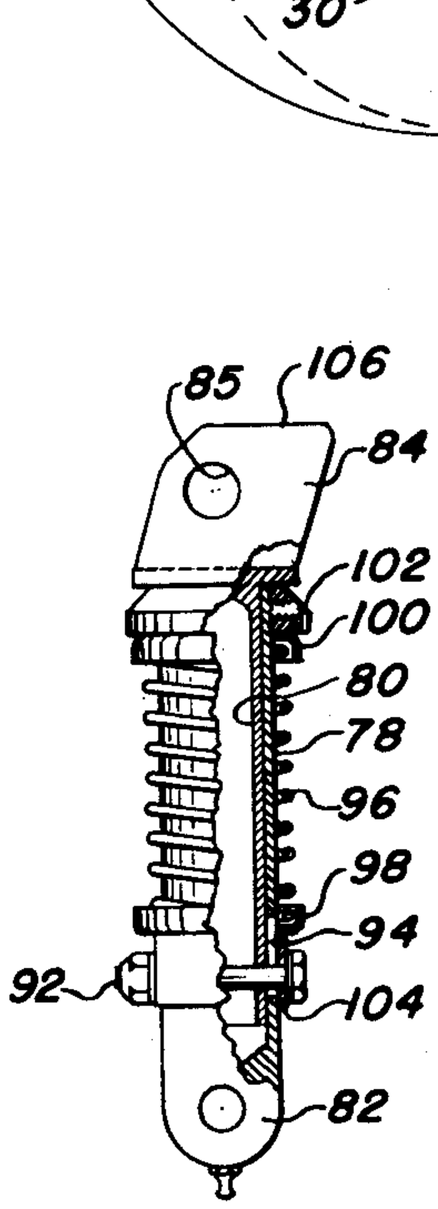

Fig. 5

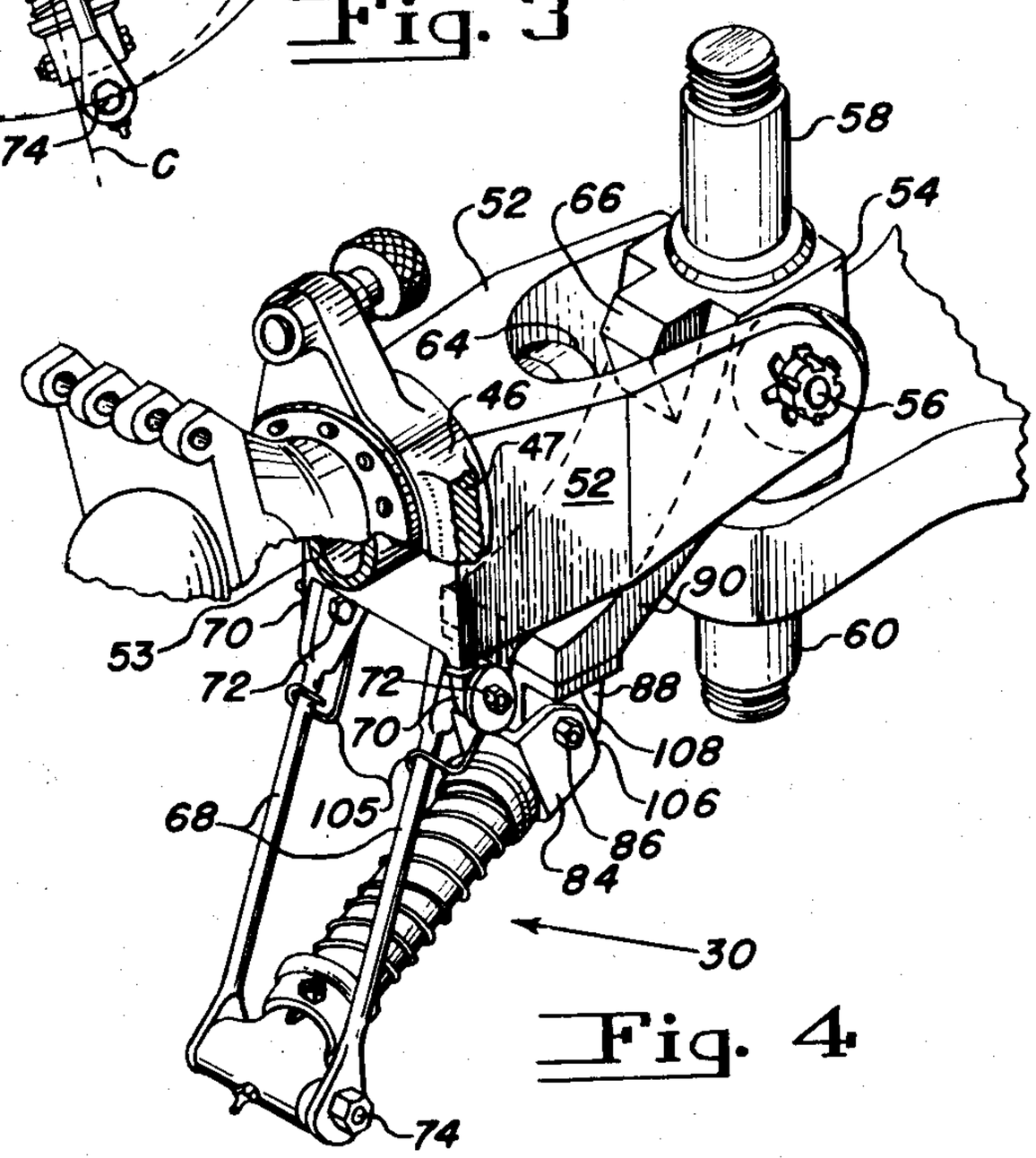

Fig. 4

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UNITED STATES PATENT OFFICE

2,628,686

ANTIFLAPPING LOCK

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Application August 18, 1951, Serial No. 242,559

9 Claims. (Cl. 170—160.55)

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This invention relates to helicopters of the type which are equipped with flapping rotor blades.

When a helicopter of this type is on the ground and its rotor blades are stationary or are rotating only slowly, the blades are susceptible to damage by a gust of wind which may flap a blade upwardly and allow it to drop violently. This may damage the blade or its mounting or it may deflect a rotating blade downwardly sufficiently to strike the fuselage of the ship and damage both the blade and the ship. Under these conditions, when the centrifugal forces acting on the blades are zero or are low, it is desirable to restrain the blades from flapping upwardly due to gusts. When, however, the blades are rotating above a predetermined safe R. P. M. at which the centrifugal forces acting on the blades straighten them and also prevent gusts from deflecting them dangerously out of their normal path of rotation, it is safe to release the lock on the blades and permit them to flap as they are intended to do in normal flight.

It is an object of this invention to provide improved means for restraining the rotor blades of a helicopter from flapping when the blades are not rotating or are rotating slowly while automatically releasing the same for flapping movement under flight conditions.

A further object of the invention is to provide a flapping lock for a helicopter blade which moves bodily with the blade as the latter moves about its drag hinge.

