

The Fairey Rotodyne: An Idea Whose Time Has Come – Again?

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BASED ON *From Autogiro to Gyroplane: The Amazing Survival of an Aviation Technology*
Published by Praeger Publishers, July 2003

I

It was first flown on November 6, 1957 at the Fairey facility at White Waltham with Chief Helicopter Test Pilot Squadron Leader W. Ron Gellatly at the helm along with Assistant Chief Helicopter Test Pilot Lt. Cmdr. John G. P. Morton as Second Pilot. In the Rotodyne¹ “Y” form (XE521), it carried a crew of two and forty passengers, and, receiving lift from fixed wings of 46 feet 6 inches, was propelled forward by two wing-mounted 3,000 shaft hp Napier Eland NEL3 turboprop engines. But this was no ordinary aircraft – its 58 foot 8 inch fuselage could lift off and cruise as a helicopter with four tip-mounted pressure jets powering rotors that provided a disk 90 feet in diameter. The tip jets of the stainless steel rotors were powered by the same Eland engines which were coupled with compressors to force air into the tip-rotor pressure jets. Fuel was mixed with the compressed air and then ignited to create thrust capable of turning the rotor. But once aloft, the Fairy Rotodyne could disengage its rotor, which would then unload and autorotate to provide approximately 65% of the aircraft’s lift. The first transition from vertical to horizontal flight was on April 10, 1958. This, then, was the realization of a quest to merge the benefits of the autogiro, helicopter and airplane² – and, viewing the surviving film of its flight, it was a stunning achievement! That film, after Westland Aircraft LTD (having acquired Fairey Aviation on May 2, 1960) cancelled the Rotodyne project with the ending of official funding on February 26, 1962, and a few surviving components in the British Rotorcraft Museum in Weston-super-Mare (sometimes on loan to the Museum of Army Flying) are all that remains of this magnificent achievement. In the words of Derek Wood, author of *Project Cancelled*, a definite discussion of the Rotodyne and the British politics that killed it, “so died the world’s first vertical take-off military/civil transport.”³

II

In many ways, the most impressive application of the autogiro principles and autorotation technologies developed by Juan del la Cierva and Harold Pitcairn, was the 1950s Fairey Rotodyne, created by Fairey Aviation LTD. Fairey, the English aircraft designer and manufacturer founded in 1915 by C. R. (later Sir Richard) Fairey, had become a public company in 1929. The roots of the Rotodyne are to be found in the most unlikely of places, namely the turning away of the Cierva Autogiro Company LTD, which had been founded on March 24, 1926, by Air Commodore J. G. Weir and Juan de la Cierva, from development of the autogiro to the helicopter. And the beginning of the untimely end of the Rotodyne, is to be found in an equally unlikely and remote event, the successful 1946 negotiation and January 1947 agreement by Westland Aircraft LTD of a license to build a modified version of the four-seat Sikorsky S-51 (re-engineered and produced as the Dragonfly in 1948) helicopter by Mr. (later Sir Eric) Menforth and Mr. E. C. Wheeldon. The eventual government decision that British helicopter development would be based on Sikorsky engine and rotor technology in the late 1950s would doom Fairey and its Rotodyne in favor of Westland!⁴

The Rotodyne, a dynamic and innovative compound helicopter, could take off and hover in helicopter mode, and, powered by its two wing-mounted Eland engines, fly with lift provided by its short wings and the unloaded rotor. Functioning as an autogiro, the unloaded rotor provided approximately 65 percent of the aircraft’s lift. The Rotodyne thrills and excites even after four decades of its first flight. The tale of the Fairey Rotodyne is of triumphant technology done in by politics and shortness of vision.

The conceptual origins of the Rotodyne are to be found in the desire to maximize the benefits of autorotation in combination with the traditional aviation flight mechanism. As will be remembered, the

autogiro arose from the desire of Juan de la Cierva to create an aircraft that could not stall. The result was the "autogiro" (he has copyrighted the term. By the 1930s others had sought to combine the benefits of fixed wing flight with that of the autogiro, as well as to combine these with the emerging helicopter technology. Each of these attempts to create a compound aircraft constitutes the technical evolutionary antecedents of the eventual Rotodyne.

Herrick HV-2A Convertaplane

The first of these attempts to combine fixed and rotary wing flight was the HV-2A Convertiplane of Philadelphian Gerald Herrick (he called his various iterations alternatively Vertoplane, Convertiplane, and the eventual generic Convertaplane).

(See photo p. 141 *The Aircraft Treasures of Silver Hill* by Walter J. Boyne - same photo on p. 65 of *Helicopters and Autogiros* by Charles Gablehouse)

Assisted by Ralph H. McClarren, then associated with the Franklin Institute of Philadelphia, Pennsylvania. Herrick and his associates sought to combine the best features of fixed-wing flight and the Autogiro. Herrick has carefully considered Cierva's developments and by early 1931 had decided that while the safety of autorotation was obvious, the problem was the relative lack of efficiency (drag) in horizontal flight. His ingenious solution, developed after much wind-tunnel experimentation, was a symmetrical airfoil, mounted on a central rotor pylon that allowed aerodynamic adjustment for control. This was, in essence, a biplane with a two-bladed single cantilever upper wing --- the Herrick Convertaplane took off as a conventional biplane and then converted into a gyroplane with the upper wing rotating to provide lift on a central pylon.

Herrick's initial design, dubbed the Vertoplane, flew for the first time on November 6, 1931. Powered by a tiny three-cylinder 48 horsepower Poyer engine (the contemporary 1931 Pitcairn PCA-2 and PCA-3 autogiros were powered Wright R-975/E and E2 engines with 240 - 300 hp, while Pitcairn's attempt to create a lighter craft, the PAA and PA-18 autogiros featured Kinner engines with 125 - 160 hp), its crash in its maiden flight resulted in the death of its pilot. Taking off in biplane mode, the pilot released the upper wing in transition to autogiro mode to descend, but the aircraft vibrated uncontrollably and almost immediately dove to the ground.

Undeterred, Herrick immediately set about designing a new model. By 1936, after much redesign and experimentation, and securing financial backing, Herrick had constructed the Herrick HV-2A. Now called the Convertaplane, this was a much more sturdy craft embodying significant design improvements - the upper wing/rotor was now reduced in size (to 24 feet) in comparison to the lower wing (28 feet); and an electric motor was employed to start the engine. Flight testing of the biplane, with full cantilever wings, but lacking struts or wires between the wings, began in October of 1936 at Boulevard Airport in Northeast Philadelphia with a pilot more distinguished by his drinking and carousing than dedication to the project. Herrick soon replaced him with George Townson who had been active with Pitcairn aviation, and who claims to have had words with Amelia Earhart just before her historical 18,415 feet altitude record in a PCA-2 in April 1 of 1931. The gross weight was 1700 lbs., and the engine was now the 125 hp, air-cooled, 5-cylinder Kinner. After the HV-2A flew satisfactorily, the flight testing turned to the autogiro (rotating wing) mode.

The HV-2A was not able to 'spin up' the upper wing (rotor) mechanically as no connection had been made to the engine, as on the Pitcairn PCA-2. In the air, the upper wing would be released to rotate, initially powered by several 5/8 inch, rubber bungee cords inside each upper wing half and running through an aluminum tube. Each of these wing cords was connected to a cable which wound around a spool. Prior to takeoff, two people would grasp each wingtip and walk twice around the central pylon in the opposite direction to autorotation - the upper wing was then locked in the biplane cantilever wing position. When the pilot released lock, the bungee cords would cause the wing to rotate for two turns at 60 revolutions per minute. The now-spinning wing would then rotate freely and the flow of air through the disk would increase its speed to 220 revolutions per minute in autorotation.

Understandably, the first tests of the HV-2V's autorotation abilities were not in conversion from horizontal flight, but in take-off as an autogiro. There, bungee cords could not provide sufficient rotation to achieve flight, so the HV-2V was taxied around the perimeter of the airport with the flow of air slowly increasing the rpm of the rotor (as with the early Cierva and Pitcairn autogiros). Takeoff was achieved with 180 rpm, and, once airborne, autorotation increased to 220 rpm. The rotorcraft flights proved the abilities of the HV-2V in autorotation flight, so the decision was made to attempt a mid-air conversion. However, in both autogiro and biplane modes, higher-than-expected draw was noted as well as a tendency to veer to one side. While the former was never solved, latter was controlled by pilot technique.

For safety the first conversions from biplane to autogiro were at low level --- and were successful. A public demonstration on July 30, 1937 gained national publicity when the media photographed the air-to-air Convertaplane conversion at 1500 feet, and the inventor was heartened by expressions of interest by United States Navy, but little came of that as no funds were provided for further development. With the coming of WWII and the public demonstrations in Germany of the helicopter, interest dimmed towards Herrick's vision although he continued to design (but not construct) more sophisticated machines, earning him the title of "dean of convertible aircraft designers". The HV-2A made more than 100 air conversions prior to retirement to the Smithsonian Institutions Silver Hill Restoration Facility in 1954. While he was the first, and for many years, the only designer of a successful convertaplane, such was the power of this conventional/rotating wing combination that other designers and innovators were also active at the time, attempts that would lead to the most successful combination of all - the Fairey Rotodyne.

Bratukhin 11-EA

By the mid-to-late 1930s Russia, aviation designer Professor Ivan Pavel Bratukhin (his student Nikolai Ilyich Kamov would figure much later in the *Russian* Rotodyne story) of the TsAGI aeronautic research facility already had several years of rotorcraft design. The Soviet Union had made a major commitment to the study of and development of aircraft with the creation of the Tsentralnyi Aero-gidrodinamicheskii Institut, the TsAGI - The Central Aero-Hydrodynamics Institute, which had been proposed originally as the Aerodynamic Section of the NTO VSNKh in October 1918 by A. N. Tupolev and Nikolai Yegorovich Zhukovsky.

Characterized by Lenin as the "Father of Soviet Aviation". Zhulovsky had previously established, along with his student Vetchinkin, an Evaluation and Test Bureau (the *Raschetno-Ispytatelnoe Biuro*) as part of the MVTU (Moscow Higher Technical School or *Vysshee Tekhnicheskoe Uchilische*, renamed the Moscow Aviation Technical School in 1919, expanded and renamed the Institute for Engineers of the Red Air Fleet in 1920, and a year after his death in 1921 at the age of 74, finally becoming the N. Ye. Zhukovsky Military Aviation Technical School), in which Russia's first aerodynamic laboratory has been set up in 1899. That Evaluation and Test Bureau was a casualty of the March 1917 Revolution - within 20 months, however, it formed the basis for the new and eventually enduring endeavor.

By November of 1918 the proposed aeronautic project, now called the TsAGI, was submitted to the VSNKh with permission coming from Russia's ruler, V. I. Lenin on December 1, 1918. Its originality was evident in that it was the first time a scientific institution combined basic studies, applied research, structural design, pilot production and testing of aircraft. (TsAGI, under Russian Federation Government Decree No. 247 or March 29, 1994, was conferred the status of the State Research Center and today claims to be the largest scientific research center in the world).

Ivan Pavel Bratukhin, born in the village of Yaschera (in the modern day Kirov region) on February 25, 1903, had become a member of the Communist Party at the age of 17 when the struggle for control of Russia was still in progress.⁵ When TsAGI set up a helicopter research section under Boris Yuriev, Bratukhin briefly joined it in 1926, but soon left for additional studies at the Bauman Technical School in Moscow, where he graduated in 1930. Returning to TsAGI, he was placed in charge of a brigade that developed the 11-EA between 1936 and 1938. This model was more of a direct predecessor

of the Fairey Rotodyne that the Herrick HV-2A in that it sought to combine the capacities of helicopter, autogyro and fixed-wing aircraft. It was, in some ways, less a predecessor in that it failed to accomplish its task. In one way, however, the EV-11 prefigured the Rotodyne in that its development fell victim to politics!

The Bratukhin-designed 11-EA (for *experimental aircraft or autogyro*) was, having been under conceptual development since 1933, constructed in 1936. With the appearance of a conventional two-passenger aircraft with a autogyro pylon topped with a six-bladed rotor consisting of three shorter rigid blades capable of feathering and three longer, articulated blades. As this craft was to take off as a helicopter, Bratukhin placed counter-torque propellers on the forward edge of each wing which would push and pull in opposite directions in helicopter (hovering) mode. In forward flight, however, both propellers pulled forward even as the rotor was unloaded as an Autogyro. The 11-EA had a streamlined fuselage and was powered by a 630 hp Curtiss Conqueror engine mounted in the forward part of the fuselage with a large fan-equipped radiator in front. Tethered flight testing began in 1936 and continued until the next year. These tests, only in limited helicopter mode, revealed control problems due to the complex 6-bladed rotor. However, external circumstances slowed testing and subsequent development by 1937 doomed this compound aircraft.

