LOVE THAT EGGBEATER

(Many of us belong to an exclusive club – those who understand the terms lead, lag, and flapback. For those who are convinced that helicopters are just collections of stuff going the same way the same day, I submit the following which was based on a Bell 47…)

PART 1

The helicopter is an amazing assortment of nuts, bolts, rotors, push-pull rods, irreversibles, longitudinal collective differential quadrants, swash plates, wobble plates, gimble rings, cuff links, trunion assemblies and other gadgets too humorous to mention. All of these are welded, riveted, bolted or sewn together to make a single machine capable of flight. In fact, it is capable of flight in any direction – backwards, forwards, sideways, up, down, and even standing still! Standing still is known as "hovering"; or, as a Dutch friend of mine was wont to say, "hoovering". This comes in handy for those who like flying but have no place to go. Helicopters are normally flown by individuals who don't like to stray far from the airport or who are known have narcissistic tendencies. In fact, as a group, helicopter pilots have long been suspected of self-abuse.

One of the more necessary components is the engine. This unit is expected to start with ordinary fuel; change the fuel to BTU, the BTU to BMEP, and the BMEP to RPM. The RPM is then transmitted through a series of shafts and gears to the main rotor blades that are responsible for the frantic eggbeater motion characteristic of the beast.

The engine has several important parts. Among those are cylinders. A cylinder is a long hole covered on one end with a plate full of smaller holes containing valves. The holes admit air and fuel…and sometimes water and carelessly misplaced tools. The other end is closed with a plug called a piston. This is free to move up and down and would come out altogether if it were not fastened to a connecting rod. The other end of the connecting rod is affixed to a crank shaft. By themselves, the piston and the connecting rod are well nigh useless for all they do is produce BMEP. However, the crank shaft is extremely important: it is responsible for converting your BMEP to RPM. Without RPM, you would be left with BMEP and some leftover BTU, which, by themselves, are not worth a pitcher of warm spit.

The output of the engine is measured in horsepower. No one knows why…it is often difficult to get a self-respecting horse within seventy yards of one of these machines. There was talk that a fellah named Jimmy Watt found that a mine pony could lift 22000 pounds one foot in one minute, added fifty percent and called the resulting figure "one horsepower". However, as no one uses horses in coal mining anymore, it's anyone's guess as to its real meaning today. For that reason, it's better to rely on instruments the electrical men have invented to measure power. They indicate power in amps, volts, or kilowatts, depending on the individual whims of the designer. With a little imagination and an E6B, these values can be converted into horsepower.

Starting the "thing" requires some knowledge of quantum mechanics, steady nerves, and a certain amount of 'je ne sais quoi', which is French for "two over easy, toast on the side". First, make a careful check of all your instruments. When converting to a new machine, many helicopter pilots make an accurate count of the cockpit instruments on their first trip. Subsequent instrument checks can then be reduced to counting; if there are supposed to be ten gauges in the cockpit and ten gauges are found, the machine is serviceable. This procedure not only gives you a little self-confidence, but also adds prestige in the eyes of the onlookers. After everything has been checked, then – and only then – is it safe to start the engine. If everything is as it should be – air, fuel, spark, Marvel Mystery oil - there will be considerable noise and the machine will commence to shake, tremble, and rock from side to side. This is a good sign that the engine has started. If the rotor has commenced to turn any time during this procedure, it is visual proof that the mast has not broken during the procedure.

When your audience has returned, synchronize your eyeballs and look wisely at the instrument panel, noting pressure and RPM. Before you forget, check the flight controls. This is important even though the controls quite often do not perform the function for which they were designed. It is embarrassing to get into the air and find these items not working properly…or, worse, not working at all! Once airborne, you are on your own: astride a brute that, like a bumblebee, looks as though it won't fly, knows that it can't fly, but does so anyway and to Hell with it!

The controls of a helicopter do not work like the controls in a fixed wing aircraft: for instance, the stick (cyclic) has no feel nor rigidity and if not held securely at all times, will fall to the floor or bounce off the instrument panel resulting in expressions of concern from the passengers. The anti-torque pedals are somewhat akin to the rudder pedals in that they both provide a resting spot for your feet. However, unlike the rudder pedals, the sole job of the anti-torque pedals is to keep the blunt end forward - except in the "hoover" when their job is to make the passengers dizzy.

The collective is the stick thingy to the left of the pilot's seat: its job is to convert the RPM and BMEP into lift. The means by which it does so is known only to some senior helicopter pilots who are extremely secretive about the whole operation, but I have included a lay-person's explanation further down. For practical purposes, suffice it to say that pulling on the lever causes things to get smaller while pushing on the lever will cause the reverse effect. Through some interconnect between the controls; the collective can also make the machine accelerate. Again, the process is rather ambiguous and not normally discussed in polite circles. However, the collective has an active part to play in a quick descent procedure called "autorotation"; more about which later.

