Contents

Foreword

by

Wing Commander K. H. WALLIS

MBE, DEng(hc), CEng, PhD.(hc), FRAeS, FSETP, FinstTA(hc), RAF (Ret'd)

I have been a pilot for over 72 years and in the last 50 years I have concentrated on the light autogyro because I was soon aware of its potential in a number of useful working roles and for the sheer joy of flying.

My first experiment was based on a 'do-it-yourself' gyro-glider design but I made mine with an engine and conventional control column rather than the "hanging stick". The 'do-it-yourself' gyro-glider design had some similarity with that of the WW2 Hafner "Rotachute". I was delighted to get my experiment to fly but I had been flying long enough to recognise some potential hazards. I retired that experiment and it now resides at the Manchester Museum of Science and Technology.

I started with a 'clean sheet of paper' to design a little autogyro with better handling characteristics and practicability and this included the offset gimbal rotor head (patented by me in the UK) and an effective rotor spin-up system. Designated the "Type WA-116", I was honoured to have my design taken on by Miles Aircraft Ltd. for a possible military role and for testing to a civil Certificate of Airworthiness Standard including electrical strain gauging of critical areas of the airframe. The C of A was achieved in August 1962 and it was a pleasure to fly the military version XR-942 at the Farnborough SBAC show of that year.

Light Autogyros have the potential to be one of the safest types of aircraft but there were soon to be accidents resulting from an irresponsible attitude to the construction and pilot training and the public image of the 'recreational gyrocopter' was severely tarnished.

Dave Organ's previous book, 'An Introduction to Ultralight Gyroplanes', published in 2002, instilled a more responsible attitude to the build and operation of the special 'member of the family of aircraft' and now this publication, **"Autogyros, Gyroplanes and Gyrocopters"** is a further extension of that responsible approach. It certainly contains an immense amount of information, covering extensively the early history of the autogyro through to currently available designs. Also provided in detail is information on the requirements to be met for a PPL(G) – Private Pilots Licence Gyroplane – through to various technical aspects such as the very necessary provision of a rotor pre-rotator system – essential in a practical autogyro.

"Autogyros, Gyroplanes and Gyrocopters" will surely be necessary reading for those already involved in flying such aircraft, in addition to those contemplating ownership and flight of such practical little aircraft. There is currently an increase in the numbers of small autogyros and their special attributes in some roles are being recognised by such organisations as the 'Skywatch' Civil Air Patrol. There is much further to go and this publication should be of real assistance in supporting the very worthwhile progress.

Finally, I must say that this class of aircraft should only have the one truly generic name –"Autogyro". That is technically correct in that it implies 'self turning' whereas "Gyroplane" and "Gyrocopter" means 'turning wing' and so could describe a helicopter. "Autogiro" spelled with an "i" instead of a "y" was used as a Copyright Trade Name by Juan de la Cierva for his autogyros. If a world record is achieved by this class of aircraft and officially recognised by the Federation Aeronautique Internationale, it is in the "Autogyres" category.

However, whatever generic name these little aircraft are given, this publication, **"Autogyros, Gyroplanes and Gyrocopters"** is certainly a true history of such aircraft and a definite contribution to their future.

Kenneth H. Wallis

Chapter 2

Birth of the Autogiro
Juan de la Cierva

Cierva's story has been told many times – all with varying degrees of accuracy. In order to appreciate the value of his contribution to aviation, it is important that it is retold here as a constructive sequence of events without the clutter of too much technical detail.

Born in 1895 as Juan de la Cierva Y Cordonia (Cordonia being his mother's name), Juan first had an interest in aeronautics when he was 14 years old. In 1911, he constructed, with the help of two friends, several model aircraft and two gliders. They then bought the remains of a wrecked biplane and rebuilt it so successfully that it became the first Spanish aircraft to fly. Its vivid red colour scheme became a familiar sight in the Madrid area but it finally fell to pieces through old age.

Before graduating from the Madrid Civil Engineering School in 1918, Cierva had competed for a 10,000 dollar prize, offered by the Spanish Government for the design and construction of a large bomber aircraft. His contribution was a biplane of 80 ft. wingspan, powered by three Hispano Suiza engines and which incorporated several advanced ideas for its day. While on its maiden flight in 1919, this excellent aircraft was destroyed while attempting a turn at too low an airspeed while too near the ground. Although the result was a mass of tangled wreckage, the pilot – a Captain Julio Rios, escaped with a few minor cuts and bruises. Commenting on this event, Cierva later stated that *"the pilot had misjudged his minimum flying speed while too close to the ground. Had the same thing happened while he was flying high, he could probably have recovered control and brought the aircraft safely down"*.

