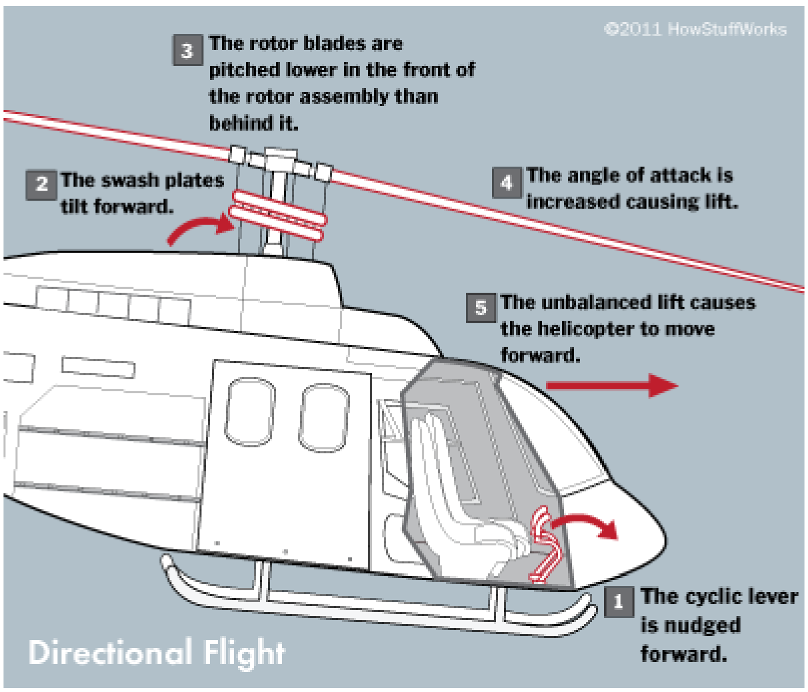
Helicopter Spare Part Component Descriptions

Helicopters are mystery machines to many, but they have become daily participants in the global milltary operations. To understand how they fly, one has to understand the various major assemblies that make a helicopter what it is and how the parts create and control lift.



The steps involved in directional flight for a helicopter

In addition to moving up and down, helicopters can fly forward, backward and sideways. This kind of directional flight is achieved by tilting the swash plate assembly with the cyclic, which alters the pitch of each blade as it rotates. As a result, every blade produces maximum lift at a particular point. The rotor still generates lift, but it also creates thrust in the direction that the swash plate assembly is tilted. This causes the helicopter to lean -- and fly -- in a certain direction. The pilot can impart additional directional control by depressing or easing up on the foot pedals, which increases or decreases the counteracting thrust of the tail rotor.

Let's assume for a moment that the helicopter we discussed in the last section needs to fly forward. This is the pilot's procedure:

1. First, he or she nudges the cyclic lever forward.
2. That input is transmitted to the lower swash plate and then to the upper swash plate.
3. The swash plates tilt forward at an amount equal to the input.
4. The rotor blades are pitched lower in the front of the rotor assembly than behind it.
5. This increases the angle of attack -- and creates lift -- at the back of the helicopter.
6. The unbalanced lift causes the helicopter to tip forward and move in that direction.

When the aircraft reaches about 15 to 20 knots of forward airspeed, it begins to transition from hovering flight to full forward flight. At this point, known as effective translational lift, or ETL, the pilot eases up on the left foot pedal and moves closer to a neutral setting. He or she also feels a shudder in the rotor system as the helicopter begins to fly out of rotor wash (the turbulence created by a helicopter's rotor) and into clean air. In response, the rotor will try to lift up and slow the aircraft automatically. To compensate, the pilot will continue to push the cyclic forward to keep the helicopter flying in that direction with increasing airspeed

Helicopter anatomy

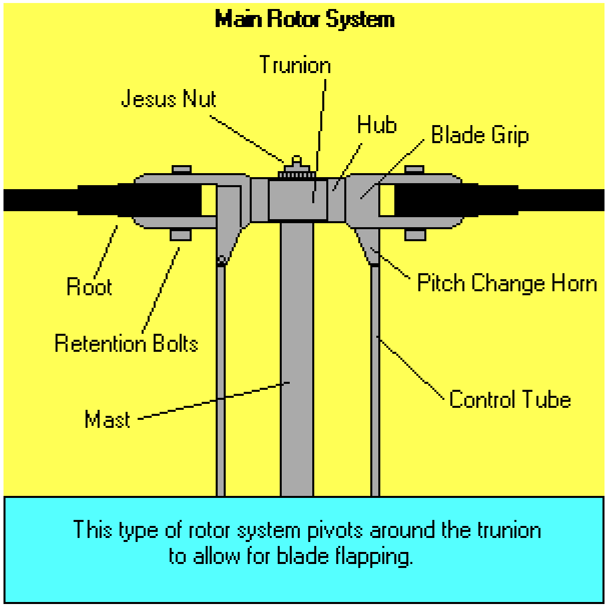
Rotary Wing Terminology

Lets talk a moment about terminology. There are many terms associated with rotary wing flight. One must become familiar with the terminology of rotorcraft before they can expect to understand the mechanics of rotary wing flight. Let's look at a few definitions.