The development of the 11-EA, characterized by a reluctance to advance to full untethered flight testing in 1937, was dictated by the official retribution for failure increasingly exacted by Joseph Stalin who saw treachery in such lack of success. Bratukhin and his associates were constantly confronted with reports of arrests of fellow engineers who had failed to deliver the desired results. As precisely observed by Lennart Anderson in *Soviet Aircraft and Aviation 1917 – 1941*, “No one wanted to risk making a mistake and be accused of sabotage.” Indeed, Bratukhin’s test pilot, Aleksei Cheremukhin was arrested and imprisoned with other Bureau colleagues.⁶ By late 1938 the political climate was such that it was judged improvident and unacceptably risky to continue the development of this compound aircraft. The 11-EA was rebuilt between late 1938 and December 1939 as the 11-EA-PV, a pure helicopter version with the wings replaced by framework booms with two auxiliary rotors on each side for torque control. Beginning flight testing in October 1940, no one mourned it when it last flew in 1941. Thus did the 11-EA pass and fail to realize a potential of combining the benefits of its individual components – that would wait for the Fairey Rotodyne. But, as will be seen, Bratukhin, would make a contribution twelve years later in the eventual design of the Kamov Ka-22, the *Vintokrulya* (“screw wing”), the *Russian Rotodyne*!

Flettner 185

That the German Anton Flettner is little remembered as a pioneering designer of rotary-wing aircraft is no doubt, in some measure, occasioned by the rather consistent destruction or abandonment of his models! His prototype helicopter of 1932, distinguished by the placement of a small engine and tractor propeller on each blade of a two-bladed rotor (thus effectively avoiding with the issue of torque derived from a airframe-mounted engine) was destroyed shortly after a successful tethered flight when it overturned in a storm! Flettner’s next design, a two-seat autogyro dubbed the Flettner Fl 184 (D-EDVE) was constructed with a three-bladed rotor and tractor propeller powered 140 hp Siemens-Halske Sh 14, 140 hp radial radial engine. This machine was also destroyed when, after being licensed in September 1936, the prototype crashed while making a left turn in preparation for landing into the wind. It was later determined that an incorrectly set stabilizer, which could not be controlled during flight, had forced the model into a 70 degree dive from about 330 feet.⁷

Flettner then created a combination autogyro/helicopter, the Fl 185 (D-EFLT). The machine was designed to take off as a helicopter with a rotor powered by the same 140 hp Siemens-Halske Sh 14 engine that had powered its predecessor. The engine was equipped with a cowl and frontal fan for cooling, and transmitted power to the rotor and two variable-pitch airscrews mounted on outrigger arms extending from the fuselage by means of a gear-box located just behind the cowling. In helicopter mode (powered rotor), the airscrews rotated in opposite directions, thus effectively resulting in antagonistic thrust designed to counter rotor-torque. But with a free rotor in autorotation, the pitch of the airscrews could be altered to provide forward thrust as they accelerated with full power then redirected from the

rotor. Unfortunately for Flettner, this prototype was abandoned after only a few test flights as he bowed to official policy and concentrated on a pure helicopter (a course of action similar to that would be taken by Bratukhin two years later).

His Fl 265 V1 prototype (D-EFLV), first flying in May 1939, was similar in airframe construction to the previous Autogiro/helicopter configuration but dispensed with the outriggers and propellers. The Fl 265 V1 innovated two two-bladed counter-rotating inter-meshing and synchronized main rotors which, because they were rotating in opposite directions, each cancelled the opposite torque. It was an elegant if complex solution to the torque issue, but in prototypic development that failed three months later, the craft crashed when the counter-rotating blades struck each other.⁸

WNF 342 V1,2,3 and 4

At the start of WWII, a recent engineering graduate, Friedrich von Doblhoff, suggested that a helicopter could be powered with ram jets designed by French engineer Rene Leduk placed on the rotors. This would effectively deal with the issues of torque caused by main frame engine placement. Enlisted in the German war effort as an employee of the Wiener Neustadter Flugzeugwerke (WNF), a Vienna aircraft manufacturer building Messerschmitt 109s, von Doblhoff recruited friends Theodor Laufer and August Stepan in the efforts to design a jet-tip helicopter in what was a visionary and unauthorized program of research. And while the test apparatus, constructed of magnesium tubing supporting a rotor with hollow blades through which compressed air and vaporized gasoline passed to an automobile spark plug positioned at a tip exit nozzle designed for ignition, was destroyed in its maiden test, observing officials were impressed. The machine had managed to not only lift off, it had also carried an anvil added to the rig to weigh it down. Destruction had come when it tilted and its rotors struck the floor, but the results led to a half-million mark authorization for an official project to design a jet tip helicopter.

The world's first tip jet powered helicopter, the WNF 342 V1 was flying in the spring of 1943. It was designed to meet a German Navy requirement for an observation helicopter to be carried by submarines and small naval vessels. It featured a frame of uncovered metal tubing with a small twin finned vertical tail and tricycle landing gear. An Argus As 411 supercharger was adapted as a compressor to provide air to the rotors, an arrangement that would then be employed on all of Doblhoff's prototypes. The V1, slightly damaged in an allied bombing raid on August 13, 1943, was soon followed by the WNF 342 V2, which added a sail-like rear fuselage faring with a single fin and an upgraded 90 hp Walter Mikron engine. It was constructed in Obergraf-fendorf, to where the WNF development program had been relocated after the bombing. Experience with the first two models convinced its inventor that the high fuel consumption of the tip-jets would make the WNF 342 prohibitively costly to operate, so the decision was made to power the rotors only on take off and landing. The rotor would be unloaded in flight and the craft would then fly as an Autogiro.

The resulting WNF 342 V3 was constructed with twin tail booms, each of which supported an oval shaped vertical fin and rudder with a horizontal stabilizer linking the booms. A BMW-Bramo Sh 14A 140 hp engine both provided forward thrust with a pusher propeller and the compressor for the jet-tip rotors. During forward flight power (air and fuel) was cut off from the rotor jet-tips as the engine was declutched from the compressor and power redirected to the propeller - lift was obtained from autorotation as the aircraft flew as an autogyro. The final model of V3 weighed 1208 lbs and had flapping and dragging rotor hinges - vertical control was achieved by varying the rotor speed.⁹ Unfortunately, the innovations incorporated in Doblhoff's third model were not enough to ensure success and after only a few flights. Fortunately no one was injured as it literally destroyed itself from ground resonance vibration.

An additional prototype was constructed before the war ended, the WNF 342 V4, the largest of Doblhoff's prototypes, and in many ways, the most significant although not for any intended reasons. The V4 could carry a crew of two in side-by-side open cockpits and the fuselage was now faired. It

retained the twin boom layout but the two verticals were replaced with a single vertical mounted on top of a horizontal tail that connected the booms. Heavier than its predecessors, the V4 weighed 1411 lbs and had a 32.68 ft. rotor, just slightly larger than the V3. It also innovatively used air pressure to control the collective pitch of the 32.42 feet diameter rotor blades - the blades could be pitched for helicopter-powered takeoff and landings, and then changed to allow for autorotation. Testing of the V4 began in the Spring of 1945, with 25 hours of flight time having been accumulated by early April., although it was not tested in forward flight over 25 - 30 mph. But it was too late - on April 7, 1945, Doblhoff and his colleagues could hear the artillery of the approaching Russian forces moved into Vienna, 18 miles to the east. After some discussion, the decision was made to load the WNF 342 V2 and V4 prototypes on a trailer and flee westward to the Americans and British. For almost twelve days the truck carrying the designers and mechanics, and towing the trailer, moved westward over roads often clogged with refugees and others doing likewise.

Eventually Doblhoff and his colleagues surrendered to American forces at Zell am See and were quickly interrogated by engineering officers who recognized the importance of the prototype and its designers. The model was crated and shipped to the United States for evaluation - followed quickly by Doblhoff who then went to work for McDonnell Aircraft as Chief Helicopter Engineer and significantly contributed to development of the McDonnell XV-1 compound helicopter convertiplane, a contemporary development of autorotation technology to the Rotodyne, which will be discussed later. Of perhaps greater importance, August Stepan, who had done the structural design and most of the test flying of the prototypes, joined Fairey Aviation as Chief Tip-Jet Engineer and contributed to the design of the Fairey Gyrodyne and Rotodyne which employed the rotor tip-jet technology for takeoffs and landing but flew as an Autogiro.

There was an additional irony for Frederick von Doblhoff - he had courted a young Austrian woman in the early 1930s who had gone to spend a summer in Czechoslovakia. The young woman was also courted there by a young man whose family had fled the Russian Revolution - and although neither would win the girl, both Frederick von Doblhoff and Igor Bensen would be instrumental in preserving auto-rotational technology in the 1950s!¹⁰ And Doblhoff was not yet finished - he would eventually come to America and be the helicopter chief engineer at McDonnell Aircraft during the development of the XV - 1, a compound helicopter contemporary of the Rotodyne also combining helicopter and autogiro technology.

Thus Herrick, Bratukhin, Flettner and Doblhoff each anticipated the Fairey Rotodyne's combination of autorotational technology with fixed-wing and helicopter technology, but each resulted in clearly unrealized potential. But there are at least two other seeming unrelated non-technical events that will come to bear on the Rotodyne, and the first of these occurred in England on the fog-shrouded morning of December 9, 1936. The KLM DC-2 (PH-AKL) flight, bound for Amsterdam from the airport at Croydon Aerodrome, London, was delayed beyond its 10:00 am scheduled takeoff, under the command of a Captain Hautmeyer, finally made an instrument takeoff, made necessary by visibility that rarely exceeded 25 yards. The pilot, though experienced, inadvertently swung subtly to left off from the white 2100 foot takeoff guideline which proved to be a fatal mistake to all but two of the sixteen people on board when the plane crashed - at the time, the worst air disaster in British history. Thus did Juan de la Cierva die - an ironic end to a man so passionately committed to developing a safe means of air travel.

Many paid tribute to de la Cierva in published obituaries and the Royal Aeronautical Society posthumously awarded Cierva its prestigious Gold Medal. Harold Pitcairn, as cited by Peter W. Brooks in his monumental work *Cierva Autogiros: The Development of Rotary-Wing Flight*, paid tribute to his friend of almost a decade¹¹ in writing:

Juan de la Cierva will be known to enduring fame as the outstanding pioneer in the field of rotary wing aircraft . . . All helicopters and similar types of craft that have shown promise of practical performance incorporate some of the principles and inventions developed by Cierva.¹²

What is significant about this moving tribute is the recognition by Pitcairn, in early 1937, of the importance of Cierva's work to ongoing helicopter development, whose technical achievements had been first demonstrated with a flight of the Focke-Achgelis Fa-61 on June 26, 1936.¹³ While Cierva's death did not stop Autogiro development in England and America, the former continuing for three years and latter hanging on for seven years, the focus of the Cierva Autogiro Company, LTD, under Dr. J[ames] A[llen] J[amieson] Bennett,¹⁴ who had become technical director after Cierva's death, shifted primarily to the design and testing of jump-takeoff rotor heads. Indeed, Dr. Bennett published a series of papers on rotor design in the United Kingdom's *Aircraft Engineering* magazine in the early 1940s, which would be the inspiration for the independent WWII Australian development of a "Rotabuggy", but that little-known story is told elsewhere.¹⁵ It is sufficient here to note that the direction of Autogiro development was even then shifting to the helicopter, a direction that would inevitably lead to the Rotodyne.

It was obvious to Harold Pitcairn that the relationship between the Autogiro Company of America and Cierva Autogiro Company, LTD had changed after the Croyden crash. He had been a member of the Board of Directors of the English company for several years and had, with some regularity (fifteen trips to Europe between 1928 and 1936, and four consultations with Cierva in America), participated in its affairs - but subsequent to Cierva's death, a distancing had taken place. The English engineers seem to be very hesitant about including Pitcairn's colleagues Agnew Larsen and Paul Stanley - a hesitation that soon descended into resentment and then outright hostility. Additionally, Dr. Bennett, Cierva's successor, seemed unwilling to share the results of current research, effectively refusing to respond to Pitcairn's legitimate in-quiries as a company director.¹⁶ He had a vital interest in this work as the Autogiro Company of America had rights to the work of the English company was then incorporated into and influenced its own work.¹⁷ It was now evident that the collaborative spirit and practices that existed during Cierva's lifetime were a thing of the past.