A further object of the invention is to provide an improved flapping restraining mechanism for helicopter rotor blades which automatically releases the blades at a predetermined rotor R. P. M. and which is extremely simple in construction and reliable in operation.

These and other objects and advantages of the invention will be pointed out in connection with the following detailed description of a preferred embodiment of the invention shown in the accompanying drawings.

In these drawings:

Fig. 1 shows a helicopter equipped with the flapping lock of this invention as the latter appears when on the ground with its rotor stationary and subjected to a wind gust.

Fig. 2 shows the helicopter of Fig. 1 with the blades unlocked and free to flap, the blades being shown in the upwardly coned position which they occupy when the blades are being rotated rapidly but at a low pitch setting.

Fig. 3 is an enlarged view of the rotor head illustrating the blade locking mechanism in the

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locked position of Fig. 1, parts being broken away to facilitate illustration.

Fig. 4. is a still further enlarged view in perspective showing the blade lock in the unlocked position of Fig. 2 in which the blade is free to flap upwardly.

Fig. 5 is an enlarged detailed view partially in section of one of the locking members.

As shown in Figs. 1 and 2 the helicopter includes a fuselage **10** which is supported on the ground on nose wheels **12** and rear wheels **14**. The fuselage includes a tail cone **16** at the outboard extremity of which a tail rotor **18** is supported for rotation about a generally horizontal axis. The main rotor generally indicated at **20** is rotatable about a rotor drive shaft **22**, the axis of rotation **24** of which is slightly upwardly and forwardly inclined. The rotor blades **26** are pivotally connected to the rotor head so that in normal flight when the R. P. M. of the rotor is high, these blades will cone upwardly as shown in Fig. 2 above the reference line **28** which is perpendicular to the rotor axis **24**.