When all the tickets have been collected, it is wise to go flying before anyone can change their minds. To get airborne is a rather technical affair and involves momentarily nullifying the Attraction Law; the principle which keeps all things on the ground. The principle states that two objects have an attraction to one another and the larger the mass, the larger the attraction. Momentarily null the Law of Attraction by pulling up on the collective and the Law of Rejection becomes prime and the helicopter leaves the ground. As long as the collective lever is off the stop and the engine is running, the helicopter will fly. However, if the engine fails, one of the two main requirements of flight - motive power – has been removed and immediate action it required.

To get the helicopter going down, the Law of Attraction must be reintroduced by lowering the collective. This will produce a descent of around 1500-2000 feet per minute and can cause unsecured items in the cockpit to float up around eye level. Dependant on the time since ingestion, these items may be intermingled with various passenger lunch bits.

Once the helicopter has reached an altitude between 75-100 feet above ground and near terminal velocity, its descent and forward speed must both be slowed to near zero before contact with any surface: this is achieved by the judicious use of the collective to maintain a fine balance between the Laws of Attraction and Rejection. Too much one way or the other can lead to disastrous results. This level of expertise comes with time and damage to at least three helicopters. However, most of the machines are repairable.

It should be noted that in the helicopter world, most students are sent solo at this stage. In the second part, we will explore lead, lag, and flap back and discuss why helicopter time in the logbook is viewed in the same light as VD in a medical record.

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PART II

In the first part, we explored the inner workings of the helicopter; its ups, its downs, its "all-arounds". In this section, we'll concentrate on some of the finer points of helicopter aerodynamics – namely: why does it take so much time and trouble to get a helicopter to do what an aircraft does so gracefully and with such ease? And why are fixed wing pilots so different from helicopter pilots?

Harry Reasoner said it best in 1971:

"The thing is, helicopters are different from planes. An airplane by its nature wants to fly, and if not interfered with too strongly by unusual events or by a deliberately incompetent pilot, it will fly.

A helicopter does not want to fly. It is maintained in the air by a variety of forces and controls working in opposition to each other, and if there is any disturbance in this delicate balance the helicopter stops flying, immediately and disastrously. There is no such thing as a gliding helicopter.

That is why being a helicopter pilot is so different from being an airplane pilot, and why, in generality, airplane pilots are open, clear-eyed, buoyant extroverts and helicopter pilots are brooders, introspective *anticipators of trouble. They know that "if something bad has not happened, it is about to."*

Now, add to this the variety of Laws under which a helicopter must operate, and you begin to understand why these machines are so humbling and cause many an under-training pilot to go home at night and cry quietly into his/her pillow. In the previous part, we covered the Laws of Attraction and Rejection; this issue, we'll cover lead, lag, and flapback.

The quest to leave the earth under the power of rotating wings is an old one and was explored by one of the Leonardos. I think the one that never heard of the Titanic stated: *"...I have discovered that a screw-shaped device (which), if it is well made from starched linen, will rise in the air if turned quickly...*"

However, this was only an experimental design, was never put into practical use, and Leonardo busied himself with writing a Code which, in later years, was turned into a movie. This was actually a good thing for we now know that had Leo's starched linen device got wet it would have curled up like a Groucho Marx vest.

One of the difficulties with rotating wings was how to overcome the problems of the difference in lift between the advancing and retreating blades. As long as there was no wind and the aircraft was in a "hoover", everything was hunky-dory. But, if the machine lurched into forward flight, all hell broke loose. The forward speed was added to the advancing blade and subtracted from the retreating blade resulting in a decided difference in lift between the two. As a rotor acts like a big gyroscope, this difference in lift is manifested ninety degrees in the direction of rotation resulting in an unwanted nose pitch-up. This was not only disconcerting but added hours to a trip as the resulting flight path was more akin to a Coney Island ride than a controlled excursion from A to B; needless to say, customers rebelled. Not only that, but the mental duress of trying to figure out where to put the stick so that the correct input would be felt at the right place ninety degrees later gave most helicopter pilots the fits. In addition, the stress on the blades as they tried to even out the lift imbalance was enormous. Helicopters would never become a viable method of transportation unless a solution was found. It was left to a fellow named Juan de la Cierva to sort things out.