By February 1937 Harold Pitcairn, concluding that the relationship between the English company and his associates then in England had deteriorated to such an extent that it no longer made any sense to maintain a presence, recalled Larsen and Stanley. However, he asked test pilot Jim Ray to remain, in part because of Ray's cordial personal and professional relationship with Reginald Brie, Cierva's chief test pilot. In this manner Pitcairn hoped to gather information on what was actually happening in Europe. The news was not encouraging - Ray, observing that the Bennett engineering group seemed to have little to do after the departure of the American observers, complained that he had little to occupy his time, and thought it appropriate to return home. Pitcairn, however, asked him to gather information on the French and German helicopter programs that were already fueling an active rumor mill. In this case the German rumors proved to be founded and ominous. Ray transmitted the information he had gathered on the very real achievements of Flettner and, after spending several weeks in Bremen, a confirmation of the seminal work of Focke-Achgelis & Company¹⁸ with its Fa-61. The Germans has been most anxious to show off the latest aviation development and had willingly and publicly demonstrated the Fa-61 from a distance - but in the Fall of 1937 the Fa-61 had been flown before the world's most famous living aviator, American Colonel Charles A. Lindbergh, then a personal guest of Hermann Goering who wanted to proclaim the advances in German air power. His reports of the vertical flight achievements of the Fa-61 were insightful, perceived of as accurate and authoritative, and alarming.¹⁹

To Pitcairn, however, whatever the comfort he derived from the Lindburgh observation that this was a prototype capable of lifting only its pilot, the most problematic and troubling report was that the Fa-61 had used some of Cierva's supposedly closely guarded parents to achieve effective collective pitch control to facilitate precise vertical flight! It had become immediately and painfully obvious to Pitcairn that the company on whose board he served had at best not kept him informed of licensing agreements with Focke (and, as it turned out, with Flettner), and at worst actively betrayed Autogiro development.²⁰ He immediately departed for England and a confrontation with his fellow board members, and most notably with Dr. Bennett.

The Board of Directors of Cierva Autogiro Company, LTD. directly informed its American member that indeed the Fa-61 had been developed under license from Cierva Autogiro of its cyclic/collective pitch control rotor hub *and that in a cross-licensing arrangement Pitcairn Autogiro had received a license to build Focke-Achgelis helicopters!* Pitcairn was stunned - it was obvious that, with Cierva

Autogiro Company seeking to form a consortium with Focke-Achgelis and the French Bréguet Company to build Fa-61 derived aircraft, the development of Autogiros in Europe was, if not ending, receiving a major setback. Far from being discouraged, however, he returned to America rededicated to development of the jump take-off autogiro and convinced that its development would henceforth be an American enterprise. Thus, for all practical consideration, seemingly ended the relationship between the American and English companies. That relationship would briefly resurface in the development of rotary aircraft during WW II, but it would never be the same.

Jim Ray returned to America on October 26, 1938. By a coincidence he traveled on the same ship that brought Raoul Hafner who was going to attend an international symposium on rotary-wing aircraft jointly sponsored by the Philadelphia chapter of the Institute of Aeronautical Science and the Franklin Institute which had been arranged by engineers Ralph Herbert McClarren and E. Burke Wilford, inventor of the Wilford Gyroplane, distinguished by its use of non-Cierva technology.²¹ Such was the significance of this symposium that both Henrich Focke and Louis Bréguet, invited but unable to attend, asked Hafner to read their scientific papers. Ray attended with associates Paul Stanley and Agnew Larsen of the Autogiro Company of America and even delivered an impromptu but well-received account of his European observations.

In light of subsequent developments, it was unfortunate that Harold Pitcairn, ill and unable to attend the symposium, was forced to rely on Ray's conclusions.

Pitcairn, having recovered several weeks after the symposium, hosted a belated homecoming for Jim Ray in his Bryn Athyn home. Ray was forthright and blunt in his observation that the FA-61 and Flettner machines, and accompanying public and professional acclaim, clearly pointed towards helicopter development, and that continued development of the Autogiro was ill-advised. Pitcairn, Stanley and Larsen were stunned when Ray recommended that the PA-36 jump take-off Autogiro be discontinued and the company's efforts be redirected towards helicopter development. It was unacceptable advice, both personally as Harold Pitcairn had been committed to Autogiro development and had been for over a decade, and economically as the company had an irreversible financial investment in its Autogiro research program. Jim Ray had to go, and in fact was terminated at the end of 1938.

But Jim Ray and Dr. J.A.J. Bennett were right – the future was to be found in the helicopter, and there was little doubt of this by the end of WWII. However, the autogiro technology refused to die, being preserved and nurtured in one stream by America's Dr. Igor Bensen and by England's Dr. J.A.J. Bennett. After WWII he had become head of the helicopter branch of Fairey Aviation. Intimately familiar with both helicopter development and the benefits of the autogiro, Bennett would be the major visionary behind the Fairey Rotodyne.

III

Helicopter development in post WWII England resumed after a general hiatus – WWII had seen some limited use of the Avro-built Cierva Autogiros and a few from America supplied by the Pitcairn-Larsen Autogiro Company, which had been created specifically by Harold Pitcairn and his long-time friend Agnew Larsen, to provide convoy protection Autogiros (PA-39s) for the Royal Navy. They had been procured in late 1940 at the suggestion of a member of the British Purchasing Commission, Wing Commander Reginald A. C. Brie, former Cierva Autogiro Company LTD chief test pilot. Although America had yet not entered the war, the economy anticipated the coming conflict and it was impossible to manufacture a new model, nor would the order of seven PA-39s be profitable – so Pitcairn and Larsen reacquired seven old PA-18 two-place, open-cockpit Autogiros and retrofitted them with direct-control, jump-takeoff systems. In a supreme irony, of the five PA-39s crated and sent by ship to England (one was retained by Pitcairn-Larsen for further development in anticipation of reorders and one was retained by Wing Commander Brie for service testing from escort ships at Newport News, Virginia), only two reached England, the others and all the spare parts for the order having been lost when the ships upon which they had been placed were sunk by German submarines!²² The few Autogiros that did fly, however, played a vital role in the development and operation of the coastal radar system, principally in

facilitating daily calibration as the Autogiros could effectively fly slowly and even hover in a sufficient headwind.

The Rotodyne began with the concept for a compound helicopter developed by Dr. J.A.J. Bennett and Captain A. Graham Forsyth of Fairey Aviation based on 1947 studies. During WWII Dr. Bennett, along with Wing Commander Reginald Brie, had served as principle technical officer to the British Air Commission in Washington, D.C. As such he was well aware of allied and German rotary wing developments including the work of Flettner and Doblhoff – he advanced the idea embodied in the Flettner 185 and the WNF 342 V 3 and 4, namely an aircraft that could take off and land vertically in helicopter mode with a power-driven rotor using a controllable-pitch propeller for yaw control. In horizontal flight, however, power would be transferred to the propeller for forward movement while lift was generated partially by the autorotating rotor and partially by small wings. The rotor's collective pitch controlled vertical lift in the helicopter mode, and would change as the throttle was opened or closed. Roll and pitch were controlled by tilting the rotor head while a single tractor propeller in the starboard wingtip was used to control yaw as well as to providing forward thrust in the autogiro mode. In this manner the Gyrodyne, as it was named, was also reminiscent of the control approach taken by Bratukhin in the 11-EA with its small wing propellers, helicopter and Autogiro modes of flight.

The first of Fairey Aviation's compound helicopter prototypes, the Gyrodyne²³, first flew on December 7, 1947, based in part on the 1938 design for the Cierva S-22/38 in response to a Royal Navy specification for a ship-based helicopter. It was powered by a relatively powerful 520 hp Alvis Leonides²⁴ radial engine and it established a new world's helicopter speed record of 124.3 mph on June 28, 1948. The technology, however derived from known sources, still embodied a leap into the unknown in terms of metal fatigue for which the previous experience of other developers did not provide – both the pilot and the observer died when the rotor head disintegrated and the Gyrodyne crashed 10 months later. Fairey Aviation then tragically realized that while it was attempting to incorporate known technological achievements into an innovative aircraft form, such a combination would require a great deal of new research and development and embarked on four years of effort.

Insert picture of Jet Gyrodyne here – see
Newman, Simon *The Foundations of Helicopter Flight*
Great Britain: Edwin Arnold Division of Hodder Headline PLC 1994 pp. 20 Plate 2.7

The result was a second prototype which featured a completely redesigned transmission system and strengthened rotor designed to withstand the stress of helicopter takeoff and landing, autogiro flight and the in-flight conversion between the two. And although the company attempted to convey to the public that the new and innovative nature of its second compound helicopter by naming it the Jet Gyrodyne, it was actually powered by the same type of Alvis radial engine that powered the original, but that is where the similarity ended --- the original gearbox transmission that shifted power from the rotor to the engine was replaced by a pair of engine-driven modified Super-marine Spitfire superchargers that served as compressors to force forced air into miniature jet nozzles located at the tip of each rotor. Fuel was forced into the nozzle by the centrifugal force of blade rotation and then ignited – effectively a Doblhoff tip jet powered helicopter. Much development and testing had gone into the technology of this new model which first flew in January 1954. The first inflight transition involving autogiro mode was on March 24, 1955 by test pilot John N. Dennis. It proved to be both underpowered and, reminiscent of the fuel-consumption problem previously confronted by Doblhoff that led to his decision to power the rotor only in takeoff and landings, could only carry enough fuel for 15 minutes. However, the Jet Gyrodyne was not designed for production but as a proof-of-concept testing platform for the technologies that would power a much grander vision which was simultaneously being developed – the Fairey Rotodyne.

Dr. Bennett and Captain Forsyth had begun articulating the Rotodyne concept in 1947 before the potential of a larger transport helicopter would be recognized.²⁵ A turbine-powered design was submitted to the British government on January 26, 1949 for a compound craft capable of carrying 20 passengers with a four-blade rotor powered by two Armstrong Siddeley Mamba engines, but the

research on the Jet Gyrodyne would result in an eventual design that incorporated jet-tip rotors. However, even though the Jet Rotodyne was still years away, Fairey began almost immediately to modify the Rotodyne design and by March of that year had formally submitted three alternative new designs: A model now powered by Mamba or Rolls-Royce Dart engines for forward flight and providing pressurized air for jet-tipped rotors in helicopter flight mode; a model with three Mamba engines, two of which would be for forward flight and one to power the jet-tipped rotors with compressed air; and a third design with two wing-mounted Mamba or Dart engines for forward flight and auxiliary air compressors for the jet-tipped rotors.²⁶ An initial development contract was awarded in October 1950 for a model based on the Dart engine, but that was modified when Lord Ernest Hives, who had originally been head of the Rolls-Royce experimental shop and chief test driver, complained that the Rolls-Royce engine design team was over-committed. The government then decided in late 1950 that the Rotodyne project would go forward with Armstrong Siddeley Mamba engines with auxiliary compressors, a power plant then dubbed the "Cobra". However, by July 1951 Fairey itself had completed a redesign of the Rotodyne to meet, in part, the requirements of the BEA articulated in 1951 for a 10-12 passenger helicopter to provide service between British cities.²⁷ Two new designs were submitted, one with two Mamba engines and a four-blade rotor, and a second with three Mamba engines and a five-blade rotor. The former had an all-up weight of 20,000 lbs and the latter, due to the increased lift of its rotor, was projected at 30,000 lbs. However, neither of these designs was to be -- for, as Rolls-Royce previously, Armstrong Siddeley complained to the government that its production facilities were also then overloaded.

There can be little doubt that the design difficulties experienced by Fairey with regard to engine procurement were an accurate reflection of the frenetic research and development effort in postwar British aviation. But there is also another possibility that is far better reflective of the politics that would eventually doom the Rotodyne project and summarily execute jet-tip power in the British rotor industry. In 1949, just after Fairey's first design submission to the government, the Director of Engine Research had publicly strongly objected to support being given to the Rotodyne project²⁸ -- eventually total support would be withdrawn and the project killed in favor of Westland and its application of its licensed Sikorsky technology. But while the opposition was known in the early 1950s, the eventual end was not, and Fairey pressed on with an alternative design.