Chapter 3

From Past to Present

With Cierva's death, rotary wing development changed course slightly and other designers came to prominence. One, who already had a financial interest in the Cierva Autogiro Company was G & J Weir Ltd. of Cathcart, Glasgow. In 1932, they embarked on a programme of Autogiro design, with a team that included Dr J.A.J. Bennett and C.G. Pullin. The first design was the W.1 – also given the Cierva type designation C28 - powered by a 40 hp. Douglas Dryad two cylinder air cooled engine and featuring a two bladed rotor system of 28ft. in diameter. In May 1933, Cierva himself piloted its maiden flight and Alan Marsh followed with the remaining flight trials.

The Weir W.2 single seat light Autogiro with modified tailplane

The W.2 followed shortly afterwards with a more powerful engine, the Weir Dryad II of 50 hp. and a modified rotor system for improved lateral control. Tailplane and fin were closer to the Cierva C.30 model but subsequently changed for an improved version some time later. This particular model has survived to this day and is now resident in the Museum of Flight, East Fortune airfield, North Berwick in East Lothian, Scotland.

The W.3 was a much improved version, fitted with the Cierva "Autodynamic" rotor head for 'jump take-offs'. Powered by a Weir Pixie I, four cylinder air cooled engine with improved landing gear and triple tail unit, it first flew on the 9th of July 1936. It was later demonstrated at Hounslow Heath and at Brooklands August Bank Holiday motor race meeting. The W.4 was the last in the series and first flew at Dalrymple, Ayrshire on the 6th of January 1938. The engine was an up-rated Weir Pixie and incorporated several refinements such as a faired pylon, improved landing gear and a more robust

Layzell Gyroplanes

Chief brains behind **'Layzell Gyroplanes'** is engineer and vehicle restorer Gary Layzell from Gloucester. Gary found his way into the world of Gyroplanes when he attended a local agricultural show where some Gyroplane enthusiasts were manning a show-stand with a static display of Gyros. That was in September 1998 and these tiny machines so impressed him that he bought a Campbell Cricket in need of restoration. During that process, he came to the conclusion that he could improve many of the mechanical aspects of the machine and in so doing, became acquainted with the P.F.A., (now the L.A.A.) and the C.A.A. After completing this project and selling it on, Gary had ideas on further improving the Cricket style of Gyroplane and his restoration project had also brought him into contact with Peter Lovegrove, the Cricket's original designer.

The Layzell AV-18A

In 1968, while working with Campbell Aircraft Ltd. at Membury, Peter designed the Cricket and has been involved in a programme of continuous improvement on these aircraft up to the present day. Peter's latest product was the Cricket MkVI and with Gary's involvement, the combined effort has resulted in the appearance of the Layzell AV-18A open framed single seat Gyroplane and the Layzell AV-18B - nacelle version. Both models have the same basic airframe of square section tubular aluminium alloy construction with both main and tailwheel suspension. Standard engine is the Rotax 582 DCDI liquid cooled driving a 52" diameter GSC Tech 111, three bladed wooden ground adjustable propeller. An optional air cooled Rotax 503 DCDI is available for the open framed model. The rotorhead is precision machined and all pivot points are fitted with bearings for long life and ease of maintenance. A pre-rotator is optional. Instruments include altimeter, air speed indicator, engine tachometer, rotor tachometer, water temperature gauge and a compass. Rotors are a pair of Rotordyne 22 ft. diameter aluminium rotors. All up weight is 650 lbs. and boasts a rate of climb of 650 ft. per minute.

In late 2008, **RotorSport** introduced an uprated version, the **MTOsport** which combines all of the above spec. plus a number of subtle improvements. The rotor head is moved forward and the stabiliser canted down for high speed stability (Vne is raised to 120 m.p.h.). The front seat is lower for better pilot protection and the seat cushions are made of Dynafoam for better impact absorption. Fuel system is modified in order to use more of the unusable fuel in steep descents with a low voltage and low fuel warning system. The nosewheel leg is raked forward without the use of centralising springs, a strengthened mainwheel undercarriage, an eight metre rotor is available for those pilots wanting more agile handling at the expense of lift performance plus a variable pitch/constant speed propeller for greater distance cruising.

The MTO sport

At time of going to press, the latest model being marketed by **RotorSport** is the **Calidus –** a state of the art design, two seat tandem Gyroplane using the same engine options as the two former models but with the added luxury of being fully enclosed. Stainless steel airframe, maximum take-off weight is 500kg, empty weight 240kg, maximum fuel is 90 litres, fixed or variable pitch propeller, choice of 8 or 8.4 metre length rotor blades, heated cockpit and luggage lockers, Vne 125 m.p.h., climb rate - up to 1500 ft/min., range - up to nine hours or 650 miles with a fuel burn of 10 litres/hour, minimum level flight speed 20 m.p.h.