Main Rotor System

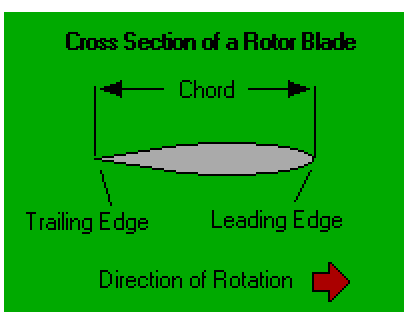
- Root: The inner end of the blade where the rotors connect to the blade grips.
- Blade Grips: Large attaching points where the rotor blade connects to the hub.
- Hub: Sits atop the mast, and connects the rotor blades to the control tubes.
- Mast: Rotating shaft from the transmission, which connects the rotor blades to the helicopter.
- Control Tubes: Push \ Pull tubes that change the pitch of the rotor blades.
- Pitch Change Horn: The armature that converts control tube movement to blade pitch.
- Pitch: Increased or decreased angle of the rotor blades to raise, lower, or change the direction of the rotors thrust force.

- Jesus Nut: Is the singular nut that holds the hub onto the mast. (If it fails, the next person you see will be Jesus).



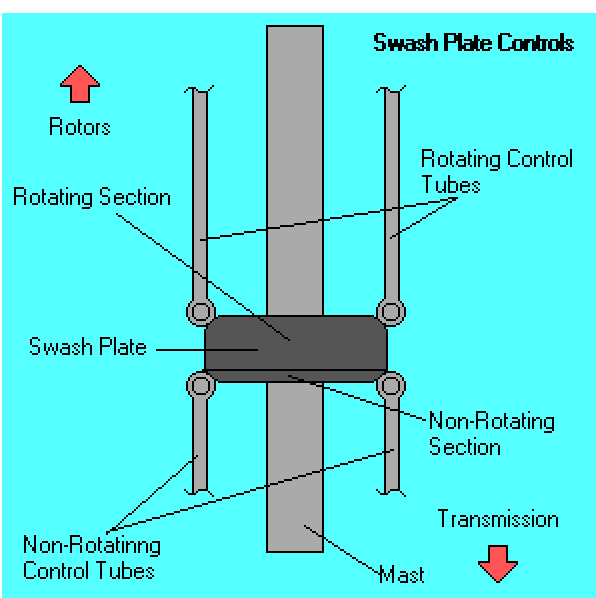
Main Rotor Blade

- Leading Edge: The forward facing edge of the rotor blade.
- Trailing Edge: The back facing edge of the rotor blade.
- Chord: The distance from the Leading Edge to the Trailing Edge of the rotor blade.

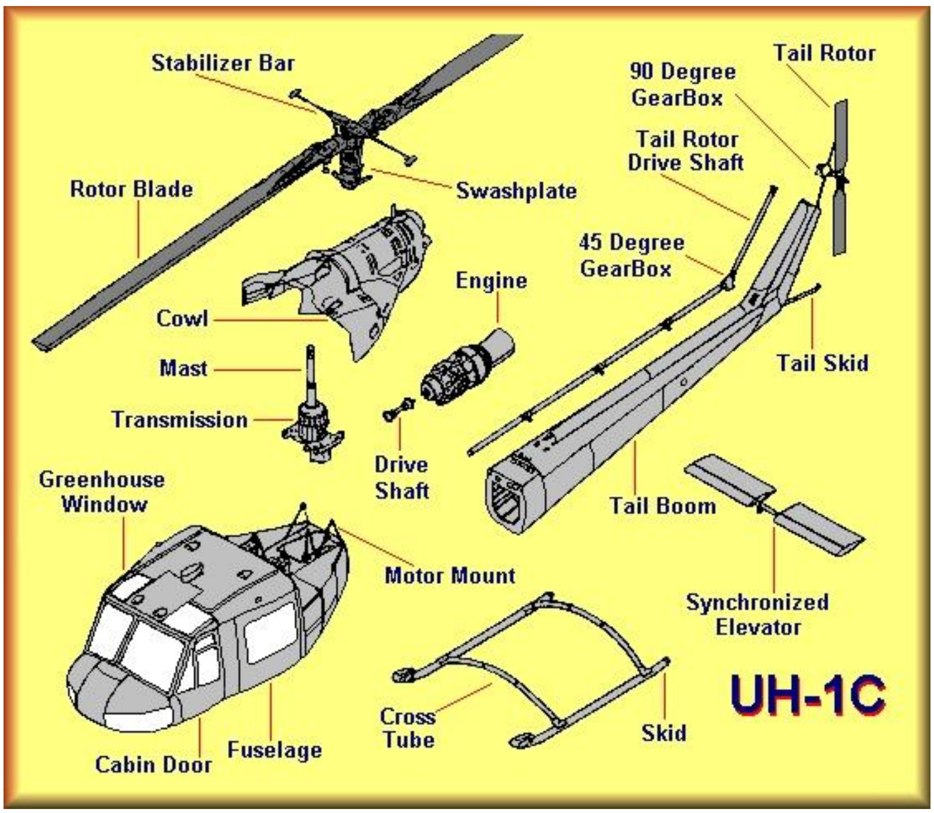


Swash Plate: Turns non-rotating control movements into rotating control movements.