By June 1952 the Rotodyne design now featured a de Havilland H.7 turbine engine combined with auxiliary compressors, the former for forward flight and the latter for rotor power, but again this was not to be as an agreement could not be reached with de Havilland and Fairey complained to the Ministry of Supply that it was being neglected. Subsequently, after consultation with the Ministry, Fairey settled on the just introduced Napier Eland engine in April 1953. Napier, under the developmental direction of A. J. Penn and Bertie Bayne, had entered into the development of gas turbine engines and its Eland engine would be produced from 1952 until 1961.²⁹ The Rotodyne "Y" prototype then went forward with two Eland N.E.1.3 engines with auxiliary compressors and a now enlarged section four-blade rotor with an all-up weight projected to be 33,000 lbs. Projected, but never realized, was a cargo version with the larger Eland N.E.1.7 engine and a flying weight of 39,000 lbs.

Insert photo of Rotodyne Y -- See Taylor, John W. R. and H. F. King *Milestones of the Air: Jane's 100 Significant Aircraft* New York: McGraw-Hill Book Company, 1969 p. 136

The British government had continued to fund Rotodyne development but funding for the proposed Eland prototype was not approved until April 1953, and itself was not free from controversy. Fairey had suggested that £ 710,000 would be sufficient for development of the airframe, but its estimate was met with great skepticism as a result of its inability to effectively project (or control) developmental costs of the Gyrodyne. The remaining Jet Gyrodyne (XD 759) had been converted to jet-tip rotor propulsion using auxiliary compressors powered by the Leonides engine to test the Rotodyne concepts, but the costs of this conversion had escalated from a projected £ 75,000 to a spectacular £ 192,000, a cost overrun of 156%! Never-the-less, even though the government had reportedly been staggered by the cost overrun of the converted Jet Gyrodyne, the Ministry of Supply

entered into a contract with Fairey aviation to construct the Rotodyne Y prototype in July 1953. The contract specified a 40 – 50 passenger model with a 150 mph cruising speed and a range of 250 nautical miles, and it was understood that a larger machine would follow.³⁰ Construction was under the direction of Captain Forsyth as in April 1952, a result of a disagreement with Fairey, Dr. Bennett had left to join Hiller Aircraft in the United States. The man who had spanned the golden age of Cierva to the Rotodyne left the project, but there was every reason to be optimistic in 1953 and believe that the Rotodyne would indeed be the most successful application of Cierva's autorotational principles. It was not to be.

Officially called an experimental compound helicopter, the Rotodyne Y (XE521 – a military registration number) featured a single four-blade main all-metal, primarily stainless steel rotor carried above its 58' 8" long fuselage on a large, fully faired dorsal pylon structure. The 90' diameter rotor was driven by pressure-jet units at the rotor tips. In horizontal flight the rotor was unloaded as an autogiro and allowed to autorotate, providing approximately 65% of the aircraft's lift, the remaining lift coming from a 46' 4" cantilever high-wing on either side of the fuselage. The wings were all-metal two-spar construction. The box-like rectangular cross-section fuselage, featuring double clam-shell doors at the rear to allow for efficient cargo and vehicle loading, was an all-metal semi-monocoque structure. The all-metal tail, box-like, was a braced monoplane type mounted on top of the fuselage and originally featured two endplate fins and two rudders, but a third central fin was added in early 1960 to improve control and increase stability. The Napier Eland N.E.1.3 turboprop engines were seated below each wing in underslung nacelles – each driving a de Thailand four-blade propeller. Fuel was carried in tanks located within each wing. The landing gear was a tricycle type with the main wheels retracting into the bottom of the engine nacelles. Taxing and landing were cushioned by the use of Oleo-pneumatic shock absorbers. The cockpit was set forward in the nose of the fuselage and featured dual controls and an unrestricted view. With an overall height of 22 feet and a design gross weight of 33,000 lbs., but sometimes flown at 38,000 lbs., it was the largest helicopter of its day, with the tail assembly being built at Fairey's Stockport factory and the fuselage, wings and rotor assembly being constructed at Hayes. Assembly of the component units took place at the airfield at White Waltham with a full-scale static test rig having been constructed at the Aeroplane and Armament Establishment at RAF Boscombe Down, Wiltshire. There the rotor and power plant were assembled and tested, including a 25 hour test of the tip jets in conformance with a required Ministry approval test. And although the noise produced by the tip-jets was already proving to be an issue, as well as the aircraft's weight,³¹ the testing went well and the civilian aviation community began to take interest. Fairey, anticipating the civilian market and the Rotodyne's ability to land in helicopter (or autogiro) mode in the midst of cities, took the noise issue very seriously and by late 1955 had tested forty different types of noise suppressors.³²

BEA was consistently updated as to Rotodyne testing program and it was generally expected that, as London-to-Paris center city service had been discussed in December 1954, the Rotodyne would enter civilian service with an 88 minute flying time. Additionally, Fairey had proposed that the second anticipated larger prototype would be capable of carrying vehicles for the military. Things were definitely looking up, but in early 1956 the government imposed serious budget limitations and there was a marked reduction in enthusiasm for programs such as the Rotodyne which had been funded as part of the Defense Budget. It had been a logical way to further the developmental program given the RAF and Army interest, but it also left the Rotodyne vulnerable to government cutbacks - which now came. The Defense Ministry withdrew further financial support by stating that there was no further military interest in the Rotodyne, effectively throwing the entire project into the civilian sector which now had to bear not only the whole developmental costs, but also the funding to develop the Eland N.E.1.3 engines for Rotodyne application. After much discussion during 1956, the government agreed to fund the Rotodyne and Eland projects until the end of September of 1957, a deadline subsequently extended through the end of the year, subject to three conditions: 1) the Rotodyne had to be a technical success; 2) Fairey Aviation secure a firm order from BEA and intents-to-purchase from other air carriers; and 3) Fairey Aviation and English Electric, the corporate parent of Napier, fund a proportion of the developmental costs. Fairey agreed because, although the first flight had slipped from its projected 1956

date, it was confident that the Rotodyne would finally take to the air in 1957 and commercial success would surely follow.³³

The Rotodyne first took to the air on November 6, 1957, and its first successful transition from vertical/horizontal/vertical flight was on April 10, 1958. There was much publicity of the Rotodyne achievement and it was the center of industry attention and public acclaim at the SBAC Show at Farnborough in September where it performed vertical and horizontal flight, a successful demonstration resulting in an order for a Rotodyne, and options for two more, from Okanagan Helicopters Ltd. of Vancouver, Canada. This was not surprising given that Fairey Aviation had previously expanded in Canada in 1948 with a plant at Eastern Passage, Nova Scotia. At the time it was viewed as a savvy business move as the air component of the Royal Canadian Navy (RCN) was being expanded with the acquisition of Canada's first fleet carrier, the 'Warrior', and its Fairey 'Firefly' aircraft. It was correctly perceived that significant opportunities for repair and conversion work would result. The company then went on to purchase a hanger at Patricia Bay, in response to the 1954 RCN commissioning of VU33 and VC922 in late 1954. In January the local newspaper, the Victoria Daily Times, quoting unnamed Fairey officials speculated, that "construction of a jet-powered helicopter of revolutionary design, with rotor, fixed wings and speeds equal to that of a DC-3, likely will be one of the first long term projects of Fairy Aviation Co. at its Patricia Bay plant." ³⁴

Okanagan officials had followed the public announcements of Rotodyne developments with great interest and avidly reported on its application to inter-city transport with enthusiasm in its 1958 Annual Report, announcing that the company would proceed with applications for permission to operate the Rotodyne in 'triangle-service' between Vancouver, Victoria and Seattle. In September 1959 Mr. Alf Stringer, Vice President of Engineering, and Carl Agar, Vice President of Operations of Okanagan, had spent two weeks at Fairey examining the Rotodyne. While impressed with its flight characteristics, Stringer commented on the noise created by the tip-jets, observing that they could be heard ten miles away, and that this would be a significant obstacle to inter-city service as few, if any, municipalities would be prepared to allow such noise in town. Indeed, it was to prove fatal to the project, but that was not evident at the time. In fact, developing commercial interest pointed to a bright future for the Rotodyne.

Fairey Aviation had been engaged in negotiations with New York Airways (NYA) in 1958, for potential purchase of the Rotodyne for inter-city service, while Japan Airlines had arranged to visit Britain to evaluate the prototype. Indeed, the Rotodyne established a world speed record on January 5, 1959 for "convertiplane" type aircraft of 190.89 mph, bettering the old record by 30 mph; and delivered an outstanding performance in June at the 1959 Paris Air Show, complete with safe autogyro landings. Kamen Aircraft Corporation had negotiated a sales and service contract and a Rotodyne manufacturing license for military³⁵ and civilian production of the Rotodyne in the United States; and NYA was so impressed by the Rotodyne's performance that it had signed a letter of intent to purchase five Rotodynes at \$2 million each, with an option for 15 additional aircraft. The latter order was subject to successful testing of the initial five, and the cost was then anticipated to be \$1.5 million per aircraft. This was of great significance as NYA was recognized as the world's first scheduled airline to exclusively use rotary-wing craft, flying commuter flights from the top of the Pan American Building in the heart of Manhattan to various outlying airports. This successful company, well versed in such commuter service and its hard-nosed economic realities, had calculated that the Rotodyne, with an enhanced 65-passenger capacity, could reduce the airline's operating cost per seat/mile by at least 50% over the helicopter.³⁶ Interest was then also expressed by Chicago Helicopter Airways and Japan Airlines, the latter who stated that it was considering the Rotodyne for travel between Tokyo and Osaka.

It was obvious, then, that the commercial desirability of the Rotodyne depended on its economic viability, and development of the larger model would require an additional 8 - 10 million British pound expenditure. Fairey, orders, options, and economic analyses in hand, approached the British government of Prime Minister Harold Macmillan for help. The PM had written on June 6, 1959 to the Hon. Aubrey Jones, Minister of Supply, in support of the Rotodyne project, stating that "this project must not be allowed to die". Fairey justifiably felt that it had cause to believe that its appeal for additional funding

would be favorably received. And while such appeared to be superficially the case, the conditions attached to an offer for half of the additional funding were to prove onerous and ultimately fatal.

The British government made its offer of continued support contingent on a firm order from BEA, but both BEA and NYA made their orders dependent on a larger prototype flying by Fall 1961. Such a larger model was also perceived as desirable as the military was pressing for a model capable of carrying 75 troops. It was to prove a daunting task as Fairey was encountering ongoing difficulties at reducing the noise produced by the Rotodyne's tip-jets. And BEA, having announced in January 1959 intent to purchase of six Rotodynes, insisted that all its requirements, including noise reduction, be met.

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Fairey, having encountered difficulties working with the Napier Company, had also become dissatisfied with the Eland engines and it was readily apparent that a 65 - 75 passenger model would require significantly more powerful engines. For while the prototype Eland N.E.1.I engine was to have started at 3,000 hp and improved to produce 4,200 hp, it never achieved more than 2,550 hp! This caused Rotodyne pilots to enrich the fuel mixture to achieve necessary power which, in turn, resulted in unacceptably high fuel consumption and was responsible, in part, for the increased noise level that concerned all potential purchasers.³⁸ The company, giving up on Napier, turned back to Rolls-Royce with its Tyne engine. This second-generation turboprop had been designed by Lionel Haworth in 1954 - 55 to take over where the Dart ended at 2,500 hp, but the engine had proved far more powerful and by the time that Fairey considered it, was comfortably rated at 4,220 hp. Fairey, confident that the Tyne could be pushed to 5,000 hp, felt it would be sufficient for the projected Rotodyne "Z." The Ministry of Supply promised to finance 50 percent of the Tyne-Rotodyne development costs (to a defined maximum), but also conditioned on a BEA order.

Fairey, then, confidently approached the design of the Rotodyne "Z". What emerged from the first design efforts was a craft now with a 56 ft 6 in span with a rotor diameter now increased to 104 ft. Fairey, in an attempt to spur both civilian interest and military support, circulated the new design and it was, for a time, rumored that the United States Army was interested in acquiring two hundred of the new larger Rotodynes. But this never materialized as such an arms procurement required evaluation, and even if Fairey had entered into production of the larger model, military import into the United States was prohibited. And while it was then suggested that Eastern Airlines, having had Autogiro experience with the 1939 - 1940 Philadelphia 30th Street Post Office-Camden, NJ Autogiro mail flights, purchase a civilian model and lease it to the Army for trials, nothing came of this. Fairey also sought Mutual Aid Money which was conditioned on an RAF order for twenty-five Rotodyne "Z"s, but the RAF publicly stated that it would not commit to more than twelve. But other events were even then coming to a head that would shortly doom the Rotodyne and insure that the larger model would never be built. While the Tyne engine would continue to be made for over thirty years, the Rotodyne had less than three years left.