The sleek lines of the Calidus

Impressive glass cockpit layout

Magni M22 Voyager

In February 2007, Magni first flew an experimental fully enclosed two seat side by side Gyroplane called the **XM 23 Orion** and in August 2008 the final version, the **Magni M 24 Orion** was displayed publicly. Basic airframe is of chrome alloy 4130 steel fabrication with a moulded carbon fibre cockpit and glass fibre tail section. Power is provided by a Rotax 914 UL Turbo (115 hp) 4 cylinder four stroke water cooled engine turning a three bladed ground adjustable 67” (1700 mm) diameter carbon fibre propeller. Magni rotor is of composite construction 28 feet in diameter. Cockpit is fitted with dual controls, padded seats with integral epoxy resin 21 gallon fuel tank. Other features include electric start, electric trim control, pre-rotator capable of speeds of up to 300 r.p.m., rotor brake, standard instrument panel with EIS instrument monitor.

Performance

Maximum speed is 105 mph with a cruise speed of 90 mph. Rate of climb is 950 ft/minute (5 m/sec.), fuel tank capacity 21 galls. (82 litres). Empty weight is 629 lbs. (285 kg.) and a maximum all up weight of 1212 lbs. (550 kg.), range 300 miles, endurance 3 hours.

The Magni M 24 Orion – courtesy of Brian Nichols

and in flight – courtesy of Magni Gyros

In April 2007, **ABS** became **Celier Aviation,** and transferred its manufacturing plant to a custom built factory in Poland and which is now run by Raphael's business partner Artur Trendak, a Polish manufacturer. Then, the factory had only four employees but by the end of that year had grown to over twenty. At the time of going to press, Xenon's are being produced at the rate of one per week by a dedicated workforce of specialists in composites, welding, electrical, production management and engineering.

Showing the neat lines of the Xenon 2/R

Two versions are available;

The **Xenon 2/R** (2 denotes the number of seats and R being the Rotax power-plant);
The **Xenon XL/Turbo** (a unique three seat Gyroplane powered by the Rotax 914 UL turbocharged engine. The three seats are arranged as a single front pilot's seat plus two side by side rear seats. Both models enjoy many common design factors including the unique body styling, twin tail booms supporting twin fin/rudder combination and topped by a large horizontal stabiliser. The cabins and tail units are hand moulded in a vinylester/fibreglass sandwich honeycombe - the horizontal stabiliser is designed to be in line with the propeller thrust line and therefore adding to stability in pitch. Masts are made of 6061 anodised alloy in a double H profile and can withstand a pull of 10.4 tons and a torsional force of 3 tons. It is attached to the cabin by a unique distribution of 12 bolts.

Chapter 6

Our friends across the 'Pond'

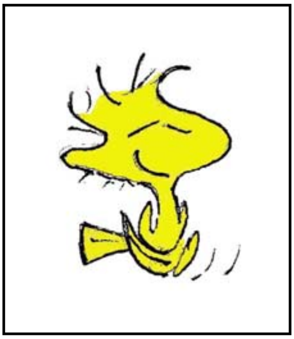
In addition to what's been mentioned in previous Chapters, the next few pages are only a representative selection of Gyroplane development in the USA up to the time of publication. We unreservedly apologise to those manufacturers and designers whom we know have also contributed to the evolution of the Gyroplane but due to their numbers, we are unable to find space here to represent them.

Twinstarr Gyroplane

This unusual design was conceived by Don Farrington, a pilot, instructor and examiner who headed the well known Farrington Aircraft Corporation at Paducah in Kentucky. After many years designing and flying many Gyroplane types including the Air and Space 18A, Don was keen to create a two seat machine that would satisfy his needs as a training aircraft. He employed Tom Davey to do the design, stress and analysis calculations that would encompass all the characteristics that Don had envisioned.

The distinctive looking Twinstarr with Lycoming powerplant and Irish registration
Photo courtesy of John Allan

While all this work was going on, Ron still had time to consider other projects, one of which was to continue his search for an engine that would suit his Little Wing Gyroplanes and at the same time evoke the glory days of Cierva, Pitcairn and Kellet. In the U.K. back in 2002, Mr Mel Morris Jones -a friend of the author - had written a short article in his own magazine 'Fly Gyro' about the possibility of using a radial engine in a conventional pusher configuration Gyroplane. He had sourced a Company in Australia, Rotec Engineering run by brothers Paul and Matthew Chernikeef. They had successfully developed a 7 cylinder four stroke air cooled radial engine of 2800cc, developing 110hp. at 3700 r.p.m. Later that year, Rotec were showing off their radial engine at the EAA Airventure Convention at Oshkosh in the U.S. fitted to a Kitfox Microlight aircraft and drawing in the crowds. Ron Herron knew they were going to be there and made a bee line for their Stand, eventually walking away with a large hole in his wallet and one of Rotec's radial engines tucked under his arm.



Woodstock

Little Wing 3, converted to the R2800 Rotec Radial engine

Ron used one of his Little Wing 3 (LW3) aircraft for his experiment and after designing a new engine mount and all the other details necessary for the transplant, the R2800 was eventually up and running and sounding good. First flight after extensive ground testing

Dominator Gyroplanes – Rotor Flight Dynamics Inc.