- Collective: The up and down control. It puts a collective control input into the rotor system, meaning that it puts either "all up", or "all down" control inputs in at one time through the swash plate. It is operated by the stick on the left side of the seat, called the collective pitch control. It is operated by the pilots left hand.
- Cyclic: The left and right, forward and aft control. It puts in one control input into the rotor system at a time through the swash plate. It is also known as the "Stick". It comes out of the center of the floor of the cockpit, and sits between the pilots legs. It is operated by the pilots right hand.
- Pedals: These are not rudder pedals, although they are in the same place as rudder pedals on an airplane. A single rotor helicopter has no real rudder. It has instead, an anti-torque rotor (Also known as a tail rotor), which is responsible for directional control at a hover, and aircraft trim in forward flight. The pedals are operated by the pilots feet, just like airplane rudder pedals are. Tandem rotor helicopters also have these pedals, but they operate both main rotor systems for directional control at a hover.

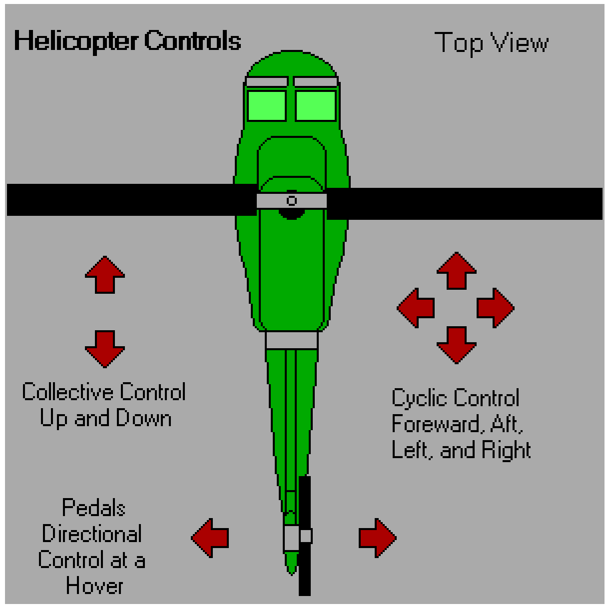


Here are some of the component parts that make up a helicopter. While this is an example of one specific helicopter (UH-1C), not all helicopters will have all of the parts listed here. Some of this may be a bit more of the same old stuff we have just discussed, but it will show everything as it relates to everything else on the aircraft and the location of each component.

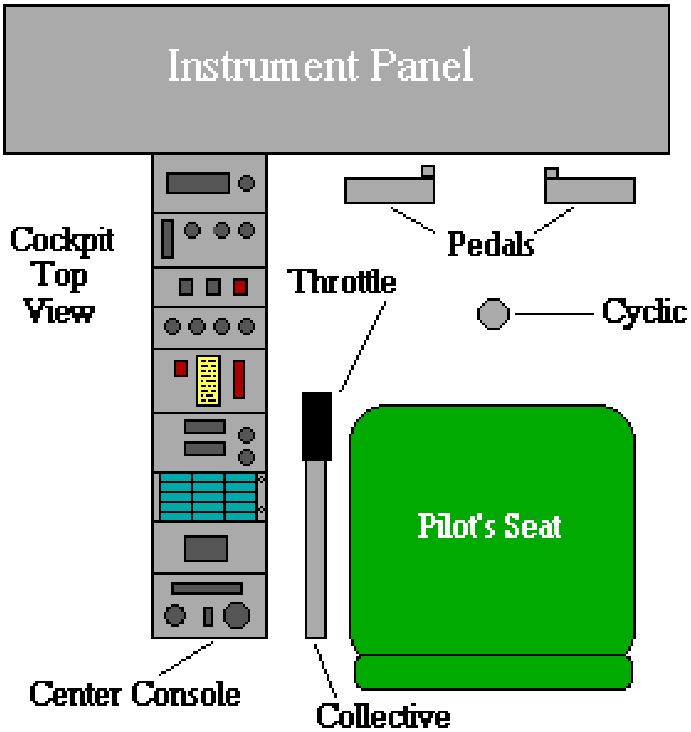


Anatomy of a Helicopter

- Rotor Blade: The rotary wing that provides lift for the helicopter.
- Stabilizer Bar: Dampens control inputs to make smoother changes to the rotor system.
- Swashplate: Transfers non-moving control inputs into the spinning rotor system.
- Cowling: The aerodynamic covering for the engine.
- Mast: Connects the transmission to the rotor system.
- Engine: Provides power to the rotor systems.
- Transmission: Takes power from the engine and drives both rotor systems.
- Greenhouse Window: A tinted window above each of the pilot seats.
- Fuselage: The body of the helicopter.
- Cabin Door: Allows access to the cabin and cockpit.
- Skids: Landing gear that usually have no wheels or brakes.
- Crosstube: The mounting tubes and connection for the skids.
- Motor Mount: A flexible way to attach the engine to the fuselage.
- Tailboom: Also known as an "empenage" is the tail of the helicopter.
- Synchronized Elevator: A movable wing that helps stabilize the helicopter in flight.
- Tailrotor: Provides anti-torque and in-flight trim for the helicopter.
- Tail Rotor Driveshaft: Provides power to the tailrotor from the transmission.
- 45 Degree Gearbox: Transfers power up the vertical fin to the 90 degree gearbox.
- 90 Degree Gearbox: Transfers power from the 45 degree gearbox to the tailrotor.
- Vertical Fin: Holds the tailrotor and provides lateral stabilization.
- Tail Skid: Protects the tailboom when landing.