While Fairey's attention was justifiably focused on the Ministry of Supply, events in the Ministry of Aviation were even then darkening the skies for rotary aircraft. The Hon. Duncan Sandys, Minister of Aviation wanted to consolidate, or "rationalize", the British helicopter industry, and felt that Westland was the logical choice as it was a major supplier of Sikorsky-licensed and derived helicopters for the military and civilian markets. Wielding government subsidies as a scalpel to dissect and reorder the British helicopter industry, Sandys selectively withdrew government support and thus forced company mergers.³⁹ In 1959 Westland took over Saunders-Roe Ltd. Then, on March 23, 1960, Westland acquired the Helicopter Division of Bristol Aircraft Ltd based at Weston-Super-Mare, Somerset, a wholly-owned subsidiary of Bristol Aeroplane Company Ltd., renaming it the Bristol Helicopter Division of Westland Aircraft Ltd. Bristol Aeroplane acquired a 10 percent interest in Westland Aircraft and Westland had now acquired all but one major British helicopter company. Less than seven weeks later it was Fairey's turn.

Duncan Sandys had withheld further contracts and support for Fairey Aviation and the company found itself without further funding for fixed-wing aircraft or guided weapons. It was made abundantly clear by Sandys that the price for further development funding for the Rotodyne would be the sale of Fairey's aviation interests, apart from specialized manufacturing as hydraulic components, to Westland. With a monthly bill of £ 70,000 just to keep the smaller Rotodyne prototype flying, and mounting

developmental costs for the larger "Z" version, Fairey had no choice and agreed to the sale. On May 2, 1960 it sold the Rotodyne and its aviation interests to Westland. At the time of the sale the Rotodyne had flown a total of 120 hours, made 350 flights and 230 transitions between helicopter and autogiro – without any accident. This safe aircraft continued to amaze all who saw it fly and there was no reason, now that Sandys had successfully engineered the consolidation of the helicopter industry, not to proceed with its development. Accordingly, Westland received a government development contract in the amount of £ 4 million and a promise of an additional £ 1.5 to facilitate the larger Rotodyne entering BEA service.

As the development of the Rotodyne "Z" continued, the design became even larger. The final version of the aircraft was to weigh 58,500 lbs with an increased rotor diameter of 109 feet and an equally impressive 75 ft wingspan. The capacity of the military version of the revised design would have been capable of carrying seventy-five troops and their operational equipment, armored cars and trucks (via the double clamshell doors in the rear of the fuselage), missiles or the fuselage of a small aircraft., and to function as a flying crane capable of lifting a 100 ft bridge span, vehicles and disabled aircraft. As admirable as these projected capabilities were, the RAF was not then interested in a compound helicopter – its focus, and budget, in the early 1960s were on nuclear deterrence. So even though there was some mild military interest, it never reached a critical mass and it was readily apparent that the civilian market would have to carry the entire project – and it was not to be. All that was left was to write the final chapter in late 1961.

The linchpin was always the BEA order, and its precondition that all its terms be met now came back to haunt Fairey in what proved to be the Rotodyne's death throes. Although concerns were voiced about the increase in weight and rising costs, the continuing noise issue became the focus of growing criticism. But before this resulted in a final cry to end the project, the issue of engine design arose one last time, this time not to be resolved successfully. It was obvious that the enlarged design would require more power than even that which would be produced by the Rolls-Royce Tyne power plant. It was suggested that power be increased by fitting a Rolls-Royce RB. 176 auxiliary booster engine in the rear of each Tyne nacelle. Government policy continued to be that development costs be shared by industry, a policy that would have required Rolls-Royce to invest an estimated £ 9 million – an expense the company was not then willing to assume.

The government then pounded the final nail in the Rotodyne coffin when it rejected a requested Westland quote for delivery of twelve Rotodyne "Z"s for the RAF and an additional six for BEA, stating that the military was no longer interested. Official funding was withdrawn on February 26, 1962 and the Rotodyne was dead as the British government and Westland fully committed to those aircraft derived from its Sikorsky license. Thus the lead in compound helicopters, and the most successful application of Juan de la Cierva's autorotational flight ended.

In 1953, in order to conceal from the public the vast sums expended to create a transatlantic airliner that was eclipsed by an American plane, the British government had ordered the two models of the Bristol Type 167 Brabazon destroyed in a similar and most disingenuous manner, the British government, which owned the prototype, also had the Rotodyne "Y" dismantled and almost completely destroyed, with only a few components surviving at the British Rotorcraft Museum, Weston-super-Mare, Avon, accessible to serious researchers with prior appointment. Even the tooling used to create the Rotodyne was destroyed and the films of its flights only surviving because of acts of rescue.

Analysis of the noise issue clearly indicates that it is incorrect to ascribe the downfall of this incredible aircraft to decibels⁴⁰: By February 1962 the noise cancellation project had resulted in 96 db at 600 ft, but those intent upon making this a seminal issue either failed to note or deliberately ignored the fact that the rotor would be powered only for approximately one minute at take off/climb out and one minute during landing. And to further minimize the Rotodyne noise, it was estimated that a vertical climb upon take off of 250 feet before acceleration to 600 feet and a standard approach angle of 15 degrees for landing would further reduce its noise. And to make a point about the reality of Rotodyne flight in the inner city, Chief Pilot Gelattly twice flew over downtown London and made multiple landings and takeoffs at the Battersea Heliport on a calm morning with no complaints raised.⁴¹ In fact, the Eland engines on the Rotodyne prototype produced less noise than the DC-8, and at the time of project

cancellation, “the continuing development of the silencers had further reduced the noise level by another 16 db.”⁴²

Politics doomed the Rotodyne even though almost 1000 passengers had participated in demonstration flights, including a significant number of the world’s airline leaders, military and government officials, with no accidents reported. This compound helicopter never failed to amaze onlookers – it flew in every Farnborough and Paris air shows from 1958 through 1962 to constant acclaim. This was the end result of the vision of Dr. J.A.J. Bennett and extensive research and development – truly a machine far ahead of its time. It is now unfairly cited as one of “the world’s strangest aircraft”⁴³ but twenty-five years earlier, the Rotodyne had been included in MILESTONES OF THE AIR: JANE’S 100 Significant Aircraft!⁴⁴

IV

The Fairey Rotodyne was perhaps the most developed application of autorotational technology, but not the only one. But its death signaled a precarious future for the rest and none was able to escape its fate. The McDonnell XV-1 program had already ended prior to the Rotodyne and the Kamov Ka-22, which most closely resembled the Rotodyne and came the closest to success, suffered a similar political fate. The other attempts were viewed as either developmental craft not destined for production, or the product of limited vision and even more limited capitalization. The creations of Bruno Nagler,⁴⁵ the Nagler Heli-Giro Aeronca conversion and VG-Vertigyro have all but been forgotten, and the late 1960s VFW (Vereingte Flugtechnische Werke) H-3 3-seat heli-gyro did not prove a viable proposition. Additionally, Anton Flettner again reappears, now the founder of his own company in New York after the war. The Fl 201 Heligyro, evolving out of his earlier work on the Fl 185, was a 30 – 40 passenger twin-rotor helicopter designed to takeoff and land as a helicopter but fly as an autogyro. Under United States Navy sponsorship the Fl 201 Heligyro was tested at New York Naval Air Station, Floyd Bennett Field the the model never advanced beyond the testing phase.⁴⁶

Each represents an attempt to advance the compound technology as did the Rotodyne, taking advantage of the discovery of Juan de la Cierva. And as the Rotodyne, each was destined for failure.

Kamov Ka-22 (The “Russian Rotodyne”)

Known in the Soviet Union as the Vintokrulya (Vintokryl) (“Screw Wing”), and dubbed “Hoop” by NATO, this impressive aircraft was called the “Russian Roto-dyne”⁴⁷, and it suffered a similar same fate. It was a transport convertiplane equipped with a rear ramp for cargo loading and larger⁴⁸ than even the proposed Rotodyne “Z” in that it was estimated that it could easily carry 80, and possibly 100, passengers or 36,500 lbs. It had an all-metal fuselage with a flight deck raised high above the glazed nose to allow excellent vision for landing in small areas, and was powered at the end of each wing by two Ivchenko AI-20V propeller-turbines, one mounted at each end of a 90 ft. tapered wing.⁴⁹ Each engine drove both a conventional four-blade propeller for forward flight and four-blade side-by-side rotor for takeoff, hovering and landing as the Rotodyne. In forward flight each rotor, which was at the very end of each wing rising from the turbine engine, was unloaded and the plane derived lift from its wings and the unloaded rotor functioning in autogyro mode. Flight testing began on April 20, 1960,⁵⁰ and it made its first, and only, public appearance at the Soviet National Aviation Day display at the Tushino Airshow on July 9, 1961 and the Ka-22’s Class E.II speed record of 221.4 mph over a 15/25 km course of October 7, 1961 and load record of 36,343 lbs to a height of 6,562 ft of November 24, 1961 still stand for convertiplanes.⁵¹

Four aircraft were built in 1959 – 1963, one at the Lubertsy experimental plant and three additional models at Tashkent.⁵² But despite its impressive performance and appearance, the program was apparently cancelled in 1964 after a crash in 1964 although its designer, Nikolai Kamov maintained that the configuration was “still active” in 1966.⁵³ There is one ironic note to the Ka-22, the echo of a voice heard before in the field of helicopter/autogyro/fixed-wing compound aircraft – that of our old

friend Professor Ivan Pavel Bratukhin. Prior to the disbanding of his engineering bureau in 1950, thirteen years after he had abandoned the 11-EA, he proposed a twin rotor, ten-seat convertiplane, dubbed the B-11, in a configuration that strongly resembled the later Kamov Ka-22. Although Bratukhin's proposal was officially ignored, the illogical speculation is that his work "may have been passed on to Kamov's staff. Certainly the *Hoop* had a passing resemblance to Bratukhin's B-11."⁵⁴

Nagler Heli-Giro Aeronca and VG-Vertigyro

The work of Austrian Bruno Nagler is generally unknown,⁵⁵ yet his work from the 1940s on the "prop-copter", incorporating two small engines mounted on the rotors driving small propellers which power the rotor minus any torque is still relevant today. After moving to America and settling in White Plains, New York Nagler embarked on several areas of aviation research and development, one of which was, similar to the Fairey Rotodyne, a pressure jet rotorcraft. Although Nagler is usually cited for his helicopter designs incorporating this technology, there are photographic records of at least two different attempts to evolve a convertiplane that could take off as a helicopter and fly as an autogyro. The obscure Nagler Heli-Giro Aeronca conversion was a pressure jet-powered rotor affixed to what appears to be a converted Aeronca K Scout with modified control surfaces, the wings removed and a reconfigured tail.⁵⁶

Less obscure, the Nagler Vertigyro VG-1 was a converted Piper Colt built to prove Nagler's Vertigyro⁵⁷ concept which clearly had its conceptual roots, although perhaps not its creative foundation, in the earlier work of Bratukhin, Flettner, de la Cierva and Pitcairn. This craft resembled the earlier Pitcairn and Kellet direct control autogyros in that it was an airplane fuselage topped by a direct control pressure-tip rotor and a tractor propeller mounted in front. It could fly as a helicopter, an autogyro and convert between the two. And using cold-pressure compressed air, the craft avoided the noise issued that recently brought down the Rotodyne. And although it was stated in 1965 that the VG-1 prototype (N5395Z)⁵⁸ would be followed by a definitive VG-2 model, there is no record of that happening as Nagler was invited by investor Darrow Thompson to set up a facility in near Phoenix, Arizona to develop a single seat homebuilt helicopter. Nagler worked on these projects until his death in 1979, but his conversions and use of pressure-tip technology for a low-cost, off-the-shelf convertiplane, remains a product of the same creative impulses and fascination with the flight possibilities of autorotation that motivated the Ka-22 and Rotodyne, and their fate was equally fatal.