Ernie Boyette from West Palm Beach became interested in Gyroplanes in 1971 when he built his first Bensen kit. He learnt to fly it like so many others at that time by studying Dr Bensen's flying manual and taking it a step at a time. He later found that the Bensen design could be improved upon and the dreaded McCulloch two stroke powerplant was the first to go - replaced by a 150 hp Lycoming. This however was a rather heavy powerplant – around 1200 lbs. – and throughout his research, Ernie found that the currently available rotor blade systems were somewhat lacking in performance. He therefore decided to do something about it himself and started designing and building rotorblade aerofoil sections using fibreglass, aluminium and composite materials in the process. Twelve different rotor designs were experimented with before he settled on a particular specification and considered the prospect of offering it to the public.

Ernie named his new rotor blades **'Dragon Wings'** and in 1986 moved to Tampa in order to get his new business started. The new blades were of extruded aluminium spar with aluminium skins which Ernie taught himself to bond to the spar using the most advanced bonding agents available. With the help of financial backers who put up the money for the tooling and first production run, it took until 1989 before the business he called **'Rotor Flight Dynamics Inc.'** really got started. Blades were assembled and test flown before delivery and were available in basically two lengths – 22 ft. and 28 ft. although he could build larger ones to special order if necessary.

From that point onwards, Ernie's business flourished, sometimes unable to keep up with demand. It did however, allow him to start research and development of new Gyroplane designs, eventually arriving at what was to become known as the **'Dominator'** Gyroplane. Again, pitch stability was Ernie's main concern and from the outset it was to be a major ingredient in the Dominator's design as was its ability to operate off rough ground. As mentioned in previous designs, aligning centre of gravity with centreline thrust plus the addition of a horizontal stabiliser eliminates the tendency for the gyroplane to become over sensitive in pitch, especially at higher airspeeds which can lead to ‘pushovers’ and P.I.O’s (pilot induced oscillation). To achieve all these features, the Dominator Gyroplane has evolved into a unique design that is recognisable everywhere. Its rather long spidery suspension legs not only allow for rough ground operation but help to align the C of G with propeller thrust line and the tall tail allows increased tail area incorporating the horizontal stabiliser. Choice of powerplant for the single seat version includes Rotax 503cc air cooled version, 582 cc, 912 or 914 liquid cooled series or a Subaru EA-81 liquid cooled engine and for the two seat version the Rotax 914 turbo, Subaru EA-81 and the Hirth four cylinder.

Dominator single seat Subaru EA-81 version with pod and windshield

Latest model off the shelf is a fully enclosed two seat side-by-side 'SportCopter II' (SCII) which comprises a fully enclosed glass fibre cockpit, triple tail unit and full suspension. Power is provided by a Lycoming 10-360 air cooled engine rated at 220 hp. The cockpit has dual controls, forced air ventilation and heating, full instrumentation and EFIS if required and has a generous amount of storage space behind the two seats. It is fitted with the latest available powerful pre-rotator system for short take-offs and the rotorhead is shock isolated from the rest of the aircraft by a compression shock mount in the longitudinal pivot.

The Sport Copter II

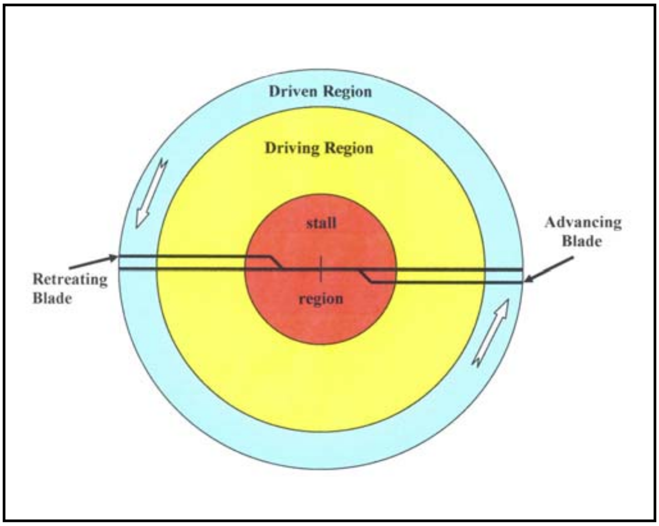
Specification

Empty weight 1000 lbs., Gross weight 1650 lbs., Service ceiling 18,000 ft., Cruising speed 100 m.p.h., Maximum speed 120 m.p.h., Rate of Climb 1000 ft/min., Range 300 miles.

As well as being President and Chief designer at Sport Copter, Jim Vanek is also a test and display pilot and is ranked as the top Gyroplane pilot in the World. In 1998 he wrote the parameters and guidelines for the FAA for looping a Gyroplane after performing the first loop in a conventional Gyroplane in 1997. (***Please readers, do not ever try this manoeuvre)***

Sadly, Jim's father Chuck, passed away on Fathers Day 2007 – an innovator and early pioneer of Gyroplane development in the U.S. who was honoured at the Hofstra University in New York in April 2003 with a 'Gyroplane Pioneer' award.