This picture illustrates how the helicopter moves when using the appropriate controls. Up and Down movements are controlled by the "Collective". Side to Side and Forward and Back motions are controlled by the "Cyclic". Lateral control (Also called directional control or "Yaw") is achieved by using the "Foot Pedals".



While you are looking at the picture of the controls (Left side of this paragraph), I will explain how to do a normal takeoff. First, you must make sure the throttle is all the way open (For a turbine powered helicopter, advanced properly for a reciprocating engine powered helicopter)Once you have established the proper operating RPM, then you can pull up slowly on the collective. As you increase collective pitch, you need to push the left pedal (In American helicopters...right pedal for non-American models) to counteract the torque you generate by increasing pitch. (In reciprocating engined models, you will advance the throttle as you increase collective pitch). Keep pulling in pitch and depressing the pedal until the aircraft gets light on the skids. You may sense a turning motion to the left or right, if so, you may need more or less pedal to maintain heading. The cyclic will become sensitive and (depending on how the aircraft leaves the ground heels or toes of the skids last) as you continue to pull in pitch and depress the pedal, you will put in the appropriate cyclic input to level the aircraft as it leaves the ground.

As the aircraft eases into the air, forward cyclic will be required to start the aircraft in a forward motion. As the aircraft advances forward, it will gain speed until about 15 knots and then the aircraft will shudder a little as you transition through ETL (Effective Translational Lift...See the unique forces page for a more in depth explanation of ETL). As you transition through ETL, the collective will need to be reduced, the pedal will need less pressure, and the cyclic will need to be forced forward to counteract the force against the front of the rotor system. Failure to push forward will result in an abrupt nose high attitude and a reduction in forward speed. After the shudder of ELT is experienced, you will see a marked gain in forward airspeed, a reduced need for pedal input and a reduced need for collective pitch as the rotor system becomes more efficient. The airspeed indicator will most likely jump from zero to 40 knots indicated airspeed and will smoothly advance as the aircraft goes faster. Now you have taken off and with a little release of foward cyclic pressure, the aircraft will establish a climb and continue to gain airspeed. At this point, the pedals are only used to trim the aircraft, and most maneuvers are accomplished by using a combination of the cyclic and collective controls. (That wasn't so hard...was it?)

Main rotor hub assembly

A helicopter's main rotor is the most important part of the vehicle. It provides the lift that allows the helicopter to fly, as well as the control that allows the helicopter to move laterally, make turns and change altitude. To handle all of these tasks, the rotor must first be incredibly strong. It must also be able to adjust the angle of the rotor blades with each revolution they make. The pilot communicates these adjustments through a device known as the swash plate assembly.

The swash plate assembly consists of two parts -- the upper and lower swash plates. The upper swash plate connects to the mast, or rotor shaft, through special linkages. As the engine turns the rotor shaft, it also turns the upper swash plate and the rotor blade system. This system includes blade grips, which connect the blades to a hub. Control rods from the upper swash plate have a connection point on the blades, making it possible to transfer movements of the upper swash plate to the blades. And the hub mounts to the mast via the Jesus nut, so named because its failure is said to bring a pilot face-to-face with Jesus.

The lower swash plate is fixed and doesn't rotate. Ball bearings lie between the upper and lower swash plates, allowing the upper plate to spin freely on top of the lower plate. Control rods attached to the lower swash plate connect to the cyclic- and collective-pitch levers. When the pilot operates either of those two levers, his or her inputs are transmitted, via the control rods, to the lower swash plate and then, ultimately, to the upper swash plate.

Using this rotor design, a pilot can manipulate the swash plate assembly and control the helicopter's motion. With the cyclic, the swash plate assembly can change the angle of the blades individually as they revolve. This allows the helicopter to move in any direction around a 360-degree circle, including forward, backward, left and right. The collective allows the swash plate assembly to change the angle of all blades simultaneously. Doing this increases or decreases the lift that the main rotor supplies to the vehicle, allowing the helicopter to gain or lose altitude.

Now it's time to see how all these parts work together to get the helicopter airborne.

Tail rotor Pitch change mechanism

Changing the Pitch

In order to be able to yaw the aircraft both right or left, the tail rotor blades need to be able to be set to both negative and positive angles of attack, unlike main rotors which are normally only capable of positive angles of attack.

The angle of attack of the tail rotor is controlled by the pilot's anti-torque pedals (they're not "rudder pedals" in a helicopter). The pedals are typically connected to the pitch change mechanism by either push pull tubes, or by cables. From the standpoint of controlling pitch, a tail rotor requires collective pitch control, but not cyclic feathering. This makes the pitch control mechanism of most tail rotors much simpler than that of the main rotor system.

The tail rotor blades must be mounted, and there must be a mechanism to change the pitch of the blades. This picture is of a Robinson R22 tail rotor. You can clearly see how the blades are attached, and how the pitch change mechanism can pivot the blades.

Freewheeling assembly

Just to the right of the upper bearing, built into the hub of the upper sheave is the freewheeling unit (sprag clutch). The purpose of the freewheeling unit is to allow the rotor to keep turning if the engine stops (so you can autorotate). Many people are confused when we talk about clutches in the Robinson, because there are two mechanisms located in approximately the same location. Jacking the upper sheave up and down tightens and loosens the belts - that is the drive engagement clutch (the one you activate in the cockpit by flipping the "clutch" switch). The freewheeling unit (sprag clutch) is built into the hub of the upper sheave and automatically allows the rotor to coast, in much the same way that a coaster brake in a bicycle allows you to pedal to turn the wheels, but allows you to stop pedalling while the bicycle continues to coast forwards.