VFW H-3

Designed by German engineer Christian Fischer, and manufactured by VFW GmbH⁵⁹ (Vereingte Flugtechnische Werke), the H-3 3-seat heli-gyro of the late 1960s – early 1970s represented an additional attempt to combine autogyro and helicopter technology to gain the benefits of autorotational flight. Fischer, an admirer of the "ingeniously simple design of the Bensen gyrocopter"⁶⁰, improved, as Nagler, the cold jet powered rotors after developing Rotodyne/Dublhoff-like "hot jet drive" powered rotors leading to serious noise issues, as with the Rotodyne before it. The prototype, developed in 1967, was a sleek aerodynamic design with an enclosed single-seat cabin, a variable control three-blade cold jet-tipped rotor to achieve helicopter flight and, in autogyro mode, the power from its Allison 250 gas-turbine engine was shifted to side-mounted ducted fans on each side of the fuselage forward of its V-tail while the unloaded rotor provided lift. By 1971 VFW was flying the H-3 in three-seat configuration in tie-down and hovering flight tests with VFW-Fokker test pilot Heinz Hoffman. After testing, VFW decided not to continue the program and this adaptation of compound technologies, as the Rotodyne, Kamov Ka-22 and others disappeared as so many before.

V

Noted aviation author Frank Anders observed in 1994 that "perhaps, like the Phoenix out of the ashes, another Rotodyne may someday rise. We can only hope."⁶¹ It now appears, with the

CarterCopter “Heliplane” that a new Rotodyne may indeed be arising, better and hopefully more successful than four decades ago. CarterCopters L.L.C., the creation of talented designer Jay Carter, Jr., intricately aware of the Rotodyne technology, has created the “Heliplane”, a VTOL design system. Its conceptual-inaction is as a gyroplane with a helicopter mode as a pilot option. Utilizing the latest in technological advancements including engine design, control mechanisms, proprietary rotor design and extensive use of composite materials, the Heliplane will have the capacity to take off, hover and land as a helicopter but cruise as a gyroplane with a rotor that is both unloaded to provide lift and also slowed to minimize profile drag and thereby maximize flight efficiency, along with efficient high-aspect ratio wings. Of particular potential interest to the military seeking such a craft for battlefield insertion, the Heliplane’s designer anticipates using autorotation for high-speed descents, thus avoiding “settling under power” in a vortex ring state. This latter characteristic should prove of great interest to the United State Marine Corps which has invested heavily; in the Bell-Boeing V-22 Osprey, a competing ‘tiltrotor’ technology that suffers from such vortex ring states. The \$44 million transport, under development for eighteen years, has crashed twice, killing all onboard. In the wake of the latest crash of April 8, 2000, one of the criticisms voiced about the Osprey is that it cannot autorotate, precisely the strength of the Heliplane.

Carter estimates that the Heliplane in CCH-T mode and largest configuration will dwarf the Rotodyne “Z” and Kamov Ka-22 with an empty weight of 90,000 lbs, a length of 106 ft and height of 43 ft. Its VTOL design take-off weight is projected at 160,000 lbs @ 7,000 ft density altitude.⁶²

Some of the efficiency of CarterCopters creations has come from the application of new technologies, just as Anders has predicted. But one example of technology application is the CC rotor. It is an ultra high inertia rotor with over twice the available inertia per pound of gross weight than any previous rotor, an efficiency derived in part from centrifugal force from 65 lbs of depleted uranium in each blade tip which keeps the rotor rigid and stable at he reduced rotor rpm and high forward speeds. The Heliplane, a combination of helicopter, gyroplane and fixed wing aircraft, may yet emerge in the 21st Century as the Phoenix to soar again in the skies about our cities, just as its Rotodyne ancestor did four decades ago!

¹ “ROTARY aeroDYNE” See Harrison, Jean-Pierre “Fairey Rotodyne” *Air Classics* Vol 22, No. 44 April 1996 pp. 44 – 47, 60 –62, 64 – 66, 79 – 80: p. 47

² The amazing abilities o the Rotodyne were routinely reported in the world’s aviation press, See e.g., “Rotodyne Demonstrates VTOL Features.” *Aviation Week*. Vol. 69 No. 14 October 6, 1958

³ For a description of the Fairey aircraft, see Taylor, H. A. *Fairey Aircraft Since 1915*. London, England: Putnam Aeronautical Books 1974, 1988; Annapolis, MD: Naval Institute Press

⁴ For a description of Westland aircraft, including the Rotodyne after the company took over Fairey Aircraft, Ltd., see James, Derek N *Westland Aircraft Since 1915*. London, England: Putnam Aeronautical Books, 1991: Annapolis, MD: Naval Institute Press.

⁵ Stalin subsequently awarded Bratukhin a Stalin Prize in recognition of his contribution to Soviet aviation in 1946. His various decorations were capped by the Order of Lenin and the Order of the Red Banner. In 1954 he became a Professor at the Moscow Aviation Institute and in 1962 was designated a Doctor of Technology; and in 1964 was titled “Honored Scientist and Engineer”.

⁶ See Everett-Heath Soviet Helicopters: *Design, Development and Tactics* London: Jane’s Publication Company 1983 pp. 146 – 147.

⁷ See Hollmann, Martin *Helicopters*. Monterey, CA: Aircraft Designs, Inc. pp. 119 – 125

⁸ Flettner would then go on to the development of what would be the best helicopter in WWII, the “synchropter”, a machine suggested by the work of Dr. J[ames] A.J. Bennett, who is discussed below, based on two off-set intermeshing counter-rotating blades. It was Flettner’s dual rotor design that gave rise to the term “eggbeater”.

⁹ See Smith J. R. and Antony L. Kay, *German Aircraft of the Second World War* England: Putnam 1972 pp. 589 for a discussion of Doblhoff; see also Halcomb, Mal “Vertical Lift, German Helicopter Development Through the End of World War II” in *Airpower Magazine* March 1990. However, for the view that Doblhoff was not the first to invent a jet-powered helicopter, see Taylor, John W. R. and H. F. King *Milestones of the Air: Jane’s 100 Significant Aircraft* New York: McGraw-Hill Book Company, 1969 p. 106 citing the initial jet-driven rotor experiments by Papin and Rouilly on March 31, 1912 during which prototype sank in Lake Cercey, Côte d’Or or even the earlier steam-jet powered model helicopter of W. H. Phillips. And although not cited in *Jane’s*, it should be noted that Harold Pitcairn, with the assistance of his old friend Agnew Larsen, had designed a helicopter with jet-tip rotors in 1916 – 1917 and successfully built flying models. Finally, see additionally Francis, Earl Devon *The Story of the Helicopter* New York: Coward-McCann, Inc. 1946 pp. 117-118 where he details the secret research in 1925 by Michael and Serge Gluhareff, working for the Sikorsky Aero Engineering Corporation, then housed in a Long Island, New York barn, into jet reaction helicopter rotors powered by compressed air. While there is no record of this research advancing to actual jet-tipped rotor, it was the next logical step.

¹⁰ For a description of the courting of the Austrian girl by both Doblhoff and Bensen, see Bensen, Igor B. *A Dream of Flight* Indianapolis, Indiana: The Abbott Company 1992 pp. 7-9.

¹¹ Frank Kingston Smith, in *Legacy of Wings: The Harold F. Pitcairn Story*, relates an enduring, but untrue myth that:

Only after Cierva’s demise did the Philadelphian learn that his friend’s estates and funds were seriously depleted by the turn of events in Spain and that Juan’s wife and children, then living in London, were virtually destitute. For many years Pitcairn quietly and without public knowledge contributed substantially to the financial support of the bereaved family.

¹² Pitcairn, H.F. “Juan de la Cierva: In Memoriam.” *Autogiro Co. of America* January 9, 1939

As stated in a communication of April 25, 2001 to the author from Juan de la Cierva, nephew of inventor Juan de la Cierva:

I have contacted a few family members old enough to remember, including cousins Jaime [de la Cierva Gómez-Acebo] second son of Juan [de la Cierva Gómez-Acebo], his sister Ana Maria who you met in Philadelphia, my older brother Ricardo and others. We all agree that there was no financial assistance from Harold Pitcairn to Juan’s family following his death.

The Spanish Civil War started in July 18, 1936. Juan died in December the same year. At the time, the entire family was indeed in very hard financial conditions, because all the family[’s] considerable assets were located in the “Red” zone of Spain, and were not recovered until the “nationalist” victory in April 1st, 1939. However, the nationalist government soon authorized banks to lend limited amounts of money secured by assets located in the red zone. The family secured some such loans and was able to live modestly until the end of the civil war. Once rescued from Santander by a British destroyer in August 1936, Juan’s wife and children lived first in Biarritz, France and then in San Sebastian, which was liberated from the reds in September 13, 1936. Juan visited them several times during his trips in and out of Europe (usually by car) until December 1936, when he died in London. . . . Juan’s only brother, my father Ricardo, was assassinated by the communists in a big 5000 people massacre which took place in November 6th, 1936 in Paracuellos, near Madrid. After Juan’s death, his family moved to an apartment in the Ondarreta section of San Sebastian, where they lived until the liberation of Madrid in March 28, 1939. Juan’s family never lived in England. My mother, myself and my brothers moved to another apartment in the Gross section of San Sebastian. Of course, we often saw our cousins during the war years.

And, in a telling comment significantly describing the friendship that existed between his uncle Juan and Harold Pitcairn, his nephew goes on to relate:

Juan had planned to educate his older children as follows: Oldest son Juan (16 in 1937) completed high school in 1937 and went to Scotland to study aeronautical engineering staying with the Weir's. He returned to Spain in 1938 to enlist in the war, and served until 1939. Jaime (15 in 1936) was to be sent to America under care of the Pitcairns and Mercedes (13) also to England to a Nun's school. These plans never materialized.

¹³ This aircraft, initially flown by test pilot Ewald Rohlfs for just twenty-eight seconds on June 26, 1936, weighed just over 2,100 lbs and was powered by a 160 hp. Bramo radial engine mounted in the front of the fuselage. It superficially resembled an Autogiro as there was a wooden propeller in the front center, but its blades had been cut down to the size of the cylinders and its only function was to cool the engine which powered the two three-bladed rotors which were mounted on lateral outriggers on either side of the fuselage. Its forward motion was derived from the rotors and, as such, it is often credited as the first "practical" helicopter. This designation could, however, be legitimately claimed by the French Bréguet-Dorand helicopter, which had set F.A.I. rotorcraft speed records in 1935 and 1936, but which was destroyed in an Allied air raid on the Villacoublay air base in 1943. But it certainly obvious that the French had not received the same publicity, or public acclaim that had been accorded Professor Heinrich K[arl] J[ohann] Focke's creation. For while there was seemingly little public awareness of the speed records of 77 mph and altitude achievement of 7,800 feet set in June of 1937, the public took sharp notice when the world's first female helicopter pilot, Hanna Reitsch (dubbed the German "Amelia Earhart" and who had recently been given the honorary rank of Flugkapitän ("Flight Captain") in recognition of her many research flights in gliders and warplanes), flew the Fa-61 inside the Berlin Deutschland-Halle, a large meeting hall, before thousand of spectators in February 1938. It has been claimed that the spectators consumed so much oxygen that it reduced the Fa-61's engine power, necessitating airing of the arena during the demonstrating flights – see Young, Warren R. *The Helicopters*, Alexandria, Virginia: Time-Life Books 1982 p. 74. Chosen, in part for her photogenic and propaganda appeal, and perhaps in equal part for her petite stature and slight weight, given the limited lifting ability of the small helicopter, it was an inspired performance. Pictures of her controlled, indoor flight stunned the world in general, and aviation designers and military leaders in particular - in American Army aviator 1st Lieutenant H[ollingsworth]. Franklin Gregory, who would become instrumental in rotary wing development, insured that rotary development funds went to the helicopter and not the autogiro. Military leaders, stunned when Hitler had revealed the new *Luftwaffe* in 1935 as a prime image of a resurgent Germany, now saw evidence of secret technological progress with the newest aerial weapon. Years later, when the female helicopter pilots would found an international organization called the "Whirly-girls", Reitsch fittingly became Whirlygirl #1, a recognition that has lasted longer than the dubious she achieved at the end of WWII. Towards the end of the war, Reitsch, then a military test pilot, flew with a male test pilot through Russian flak to visit Hitler in the Berlin Bunker. The legend, which then circulated that Reitsch had subsequently flown Hitler to safety, resulted in her imprisonment and intense questioning by Allied intelligence officers after the war's end. See Roseberry, C. R. *The Challenging Skies: The Colorful Story of Aviation's Most Exciting Years 1919 – 39*. Garden City, New York: Doubleday & Company 1966 p. 428

¹⁴ D.Sc., Ph.D., D.I.C., F.R.Ae.Sc., Professor Aerodynamics and Deputy Principal, College of Aeronautics in 1961.