During vertical auto-rotational descent, the rotor disc is divided into three regions:

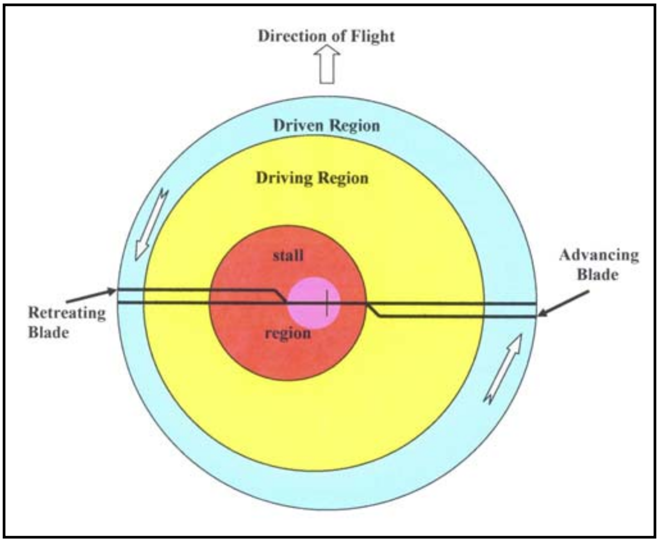


1. The **driven region**, also called the propeller region, is nearest to the blade tips and normally consists of about 30% of the radius. The total aerodynamic force in this region is inclined slightly behind the rotating axis. This results in a drag force which tends to slow the rotation of the blade.

2. The **driving region** or auto-rotational region, normally lies between about 25% to 70% of the blade radius. Total aerodynamic force in this region is inclined slightly forward of the axis of rotation. This inclination supplies thrust which tends to accelerate the rotation of the blade.

3. The **stall region** includes the inboard 25% of the blade radius. It operates above the stall angle of attack and causes drag which tends to slow the rotation of the blade.

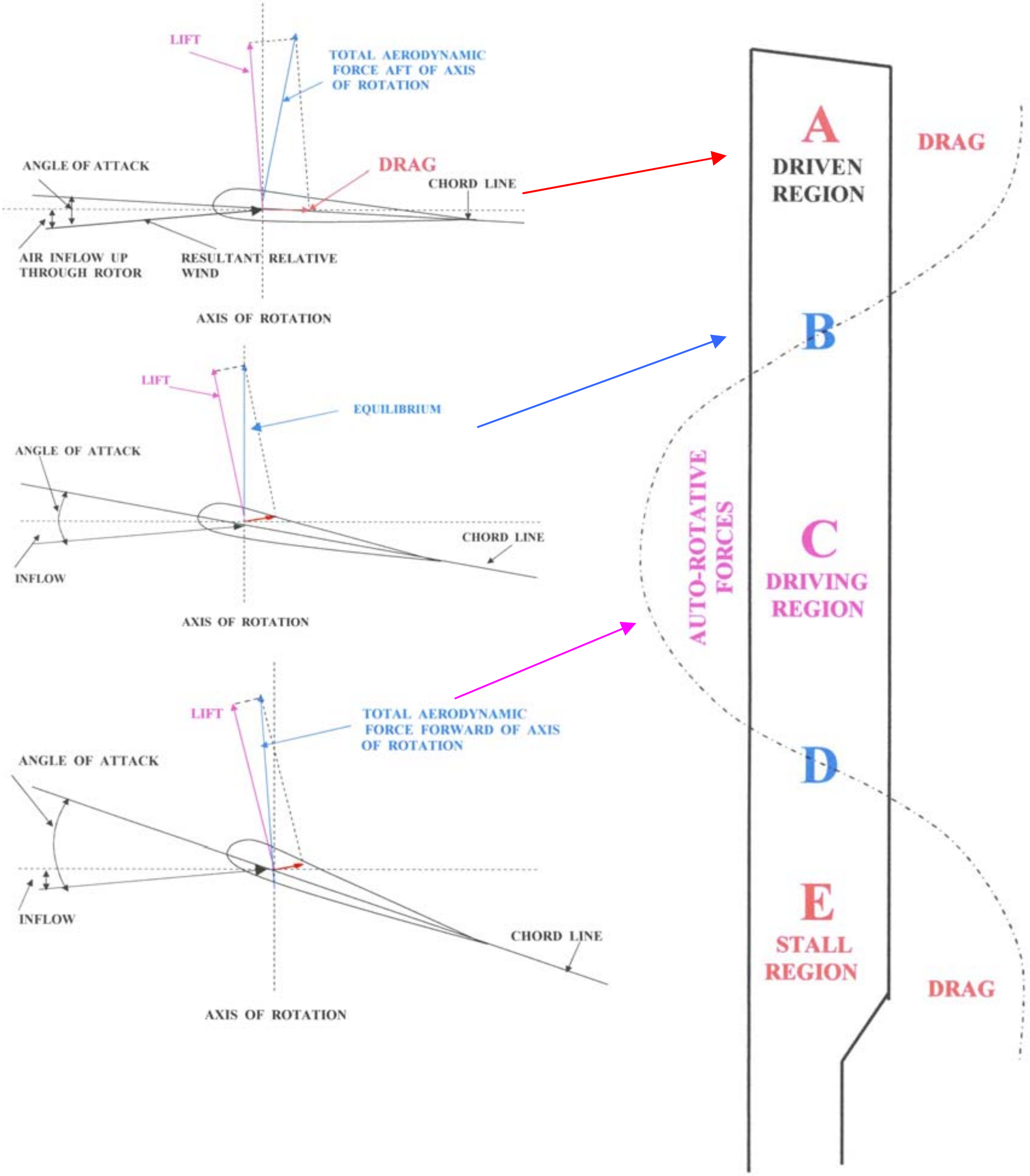
Aerodynamics of Auto-rotational State in Forward Flight