Swashplate assembly

The swash plate assembly has two primary roles:

Under the direction of the collective control, the swash plate assembly can change the angle of both blades simultaneously. Doing this increases or decreases the lift that the main rotor supplies to the vehicle, allowing the helicopter to gain or lose alltitude.

Under the direction of the cyclic control, the swash plate assembly can change the angle of the blades individually as they revolve. This allows the helicopter to move in any direction around a 360-degree circle, including forward, backward, left and right.

The swash plate assembly consists of two plates -- the fixed and the rotating swash plates -- shown above in blue and red, respectively.

The rotating swash plate rotates with the drive shaft (green) and the rotor's blades (grey) because of the links (purple) that connect the rotating plate to the drive shaft

The pitch control rods allow the rotating swash plate to change the pitch of the rotor blades.

The angle of the fixed swash plate is changed by the control rods (yellow) attached to the fixed swash plate.

The fixed plate's control rods are affected by the pilot's input to the cyclic and collective controls.

The fixed and rotating swash plates are connected with a set of bearings between the two plates. These bearings allow the rotating swash plate to spin on top of the fixed swash plate.

Tail rotor gear assembly

The tail rotor in a helicopter is used to balance the forces of the main rotor so that a pilot can control the aircraft azimuth or heading. Currently, the main turbine of the helicopter drives the tail rotor via a mechanical shaft and gears similar to the way power is transferred from an automobile engine to the rear wheels of a car. This mechanical linkage imposes a fixed speed relationship between the main rotor and the tail rotor, which can be detrimental in certain flying conditions. If the tail rotor can be run independently of the main rotor, improvements in the maneuverability of the helicopter can be achieved.

An independent electric tail rotor drive would add considerable flexibility to the operation of the helicopter and allow optimized usage of the tail rotor propeller. Benefits include the ability to:

achieve more efficient forward flight.

help prevent tail rotor stall.

help compensate for the loss of tail rotor thrust and improve aircraft control in turbulent wind conditions.

enable azimuth control when taking off from icy surfaces or from the water with float landing gear.

include a hinged tail on the helicopter that could be folded for storage.

eliminate (usually fatal) tail rotor gearbox failures, substantially improving vehicle safety and reliabiity

By applying more or less pitch (angle) to the tail rotor blades it can be used to make the helicopter turn left or right, becoming a rudder. The tail rotor is connected to the main rotor through a gearbox. When using the tail rotor trying to compensate the torque, the result is an excess of force in the direction for which the tail rotor is meant to compensate, which will tend to make the helicopter drift sideways. Pilots tend to compensate by applying a little cyclic pitch, but designers also help the situation by setting up the control rigging to compensate. The result is that many helicopters tend to lean to one side in the hover and often touch down consistently on one wheel first. On the other hand if you observe a hovering helicopter head-on you will often note that the rotor is slightly tilted. All this is a manifestation of the drift phenomenon.

Transmission assembly

A helicopter rotor transmission assembly for translating motion of a drive shaft driven by a helicopter engine into rotary motion of a helicopter rotor mast that carries rotor blades. The transmission assembly includes a fixed outer housing, an inner housing carried within the outer housing and adapted to rotate relative to the outer housing by the drive shaft, and a ball received in the inner housing so as to be rotatable relative to the inner housing about one axis, and constrained from rotation about the two orthogonal axes. The ball is adapted to receive the rotor mast so that the mast can be driven to both spin and tilt

Rotor brake disc

some rotor brake discs were being delivered
with primer on the friction surfaces. The primer prevents corrosion on the rotor brake discs until installation.
When the rotor brake is applied, the primer burns off and induces chattering (stick/slip) of the rotor brake. This could be detrimental to the gears inside the drive train.
We recommend that the primer be removed from the rotor brake discs friction surfaces before installation
note, if the rotor brake is installed but the helicopter is not equipped with a rotor brake kit, it is recommended to leave the primer on the disc

Rotor brake calipers

A helicopter rotor brake having a disk connected angularly to a helicopter rotor; a brake caliper having friction members cooperating with the disk; and an actuating device for moving the brake caliper, parallel to the plane of the disk, between a work position engaging the disk and wherein the brake caliper may be operated to brake the rotor, and a safety position releasing the disk and wherein any possibility of the friction members interacting with the disk is prevented.

Main driveshaft

Main helicopter drive for transmitting drive to the countershaft even when the main shaft connected to the rotor is idle, and on which a sleeve, turned by a drive shaft and connected by gears to the countershaft, supports in rotary and axially-sliding manner, an inner tubular body angularly integral with the main shaft; an actuator being connected to the said tubular body for moving it between a normal position, in which the said tubular body is connected to the said sleeve by a freewheel on the latter, and a position in which the said freewheel engages the outer casing of a bearing fitted on to the said tubular body.