¹⁵ See Issacs, (Group Captain) Keith "Project Skywards" *Rotorcraft* Vol. 32 No. 4 June – July 1994 pp. 6 – 9 (detailing the development of the DCA Fleep Rotary-Wing Glider or 'Flying Jeep', the Australian independent version of the Rotabuggy)

¹⁶ At the time of his death, Cierva and his engineers had been researching the fixed-spindle direct- control cyclic/collective pitch rotor heard

¹⁷ As observed by Dr. Bennett in "The Era of the Autogiro" in the October 1961 issue of *The Journal of the Royal Aeronautical Society* (Vol. 65 No. 610):

The Autogiro principle, which was concerned basically with blade auto-rotation at a positive pitch angle, was covered by Cierva's first application for apparent but, with little knowledge of patent law at the time, he allowed this early parent application to lapse in favour of the other relating to a single rotor with articulated blades. Convinced that no Autogiro could be successful without this particular feature, he abandoned the possibility of securing a very broad parent on the basic principle of the Autogiro. In trying to re-claim later what he had lost, most of his subsequent British parents were restricted in their application to rotorcraft with autorotative blades, Cierva having established a clear distinction between the Autogiro and helicopter. *In the United States, however, no such distinction was made and most of Cierva's American parents were considered to applicable to helicopters as well as Autogiros.* (emphasis added).

This lesson had not been lost on Harold Pitcairn, who was extremely careful and attentive to his patent applications filed by the Philadelphia firm Synnestvedt & Lechner. Pitcairn's lawyer and long time-friend Raymond Synnestvedt, had advised him as early as 1924 to parent all rotary wing inventions, even on those concepts that were not then successful, in the belief that even the theoretical might become practical and eventually profitable. He carefully secured extensive patent protection on his work and that of his associates. The 1936-38 rotorhead work of Cierva Autogiro Company, which was supposed to be shared with Pitcairn, was significant in term of the development of the PA-36 jump-takeoff model with its parented complex cyclic/collective pitch rotor head which was "the watershed design for rotary wing flight. Every mechanism before it was made obsolete the day it flew successfully." (See Frank Kingston Smith's "Mr. Pitcairn's Autogiros" in the March, 1983 *Airpower* (Vol. 12 No. 2) Pitcairn's patent would furnish the basis for his eventually successfully suit for royalties against the United States government.

¹⁸ "The FA-61 (D-EBVU) was the special creation of World War I pilot Professor Henrich K. J. Focke, formerly the design chief of an established firm that bore his name, Focke-Wulf [Flugzeugbau G.m.b.H.], who had been displaced [in 1933] by the Nazis as being "politically unsafe." The Professor Focke promptly started a small new company – Focke-Achgelis [G.m.b.H]– devoted to the perfection of rotating-wing aircraft, a subject in which he was strongly interested. His company had a license agreement with Cierva to build Autogiros – the first was a Cierva C.19 - and the Autogiro influence was evident in the Fa-61." – *Helicopters and Autogiros* by Charles Gablehouse Philadelphia and New York: J. B. Lippincott Company 1967 pp. 76-77.

¹⁹ As cited by Martin Hollman in the introduction to *Helicopters*, the second prototype Fa-61 (D-EKRA) established the following F.A.I. world records for helicopters:

25/26 June 1937 (pilot Ewald Rohlf)

m 2,439 (8,001 ft.) altitude
 m 1 hr. 20 min. endurance
 m 80.6 km (50 miles) distance⁴ in a straight line
 m 122.5 km (76.1 miles) distance over a closed circuit
 m 16.4 km/hr (10.1 m.p.h. speed over a closed circuit

25 October 1937 (pilot Hanna Reitsch)

m 108.97 km (67 miles) distance in a straight line

20 June 1938 (pilot Karl Bode)

m 230.3 km (143 mountains) distance in a straight line

29 January 1939 (pilot Karl Bode)

m 3,437 m (11,243 ft) altitude

²⁰ Indeed, after being introduced by Dr. J.A.J. Bennett, Chairman of the Rotorcraft Section of the Royal Aeronautical Society on October 23, 1964, Professor Focke, who had by then been awarded the Lilienthal Medal

and the Prandtl-Ring by the Wissenschaftl. Gesellsch. f. Luftfahrt, delivered the Fifth Cierva Memorial Lecture. (Dr. Ludwig Prandtl, Professor at the University of Goettingen, had previously been the recipient of the second Daniel Guggenheim gold medal for notable achievement in aeronautics ‘for pioneering and creative work in the theory of aero-dynamics’ and was recognized in 1930 as “one of the world’s most eminent authorities on aerodynamics and other sciences underlying the art of aviation.” See *The Journal of The Royal Aeronautical Society* July 1930 p. 8). In that lecture, Focke paid tribute to Cierva’s work as being *the* significant contribution to the eventual development of the helicopter. Igor Sikorsky would later state that Cierva had shortened the development of the helicopter by 10 years!

²¹ See “The Wilford Gyroplane” in *Aero Digest* February 1932 pp. 56-57. E. Burke Wilford, who had previously done significant work for the Pennsylvania Aircraft Syndicate directed towards aircraft safety, purchased the parent rights to the work of German inventor and aircraft designers Walter Rieseler and Walter Kreiser in 1925, thus predating Pitcairn’s involvement with Cierva. He called his craft a Gyroplane as Cierva had copyrighted and trademarked that term, much as Igor Bensen would later do with the term “Gyrocopter”. It was distinguished by a smaller rotor that operated at higher r.p.m. and a rotor with rigid feathering blades which generate a high lift without excessive weight to equalize the lift between the advancing and retreating blades. While the Army Air Corps would eventually evaluate his Gyroplane, Wilford was never a serious contender to either Pitcairn or Kellett in Autogiro development. This was, in part, because his test pilot Joseph McCormick, brother of William McCormick who had been with RADM Richard Evelyn Byrd to the South Pole as his Autogiro pilot, died in a 1934 crash. See also Gablehouse, Charles *Helicopters and Autogiros* Philadelphia and New York: J. B. Lippincott Company 1967 pp. 62-664; Francis, Earl Devon *The Story of the Helicopter* New York: Coward-McCann, Inc. 1946 p. 103. [Francis claims somewhat fancifully that it was Wilford that suggested to Dr. Henrich Focke that he acquire the German manufacturing rights to the Cierva Autogiros in 1928, but while the meeting between the two is documented, neither the suggestion nor the imputed subsequent action is. See e.g., Smith J. R. and Antony L. Kay, *German Aircraft of the Second World War* England: Putnam 1972.

²² But see Brooks, Peter W. *Cierva Autogiros: , The Development of Rotary-Wing Flight*. Washington, D. C.: Smithsonian Institution Press, 1988 pp. 228 – 229:

None of the seven PA-39’s (BW828 to BW834) were ever employed on actual operations in the intended role. Five were to have been used to by the RAF for communication duties but only two reached the United Kingdom and apparently only one (probably BW833) was flown there – initially at Duxford by Alan Marsh and probably later at Boscome Down. Three (BW828 – BW830) were damaged – according to one account, deliberately sabotaged – in January 1942 in Canada while being loaded for shipment to the United Kingdom and were scrapped together with spares in the same consignment. At the time it was stated that they had been lost at sea when their ship was torpedoed.

²³ “GYROtory aeroDyne” See Harrison, Jean-Pierre “Fairey Rotodyne” *Air Classics* Vol 22, No. 44 April 1996 pp. 44 – 47, 60 –62, 64 – 66, 79 – 80: p. 46.

²⁴ Although utilizing Greek names such as Pelides, Pelides Major, Alcides and Maeonides for its line of engines, Alvis was an English company known primarily for its manufacture of fine automobiles. In 1935 it had secured a license for several Gnome-Rhône engines (which itself had become a licensee of the Bristol Aeroplane Company in 1921). The Leonides, developed by Captain G. Smith-Clark was a radial engine with 9 two-valve cylinders. It was an excellent well-received power plant that delivered 450-550 hp at only 693 lbs. The engine had an efficient low-pressure fuel-injection system and was England’s last high-power production piston engine with the last models produced in late 1966 (the final production models achieved 640 hp). Alvis later also developed non-radial 14-cylinder 2-row Leonides Major engines that developed up to 850 hp. For a complete description of Alvis, see *The World Encyclopedia of Aero Engines* (4th ed) Sparkford. Nr. Yeovil, Somerset: Patrick Stephens Limited 1998

²⁵ In 1948 the Minister of Civil Aviation had appointed an Inter-departmental Helicopter Committee to report on the future of the commercial helicopter in England. The first draft report was delivered in 1951 and projected 10-12 passenger helicopter service between British cities on a limited basis by 1954 and that, gaining acceptance, would become an integral part of commercial air service for both passengers and freight. Subsequently, by 1952 British European Airways (BEA) circulated a development requirement for the “Bealine-Bus”, a multi-engine 30-seat helicopter for inter-city transport.

²⁶ There were several forms of jet tipped drives available, or in various stages of development: a) the *pressure jet* - in which gas, produced in the fuselage, is fed to the rotor hub via rotating seals and then to the individual blades where it passes through ducts through the airfoil section to the tips. The exit from the blades is at a 90 degree angle. The pressure powers the rotor blades but often yields inefficient results so the thrust must be increased by adding fuel to the flow of gas which is ignited at the nozzle tip. If this reheating at the tip is implemented, the blade weight must be increased by thermal shielding of the inner parts of the blade itself; b) *tip mounted gas turbine* - in which a gas turbine jet engine is mounted at the tip of each rotor blade. The fuel for each engine is provided through tubes in the rotor blades; c) *tip mounted pulse jet* - which can operate with a stationary rotor and exhibits greater fuel efficiency, but has a limited life span and increased drag due to the longer jet pipe; and d) *tip mounted ram jet* – simplest mechanical application of jet tipped technology, but as the rotor must be moving, cannot operate with a zero rotor speed. Each of these presents serious challenges to the designer, including 1) stronger (heavier) blades and mounting rotor hubs due to increased weight at the blade tips where the nozzle or jet tube is located; 2) increased drag at the blade tips where jets are located; 3) need for extensive internal ducting and seals due to fuel flow and ignition, thus a more complicated hub and blades; and 4) the need to deal with increased noise due to jet fuel ignition, increased fuel requirements and cost, and in a more contemporary manner than in the 1950s, to deal with pollution concerns. For a more complete discussion of the mechanical issues of tip driven rotorcraft, see Newman, Simon *The Foundation of Helicopter Flight* Great Britain: Edwin Arnold Division of Hodder Headline PLC 1994 pp. 21 – 22.

²⁷ See Endnote xvi.

²⁸ See Wood, Derek *Project Cancelled: British Aircraft That Never Flew* Indianapolis/New York: The Bobbs-Merrill Company Inc. 1975 pp. 109- - 129

²⁹ The Eland would be almost the last hurrah for D. Napier & Son - in 1960 it was divided and Napier Aero Engines Ltd became a subsidiary of Rolls-Royce in 1962, a year after it had ceased production of the Eland power plant.

³⁰ The Rotodyne “Y” was much smaller than the projected commercial version, the Rotodyne Z, which was to be powered by two Rolls-Royce Tyne turboprop engines and carry 54 - 70 passengers. It was never built.

³¹ By 1956, the rotor system weighed in at 5,503 lbs, which was 68% above the originally estimated 3,270 lbs.

³² Based on the measurements taken with the Jet Gyrodyne fitted with tip-jets, Fairey anticipated that the Rotodyne noise-level at 200 ft altitude from both engines would be 106 PN dB. Fairey hoped to reduce this to a more acceptable 96 PN dB, but while the estimated sound level was correct, the reduction was never achieved and the Rotodyne remained a loud machine. The claim, however, that the Rotodyne failed because of its noise level is overly simplistic and certainly self-serving.