When the helicopter is on the ground and the rotor is either not rotating or is rotating slowly the blades **26** are subject to damage from gusts of wind which may whip the blades upwardly and allow them to drop suddenly with destructive force. In accordance with the present invention flap restraining locking means generally indicated at **30** is provided for each blade of the rotor which automatically operates in response to changes in R. P. M. of the rotor to permit the blades to flap upwardly in flight when the speed of the rotor is sufficient to generate blade protecting centrifugal forces but which locks the blades against upward flapping when they are stationary or rotating too slowly to produce these protective forces. Since the locking mechanisms associated with the several blades are identical, only one will be described.

The rotor head is mounted on the upper end of rotor drive shaft **22** and as shown in Fig. 3 includes parallel upper and lower plates **32** and **34** which are spaced apart on shaft **22** by a hub **36**. The hub **36** has upper and lower flanges, and bolts **38** extend through these flanges and pass through the plates **32** and **34** to secure the latter in fixed parallel relation on shaft **22** and at right angles thereto.

The blades are pivotally supported at their inboard ends in spaced relation about the periphery of plates **32** and **34**, the attaching means for one blade being shown in Fig. 3. The inboard end of each blade spar carries a fitting **40** which is se-

cured to a like fitting **42** by two pivot pins **43** and **44**, a construction frequently used to permit folding of the blades by removing pin **43** and folding the blade on pin **44**. During this folding movement the member **42** is permitted to rotate relative to a collar **46** which is part of the blade pitch control horn **47** (only a portion of which is shown) upon withdrawal of a pin **48** from the flange **50** on member **42**. This blade folding mechanism is more fully shown and described in Patent No. 2,405,777, issued to me on August 13, 1946.

To provide blade pitch change the member **46**, which carries blade pitch horn **47**, is rotatably mounted on spindle **53** on the end of the flapping link, or hinge, **52** which is bifurcated at its inboard end to receive block **54** comprising the central portion of the drag hinge. A horizontal pin **56** extends through the bifurcated ends of flapping link **52** and through the block **54** and constitutes the flapping pivot for the blade. The block **54** of the drag hinge has integral upper and lower trunnion-like members **58** and **60** which are journalled in bearings (not shown) in plates **32** and **34** respectively, caps **60** and **62** being provided to enclose these bearings.

Upward flapping movements of the blade are limited by the engagement of surfaces **64** and **66** (Fig. 3) on flapping link **52** and block **54** respectively. Somewhat similar stop means are provided to prevent movement of the flapping link **52** beyond a certain distance below the horizontal position of this link shown in Fig. 3. These stop means are shown in my copending application Serial No. 208,911, filed February 1, 1951. As these stops form no part of the present invention they have been omitted from the drawings in the interest of clarity.

The flap restraining means **30** of the invention consists essentially of two linkages comprising a toggle, one of these linkages is shown in detail in Fig. 5 and the other includes a pair of parallel links **68** each of which is pivotally connected by a bolt **72** to one of a pair of spaced ears **70** depending from the flapping link **52**. The lower ends of links **68** are connected by a through bolt **74** to the other toggle linkage, the bolt **74** comprising the common pivotal connection of the toggle assembly.

Referring to Fig. 5, it will be noted that this toggle linkage includes outer and inner telescoping cylindrical members **78** and **80**. The outer cylindrical member **78** carries an apertured lug **82** through which bolt **74** extends while the inner cylinder carries a bifurcated lug **84** having apertures **85** through which the bolt **86** extends, this latter bolt also extending through depending ear **88** carried by a downwardly and outwardly extending bracket **90** which is formed integral with the drag link block **54**. It will thus be evident that the two bolts **72** comprise the pivotal support for one end of the toggle mechanism and the bolt **86** comprises the pivotal support for the other end thereof, while bolt **74** comprises the common pivotal connection for the toggle linkages.

The outer and inner tubes **78** and **80** are permitted a small amount of axial movement by reason of the limited movement of a through bolt **92** carried by cylinder **80** in diametrically opposed longitudinal slots **94** in cylinder **78**. This slot and bolt arrangement also prevents possible torsional displacement between these parts. The tubes **78** and **80** are constantly biased into the contracted position thereof shown in Fig. 5 in

which the end of tube **78** engages lug **84** by a compression spring **96**, the opposite ends of which rest in cup-shaped washers **98** and **100**. Cup **100** is supported by a nut **102** threaded onto the end of cylinder **78** while cup **98** is supported by a collar **104** which loosely surrounds tube **78** and is connected to the inner tube **80** by bolt **92**. The spring **96** is sufficiently compressed between its end abutments to continuously urge the telescoping tubes **78** and **80** into their contracted positions as limited by the engagement of the free end of tube **78** and nut **102** with lug **84**.