Mast assembly

The present invention provides a main rotor assembly for a helicopter that can easily generate lift forces and improve output and flight stability. The main rotor assembly for a helicopter includes a mast that is provided to stand in a helicopter body and is supplied with power from an engine so as to be rotated, a plurality of blades provided along the circumference of the mast so that pitches are adjusted to generate lift forces during the rotation of the mast, first and second swash plates provided to the mast so as to become horizontal or inclined in one direction, a plurality of control rods connecting the blades to the swash plates so that pitches of the plurality of blades change when the posture of the swash plates changes, and a plurality of push rods that are supplied with power from a driving source and make the two swash plates horizontal or inclined in one direction.

Swashplate assembly

The swashplate changes the pilot's linear cyclic & often collective control inputs into rotary blade pitch angle changes in the main It is the position of the swashplate that determines which direction the rotor disk will move in.

The swashplate is usually made up of two halves. The top half rotates with the rotor (usually pulled around by the washout & washout guide while the bottom half does not (aligned with the helicopter body by the anti-rotation bracket Due to the use of a spherical bearing in the center, the swashplate is free to tilt in response to control inputs, and transfers those inputs through the linkages to the rotor blades

In mechanical terms, the lower (non-rotating) part of the swashplate forms a *cam*, and the upper rotating part its *cam follower*. This is slightly unusual, as it is normally the cam that is thought of as rotating, and its follower that is held stationary.

42 degree gear box

90 degree Gearbox assembly

Quill gearboxes are common in helicopters due to their relatively light weight caused by the hollow nature of quills. These assemblies allow different gear ratios, which let a helicopter change gears without switching through multiple gears.

Besides being light and strong, quill gearbox assemblies are also smaller than many other types of gear housings. This is because the quills are not only hollow, they are also smaller than most shafts connected to gears.

Helicopter gearboxes in general must be very rigid in construction, otherwise they will produce excessive vibration. Gearboxes need regular pre-flight inspection.

The transmission system conveys power between the engine and the main and tail rotors and at the same time reduces engine rpm to proper rotor rpm. This system is made up of the centrifugal clutch assembly; the main drive shaft from the engine; the main gear box; the tail drive shaft; the intermediate gear box; the drive shaft to the tail rotor; and the tail gear box.

Centrifugal clutch

The automatic centrifugal type clutch installed on the engine crankshaft consists primarily of a lower or driving disc and upper or driven disc. The driving disc is mounted on the splined engine crankshaft and has a single row of 24 clutch shoes. The driven disc is supported by two single row bearings and the engine shaft nut on the upper part of the crankshaft. The four purposes of the clutch assembly are: to provide cooling air to the engine at all times; to provide ram air for the carburetor; to provide a means of “soft” engagement between the engine and the transmission system; and to act as a flywheel for the engine.

Main gear box

The main gear box is located on the top of the cabin just aft of the cockpit. It has three primary functions: it changes the angle of the drive from the engine to the main rotor assembly; it reduces the engine rpm to rotor rpm; and it proves a means of driving the tail rotor and the gear box accessories.

The gear box is made up of an upper housing assembly, a lower housing assembly, and a ring gear, bolted between them. Gear reduction is accomplished by the input bevel gears and two-stage planetary gear system. The gear reduction ratios are as follows:

The gear box lower housing incorporates an accessory drive section at the rear. Accessory drives are provided for the generator, the generator blower, the transmission oil pump, the rotor tachometer-generator, the hoist hydraulic pump, and the servo mechanism hydraulic pump.

The main rotor assembly is mounted above the center section of the helicopter and is splined to the drive shaft rising out of the main gear box. The main rotor assembly serves as an attachment for the three main rotor blades, rotates them by engine power, and controls their pitch. The main rotor assembly consists of a hub assembly including three vertical hinge assemblies, three sleeves, spindle, and blade horn assemblies, an upper plate, a lower plate, and a bracket, three damper assemblies; three droop restrainer assemblies; three anti-flapping restrainer assemblies; and a star assembly.

Tail rotor pitch change assembly

A hub-protecting cap for use with a helicopter. The helicopter has a fuselage, a tail rotor assembly operatively coupled to the fuselage for rotation relative to the fuselage about a tail rotor axis, at least one tail rotor blade detachably connected to the tail rotor assembly, a retention pin, and a pitch control link mechanism. The hub-protecting cap comprises a cap body portion, a pin-receiving aperture, and a link-attaching portion. The cap body portion is adapted to be attached to a hub portion of the tail rotor assembly in a manner to cover the hub portion when the tail rotor blade is detached from the tail rotor assembly. The cap body portion has a hub socket adapted such that pitch change bearing surfaces of the hub portion are within the hub socket of the cap body portion when the cap body portion is attached to the hub portion. The pin-receiving aperture is through the cap body portion. The pin-receiving aperture is sized and located to align with a portion of a retention strap of the tail rotor assembly and to receive a retention pin when the cap body portion is attached to the hub portion. The link-attaching portion extends from the cap body portion. The link-attaching portion is sized and adapted for attachment to a pitch control link mechanism of the tail rotor assembly when the cap body portion is attached to the hub portion.

Tail rotor Driveshaft hangar assembly

The tail rotor drive shaft consists of five drive shafts and three hanger bearing assemblies. The drive shaft sections are constructed of aluminum alloy tubing with curvic couplings riveted to each end. All shafts are made and balance to a master shaft for interchangeability. Each hanger bearing assembly consists of couplings on a short splined shaft mounted through a single-row, sealed ball bearing in a ring-shaped hanger, equipped with mounting flanges for attachment to the tailboom. The assemblies, 42 degree gearbox, and 90 degree gearbox connect the transmission tail rotor drive quill to the tail rotor.