³³ Indeed, in November 1956, Fairey Aviation’s advertisements for the Rotodyne announced that it “will be the first large transport aircraft to offer high cruising speed with the ability to operating from small landing sites” and “[t]he Rotodyne, being independent of conventional runways, will bring the advantages of air transport to almost every locality.” See “The Aeroplane.” November 23, 1956 p. 26; see also “The Illustrated London News.” August 30, 1958, in which the Fairey Aviation advertisement, touting “Rotodyne travel” and showing the Rotodyne being boarded by passengers in Paris with the Eiffel Tower in the background, announced that “[f]orty-eight people will settle themselves in the wide, comfortable cabin of the Fairey Rotodyne, as some small open space in the middle of a town. The Rotodyne will lift them vertically far above chimney-smoke and church spires – and then, gradually transferring the power of its two turbine engines from the big rotor to the forward propellers, it will whisk them

across land and water at nearly 200 m.p.h.. Over the destination – the center of a city, not some airport far outside – the rotor will lower them, straight down, to a safe arrival. A new conception in aircraft design has brought this kind of travel into plain sight – the Rotodyne which is neither aeroplane nor helicopter, but something of both, and the world’s first Vertical Takeoff Airliner.”

³⁴ For a description of the Fairey Aviation Canadian involvement, see *West Coast Aviator* “THE FAIREY ROTODYNE – Nearly The Answer” September/October 1995 pp. 35 – 37.

³⁵ The proposed US Army/Kamen Rotodyne utilized two General Electric T-64 gas turbine engines with a cruising speed projected to be 200 plus knots with an 1800 plus miles range. See Harrison, Jean-Pierre “Fairey Rotodyne” *Air Classics* Vol 22, No. 44 April 1996 pp. 44 – 47, 60 –62, 64 – 66, 79 – 80: p. 60 – Photo Caption.

³⁶ NYA calculated that the break-even load for the Rotodyne, with enlarged capacity, would be 45 – 50% whereas that of the largest passenger helicopters, the Sikorsky S-61L and Vertol 107 II (seating 25 and 28) rose to 80%. The projected Rotodyne operating cost was estimated to be four cents/seat/mile while the Vertol would cost at least 12 cents and the Sikorsky even more. The Rotodyne’s economic efficiency was derived, in part, from its ability to land in the inner city and avoid the necessity of extensive ground travel to and from an outlying airport. See Harrison, Jean-Pierre “Fairey Rotodyne” *Air Classics* Vol 22, No. 44 April 1996 pp. 44 – 47, 60 –62, 64 – 66, 79 – 80: p. 62.

³⁷ Lord Douglas of Kirtleside, then Chairman of BEA, stated in January of 1959 that “We are also saying that we foresee an ultimate Corporation requirement for up to twenty of these aircraft for operations on our shorter cross-Channel and domestic routes.” See Wood, Derek *Project Cancelled: British Aircraft That Never Flew* Indianapolis/New York: The Bobbs-Merrill Company Inc. 1975 p. 121.

³⁸ In fact, noise had already proven an insurmountable problem for an American predecessor convertiplane, the McDonnell XV-1 compound helicopter that was similar in concept but much smaller (26 ft long; weight of 4277 lbs empty; 5505 lbs gross weight) than the Rotodyne in the mid-1950s. In 1949, while the Rotodyne vision was first being articulated, the Convertible Aircraft Congress in America sought to stimulate development of an observation and reconnaissance convertiplane. Of the designs that were submitted and selected for development, the McDonnell XV-1, a compound helicopter (more properly, convertiplane) was one of the most impressive. Chief engineer was jet-powered rotor pioneer Friedrich von Doblhoff and the XV-1 was powered by pressure jets and tip-burning rotors. It carried two passengers and derived its lift in take off, landing and hovering from a three-blade pressure-jet-driven rotor. In forward flight lift came from an unloaded rotor, small wings with thrust coming from a pusher-propeller located between a twin-boom configuration. The XV-1 made successful conversions between helicopter and autogyro modes in 1955 and achieved speeds of 200 mph (initially a record for helicopters, but later rescinded as the craft was redesignated a “convertiplane”), “configuration-induced aerodynamic problems and the excessive noise of the tip jet burning prompted the phaseout of the XV-1.” See Schneider, John J. “Rotary-Wing V/STOL” in Boyne, Walter J. and Donald S. Lopez *VERTICAL FLIGHT: The Age of the Helicopter* Washington, D.C.: Smithsonian Institution Press 1984 pp.178 – 179 (emphasis added). The XV-1 was discontinued in 1956 and today the McDonnell XV-1 ‘Convertiplane’ (SN 53-4016) resides in the United States Army Aviation Museum, and National Air & Space Museum, Smithsonian Institution, Washington, D.C.

³⁹ The Defense White Paper of 1957 had concluded *inter alia* that there must be a “consolidation of the British aviation industry.” The result of this forced consolidation was that in 1956 there were 15 major aviation manufacturers in the United Kingdom, but by the end of 1960, only three remained – two fixed-wing and one rotary wing – Westland. See “TSR2 - If Only . . .” *Aircraft Illustrated*. Vol. 34 No. 6 June 2001 pp. 50 – 54: 53

⁴⁰ Indeed, in 1989 one publication, apparently abandoning the “party line” of cancellation due to noise, claimed that the Rotodyne was cancelled because “the lumbering Rotodyne was a clumsy aircraft to fly/” *The Flat Risers: The Ups & downs of VTOL (Part 2)* *TakeOff*. Vol. 1 Part 5 1989 pp. 138 – 143 p. 139

⁴¹ In fact, only two comments were received as a result of the Battersea flights: A lady inquired, on behalf of her son, if that indeed had been the Rotodyne; and a second from a woman whose ‘light sleeping baby’ had not in the

least been disturbed by its flight. See Harrison, Jean-Pierre “Fairey Rotodyne” *Air Classics* Vol 22, No. 44 April 1996 pp. 44 – 47, 60 –62, 64 – 66, 79 – 80: p. 61.

⁴² See Anders, Frank “The Problem Solver” *Air Classics* Vol. 30 No. 10 October 1994 pp. 50 – 58: 53

⁴³ Taylor, Michael *The World’s Strangest Aircraft: A Collection of Weird and Wonderful Flying Machines* New York: Barnes and Noble Books 1996 pp. 89 – 91.

⁴⁴ Taylor, W. R. and H. F. King *Milestones of the Air: JANE’S 100 Significant Aircraft* New York: McGraw-Hill Book Company 1969 pp. 136 – 137. Also included were the Cierva Autogiro and Doblhoff WNF 342.

⁴⁵ Bruno Nagler had been an associate of Raoul Hafner in early helicopter design. Additionally, after returning to Austria from England in 1935, Nagler joined Franz Rolz in a similar endeavor, producing a helicopter that could only hover within its ground cushion. By 1940 they had changed developmental direction towards very small helicopters designed for recreation, postal delivery and other activities in rural Austria. By 1945 they had completed three different aircraft (and designed a fourth), one of which, the Nagler-Rolz 54 of 1943 is currently in the National Air and Space Museum of the Smithsonian Institution. See See Hollmann, Martin *Helicopters*. pp. 37 – 38

⁴⁶ Hollmann, Martin *Helicopters*. pp. 130 - 131

⁴⁷ See Everett-Heath *Soviet Helicopters: Design, Development and Tactics* London: Jane’s Publication Company 1983 p. 33 “The Ka-22 could be considered the Soviet answer to Britain’s compound helicopter, the Rotodyne, which first flew in 1957 but was abandoned five years later.” See also *Helicopters and Autogiros* by Charles Gablehouse Philadelphia and New York: J. B. Lippincott Company 1967 pp. 108 – 109: “Although much larger and somewhat faster, the Kamov Ka-22 which attracted world attention at the Soviet Aviation Day Tushino air display in 1961 could be considered as the Russian counterpart to the *Rotodyne*..”

⁴⁸ The following were *estimated* dimensions of the Ka-22: Normal loaded weight – 65,000 lbs.; maximum loaded weight – 72,000 lbs; rotor diameter (each) 65 ft. 8 in.; wing span – 67 ft.; fuselage length – 75 ft.; overall height – 27 ft. See Green, William and Gerald Pollinger *The Aircraft of the World* New York: Doubleday and Company, Inc. 1965 p. 322.

⁴⁹ Alternatively reported as a 6,500 hp Soloviev D-25VK engine, a nine-stage single-spool turboshaft modified from the D-25V engine previously used on the Mil Mi-6, Mi-10 and V-12 helicopter,. Accuracy is difficult because the western press only saw the Vintokryl once.

⁵⁰ The crew of five consisted of: D. K. Yefremov, V. M. Evdokimov, V. B. Alperovich, E. I. Filatov, and Yu. I. Emelianov.

⁵¹ See Everett-Heath *Soviet Helicopters: Design, Development and Tactics* London: Jane’s Publication Company 1983 pp. 162 – 163; see also *World & United States Aviation & Space Records* Washington, D.C.: National Aeronautic Association 1987 pp. 89 – 90 As of June 6, 1989 the Kamov Ka-22 held every world record for convertiplane, with pilot D. K. Yefremov, with the exception of the Rotodyne record over a closed circuit of January 5, 1959.

⁵² See Kamov page at www.aviation.ru; see also Savine, Alexandre <http://hep2.physics.Arizona.edu/~savin/ram/ka-22.html>

⁵³ Everett-Heath *Soviet Helicopters: Design, Development and Tactics* London: Jane’s Publication Company 1983 p. 33. The author then goes on to speculate there that:

It is not known exactly why further development of this aircraft was not pursued. It may have been because at any state of flight either the rotors or propellers were not earning their keep. Attempts to avoid such superfluous units whose weight reduced the useful load led in the USA to wing with a tilting rotor, a configuration employed in the Bell XV-3 which first flew in 1955.

⁵⁴ Everett-Heath *Soviet Helicopters: Design, Development and Tactics* p. 32.

⁵⁵ For a description of Nagler's life and work, see Parham, Don "The Bruno Nagler Story" *Homebuilt Rotorcraft* Vol 12, No. 3 March 1999 pp. 8-12. For a specific analysis of the Nagler Vertigyro, see Parham, Don "Nagler's Vertigyro." *Homebuilt Rotorcraft* Vol. 14 No. 7 July 2001 pp. 8 - 10.

⁵⁶ For a photograph of this obscure and enigmatic aircraft by noted aviation photographer, Howard Levy, see Townson, George and Howard Levy "The History of the Autogiro: Part Two" *Air Classics Quarterly Review* Vol. 4 No. 3 Fall 1977 p. 113.

⁵⁷ For a picture and technical description of the obscure Nagler Vertigyro VG-1, see See Green, William and Gerald Pollinger *The Aircraft of the World* New York: Doubleday and Company, Inc. 1965 p. 338 and Parham, Don "Nagler's Vertigyro." *Homebuilt Rotorcraft* Vol. 14 No. 7 July 2001 p. 9.

⁵⁸ For a picture of Nagler's Vertigyro in flight, see *Popular Rotorcraft Flying* Vol 2 No. 2 Spring 1964 p. 15

⁵⁹ Established in late 1963 from a merger of Focke-Wulf GmbH and Weser Flugzeugbau GmbH, and joined in 1964 by Ernst Weser Flugzeugbau. During 1968 – 1969 acquired 65% holding in Rhein-Flugzeugbau GmbH, later acquiring 100%. In January 1969 became partner with Fokker of the Netherlands and was renamed VFW-Fokker, which lasted until 1980. It ended as a member of the European Spacelab Consortium and was taken over by Messerschmitt-Bölkow-Blohm GmbH in 1981.

⁶⁰ For a description of Christian Fischer, VFW and the design of the Heli-Gyro, see Fischer, Albert G. "Germany's VFW Sports a Hollow-Bladed Helicopter-Autogyro – with a McCulloch!" *Popular Rotorcraft Flying* Vol. 5 No. 3 September 1967 p. 30; see also "VFW Joins the Parade" *Popular Rotorcraft Flying* Vol. 9 No. 4 July-August 1971 p. 31.

⁶¹ See Anders, Frank "The Problem Solver" *Air Classics* Vol. 30 No. 10 October 1994 pp. 50 – 58: 58. He also stated, commenting on the demise of the Rotodyne, that "[r]emembering that all this occurred over 30 years ago. Had this concept continued – accentuated with modern technology engines with low fuel consumption and electronics for the complex hydraulic control system – commercial aviation would have had a transport of enormous potential competing with both fixed and rotary wing machines." p. 57

⁶² For a complete discussion of the performance standards of the Heliplane, see http://www.cartercopters.com/precision_strike_paper.html

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