The locking toggle **30** is constantly biased by torsion springs **105** into the slightly over-center position shown in Fig. 3. As best shown in Fig. 4 these springs, which extend back of bolts **72**, have their longer ends hooked over links **68** and their shorter ends hooked over ears **70** so as to bias links **68** about bolts **72** in a counterclockwise direction.

In the over-center position of the toggle shown in Fig. 3, the pivot bolt **74** has passed slightly to the right of a straight line C intersecting the pivot bolts **72** and **86** for the opposite ends of the toggle. The toggle is arrested in this slightly over-center position by the engagement of abutment surfaces **106** on the ends of the parallel ears of lug **84** with the abutment surfaces **108** of bracket **88** as shown in Fig. 3.

When the helicopter is on the ground and the rotor is either stationary or is turning slowly the locking toggle mechanism **30** occupies the over-center position shown in Figs. 1 and 3 in which the toggle locks the flapping link **52** and hence the blade against upward flapping movement due to a gust of wind W indicated in Fig. 1. Any tendency for the blade to move upwardly is absorbed in the toggle by thrust forces acting against the substantially in-line pivots **72**, **74** and **86**. The toggle in the Fig. 3 position effectively resists this thrust because the end of tube **78** carrying nut **102** engages lug **84**, the toggle thus becoming a compact and rigid strut to resist upward forces directed against the blade. The relatively light force tending to rotate the toggle about the bolt **86** due to the over-center position of bolt **74** is resisted by the flat abutment surfaces **106** and **108** previously described.

When the speed of the rotor is increased to a predetermined R. P. M. at which the centrifugal forces acting on the blades are sufficient to safeguard the blades against flapping due to gusts of wind or the like, the centrifugal forces acting on the toggle mechanism **30** overcome the bias of springs **105** and the toggle moves into the broken position shown in Figs. 2 and 4, in which the blade is free to flap upwardly due to aerodynamic forces acting thereon.

It will be noted that in moving from the over-center locked position of Fig. 3 to the broken unlocked position of Fig. 4 the centrifugal forces have only to overcome the bias of springs **105** as the bolt **92** moves upwardly in slot **94**. This slight telescoping movement of the tubes **78** and **80** is required due to the fact that the distance from bolt **74** to bolt **86** is somewhat less than the distance from bolt **74** to bolts **72**. This telescoping movement afforded during the movement of bolt **92** in slot **94** thus enables the toggle to move from a blade locking position to a blade unlocking position even though the blade continues to rotate in a horizontal position as it may do if no blade pitch is imposing on the blade. The above described movement of the locking toggle from blade locking position to blade unlocking position

occurs at a much lower R. P. M. than that required for flight so that as the helicopter rotor is speeded up and the blade pitch is increased the blades will always be unlocked and free to come upwardly as the helicopter takes off.

Similarly when the helicopter comes in for a landing, as the blades slow down with the helicopter resting on the ground, the springs 105 will snap the locking toggles into the Fig. 3 position at the critical R. P. M. below which the centrifugal forces acting on the blades due to their rotation is not enough to protect the blades against being blown upward by a gust of wind.

While I have shown and described a preferred embodiment of the invention, it will be understood that various changes may be effected in the construction and arrangement of the parts without departing from the scope of the invention.

I claim:

1. In a helicopter rotor, a hub, a drag hinge pivoted to said hub having a depending projection, a blade having a root portion pivoted to said drag hinge for flapping movements, said root portion having a depending portion terminating adjacent said projection, and centrifugally operated locking means including a toggle having a pivotal connection at its opposite extremities with said blade and with said projection and movable bodily with said blade as the latter moves about said drag hinge for effecting a locking connection between said projection and said depending portion and preventing upward flapping of said blade when the latter is rotating below a predetermined R. P. M.

2. In a helicopter rotor, a hub, a drag hinge pivoted to said hub having a depending projection, a blade having a root portion pivoted to said drag hinge for flapping movements, said root portion having a depending portion terminating adjacent said projection, centrifugally operated locking means including a toggle having a pivotal connection at one end with said blade root portion and at its other end with said projection and movable bodily with said blade as the latter moves about said drag hinge for effecting a locking connection between said projection and said depending portion and preventing upward flapping of said blade when the latter is rotating below a predetermined R. P. M., and spring means carried by said root portion and bearing against said toggle for constantly biasing the latter toward blade locking position.