Oil cooler blower assembly

Rotor brake quill

helicopters are equipped with a brake for rapidly arresting the rotor on landing.

Rotor disk brakes are known, which comprise a disk connected angularly to the rotor; and a brake caliper having friction members between which the disk is interposed, and which cooperate with the disk when the caliper is operated to brake the rotor.

Though measures are normally taken to prevent the caliper being operated in flight, a remote possibility still exists, in the event of a malfunction, of the friction members cooperating with the disk even without the caliper being operated, thus resulting in heat being generated due to friction.

Despite all the precautions taken, overheating of the brake may not only impair operation of the brake itself but also, in extreme cases, endanger flight of the aircraft

there is provided a helicopter rotor brake comprising a disk fitted integrally to a transmission member connected angularly to a helicopter rotor; a caliper having friction means cooperating with said disk to brake said rotor; and supporting means for supporting said caliper; characterized by comprising actuating means interposed between said supporting means and said caliper to move said caliper, parallel to the plane of the disk, between a work position engaging said disk and wherein said friction members face the disk and cooperate with the disk when said caliper is operated, and a safety position releasing said disk and wherein said friction members are moved from the disk in a direction parallel to a plane of the disk.

Stabilizer bar

The stabilizer bar is a weighted, rotating unit mounted above and across the main rotor suspended in pivotal bearings of supports bolted to the rotor hub trunnion. The supports also contain the stops that limit bar travel. Each side of the bar frame is connected through a control tube to a damper on the mast. Stabilizer bar mixing levers are connected into main rotor control linkage by control tubes from the scissor levers and by pitch change links connected to the pitch horns on the blade grips.

Stabilizer Bar Operation:

The stabilizer bar is connected into the flight system in such a manner that the inherent inertia and gyroscopic action are induced into the rotor system to provide a measure of stability for all flight conditions. If, while hovering, the helicopter's attitude is disturbed, the bar tends to remain in its present plane. The relative movement between the bar and the mast will cause the blades to feather and return the rotor to its original plane of rotation. When the rotor disc is displaced by cyclic action, initially a portion of the cyclic movement is removed, but because of pendulum action of the helicopter, the mast is displaced. Now, because of the restraining and damping action of the dampers, the bar possesses a mast-following characteristic. The time it requires the bar to follow the mast and return all the cyclic control to the rotor is determined by damper timing (5 ± 1 second). A compromise between gyroscopic action and damper timing is maintained during flight which allows the bar to provide a measure of stability, yet still affords the pilot complete control of the helicopter.

Scissors and sleeve

Tail rotor hub assembly

Hub and sleeve assembly

A hub assembly for a helicopter rotor system having a monolithic thin-wall hub shell made from composite material and including centrally apertured upper and lower wall portions integrally joined at the outer periphery of the shell and spaced apart at inner regions. The upper and lower wall portions cooperate to define a plurality of bearing sockets angularly spaced relative to the axis of rotation and connecting webs extending between angularly adjacent sockets. Elastomeric blade retaining bearing assemblies supported within the sockets retain and support rotor blades for articulate movement. Each bearing assembly has a seating surface which cooperates with an associated bearing surface on the socket in which it is contained to prevent relative rotation therebetween. Mounting flanges on the helicopter rotor shaft and retaining flanges on the hub shell are arranged to permit the rotor system to be lowered on the rotor shaft when the retaining flanges are disconnected from the mounting flanges.

A hub assembly for a helicopter having a rotor shaft including axially spaced apart upper and lower annular mounting flanges, at least one of the mounting flanges extending radiallyoutwardly from the shaft and defining a generally radially disposed mounting surface, said hub assembly comprising a monolithic thin-wall hub shell having plate-like upper and lower wall portions integrally joined only at the outer periphery of the hubshell and spaced apart at inner regions of said hub shell, said upper and lower wall portions having coaxially aligned and axially spaced central apertures communicating with the interior of said hub shell for receiving the rotor shaft coaxiallytherethrough, said hub shell having means for retaining it in assembled relation with the rotor shaft and with the central axis of the hub shell coaxially aligned with the axis of the rotor shaft for rotation with the rotor shaft and including at leastone annular retaining flange surrounding an associated one of said central apertures and having a generally radially disposed seating surface for seating engagement with said mounting surface, said upper and lower wall portions defining a plurality ofintegral bearing retaining sockets angularly spaced relative to said hub shell axis and webs integrally joined to and extending between said bearing retaining sockets, each of said bearing retaining sockets including an integral end wall at the radialouter end thereof, said end wall having an aperture therethrough and a generally radially inwardly facing bearing surface surrounding said aperture, a plurality of blade retention bearings, each of said blade retention bearings received within anassociated one of said bearing retaining sockets, each of said blade retention bearings having annular laminates for receiving therethrough the shaft of an associated rotor blade, each of said blade retention bearings having an outer end member includinga radially outwardly facing seating surface engaging an associated bearing surface, and means for releasably retaining each of said blade retention bearings in assembled relation with said hub shell with the seating surface thereof in complementaryface-to-face engagement with an associated bearing surface, at least one of said central apertures being of sufficient size to allow a blade retention bearing to pass freely therethrough when said hub assembly is out of assembled relation with the rotorshaft to allow assembly of said blade retention bearings within said hub shell.