Auto-rotational force in forward flight is produced in exactly the same manner as when the Gyroplane is descending vertically in still air. However, because forward flight changes the inflow of air up through the rotor disc, the driving region and stall region move toward the retreating side of the disc where the angle of attack is larger:
Because of lower angles of attack on the advancing side blade, more of that blade falls into the driven region.

On the retreating side, more of the blade is in the stall region, and a small section near the root experiences a reversed flow. The size of the driven region on the retreating side is reduced.

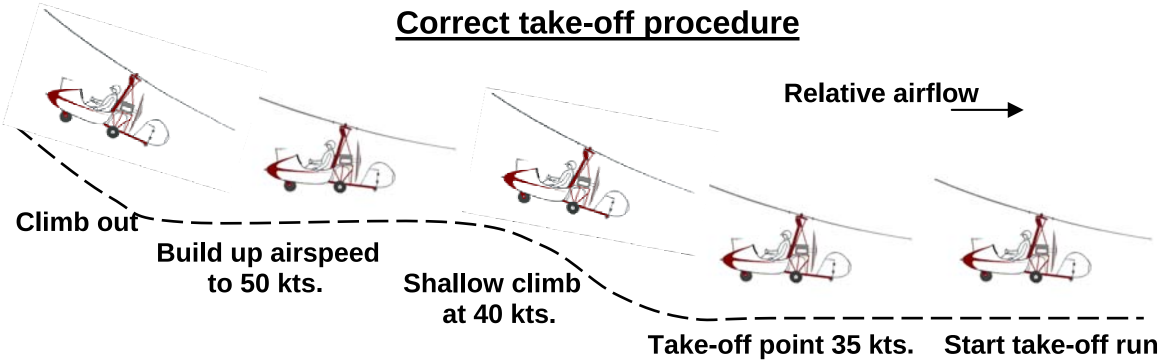
The following diagrams show three blade sections that illustrate force vectors in the driven region **"A"**, a region of equilibrium **"B"** and the driving region **"C".**



Chapter 8

Handling the Theory

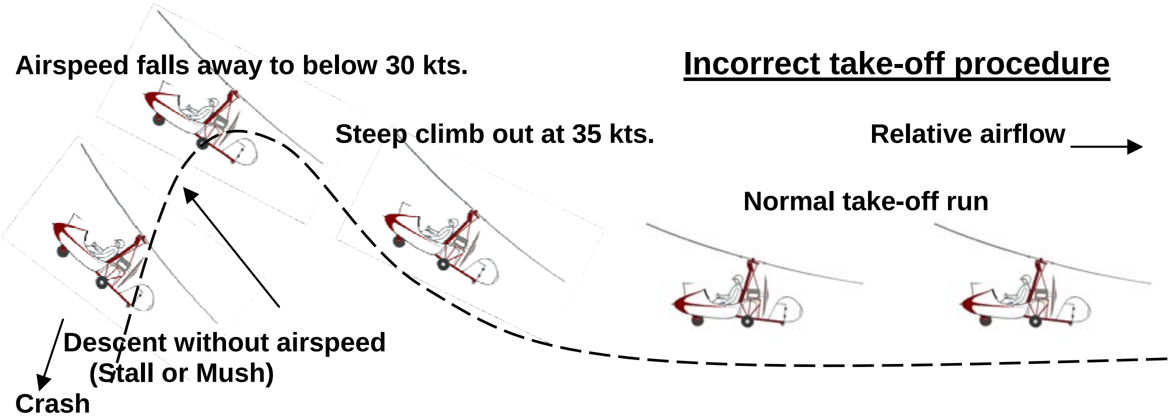
For the moment, let us consider a single seat Gyroplane in airworthy condition, the fully qualified pilot at the controls and both ready for flight. The take-off run without a pre-rotator and no wind will be in the region of about 300 metres – not very satisfactory these days. Most, if not all modern Gyroplanes are fitted with some form of device for initially bringing the rotor blades up to speed in the right direction – commonly known as a pre-rotator or pre-spin. These will be fully described in a later chapter so we won't go into too much detail here. Suffice to say that to shorten the take-off run to within say 50 to 75 metres in a no wind situation, initial rotor speed will have to be in the region of 175 r.p.m. before a take-off run is attempted. With a headwind speed approaching 10 knots, the take-off run will be considerably shorter.