3. An anti-flapping lock for a helicopter rotor having a hub and a blade pivoted thereto on flapping and drag hinges, said lock comprising a centrifugally operated toggle having its ends pivotally connected to said flapping and drag hinges respectively and bodily movable with said blade as the latter moves about said drag hinge, stop means on said drag hinge for arresting the inward swinging movement of said toggle in a slightly over-center position, and spring means carried by said flapping hinge and engageable with said toggle for constantly biasing the latter into said over-center position.

4. A centrifugally operated anti-flapping lock for a helicopter rotor having a hub, a drag hinge pivoted on said hub, a flapping hinge pivoted on said drag hinge and a blade mounted on said flapping hinge, said lock comprising two toggle links having a common pivotal connection at one end and having their free ends pivotally connected to said flapping and drag hinges respectively, said toggle being movable with the blade as the latter flaps upwardly between a straightened position in which the blade is locked against upward flapping and a broken position permitting blade flapping, stop means engageable by one of said links for arresting said toggle links in said straightened position, and spring means carried by said flapping hinge and engageable with one of said toggle links for constantly urging said links toward said straightened position.

5. In a helicopter rotor, a hub rotatable about an upright axis, a drag hinge pivoted to said hub, a blade pivoted to said drag hinge for flapping movements, and means bodily movable with said blade as the latter moves about its drag pivot for locking said blade against upward flapping movement whenever the speed of the rotor is below a predetermined R. P. M. including a locking toggle having its extremities connected between said drag hinge and said blade, said toggle occupying a substantially on-center upright position when said rotor speed is below said predetermined R. P. M. and having centrifugal force responsive means adjacent its common pivot for breaking said toggle when said hub is rotated above said speed to unlock said blade for upward flapping movement.

6. A centrifugally operated anti-flapping lock for a helicopter rotor having a hub, a drag hinge pivoted on said hub, a flapping hinge pivoted on said drag hinge and a blade mounted on said flapping hinge, said drag hinge having a portion extending outboard beneath said flapping hinge, said lock comprising two toggle members pivotally connected together at adjacent ends and adapted when in position to lock said flapping hinge to lie in a collapsed over-center position, means pivotally connecting the free end of one member with said extension, means pivotally connecting the free end of the other member with said flapping link, stop means on said drag hinge engageable with one of said toggle members for arresting said toggle members in said collapsed position with the common pivot of said toggle members located slightly inward beyond a line intersecting both pivotal connections for the ends of said toggle members, and spring means carried by said flapping hinge and acting on one member of said toggle for constantly urging said toggle into engagement with said stop means.

7. In a helicopter having a rotatable hub and a blade pivoted to said hub for flapping movement, said blade being connected to said hub by pivoted drag and flapping hinges, means operable in response to the speed of rotation of said hub for limiting flapping movement of said blade about its flapping hinge comprising toggle mechanism connected between said flapping and drag hinges and movable bodily with said blade as it pivots about the latter and movable between a slightly over-center locked position and a broken unlocked position concurrently with flapping movements of said blade, stop means on said drag hinge for arresting said toggle in said over-center position, and means carried by said flapping hinge and acting on said toggle for constantly biasing said toggle mechanism into blade locked position against said stop means, said toggle having centrifugal force responsive means for overcoming said biasing means and moving said toggle into unlocked position when said hub attains a predetermined speed to release said blade for flapping movement.

8. In a helicopter, a rotor hub, a drag hinge pivoted on said hub for movement about a generally vertical axis, a flapping hinge pivoted on said drag hinge for movement about a generally

horizontal axis, said drag hinge having a depending extension which lies beneath said flapping hinge, and centrifugally operated locking means including a toggle connected between said extension and said flapping hinge and movable out of locking position with said blade as the latter flaps upwardly for positively locking said blade against upward flapping movement whenever said rotor is turning below a predetermined R. P. M.

9. In a helicopter, a rotor hub, a drag hinge pivoted on said hub for movement about a generally vertical axis, a flapping hinge pivoted on said drag hinge for movement about a generally horizontal axis, said drag hinge having a depending extension which lies beneath said flapping link, a toggle mechanism having its extremities

pivotally connected to said extension and to said flapping link respectively, and spring means carried by said flapping hinge and engageable with said toggle mechanism for normally biasing said mechanism to an on-center locking position.

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