Tail rotor assembly

A helicopter including a driven rotor assembly provided with a hub having oscillatable rotor blades extending outwardly therefrom and axially spaced portions of the hub having outer peripheral portions of a pair of annular flexible and elastic supporting diaphragms anchored relative thereto. Inner peripheral portions of the diaphragms are deflected and stretched toward each other and anchored to a supporting flange carried by a central rotary drive shaft of the rotor assembly. A sleeve is longitudinally shiftably mounted on the shaft below the rotor assembly and supports, through the utilization of a flexible and resilient diaphragm, a larger sleeve structure therefrom for universal angular displacement of the sleeve structure relative to the sleeve. The sleeve structure includes control arms operatively connected to the rotor blades for oscillation of the latter in response to axial shifting of the sleeve structure relative to the sleeve. First control structure is provided for axially shifting the sleeve on the drive shaft and second control structure is provided for universally angularly displacing the sleeve structure relative to the sleeve. The helicopter further includes a third diaphragm supported control structure whose diaphragm is flexed in opposition to the flexed diaphragm of the second control structure and is manually universally shiftable and operatively connected to the second control structure for similar universal displacement thereof.

Rotor brake

helicopters are equipped with a brake for rapidly arresting the rotor on landing.

Rotor disk brakes are known, which comprise a disk connected angularly to the rotor; and a brake caliper having friction members between which the disk is interposed, and which cooperate with the disk when the caliper is operated to brake the rotor.

Though measures are normally taken to prevent the caliper being operated in flight, a remote possibility still exists, in the event of a malfunction, of the friction members cooperating with the disk even without the caliper being operated, thus resulting in heat being generated due to friction.

Despite all the precautions taken, overheating of the brake may not only impair operation of the brake itself but also, in extreme cases, endanger flight of the aircraft

there is provided a helicopter rotor brake comprising a disk fitted integrally to a transmission member connected angularly to a helicopter rotor; a caliper having friction means cooperating with said disk to brake said rotor; and supporting means for supporting said caliper; characterized by comprising actuating means interposed between said supporting means and said caliper to move said caliper, parallel to the plane of the disk, between a work position engaging said disk and wherein said friction members face the disk and cooperate with the disk when said caliper is operated, and a safety position releasing said disk and wherein said friction members are moved from the disk in a direction parallel to a plane of the disk.

Tail rotor Blade bearing change

The rotor blade of the present invention incorporates a number of novel features in order to increase its reliability and strength while reducing its weight. In certain embodiments, the rotor blade of the present invention incorporates a flexural strap in place of traditional pitch bearings. In certain embodiments, the rotor blade of the present invention is manufactured using a unique fiber placement layup technique to reduce failure modes and maximize the fatigue strength of the part.

Main Rotor Design

There are almost as many designs for helicopter main rotors as there are different models of helicopter. Still, there are several main classes of main rotor. Generally, the major classification is by the type of rotor head used. The most common are:

- Rigid
- Semi-rigid
- Fully Articulated

We will now look at several rotorblade designs.

Airfoil, lift & drag

> Probably the single most important rotor design parameter is its Lift/Drag ratio which should be as high as possible.

- This ratio depends on the design of the aerofoil, and before we go on to discuss a number of types, we will first introduce the fineness ratio. This is the thickness of the airfoil as a percentage of the chord length. A blade with a good L/D performance has a fineness ratio of about 15%, with its maximum chamber being a quarter of the way back from the leading edge. A typical L/D value for a helicopter blade is 30:1.
- The types of aerofoils used with a rotorblade differ (figure below). For a long time, most of them were symmetrical. However, a higher L/D ratio is possible with non-symmetrical versions. Due to the greater internal forces occurring in these types of blades, they only came into existence when the appropriate composite materials were developed. These can cope with the high internal strain, while their weight is kept low.

Blage twist & tapper

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- When a blade rotates, each point on it travels at a different speed. The further away from the root, the higher the velocity. This means that the contribution to lift and drag of every point on the blade differs, with each aspect getting larger when moving closer to the rotor tip. Clearly, the lift distribution over the blade is not constant. This is not a desirable situation, because the contribution diminishes when getting closer to the root. To change this distribution, blades are twisted and, sometimes, also tapered. The twist is such that the angle of attack increases when travelling towards the root, producing more lift. Tapering the blade also contributes to achieving a more evenly spaced lift distribution. With blade tapering, the blade's surface gets larger when travelling towards its root. Both tapering and twisting can be observed when looking carefully at rotorblades at rest. Note that blade tapering is not always used (especially on metal blades because of a more complicated fabrication process).
- Blade twist and taper leads to large angles of attack and large blade surfaces at the root. However, close to the root, the blade is travelling over the hull, so the generated downwash does not contribute to helicopter thrust. For this reason, rotorblades are often cut out near the root. Another reason for rotor blade cut out is to reduce the effects of potential reverse flow (on the retreating rotorblade) when flying at high speeds.

- Rotorblades are constantly strained by moments that try to twist them. This twisting has its origins in the moments which exist between the centre of pressure (due to the aerodynamic forces) and the mass centroid over the chord line. The blade designer must take these twisting moments into account by designing a blade with high torsional stiffness. He must also ensure that the mass centroid is located ahead of the centre of pressure for all blade angles (in its operational range). In this way, lift tends to lower the angle of attack: a stable condition.