The whole idea of the above is to gradually increase the rotational speed of the rotor blades while moving the Gyroplane forward and feeding the approaching airflow up through the rotors at a gradually increasing rate, thereby inducing an acceleration in rotor r.p.m. The pre-rotator greatly assists this process and skill is required to execute a good take-off using a combination of both correct airspeed and angle of attack of the rotor disc. Once the blades are accelerating, there will come a point where lift overcomes the drag of the rotor disc and at about 250 r.p.m., the Gyroplane will show signs of wanting to leave the ground. Initially, the nose will lift and the temptation is to keep powering the Gyroplane forward in the nose-up attitude and hope it will eventually clear the ground.

As some of us have found out to our cost, it will leave the ground but with so much drag from the rotor disc, that restoring flight airspeed becomes nigh on impossible and the Gyroplane will sink to the ground and probably roll over on impact. The correct procedure when the nose starts to lift is to ease the control column forward, setting the nose-wheel back on the ground again while at the same time gradually increasing the speed of the Gyroplane. This process temporarily eases the drag on the rotor disc until the nose starts to lift again and the same procedure is carried through again.

This procedure is known as wheel balancing i.e. balancing the Gyroplane on its main wheels while accelerating both the Gyroplane and the rotor speed.



Rotor speed for most single seat Gyroplanes at the take off point is around 275 r.p.m. and this is usually accomplished when the aircraft is doing around 30 to 35 kts. (depending upon the total all-up weight being flown). Once the aircraft decides to leave terra firma, it should be in an almost level attitude – and the pilot's job is to keep the aircraft airspeed accelerating up to its normal recognised best climb speed of between 40 to 45 kts. There will inevitably be a lateral torque reaction from the rotational speed of the engine, the direction of which depends on whether the propeller is rotating clockwise or anti-clockwise. The experienced pilot will know and anticipate this reaction on take-off and will make the necessary control inputs to keep the aircraft balanced. While this is happening, the rotor speed is also accelerating and when the Gyroplane achieves cruising speed of around 55 kts., the rotor speed will be in the region of 350 r.p.m.

Now the Gyroplane is in equilibrium – level flight at cruise speed of around 55 kts.

As the Gyroplane is a three-axis machine, gentle turns left or right (port or starboard) can be made using the usual combination of joystick and rudder pedals. If the turns are tight, the Gyroplane will lose airspeed and adopt a nose down attitude – this is to be avoided. While in the turn, keep eyes on the airspeed indicator to maintain airspeed above 50 kts. and make the necessary joystick and throttle adjustments to keep the nose from dropping. When rolling out of the turn to return to level cruise speed, ease the joystick forward and throttle back slightly. To climb, increase throttle setting and ease back on the joystick so that a climb speed of between 40 and 45 kts is achieved. To descend, decrease the throttle setting and allow the Gyroplane to descend at around 50 kts.

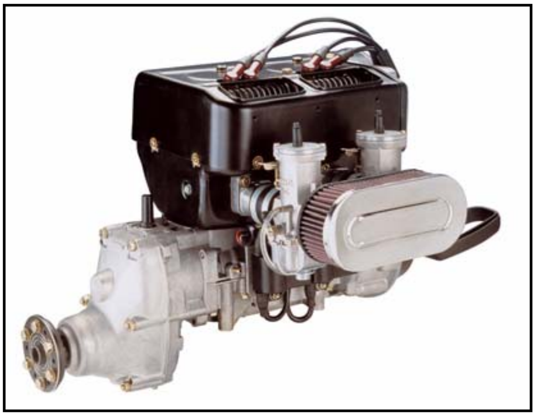
Chapter 9

Powerplants

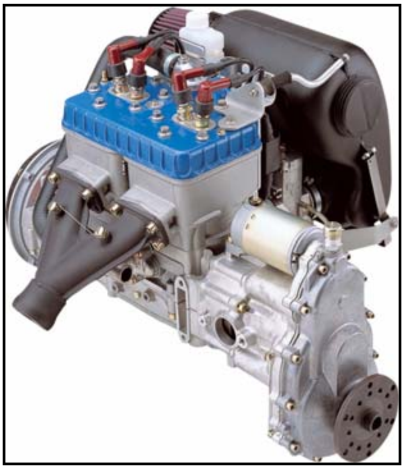
It is a known fact that some pilots have little or no knowledge of the internal workings of the internal combustion engine and whilst it isn't necessarily essential to have a deep understanding of its theory and design, it is perhaps important that the basic principles of the engine or powerplant should be understood.
Aviation powerplants run into many categories these days but for Gyroplanes only two types need concern us.