Juan de la Cierva was born in Murcia, Spain. After receiving his engineering degree in 1918, he built the first tri-motor airplane. Its crash in 1919 after a stall convinced him that aviation safety called for stall-proof aircraft that could make steep takeoffs and landings at slow speeds. He decided that only the wing and not the body should be used to maintain lift. He began experimenting with rotating-wing aircraft in 1920 and developed the autogiro as a more stable form of aircraft. His first attempts with rigid rotors were unsuccessful. He then applied the idea of mounting the blades to the hub of the rotor on hinges so they could flap or move up and down. This would equalize lift on advancing and retreating sides of the rotor while in forward flight. So, when the blade is advancing into the wind, the blade is allowed to rise which reduces its angle of attack. However, this means that the blade is now describing a smaller circle, which, if left unchecked, would violate the Law of Conservation of Momentum. No duff. I don't make this stuff up.

In accordance with the same principle that sees a figure skater increase rotation speed when he/she pulls their arms into their body during a spin, so too does the speed of the rotor blade increase slightly during the advancing portion of the circle. The reverse is true of the retreating blade and the increase and decrease in speed causes the blade to move forward and aft of a "neutral" position as it circles the mast: it "leads" and "lags". In the early days of helicopter flight, a camera was mounted on the top of the mast aimed down the leading edge of one of the blades and the instrument activated during flight. In addition to the leading and lagging that went on during every revolution, lateral waves were seen to develop on the blade that rivaled those produced by the mythical Ogopogo in the Okanagan. As the blades of the day were fabricated from wood, it was no wonder that helicopter pilots of the period could be reduced to blubbering hysteria by popping an inflated brown paper bag behind their backs. They just knew that *"if something bad had not happened, it was about to…"*

Now, in the helicopter world, "flapback" is not the same as Rene Levesque's hair style. "Flapback" is a known aerodynamic feature of helicopter flight, but explanations for it are few and far between. However, one of the more believable interpretations posits that "When the Law of Attraction has been reduced by an amount sufficient to allow the helicopter to rise approximately three feet into the air, a slight forward movement of the cyclic will allow the machine to accelerate toward the front. Now, at an airspeed of around fifteen to twenty miles an hour, an interesting phenomenon occurs: the helicopter will start to slow down *with no input from the pilot*! (Ed: italics added for emphasis). In the early days of helicopter flight, this created no end of problems to the progress of a flight: the helicopter would start to accelerate forward and then, for no apparent reason, would slow down and stop. This, of course, would necessitate starting all over again; but, when the magic fifteen or twenty miles an hour was attained, the helicopter would again come to a stop. You can imagine what this could do to the bottom line of a chartering company. Eventually, high speed photography revealed the truth of the situation: as the helicopter attained the above-noted speeds, the whole rotor system would appear to "rock" back, thus removing the forward component of lift and thereby slowing the machine to a standstill. The solution to the problem was found to be a simple one: as the "flapback" starts to occur, *keep moving the cyclic forward*. (Ed: italics added for emphasis) For the time, it was revolutionary and probably kept the idea of the helicopter and vertical replenishment from going the way of the Red River Oxcart. The reason for this "flapback" took a little longer to decipher.

It appears that the dissymmetry of lift was indirectly the culprit. To counter that problem, the aforementioned de la Cierva had allowed the individual blades to pivot as they rotated around the mast. This meant that the blade reached its zenith over the nose and its nadir over the tail. The coriolis effect on the rotor coupled with the tangential angular acceleration at the tips produced a sudden back movement or “rocking” of the whole rotor system. Although counterintuitive, the reaction is in complete agreement with the dictum of Conservation of Energy, videlicet: “Energy can be neither created nor destroyed; it can only be changed in form”.

When a trainee has mastered helicopter flight to the extent that reusable machines are the result of three consecutive flights, he/she is considered to have completed the course and is now ready to go to work. However, as there exists the distinct possibility that there will be situations in which the skill level of the pilot is not up to the demands of a particular circumstance, most helicopter pilots are required to accumulate their first thousand hours of experience north or south of the sixtieth parallels. This ensures that the only observers to minor “learning experiences” are penguins or polar bears who are both known to be extremely dismissive of anything that flies and are notoriously poor witnesses.

Helicopter pilots aren’t born with paranoid tendencies; it can take upwards of two thousand hours of flying to realize that you’re smack dab in the center of a million parts rotating rapidly around an oil leak waiting for metal fatigue to set in. In the next thousand hours comes the knowledge that helicopter flight has nothing to do with aerodynamics, the machine just beats the air into submission. Around the five thousand hour mark, conversation with a Zen master is rewarded with awakening awareness that helicopters don’t really fly: they’re so ugly that the earth rejects them. This knowledge can seriously damage the psyche of gentle, fragile souls.

So, the next time you chance upon a helicopter pilot sitting in a dark corner quietly nursing a Shirley Temple, cut him a little slack if he seems a little reluctant to discuss his line of work. He’s probably lonely, unsure of himself, a touch paranoid, and highly suspicious of why you would want to know about the secret workings of a helicopter.

Don’t let that stop you from inviting him home for a drink, though.

Compiled by John Swallow