1. **The two-stroke engine.**
2. **The four-stroke engine.**

The two stroke engine which most of us are now familiar with is the **Rotax** – either the earlier 447-40hp and 503- 50hp or the later 532-60hp and 582-65hp series –although some are now being rated as a 603. All have one similarity – two cylinders and a reduction gearbox. The 447 and 503 are both air cooled and use an integral fan for cooling purposes while the 532, 582 and 603 are water cooled and need a radiator and coolant for that purpose. All are fed by either a single or twin carburettors whose job it is to mix the correct petrol/air combination in order for the engine to function correctly.



Rotax 503UL – 50hp 2 carbs.



Rotax 582 UL - 65hp -2 carbs.

Because two-stroke engines have no integral means of lubricating its working parts, the fuel contains a small proportion of special lubricating oil that is pre-mixed in the aircraft's fuel tank. The proportions used are very critical for the efficient running of the engine and can be as little as a 50:1 ratio but reference should always be made to the Manufacturers recommended ratios before running the engine. Igniting the petrol/air mixture when it is compressed within the engine is by means of a spark plug (actually it's two plugs per cylinder). The two plugs create a spark which is generated at a critical time within the compression period from a set of ignition coils situated within the flywheel. The timing of the ignition system is critical and is set at a pre-determined angle before the piston reaches top dead centre.

As can be seen from the diagrams below, the petrol/air mixture (orange) is drawn into the crankcase via the inlet reed valve as the piston ascends from its bottom dead centre position **(Fig. 1.)** while the previous intake of mixture is being compressed by the upward motion of the piston (blue). This is then ignited by a spark plug **(Fig. 2.)** and the resultant explosion inside the cylinder (red) causes the piston to descend and the engine to rotate via the connecting rod and crankshaft combination. The descending piston passes the exhaust port and the expanding exhaust gases escape **(Fig. 3.)** while a little further down, the mixture (orange) is able to enter the cylinder through an inlet port with the help of the scavenging motion of the descending piston. The piston then passes bottom dead centre and begins to ascend again **(Fig. 4.)**, the reed inlet valve will open again and so the process is repeated cycle after cycle. The resultant rotation continues and power is transmitted from the crankshaft through the reduction gearbox to the propeller.

Fig. 1.

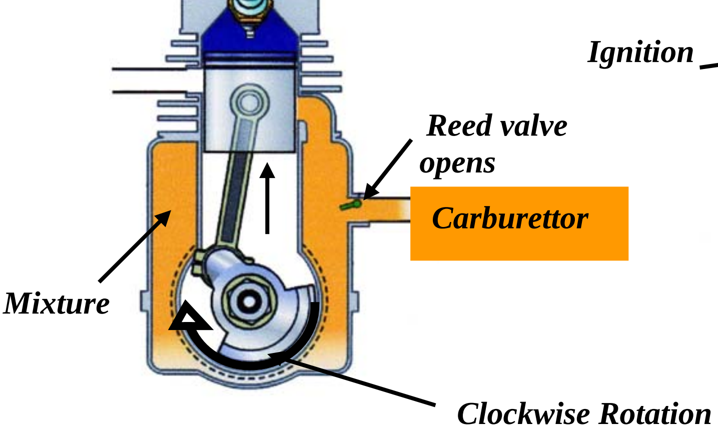


Fig. 2.

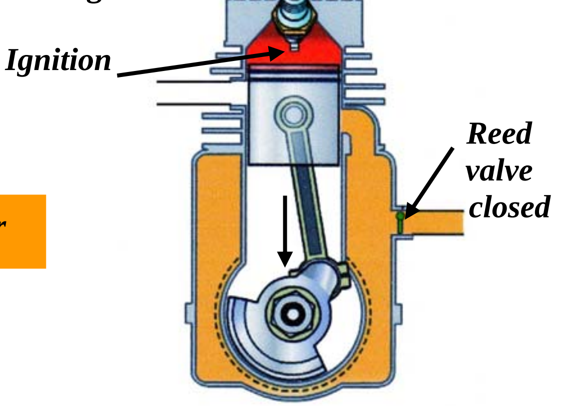


Fig. 3.

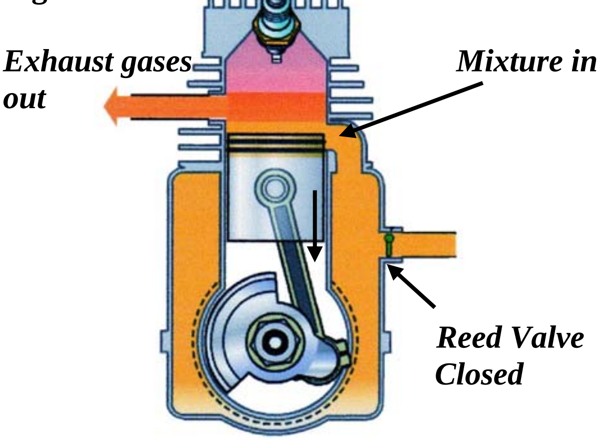


Fig. 4.